

SUSTAINABLE GROUNDWATER MANAGEMENT IN LAGOS, NIGERIA: THE REGULATORY FRAMEWORK

ADEBOLA OGUNBA

**THESIS SUBMITTED TO THE FACULTY OF GRADUATE AND
POSTDOCTORAL STUDIES IN PARTIAL FULFILMENT OF THE
REQUIREMENTS FOR THE DOCTOR OF PHILOSOPHY DEGREE IN
LAW**

GRADUATE STUDIES IN LAW

FACULTY OF LAW

UNIVERSITY OF OTTAWA

© ADEBOLA OGUNBA, OTTAWA, CANADA, 2016

ABSTRACT

This doctoral research focuses on groundwater degradation in Lagos, Nigeria. Groundwater is a critically important natural resource in Lagos that is presently troubled by pollution that emanates from solid waste and wastewater. The city generates 10,000 metric tons of waste and 350 million gallons of wastewater daily, all of which are improperly managed and are heavily polluting its groundwater. This direct environmental pollution is aggravated by indirect problems of over-urbanization, and legal and institutional shortcomings. Over-urbanization in Lagos has resulted into a monumental population of 21 million people in the tiny city, which generates the enormous quantities of solid waste and wastewater. The population places a tremendous burden on the city's water resources, forcing residents to revert to groundwater which is suffering the plight of pollution, and hence the concern of this research. The pollution problem is worsened by civic apathy to environmental matters, and unresolved by a nascent water sector whose evolving governance structures do not adequately address the multi-dimensional pollution problem. In the final analysis, the absence of holistic and comprehensive groundwater legislation that addresses all these problems challenges the sustainability of this vital resource.

The research adopts a cross-disciplinary approach by combining several methodologies: historical legal analysis, important insights from scientific studies and from sociological studies that rationalize the demographical movement to Lagos which is at the root of the pollution problem; field work investigation to confirm the fact, source, and extent of polluted groundwater; and a comparative approach by examining the European Union's legal framework for managing groundwater and waste in order to extract sustainable practices for adoption in Lagos. It concludes with a range of recommendations for incorporation into a legal framework

that will help to improve the sustainability of the groundwater resource. The study contributes to knowledge by attempting to close a vacuum, which is the paucity of studies that investigate underlying social factors that trigger groundwater pollution, and also by providing broad and holistic recommendations for law reform. It addresses the role of law in remediating the pollution, managing the effects of over-urbanization and overpopulation on groundwater, strengthening institutions, and eliminating legal inadequacies.

Table of Contents

ACKNOWLEDGMENTS.....	xv
DEDICATION.....	xvii
OVERVIEW OF THESIS	xix
CHAPTER 1 GENERAL INTRODUCTION	1
1.1 Introduction to Lagos, Nigeria	1
1.1.1 Origin, Population and Economic Prominence	1
1.1.2 Groundwater in Lagos	4
1.1.3 Hydrogeology of Lagos	4
1.2 Statement of Research Problem	9
1.2.1 The Environmental Problem: Municipal Solid Waste and Sewage.....	9
1.2.2 Social Problems: Urbanization and Apathy.....	12
1.2.3 Institutional Problems.....	14
1.2.3.1 A Meagre Regulatory Framework.....	14
1.2.3.2 A Nascent Water Sector.....	15
1.3 Research Objective.....	16
1.4 Research Questions.....	17
1.5 Methodology.....	17
1.6 Contribution of Research to Knowledge.....	20
1.7 Argument for the Thesis.....	20
1.8 Presentation of Chapters.....	22

CHAPTER 2: SUSTAINABLE DEVELOPMENT.....	25
2. Introduction	25
2.1 A Brief History of Sustainable Development.....	29
2.1.1 Silent Spring.....	29
2.1.2 The World Commission on Environment and Development.....	31
2.2 The Pillars of Sustainable Development.....	34
2.2.1 Ecologically Sustainable Development.....	35
2.3 Core Principles of Sustainable Development Relating to Water.....	37
2.3.1 The International Conference on Water and the Environment.....	37
2.3.1.1 Water Conservation and Reuse.....	38
2.3.1.2 Water and Sustainable Urban Development.....	39
2.3.2 The United Nations Conference on Environment and Development.....	39
2.3.2.1 Agenda 21.....	40
2.3.2.1.1 Integrated Water Resources Management.....	41
2.3.2.1.2 Water Resources Assessment.....	41
2.3.2.1.3 Protection of Water Resources and Water Quality.....	42
2.3.2.1.4 Sustainable Urban Development and Water.....	42
2.3.3 The United Nations Conference on Sustainable Development.....	43
2.3.4 The United Nations Sustainable Development Summit.....	44
2.4 Environmental Law Principles in Sustainable Development.....	47

2.4.1 The Polluter Pays Principle.....	47
2.4.2 The Principle of Prevention	48
2.4.3 The Precautionary Principle.....	48
2.4.4 Environmental Impact Assessment.....	50
2.5 Summary	51
2.6 Conclusion.....	52
 CHAPTER 3: THE NATURE, CHARACTERISTICS AND IMPORTANCE OF GROUNDWATER.....	 53
3.1 Nature and Characteristics of Groundwater.....	54
3.2 Groundwater's Comparative Advantages over Surface Water	56
3.3 The Global Importance of Groundwater.....	59
3.4 The Importance of Groundwater in Lagos.....	65
3.5 Conclusion.....	68
 CHAPTER 4: URBANIZATION IN LAGOS.....	 70
4.1 The Concept and Evolution of Urbanization.....	70
4.1.1 Relevant Urbanization Theories and Dimensions.....	75
4.1.2 Rural-Urban Migration Theories	75
4.1.2.1 Migration to Lagos.....	76
4.1.3 Natural Population Increases.....	79

4.1.3.1 Natural Population Increases as a Population Enhancer	
in Lagos.....	80
4.1.3.2 The Implications of a Large Population: Malthusian	
and Bartlett's Theories.....	82
4.2 Dimensions of Urbanization.....	87
4.2.1 Over-Urbanization.....	87
4.2.2 Urban Primacy.....	91
4.2.3 Urban Bias.....	94
4.3 The Significance of Lagos	96
4.4 Problems of Large Cities.....	98
4.4.1 Water Shortage.....	99
4.4.2 Vast Waste Generation.....	100
4.4.3 Groundwater Pollution by Solid Waste and Wastewater.....	100
4.5 Summary.....	103
4.6 Conclusion.....	105

CHAPTER 5: PROBLEMS CONFRONTING GROUNDWATER IN LAGOS

PART I: The Problem of Solid Waste in Lagos.....	107
5.1 A Conceptualization of Solid Waste.....	107
5.1.1 Sources and Composition of Solid Waste.....	109
5.1.2 Move from Landfill based to Resource based Waste Management.....	109

5.2 Municipal Solid Waste Management in Lagos.....	110
5.2.1 Profile of Lagos Waste Dumps.....	112
5.2.2 Volume of Waste Generated.....	112
5.2.3 Composition of Waste in Waste Stream.....	112
5.3 Pollution of Groundwater by Open Waste Dumps in Lagos.....	114
5.3.1 Empirical Research Findings on Waste Dump Pollution of Groundwater.....	115
5.4 Report of Field Trip to Lagos.....	121
5.4.1 Summary of Research Findings on Solid Waste Management.....	122
5.4.2 Analysis and Discussion	124
5.5 Polluted Groundwater and Human Health.....	129
5.6 Mitigating Harm at Waste Disposal Sites.....	131
5.7 Probable Alternatives to Open Dumping of Waste in Lagos.....	132
5.8 Summary.....	135
PART II: The Menace of Wastewater to Groundwater	
5.9 Definition of Wastewater.....	137
5.10 History of Wastewater Management in Lagos.....	138
5.11 Current Wastewater Management Practices.....	139
5.11.1 Domestic Sewage.....	140
5.11.1.1 Empirical Research Findings on Domestic Sewage Pollution of Groundwater.....	143

5.11.2 Industrial Wastewater.....	144
5.11.2.1 Empirical Findings on Industrial Wastewater Pollution of Groundwater.....	145
5.12 Report of Field Trip to Lagos.....	146
5.13 Summary of Research Findings on Wastewater Problems.....	146
5.14 Discussion and Analysis	148
5.15 Description of Chemical and Microbial Contaminants in Leachate/Wastewater....	153
5.15.1 Chemical Contaminants.....	154
5.15.1.1 International Case Studies	158
5.15.2 Microbial Contaminants.....	159
5.15.3 Profile of Hazardous Chemical and Microbial Contaminants in Groundwater	160
5.16 The Usefulness of Wastewater.....	162
5.16.1 Treating Wastewater.....	162
5.16.2 Using Raw Wastewater.....	164
5.17 Summary.....	166
5.18 Conclusion.....	170

CHAPTER 6: A REVIEW OF THE LEGAL AND INSTITUTIONAL FRAMEWORKS FOR GROUNDWATER IN LAGOS

6.1 History of Environmental Regulation in Nigeria.....	172
---	-----

6.1.1 The Colonial Period.....	174
6.1.2 Petroleum-focused Environmental legislation.....	177
6.1.3 Rudimentary and Perfunctory	179
6.1.4 Contemporary Period.....	184
6.2 Environmental Management Institutions in Lagos.....	189
6.3 Current Legal Framework for Groundwater in Lagos.....	193
6.3.1 Federal Framework.....	195
6.3.2 A Review of NESREA Regulations on Groundwater.....	202
6.3.2.1 Groundwater Quality Protection under NESREA.....	203
6.3.2.1.1 Industrial Effluents and Leachates.....	203
6.3.2.1.2 Control of Manufacturing Wastewater.....	206
6.3.2.1.3 Domestic Effluents.....	208
6.3.3 General Appraisal of Federal Laws Relating to Groundwater.....	211
6.4 State Regulation of Groundwater in Lagos.....	212
6.4.1 Lagos State Policy on the Environment.....	213
6.4.2 The Lagos Water Sector Law.....	214
6.4.2.1 Groundwater Abstraction under the Water Sector Law.....	215
6.4.2.2 Groundwater Quality Preservation under the Water Sector Law.....	216
6.4.3 The Lagos State Environmental Protection Agency Law.....	220
6.5 Laws Relating to Solid Waste Management in Lagos.....	221

6.5.1 Lagos State Waste Management Authority Law (LAWMA).....	222
6.5.1.1 The Environmental Pollution Control Law.....	223
6.5.1.2 The Environmental Sanitation Law.....	223
6.5.2 Appraisal of Lagos Framework for Groundwater.....	225
6.5.3 Addressing the Difficulties within the Overall Federal and Lagos Legal Frameworks.....	225
6.6 Tackling Institutional Difficulties.....	231
6.6.1 Effects of Overlaps and Fragmentation.....	234
6.6.2 Probable Solutions to the Institutional Difficulties.....	235
6.7 Summary of Section Recommendation.....	236
6.8 Examination of the European Union Frameworks.....	238
6.9 The EU Urban Wastewater Treatment Directive.....	238
6.9.1 Section Recommendation.....	243
6.10 EU Framework on Solid Waste Management.....	244
6.10.1 The Waste Directive.....	245
6.10.2 The Landfill Directive.....	251
6.10.3 The Packaging and Packaging Waste Directive.....	253
6.10.4 Summary of Recommendations for Waste Management.....	253
6.11 The EU Water Framework Directive.....	257
6.11.1 Water Quality Safeguards.....	258
6.11.2 Water Quality Monitoring and Restoration.....	259

6.11.3 Integrated Water Resources Management.....	260
6.11.4 Reporting on the Status of Waters.....	260
6.12 The EU Groundwater Framework.....	263
6.12.1 Comparison of the Water Directives with Lagos Framework.....	264
6.13 Directive on the Protection of Groundwater against Pollution by Certain Dangerous Substances.....	269
6.14 Summary of the EU Directives on Water and Groundwater.....	270
6.15 Conclusion.....	271
CHAPTER 7: RECOMMENDATIONS FOR ACHIEVING SUSTAINABLE GROUNDWATER MANAGEMENT IN LAGOS	
7.1 Overcoming Chronic Water Shortage to Reduce Pressure on Groundwater.....	273
7.1.1 Changing the Conventional Approach to Managing Water: Soft versus Hard Approaches.....	274
7.1.2 More Unconventional Methods to Increase Water Supply.....	280
7.1.2.1 Wastewater Recycling and Reuse.....	281
7.1.2.2 Storm Water and Rainwater Harvesting.....	283
7.1.2.3 Desalination of Seawater.....	284
7.1.3 Section Recommendation.....	288
7.2 Alternative Solid Waste and Wastewater Options to Protect Groundwater.....	290
7.2.1 Solid Waste Management.....	291

7.2.1.1 The Engineered Waste Dump.....	291
7.2.1.2 Optimizing Benefits of Scavenging Activities.....	295
7.2.1.3 Remediating Waste Dumps.....	297
7.2.2 Wastewater Management.....	298
7.2.2.1 Industrial Wastewater.....	298
7.2.2.1.1 Phytoremediation of Industrial Wastewater	300
7.2.2.2 Domestic Sewage Treatment.....	302
7.2.3 Wastewater Reuse.....	302
7.2.4 Section Recommendation.....	304
7.3 Overcoming Industrial Apathy to Groundwater Protection.....	306
7.3.1 Education about the Usefulness of Wastewater	307
7.3.2 The ‘Water - fit’ Concept in Wastewater Treatment.....	307
7.3.3 Social factors Influencing Environmental Behaviour.....	309
7.3.4 Incentives to Induce Environmental Compliance.....	309
7.4 Balancing Environmental and Economic Policies to Safeguard Groundwater.....	311
7.4.1 Corporate Environmental Awareness.....	315
7.4.2 Corporate Responsibility for Environmental Protection.....	315
7.4.3 Instituting Environmental Impact Assessment within Industrial Processes.....	316
7.5 Conclusion of Discussion about Problems Confronting Groundwater in Lagos.....	318
7.6 SUMMARY OF RECOMMENDATIONS FOR LAW AND POLICY.....	319

7.6.1 Resolving Fragmented Legal frameworks and Institutional Difficulties.....	319
7.6.2 Water Shortage and Pressures on Groundwater.....	320
7.6.3 Alternative Solid Waste and Wastewater Management Options to Protect Groundwater.....	320
7.6.3.1 Solid Waste Recommendation.....	320
7.6.3.2 Wastewater Recommendation.....	321
7.6.4 Tackling Industrial Apathy and Pollution from Manufacturing.....	321
7.6.5 The Problem of Balancing Environmental and Economic Policies.....	322
7.7 The Role of Legislation in Sustainable Groundwater Development in Lagos.....	322
7.8 Achieving Sustainable Groundwater Management in Lagos.....	325
7.9 Conclusion of Thesis.....	327
BIBLIOGRAPHY.....	330
APPENDIX	365
Compendium of Interview Questions	365
Ethics Approval.....	375

ACKNOWLEDGMENTS

My doctoral degree program has been a long and arduous journey whose success I owe to a number of people and organizations that I would like to acknowledge.

First, I am deeply grateful to my Supervisor, Professor Jamie Benidickson. Pursuing a doctorate degree in Canada has been a major undertaking for me, and would not have happened, but for his recommendation to the Graduate Studies unit to admit me. He paved the way by opening the door of opportunity for me to undertake this high level of graduate study. Besides that, he consistently worked to ensure my success by providing various forms of much-needed support throughout the challenging program. In addition, my writing improved considerably under his expert tutelage. For your support, kindness and mentorship, I thank you very sincerely.

I am indebted to Professor Nathalie Chalifour, a “life-saver”, whose kind acceptance to serve on my thesis Committee at a critical time, and her consistent willingness to sacrifice her time to help my research work has propelled this process to its successful conclusion. I have been particularly touched by your thoughtfulness towards graduate students. Thank you for having the interest of graduate students at heart. Thanks also for guiding me to participate in programs that helped to shape my academic experience.

My profound gratitude goes to the International Development Research Center (IDRC), Canada for funding my field research through the IDRC Doctoral Award, which provided me with funds to embark on field research work in Nigeria. I also want to thank the Ontario Government for its Student Opportunity Grants that eased my academic journey.

My thanks go to my colleague, Siobhan Airey, who initiated graduate workshops where I presented my research and obtained very useful comments from Professors and other colleagues.

I also thank Professor Angela Cameron who offered important tips about stylish writing through these workshops.

I am grateful to Professors Joshua Ramisch and Sylvie Paquerot who served on my thesis Committee until the exigencies of other pressing assignments required them to disengage.

I would like to recognize my former Pastor, Reverend Dike Odimuko, who until his transfer to another city, was ever-present with encouragement, spiritual guidance and support. Thank you for your compassion and availability.

I am indebted to Dr. Lekan Asikhia, my former head of department at Covenant University, Nigeria, and Professor Rotimi Ajayi, former Dean of the College of Business Studies who both supported my decision to relocate to Canada for graduate studies. Not forgotten is Professor Oyelowo Oyewo, former Dean of the Faculty of Law, University of Lagos, whose timely and critical comments on my first article, which ultimately formed the basis of my doctoral proposal, helped to steer me in the right direction.

My field research work was enabled by the kind involvement and contributions of many people in Nigeria. In this respect I wish to thank Professor Ezekiel Longe and Professor Lekan Oyebande, both of the University of Lagos, Nigeria, who agreed to participate in interviews and to offer expert advice on the subject of my study. I am also grateful to Dr. Mayowa Fasona who made important linkages on my behalf.

I would also like to acknowledge the help of the following departments in Lagos for providing me with valuable information, documentation, and the opportunity for interviews: the Lagos State Ministry of the Environment; Ministry of Economic Planning & Budget; Lagos State Bureau of Statistics; Lagos State Water Regulatory Commission; Lagos Water Corporation;

Lagos State Waste Management Authority; Lagos State Environmental Protection Agency; and the Lagos State Wastewater Management Office.

I must not forget Professor Drew Kershen of the University of Oklahoma, who selflessly assisted in reviewing my research proposal that earned me a place and a scholarship at University of the Pacific, and which ultimately, formed the basis of my admission to University of Ottawa. My thanks also go to Professor Jeremy Mullem for his support during the doctoral process.

Finally, I must mention James Adeshubomi Ogunba, my “son” who has consistently been my supportive little friend throughout this journey. I thank my brother, Kolawole Ogunba for his technical contributions and moral support, and I am also grateful to Nathaniel Adeleke for his unwavering presence through this process.

Thank you everyone; I could not have succeeded without your valuable support.

DEDICATION

I dedicate this thesis to the Almighty God whose consistent interventions ensured my success at this enterprise.

Overview of Thesis

*“We used to think that energy and water would be the critical issues for the next century. Now we think water will be the critical issue.”*¹

In order to properly appreciate the opportunities to safeguard groundwater quality and sustainability in the context of a megacity in a developing country, Nigeria, it is appropriate to first appreciate the general and global challenges of water management in the 21st Century.

Water, which is composed of both surface and groundwater, is an ancient and fundamental resource which is unarguably indispensable to human life. It is the life force of the planet.² As a finite resource, national governments, international organizations, and scholars now acknowledge that water is crucial to life, to social development, to poverty alleviation, to health and to economic development. Dependable water supplies contribute to the growth of national Gross Domestic Product (GDP), but lack of water promotes economic stagnation and decline.³ Water is used in the direct production of agricultural goods, accounting for between 70% and 90% of water use across countries, and is thus critical to food security.⁴ It is used to produce the vast amounts of energy (electricity and gasoline), which in turn, enables the production of goods (particularly true for Nigeria in which nearly all the country’s electricity is hydro-powered). According to the World Energy Council, hydroelectric power contributes 15% of global

¹ M. Tolba, former Head of the United Nations Environment Program, quoted by Marq de Villiers, *Water: The Fate of Our Most Precious Resource* (New York, NY: Houghton Mifflin Co., 2001).

² E., C. Corcoran, C. Nellemann, E. Baker, R. Bos, D. Osborn, & H. Savelli (eds.) *Sick Water? The Central Role of Wastewater Management in Sustainable Development*, (2010) A Rapid Response Assessment, United Nations Environment Program, UN-HABITAT, GRID-Arendal, Online: www.grida.no/publications/rr/sickwater/ (hereafter “Sick Water Report”).

³ P.H. Gleick, “Water in Crisis: Paths to Sustainable Water Use” (1998) 8(3) *Ecological Applications* 571; World Savvy Monitor, *Water as Key to Economic Development*, Online: <http://worldsavvy.org>.

⁴ Food and Agriculture Organization of the United Nations, *Monitoring Agricultural Water Use At Country Level: Experiences of a Pilot Project in Benin and Ethiopia* (2011) at pg. ix; D. Pimentel et al, “Water Resources: Agricultural and Environmental Uses” (2004) 54(10) *Bio Science* 909.

electricity production.⁵ Water also helps in overcoming poverty and in meeting the Millennium Development Goals which in turn are central to achieving sustainable development.⁶ Additionally, a healthy aquatic ecosystem provides a range of invaluable services to human life including food, medicines, shoreline protection, and carbon sequestration (the process of capturing carbon dioxide and slowing down the accumulation of greenhouse gases).⁷ Water is a vital resource which governs the viability of all ecosystems and provides the basis for socio-economic development, and thus there is truly no substitute for water to sustain life on the planet.⁸

Water has also been known to play a major role in the evolution of culture and community. It has determined historical human settlement patterns around the world in that the health, welfare, and the potential development of societies have been dependent on the availability of water nearby.⁹ Historical accounts affirm that the early civilizations settled and developed near major perennial rivers such as the Nile, and the Tigris-Euphrates.¹⁰ Communities have either prospered or faded away due to the presence or absence of water.¹¹ Water supports

⁵ World Energy Council, *World Energy Resources: 2013 Survey*, (2013), at pg. 17 (Available online).

⁶ United Nations Conference on Sustainable Development (Rio + 20), *The Future We Want*, (2012), Art. 119 (Available online).

⁷ Sick Water Report, *supra*, note 2; Federal Environmental Protection Agency, Nigeria *National Policy on the Environment* (1999), S. 68.

⁸ S.L. Poster, G.C. Daily & P.R. Ehrlich, "Human Appropriation of Renewable Fresh Water", (1999) 271 *Science* 785.

⁹ J. W. Dellapenna & J. Gupta, "The Challenges for the Twenty-First Century" in J.W. Dellapenna & J. Gupta, eds., *The Evolution of the Law and Politics of Water* (Springer: 2009) 391.

¹⁰ These two large rivers located in former Mesopotamia (currently parts of Iraq, Iran, Syria and Turkey) enabled the construction of irrigation projects to grow food and fiber thousands of years ago. Owing to abundant food production that the ancient irrigation projects allowed, the region between the rivers was known as the 'Fertile Crescent'. Thus Mesopotamia saw the earliest emergence of a literate urban civilization, for which reason it is often described as the "Cradle of Civilization": V.T. Cech, *Principles of Water Resources - History, Development, Management, and Policy* (USA: Wiley, 2003) at pg. 446; A. Baba & G. Tayfur, "Groundwater Contamination and its Effects on Health in Turkey" (2011) 183 *Environ Monit. Assess* 77.

¹¹ K. Conca, *Governing Water: Contentious Transnational Politics and Global Institution Building* (Massachusetts: The MIT Press, 2006) at pg. 74; D. Fisher, *The Law and governance of Water Resources: The Challenge of Sustainability*, (Cheltenham: Edward Elgar Publishing, 2009). M. Gorbachev also commented about water's powers

cultural uses including tourism and recreation.¹² Water has also played a notable role in national integrity and international security, being employed by colonial leaders to define borders for territories, and has been used as a goal or tool for war, as well as a target of terrorism.¹³

In 2003, at the World Water Forum in Japan, water was the central theme in all the sessions on climate change, pollution, cultural diversity, energy, agriculture, environment, and poverty. In the same year, the United Nations General Assembly decided that the years 2005-2015 should be named the ‘International Decade for Action Water for Life’. The goal of this initiative was to promote efforts to fulfill international commitments made about water and water-related issues in the United Nations Millennium Development Goals (MDGs).¹⁴

Water’s direct connection to all aspects of human life and health, as well as its link to major global challenges of poverty and sanitation, make it critical to sustainable development. According to the United Nations, “Water holds the key to sustainable development. We need it for health, food security and economic progress...”¹⁵

Discussions about the primacy of water led to the United Nations’ Comment which acknowledges water as indispensable for leading a life in human dignity and as a prerequisite for realizing other human rights, and thus should be an affordable social and cultural good rather than an economic commodity.¹⁶ Finally in 2010, the United Nations’ General Assembly

in determining human migration: M. Gorbachev, President of Green Cross International, quoted in Peter Swanson’s *Water: The Drop of Life*, (Northword Press 2001).

¹² Food and Agriculture Organization of the United Nations, *Law for Water Management, A Guide to Concepts and Effective Approaches*, (Rome: Electronic Publishing and Support Branch, 2009).

¹³ Peter Gleick, “Water and Terrorism” (2006) 8 Water Policy 481.

¹⁴ The title was based on the UN’s first World Water Development Report, “Water for People, Water for Life”: United Nations Educational, Scientific and Cultural Organization, *2005-2015 International Decade for Action ‘Water for Life’* Online: <http://www.unesco.org/new/en/natural-sciences/environment/water/water-for-life/>

¹⁵ Ban Ki-Moon, (Secretary-General), Remarks made at the 2013 Water Summit in Budapest, Hungary, October 8th 2013. Online: UN News Centre. See also *The Future We Want*, S. 119 (Available online).

¹⁶ United Nations Committee on Economic, Social and Cultural Rights, Comment in Document E/C.12/2002/11 (2002), Available online.

recognized that a human right to safe drinking water and sanitation is necessary for attaining all other human rights, and clarified the importance that nation states should accord to water access by their citizens.¹⁷ It adopted a binding resolution that the right to safe drinking water and sanitation, which derives from the right to an adequate standard of living, is vitally connected to the right to life and human dignity to which every human being is entitled.¹⁸ This affirms a human right to water, promotes water to the sacred realm of fundamental human rights rather than a mere derivative right, and lays to rest arguments in the international community about the importance that nation states should accord to water access by their citizens.

Nigeria voted in favor of the resolution proposing a human right to water. Prior to this, in 2005, it had also adopted the human rights' approach to environmental protection by interpreting its constitutional guarantee of a right to life to include an environmental right - the right to a healthy environment.¹⁹ By extension, it is arguable that water as an environmental resource without which human life cannot be sustained is properly situated within environmental rights to which every Nigerian citizen may aspire.²⁰

¹⁷ United Nations General Assembly Resolution 64/292 of 28th July 2010. Its Human Rights Council re-affirmed the human right to safe drinking water and sanitation in October 2011, (available online); see also: I.S. Akoteyon, "Evaluation of Groundwater Quality Using Water Quality Indices in Parts of Lagos - Nigeria" (2013) 6(1-2) *Journal of Environmental Geography* 29.

¹⁸ United Nations Human Rights Council, Online: <http://www.un.org/apps/news/story.asp?NewsID=36308>

¹⁹ *Gbemre v Shell Petroleum Development Company Nigeria Ltd. & Anor* (2005) AHRLR 151. In that case, the Nigerian Court interpreted Ss. 33 & 34 of the 1999 Nigerian Constitution which guarantees a right to life as wide enough to include a right to a pollution-free, safe environment. Access to justice for the enforcement of a right to a clean environment has since been eased by the enactment of the Fundamental Rights Enforcement Procedure Rules (2009) further to S. 46(3) of the Constitution. The Rules ease the procedure for petitioning, and also allow a court to have regard to other municipal, regional, or international bills of rights to advance an applicant's rights.

²⁰ However, Nigeria has not implemented the human right to water by establishing a system that guarantees a minimum daily supply of water to all citizens and enable it to meet the Millennium Development Goals on Water and Sanitation by 2015. Civil organizations have since been urging the Federal Government to implement the resolution in real terms rather than paying lip service to a right to water. Such organizations include: Society for Water and Public Protection, the Society for Water and Sanitation, the Justice and Peace Commission, and the West Africa Regional Learning Center for Sanitation. See "Nigerian Groups Seek Implementation of UN right to water resolutions" Online: <http://canadians.org/fr/node/7283>

However, as important as water is globally, it is currently facing a global crisis. Growing human populations, demographic movements, urbanization, industrialization, and changes in consumption and production patterns have combined to accentuate water demands, placing pressure on finite water resources, and creating new difficulties in water management. Therefore, problems of diminution in quantity and declining quality have subsequently emerged. Many regions suffer from severe water shortages, with over a billion people lacking access to safe drinking water and basic sanitation. Quality deterioration, particularly in developing countries, further compounds the water problem. Rapid urbanization and industrialization are causing larger volumes of wastewater to be produced, and its uncontrolled discharge is threatening the integrity of water and causing harm to human health.²¹ In the developing countries of Sub-Saharan Africa in which Nigeria is situated, the United Nations estimates that 90% of all wastewater is discharged directly and untreated into surface water bodies including rivers, lakes and oceans.²² As a result, water borne illnesses that are triggered by the contaminated waters abound. The unsafe wastewater disposal practice also seriously undermines the sustainability of aquatic life and the string of human benefits derived from aquatic ecosystems including food and medicines that are often taken for granted. In addition, it is responsible for the emergence and persistence of de-oxygenated dead zones which are growing rapidly within seas and oceans.²³ Although untreated wastewater discharge is primarily a concern of surface water, the connection between surface and groundwater in the hydrologic cycle makes it one of equal threat to groundwater quality. The concerns as affecting groundwater quality require regulatory responses that are discussed later in this thesis.

²¹ Sick Water Report, *supra*, note 2 at pg. 9.

²² *Ibid*, at pgs. 5 & 19. Nyenje however reports a figure of 30%: P.M. Nyenje, "Eutrophication and Nutrient Release in Urban Areas of Sub-Saharan Africa - A Review" (2010) 408 *Science of the Total Environment* 447.

²³ Sick Water Report, *supra*, note 2, at pgs. 16 & 19.

In view of all these problems, the world faces a water quality crisis in the 21st Century, and water may aptly be described as a resource under considerable pressure.²⁴ Thus, preserving and safeguarding the quality of water, and of freshwater particularly, has been top on the list of burning international issues of the 21st Century for many years. In 2000, the Second World Water Forum, while stressing the vitality of water for human life, ecosystem health and national development, recognized water security as a critical concern for the 21st century.²⁵

Within the water cycle, groundwater, which is the particular subject of this study, is a major component of the total water available. Scholars generally agree that there is no real distinction between surface and groundwater because the two streams of water form a continuum in the hydrologic cycle, and the expressions “groundwater” and “surface water” merely describe their respective physical locations.²⁶ Groundwater is the largest single source of fresh water, constituting 95% of the fresh water on earth.²⁷ Nearly half of the world's population depends on groundwater sources for drinking water supply and for other uses.²⁸ An enormous proportion of the world's rural population receives a safe supply of water that comes from a groundwater

²⁴ Food and Agriculture Organization of the United Nations, *Law for Water Management, A Guide to Concepts and Effective Approaches*, supra note 12; Stockholm International Water Institute, *Water Management in Developing Countries – Policy and Priorities for EU Development Cooperation* (Available online).

²⁵ World Water Council, Second World Water Forum, Ministerial Declaration of the Hague on Water Security, (Available online).

²⁶ R. Glennon, *Water Follies: Groundwater Pumping and the Fate of America's Freshwaters* (Washington D.C. Island Press, 2002); United States Geological Survey, Circular 1139, *Groundwater and Surface Water: A Single Resource*, (Available online). The hydrologic cycle is the continuous motion of water on, above and below the earth. The two systems of water are connected in that groundwater zones are recharged by surface water, whilst groundwater discharges into surface water systems: Vladimir Novotny, *Water Quality: Diffuse Pollution And Watershed Management* 328, (John Wiley & Sons Inc., Hoboken, New Jersey, 2003).

²⁷ B.L. Morris et al, *Groundwater and its Susceptibility to Degradation: A Global Assessment of the Problems and Options for Management*. Early Warning and Assessment Report Series, RS. 03-3. (Nairobi, Kenya: United Nations Environment Programme, 2003), Intro pg. 1.

²⁸ Ibid. This observation was also made in 1998, at the Sixth Annual World Water Day. Online: <http://www.worldwaterday.org/wwday/1998/>.

aquifer.²⁹ In acknowledgment of its importance, the United Nations declared the year 2003 as the International Year of Freshwater.

Groundwater has secured a central place in the international spotlight as that universal natural resource that is critical to man's existence on the earth. Pressures from burgeoning populations, water pollution, climate change, and increasing water shortages described earlier are combining to focus a lot more attention on groundwater as the only other component of the water cycle available for human use. Its varied descriptions as "buried treasure" and "liquid gold"³⁰ underline its importance as part of the earth's "fragile" natural resources that require sustainable management.³¹ Scholars have described groundwater as critical to humanity, being the most reliable water source for irrigation, and have also found a positive correlation between groundwater access and reduction in poverty amidst farmers.³² It is thus very concerning that this hidden resource that is so important to life is encountering serious degradation that is occurring mainly from pollution.

With this overview of the importance of water and of the global water challenges discussed in the preceding paragraphs, the specific research problem of this thesis is the quality problem posed to groundwater in Lagos. Groundwater in Lagos is an extremely important natural resource and the pervasive resort of nearly all residents, including industrial operators, and the Lagos Water Corporation which is responsible for water supply.³³ In spite of its importance

²⁹ B.L. Morris et al, *supra*, note 27.

³⁰ Maria Trainer, "Goals, Gaps and Governance: The Holy Grail in Preserving Canada's Liquid Gold" (2010) 380 *Journal of Hydrology* 1.

³¹ B.L. Morris et al, *supra*, note 27, at Intro pg. 1.

³² M. Moench, "Groundwater and Poverty: Exploring the Connections" (Available online); Tushar Shah, D. Molden, R. Sakthivadivel, & D. Seckler, *The Global Groundwater Situation: Overview of Opportunities and Challenges* (Sri Lanka: International Water Management Institute, 2000) at pgs. 3-4

³³ D.N. Obiora, & O. S. Onwuka, "Groundwater Exploration in Ikorodu, Lagos-Nigeria: A Surface Geophysical Surface Contribution" (2005) 6(1) *The Pacific Journal of Science and Technology* 86; I.S. Akoteyon, "Evaluation of

however, it is encountering severe pollution from solid waste and wastewater emissions. A formidable solid waste management problem and a troubling persistence of untreated toxic wastewater emissions threaten to destroy this vital natural resource. Presently, a steady trend of pollution from these sources is occurring with increasing frequency and calling for urgent attention. This disturbing environmental problem is aggravated by a high rate of urbanization and the resultant precipitous population in Lagos, and forms the subject matter of this study.

CHAPTER 1: GENERAL INTRODUCTION

This chapter introduces the distinctive features of the city of Lagos including its hydrogeology. It outlines the groundwater research problem and the methodology employed to address it in the subsequent chapters that deal with groundwater threats, the existing regulatory framework and opportunities for comprehensive reform which draw in part on the comparative experience of the European Union.

1.1 Introduction to Lagos, Nigeria

1.1.1 Origin, Population and Economic Prominence

Lagos is a coastal city located in the southwest of Nigeria, which is on the west coast of Africa. A former colonial city, it was legally upgraded to a state on May 27th, 1967 during the creation of additional states in the country.³⁴ It was the direct outcome of the amalgamation of the former Lagos Federal Territory (consisting of Lagos Island, Ikoyi, Victoria Island, and Iddo Island) with the former colony province of Western Region (comprising Ikeja, Epe, Ikorodu, and Badagry).³⁵ Lagos has a long coastline of 200 kilometers along the Atlantic Ocean, and an area of 3,577 square kilometers of which 21% is made up of lagoons and water ways. Its comparatively small geographical space makes it the smallest of the 36 states in the country (0.4% of Nigeria).³⁶ Lagos was the administrative capital of Nigeria until 1976 when Abuja,

³⁴ The State Creation and Transitional Provisions Decree (1967) restructured Nigeria into 12 states from its previous design as a federation and three regions (Eastern, Western, and Northern Regions). Lagos was previously part of the Western Region. Although upgraded to a state, scholars and administrators still describe it as a city, and thus ‘city’ and ‘state’ are used interchangeably in reference to Lagos within this thesis.

³⁵ Lagos State Ministry of Economic Planning and Budget, *Digest of Statistics* (2011).

³⁶ Lagos State Government, *State of the Environment Report- Lagos* (2010), at pg. 2; Lagos State Environmental Protection Agency, *Policy on the Environment* (1989), at pg. 1; O.J. Aderinola, E.O. Clarke, O.M. Olarinmoye, V. Kusemiju & M.A. Anatekhai, “Heavy Metals in Surface Water, Sediments, Fish Periwinkles of Lagos Lagoon” (2009) 5 (5) *American-Eurasian J. Agric. & Environ. Sci.* 609.

which is located in central Nigeria, legally replaced it, although the Federal Government moved physically many years later, in 1991.³⁷

Spectacular population growth in the Lagos city, which started in 1950 in spite of its relatively small geographical space, is believed to have spearheaded urban population growth across Nigeria.³⁸ Lagos has a population of 21.8 million, the largest in the country, accounting for nearly 10% of the country's overall population, a "disproportionate share of the nation's population", and making it a megacity within Nigeria.³⁹ With its massive and increasing population, and high rate of urban growth, the United Nations has described Lagos as the fastest growing megacity in the world.⁴⁰ Lagos also features the highest concentration of human beings within the smallest landmass in Africa.⁴¹

³⁷ Federal Capital Territory Act, Cap F128, Laws of the Federation of Nigeria, Revised Ed., (2004), S.1. This study focuses on the Lagos metropolis in particular, which is simply referred to as 'Lagos' and this term describes the heart of the state in which 95% of the population resides, and in which nearly all of the commercial activities take place: *State of the Environment Report-Lagos*, supra, note 36.

³⁸ O. Olokesusi, "Lagos: The Challenges and Opportunities of an Emergent African Megacity" Presented at the Nigerian Institute of Social and Economic Research (NISER) Seminar Series (2011), Available online.

³⁹ *State of the Environment Report- Lagos 2010*, supra, note 36, at pg. 4. (2010); United Nations Human Settlements Programme, *The State of World Cities Report 2006/2007*, (Available online). The population figure is an estimate which is based on a population growth rate of 3.2% from the baseline figure of 17.5 million which Lagos State Government generated during a census that it conducted concurrently with that of the Federal Government in 2006. Officials of the federal government who carried out a national census in 2006 recorded Lagos' population as 9 million, but Lagos state disputed this figure, preferring its own recording of 17.5 million. The matter of population size of Lagos is thus controversial, but regardless of the disagreement, this thesis adopts the official figure given by the Lagos State government which is supported by publications from other Lagos State departments as well as by renowned scholars. For example, Mabogunje, referred to a figure of 15.7 million as far back as 2002, which provides a good basis to presume that a population of 17.5 million in 2006 is probably more realistic. Longe's estimate of 13 million in 2010 also suggests a population that would have exceeded 9 million by 2006. Adepelumi & Omotosho also referred to 15 million in 2008: A. Mabogunje, "Reconstructing the Nigerian City: The New Policy on Urban Development and Housing" in D. Amole, A. Ajayi & A. Okewole, eds., *The City in Nigeria: Issues, Challenges and Strategies*, (Ile-Ife, Nigeria, Obafemi Awolowo University 2002); E.O. Longe, "Groundwater Resources Potential in the Coastal Plain Sands Aquifers, Lagos, Nigeria" (2011) 3(1) Research Journal of Environmental and Health Sciences 1; A.A. Adepelumi & E.J. Omotosho, "Delineation of Saltwater Intrusion Into the Freshwater Aquifer of Lekki Peninsular, Lagos, Nigeria", (2009) 56 Environ Geol. 927.

⁴⁰ UN-HABITAT), *State of the World's Cities 2006-2007*, (Available online).

⁴¹ Olokesusi, supra, note 38.

The Lagos city is Nigeria's commercial capital. It has 10,000 commercial ventures and 22 industrial estates.⁴² It accounts for over 60% of Nigeria's industrial and commercial activities, 70% of national maritime cargo freight, and over 50% of Nigeria's energy consumption.⁴³ It contributes 35% to the national Gross Domestic Product, and 62% to the non-oil national Gross Domestic Product, thus making it the leading contributor to that sector.⁴⁴ It has the largest stock exchange in West Africa and 200 financial institutions.⁴⁵ It is the headquarters of many national and international corporations, especially the petroleum exploration corporations which are at the core of Nigeria's economic growth. Lagos' ports contribute 50% of national port revenue, and it accounts for over 70% of international air traffic, and 50% of local air traffic.⁴⁶ Lagos also hosts 20% of the nation's small and medium enterprises, armed with the highest adult literacy in the country.⁴⁷ It is the locus of manufacturing and financial services for the nation, and facilitates trade and human interactions with the rest of the world.⁴⁸ Overall, Lagos has a scale of economic activity that is unequalled by any other state in Nigeria. Based on these facts, if Nigeria were ultimately to become a major emerging market as predicted, (having been described as one of the 11 countries with a high potential of becoming the world's largest economies in the 21st

⁴² Lagos State Ministry of Economic Planning and Budget, *Lagos State Development Plan 2012-2025*, (2013) at pg. 41; B.R. Fashola, Lagos State Governor's Keynote address presented at the 6th Lagos State Economic Summit "Ehingbeti 2012" at Eko Hotel on April 23-25, 2012.

⁴³ Ibid.

⁴⁴ Ibid.

⁴⁵ Ibid.

⁴⁶ Ibid.

⁴⁷ Ibid. See also: O. Aganga, Commissioner for Trade and Investment, "Investment Climate and Competitiveness in Nigeria: Lagos State Holds the Key" Presentation made at the 6th Lagos State Economic Summit "Ehingbeti 2012" April 23-25 2012.

⁴⁸ *State of the Environment Report-Lagos*, supra, note 36.

century), Lagos would be central to that strategy. It would remain “at the core of Nigeria’s growth success”.⁴⁹

1.1.2 Groundwater in Lagos

The groundwater problems originating in this densely populated metropolitan state are the focus of the following analysis.

1.1.3 Hydrogeology of Lagos

Understanding the hydrogeology of Lagos is important for an effective graphic appreciation of the groundwater pollution problem, and thus some detailed information about this will immediately follow.

Hydrogeology is the interrelationship of geologic materials and processes with water.⁵⁰ The geological formations beneath the earth and their characteristics determine the availability of groundwater in any location. At some depth below the ground, the soil and rocks are saturated with water; the top of the saturated zone is the water table while water stored within the saturated zone is groundwater which flows through the rock and soil layers of the earth.⁵¹

Lagos hydrogeology occurs within the larger geological profile of Nigeria. Nigeria has two major rock types: the Crystalline Basement Complex volcanic rocks of the igneous rock type (also known as Pre-Cambrian rocks), and the Sedimentary Cretaceous-Tertiary rocks.⁵² Due to their lithology, the Basement rocks are generally difficult to drill, are relatively shallow, have

⁴⁹ R. Khan, “From BRICS to BRINCS: Lagos Holds the Key” Presented at the 6th Lagos State Economic Summit “Ehingbeti 2012” at Eko Hotel, April 23-25 2012.

⁵⁰ C.W. Fetter, *Applied Hydrogeology*, (N.J, U.S.: Prentice-Hall, 2001) at pg. 3.

⁵¹ Ibid.

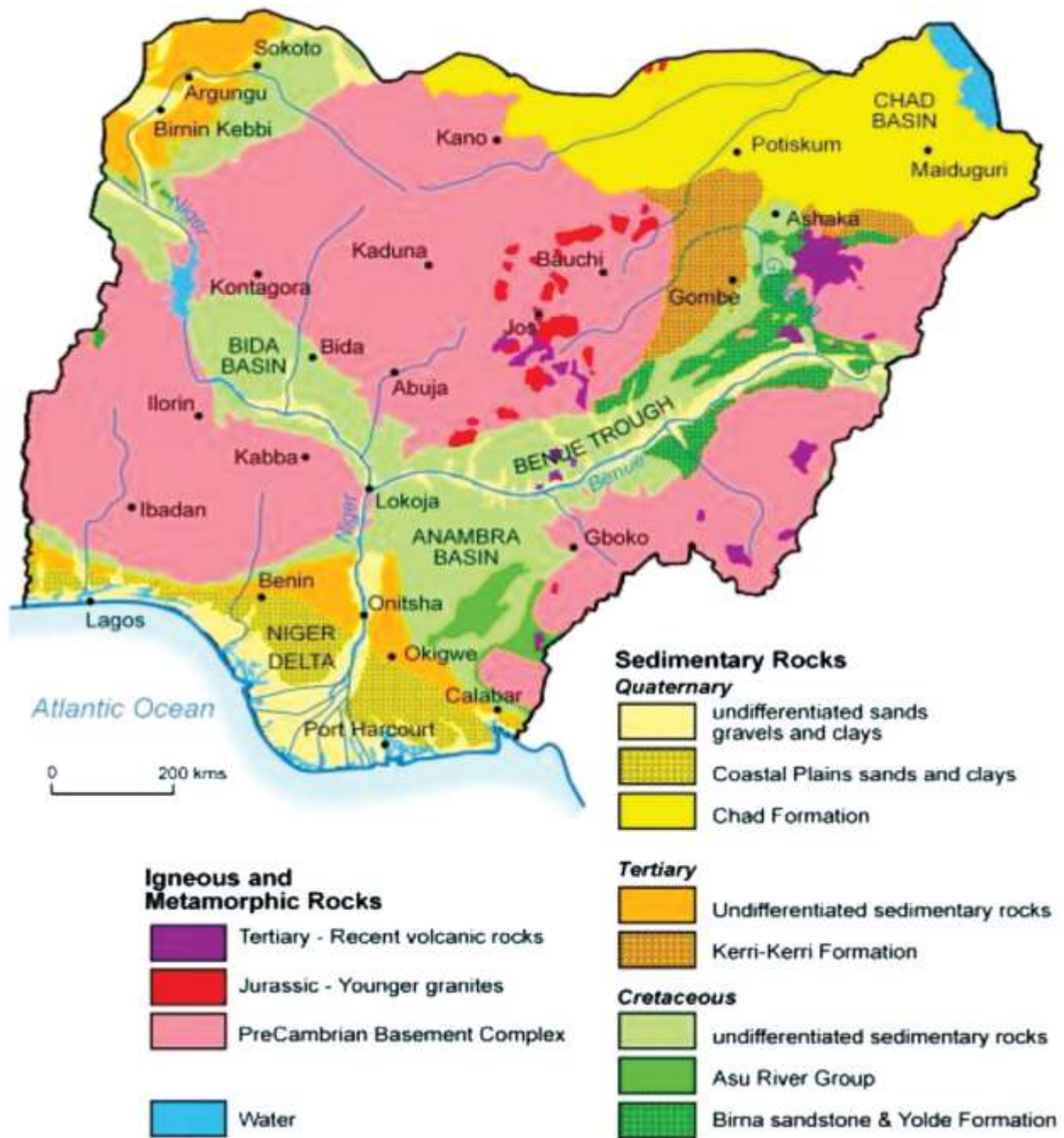
⁵² SEDEC Associates, *2008 State of the Nigerian Environment Report* (Nigeria, Federal Ministry of the Environment 2008) at Chapter 5; See also C. N. Akujieze, S.J.L. Coker & G.E. Oteze, *Groundwater in Nigeria - A Millennium Experience - Distribution, Practice, Problems and Solutions* (2003) 11 *Hydrogeology Journal* 259.

low permeability, and a limited capacity to bear water.⁵³ This rock type occurs in the Northern parts of the country. The Sedimentary rocks, on the other hand, which are the result of natural weathering processes, are mostly composed of fragments or particles, or ‘sediments’ that are compacted and cemented together. Organic sedimentary rocks are formed from the accumulation of plant and animal remains which results in their being rich in fossils, and thus they have good ground water prospects. This type of rock is prevalent in Lagos.⁵⁴ The map below situates Lagos in the Sedimentary rock region within Nigeria’s geological profile.⁵⁵

⁵³ 2008 State of the Nigerian Environment Report, supra, note 52, at pg. 289.

⁵⁴ Ibid; British Geological Survey, *Groundwater Quality: Nigeria* (2003), Available online.

⁵⁵ S.M.A Adelana, P.I. Olasehinde, R.B. Bale, P. Vrbka, A.E. Edet & I.B. Goni, “An Overview of the Geology and Hydrogeology of Nigeria” in *Applied Groundwater Studies in Africa*, (Taylor & Francis Group, London U.K, 2008) 171.



Generalized Geological Map of Nigeria Showing Lagos with the Sedimentary Rock Type

Source: Adelana, et al, (2008) note 55.

Following from this national geological profile, the aquifers (water-bearing permeable rocks) in Lagos fall within the Dahomey Sedimentary Basin. The Basin is made up of very

weathered and porous sandstones and gravels. The aquifers determine groundwater availability in Lagos, and are four in number: the Recent Sediments, the Upper Coastal Plain Sands, the Lower Coastal Plain Sands, and the Abeokuta Formation. They are referred to as the first, second, third, and fourth aquifers respectively, and in combination, make up the hydrogeological profile of Lagos from which groundwater is increasingly drawn.⁵⁶

The *Recent Sediments* forms a shallow, unconfined water table aquifer that is made up of sand and clay, and is restricted to the coastline and floodplains of the major rivers. It is commonly exploited individually through hand dug wells and shallow boreholes and mainly extracted for small and private domestic water supply. It is the most inexpensive to exploit because of its location close to the ground's surface, but this fact of proximity places it at risk of pollution from sewage and waste disposal practices. Due to its low yield, it is considered of minor importance as a major water supply source.⁵⁷

The bi-level *Coastal Plain Sands* aquifers consist of sands with intervening clay and occur throughout Lagos. They are the most significant because they provide substantial quantities of water. Over 95% of all boreholes in Lagos obtain their water from this aquifer. It is sub-categorized into Upper and Lower Plain Sands.⁵⁸

The *Abeokuta Formation* consists of sand and gravel and occurs throughout Lagos. It is a deep and highly productive aquifer. But although a high-yielding aquifer, it occurs at a great

⁵⁶ I.I. Balogun, I.S. Akoteyon & O. Adeaga, "Evaluating Land Use Effects on Groundwater Quality in Lagos-Nigeria Using Water Quality Index, (2012) 4(2) J. Sci. Res. 397; A.U. Oteri & F. P. Atolagbe, "Saltwater Intrusion into Coastal Aquifers in Nigeria" (2003), the 2nd Intl. Conf. on Saltwater Intrusion and Coastal Aquifers - Monitoring, Modelling, and Management. Mérida, Yucatán, México, (Available online).

⁵⁷ E.O. Longe, S. Malomo, & M.A. Olorunniwo, "Hydrogeology of Lagos Metropolis" (1987) 6(2) Journal of African Earth Sciences 163; Lagos State Government, *State of the Environment Report- Lagos 2010* at pg. 30; See also Coode Blizzard Ltd, *Hydrogeological Investigation of Lagos State*, Final Report, Vol. 1, (1997), at pg. 5.5.

⁵⁸ Coode Blizzard Ltd, *Hydrogeological Investigation of Lagos State*, supra, note 57, at page 5.3. Due to sub-categorization of the Coastal Plain Sands aquifer into two layers, scholars sometimes describe the aquifer horizon in Lagos as three, rather than four, i.e. merging the two levels into one. Both descriptions are in essence accurate.

depth that is costly to extract, and is therefore mostly accessed by large corporations especially within the Ikeja industrial area in Lagos.⁵⁹ The water extracted from this aquifer is hot with a mean temperature of 80 C.⁶⁰

In Lagos, groundwater is extracted from these aquifers through wells and boreholes. Due to sporadic and inadequate water supply from the Lagos Water Corporation which is responsible for water supply, there is a pervasive resort to, and dependency on groundwater for both domestic and industrial uses. Overall, 92% of residents exploit groundwater from these aquifers and depend exclusively on it for domestic sustenance.⁶¹ Industrial use of groundwater has also been expanding since the 1960s in the industrial districts (Ikeja, Ilupeju, Ikorodu and Apapa) within the Lagos metropolis.⁶² Groundwater exploited from aquifers is therefore an extremely valuable natural resource in Lagos. Unhappily, the resource in this highly populated city is presently troubled by pollution that is emanating from unfavorable solid waste and wastewater disposal methods.

⁵⁹ A.U. Oteri, "Coastal Groundwater Resource-Abstraction, Quality and Related Environmental Concerns: Lagos State Case Study" Presented at Lagos State Water Regulatory Commission's Workshop, June 2013. Guinness Nigeria PLC and Cadbury PLC are two of such corporations that exploit the Abeokuta formation in Ikeja, Lagos.

⁶⁰ Coode Blizzard Report, *supra*, note 57. See also: A.U. Oteri, "Coastal Groundwater Resource-Abstraction, Quality and Related Environmental Concerns: Lagos State Case Study" Presented at Lagos State Water Regulatory Commission's Workshop on Groundwater, June 2013. Some scholars identify other geological formations as Ilaro and Ewekoro formations, but Coode Blizzard reports that the Ilaro formation is not considered to be an aquifer because of its composition of shale clay (page 5.2 of the Report, *supra*, note 57). Although this varies from Longe and Oteri's findings, it may be rationalized that the Ilaro Formation does overlie the Abeokuta Formation as scholars have averred, and that Coode Blizzard merely minimizes Ilaro for its own reasons: Longe et al, *supra*, note 57; A.U. Oteri & E.P. Atolagbe, "Saltwater Intrusion into Coastal Aquifer in Nigeria" Presented at 2nd International Conference on Saltwater Intrusion and Coastal Aquifers in Yucatan, Mexico (2003); M.E. Offodile, *Groundwater Supply and Development in Nigeria* (University of Ibadan Press, 2002); D.N. Obiora, & O. S. Onwuka, "Groundwater Exploration in Ikorodu, Lagos-Nigeria: A Surface Geophysical Surface Contribution" (2005) 6(1) *The Pacific Journal of Science and Technology* 86.

⁶¹ Lagos State Government, *Lagos State Water Supply and Sanitation Policy* (Final Draft 2012), pg. 30; A.A. Adepelumi & E.J. Omotosho, Delineation of Saltwater Intrusion Into the Freshwater Aquifer of Lekki Peninsular, Lagos, Nigeria, (2009) 56 *Environ Geol.* 927: DOI 10.1007/s00254-008-1194-3.

⁶² Coode Blizzard Report, *supra*, note 57. Guinness Nigeria PLC and Cadbury PLC mentioned earlier (*supra* note 26) exploit groundwater substantially.

1.2 Statement of the Research Problem

Although the primary concern of this study is the pollution of groundwater, the problem occurs within a complex socio-legal framework that is summed into three categories: environmental, social, and institutional problems. Environmental problems occur as direct pollution of groundwater by solid waste and wastewater emissions. The twin sources of this pollution are respectively, the open waste dumps that leach into groundwater (open dumps are the official method of solid waste disposal), and untreated wastewater from industrial processes and (to a smaller degree) from domestic sources. Underlying this environmental problem, urbanization into Lagos, which has resulted into a massive and burgeoning population, represents the social problem that is at the root of the pollution. The large population generates enormous quantities of solid waste and wastewater that place tremendous pressure on the state's water and waste management resources, and this is worsened by public apathy to environmental protection. A nascent water sector, whose governance structures are still evolving in spite of the city's age and relative sophistication, is an institutional problem that needs to be addressed. In the final analysis, the regulatory framework is fragmented and rudimentary, and encounters the thorny problem of non-compliance. Each of these specific categories is discussed further below.

1.2.1 The Environmental Problem: Municipal Solid Waste and Wastewater

To a significant degree, the problem of groundwater contamination in Lagos arises from a waste management problem. Lagos residents generate 10,000 metric tons of diverse solid wastes daily.⁶³ The waste management agency collects the bulk of solid waste and disposes them in open dumpsites without treatment. The unhealthy open dumps constitute a serious health hazard

⁶³ J.O. Olubori, GM Technical Services, Lagos State Waste Management Authority, "The City of Lagos: Solid Waste Management", Presented at International Solid Waste Association (ISWA) World Congress, Vienna, Austria, (2013).

owing to the diverse mix of the untreated wastes in them. Of these, electronic waste is perhaps the most hazardous. Electronic waste is termed the most rapidly growing waste problem in the world, particularly because of its toxic mix of chemical substances like lead, printing wiring boards, and cathode ray tubes that are potentially dangerous to humans who are in contact with them.⁶⁴ Electronic waste presents a more serious dimension to the waste problem for a city that is still sadly lacking a safe handling of basic municipal waste.⁶⁵ The used electronic equipment is disposed along with municipal waste in open dumps without further treatment, and its potential to leach toxic elements into the surrounding groundwater constitutes a real threat to human health especially when the dumpsite is close to drinking water wells.⁶⁶ This practice of improper electronic waste disposal prompted Nnorom & Osibanjo to describe it as the “worst global example of waste mismanagement”.⁶⁷ Collectively, the practice of open dumping of diverse wastes creates a potential for harmful leachates to percolate into groundwater, in addition to the waste dumps being a breeding ground for dangerous and diverse rodents. Newly formulated international policies for sustainability suggest that there will be less tolerance in the international community for waste dumping in the years to come, in favor of environmentally safer options, especially the harnessing of waste for renewable energy.⁶⁸

The second dimension of the environmental problem is industrial and domestic wastewater. Residents generate an estimated 350 million gallons of wastewater daily from both

⁶⁴ Jim Puckett et al, *Exporting Harm: The High-Tech Trashing of Asia*. (2002)The Basel Action Network (BAN). Online: <http://www.ban.org/E-waste/technotrashfinalcomp.pdf>.

⁶⁵ I. Nnorom & O. Osibanjo, “Electronic Waste (E-Waste): Material Flows and Management Practices in Nigeria” (2008) 28 Waste Management 1472. The introduction of computers, and the surge in its use since the 1990s fueled by many factors including growth in internet use, reduced equipment prices, rapidly evolving technology, and a high obsolescence rate, has created a nagging problem of safe disposal of electronic waste generally.

⁶⁶ The country as a whole still lacks a significant form of e-waste recycling in spite of regulations that aim at preventing and minimizing pollution from the electronics sector in particular. The Regulations specify the 5Rs in treating electrical waste: Reduce, Repair, Re-use, Recycle, and Recover: National Environmental (Electrical/Electronic Sector) Regulations, Official Gazette (2011), Ss. 2-3.

⁶⁷ Nnorom & Osibanjo, *supra*, note 65, at pg. 1476.

⁶⁸ United Nations Climate Change Conference (2015), *Paris Decision*, Preamble.

sources within the Lagos metropolis.⁶⁹ The Lagos city is the locus of manufacturing and of financial services for Nigeria as described earlier, and has a massive scale of economic activity that is unequalled by any other city. As a result of its large-scale commercial activity, particularly manufacturing, industries in Lagos generate vast quantities of industrial wastewater. Industrial wastewater is very concerning because of the high concentration of toxic compounds that are employed within manufacturing and other industrial processes, and also because industry operators discharge these effluents into the environment with minimal treatment.⁷⁰ Untreated wastewater discharged into the environment constitutes a threat to human and ecological health.⁷¹

Apart from industrial wastewater, municipal wastewater from domestic sources is another problem for groundwater. Wastewater from bathrooms and kitchens is collected individually in each building through an on-site sanitation system that employs the use of septic tanks.⁷² This system creates a distributed or diffused method of sewage ejection that is hazardous because of the non-uniformity in design of these structures, and the usual non-inclusion of a primary treatment device in them. Consequently, the wastewater is released untreated into the soil, constituting a real threat that the pathogens in it will migrate into groundwater. The septic tanks are also sometimes wrongly situated too close to wells which abstract groundwater for drinking,

⁶⁹ Lagos State Wastewater Management Office, “Institutional, Regulatory and Legal Framework of Lagos State Wastewater Management Office” (2012). Paper presented to the Lagos State Government in August 2012.

⁷⁰ Ibid. The Lagos State Environmental Protection Agency (LASEPA) is responsible for regulating wastewater from industries and has Standards for the effluents from industrial activities but laments low industry compliance: Lagos State Government, Final Report on Effluent Limitations Standards and Guidelines (1999).

⁷¹ A.U. Oteri, “Coastal Groundwater Resource- Abstraction, Quality and Related Environmental Concerns: Lagos State Case Study” LSWRC Workshop on Groundwater, June 2013; E.O. Longe, “Groundwater Resource in Water Supply: Lagos State Case Study” (2013) LSWRC Groundwater Workshop June 4th 2013. Although the city has a few wastewater treatment plants, many of these are in varying degrees of disrepair, including that of the major industrial estate in Ikeja: Lagos State Wastewater Management Office, “Institutional, Regulatory and Legal Framework of Lagos State Wastewater Management Office”, *supra*, note 68. Industrial non-compliance with effluent limitation standards reflects in the color and turbidity of sewage discharged into the environment.

⁷² UN Habitat, (2008) *Global Atlas of Excreta, Wastewater Sludge, and Biosolids Management: Moving Forward the Sustainable and Welcome Uses of a Global Resource (Nairobi Kenya: 2008)* “Nigeria” at pg. 457.

with pollution occurring as a result. Although there are some rules governing the locations of septic tanks in terms of minimum location specifications from wells and other potable water supplies, there does not appear to be much compliance.⁷³ Lagos is a substantially built environment whose preliminary urban planning did not take into account centralized wastewater collection and treatment. The diffuse ejection method is ridden with the problem of leaching of very harmful contaminants into surrounding groundwater, quite apart from the frequent need for dislodging septic tanks.⁷⁴ Although wastewater discharge is primarily a problem of surface water bodies, the connection of both streams of water in the hydrological cycle makes it a problem for groundwater as well. Due to this connection, groundwater pollution is imminent, as the toxic components of the effluent discharges eventually reach groundwater and contaminate it.⁷⁵ Improperly managed wastewater has rightly been described as a major challenge to development and a cause of poverty because it generates healthcare costs and lost labor productivity.⁷⁶

1.2.2 Social Problems: Urbanization and Apathy/Non-compliance

The groundwater quality problem discussed so far is occurring within a context of over-urbanization in Lagos. Urbanization, the large and increasing influx of people into an urban area, is a natural process in development, and a major contributor to economic development in that it

⁷³ See for instance: National Environmental (Sanitation and Wastes Control) Regulations, Federal Republic of Nigeria Official Gazette, (2009) No. 60, Vol. 95, S. 10 and Schedule IV (discussed in more detail in Chapter 6, as part of the regulatory framework for groundwater). The problem of non-compliance is due in part to the rules being fairly recent compared to many of the non-compliant structures which have pre-existed the laws by several years.

⁷⁴ D. Olanrewaju, "Soak-away Systems and Possible Groundwater Pollution Problems in Developing Countries" (1990) 110 *Perspectives in Public Health* 108.

⁷⁵ B.C.E. Egboka, G.I. Nwankwor, I.P. Orajaka, and A.O. Ejiofor, "Principles and Problems of Environmental Pollution of Groundwater Resources with Case Examples from Developing Countries" (1989) 83 *Environmental Health Perspectives* 39.

⁷⁶ Sick Water Report, *supra*, note 2.

encourages product specialization by leveraging on the population mass (scale economies), and the concentration of similar industries (localization economies).⁷⁷

Urbanization in Lagos is therefore not *ipso facto* an anomaly. However the problem has occurred because of absolute and unrestrained increments and an overall explosive population growth rate that totally outstrips infrastructure in a pattern that scholars find to be typical of Third World demographic processes generally.⁷⁸ It is in sharp contrast to the pattern of urban development in First World cities which were progressive, and which allowed for the concurrent design and development of a full range of complementary social institutions, particularly of commensurate waste and wastewater management infrastructure that have guaranteed an overall good quality of urban life.⁷⁹ The high growth rate in Lagos is also enhanced by national social factors which encourage childbearing.⁸⁰ The city's growth rate exceeds the government's ability to plan for and manage important infrastructural facilities notably for appropriate solid waste treatment, safe wastewater disposal, and adequate water supply. According to the United Nations, Lagos is the fastest growing megacity in the world with the potential to become a world city and to compete with long-established cities in Europe and North America which have

⁷⁷ Vernon Henderson, "Urbanization in Developing Countries" (2002) 17 the World Bank Research Observer 89, at pg. 94.

⁷⁸ J. Kasarda & E. Crenshaw, "Third World Urbanization: Dimensions, Theories and Determinants" (1991) 17 Annual Review of Sociology 467; O. Varis, A. Biswas, C. Tortajada, & J. Lundqvist, "Megacities and Water Management" (2006) 22(2) Water Resources Development 377.

⁷⁹ Vernon Henderson, *supra*, note 76, at pg. 90; O. Varis et al, *supra*, note 78; Kasarda & Crenshaw, *supra*, note 77.

⁸⁰ Cultural and religious factors have contributed to Nigeria's large population of 170 million people. Everyone is expected to marry and to procreate, because marriage is perceived as a very respectable and required social institution, and a woman's status is enhanced by childbearing. Within marriage, premium has traditionally been placed on male children, and this has often resulted in repeated births in an effort to secure one. The two main religions, Christianity and Islam, although differing in fundamental ideologies, both promote childbearing as gifts from God: O. H. Kokole, "The Politics of Fertility in Africa" (1994) 20 Population and Development Review 73. See also E.C. Onwuka, "Another Look at the Impact of Nigeria's Growing Population on the Country's Development" (2006) 21(1) African Population Studies. Online: <http://bioline.org.br/pdf?ep06001>; S.F. Iwejingi, "Population Growth, Environmental Degradation, and Human Health and in Nigeria" (2011) 8(4) Pakistan Journal of Social Science 187.

traditionally laid exclusive claim to that status.⁸¹ Its exponential growth rate has led to an “over-urbanized” city a phenomenon that causes public services to be over-burdened, and that tends to outstrip overall economic development, amongst other related problems.⁸² Scholars do acknowledge that the most significant consequence of overly large populations is the dire impact on environmental resources.⁸³ This observation is true of Lagos where urbanization has occurred at such a rapid rate that water, wastewater, and solid waste management infrastructure have not kept pace with it.

Apathy and non-compliance with environmental laws represents the other dimension of social problems that affect groundwater quality. The apathetic attitude to environmental security especially by industrial operators, which has implied non-compliance with environmental regulations on effluent discharges and treatment to specified standards, is a particularly distressing problem.⁸⁴

1.2.3 Institutional Problems Affecting Groundwater Management

1.2.3.1 A Meagre Regulatory Framework

The existing rudimentary and fragmented regulatory framework does not offer enough protection for the groundwater resource. No single law is dedicated to groundwater in Lagos. Rather, as this thesis will document in Chapter 6, a combination of federal and state laws provides at best a cursory and fragmented framework to which problem of vagueness, legal

⁸¹ UN Habitat, State of the World's Cities 2006/7 Urbanization. Online: http://www.unhabitat.org/documents/media_centre/sowcr2006/SOWCR%202.pdf

⁸² Kasarda & Crenshaw (supra, note 78) discussed more criticisms of urbanization as causing saturated urban labor markets, distorted sectorial development in national economies, retarded economic growth due to high costs of urban development.

⁸³ Paul Ehrlich & Anne Ehrlich, “The Population Explosion: Why We Should Care and What We Should Do About It” (1997) *Environmental Law* 1187, at pg. 1188; S.F. Iwejingi, supra, note 80.

⁸⁴ Personal discussions with Lagos State Government officials confirmed the pervasive attitude and are discussed in more detail later in Chapter 5.

pluralism, gaps in legislation, and non-compliance attend. The regulatory attempts are superficial, spread out over several enactments, and are not complied with. Thus dangerous wastewater disposal practices and wrongful solid waste handling have continued virtually unheeded and unaddressed by law, even as the pollution of groundwater escalates. Limited regulation has also encouraged a culture of indiscriminate exploitation of groundwater that, combined with careless waste habits, has put the groundwater resource at a very serious risk from the perspectives of quality and sustainable supply.

1.2.3.2 A Nascent Water Sector

An inadequately structured water sector characterizes the institutional framework for groundwater in Lagos. Lagos has never had a governing Ministry of Water Resources, but rather the Lagos State Water Regulatory Commission was created only lately in 2012. It oversees the water sector which comprises the Lagos Water Corporation and the Lagos Wastewater Management Office. The Commission aims at achieving sustainable water supply and wastewater management services, but is still streamlining its functions amidst pre-existing structures and overlapping responsibilities between the water sector operators. Functional overlaps are occurring, whilst responsibilities still need to be clarified, streamlined and monitored for effectiveness.⁸⁵ It appears that the ultimate impact of the Regulatory Commission on water quality and water supply may not be discernible for some time, and in the meantime groundwater has not received the attention and protection that it requires.

⁸⁵ The Lagos State Water Sector Law (2004) establishes the Commission with regulatory functions similar to those of the Water Corporation. An example is the responsibility for public sewers for wastewater that the Water Sector Law places on the Water Corporation, whereas the Lagos Wastewater Management Agency now has that exclusive responsibility (S.95, Water Sector Law). Personal discussions with the head of the Commission in 2013 confirmed the presence of these functional overlaps.

The Lagos Water Corporation, although charged with responsibility for water supply meets only 30% of the city's water needs, hampered by a diversity of operational difficulties that range from financial limitations to power outages that constantly disrupt water pumping and transportation processes.⁸⁶ In the present state of an inadequate managerial framework, the groundwater pollution problem is escalating and threatening the sustainability of an invaluable resource which is needed for life and economic development in the city. Over the years, empirical studies conducted by scientists on the state of groundwater in the city have consistently affirmed proliferate and escalating degradation of groundwater that is caused by the migration of diverse pollutants into groundwater from solid waste and wastewater.⁸⁷

1.3 Research Objective

This doctoral research project focuses on the problem of groundwater degradation caused directly by municipal solid waste and wastewater, and indirectly by root social and institutional problems in Lagos, Nigeria. The purpose of the study is to describe the impact of waste and wastewater on groundwater sustainability in Lagos and to examine opportunities for law reform. It will involve an exhaustive discussion of the causes of the poor state of groundwater, and, following a careful examination of the existing legal framework, will lead to a formulation of

⁸⁶ Lagos Water Corporation, *Water Supply Plan 2010 – 2020* (April 2012).

⁸⁷ I.S. Akoteyon, "Evaluation of Groundwater Quality Using Contamination Index in Parts of Alimosho, Lagos Nigeria" (2012) 4(4) American Academic & Scholarly Research Journal; E.O. Longe & M.R. Balogun discuss potential contamination in "Groundwater Assessment Near a Municipal Landfill Lagos Nigeria" (2010) 2(1) Research Journal of Applied Sciences, Engineering and Technology 39; A. Ikem, O. Osibanjo, M.C.K. Sridhar & A. Sobande, Evaluation of Groundwater Quality Characteristics Near Two Waste Sites in Ibadan and Lagos, Nigeria, *Water, Air and Soil Pollution* 140: 307-333 (2002); A.Y. Sangodoyin & O.M. Agbawhe, (1992) Environmental Study on Surface and Groundwater Pollutants from Abattoirs Effluents" *Bioresource Technology* 41, 193-200 (1992); O.L. Asubiojo et al, (1997) "Trace Elements in Drinking and Groundwater Samples in Southern Nigeria" 208 (1-2) *The Science of the Total Environment* 1; A.O. Eruola et al, "Assessment of Effect of Sewage Intrusion from Septic Tanks into the Consumable Hand dug Wells in Lagos State, Nigeria (2013) 13 *Global Journal of Science Frontier Research* ISSN:2249-4626 & Print ISSN: 0975-5896.

recommendations for a legal framework for managing pollution and ensuring sustainability of groundwater in Lagos.

1.4 Research Questions

This study has endeavored to answer the following questions:

1. What are the direct environmental problems, and the indirect social, and institutional threats that contribute to groundwater degradation in Lagos?
2. How can law resolve the current fragmented and cursory frameworks and formulate a comprehensive one that addresses the direct and indirect problems that confront groundwater, thus safeguarding groundwater sustainability in Lagos?

1.5 Methodology

This study adopts a **cross-disciplinary approach** by combining a number of methods to enhance the legal research and to achieve its objective. It employs the historical methodology, a comparative legal approach, insights from sociological and scientific studies, analysis of field work undertaken, and analysis of information in official documentation obtained from Lagos state departments.

The **historical method** is the process of extracting general facts through attention to chronology and to the evolution of the subject of study. In this thesis, it enables a review of the contributions of groundwater to human life in Chapter 3, which underscores its importance and the rationale for the present study. The method also is also employed to appraise the evolution of sustainable development in Chapter 2, and leads to the extraction of pertinent principles for

water management as a benchmark on which development in Lagos is evaluated. These historical reviews provide the conceptual basis for the study.

Still employing the historical methodology, the study also examines the origin of environmental legislation in Nigeria in Chapter 6. The method facilitates the tracking of its evolution up until the emerging efforts to regulate groundwater. Following from the historical review, it analyzes primary sources of law including the federal laws and Lagos state's environmental laws, regulations made under them, and Nigeria's Constitutional law.

Following the historical legal review in Chapter 6, the study employs the **comparative approach** in the same chapter to examine and compare pertinent aspects of the European Union's legal framework for groundwater and (due to their intersection), solid waste and wastewater management in Lagos. The comparison is being made in order to aid the proposed recommendations for law reform. The process ascertains similarities and differences in legal provisions between the two systems, and recommendations are being offered based on analysis and aggregation of the perceived best management solutions offered by the European Union.

A review of **sociological and scientific studies** provides important insights for the research. The sociological theories on urbanization in Chapter 4 explain it as a demographic phenomenon which is the context in which the groundwater pollution problem is occurring in Lagos. They provide understanding of the migration to Lagos which accounts for the generation of massive quantities of waste and wastewater that pollute its groundwater. The theories also explain the reasons for the lackluster attitude of industrialists to compliance with environmental standards for wastewater.

The **empirical studies** discussed in Chapter 5 provide insights on the causes, sources, and extents of groundwater pollution from municipal solid waste and wastewater, as well as the implications for human health. The references to scientific studies provide a real account of the groundwater pollution occurring in Lagos over a ten-year period, from 2002 until 2012. The thesis also draws from studies on water and waste management. In addition, aspects of public health are incorporated in the analysis.

Field work carried out in Lagos over a period of ten weeks between 2012 and 2013 is reported in Chapter 5. It includes a series of interview sessions held with each of the following categories of people:

- Officials of Departments within Lagos State which are responsible for water, solid waste and wastewater management. These are: Lagos Water Corporation (LWC); Lagos State Waste Management Authority (LAWMA); Lagos State Ministry of the Environment; Lagos State Environmental Protection Agency (LASEPA); Lagos State Wastewater Regulatory Commission (LASWAMO); and Lagos State Water Regulatory Commission (LASWARC), which is the present regulator of the water sector;
- Two senior Professors at the University of Lagos who have published on groundwater, and who are also consultants to the Lagos State Government. They provided updated information about the quality problems besieging groundwater. Collectively, they gave an overview of the water supply problems, the status of wastewater and waste management, and the causes of groundwater pollution.

Field work also included visits to key locations: Ikeja mini water treatment plant where groundwater is extracted, treated, and distributed daily to residents; *Ikosi* market where a waste-to-energy pilot program is being tested as part of emerging recycling efforts; the major waste

dump, *Olushosun*, for observation of the status of the major waste dumpsite in Lagos and of the recycling activities there. A proposed fourth trip to *Odogunyan* to view the status of solid waste recycling efforts was aborted due to unavailability of tour facilitators. The findings of the field work and interviews are presented in Chapter 5.

1.6 Contribution of Research to Knowledge

This study addresses a vacuum, which is the paucity of studies that investigate the fundamental social factors that elicit the pollution problem confronting groundwater, with a view towards law reform. The purpose of the study is to develop recommendations for a legal framework that will facilitate the integration of groundwater protection with socio-economic activities, particularly the industrial activities that are geared towards economic development in Lagos. The study hopes to contribute to knowledge by linking relevant social studies to law and thereby derive recommendations that are made up of best practices that are tenable for the case of a megacity in a developing country.

1.7 Argument for the Thesis

Development in Lagos in terms of urbanization, population growth, and industrial growth has conferred an enviable economic status and urban primacy on Lagos. Its present status appears to confirm theories which affirm that urbanization works together with industrialization to accomplish economic development. These theories are discussed in Chapter 4.

However, this thesis argues (in Chapters 2, 4 and 5) that development in Lagos is occurring at the expense of its groundwater, and will therefore be ecologically unsustainable in the long term. Groundwater is extremely important in Lagos because nearly all residents rely on it for

sustenance, and even industrial activities rely significantly on groundwater. The argument is based on the following premises:

The high urbanization rate and the resultant population which are at the root of groundwater pollution are critically out of control. But these need to be controlled through definitive steps as imperatives for sustainable development.⁸⁸ The argument will be reinforced with principles of sustainability that have been agreed on at international agreements which also recommend strategies to mitigate the adverse effects of population on the environment in general and on groundwater in this case.

It is also argued that as the current inadequate legal framework and institutions in Lagos have not kept pace with the city's development, strengthening its laws and institutions in compliance with sustainable development principles, will be required tools to achieve sustainability in the peculiar socio-economic context of Lagos.

Human survival depends on nature, and therefore activities have to be adapted within its capacity limits. Economic development that erodes natural capital will not be successful, because it is the basis of human existence. Development strategies and programs which do not take sufficient account of a critical resource such as groundwater degrade the resource base upon which future growth is dependent. The benefits associated with development must not be derived by harming the environment on which life depends. Working against nature and ignoring natural processes will ultimately defeat development goals, and a society that continues to use or abuse a natural resource extremely faces the risk of collapse. The use of groundwater must proceed at a

⁸⁸ The concept of sustainable development is fully discussed in Chapter 2, *infra*.

lesser rate than its natural replenishment. Although this principle refers primarily to rates of exploitation, it is extendable to decline on account of pollution as the case of Lagos typifies.

The principles of sustainable development for water resources which acknowledge its intersection with urbanization, waste management, and population will be employed as the benchmark for evaluating the development trends in Lagos, and will enable the derivation of holistic recommendations for Lagos.

This thesis illustrates how the problem of groundwater sustainability affecting several millions of people can be addressed. It explores the role of law in reversing the unsustainable trends of over-urbanization, and in encouraging measures to reduce the burden on Lagos. It endeavors to articulate prescriptions for a management framework that are carved out especially for Lagos' circumstances and that reflect the city's environmental and developmental context. Some of these might eventually form the basis of recommendations for application in the developing world. The thesis is committed to contributing to a sustainable spring of groundwater which is insulated from all pollution.

1.8 Presentation of Chapters

Chapter 2 introduces the concept of sustainable development as the standard on which development in Lagos is evaluated. It outlines the historical evolution of the concept, and the general agreements at important international meetings. It also extracts the pertinent principles relating to water resources management as well as environmental law principles for analysis across the thesis in relation to groundwater law in Lagos.

This is followed in Chapter 3 by a discussion of the relevant literature on groundwater, and an examination of its global contributions as a basis for appreciating its overall importance.

This precedes a discussion of its specific importance and contribution to life and industrial growth in Lagos.

Chapter 4 is an overview of urbanization, the social context in which pollution of groundwater is occurring in Lagos. The chapter reviews theories that explain the motivations for migration into Lagos, which accounts for the overly large population in the megacity, and which is also enhanced by a national high rate of population growth. It clarifies that although Lagos has in consequence of urbanization and development made significant national contributions and has an enviable dominant status, the status may not be maintainable because its groundwater, which is a major contributor to its development, is not secured. It also discusses the probable environmental consequences of an over-urbanized city, as a prelude to the next chapter's discussion of actual pollution that has occurred.

In Chapter 5, the core of the research, the problems of solid waste and wastewater pollution of groundwater that emanate from the large, urbanized population are discussed. This is immediately followed by the results of the field work which are presented separately for solid waste and wastewater. The chapter concludes with a consideration of the implications of polluted groundwater on human health.

Chapter 6 contains the discussion of the legal and institutional framework for groundwater. It incorporates an appraisal of the limitations of the current legal and institutional system following a historical review of the evolution of environmental legislation in Nigeria. The legal frameworks for groundwater, waste, and wastewater are reviewed and recommendations made to improve them in the overall interest of groundwater security. The legal frameworks are also compared to that of the European Union, and best management practices are extracted for

application in Lagos. Recommendations are also made to tackle the perceived problems within environmental governance institutions in an effort to secure groundwater.

Chapter 7 concludes the thesis with a discussion and summarization of each segment of the overall problems confronting groundwater, and of probable solutions. This is followed by recommendations in each category of the problems for incorporation in a legal framework that is expected to contribute to groundwater security in Lagos. The chapter ends by summarizing all the recommendations.

CHAPTER 2

SUSTAINABLE DEVELOPMENT⁸⁹

2. Introduction

Sustainable Development refers to a path of human development in which resource use aims to meet human needs while at the same time ensuring the maintenance of natural systems and the environment, so that the needs of both present and future generations are met.⁹⁰ At the core of the concept is the preservation of natural capital.⁹¹ Sustainable development is now regarded as the norm or overarching paradigm for safeguarding the environment and for ensuring a good quality of life on earth.⁹² International discourses about the sustainability of development which began in the 1960s with the evidence of the progressive destruction and depletion of ecological capital have continued in earnest throughout the world.⁹³ The critical change in thinking by governments and developmental agencies is that development and environment are not mutually exclusive. It is now understood that a healthy environment is essential for

⁸⁹ In this thesis, 'Development' is used in the broader sense of the collective processes of change toward improvements in quality of life for human beings and their communities. This inclusive definition accommodates industrialization and urbanization which are at the core of the socio-economic fabric in Lagos, and which are also indirectly responsible for the pollution trends identified by this study. Support for widening the concept of development can be found in the Founex Report: *The Founex Report on Development and the Environment*, Ch. 1.6 (available online). See also: Lynton K. Caldwell, "Political Aspects of Ecologically Sustainable Development" (1984) 11(4) *Environmental Conservation* 299, at pg. 303.

⁹⁰ The World Commission on Environment and Development, *Our Common Future*, (Oxford & New York: Oxford University Press, 1987); J.M. Harris, "Sustainability and Sustainable Development", *International Society for Ecological Economics*, Internet Encyclopaedia of Ecological Economics (online); I.A. Agboje, A. Adetola & B.O. Irhivben, "Performance Assessment of Solid Waste Management following Private Partnership Operations in Lagos State, Nigeria (2014) *Journal of Waste Management*, online: <http://dx.doi.org/10.1155/2014/868072>.

⁹¹ Natural capital is defined as the world's stock of natural assets which includes water, soil, air, geology, and all living things: World Forum on Natural Capital, *What is Natural Capital?* (Edinburgh 2015), Online: <http://naturalcapitalforum.com/about/>.

⁹² D. B. Magraw & L.D. Hawke, "Sustainable Development", in D. Brodansky, J. Brunnee & E. Hey, *The Oxford Handbook of International Environmental Law* (Oxford: Oxford University Press, 2007) 613.

⁹³ Meetings to assess the environmental impact of human activities began in 1968 when the Biosphere Conference addressed in serious terms the unprecedented pressures of increased human needs on the environment: Intergovernmental Conference of Experts on the Scientific Basis for Rational Use and Conservation of the Resources of the Biosphere (the Biosphere Conference), *Final Report*, (Paris, 1968), Online: <http://unesdoc.unesco.org/images/0001/000172/017269eb.pdf>

sustainable development and a healthy economy. As succinctly surmised by a scholar, “There will be no sustained development or meaningful growth without a clear commitment at the same time to preserve the environment and promote the rational use of resources”.⁹⁴ Sustainable development principles thus represent the predominant international standard on which development initiatives are evaluated, and, accordingly, will be employed in this thesis for the purpose of assessing development processes in relation to groundwater pollution in Lagos, and will seek opportunities for law reform.

The economy and the environment are necessarily interwoven because economic growth depends on extractions from the natural resources in the environment. According to Rees, environment and economy have always been “fully and inextricably integrated” as the human economy is fundamentally dependent on materials from the biosphere.⁹⁵ This tenacious link was clearly expressed in the Rio Principles as follows: “In order to achieve sustainable development, environmental protection shall constitute an integral part of the development process and cannot be considered in isolation from it”.⁹⁶ Environment and development are really just 'two sides of the same coin'. Therefore the apparent conflicts between economic development and the environment cannot be wished away, but should rather be addressed.⁹⁷ Bartelmus observes that there is the growing recognition that the overall goals of environment and development are not in conflict but are indeed the same, namely the improvement of the human quality of life or welfare

⁹⁴ M. Tolba, *Development without Destruction* (Dublin, Ireland: Tycooly International, 1982).

⁹⁵ W. Rees, “The Ecology of Sustainable Development” (1990) 20(2) *Ecologist* 18, at pgs. 18-19.

⁹⁶ United Nations Conference on Environment and Development, *the Rio Declaration* (Rio de Janeiro, 1992) Principle 4. See also: M. Tolba, *Development without Destruction*, supra, note 94.

⁹⁷ P. Nijkamp & F. Soetaman, “Ecologically Sustainable Economic Development: Key Issues for Strategic Environmental Management” (1988) 15(3-4) *Int. Journal of Social Economics* 88, at pg. 89.

for present and future generations.⁹⁸ Merging economic development with environmental protection is the most critical imperative of sustainable development.

The sustainability drive was triggered by the excesses of the development process in the First World which had involved unrestrained extraction and use of natural resources, and the employment of optimal production processes. Large productive capacities in industry and agriculture, the growth of complex systems of transportation and communication, and the evolution of massive urban conglomerations characterized this period.⁹⁹ The countries placed premium on economic growth and technology, and, had environmental concerns arisen at this time, they would likely have been waved off as the “price of progress”.¹⁰⁰ Innovations and new technologies within the “feverish industrialization” that characterized the 19th and 20th Centuries accomplished very high standards of living, and also encouraged consumption patterns that were consistent with the escalating level of advancement.¹⁰¹ Belatedly however, it was realised that the path to these enviable achievements which had produced remarkable improvements in human welfare had concurrently disrupted and damaged the human environment with some devastating and irreversible consequences, and was depleting the ecological base at a pace that could not continue if life on earth was to be sustained. Global warming (now referred to as ‘climate change’) which showed up as a continuous rise in the earth’s atmospheric temperature, and ozone layer depletion (both caused by emissions of greenhouse gases) as well as acid rain and

⁹⁸ P. Bartelmus, *Environment and Development* (Allen and Unwin, London, U.K. 1986) at pgs. 13-14.

⁹⁹ *The Founex Report on Development and Environment*, (1971), Ch. 1 (Available online).

¹⁰⁰ M.R. Biswas & A.K. Biswas, “Complementarity between Environment and Development Processes’ (1984) 11(1) *Environmental Conservation* 35.

¹⁰¹ R.A. Frosch & N.E. Gallopoulos, “Strategies for Manufacturing” (1989) 189(3) *Scientific American* 152.

deforestation were some of the clear feedback from the environment to the economies that untold harm had been done by unrestrained industrial production processes over the years.¹⁰²

Global concerns now center on the future of earth's climatic conditions and on humanity's survival on the planet. In an age where human activities are placing tremendous pressures on natural resources, the world is increasingly seeking more sustainable methods of living on the earth, and of interacting with and using nature's resources. Confronted with the real threats of irreversible pollution and depletion of natural resources, national governments and international agencies are mobilizing the international community to make concerted efforts to adopt more environment-friendly practices within development. Appeals have also been made to developing nations which are in their respective development processes to find alternative, less harmful, and less destructive approaches in the interest of all humanity, and not to adopt the model of their developed counterparts.¹⁰³ After all, there is only one irreplaceable earth that is available to, and shared by all of humanity.¹⁰⁴

¹⁰² J. MacNeill, "Strategies for Sustainable Economic Development" (1989) 261(3) *Scientific American* 154; Biswas & Biswas, *supra*, note 99; Caldwell, *supra*, note 89, at pgs. 301-303; S.E. Ebomhe, "Environmental Legislation Changes in Nigeria: What Impact on Foreign Investment?" (2006), Available online.

¹⁰³ United Nations Human Settlements Programme UNHABITAT, *The Future of African Cities* (2010), (Available online). Developing nations have historically and understandably perceived these calls as limiting their expectations of economic development. Some scorned the appeals, viewing the calls for sustainable development as a new form of colonialism, as unwarranted interference with their economic development, or as a deliberate ploy to keep them subservient. Their resentment has been fuelled by understanding that the clamouring for alternative paths to development originates from developed countries which have had free, unimpeded use (and abuse) of the environment in their respective developmental processes. These economically-secured nations singularly caused the problems complained of, whereas their developing counterparts have not made any such contribution. Therefore in the 1970s especially after the 1972 United Nations Conference on the Human Environment in Stockholm, when calls for more sustainable paths to development were urged, developing nations needed to be persuaded that long-term sustainable development could only be achieved through sound environmental management. To this argument, developing nations have countered that "sustained economic growth", rather than sustainable development, should be the paradigm: Dan Tarlock, "Ideas without Institutions: The Paradox of Sustainable Development" (2001) 9 *Ind. J. Global Legal Stud.* 35; D. B. Magraw & L.D. Hawke, "Sustainable Development" in D. Bodansky, J. Brunnee, and E. Hey, *The Oxford Handbook of International Environmental Law* (Oxford: Oxford University, 2007) 613. As a result, developing nations have historically demanded for a transfer of resources and technology from developed countries to them as a condition for complying with the terms for sustainable development. Arguments have indeed been made for assistance to be provided them to find alternative less damaging paths to their respective developments: A. Rogers, *The Earth Summit* (Los Angeles: Global View Press, 1993); See also: Armitrajeet Batabyal, "Developing Countries and Environmental Protection: The Effects of Budget Balance and Pollution

Within the concerns for sustainable natural capital, water is especially concerning as a natural resource that is critical to life but which is susceptible to pollution. The pollution emanates from diverse anthropogenic activities that result in its being retained in harmful chemical combinations. To avert this, it has become necessary to devise means of protecting this natural resource by applying the relevant principles of sustainable development.

Therefore the following discussion on sustainable development attempts to extract sustainable development principles that focus on water for analysis later in the thesis. These would be the standard to analyze the present use and management of groundwater in Lagos. The discussion will be preceded by a review of the evolution of the idea of sustainable development in international law and policy.

2.1 A Brief History of Sustainable Development

2.1.1 Silent Spring

In 1962, Rachel Carson brought together research on toxicology, ecology, and epidemiology to infer that the agricultural pesticide, *Dichloro-diphenyl-trichloroethane* (DDT) was building up to catastrophic levels in the environment. DDT was developed as a synthetic insecticide to counter insect-borne human diseases and was also used in agricultural pest control

Ceiling Constraints” (1997) 54 *Journal of Development Economics* 285; L. Egunjobi, “Issues in Environmental Management for Sustainable Development in Nigeria” (1993) 13 (1) *The Environmentalist* 33. However it goes without saying that in its own interest, each nation owes its citizens the responsibility to doggedly pursue the security of its own environmental resources, by averting deterioration and depletion of its critical natural resources, especially water. And developing nations have the privilege of learning from the costly errors of their counterparts and can thus avoid irreversible damage of which undeniable proofs abound. Besides, they do have a genuine stake because environmental problems tend to accompany development processes. Environmental degradation has a global impact, and there is also impact on economic relations with developed countries: The Founex Report, *supra* note 99, at Ch. 1.3.

¹⁰⁴ The Founex Report, *supra*, note 99; Mostafa K. Tolba, “Only One Earth”, *Science for Better Environment*, Proceedings of the International Congress on the Human Environment (Oxford, England: Pergamon Press Ltd., Kyoto, 1975) 7, at pg. 14.

because of its miraculous capacity to kill hundreds of different kinds of insects at once.¹⁰⁵

Developed in 1939, it distinguished itself during World War II by ridding the South Pacific islands of malaria-causing insects amongst American troops.¹⁰⁶ However, in her book, *Silent Spring*, Carson demonstrated that DDT was causing damage to animal species and human health, and she queried the pervasive belief in technological progress that occurs at the expense of life and health.¹⁰⁷ As a result of her painstaking research efforts, the United States Government re-evaluated DDT, confirmed her findings, and eventually banned its use.¹⁰⁸

The most important legacy of Carson's *Silent Spring* is that it informs public awareness that nature is vulnerable to harmful human interventions in the form of dangerous chemicals introduced into the environment which have a great potential for damaging living tissues, and also that technological progress can sometimes be very injurious to natural processes.¹⁰⁹ Her book prepared the way for the rise of environmental and Green movements worldwide, and encouraged conservationists, ecologists, biologists, and organic farmers to join in the American environmental movement. According to Dunn, her efforts set the stage for the sustainable development environmental thinking that is currently a worldwide movement.¹¹⁰ Carson's work was also effective as it resulted in major legislative revisions in the United States, and the creation of the United States' Environmental Protection Agency in 1970.¹¹¹

¹⁰⁵ United States Environmental Protection Agency, *DDT - A Brief History and Status*, Online: <http://www2.epa.gov/ingredients-used-pesticide-products/ddt-brief-history-and-status>

¹⁰⁶ Ibid.

¹⁰⁷ R. L. Carson, *Silent Spring*, (New York: Houghton Mifflin Company, 1962), available online.

¹⁰⁸ *DDT - A Brief History and Status*, supra note 104.

¹⁰⁹ Natural Resources Defence Council, *The Story of Silent Spring*, Online: <http://www.nrdc.org/health/pesticides>

¹¹⁰ R. Dunn, "In Retrospect Silent Spring", (2012) 485 *Nature* 578, also available online at <http://www.nature.com/nature/journal/v485/n7400/pdf/485578a.pdf>.

¹¹¹ The U.S. legislature revised its laws on chemicals, namely the 1910 Insecticide Act and the Insecticide, Fungicide, and Rodenticide Act of 1947, which had hitherto dwelt on registration, labeling, and efficacy of pesticides, but not on regulating their use. Numerous subsequent reviews, culminating in the 1972 Federal Environmental Pesticide Control Act, include stipulations to pay attention to safety considerations in pesticide labeling. They also mandate the Environmental Protection Agency to regulate the use and sale of pesticides to

Over time, several important international policy forums, including meetings and deliberations in Africa, have taken place to address the perceived and increasingly alarming impacts of anthropogenic activities on the environment.¹¹² These culminated in the World Commission on Environment and Development which popularized the concept of sustainable development.

2.1.2 The World Commission on Environment and Development (the Brundtland Commission)

The United Nations called for a global enquiry into the state of the world with the inauguration of the World Commission on Environment and Development (the Brundtland Commission) in 1983. Emerging information about the harmful effects of industrial production processes, the threat of surging populations, and fears about increasing depletion and degradation of the earth necessitated this enquiry.¹¹³ The industrial processes of mass production and the high levels of human consumption had combined to cause the depletion of natural resources and the occurrence of troubling environmental challenges such as ozone depletion, global warming, acid

protect human health and to preserve the environment. In 1976, the Toxic Substances Control Act directed the Agency to protect the public from “unreasonable risk of injury to health or the environment”: *DDT - A Brief History and Status*, supra note 104. See also: United States Environmental Protection Agency, The Birth of EPA, Online: <http://www2.epa.gov/aboutepa/birth-epa>.

¹¹² The 1968 Biosphere Conference (supra note 93) observed and lamented the “very rapid growth of the human population” and the unprecedented pressures of increased human needs on the environment. It clarified that the critical balance to be achieved between inevitable consumption and depletion of natural capital is “the wise use of resources”. Later meetings included the 1972 UN Conference on the Human Environment which focused on human activities’ impact on the environment, access to water, and population growth. The 1971 Founex Conference was a meeting of experts which was convened out of concern that the massive scale of development was causing serious hazards to human health and disruptions to the environment. These Conferences all recognized that environmental destruction at an unprecedented level was taking place. Africa was not left out of the train of events, as a series of conferences aimed at protecting natural resources within the region started from 1900. The meetings took place both during and after colonial administrations, and included: the Convention for the Preservation of Wild Animals, Birds and Fish in Africa, (London, 1900); the Convention Relative to the Preservation of Fauna and Flora in their Natural State (London, 1933); and the 1968 African Convention on the Conservation of Nature and Natural Resources (Algiers, 1968). Both the London and the Algiers Conventions are credited with directly leading to the evolution of national legislations and environmental practices around the African continent, although, as Ogolla noted, little more than nature, natural resources, and public health were addressed: J.M. Takang, “From Algiers to Maputo: The Role of the African Convention on the Conservation of Nature and Natural Resources in the Harmonization of Conservation Policy in Africa” (2014) 17 *Journal of International Wildlife Law and Policy* 165; B.D. Ogolla, “Environmental Law in Africa: Status and Trends” (1995) *International Business Lawyer* 412.

¹¹³ Jim McNeill, “Strategies for Sustainable Economic Development” (1989) 261(3) *Scientific American* 154.

rain, and ocean pollution on a global scale. The tacit question which the United Nations' General Assembly posed was how to meet the needs of the generation at that time without compromising the ability of future generations to meet theirs? ¹¹⁴

In 1987, the Commission published its report, *Our Common Future*.¹¹⁵ The Report references 'sustainable development' as the paradigm for development activities, and analyzes the concept in many ways that are pertinent to the present study:

- Development that does not integrate the environment into the economics is not sustainable;
- Development should not endanger the natural systems that support life on earth, that is, the atmosphere, waters, soils and living creatures;
- (industrial) development that hurts or destroys natural resources that sustain life is unsustainable;
- Where development entails exploiting a renewable resource at a faster rate than nature's limits, or causes harmful emissions that exceeds nature's ability to attenuate or repair, it is unsustainable;
- Consumption standards have to be within the bounds of the ecological possible and to which all can reasonably aspire;
- Societies that continue to use up natural resources and that persist in producing waste and polluting the environment will severely lower their quality of life;
- Development should meet the needs and aspirations of the present generation without compromising the ability of future generations to meet their own needs.¹¹⁶

¹¹⁴ Ibid.

¹¹⁵ The World Commission on Environment and Development, *Our Common Future* (Oxford, New York: Oxford University Press, 1987).

¹¹⁶ Ibid, Chapter 2, at pgs., 43 - 44.

The Brundtland Conference proffered specific strategic imperatives or directions which are the requirements of a sustainable system, and that are very relevant for the present study. It noted that population must not be so large that it places an unbearable burden on the environment and on available resources. It also stressed the importance of reducing the energy and resource content in manufacturing, and of re-orientating technology whenever required. Overall, there is emphasis on the importance of synchronizing development initiatives with environmental concerns in decision-making.¹¹⁷ The guidelines are important for determining an acceptable path of development in Lagos.

The idea of sustainable development has been enthusiastically embraced as the answer to a much-needed call for political recognition of global environmental decay. Rees argues that it presents an opportunity for man to correct the errors of the past and to cultivate a gentler, more stable and balanced relationship with the natural world.¹¹⁸ It is understood that since all life depends on natural resources including water, they require careful management to preserve them.¹¹⁹

Sustainable development also incorporates the concept of intergenerational equity in that development must meet the needs and aspirations of the present generation without compromising the ability of future generations to meet their own needs.¹²⁰ This is premised on the idea that all generations are equal, none may be preferred over the other, and therefore all have an equal place in relation to the natural system. It also imports that humans have a relationship both with other generations and with nature. Weiss discusses sustainability from a

¹¹⁷ *Our Common Future*, supra note 115, at pgs. 49-65.

¹¹⁸ W. Rees, supra, note 95.

¹¹⁹ Magraw & Hawke, supra, note 92, at pg. 620.

¹²⁰ *Our Common Future*, supra note 115, Chapter 2, pg. 43. The Rio Declaration, infra, also clarifies that the right of development must be fulfilled so as to equitably meet the developmental and environmental needs of both present and future generations: Principle 3, Rio Declaration.

normative standpoint in which the earth and all its resources are in a ‘trust’ to a particular generation of humans for both its benefit and the benefit of future inhabitants of the earth. The natural resources passed to the present generation are both for its benefit and also to be held in trust for future generations. Future generations should have at least the same possibilities as people who are currently living.¹²¹ Following from this premise, depletion and irreversible degradation cannot ensure sustainability. Case law has further supported this principle of inter-generational equity as exemplified in the Philippines case of *Oposa v Factoran*. In that case, the court declared that the plaintiffs who brought a class suit to prevent deforestation for themselves and for the benefit of future generations had a legal standing to do so on the basis of inter-generational responsibility and inter-generational justice.¹²² Although unprecedented at that time, the case has since gained international validation and has been cited in many subsequent cases.¹²³ Inter-generational equity is relevant in the context of groundwater in Lagos. It is an impetus to preserve groundwater now so that future generations may also partake of it.

2.2 The Pillars of Sustainable Development

There have been many formulations of sustainable development, each reflecting particular values and priorities.¹²⁴ In spite of differences in conceptual approaches however, it is clear that the purpose is to avert the undesirable social and environmental consequences of

¹²¹ E. Weiss, “In Fairness to Future Generations and Sustainable Development” (1992) 8(1) American University Int. Law Review 19.

¹²² *Oposa v Factoran*, GR No. 101083 (30 July 1993) Supreme Court, Republic of the Philippines.

¹²³ For instance, the United Nations Environmental Programme regards the case as an authoritative one for judicial thinking in environmental governance. It lauds the court’s judicial interpretation of the right to life and for promoting natural resources conservation, achieving equity and justice, and generally for implementing the goals of sustainable development: L. Kurukulasuriya, (Chief, Environmental Law Program, United Nations Environment Programme) “The Role of the Judiciary in Promoting Environmental Governance and the Rule of Law” Prepared for Global Environmental Governance: the Post-Johannesburg Agenda Yale Centre for Environmental Law and Policy, New Haven (October 2003).

¹²⁴ MacNeill views these differing interpretations as being so disparate as to amount to “a new way to define infinity...”: J. MacNeill, “The Forgotten Imperative of Sustainable Development” Presented at Pace University on April 20th, (2006) at pg. 4.

economic or other development. It is generally agreed that there are three pillars: economic (sound economic growth); social (equity), and ecological (environmental protection). They are also expressed, in Flint & Houser's words, as economic vitality, ecologic integrity, and social equity.¹²⁵ Within these three pillars, the environmental aspect, also termed ecologically sustainable development, is the most pertinent to this research.¹²⁶

2.2.1 Ecologically Sustainable Development

The application of ecological considerations to development goals and processes is termed ecologically sustainable development.¹²⁷ Ecological sustainability is development that does not sacrifice the future quality of life for short term gains, and that maintains the critical ecological processes on which all life depends.¹²⁸ It implies all the following components: efficient use of natural resources, waste reduction and pollution control; conservation of natural capital which is essential for sustainable production; and the ability of the environment to support required levels of environmental quality and natural resource extraction rates indefinitely. It requires maintaining a stable resource base and avoiding over-exploitation of

¹²⁵ R.W. Flint & W.L. Houser, *Living a Sustainable Lifestyle for our Children's Children*, (Authors Choice Press, California, U.S., 2001), Available online.

¹²⁶ Although there are three sustainability pillars, not all the goals may realistically be achieved at the same time. Harris (supra note 90), argues quite rightly that categorizing sustainable development into three compartments complicates the otherwise simple understanding of the concept by presenting three separate goals. This immediately presents difficulties or conflicts in attempting to achieve all three goals at once, and raises the question of which goal should be preeminent, and how success or failure should be determined. He cites many national and international problem-solving efforts that focus on only one pillar at a time; for instance, the United Nations Environment Programme, national environmental protection agencies, and environmental NGOs focus on the environmental pillar; The World Trade Organization and the OECD focus mostly on economic growth, although giving some attention to social sustainability such as war reduction and justice; even the United Nations focuses predominantly on economic growth of developing countries, i.e. the economic pillar. Besides, its frequent references to "the three dimensions of sustainable development" implicitly suggest that although the ultimate goal is to achieve all three, they are individual and separate. Norgaard very insightfully surmises that only one objective can be maximized at a particular time: J.M. Harris, supra, note 90; The United Nations Conference on Sustainable Development (Rio + 20), *The Future We Want*, Arts. 56 & 58; R. B. Norgaard *Development Betrayed* (London, Routledge, 1994) at pg. 22.

¹²⁷ Intergovernmental Conference of Experts on the Scientific Basis for Rational Use and Conservation of the Resources of the Biosphere (1968), supra, note 93. See also: L.K. Caldwell, supra, note 89.

¹²⁸ Business Dictionary, online: <http://businessdictionary.com>.

renewable resources or depletion of non-renewable resources (or if depleted, that a substitute is available).¹²⁹ Also implicit in its definition is the importance of placing limits on population and consumption levels because of the negative ecological side effects that they impose.¹³⁰ Environmental sustainability entails understanding the processes of natural and aquatic systems ecosystems in order to properly design sound economic development strategies.¹³¹

Where developmental activities ignore or neglect environmental considerations, they have dire effects and may even halt the development process. Caldwell cites numerous cases of developmental activities around the world that neglected ecological factors, and in consequence, either failed or caused severe environmental and health problems for residents.¹³² Developmental activities therefore require the effective integration of environmental considerations in decision-making processes. All the criteria listed for ecological sustainability are applicable in the context of groundwater sustainability in Lagos, and will be pooled together with sustainability principles which address water management that are discussed next.

Concerns about water adequacy and quality both for present and future users has consistently formed a significant part of collective international efforts to safeguard the environment. This has culminated in a number of meetings which urge nations to observe certain guiding and holistic principles designed to protect the resource.

¹²⁹ R.W. Flint & W.L. Houser, *supra*, note 125. See also: J. M. Harris, *supra*, note 90.
<http://www.thwink.org/sustain/glossary/ThreePillarsOfSustainability.htm>.

¹³⁰ L.K. Caldwell, *supra*, note 89, at pg. 302.

¹³¹ The United Nations refers to an ecologically sustainable system as a “green economy” and as an important tool towards sustainable development. A green economy promotes sustainable production patterns: the *Future We Want* (2012), Arts. 56-74.

¹³² For instance in El Salvador, the socio-political system disintegrated in the 1980s following soil erosion and premature siltation of the 5 November Dam, both of which occurred as a result of indiscriminate stripping of forests and over-grazing. In Venezuela, the previously beautiful Lake Valencia progressively suffered severe pollution and salinization due to industrial activities that were initiated without regard to ecological consequences. Water-borne diseases also increased greatly: L.K. Caldwell, *supra*, note 89.

2.3 Core Principles of Sustainable Development Relating To Water

Water is at the core of sustainable development because of its close link to major global challenges including sanitation and poverty reduction.¹³³ It is thus important that water should be integrated into sustainable development. Apart from the general principles that it enunciated, the Brundtland Commission found a firm link between general principles of sustainability and water use that are particularly relevant for this thesis. The idea of an integrated approach to water management was conceived, and is now an international concept that is being mooted based on the understanding that the problems of fresh water stress and unsatisfied human water needs require a more comprehensive conceptual framework to tackle them effectively.

Subsequent to the Brundtland meeting, the United Nations convened a number of additional meetings that emphasized the role of water within development. The meetings include: the 1992 International Conference on Water and the Environment (the Dublin Conference); The 1992 United Nations Conference on Environment and Development (Rio Conference); the 2012 United Nations Conference on Sustainable Development (Rio+20); and the recent 2015 United Nations Sustainable Development Summit (Transforming Our World). The relevant principles on water are extracted in the following discussion.

2.3.1 The International Conference on Water and the Environment (the Dublin Conference)

The International Conference on Water and the Environment took place in Dublin, Ireland, in January 1992.¹³⁴ The Dublin meeting was convened in acknowledgment that scarcity and misuse of fresh water poses a serious and growing threat to sustainable development and

¹³³ United Nations Conference on Sustainable Development, *The Future We Want* at pg. 23; Second World Water Forum, *Ministerial Declaration of the Hague on Water Security in the 21st Century*, (2000) both available online

¹³⁴ International Conference on Water and the Environment, *Dublin Principles* (1992), Principles 1 - 4. (Available online).

protection of the environment. Experts view the global water resources picture as critical, and that unless water is more effectively managed in the future than it has been in the past, human health and welfare, industrial development and the survival of ecosystems will all be at risk. The outcome of the meeting was agreement on some important and relevant global principles known as the 'Dublin Statement':

- Fresh water is a finite and vulnerable resource which is essential to sustain life, development and the environment;
- Water development and management should be based on a participatory approach that involves users, planners and policy makers at all levels;
- Water has an economic value in all of its competing uses and should be recognized as an economic good.

The Dublin Statement emphasizes that water scarcity and the misuse of fresh water is a serious and growing threat not only to the environment, but also to sustainable development, and thus recommends a number of action steps.¹³⁵

2.3.1.1 Water Conservation and Re-use:

The Dublin Statement places premium on water savings in every sector, elimination of excessive waste, and on water recycling in the industrial sector. It notes the excessive waste in water use, and emphasizes water savings especially within industrial and domestic water use, pointing out that recycling can reduce the consumption of many industrial consumers by 50% or more, with the additional benefit of reduced pollution. It also observes that an average of 36% of the water produced by urban water utilities in developing countries is "unaccounted for", an

¹³⁵ Ibid.

unacceptable trend that requires better management to reduce these costly losses. It estimates that the combined savings in industry and domestic water supplies can significantly defer investment in costly new water-resource development and have enormous impact on the sustainability of future supplies.

2.3.1.2 Water and Sustainable Urban Development:

The Dublin Statement notes the threat to urban development by historically excessive water use and reckless discharge of municipal and industrial wastes. It states that future guaranteed supplies will have to be based on appropriate water charges and discharge controls.¹³⁶

The Dublin Meeting urged governments that would attend the subsequent Rio Conference on Environment and Development (the Rio Conference) to translate those recommendations into urgent-action programs for water and sustainable development.

2.3.2 The United Nations Conference on Environment and Development (the Rio Conference)

The United Nations Conference on Environment and Development (the Rio Conference) took place in the same year as the Dublin Conference. Its declaration states that human beings are central to sustainable development and are entitled to a healthy environment in harmony with nature, and thus their well-being depends on the quality of the environment. The meeting first agreed on a number of Sustainability Principles for environmental protection that are applicable within this research:

- The Rio Conference reiterates the inextricable link between environment and development, stating that in order to achieve sustainable development, environmental protection should

¹³⁶ Ibid; E. Gorre-Dale, "The Dublin Statement on Water and Sustainable Development", (1992) 19(2) Environmental Conservation 181.

constitute an integral part of the development process and cannot be considered in isolation from it;

- States should reduce and eliminate unsustainable patterns of production and consumption and promote appropriate demographic policies in order to achieve sustainable development and a higher quality of life for all people;
- States should enact effective environmental legislation, standards, management objectives and priorities that reflect the environmental and developmental context to which they apply.
- The Precautionary Principle should be widely applied in environmental protection;
- Environmental Impact Assessment should be taken seriously as a national instrument, to appraise proposed activities that are likely to have a significant adverse impact on the environment and are subject to a decision of a competent national authority.¹³⁷

2.3.2.1 Agenda 21

In addition, the Rio Conference produced Agenda 21, an important documentary plan of action whose primary goal is to ensure that development proceeds in a sustainable manner in the 21st Century. Agenda 21 re-iterates the Dublin Statement about the finiteness of water and its economic value. It observes that innovative and improved local technologies are necessary to fully use limited water resources and to safeguard water from pollution. Scarcity, pollution, gradual destruction of freshwater and encroachment of incompatible activities demand an integrated water resources planning and management. It also notes that incentives are important for promoting appropriate environmental behavior. It outlines specific programs for action at

¹³⁷ Rio Principles 4, 8, 11, 15, & 17.

national levels: water resources assessment that includes determining the sources, quality, dependability, and human activities that affect those water resources.¹³⁸

Agenda 21 recommends specific guidelines for water management. Stressing that freshwater is a unitary resource that requires holistic management and recognition of the interconnectedness of the elements related to freshwater and freshwater quality, it recommends the strengthening of key managerial elements, i.e., human resources, legal instruments and institutional capacity-building. Four of its outlined program areas for action are material to the present study. They are: Integrated Water Resources Management, Water Resources Assessment, Protection of Water Resources quality, and Sustainable urban development in the water context, all of which are discussed next.¹³⁹

2.3.2.1.1 Integrated water resources management

This aspect stresses that nation states should optimize water resources allocation under physical and socio-economic constraints; technology should be deployed to maximize limited water and to protect water from pollution; and water use development schemes ought to be concurrently supported by water conservation and waste minimization measures. Water conservation must be promoted through improved water-use efficiency. It encourages the discovery and use of new and alternative sources of water supply including seawater desalination, artificial groundwater recharge, wastewater reuse and recycling, and use of marginal quality water.¹⁴⁰

2.3.2.1.2 Water resources assessment

¹³⁸ Agenda 21, Chapter 18.

¹³⁹ Ibid.

¹⁴⁰ Ibid.

This part clarifies that the practical basis for sustainable water management is to identify potential sources of freshwater supply, the dependability and quality of water resources, and the human activities that affect water.¹⁴¹

2.3.2.1.3 Protection of water resources and water quality

Agenda 21 acknowledges that major problems affect water quality, especially: inadequately treated sewage; insufficient control over the discharges of industrial wastewater; and ill-considered location of industrial plants. These problems arise from environmentally unfriendly development models, and from a lack of public awareness and education about surface and groundwater resource protection. Thus a preventive approach is necessary whenever suitable, to avoid costly measures to rehabilitate and to treat polluted water, and to develop new water supplies. Water pollution should be prevented through a combination of pollution reduction at source, environmental impact assessment, and standards for point source discharges. For groundwater, aquifer pollution prevention through regulation of toxic substances that infiltrate into the ground and establishment of protection zones in groundwater recharge and abstraction areas is recommended. Also recommended is the design of landfills based on sound hydrogeological information, and promoting measures to safeguard the integrity of wells and well head to reduce the probable intrusion of pathogens and toxic chemicals into aquifers, and monitoring of waters receiving wastes.¹⁴²

2.3.2.1.4 Sustainable urban development and water:

¹⁴¹ Ibid.

¹⁴² Ibid Art. 18.35.

Agenda 21 also acknowledges that special attention ought to be given to the increasing effects of urbanization on water demands, as well as the role of municipal authorities that are charged with responsibility for water supply. Therefore, measures need to be adopted in order to protect water resources from degradation. Such measures should include: control of industrial pollution sources; promoting the recycle and reuse of wastewater and solid waste, of sanitary waste disposal, and of urban storm water drainage; the public's awareness and participation in rational water use, collection and recycling, and sensitization of the public to protecting the quality of water within the urban environment.¹⁴³

It is very remarkable that these provisions identify and deal with many aspects of the problems that trouble groundwater in Lagos, that is, the intersections of urbanization, population growth and industrialization as well as the important role of institutions, which are core to this thesis. They also touch on optimizing water resources within socio-economic constraints, maximizing limited water through efficient use and technology, and the discovery of alternative sources of water supply, all of which form part of discussions within this thesis.

2.3.3 The United Nations Conference on Sustainable Development (Rio + 20)

The United Nations Conference on Sustainable Development (Rio + 20) which took place in 2012 produced *The Future We Want*. The document re-affirms earlier commitments to achieve sustainable development by protecting the resource base on which economic and social development was premised. It emphasizes that water is at the core of sustainable development, and the importance of linking it to sustainable development measures. For this reason it reiterates the objective of achieving the Millennium Development Goal to halve the proportion of people without access to safe drinking water and basic sanitation, to manage water efficiently,

¹⁴³ Ibid.

and to realize the human right to safe drinking water.¹⁴⁴ Its emphasis on the need to significantly reduce water pollution, increase water quality and efficiency, improve wastewater treatment, and reduce water losses is consistent with this thesis. Also pertinent is the requirement to address the balance between water supply and demand, as well as to incorporate non-conventional water resources in water supply.¹⁴⁵ Overall, the *Future We Want* reaffirms the Rio Principles discussed earlier.

2.3.4 The United Nations Sustainable Development Summit (Transforming Our World)

The United Nations Sustainable Development Summit took place in September 2015 with the objective of adopting the post-2015 development agenda, and to be known as “Transforming Our World: The 2030 Agenda for Sustainable Development”.¹⁴⁶ In order to achieve its overall objective, the Conference enjoins nations to achieve 17 Goals by 2030, of which 2 are relevant to this study.

The first is the Goal on water and sanitation, described as the objective to ‘ensure availability and sustainable management of water and sanitation for all’.¹⁴⁷ This goal has two targets: improvement in water quality, and increase in water quantity. Achieving better water quality is to be accomplished by adopting five measures: reduction in pollution, elimination of dumping, minimization of the release of hazardous chemicals, halving of the proportion of untreated wastewater, and increasing recycling and safe reuse.¹⁴⁸ In terms of increasing water

¹⁴⁴ United Nations Conference on Sustainable Development (Rio + 20), *The Future We Want* (2012) Arts. 119-121

¹⁴⁵ Ibid, Arts. 123 -124.

¹⁴⁶ United Nations Sustainable Development Summit, Transforming Our World: the 2030 Agenda for Sustainable Development, available online.

¹⁴⁷ Ibid, Goal No. 6.

¹⁴⁸ Ibid.

quantity, this is to be achieved by increasing water use efficiency, and by ensuring sustainable water withdrawals and supply of freshwater to address water scarcity.¹⁴⁹

The other pertinent goal is to ‘Ensure Sustainable Consumption and Production Patterns’.¹⁵⁰ In this case, nations are to achieve environmentally sound management of chemicals and wastes throughout their life cycle, and to reduce their release into water and soil in order to minimize their adverse effects on human health and the environment. By the 2030 deadline, they are expected to have substantially reduced waste generation through application of the principles of Prevention, Reduction, Recycling and Reuse.

The two relevant sustainable development goals discussed here are in tandem with similar provisions in the Rio Declaration and *The Future We want* discussed earlier. In summary the key principles of water sustainability agreed upon at the international policy forums discussed here as relating to water within all the international meetings which are relevant for this thesis are:

- the critical role of regulation, legal instruments and of institutions in water governance;
- the intersection of solid wastes and wastewater, as well as waste management, with water, and thus the importance of preventing harmful emissions by managing all in a healthy manner;
- the importance of prior hydrogeological assessments in designing waste facilities;
- the essence of optimizing water use by eliminating wasteful water use and water losses during distribution;

¹⁴⁹ Ibid.

¹⁵⁰ Ibid, Goal No 12.

- addressing the balance between water supply and demand, and valuing water by optimizing the use of all aspects of urban water including non-conventional water resources to augment water supply;
- the need to reduce or eliminate unsustainable production patterns, minimizing wastes, and reducing hazardous wastes;
- the contribution of incentives to promoting appropriate environmental behavior; and
- the relevance of incorporating environmental principles including Prevention, Precaution, Polluter Pays and Environmental Impact Assessment into water resources management.

All these guiding principles are consistent with principles of ecological sustainability that were discussed earlier, which, in summary, entail factoring in all the aspects of development to ensure maintenance of the critical ecological resources on which all life depends. The discussions in subsequent chapters of this thesis will reflect the sustainable development principles that pertain to water which have been extracted from the international Conferences. The principles will form the basis of analysis of paths to re-thinking the approach to water management in Lagos and especially of improving the quality of groundwater. They will be applied to evaluate the interactions of industrial processes, population, and wastes with groundwater, and the present management of water resources in Lagos.

Further, since it is generally accepted that excessive consumption contributes to unsustainable development, this thesis will explore alternative ways to water management that de-emphasizes the continuous search for new sources of water to meet the water demands of its burgeoning population, i.e. a soft approach to water management. The approach expects to help tackle a long-standing problem of water inadequacy.

Some environmental law principles that featured in the meetings are important and deserve a special mention because of their relevance and applicability to this thesis. These are: Prevention, Precaution, Polluter Pays, and Environmental Impact Assessment.

2.4 Environmental Law Principles in Sustainable Development

2.4.1 The Polluter-Pays Principle

The Polluter Pays Principle is a principle for the allocation of the costs of pollution control, and states that a person that is responsible for damage to the environment should bear the costs associated with it. Its main objective is the cleanup of pollution.¹⁵¹ The Rio Declaration expressly recognizes this principle and recommends that States should incorporate it within their environmental enactments by developing national law regarding liability and compensation for the victims of pollution and other environmental damage. It provides that: “States shall develop national law regarding liability and compensation for the victims of pollution and other environmental damage. National governments are required to promote internalization of environmental costs and the use of economic instruments, taking into account the approach that the polluter should, in principle, bear the cost of pollution, with due regard to the public interest and without distorting international trade and investment”.¹⁵²

This thesis will apply the Polluter Pays Principle to tackle the problem of polluters of groundwater in Lagos, especially from the manufacturing industries. The principle will be employed to apportion responsibility, mandate pollution abatement, and enforce cleanup.

¹⁵¹ The Council of the OECD formally conceptualized this principle in 1972 following concerns about the international economic implications of environmental control measures, and it has since formed a part of environmental law principles: S.E. Gaines, “The Polluter Pays Principle: From Economic Equity to Environmental Ethos” (1991) 26 Tex. Int. Law J. 463. See also: M.R. Grossman, “Agriculture and the Polluter Pays Principle” Netherlands Comparative Law Association (Available online).

¹⁵² Rio Principle 13.

2.4.2 The Principle of Prevention

The Prevention Principle encourages action to be taken to protect the environment at an early stage, that is, to anticipate damage that may occur and to avert it rather than react by repairing damage after it has occurred.¹⁵³ As a principle to eliminate or reduce pollution at source, the prevention principle is a major step to safeguard the environment, and thus an important component of sustainable development.

Prevention is evidently a governing principle that underlies the carefully detailed provisions for waste treatment in the European Union's framework. Such provisions cover the transportation, treatment, storage, and disposal of waste and wastewater, and will be the benchmark to be applied by this thesis in evaluating Lagos' framework.¹⁵⁴ The applicability of this principle will be explored in the context of disposal of solid waste and wastewater with a view to protecting groundwater in Lagos.

2.4.3 The Precautionary Principle

The Precautionary Principle also aims to avoid harm to the environment and goes further than the Prevention Principle. It requires that where there are threats of serious or irreversible damage, lack of full scientific certainty should not be used as a reason for postponing cost-effective measures to prevent environmental degradation.¹⁵⁵ The international Conferences stress

¹⁵³ European Environment Agency, Environmental Terminology and Discovery Service, Online: <http://glossary.eea.europa.eu/>.

¹⁵⁴ See *infra*, Chapter 6, EU Directives regarding water, solid waste, wastewater and groundwater: Directive 2000/60/EC of the European Parliament and the Council Establishing a Framework for Community Action in the Field of Water Policy; Directive 2008/98/EC of the European Parliament and of the Council on Waste and Repealing Certain Directives; European Union Council Directive 91/271/EEC of 21st May 1991 Concerning Urban Wastewater Treatment; Directive 2006/118/EC of the European Parliament and of the Council on the Protection of Groundwater Against Pollution and deterioration.

¹⁵⁵ The principle is believed to have emerged in the 1970s in Germany, where the early conception of precaution was formulated in order to avoid environmental damage by careful forward planning (termed 'vorsorge' in German, meaning 'foresight'). Originally situated within agriculture and used to tackle environmental degradation such as

that the precautionary approach is to be widely applied by States in order to protect the environment. For instance, the Rio Declaration states: "In order to protect the environment, the precautionary approach shall be widely applied by States according to their capabilities. Where there are threats of serious or irreversible damage, lack of full scientific certainty shall not be used as a reason for postponing cost-effective measures to prevent environmental degradation".¹⁵⁶

The wisdom of preventing potential adversity and of probable costly remediation measures, even if the certainty and the exact degree of seriousness are not known, is the essence of the Precautionary Principle. It is also known as 'caution in advance' or 'caution practiced in the context of uncertainty'.¹⁵⁷ It encourages a readiness to take action in advance without scientific proof of the need for the proposed action on the basis that further delay can ultimately be very costly for both society and nature, as well as unfair to future generations. But where environmental regulations and other decisions have failed to adequately protect human health and the environment with the evidence of deteriorating natural resources, new principles for conducting human activities will be necessary.

However, it appears that there is not a commonly accepted interpretation and implementation of the principle. Scholars remark that just like sustainable development, it has been subject to various interpretations, and that there is no set of criteria to guide its implementation. Freestone observes that there is a certain paradox in its widespread and rapid

acid rain and pollution of the red sea, it was standardized into a principle and became a requirement of industrial operators to adopt the best abatement technology in order to minimize pollution at source: T. O'Riordan & A. Jordan, "The Precautionary Principle in Contemporary Environmental Politics" (1995) 4(3) Environmental Values 191.

¹⁵⁶ Rio Principle 15.

¹⁵⁷ T. O'Riordan & A. Jordan, "The Precautionary Principle: A Legal and Policy History", in M. Martuzzi & J. Tickner, *The Precautionary Principle: Protecting Public Health, the Environment and the Future of our Children* (World Health Organization, 2004).

adoption and that no one is quite sure what it really means.¹⁵⁸ In its state of flux, it is open to best interpretation and application.¹⁵⁹

But regardless of the divergence of ideas about the scope of the principle its intention to prevent damage even in the face of scientific uncertainty is evident. This “intuitively simple idea”, as O’Riordan & Jordan express it, is that avoiding risk should become an established norm, and that decision makers should act in advance of scientific certainty. Therefore proactive action, cost-effectiveness, and safeguarding ecological space are at the core of the principle.¹⁶⁰ It is closely linked to environmental impact assessment, which is a precautionary and preventive mechanism to avoid environmental harm as much as possible. These will be applied in exploring future preventative measures to secure groundwater in Lagos.

2.4.4 Environmental Impact Assessment

Environmental impact assessment is to be undertaken for proposed activities that are likely to have a significant adverse impact on the environment and are subject to a decision of a competent national authority.¹⁶¹ It will be argued in this thesis that environmental impact assessment as a form of precaution should be firmly implemented for future activities in waste and wastewater management and especially within economic growth efforts in Lagos. This would hopefully counter the harmful effects on groundwater in the city.

¹⁵⁸ D. Freestone, “The Precautionary Principle” in R. Churchill and D. Freestone, eds., *International Law and Global Climate Change* (London: Graham and Trotman 1991).

¹⁵⁹ Gullet states that the principle is not a nebulous idea, but rather a clear one with minimum content. He argues that the best way to implement the principle so that it influences environmental management practices is to integrate it into EIA regimes, in substantive provisions of laws rather than merely featuring in the preambles. He describes Precaution and EIA as complementary, and EIA as precautionary in a minimal sense because it is premised on addressing uncertainty about future environmental effects: W. Gullet, “Environmental Impact Assessment and the Precautionary Principle: Legislating Caution in Environmental Protection” (1998) 5(3) *Australian Journal of Environmental Management* 146, at pgs. 147-148.

¹⁶⁰ O’Riordan & Jordan, *supra*, note 154, at pg. 194.

¹⁶¹ Rio Principle 17.

These four principles, together with the sustainability principles extracted from the international Conferences, are relevant for preventing further harm to groundwater resources by anthropogenic activities, especially industrial processes, and to the overall formulation of prescriptions for best practices in groundwater management and are important in the Lagos context.

2.5 Summary

Sustainable development is a contraction of all the components of a balanced development. Since all life depends on natural resources to survive and to thrive, it is inevitable that extractions and use of these resources will continue. What is important is to maintain a balance between the use and the replenishment, and to minimize damage as much as possible/feasible. Natural resources are not available *ad infinitum*, and so, depleting them or degrading them beyond the capability of nature to replenish repair them puts human life at great risk. Although the ultimate goal of sustainability is global in context, it is meaningful and actualized when practiced and implemented through local initiatives in cities.¹⁶²

Water is critical to life and to the sustainability of development programs anywhere in the world, and a basic requirement for the development of countries. It is thus cardinal to sustainable development.¹⁶³ The importance of groundwater in particular has increasingly become apparent for the continued well-being and development of developing countries, especially those located in the arid and semiarid regions. Increasingly, planners and decision makers have started to appreciate the importance of efficient water management for sustainable development of their

¹⁶² A.O. Ilesanmi, “Urban Sustainability in the Context of Lagos Megacity” (2010) 3(10) *Journal of Geography and Regional Planning* 240.

¹⁶³ World Savvy Monitor, *Water as Key to Economic Development*, Online: <http://worldsavvy.org>.

countries. This is increasingly so as new sources of water are becoming scarce, more expensive to develop and requiring more expertise and technological know-how for planning, design and implementation. It has become apparent that water can no longer be treated as a cheap resource which can be used, abused or squandered with impunity.¹⁶⁴

2.6 Conclusion

This Chapter has appraised sustainability as a necessary standard for development, and has drawn out important principles for application to the case of groundwater in Lagos. The next Chapter will review the literature on groundwater, exploring its peculiar nature, special characteristics, and its global contributions to economic and social development in order to appreciate and underline its importance in Lagos.

¹⁶⁴ A.K. Biswas, “Water for Sustainable Development in the 21st Century: A Global Perspective” (2007) International Journal of Water Resources Development 219.

CHAPTER 3: THE NATURE, CHARACTERISTICS AND IMPORTANCE OF GROUNDWATER

This chapter provides a discussion of the distinctive attributes of groundwater as well as its global contributions to human life in order to facilitate a full appreciation of its special significance. Groundwater's importance is accentuated in Lagos where industrial activities which are at the core of the city's economic growth, as well as the survival of nearly all of its residents depend, and this justifies concerns about its degradation.

Groundwater is the ubiquitous but hidden counterpart of surface water that has gradually found a place in the international spotlight as one of the critical environmental resources of the twenty first century. As a source of water which is indispensable to human life, it is the subject of increasing attention in many regions of the world on account of its cardinal or 'pivotal role' in human and economic development.¹⁶⁵ Although the quantity of water on earth does not change appreciably and has remained the same for billions of years, 97% is saltwater that is not useful for either human consumption or for agricultural applications except after expensive desalination processes. The bulk of the world's fresh water is inaccessible water contained largely in glaciers in the Polar Regions of Antarctica and Greenland, and beyond human reach.¹⁶⁶ The remaining freshwater is contained in aquifers, rivers and lakes. Accessible groundwater makes

¹⁶⁵ B.L. Morris et al, Groundwater and its Susceptibility to Degradation: A Global Assessment of the Problems and Options for Management. Early Warning and Assessment Report Series, RS. 03-3. (Nairobi, Kenya: United Nations Environment Programme, 2003), Intro pg. 1; Maria Trainer, "Goals, Gaps and Governance: The Holy Grail in Preserving Canada's Liquid Gold" 2010) 380 Journal of Hydrology 1.

¹⁶⁶ P. Gleick, "Making Every Drop Count", (2001) 284(2) Scientific American 28; P. Gleick & M. Panaliappan, "Peak Water Limits to Freshwater Withdrawal and Use" (2010) 107(25) PNAS 11155.

up about 95% of these freshwater reserves worldwide, and thus its cardinal place need hardly be emphasized.¹⁶⁷

3.1 Nature and Characteristics of Groundwater

Groundwater occurs in many different geological formations, in igneous, sedimentary and metamorphic rocks beneath the earth's surface. Nearly all rocks in the upper part of the Earth's crust regardless of their type, origin or age, possess openings called pores or voids. Groundwater is water located in these soil pore spaces and in the fractures of these lithological formations.¹⁶⁸ The volume of water contained in the rock depends on the percentage of these openings or pores in a given volume of the rock, which is termed the porosity of the rock: more pore spaces result in higher porosity and more stored water. The point or depth at which soil pore spaces or fractures and voids in rock become completely saturated with water is called the water table.¹⁶⁹ Below the water table, the water pressure is great enough to allow water to enter wells, and this enables groundwater to be withdrawn for use.¹⁷⁰ Thus, groundwater refers to all the water occupying the voids, pores and fissures within these geological formations.

Aquifers hold groundwater underground. An aquifer is a geologic unit that can store and transmit groundwater at a rate that is fast enough to supply a substantial amount to wells.¹⁷¹

Aquifers are variable in texture, ranging from sand or gravel, to massive fractured rock with

¹⁶⁷ B.L. Morris et al, *supra*, note 165.

¹⁶⁸ J. Toth, "Groundwater in Igneous, Metamorphic and Sedimentary Rocks", *Encyclopaedia of Life Support Systems (EOLSS)* (Available online).

¹⁶⁹ *Ibid.*

¹⁷⁰ United States Geological Survey (USGS), *Groundwater and Surface Water - A Single Resource*, U.S. Geological Survey Circular 1139, Available online; World Health Organization, *Water Quality Assessments-A Guide to Use of Biota, Sediments and Water in Environmental Monitoring* (London, England: F & FN Spon 1996) Available online; A.A. Alabi, R. Bello, A.S. Ogungbe & H.O. Oyerinde, "Determination of Groundwater Potential in Lagos State University, Ojo; Using Geoelectric Methods (Vertical Electrical Sounding and Horizontal Profiling)" (2010) 2(5) Report and Opinion 68 (Available online).

¹⁷¹ C.W. Fetter, *Applied Hydrogeology*, 4th Ed. (Prentice-Hall, New Jersey: 2001), at pg. 95. The word 'Aquifer' is from the two Latin words, 'aqua', meaning water, and 'ferre', meaning to bear or to carry.

water-bearing cracks or openings. They have the capacity to conduct water and are permeable enough to support water extractions through wells, springs or boreholes for individual, commercial or industrial uses.¹⁷² An aquifer may be an unconfined water table aquifer which is close to the earth's surface, or a confined 'artesian' aquifer, meaning that it has an impermeable layer both above and beneath it, making it generally less susceptible to drought conditions.¹⁷³

As mentioned in Chapter 1, the occurrence of groundwater in any region depends on the geologic and rock-weathering features. These determine the complexity of the hydrogeological environment in terms of aquifer thickness and permeability, and of groundwater recharge. Groundwater is a 'replenishable resource', as it is periodically recharged by precipitation, which includes snow, sleet, hail, and principally, rainfall.¹⁷⁴ But in some contexts it is arguably non-renewable because of its disparate occurrence across regions, which is determined by variable factors including location, geological factors, and rainfall patterns.¹⁷⁵ Rainfall trends in particular which consists of both historical (the accumulated reservoir over thousands of years) and current patterns also determine the quantity of groundwater available in any given area, and constitute

¹⁷² Muiz Banire, "The Adverse Effects of Over-Exploitation of an Aquifer on the Environment". Paper presented at a workshop organised by the Lagos Water Corporation in Ikeja, Lagos, Nigeria, December 2007.

¹⁷³ C.W. Fetter, *supra*, note 171, at pg. 96; United States Geological Survey, Groundwater and Aquifers FAQs, online: <http://www.usgs.gov/faq/categories/9812/2776>.

¹⁷⁴ G.C. Ufoegbune, K.I. Lamidi, J.A. Awomeso, A.O. Eruola, O.A. Idowu & C.O. Adeofun, "Hydro-geological Characteristics and Groundwater Quality Assessment in Some Selected Communities of Abeokuta, Southwest Nigeria" (2009) 1(1) *Journal of Environmental Chemistry and Ecotoxicology* 010.

¹⁷⁵ Nigeria models the disparate nature of groundwater in that uneven rainfall distribution and contrasting rock types across the country give rise to a 'wet' south with considerable groundwater supplies on one hand, and a comparatively 'arid' north with limited yields of groundwater on the other hand. Arguments in support of groundwater as a non-renewable resource are thus prevalent in arid regions which have deep confined aquifers where the time needed for replenishment sometimes runs into hundreds or even thousands of years due to infrequent rainfall for recharge. Such a long period exceeds the normal time frame of human activity in general, hence the reference to it as non-renewable, and (where aridity is chronic), to the mining of aquifer reserves: The World Bank, *Sustainable Groundwater Management Concepts and Tools, Utilization of Non Renewable Groundwater: A Socially-Sustainable Approach to Resource Management* (2005). Online: <http://www.cap-net.org/documents/2003/09/utilisation-of-non-renewable-groundwater-a-socially-sustainable-approach-to-resource-management.pdf>.

the seasonal replenishment.¹⁷⁶ Therefore the frequency of rainfall is a very important factor for groundwater sustainability.¹⁷⁷ Following from this, in regions with substantial rainfall, the chances of wide-ranging depletion of aquifers, barring unforeseen climatic changes, is minimal.

Groundwater is inextricably linked to surface waters as part of the hydrologic cycle, which is a continuous movement of water on, above, and beneath the earth.¹⁷⁸ Groundwater quality is a direct function of the natural composition of the water, the type of mineral matter that the water contacts and the varied chemical compositions of the soil and rock with which it interacts.¹⁷⁹ For this reason, Fetter remarks that groundwater is never strictly “pure” because it invariably contains a measure of dissolved gases and solids.¹⁸⁰ The interaction of soil, water, and rock underground results in weathering and enrichment of the groundwater with ammonium ions and with naturally-occurring nitrogen which are harmless until they reach a very high concentration that is dangerous to human health.¹⁸¹

3.2 Groundwater’s Comparative Advantages over Surface Water

Groundwater’s situation below the earth’s surface shields it from usual environmental pollutants and protects it from pathogenic contamination that emanates from human activities. In effect, it maintains a comparatively good microbial quality, even when untreated, compared with

¹⁷⁶ A. M. MacDonald, H.C. Bonsor, B.E.O. Dochartaigh, and R.C. Taylor, “Quantitative Maps of Groundwater Resources in Africa” (2012) 7 Environmental Research Letters 024009; SEDEC Associates, *2008 State of the Nigerian Environment Report*, (Abuja, Nigeria: Federal Ministry of the Environment, 2008), Chapter 5 at pg. 291.

¹⁷⁷ Akujieze et al, “Groundwater in Nigeria - A Millennium Experience - Distribution, Practice, Problems, and Solutions” (2003) 11 Hydrogeology Journal 259.

¹⁷⁸ Vladimir Novotny, *Water Quality Diffuse Pollution and Watershed Management* (New York: John Wiley & Sons Inc., 2003) at pg. 196.

¹⁷⁹ C.W. Fetter, *supra*, note 171, at pg. 346.

¹⁸⁰ *Ibid.*

¹⁸¹ A.N. Amadi, “Effects of Urbanization on Groundwater Quality: A Case Study of Port-Harcourt, Southern Nigeria” (2010) 11(2) Natur. Appl. Sci. J. 143. For instance, a nitrogen concentration above 50 mg/l in drinking water is above the safe level that is recommended by the World Health Organization and the Nigerian Standards for Drinking Water Quality (NSDWQ): World Health Organization, *Guideline for Drinking Water Quality* (2002), and the Nigerian Standards for Drinking Water Quality (2007) Table 2.

its surface counterpart.¹⁸² It generally requires only minimal treatment to make potable and is thus cheaper to process.¹⁸³ Further, aquifers possess natural capacities to attenuate (reduce) pollution.¹⁸⁴ This reduces harmful effects of pollution, thereby making groundwater resilient.¹⁸⁵ This natural, self-purifying characteristic is unique to groundwater. Conversely however, although contamination takes a longer time to manifest in groundwater, when it eventually does, it is difficult and expensive to remediate.¹⁸⁶

Aquifers are natural underground reservoirs with enormous water storage capacities which sometimes exceed that of surface water. As an illustration, in the United States, 500 cubic kilometers of groundwater was once abstracted, over time, from a single aquifer, the Ogallala aquifer, and this quantity represented triple the combined volumes of the country's two vast surface Lakes Kariba and Nasser.¹⁸⁷ The huge storage capacity of aquifers makes groundwater reliable in dry seasons or droughts. It is thus less affected by catastrophic events.¹⁸⁸ Experts

¹⁸² B.L. Morris et al, *supra*, note 165.

¹⁸³ R.C. Calow, A.M. MacDonald, A.L. Nicol, & N.S. Robins, "Groundwater Security and Drought in Africa: Linking Availability, Access and Demand" (2010) 48 *Ground Water* 246.

¹⁸⁴ Natural attenuation means the reduction in mass or concentration of a compound in groundwater over time or distance from the source of constituents of concern due to naturally occurring physical, chemical and biological processes such as biodegradation, dispersion, dilution or absorption. The U.S. Environmental Protection Agency also defines it as "a variety of physical, chemical, or biological processes that, under favourable conditions, act without human intervention to reduce the mass, toxicity, mobility, volume, or concentration of contaminants in soil or groundwater. These in situ processes include biodegradation; dispersion; dilution; sorption; volatilization; radioactive decay; and chemical or biological stabilization, transformation, or destruction of contaminants": United States Geological Survey, *Definitions*, (2014) Online: http://toxics.usgs.gov/definitions/natural_attenuation.html; USGS, *Natural Attenuation Strategy for Groundwater Cleanup Focuses on Demonstrating Cause and Effect* (2014) Online: <http://toxics.usgs.gov/pubs/eos-v82-n5-2001-natural/>

¹⁸⁵ J.W. Davis, N.J. Klier & C.L. Carpenter, "Natural Biological Attenuation of Benzene in Groundwater Beneath a Manufacturing Facility (1994) 32(2) *GROUNDWATER* 215; B.L. Morris et al, *supra*, note 165, at pg. viii

¹⁸⁶ M.A. Dan-Hassan, "Spatial and Temporal Distribution of Nitrate Pollution of Groundwater of Abuja Nigeria" (2012) 4(3) *Int. Journal of Chemistry* 104.

¹⁸⁷ B.L. Morris, et al, *supra*, note 165, at pg. 2. The Ogallala aquifer underlies a considerable proportion of 8 states in the United States: Nebraska, Texas, Colorado, South Dakota, Wyoming, Kansas, Oklahoma, and New Mexico. Lake Nasser is a huge reservoir in southern Egypt, is 550km long, 35km wide, and covers an area of 5,250 square km. Lake Kariba lies between Zambia and Zimbabwe, is 220km long, 40km wide and covers an area of 5,580 square kilometres.

¹⁸⁸ *Ibid*.

recommend its development and use in arid areas as a safeguard or back up to available surface water.¹⁸⁹

An important characteristic of groundwater is ubiquity, being ‘widely distributed’ underground with quantities varying according to the historical accumulated storage, and the seasonal replenishment. Using appropriate abstraction technology, it can be located close to the intended point of use in a manner that minimizes the cost of elaborate reticulation systems.¹⁹⁰

Groundwater is relatively simple to exploit, and inexpensive to maintain and operate. In developing countries like Nigeria that have limited regulation of the resource, it is quite easy for individuals or corporate entities to construct wells or bore holes for their private uses.¹⁹¹ Its easy accessibility and less capital intensive nature make it attractive to farmers. Shah et al argue that irrigation from groundwater sources is more productive than from surface water because of a tendency by farmers to economize on its use and to maximize its efficiency.¹⁹² In apparent support of their argument, Dhawan cites India, where farm yields from groundwater-irrigated farms were reportedly up to three times more than yields from those irrigated with surface water in the late 1980s.¹⁹³ Similar arguments about its utility in agriculture have been made in other parts of the world, notably northern Spain and south Asia.¹⁹⁴

¹⁸⁹ M.E. Offodile, “The Development and Management of Ground Water for Water Supply in Nigeria” Presented at the 2nd Fellow’s Workshop of NMGS, Jos, Nigeria. (2000); Calow et al, supra, note 183.

¹⁹⁰ A.M. MacDonald & R.C. Calow, “Developing Groundwater for Secure Water Supplies in Africa” (2009) 248 *Desalination* 546; Ufoegbune et al, supra, note 174; 2008 *State of the Nigerian Environment Report* supra, note 170, Chapter 5, at pg. 291.

¹⁹¹ B.L. Morris et al, supra, note 165, at Intro pg. 2.

¹⁹² Tushar Shah, D. Molden, R. Sakthivadivel, & D. Seckler, *The Global Groundwater Situation: Overview of Opportunities and Challenges*” (Sri Lanka: International Water Management Institute, 2000) at pgs. 3 - 4.

¹⁹³ B.D. Dhawan *Studies in Irrigation and Water Management* (New Delhi: Commonwealth Publishers, 1989)167.

¹⁹⁴ Tushar Shah et al, supra note 192 at pg. 4. It would be interesting to know if this higher yield is attributable to some unique feature inherent in groundwater that makes a given quantity go farther than the same amount of surface water.

Collectively, these comparative advantages of groundwater over surface water explain the reason for groundwater being described as “one of the most valuable natural resources possessed by many developing nations.”¹⁹⁵

3.3 The Global Importance of Groundwater

Groundwater is an extremely important resource throughout the world in both developed and developing nations, as the largest single source of fresh water available for use by humans.¹⁹⁶ Nearly half of the world's population depends on groundwater sources for drinking water supply and for other uses.¹⁹⁷ A significant proportion of the world's rural population receives a safe supply of water that comes from a groundwater aquifer. It also contributes to the base flow of natural systems including streams and rivers.¹⁹⁸

However, in spite of its importance, groundwater was historically overlooked in water management planning, and its apparently inexhaustible supply and seamless potable quality were taken for granted, such that its peculiar characteristic of being an ‘invisible’ resource became virtually synonymous with being an ‘ignored’ or ‘neglected’ resource.¹⁹⁹

Historically in the 19th Century, in some jurisdictions such as the United States, legislative action in the formulation of legal rules for the incidents of groundwater – extraction,

¹⁹⁵ Kofi Annan (former United Nations’ Secretary General), Comments made during the 6th World Water Day Conference in 1998, themed “Groundwater-The Invisible Resource” www.worldwaterday.org/wwday/1998/.

¹⁹⁶ B.L. Morris, *supra*, note 165, Introduction, at pg. 1.

¹⁹⁷ Kofi Annan, *supra*, note 195, as part of comments made at the Sixth Annual World Water Day.

¹⁹⁸ Rob De Loe & Reid Kreutzweiser, “Closing the Groundwater Implementation Gap” (2005) 36(2) *Geoforum* 241, at pg. 242.

¹⁹⁹ D. Tarlock & S. Deutsch, “Symposium on Prevention of Groundwater Contamination in the Great Lakes Region- Foreword” (1989) 65 *Chi.-Kent L. Rev.* 345. Adelana et al who wrote about groundwater in Nigeria describe a pervasive perspective of groundwater as a “free gift from God” and thus no deliberate planning to safeguard its quality or to secure its sustainability is being taken: S.M.A Adelana, P.I. Olasehinde, R.B. Bale, P. Vrbka, A.E. Edet & I.B. Goni, “An Overview of the Geology and Hydrogeology of Nigeria” in *Applied Groundwater Studies in Africa*, (2008) 171.

protection, safeguarding, recharge and locating of wells – was slow, thus compelling judicial intervention by the courts who made incremental rules as the cases arose. By contrast surface water traditionally had a much higher value, and was “...anciently important to a far greater degree than groundwater”.²⁰⁰ Legal scholarship at the time focused on surface water and its inter-relationship with land, as well as to incidental issues of surface water rights. Groundwater was practically ignored for a considerable time, thus lending credence to expert’s statements that groundwater was an ignored, neglected resource, as mentioned above.

This continued until the stark reality of actual and impending water shortages caused by diverse events especially climate change and population explosion to mention a few, began to place immense pressure on its surface counterpart and to force attention to the sole alternative, as mentioned in Chapter 1. Gleick evaluates the upsurge in water use as doubling since 1900 on account of expanding populations.²⁰¹ Currently, a fifth of the world’s population, that is, over a billion people is living in regions of water scarcity, and experts predict that this figure will increase to 3 billion by 2025.²⁰² These are potential regions of “water stress”, that is, areas where water consumption will exceed 10% of renewable freshwater sources by the dates indicated.²⁰³ The global challenges to water supply generally have increased the importance of groundwater and compelled societies to appreciate the vulnerability of this sole alternative water source. The importance of groundwater is now accentuated by the pressures occasioning water shortages generally, the reality of potential threats to groundwater, and the actual crises that have

²⁰⁰ Earl F. Murphy, “The Recurring State Judicial Task of Choosing Rules for Groundwater Law: Occult Still” (1987) 66 Nebraska Law Review 120, at pg. 121.

²⁰¹ P. Gleick, *supra*, note 166; P. Gleick & M. Panaliappan, *supra*, note 166.

²⁰² E. C. Corcoran, C. Nellemann, E. Baker, R. Bos, D. Osborn, & H. Savelli (eds.) “Sick Water? *The Central Role of Wastewater Management in Sustainable Development*, (2010) A Rapid Response Assessment” United Nations Environment Program, UN-HABITAT, GRID-Arendal. Online: www.grida.no/publications/rr/sickwater/ (hereafter “Sick Water Report”) at pg. 10. See also P. Gleick, *supra*, note 166.

²⁰³ The United Nations offered this definition of ‘water stress’ that was cited by P. Gleick & M. Panaliappan in note 166, *supra*.

occurred.²⁰⁴ All these necessitate stringent measures to safeguard both its quality and its availability.

As a source of water, groundwater availability has been a major determinant of settlement patterns particularly in the more arid geographical zones of Africa, as discussed in Chapter 1.²⁰⁵ According to Gleick, “The history of human civilization is entwined with the history of the ways that man has learned to manipulate water resources”.²⁰⁶

In many European countries, groundwater provides a readily available “on demand” and inexpensive source of water for domestic use, constituting nearly 29% of total water abstracted. Although agriculture which previously demanded a significant amount of water appears to have declined in the continent, it is still responsible for about 30% of groundwater abstractions.²⁰⁷ Developing countries in Asia and Africa have increasingly exploited groundwater for agriculture in the past decades.²⁰⁸

Because groundwater has an overall slower response to changing atmospheric conditions, it provides a natural buffer against climatic variations including drought and water demands.

²⁰⁴ Groundwater pollution in Walkerton, Canada, escalated to a full-fledged crisis with tragic consequences in 2000: The Walkerton Inquiry, reported in *Ontario, Report of the Walkerton Inquiry Part I* (Toronto: Ministry of the Attorney General 2002).

²⁰⁵ K. Conca, *Governing Water: Contentious Transnational Politics and Global Institution Building* (Massachusetts: The MIT Press, 2006) at pg. 74; D. Fisher, *The Law and governance of Water Resources: The Challenge of Sustainability*, (Cheltenham: Edward Elgar Publishing, 2009); R. C. Calow, N. S. Robins, A. M. Macdonald, D. M. J. Macdonald, B. R. Gibbs, W. R. G. Orpen, P. Mtembezeka, A. J. Andrews & S. O. Appiah, “Groundwater Management in Drought-prone Areas of Africa” (1997) 13(2) *International Journal of Water Resources Development* 241.

²⁰⁶ Peter Gleick, *Making every Drop Count*, supra, note 166.

²⁰⁷ K.M. Hiscock et al, “Sustainable Groundwater Development”, in Hiscock et al, eds., *Geological Society London Special Publications* (London: Geological Society of London, 2002) 1, at pg. 4.

²⁰⁸ *Ibid*, at pg. 10.

Combined with its vast storage capabilities and seasonal replenishment, it amounts to a formidable resource indeed.²⁰⁹

As a source of the total water available to a nation, and a component of the hydrologic cycle, groundwater has the potential to contribute to a nation's economic development. This potential was once realized in Jordan, where groundwater supported the natural springs which in turn supplied the Azraq oasis that was a habitat for diverse terrestrial, native and aquatic species. The unusual congregation of species constituted a major tourist attraction to foreign visitors until the groundwater was depleted.²¹⁰ Bangladesh also successfully established a sustainable groundwater-based irrigation system in a dry and semi-arid region of the country.²¹¹ Canada's Water Opportunities Act²¹² has harnessed the nation's gift of abundant water with cutting edge water and waste water treatment technologies for exports and earnings that are expected to economically advance the Ontario province specifically, and the country generally.²¹³ Describing groundwater as the most reliable water source for irrigation, Moench found a positive correlation between groundwater access and poverty reduction amongst farmers in India.²¹⁴

In summary, the importance of groundwater has long been established. "It is one of the most important natural resources that are of vital importance to cities, industries, agriculture, and

²⁰⁹ Calow et al, *supra* note 205, at pg. 242. With warmer climates and continent-wide droughts, additional stress is placed on water resources, and groundwater has assumed even greater importance. Scholars record an overall increase in drought affected areas from 1% to 3% of the earth's landmass, and that this is likely to worsen: R.C. Calow, A.M. MacDonald, A.L. Nicol, and N.S. Robins, (2010) 48 *Ground Water* 246; "Groundwater Security and Drought in Africa: Linking Availability, Access and Demand" M.R. Hulme, T. Doherty, T. Ngara, M. Mew, and D. Lister, "African Climate Change: 1900-2000" (2000) *Climate Research* 145; E.J. Burke, S.J. Brown, and N. Christidis, "Modeling the recent Evolution of Global Drought and Projections for the Twenty-first Century with the Hadley Centre Climate Model" (2006) 7 *Journal of Hydrometeorology* 1113.

²¹⁰ Tushar Shah et al, *supra*, note 192, at pg. 5.

²¹¹ I.M Faisal, M. Parveen, & M.R. Kabir, "Sustainable Development through Groundwater Management: A Case Study of the Barind Tract" (2005) 21 *Int. J. of Water Res. Dev.* 425.

²¹² Water Opportunities Act, SO 2010, c 19.

²¹³ The rationale for the law is reflected in the discussions and debates on the Act prior to enactment: Ontario, Legislative Assembly, *Hansard* 39th Leg, 2nd Sess., No. 72 (13 September 2010) at 2 (Helena Jaczek).

²¹⁴ M. Moench, "Groundwater and Poverty: Exploring the Connections" (Available online).

people of the world”.²¹⁵ The importance of groundwater around the world is depicted by the pervasive reliance on it. All around the world, cities across Asia, Africa, North America and Europe have become critically dependent on groundwater.²¹⁶ The United Nations Environment Programme has rightly described this widespread and universal reliance on groundwater as ‘enormous’.²¹⁷

In the United States, over 95% of the rural population depends on aquifers for drinking water. Groundwater provides 50% of the drinking water and is essential to the vitality of agriculture and industry as well as the health of rivers, wetlands and estuaries.²¹⁸ Groundwater supplies water to rivers during periods of drought, and is regarded as one of the nation’s most valuable natural resources.²¹⁹

In Canada, groundwater constitutes a major percentage of freshwater supply for domestic, industrial, and agricultural uses, and it is estimated that about ten million Canadians rely on it for drinking water.²²⁰ It is a major contributor to stream and river flow, it sustains wetlands, and influences the quality of lake water, thus having significant impacts on the nation’s ecology. The Canadian Task Force on Groundwater Resources describes it as the source of water supply for up to 30% of Canada’s total population.²²¹

²¹⁵ A. Zaporozec, Ground-Water Pollution and its Sources, (1981) 5.5 GeoJournal 457.

²¹⁶ R. Hayton & A. Utton, International Transboundary Resources Center, “Transboundary Groundwaters: The Bellagio Draft Treaty” (1989) 29(3) Natural Resources Journal 663 (also available online).

²¹⁷ Morris et al, *supra*, note 165.

²¹⁸ T. Reilly, K. Dennehy, W. Alley & W. Cunningham, United States Geological Survey, Groundwater Availability in the United States, Circular 1323 (2008). Hereafter ‘USGS report’. Report available at: www.usgs.gov. See also Allyn Turner, “The Federal Groundwater Regulation and Policy: Improvements under the Horizon?” (2008) 10 J. Nat Resources & Envtl. Law 323.

²¹⁹ *Ibid.*

²²⁰ Maria Trainer, *supra*, note 165.

²²¹ Canadian Geoscience Council, *Groundwater Issues and Research in Canada*. (2000) Online: http://earthsciencescanada.com/cfes/_ARCHIVE_jan7_2011/papersandreports/gwish.html

In China, the Huang-Hua-Hai aquifer supplies about 160 million people, whilst almost a third of Asia's drinking water is estimated to be derived from groundwater.²²² Increased reliance on groundwater especially in agriculture has been referred to as a 'silent revolution'.²²³

Increasingly, developing countries depend more on groundwater due to unreliable public water supplies. In Africa, groundwater is the major source of drinking water, where it has been forecast that its use for irrigation will increase considerably to tackle the growing food insecurity.²²⁴ Although data on the precise quantities in Africa was previously lacking, recent studies by MacDonald et al indicates that groundwater has a considerable volume that is more than 100 times the annual renewable freshwater resources in Africa.²²⁵ Several countries in Africa also depend on groundwater for significant proportions of their water needs.²²⁶ In some parts of Asia and Africa, groundwater management is being harnessed to provide a means of livelihood for the poor.²²⁷

In Nigeria, there is increased dependence on it in both urban and rural areas due to a generally unreliable public water supply system which depends mainly on surface water. Water supply shortages are occurring in spite of the apparent abundance of surface water which is enhanced by heavy annual rainfall that is characteristic of most parts of the country.²²⁸ In the nation's capital Abuja, scholars regard groundwater as playing a major part in the city's

²²² B.L. Morris et al, *supra* note 165, at pg. 3.

²²³ M.R. Llamas & P. Martinez-Santos, "Intensive Groundwater Use: A Silent Revolution that Cannot be Ignored?" (2005) 8 *Water Science and Technology* 167. Online: <http://www.rac.es/ficheros/doc/00247.pdf>

²²⁴ A.M. MacDonald & R.C. Calow, *supra* note 190.

²²⁵ A.M. MacDonald, H.C. Bonsor, B.E.O. Dochartaigh, & R.G. Taylor, "Quantitative Maps of Groundwater Resources in Africa" (2012) 7(2) *Environ. Res. Lett.* 024009.

²²⁶ Such African countries include: Cote D'Ivoire, Republique du Benin, Burkina Faso, Mali, Niger Republic, Central African Republic, Senegal, Mauritania, and Togo. See B.L. Morris et al, *supra*, note 165.

²²⁷ A fuller discussion of the groundwater opportunities in Asia can be found in Tushaar Shah et al, *The Global Groundwater Situation: Overview of Opportunities and Challenges* (Sri Lanka: International Water Management Institute, 2000).

²²⁸ *2008 State of the Nigeria Environment Report*, *supra*, note 176.

development mainly because the majority of households and government establishments depend solely on wells and boreholes that exploit groundwater, for sustenance.²²⁹ Indeed, groundwater “...provides the immediate panacea for the provision of potable water to the majority of Nigerians despite the varied climatic environments”.²³⁰

3.4 The Importance of Groundwater in Lagos

Although Lagos is an island with 21% of its 3,577 square kilometers made up of lagoons and water ways as mentioned in Chapter 1, these are mostly brackish waters or polluted lagoons, especially the Lagos Lagoon, which writers describe as the “ultimate sink” for waste disposal since the latter portion of the 19th Century.²³¹ These surface waters have historically been unfit for human consumption on account of pollution from urban and industrial waste, thus giving rise to a sad paradox of scarcity in the midst of plenty, as well as to an endless search for good water sources.²³² As a highly industrialized city, repeated discharges of industrial effluents into surface

²²⁹ M.A. Dan-Hassan, P. I. Olasehinde, A. N. Amadi, J. Yisa & J. O. Jacob, “Spatial and Temporal Distribution of Nitrate Pollution in Groundwater of Abuja, Nigeria” (2012) 4(3) International Journal of Chemistry 104.

²³⁰ M.E. Offodile, supra, note 189.

²³¹ O.J. Aderinola, E.O. Clarke, O.M. Olarinmoye, V. Kusemiju & M.A. Anatekhai, “Heavy Metals in Surface Water, Sediments, Fish Periwinkles of Lagos Lagoon” (2009) 5 (5) American-Eurasian J. Agric. & Environ. Sci. 609, at pg. 610.

²³² Lagos State Government, *State of the Environment Report – Lagos 2010* at page 2. The search for potable water began in 1901 by colonial administrators within the Federal Ministry of Works. After unsuccessful attempts to find a good water source on the island, the Ministry eventually found one in Iju, a suburb on the outskirts of Lagos where water flowed in from the Ogun River in Ogun State. Iju Water Works became the first water treatment plant to be constructed in 1910. It abstracted raw water from spring water trenches in Iju Hills and had an initial capacity of 2.42 million gallons daily (MGD). From this initial capacity, the Lagos Water Corporation currently has installed capacity of 210 MGD, from three major water treatment plants and 48 mini/micro water plants which exploit groundwater exclusively: Lagos Water Corporation, Organization History, Online: http://www.lagoswater.org/about_us.php; A.U. Oteri; Lagos Water Corporation, *Lagos Water Supply Plan 2010-2020* (2012). LWC has made several efforts to increase its production capacity over the years. In 1943, it increased to 6MGD and extended its services to Lagos Island, Apapa, and Ebute Metta. A further increase to 11 MGD took place in 1954, then to 24 MGD in 1964, and later to 45 MGD in 1985. Since then, and owing to the ever-growing population, LWC also found new sources of water. In 1977, Ishasi water treatment plant was established, which derived its water from River Owo, and directed to serve residents of the Satellite Town. A third water treatment plant, the Adiyin Water works, was commissioned in 1992. In 1980 LWC constructed 10 mini water treatment plants each with a capacity of three million MGD to complement water hitherto sourced from surface water: A. Olukoju, *Infrastructure Development and Urban Facilities in Lagos, 1861-2000* (2003) Occasional Publication No. 15, Institut Français de Recherche en Afrique, Ibadan.

water bodies pollute the water, making the water too contaminated and too costly to treat for public supplies. This has also compelled the Lagos Water Corporation to rely more on groundwater to augment its own supplies from surface water.²³³ Groundwater therefore serves as an alternative water source for such surface waters that are either too saline or too polluted by industrial and other activities.²³⁴ The resort to groundwater, as Longe et al observe, is enhanced by increasing knowledge about the vast water resources available underground.²³⁵ The Lagos Water Corporation draws “heavily” on groundwater for daily domestic water supplies to address the shortfall created by inaccessible surface water resources.²³⁶

But in spite of the Corporation’s efforts with both surface and groundwater, the large population in Lagos increasingly minimizes the efforts. Although Lagos has the smallest geographical area of 3,577 square kilometers as mentioned in Chapter 1, it has the largest urban population in the country due to an extremely high rate of rural-urban in-migration from other states. The population defies municipal plans for social amenities, and stretches the existing infrastructure, especially water, colossally.²³⁷ Thus in spite of all the efforts by the Water

²³³ D.N. Obiora, & O. S. Onwuka, “Groundwater Exploration in Ikorodu, Lagos-Nigeria: A Surface Geophysical Surface Contribution” (2005) 6(1) the Pacific Journal of Science and Technology 86. Consultants to the Lagos State Government had recommended in 1997 that the Water Corporation should augment its existing water supply sources to include aquifers within the newly reclaimed parts of the Lagos Island. Such wells should ideally be located in the western Lekki Peninsular if exploiting the lower Coastal Plains Sands, and located between Ikorodu and Epe, if exploiting the Abeokuta Formation. They also advised that the boreholes should be constructed with fiber glass casings to avoid corrossions that had previously caused sudden and catastrophic failures of boreholes. It is not clear however if this recommendation was implemented: Coode Blizzard, *Hydrogeological Investigation of Lagos State*, Final Report (1997). The history and functions of the Lagos Water Corporation along with other key environmental management agencies in Lagos are discussed in more detail in Chapter 6.

²³⁴ A. Olufemi, “Assessment of Groundwater Quality and Saline Intrusions in Coastal Aquifers of Lagos Metropolis, Nigeria” (2010) 2(10) Journal of Water Resource and Protection 849.

²³⁵ E.O. Longe, S. Malomo & M.A. Olorunniwo, “Hydrogeology of Lagos Metropolis” (2007) 6(2) African Journal of Earth Sciences 163.

²³⁶ Lagos State Government, *State of the Environment Report - Lagos* (2010) at pg. 30.

²³⁷ K..A.Yusuf, “Evaluation of Groundwater Quality Characteristics in Lagos-City” (2007) 7(13) Journal of Applied Sciences 1780. The water supply problem in Lagos has a long history, originating during colonial rule when administrators disallowed expenditure on water infrastructure based on the “Manchester doctrine” of minimal expenditure in overseas colonies: A. Aderibigbe, *Expansion of the Lagos Protectorate, 1863-1900* (Ph.D. Thesis, University of London: 1959) [unpublished].

Corporation to enhance water supply in Lagos, the surging population has depreciated these efforts, and in consequence the Corporation meets only 30% of the state's water demands.²³⁸ The Corporation's efforts are further hampered by water losses which occur during transportation due to damaged equipment, as well as erratic electricity supply which frequently interrupts water production processes.²³⁹

As a result of the Corporation's failings, residents resort to exploiting groundwater for domestic, commercial, and industrial uses.²⁴⁰ Since planned infrastructure did not contemplate the huge and increasingly burgeoning population, and the Lagos Water Corporation is unable to meet the demand, residents are left with no choice than to abstract groundwater individually to solve the water problem.²⁴¹ Private individuals and households own most shallow water wells in Lagos, and depend on groundwater exclusively. As mentioned earlier, groundwater is attractive because it is relatively inexpensive to exploit, as construction and labor costs for digging wells and boreholes are generally low, and thus the population is able to meet its water needs. Groundwater therefore constitutes the major source of drinking and domestic uses of water in

²³⁸ Lagos Water Corporation, *Lagos Water Supply Plan 2010-2020* (2012). The Corporation admits its inability to fully meet the water demands of the population. The water scarcity has necessitated the corporation's current efforts to increase capacity of its water treatment plants from 210 MGD to 745 million gallons per day through a 10-year Master Plan under a Public Private Partnership Plan: Lagos State Government, Second National Urban Water Sector Reform Project (Cr 40860), Terms of Reference for Public Private Partnership Technical Advisory Services for LWC Existing Assets, December 2012.

²³⁹ A.M. Gbadebo & A.M. Taiwo, "Geochemical Characterization of Phraetic Aquifers in areas of Sango, Southwestern Nigeria, (2011) 12 J. World Appl. Sci. 815.

²⁴⁰ I.S. Akoteyon, "Evaluation of Groundwater Quality Using Water Quality Indices in Parts of Lagos - Nigeria" (2013) 6(1-2) Journal of Environmental Geography.

²⁴¹ A.A. Adepelumi et al, "Delineation of Saltwater Intrusion into the Freshwater Aquifer of Lekki Peninsular, Lagos, Nigeria" (2008) 56 (5) Environmental Geology 927, Online: <http://www.springerlink.com/content/ekj1477561052r10/fulltext.pdf>. The nation has abundant water resources, and annual rainfall of up to 4000 mm in many of its regions provides substantial replenishment for its freshwater sources.

Lagos state.²⁴² In 2007, Longe et al estimated that 10 million gallons of water were being extracted from the aquifers daily.²⁴³

Apart from individual needs, industrial growth on which the city's development is premised depends on a significant amount of water that is sourced from aquifers. Large industries depend on groundwater which is usually sourced from the deep confined Abeokuta Formation described in Chapter 1. Therefore, maintaining Lagos' enviable status as the national economic nerve center, as well as sustaining its economic growth, will depend on groundwater which is viewed as an economic resource in this context.²⁴⁴ Water is critical for industrial development in Lagos as the city places a special premium on manufacturing to sustain its development, and ultimately its remarkable contributions to the national economy.²⁴⁵

3.5 Conclusion

This chapter has reviewed the important contributions of groundwater around the world, and especially in Lagos. It explored the literature on its characteristics, comparative advantages over surface water and global importance in the present age of water stress. It highlighted the contributions of groundwater to livelihood and to development in Lagos, which accentuates its importance in the city and serves as the basis for the current efforts to secure this critical resource.

²⁴² I.I. Balogun, I.S. Akoteyon and O. Adeaga, "Evaluating Land Use Effects on Groundwater Quality in Lagos Nigeria Using Water Quality Index (2012) 4(2) J. Sci. Res. 397.

²⁴³ Longe et al, supra, note 235; G.O. Adewuyi, O.U. Oputu and M.A. Opasina, "Assessment of Groundwater Quality and Saline Intrusions in Coastal Aquifers of Lagos Metropolis" (2010) 2 Journal of Water Resources and Protection 849.

²⁴⁴ Balogun et al, supra note 242

²⁴⁵ Lagos State Government, *Lagos State Development Plan 2012 – 2025* (Lagos: Ministry of Economic Planning and Budget, 2013) at pg. 45.

The next chapter will review literature on urbanization, which is the demographical movement to Lagos that has brought such considerable pressure to bear on water resources, and has caused serious quality problems for the city's groundwater as a result.

CHAPTER 4

URBANIZATION IN LAGOS

Chapters 1 and 3 identified urbanization and the consequential large population in Lagos as the catalyst of polluted groundwater in Lagos, with a promise to expand on that social phenomenon. The present chapter will now explore the ramifications of urbanization by reviewing relevant theories that explain the motivations for demographical movements in general, and the implications of a large population. It will discuss the importance of urbanization as an indicator of city growth with attendant benefits, but also how extreme growth can counter development by creating diverse problems, especially water pollution. The theories and analysis form the basis of the argument that unsustainable growth in Lagos is harming the city's groundwater. In this chapter, the terms 'urban' and 'city' are used synonymously.

4.1 The Concept and Evolution of Urbanization

Urbanization is the demographic transition that redistributes populations from rural areas to urban areas, and is a worldwide social phenomenon that is marked by the growth of populations in cities.²⁴⁶ It has the potential to result into agglomerations known as megacities which are high density metropolises of more than ten million people, of which Lagos is an

²⁴⁶ D. Satterthwaite, G. McGranahan & C. Tacoli, "Urbanization and its Implications for Food and Farming" (2010) 365 *Philosophical Transactions of the Royal Society B*. 2809; M. Chen, H. Zhang, W. Liu, W. Zhang, "The Global Pattern of Urbanization and Economic Growth: Evidence from the Last Three Decades" (2014) *PLoS ONE* 9(8): e103799. doi:10.1371/journal.pone.0103799. Chen et al point out that it is not merely a change in numbers, but involves a series of changes from rural to urban styles in terms of industry structure, employment, living conditions, and social public services.

example.²⁴⁷ It sometimes also creates the primate city, a city that is dominant within a national urban system in terms of population size or economic activity, or both.²⁴⁸

Urbanization started during the industrial revolution and accelerated after 1950, in a period that coincided with similar rises in world population growth.²⁴⁹ In 1983, Mabogunje observed that urbanization trends increased after the end of the Second World War, when the volume of people that migrated into cities surged greatly, with a large proportion concentrated in big cities.²⁵⁰ Clark wrote that before the 19th Century, limited food and transportation constrained urban movement, with less than 3% living in urban areas. He surmised that 1996 was probably the year in which the world recorded a 50% rate of urbanization, although credit is not usually accorded to this year.²⁵¹ Urban centers are now predominant in the world.

As the world population is doubling, the world's urban population is tripling. The United Nations' recent report in 2014 indicates that 54% of the world currently lives in urban areas.²⁵² It also estimates that by 2050, 66% of the world's population will be urban. By this time, with an estimated population of 212 million, it expects that Nigeria, (together with India and China), will account for 37% of the projected growth of the world's urban population.²⁵³ With these trends, it

²⁴⁷ United Nations Human Settlements Program (UN-HABITAT), *State of the Worlds Cities 2006/7* (Available online).

²⁴⁸ J.D. Kasarda & E. Crenshaw, "Third World Urbanization: Dimensions, Theories, and Determinants" (1991) 17 *Annual Review of Sociology* 467 at pg. 471; M. Jefferson, "The Law of the Primate City" (1939) 29(2) *Geographical Review* 262.

²⁴⁹ David Leon, "Cities, Urbanization and Health" (2008) 37(4-8) *International Journal of Epidemiology* (Editorial) 4.

²⁵⁰ A. L. Mabogunje, "The Case for big Cities" (1983) 7(5) *HABITAT INTL* 21.

²⁵¹ D. Clark, "Interdependent Urbanization in an Urban World: An Historical Review" (1998) 164 *the Geographical Journal* 85. See also X. Peng, X. Chen, & Y. Cheng, "Urbanization and its Consequences" *UNESCO Encyclopaedia of Life Support Systems 9OELSS*) Vol. II.

²⁵² United Nations, Department of Economic and Social Affairs Population Division, *World Urbanization Prospects: the 2014 Revision, Highlights* (Available online).

²⁵³ *Ibid.*

is no wonder that the United Nations remarked that practically one of every two people on the planet is a ‘cityzen’, that is, a city dweller.²⁵⁴ The world is indeed an urban place.

Urbanization is closely linked to development, and is often employed as a benchmark to assess the level of development. As a city industrializes, it further attracts the inflow of people because of the opportunities to work in an urban area.²⁵⁵ Tolley aptly comments that the explanation of urbanization is really an explanation of economic activity in cities, as cities grow because of the presence of productive engagements for people within them.²⁵⁶ Scholars agree that there is a positive correlation between urbanization and development, although they are not always in accord about which is the precursor to the other.²⁵⁷ When properly harnessed, urbanization is a major contributor to economic development, as has been the experience of

²⁵⁴ United Nations Human Settlements Programme (UN-HABITAT), World Urban Forum III, Urbanization Facts and Figures (2006), Available online.

²⁵⁵ N. Harris, “Urbanization, Economic Development and Policy in Developing Countries” (1990) Working Paper No. 19. Henderson elaborates that urbanization contributes significantly to industrialization because most manufacturing and service production is more efficiently undertaken in urbanized areas where companies take advantage of the best technological and managerial practices, transportation services, and skilled workers: J.V. Henderson, “Urbanization in China: Policy Issues and Options” (2009), available online at www.econ.brown.edu

²⁵⁶ G.S. Tolley, “Urbanization and Economic Development”, Online: www.rrojasdatabank.info, at pg. 15.

²⁵⁷ Tolley thinks it a reasonable assumption that most urbanization is the result of economic development processes. Harris however believes that the association of urbanization with changes in economic activities is not a simple one due to the interaction of very variable and complex historical and social determinants of urbanization across countries. He concludes that a close relationship between them is difficult to forge, but concedes that high rates of economic growth coincide with increased urbanization. Henderson asserts that the association between development and urbanization is not causal, i.e. that urbanization per se does not cause growth, but rather one of equilibrium, citing urbanization in many developing countries without significant per capita growth between 1970 and 2000 as illustration. At any rate, irrespective of which event precedes the other, development and urbanization are closely intertwined, and with more industrialization as is the case with Lagos, there is more urbanization. Foster describes the two phenomena as “inseparable”. Kasarda & Crenshaw express as “unequivocal” the fact that a high rate of development leads to a correspondingly high urbanization rate, which they explain as the necessity for the spatial concentration of labour and consumer markets to match the soaring economic activities: G.S. Tolley, *supra* note 256; N. Harris, *supra* note 255; S.S.D. Foster, “Impacts of Urbanisation on Groundwater” UNESCO-IHP III International Symposium, URBAN WATER 88 (1988); V. Henderson, “Cities and Development” (2010) 50(Journal of Regional Science 515; J.D. Kasarda & E.M. Crenshaw, “Third World Urbanization: Dimensions, Theories, and Determinants” (1991) 17 Annu. Rev. Sociol. 467 at pg. 486. See also: B. Cohen, “Urbanization in Developing Countries: Current Trends, Future Projections, and Key Challenges for Sustainability” (2006) 28 Technology in Society 63.

developed countries, and of some developing countries such as China.²⁵⁸ But if excessive or improperly managed, urbanization can result in a horde of problems including slum growth, crime, and environmental problems especially groundwater pollution as Lagos presently experiences.²⁵⁹

The urbanization rates in developing countries are extremely high.²⁶⁰ The uniqueness of urbanization within these countries is that the national per capita wealth does not match the urban growth.²⁶¹ Nor does it correspond with infrastructural provisions.²⁶² Davis notes that Third World urbanization without growth continued its high-speed pace through the 1980s and 1990s in spite of falling real wages, soaring prices and skyrocketing urban unemployment. The ‘perverse’ urban boom contradicted scholarly models which had predicted that the negative

²⁵⁸ China has been able to profitably harness the benefits of urbanization to advance its economy over the past few decades, and to reduce its extremely high poverty rate. It moved from being a predominantly rural economy engaged in farming to an industrial and service economy that operates in urban areas. Its urban transformation has increased incomes, raised living standards, and made China the largest exporter and manufacturer in the world. Real per capita income increased 16 times between 1978 and 2012, and half a billion people moved up from the poverty level: The World Bank, *Urbanization and Economic Growth*, (Available online).

<https://www.worldbank.org/content/dam/Worldbank/document/EAP/China/Urban-China-SRs1-3.pdf>; China Daily USA, *Changing Nature of Urbanization*, Online: www.usa.chinadaily.com.cn.

²⁵⁹ The World Bank, *Developing Countries Need to Harness Urbanization to Achieve the MDGs*: IMF-World Bank Report, Online: www.worldbank.org.

²⁶⁰ Historians recorded that urbanization and economic activities in Nigeria predated that of developed regions of the world but that owing perhaps to limited documentation it is presumed to have started after the coming of Europeans in the 19th Century. Mabogunje wrote that a wide range of economic activities were already taking place in Nigeria and had effectively created a unique system of cities before the European penetration. In northern Nigeria, commercial activities dated back to the medieval period at which time the region participated extensively in inter-regional trade with North Africa with Kano as the commercial nexus. In western Nigeria (where Lagos is located), the Yoruba were major participants in long-distance trade between the north and the west of Nigeria. South eastern Nigeria had limited urban development before the colonial era (1885-1960), but still, transatlantic trade had led to the growth of towns. Dike remarked that the towns grew between 1450 and 1800 and were constituted by all tribes within the Delta hinterland with Bonny as the main seat of palm oil and slave trade. Therefore a system of towns and cities in which trade was a significant part did exist before the Europeans colonized the country. More pertinently, people made spatial adjustments (urban movements) to facilitate their various trades: A. Mabogunje, “Urbanization in Nigeria: A Constraint on Economic Development” (1965) 13(4) *Economic Development and Cultural Change* 413, at pgs. 414-418.; K.O. Dike, *Trade and Politics in the Niger Delta, 1830-1885: An introduction to the Economic and Political History of Nigeria* (Oxford: Clarendon Press, 1956) at pg. 24.

²⁶¹ David Leon, *supra*, note 249. In his more recent study, Henderson notes that historically, urbanization without growth in some African countries may have been fuelled by a push out of rural areas due to war and inadequate rural infrastructure: Henderson, “Cities and Development,” (2009) 50(1) *Journal of Regional Science* 515.

²⁶² D. Drakkakis-Smith, *Third World Cities* (London and New York: Routledge, 2000).

feedback about urban recession ought ordinarily to have slowed down or even halted the movement from rural areas.²⁶³ Other scholars point out that urban growth patterns in these countries are sharply different from that of developed countries which, although highly urbanized, generally maintain stable growth patterns. Kasarda & Crenshaw refer to unusual and “absolute increments of Third World urban populations”, while Jedwab et al describe the developing urbanized cities as “dramatically urbanized”.²⁶⁴ Similarly, Biswas et al find the rate of growth to be explosive, especially after 1960.²⁶⁵ Writing about Africa’s historical urbanization pattern, Mabogunje was of the opinion that the urbanization rate was “sudden and overwhelming” and one that created an initial reaction that was “almost one of despair”.²⁶⁶ The precipitous growth trend prompted Cohen to suggest that this fact alone may necessitate a halting of the urbanization process.²⁶⁷ Excessively large and rapidly growing urban populations therefore characterize the developing world, and have become a consistent feature of their cities.²⁶⁸

Rural-Urban-Migration theories explain urbanization and describe the root causes of the demographical movement. In addition, the Malthusian and Bartlett theories on population growth

²⁶³ M. Davis, *Planet of Slums*, (2004) 26 *New Left Review* 5. Davis describes the trend as a form of urban involution marked by vast expansion in combination with economic decline.

²⁶⁴ J.D. Kasarda & E. Crenshaw, *supra*, note 248, at pg. 468; R. Jedwab, L. Christiaensen, & M. Gindensky, “Demography, Urbanization and Development: Rural Push, Urban Pull and...Urban Push?” (2014) Online: <http://www.parisschoolofeconomics.eu/IMG/pdf/pse-rues-juin2014-jedwab.pdf>.

²⁶⁵ A. Biswas, J. Lunqvist, C. Tortajada, & O. Varis, “Water Management for Megacities” Online: <http://www.scholar.google.ca/scholar>.

²⁶⁶ A. Mabogunje, “The Case for Big Cities” *supra*, note 250, at pg. 24. Henderson recorded that historical urbanization in developed countries occurred at an overall measured and slower pace than in developing countries. He cited the trend in United States which was 40% urbanized in 1930, 70% in 1960, and 75% in 1990. By sharp contrast, South Korea was 40% urbanized in 1970, and jumped to 78% urbanization by 1990. Therefore it achieved in just 20 years what took the United States 60 years to accomplish: V. Henderson, “Urbanization in Developing Countries” (2002) 17 *World Bank Research Observer* 89.

²⁶⁷ B. Cohen, “Urban Growth in Developing Countries: A Review of Current Trends and a Caution Regarding Existing Forecasts” (2004) 32 *World Development* 23.

²⁶⁸ M. Timberlake & J. Kentor, “Economic Dependence, Overurbanization, and Economic Growth: A Study of Less Developed Countries” (1983) 24 *the Sociological Quarterly* 489.

and natural increases also describe the implications of a large population. As discussed below, theories on Over-Urbanization, Urban Primacy, and Urban Bias further explain some dimensions of urbanization that are applicable to Lagos.

4.1.1 Relevant Urbanization Theories and Dimensions

4.1.2 Rural-Urban Migration Theories

Migration has a historical role as part of the human experience, and has accelerated, globalized, and diversified.²⁶⁹ Around the world, migration from rural to urban areas and the resultant urban population growth have been very pervasive and persistent, and thus prompted their description as “uninterrupted and accelerating” phenomena.²⁷⁰ Migration accounted for about half of the urban growth in Africa during the 1960s and 1970s and about 25% of urban growth in the 1980s and 1990s.²⁷¹ Migration is thus a major factor in urban growth, and the movement of labor from rural to urban areas is an important part of the urbanization process.

Theories that explain why people move are described as the Rural-Urban migration theories. Rural-Urban migration is explained as the "push" from agriculture in rural areas and the "pull" of relatively higher urban wages in urban cities. Harris & Todaro who based their studies on developing countries observed that although agricultural production in rural areas was significant, rural labour persisted in migrating to cities in spite of significant unemployment in urban areas. In their effort to rationalize this apparently illogical urban movement, they deduced that migration will occur for as long as the urban expected income is higher than the rural

²⁶⁹ Russell King, “Theories and Typologies of Migration: An Overview and a Primer”, Willy Brandt Series of Working Papers in International Migration and Ethnic Relations (2012), Available online.

²⁷⁰ S.S.D. Foster, “Impacts of Urbanization on Groundwater” UNESCO-IHP III International Symposium Urban Water 88, April 1988. (Available online).

²⁷¹ M. Brockerhoff, “Fertility and Family Planning in African Cities: The Impact of Female Migration” (1995) 27 Journal of Biosocial Science 347.

income expectation.²⁷² Braun explains this further by saying that migration is based on a human tendency to relocate to prosperous regions while moving away from declining areas.²⁷³ Migration is therefore a root factor in urbanization, and also a major component of rapid, unplanned growth of cities especially in developing countries.²⁷⁴

4.1.2.1 Migration to Lagos

Steady migration to Lagos over the years is evidence both of the appeal that a city can have to the rural populace, and of the dramatically high urban growth rates that can, in consequence, occur. The movement to Lagos has been steadily escalating over the years. Spectacular urban growth in Lagos dates back to the early 1800s, when its favorable location on the only permanent break on the West African coastline made it attractive to the European settlers. From being a small slave port in 1800, it grew to become the most important port on the West African coastline. In particular, the southern shores of Lagos Island were conducive to the early European traders on account of the frontage which was suitable for constructing piers and wharves for receiving ships. That area became and remains the central business district in Lagos. Its strategic location has unceasingly attracted people and this resulted in a large and steadily

²⁷² J.R. Harris & M.P. Todaro, "Migration, Unemployment and Development: A Two-Sector Analysis" (1970) *American Economic Review* 126. More recent work affirming their theories include: J.R. Aworemi, A. Adegoke, & N. Opoola, "An Appraisal of the Factors Influencing Rural-Urban Migration in Some Selected Local Government Areas of Lagos State Nigeria" (2011) 4(3) *Journal of Sustainable Development* 136; B. Cohen "Urban Growth in Developing Countries: A Review of Current Trends and a Caution Regarding Existing Forecasts" (2004) 32 *World Development* 23 (2004).

²⁷³ J. van Braun, "Towards a Renewed Focus on Rural Development" (2004) 11(2) *Agriculture & Rural Development*. Rural migration has been described as a powerful sign of regional inequality in access to opportunities and living standards, and a systematic bias against the rural economy in allocation of developmental resources. The bias reflects in inadequate infrastructure that hinders efforts at rural poverty reduction and perpetuates the urban-rural gap: D. J. Bezemer & D. Heady, "Agriculture, Development and Urban Bias", MPRA Paper No. 7026. Online: <http://mpra.ub.uni-muenchen.de/7026/1/MPRApaper7026.pdf>

²⁷⁴ M. Jahan, "Impacts of Rural Urban Migration on Physical and Social Environment: the Case of Dhaka City" (2012) *Int. Journal of Development and Sustainability* 186.

rising population. From a meagre 20,000 in 1850, the city leaped to 17.5 million by 2006, on which its current estimate of 21.8 million is based.²⁷⁵

Migration to Lagos has also been underscored by its former status as Nigeria's administrative capital until 1991, as mentioned in Chapter 1. Although it yielded this status in 1991, its perception as a prosperous city continues to draw people to it in the expectation of a better standard of life. Migration has therefore remained steady, particularly as the city is modernizing and improving its aesthetics. Aworemi et al suggest that the drift to Lagos is motivated by hopes of employment, of access to education, improved health care and better social amenities, boredom with agriculture, and the presence of recreational facilities in Lagos.²⁷⁶ All these reasons support the migration theories about the pull of urban areas and explain the attractiveness of this small island to the populace.

Regrettably, these moves are without regard to the impact on either the deserted region (economic decline, poverty and food insecurity), or on the destination cities.²⁷⁷ The expectation of higher income and better quality of life has not necessarily materialized for a sizeable proportion of Lagos immigrants. Rather, it has created an unplanned population mass that has in turn caused severe problems such as traffic congestion, air pollution, slum growth and pressures on available infrastructure especially water. The trend is in tandem with scholarly assertions that migration on a large and sustained scale tends to create a situation of unplanned population

²⁷⁵ Scholars describe the population trend thus: 1900 (40,000); 1931 (100,000); 1950 (250,000); 1964 (500,000); 1968 (950,000); 1980 (3.6 million); 1985 (5 million); 2006 (17.5 million) 2013 (21.88 million): A. Mabogunje, "The Evolution and Analysis of the Retail Structure of Lagos, Nigeria" (1964) 40(4) *Economic Geography* 304; L.H. Muench & C.Z. Muench, "Planning and Anti-planning in Nigeria: Lagos and Ibadan" (1968) 34(6) *Journal of the American Institute of Planners*, 374; E.O. Longe, S. Malomo, & M.A. Olorunniwo, "Hydrogeology of Lagos Metropolis" (1987) 6(2) *Journal of African Earth Sciences* 163.

²⁷⁶ J. Aworemi, A. Adegoke, & O. Nurain, "An Appraisal of the Factors Affecting Rural Urban Migration in Some Selected Local Government Areas of Lagos State Nigeria" (2011) 4(3) *Journal of Sustainable Development* 136.

²⁷⁷ *Ibid.*

explosion which surpasses infrastructural supplies, and results in difficulties on a broad scale.²⁷⁸ Poverty and slum growth, when juxtaposed with pockets of affluence that are evident within the metropolis, creates a city of startling contrasts. Gandy describes Lagos as portraying the paradoxical characteristics of the contemporary African city as a dysfunctional yet dynamic form. He also references a colonial administrator's description of the paradox in Lagos as "the sharp contrast of thriving city and primitive rusticity" where "substantial residences" of wealthier Africans can be found "side by side with slums..."²⁷⁹ Kaplan similarly writes that Lagos's "... overcrowding makes it the cliché par excellence of Third World urban dysfunction".²⁸⁰ Gandy, who notes the fast growth in conjunction with minimal social investments, also affirms that Lagos has none of the infrastructures, systems or even environmental resources to support a population considerably below its current level.²⁸¹ The United Nations has described Lagos city as the fastest growing megacity in the world.²⁸²

It is important to note that the population in Lagos is not only due to migration, but is also linked to, and greatly enhanced by natural population increase which is discussed next.

²⁷⁸ Ibid. Traffic congestion, infrastructural decay, ad hoc expansion of slum housing territories to accommodate immigrants, and social misfits known as "area boys/girls" are a few of the dire results of the urban movement in Lagos.

²⁷⁹ M. Gandy, "Planning, Anti-planning and the Infrastructure Crisis Facing Metropolitan Lagos" (2006) 43(2) *Urban Studies* 371, at pg. 376, where he cites Commissioner Carr's remarks; A.O. Ilesanmi, "Urban Sustainability in the Context of Lagos Megacity: (2010) 3(10) *Journal of Geography and Regional Planning* 240.

²⁸⁰ R. Kaplan, *The Coming Anarchy, Shattering the Dreams of the Post Cold War* (Random House New York, U.S. 2000). The high migration rate which is further encouraged by its current modernization efforts has led to a thriving informal market of peddlers and hawkers of wares who infiltrate the streets due to a dearth of formal employment, and cause major traffic obstructions. Migrants are also unable to afford the astronomical rents that characterize the city's accommodation and this forces them to erect shanties in the city's suburbs.

²⁸¹ M. Gandy, "Learning From Lagos" (2005) 33 *New Left Review* 37.

²⁸² UN HABITAT. *State of the World's Cities 2006-2007* (Available online). Although the 2006 national census recorded that the state's population was 9 million, this figure was contradicted by Lagos state's concurrent survey that recorded a population of 17.5 million. To lend credence to the state's figures, Mabogunje, a very renowned scholar, had referred to a figure of 15.7 million as far back as 2002. See A. Mabogunje, "Reconstruction the Nigerian City: The New Policy on Urban Development and Housing" National Conference on the City in Nigeria, Ile-Ife, 2002.

4.1.3 Natural Population Increase

Not only do cities grow from migration, they also expand from natural increases in population, which is the rate of births minus deaths. Migration and natural increases are two apparently distinct phenomena, but become interconnected where a high national rate of increase is at the root of the outward movement to a bigger city. Both Jefferson and Satterthwaite et al in separate research efforts make the connection between the seemingly separate events by affirming that cities grow by the excess of births over deaths as well as by the attraction of employment opportunities.²⁸³ The two phenomena dominated demographic trends in the 20th Century, causing a consistent rise in the proportion of the world's population that live in urban areas, and leading to predictions about a likely sustenance of the urban trend in the future.²⁸⁴

According to Hawley, high fertility rates and the gradual elimination of crude birthrates with improved medical care, have contributed to high, “precipitous” population rates in rural areas. The incidence of high population is more pronounced in regions like sub-Saharan Africa (Nigeria's location) where policies limiting child numbers are rare, and where strong cultural and religious beliefs encourage the birthing of large numbers of children. The consequential high populations in the rural areas usually outstrip job opportunities there, and encourage urban migration. Migration is in response both to the poverty experienced in the rural areas, and to the perception of better opportunities in urban areas. The interconnectedness is in the potential for

²⁸³ Jefferson, *supra*, note 248; Satterthwaite et al, *supra*, note 246.

²⁸⁴ British Geological Survey, *Impact of Urbanization on Groundwater Quality* (Project Summary Report). The United Nations in 1989 had predicted that during the 1990s, the urban population in developing regions would rise to approximately two billion people and that shortly after the turn of the century most of the Third World would be comprised of urban residents. It also predicted that by 2000, more than 50% of the world's population would have become urban dwellers. The UN also predicted that by 2010, half of the world's population would live in towns or cities. These predictions have come to pass: United Nations, *Prospects of World Urbanization*, 1988 (1989); S.S.D. Foster, *supra*, note 270; B.L. Morris, R.G. Litvak, and K.M. Ahmed, “Urban Groundwater Protection and Management: Lessons from Developing Cities in Bangladesh and Kyrgyzstan” in K.W.F. Howard and R.G. Israfilov, eds., *Current Problems of Hydrogeology in Urban Areas, Urban Agglomerates, and Urban Centres*, NATO Science Series, (Kluwer Academic Publishers, 2002) 77; UNCHS, *Global Report on Human Settlements*, UN Center for Human Settlements (Oxford University Press, New York 1987). Finally, see United Nations, *World Urbanization Prospects the 2011 Revision*, (United Nations, New York 2012) Available online.

excessive migration of this surplus population to cities, from which a highly urbanized city such as Lagos emerges.²⁸⁵

4.1.3.1 Natural Population Increase as a Population Enhancer in Lagos

Nigeria experiences a high national population growth rate of 2.7% and a steadily rising population which was 159.7 million in 2010, and is currently estimated at 177 million.²⁸⁶ Social and religious beliefs act as catalysts to this natural increase. The socio-cultural value system has historically encouraged families to have a sizeable number of children to assist in the farms and as insurance for old age.²⁸⁷ Socially, marriage remains a respectable and required status for every adult, and each family is expected to bear children after marriage, as a natural progression. Premium has also traditionally been placed on male children, and this has often resulted in repeated births in efforts to secure a male child. The extended family tradition encourages the pooling of risks and resources and many cultures within the country still regard children as security for old age in a nation that is still sadly lacking an enduring social security system.²⁸⁸

In terms of religion, the two major national religions, Islam and Christianity, although differing in fundamental ideologies, indirectly promote childbearing by teaching that children are gifts of God, and therefore that procreation should be encouraged, not curtailed; on one hand Islam encourages polygamy and multiple childbearing, whilst Christianity, although promoting

²⁸⁵ A.H Hawley, *Urban Society: An Ecological Approach* (New York 1971), cited by J. Shandra, B. London, & J. Williamson, "Environmental Degradation, Environmental Sustainability, and Over-urbanization in the Developing World: A Cross-National Analysis (2003) 46 Sociological Perspectives 309.

²⁸⁶ United Nations, *World Population Prospects: the 2012 Revision* (2014) available online; The U.S. Central Intelligence Agency, *The World Factbook* (2015) available online: <https://www.cia.gov/library/publications/the-world-factbook/geos/ni.html>. There has not been any official census since 2006, and thus it has been expedient to cite a reliable external source for the current estimate.

²⁸⁷ O.H. Kokole, "The Politics of Fertility in Africa" (1994) 20 *Population and Development Review* 73; E.C. Onwuka, "Another Look at the Impact of Nigeria's Growing Population on the Country's Development" (2006) 21(1) *African Population Studies*. Online: <http://www.bioline.org.br/pdf?ep06001> on Oct. 9th 2012; S.F. Iwejingi, "Population Growth, Environmental Degradation, and Human Health and in Nigeria" (2011) 8(4) *Pakistan Journal of Social Science* 187.

²⁸⁸ *Ibid.*

abstinence amongst single people, also signals childbearing as a gift of God whilst discouraging abortions.²⁸⁹ From this social fact it may be inferred that cultural and religious values in Africa significantly affect a family's decision to have additional children regardless of its economic status.

The high rate of growth is partly due to a robust fertility rate and a decline in its death rate; the death rate has declined to 1.3%, on account of better medical care, scientific breakthroughs that control infectious diseases, and better sanitation generally.²⁹⁰ While this is gratifying because it signifies progress in achieving the Millennium Development Goal on halting and reversing the incidence of major diseases, it has enhanced a high national growth rate.²⁹¹ The high growth rate in turn accounts for the large number of migrants to Lagos. It also confirms findings mentioned above about the interconnection of migration and natural increases.²⁹² The numerous rural dwellers, burdened by the shortage of gainful work, and attracted by the perception of a higher quality of life in Lagos, move into Lagos. As a result Lagos is compelled to host and cater for a precipitous population, which is an unbalanced proportion of the national population.²⁹³ The large population in Lagos is in turn causing serious

²⁸⁹ The Bible states that "Children are the heritage of the Lord and offspring are a reward from him. Like arrows in the hands of a warrior are children born in one's youth. Blessed is the man whose quiver is full of them. He shall not be ashamed when he contends with his opponents in court": The Holy Bible, (New International Version) Psalms, Chapter 127, vs. 3-5.

²⁹⁰ B.D. Umoh, *Population Studies for Nigeria: A New Perspective*, (Institute for Development Studies, University of Nigeria Enugu: 2001) at pgs. 51- 52. The United Nations predicts that this high rate will result in Nigeria surpassing many countries in a few years: United Nations, Department of Economic and Social Affairs, *World Population Prospects, the 2012 Revision*, Online: <http://esa.un.org/unpd/wpp/Documentation/publications.htm>

²⁹¹ Millennium Summit of the United Nations, *United Nations Millennium Declaration* (2000), Millennium Development Goal No. 6 to Combat HIV/AIDS and other Diseases.

²⁹² J.M. Shandra, B. London, & J.B. Williamson, "Environmental Degradation, Environmental Sustainability, and Overurbanization in the Developing World: A Quantitative, Cross-National Analysis" (2003) 46 *Sociological Perspectives* 309.

²⁹³ Lagos State Government, Bureau of Statistics, *Digest of Statistics* (2012).

environmental problems especially in waste and sewage management and groundwater pollution.²⁹⁴

4.1.3.2 The Implications of a Large Population: Malthusian and Bartlett Theories

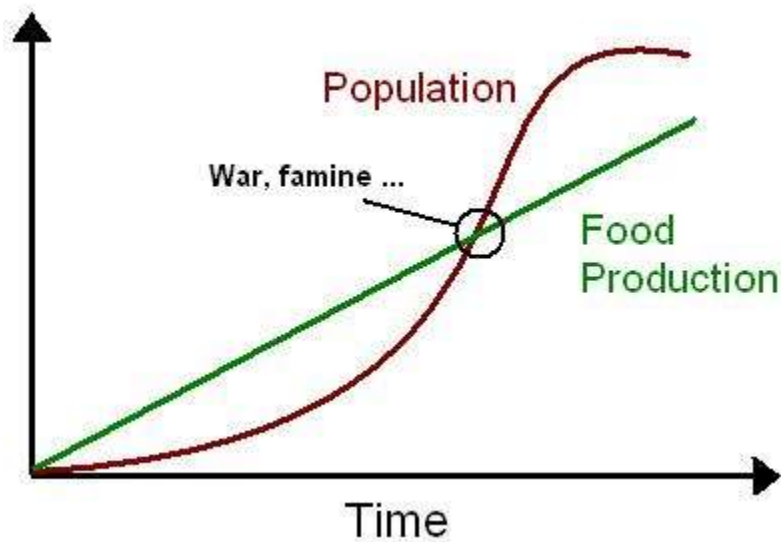
Several years ago, Thomas Malthus examined the implications of a high national population growth rate in his study of population growth.²⁹⁵ According to his findings, population grows exponentially (i.e., doubling with each cycle) whereas food supply only grows arithmetically, (i.e. by the repeated addition of a uniform increment in each interval of time). This scenario of arithmetical food growth with concurrent geometric human population growth portends a future where humans will exhaust resources and be left with nothing to live on. He warned that without control, population growth will exceed resource growth, and the need for food will later surpass its availability. Thereafter, catastrophes such as famine, disease, and war will occur as natural checks to reduce the overpopulation. To avoid such dire catastrophes, he urged controls on population growth through pervasive moral restraint in the form of abstinence, or sterilization, or failing that, the imposition of criminal sanctions for those with more children than they could support. His theory is represented in the diagram below.²⁹⁶

²⁹⁴ Nigeria is a major enabler of population growth in sub-Saharan Africa, contributing 20% of the population in that region between 1960 and 2000. The population size has caused the country to be described as a high potential contributor to global warming and climate change, although this is not yet proven as a fact. Gro Brundtland who views large populations as the most serious and intractable problem facing nations, paints a dire but factual picture of the implications of unrestrained population growth: worldwide famine, migrations on a colossal scale, and ensuing wars for scarce natural resources. However, population control measures are beyond the scope of this study: 2008 *Nigeria State of the Environment Report*, at pg. 19; Victor Ukpoko, "Population Growth and Economic Growth in Africa" (2002) 18(4) *Journal of Developing Societies* 315, at pg. 318; G.H. Brundtland, "Population, Environment, and Development" (1993) 19(4) *Population and Development Review* 893, at pg. 894.

²⁹⁵ Thomas Malthus, "An Essay on the Principle of Population" (1798) Online: <http://www.esp.org/books/malthus/population/malthus.pdf> Famines have since occurred in individual regions, as confirmation of his warnings; AAG Centre for Global Geography Education, Population and Natural Resources Module, *Malthusian Theory of Population*, available online. Although the catastrophes he predicted have not taken place on a global level, it is argued that combined environmental problems including global warming and pressures on food production make the issue of over-population a real and continuing global threat.

²⁹⁶ AAG Centre for Global Geography Education (2011), Online: http://cgge.aag.org/PopulationandNaturalResources1e/CF_PopNatRes_Jan10/CF_PopNatRes_Jan108.html.

A Graph showing the growth of population in relation to food supply



Source: adapted from AAG Centre for Global Geography Education, note 290

Bartlett offers an equally insightful exposition of the relation of population to sustainability in order to clarify the dangers of an inordinately large population. In his “Laws of Sustainability”, he explains that large populations and their related high rates of resource consumption cannot be sustained in the long term.²⁹⁷ According to him, a population growth rate that is less than, or equal to zero along with declining rates of resource consumption is a necessary condition for a sustainable society. A development program that does not plan to achieve zero population growth is unlikely to be sustainable. Thus governmental agencies that are charged with protecting the environment and promoting "sustainability" will, in the long run, be irrelevant, unless they address seriously and quantitatively the concept of carrying capacities after studying the demographic causes and consequences of environmental problems. Significantly, while the benefits of population growth and of growth in the rates of consumption of resources accrue to a few, the costs of population growth and growth in the rates of consumption of resources are borne by all of society. Further, when rates of pollution exceed the

²⁹⁷ A. Bartlett, “Laws of Sustainability” (Available online). See particularly the 1st - 3rd, and 8th - 14th laws.

natural cleansing capacity of the environment, it will be easier to pollute than to clean up the environment. Therefore, “the only smart growth is no growth.”²⁹⁸

Bartlett’s analysis connects population to sustainable development by pointing out the inexpediency of a certain level of population growth. His theory is interesting and pertinent for this thesis because an over-populated Lagos city constitutes a major problem for groundwater and one that raises questions about the viability of maintaining the current economic growth process in the important megacity. As discussed in Chapter 1, population control as an imperative to sustainable development has been a resounding theme at sustainable development discourses starting at the Paris Biosphere Conference in 1968, continuing to the Rio Conference in 1992, emphasized in *Our Common Future* in 1987, and it continues to feature prominently in current international discourses. The Paris Conference noted the deterioration of the environment due to the “very rapid growth of the human population and its aggregation in large urban concentrations”. In *Our Common Future*, the World Commission on Environment and Development stated that population must not be so large that it places an unbearable burden on the environment and on available resources. The Rio Conference in *Agenda 21* also observed that the growth of world populations place increasingly severe stress on the life-supporting capacities of the planet, and is adversely affecting natural resources. In 2012, the UN Conference on Sustainable Development (Rio + 20) in *the Future We Want* recognized the role of population in sustainable development, and affirmed a commitment to addressing the problems that demographic changes pose in national urban development strategies.²⁹⁹

²⁹⁸ Ibid.

²⁹⁹ Paris Conference on the Rational Use of the Biosphere, *Conclusion*; United Nations Conference on Environment and Development, *Agenda 21*, S. 5.3; World Commission on Environment and Development, *Our Common Future*, Arts. 49-55; United Nations Conference on Sustainable Development (Rio + 20), *The Future We Want*, Art. 144.

Interestingly the implications of population growth have historically generated heated arguments in the international community since the 1900s. Conflicting points of view about whether population is a problem, and if it is, how it can be managed, resulted in *the great population debates* of the 20th Century. Demographers and agriculturalists warn about the dangers of unrestrained population growth which were observed in Asia.³⁰⁰ Marxians and Feminists argue that population explosion is not a cause in itself, but rather the result of social and economic inequities. Feminists argue further that in formulating population policy, consideration needs to be given to gender equality in granting women access to education, to financial credit, and to equality in inheritance. On how to manage population growth rates, “family planners” argue that the availability of contraceptives will curb the high fertility rate, but the “developers” disagree, maintaining that poverty causes a strong motivation to have many children, and that such motivation does not change simply because contraceptives are available.³⁰¹

More recently, some economists have intimated that a rapidly growing population without a corresponding growth or development of natural resources inevitably leads to poor economic performance because environmental resources invariably have to be diverted to current consumption rather than to investment.³⁰² Such rapid population growth without a concurrent growth in natural resources leads to the Malthusian trap, a state of poor economic performance

³⁰⁰ A.J. Cole & E.M Hoover, *Population Growth and Economic Development in Low Income Countries* (Princeton, NJ: Princeton University Press 1958); G. Myrdal, *The Challenge of World Poverty* (New York NY: Pantheon Books 1970).

³⁰¹ S. Sinding, “The Great Population Debates: How Relevant Are They for the 21st Century?” (2000) 90 *American Journal of Public Health* 1841.

³⁰² V. Ukpolo, “Population Growth and Economic Growth in Africa” (2002) 18(4) *Journal of Developing Societies* 315.

caused by output being lower than the minimum required for survival.³⁰³ However, other Economists (Optimists) believe that population growth acts as a stimulant to technological growth on the basis that a larger population produces more people with innovative ideas and entrepreneurship. They argue that since “necessity is the mother of invention”, people will be compelled for survival’s sake to prevent famine by conceptualizing profitable novel activities.³⁰⁴ But the facts in many nations appear to deny this latter claim, as millions continue to starve in over-populated regions, notably in Africa. Besides this, the argument appears flawed because it assumes that an increase in population automatically translates to a corresponding increase in educated intellectuals with the competence to grow a nation.

Regardless of the directions that international discourses on population may take however, it is important to appreciate the nexus between population and environmental resources. It has been persuasively mooted that population is likely to remain a very vital part of water development planning. As Gleick concisely expresses it, it is impossible to discuss water with a view to finding sustainable solutions “...without also understanding the enormously important role of population dynamics and population growth”.³⁰⁵ The dimension of excessive population growth is especially pertinent in that urbanization and the resultant population mass sometimes occur at a rate that is too rapid for the concomitant development of adequate water and wastewater infrastructure, as is the case with Lagos.

³⁰³ I. Ehrlich & F. Lui, “The Problem of Population Growth: A Review of the Literature from Malthus to Contemporary Models of Endogenous Population and Endogenous Growth” (1997) 21 *Journal of Economic Dynamics and Control* 205.

³⁰⁴ J.L. Simon, *The Ultimate Resource* (Princeton, NJ: Princeton University Press, 1981). Others are of the “Neutralists” view that there is no connection between population growth and economic growth: Didier Blanchet, “On Interpreting Observed Relationships between Population Growth and Economic Growth: A Graphical Exposition” (1991) 17 *Population and Development Review* 105.

³⁰⁵ Peter Gleick, *The World’s Water Volume 7: The Biennial Report on Freshwater Resources* (Island Press Washington D.C: 2011).

With a high urbanization rate and the large population in Lagos, residents are overwhelming and degrading the city's water: available water from public supplies is totally inadequate to meet the ever-rising demands; anthropogenic activities are producing a quantum of waste and wastewater that the municipal government cannot competently manage; and the agglomeration of people (and industries) is discharging raw, untreated wastewater into the environment and polluting groundwater distressingly. The situation confirms Agunwamba's earlier warning that rapid urbanization and a high population growth rate in Nigerian cities compound the problem of effective environmental management.³⁰⁶

Having reviewed the contributors to urban growth and population in Lagos, the next section will endeavor to shed light on some additional dimensions to the urbanization problem in Lagos, which are: Over-Urbanization, Urban Primacy, and Urban bias.

4.2 Dimensions of Urbanization

4.2.1 Over-Urbanization

Over-urbanization is an evaluative concept that refers to cities that have larger urban populations than can be effectively employed or supported by their level of development.³⁰⁷ Unrestrained city growth especially in developing countries has led critics to infer that urbanization in developing countries contradicts the positive correlation that ordinarily exists

³⁰⁶ J. C. Agunwamba, "Solid Waste Management in Nigeria: Problems and Issues" (1998) 22(6) *Environ Management* 849.

³⁰⁷ Theorists have proffered differing and controversial benchmarks for evaluating urbanization. Some theorists posit that over urbanization occurs when the current less developed countries are more urbanized than the developed ones were at the same level of development. Early proponents of the theory claim that nations are over-urbanized when they contain a smaller industrial employment base than wealthy countries did at comparable levels of urbanization. But this thesis argues that such benchmark for evaluating urbanization is inherently flawed for being too ethnocentric. A more objective measurement could be one of cost and benefit, in which the social costs of the agglomeration (the resultant "social disorganization") are demonstrably far in excess of the benefits: P. Bairoch, *The Economic Development of the Third World Since 1900* (University of California Press, Berkeley, California, 1975). Better still, over urbanization occurs when urban populations exceed the capacity to cater for them.

between urbanization and development, which was discussed at the start of this chapter. Although theorists have over the years proffered differing benchmarks for evaluating urbanization, this thesis prefers to adopt the simple idea that over-urbanization occurs when urban populations exceed the capacity to cater for them.³⁰⁸ Since urbanization is underlain by a high rate of natural population growth as discussed earlier, scholars affirm that a high population growth rate fosters high levels of over-urbanization in developing countries, and this appears to be verified in the case of Lagos.³⁰⁹

The matter that calls for concern in an over-urbanized city is its tendency to surpass existing social structures. Kasarda & Crenshaw noted its tendency to outstrip industrial and overall economic development, and to be totally independent of employment especially in developing cities.³¹⁰ Saturated urban labour markets, truncated opportunities in rural areas, distorted sectorial development in national economies, isolation of large portions of urban and rural population from the fruits of economic development, and delayed economic growth on account of high costs of urban development, have all been attributed to over-urbanization.³¹¹ It has also been described as a perverse stream of migration that draws the economic strength of the

³⁰⁸ Hoselitz hints at this preferable benchmark for measuring the level of urbanization. Indeed developed countries do not necessarily provide the perfect urbanization path to development otherwise the concerns over the damage inflicted on the environment from their developmental activities would not have arisen. Other conceptualizations of over-urbanization include the ratio of the percentage of a country's total population that lives in urban areas to some measure of the level of development; the ratio of urban population to secondary and tertiary employment; and the ratio of the rate of urbanization, usually from rural-urban migration, to economic development. However, economic analysis is beyond the scope of this thesis, and these related theories have only been mentioned for probable future reference. See: B.F. Hoselitz, "Urbanization and Economic Growth in Asia" (1957) 6(1) *Economic Development and Cultural Change* 42 D. Hibbs, *Mass Political Violence: A Cross-National Causal Analysis* (New York, Wiley and sons, 1973); H. Moir, "Relationships Between Urbanization Levels and the Industrial Structure of the Labor Force" (1976) 25 *Economic Development and Cultural Change* 123; S. Wellisz, "Economic Development and Urbanization" in L. Jacobsen and V. Prakash, eds. *Urbanization and National Development*, (Beverly Hills Calif Sage Publications 1973).

³⁰⁹ J. Shandra, B. London, & J. Williamson, "Environmental Degradation, Environmental Sustainability, and Overurbanization in the Developing World: A Quantitative, Cross-National Analysis" (2006) 46(3) *Sociological Perspectives* 309.

³¹⁰ Kasarda & Crenshaw, *supra*, note 248 at pg. 470.

³¹¹ P. Bairoch, *Cities and Economic Development from the Dawn of History to the Present* (Chicago: University of Chicago Press 1988); J. Gugler, "Overurbanization Reconsidered", (1982) 31 *Econ. Dev. Cult. Change* 173.

rural areas without necessarily conveying large benefits to urban production.³¹² Other scholars are particularly critical of the informal sector - a product of urbanization - blaming it for hindering national economic development by failing to increase national productivity even though it provides employment for the poorer classes.³¹³

Over-urbanization results into a wide range of problems. The most obvious are unbearable congestion, housing shortages, dense human traffic, vehicular congestion, environmental pollution, and artificial territorial expansions that manifest as slum settlements.³¹⁴ In developing countries particularly, it places tremendous pressures on existing infrastructure where there is no concomitant social developments to match the urban growth. In Asia, Hoselitz observes that the highly urbanized early Asian cities, particularly Djakarta and Karachi, have historically experienced very rapid growths and tend to assemble vast populations without the availability of corresponding employment or housing.³¹⁵

Experts have cautioned for a long time that population growth that is unaccompanied by adequate social arrangements causes glaring and troubling human problems of the deepest intensity. Population is indeed a problem for sustainability where the proper infrastructure and institutional frameworks which would otherwise have contributed to sustainability are lacking. The carrying capacity of any city experiencing rapid population growth will eventually be over-extended, and the economies of size displaced by the dis-economies of inadequate

³¹² S. Wellisz "Economic Development and Urbanization" in L. Jakobson & V. Prakash (eds.) *Urbanization and National Development* (Beverly Hills: Sage 1971).

³¹³ M. Timberlake & J. Kentor, "Economic Dependence, Over urbanization, and Economic Growth: A Study of Less Developed Countries" (1983) 24 *Sociological Quarterly* 489.

³¹⁴ This is apart from depleting the human resource that necessary to sustain agricultural production in rural areas and causing impoverishment, a fact that eludes the mind of intending migrants who are attracted to cities without regard for the problems they create as a result. In Nigeria, agriculture which was previously the main occupation of the national economy became relegated to the rear in favour of petroleum exploration, and the country was compelled to resort to agricultural importations: J.R. Aworemi et al, *supra*, note 276.

³¹⁵ B.F. Hoselitz, *supra*, note 308.

infrastructure.³¹⁶ Experts warn that in consequence, water supply shortages, lack of wastewater treatment, congestion and deteriorating housing will all be manifestations of environmental stress.³¹⁷ Such early warnings ought to have stirred intellectual discourses that would likely have resulted into strategies to mitigate the rural outward flows, enhance rural development to stem the urban drift, and achieve an overall slower trend of urban growth. For a city like Lagos, its colonial administrators could have addressed the migration problem by putting in place a system to control it, and a perhaps a deliberate strategy to de-concentrate at a particular level of congestion. However, the usefulness of even these efforts would probably have been limited since continuity could not have been guaranteed after their departure.³¹⁸

Monumental demands on water supply, massive generation of waste and wastewater, and the inability of the responsible agencies to cater to these environmental needs make Lagos unarguably an over-urbanized city. Certainly the population which is the result of unchecked urbanization has outstripped necessary waste management and wastewater management infrastructure, and groundwater has been degraded in consequence.³¹⁹

³¹⁶ The *Founex Report on Development and the Environment* (1971), at Chapter 3. Available online

³¹⁷ Ibid.

³¹⁸ It is curious that such an important city could be allowed to degenerate into such a deplorable state of infrastructural inadequacy. The origin of the problem, according to writers, was that colonial administration did not address either overcrowding or insufficient urban infrastructure at the early stage. According to Aderibigbe, this was due to the Manchester doctrine of minimal financial support for overseas colonies that made sure that Lagos would be seen as little more than an entrepot of trade. An apparent segregation strategy between wealthy enclaves and indigenous populations also caused a disproportionate concentration of urban infrastructure in the colonialists' enclaves in choice areas of Ikoyi and Ikeja, a segregation that is still evident in modern times: A.A.B. Aderibigbe, *Expansion of the Lagos Protectorate, 1863-1900* (PhD Thesis, SOAS, University of London, 1959) [unpublished] at pg. 8.

³¹⁹ Gandy wrote that "Lagos is now one of a number of rapidly growing cities in the global South which appear to challenge many previously held assumptions about the relationship between economic prosperity and demographic change: unlike the experience of 19th century Europe and North America, for example, we observe a form of urban 'involution' marked by vast expansion in combination with economic decline". His remarks are consistent with observation made by Kasarda & Crenshaw that urbanization in the Third World is usually absolute and seemingly independent of manufacturing or industrial employment and featuring trends that are not comparable to the development experiences of many cities in western countries, in other words, over-urbanization. A point of disagreement with Gandy, however, is his description of Lagos as suffering economic decline. Extreme as the

Over-urbanization and city primacy are intertwined. This is because the move to cities often results into a preference for a particular city for a number of reasons, and transforms it into a dominant city. Urbanization and the attendant influx into preferred cities are thus major contributors to primacy in a city. Primate cities usually have advantageous features such as a strategic location, the presence of financial and other markets, a congregation of industrial complexes or a combination of these reasons. The discussion below will examine the concept in more detail.

4.2.2 Urban Primacy

Urban Primacy is the domination of a country's hierarchy by a single city.³²⁰ Mark Jefferson early work conceptualized the idea of city primacy as one of supereminence and leadership that is borne out of large size, a high level of commerce and overall national influence.³²¹ He described a primate city as "disproportionately large and exceptionally expressive of natural capacity and feeling". His inference was made from a study of London (Britain), Copenhagen, and Mexico City. The "Law of the Capitals", he said, stipulates that the largest city will be super-eminent, both in size and in national influence. "All over the world it is the Law of the Capitals that the largest city shall be super-eminent, and not merely in size, but in

demographic movement to Lagos may be, it is a prosperous city and a major contributor to national wealth, although portraying a paradox of booming economic activities and industrial growth on one hand, and a sharp inadequacy of social amenities on the other hand: M. Gandy, "Planning, Anti-Planning and the Infrastructure Crisis in Metropolitan Lagos (2006) 43(2) Urban Studies 371; Kasarda & Crenshaw, *supra*, note 248.

³²⁰ M. Jefferson, *supra*, note 248.

³²¹ *Ibid.* Subsequent work by Galiani & Kim in the Americas affirms Jefferson's "laws of capitals". They found that in Mexico, Argentina, and Brazil, primacy is caused by political centralization that places greater premium on the welfare of residents of capital cities. By contrast, in the United States, capital cities are intentionally located in small towns and rural areas in geographically central locations, while large urban centres do not have disproportionate political advantages. National and state expenditures on infrastructure such as roads, highways, and education are often biased toward rural areas and small towns and this fosters the growth of smaller communities: S. Galiani & S. Kim, "Political Centralization and Urban Primacy: Evidence from National and Provincial Capitals in the Americas" in D.L. Costa & N.R. Lamoreaux, eds., *Understanding Long-Run Economic Growth: Geography, Institutions, and the Knowledge Economy* (University of Chicago Press, U.S. 2011) 121, Online: <http://www.nber.org/books/cost10-1>

national influence” As later authors have expressed it, dominance, especially in terms of population size, is central to primacy.³²²

Jefferson expressed the belief that the attraction to cities is sometimes due to advantageous locations “on lines of communication” (like New Orleans at that time), or in natural crops (as had Chicago, Seattle, and Pittsburgh in the U.S.), or in the innovativeness of ideas (like Detroit), or a combination of these. The actual factors would vary from city to city, and that therefore cities’ individual growth rates would vary.³²³ Although there is reservation over some portions of Jefferson’s theory (expressed in the footnotes), the idea of primacy, and descriptions of its usual incidents and peculiar features is very sound.³²⁴ The theory has assisted modern understanding of primate cities as hosts of the core financial, political, cultural, economic, and major transportation resources in a country.³²⁵ It enables a proper understanding of the evolution and characteristics of an inordinately dominant city like Lagos. Ilesanmi summarizes primacy as the demographic, economic, social and political dominance of one city over all others within an urban system.³²⁶

Arnold Linsky who built upon Jefferson’s theory, found from empirical analysis that former colonial cities tend to have a high primacy. He also inferred that primacy is characteristic

³²² J.D. Kasarda & E. Crenshaw, *supra*, note 248.

³²³ Jefferson, *supra*, note 242.

³²⁴ Jefferson’s opinion that the primate city contributes to the unification of a country is acceptable with some reserve. Whilst it is true that migrants usually retain contacts with their roots, people migrate primarily for personal, usually economic reasons. Their coming together, although ideally a melting pot of diverse cultures, does sometimes lead to ethnocentrism and social alienation, especially in a culturally diverse place, as Mabogunje rightfully observed. The same reserve applies to Jefferson’s theory that primacy of a leading city is an earmark of intense nationalism of city-born dwellers. Besides, his frequent references to the largeness of primate cities must surely mean population size, and not geographical size, as come megacities, notably Lagos, are tiny and occupy a very small comparative space and yet host some of the largest populations.

³²⁵ Primate cities exist in most countries and such cities include Istanbul (Turkey), Moscow (Russia) Seoul (South Korea), Jakarta (Indonesia), Tokyo (Japan). But countries such as the U.S. are noted to have more evenly distributed power between cities, as mentioned in note 315, *supra*.

³²⁶ A.O. Ilesanmi, “Urban Sustainability in the Context of Lagos Mega-city” (2010) 3(10)

of countries with low per capita income, that are highly dependent on exports, that have a colonial history, and those that have a fast rate of population growth.³²⁷ Out of his findings, two are true of Lagos: its colonial history, and a fast rate of population growth.

Lagos has emerged as Nigeria's primate city.³²⁸ Its primacy status emanated from its dominance in commerce and huge contributions to the national economy, and its sheer population size. Its primacy originated when Nigeria's colonial administrators made Lagos the capital city of Nigeria during their occupation of Nigeria (from 1861 until 1960), a position that it maintained until 1991. During that period, major governmental departments, financial markets, regulators, and multinational corporations were located in Lagos. These include the Central Bank, the Nigerian Stock Exchange, Securities and Exchange Commission, nearly all commercial and merchant bank headquarters, corporate Registrars of blue chip companies, and multinational corporations especially the petroleum exploration companies which are at the core of the country's economy.

The strategic location of Lagos has also predisposed it to primacy. As mentioned earlier in this chapter, the early European settlers favored Lagos on account of its strategic location close to the Atlantic Ocean and with the presence of sea and air ports that facilitate trade with the rest of the world. Major sea and airports are located in Lagos and remain functional there. With all these features of Lagos, it is understandable that people have flocked to this remarkable, tiny coastal city. Therefore the factors that have enhanced Lagos' primacy status include its being the former capital, its strategic location, its overwhelming industrial presence, and the location of major government departments, corporate offices, industries, and financial markets within it.

³²⁷ A. Linsky, "Some Generalisations Concerning Primate Cities" (1965) 55(3) *Annals of the Association of American Geographers* 506.

³²⁸ Wikipedia, *List of Primate Cities*, online: http://en.wikipedia.org/wiki/list_of_primate_cities

Cumulatively, and in conjunction with industrial development, these features of the Lagos experience have contributed to population growth and the accompanying pressures on water supply and security.

Lagos industrial development has also been remarkable, and a further attraction to people. As far back as the 1960s, Muench & Muench who did a comparison with Ibadan, another city in southwest Nigeria, described the “... much greater industrialization of Lagos...” and that a single one of its estates, the Ikeja industrial estate already had 10,000 employees at that time.³²⁹ Lagos currently hosts a very large proportion of industry in Nigeria, including large, small and medium enterprises, as discussed earlier in Chapter 1. Overall, Lagos makes the single, largest contribution to the national economy. It is no wonder that it has been estimated that if Nigeria were ultimately to become a major emerging market as predicted, Lagos would be central to that strategy. It would remain “at the core of Nigeria’s growth success”.³³⁰

Closely related to urban primacy is urban bias, which is the tendency for policies to prioritize urban areas and to encourage the location of major financial or economic instruments in a single urban area. The term is discussed below.

4.2.3 Urban Bias

Experts have observed the tendency for policies to favor larger cities, and to encourage the location of industries within them. In China for example, plants in big cities receive preferential access to the latest technology, the best managers, funding, and export-import

³²⁹ L.H. Muench & C.Z. Muench, “Planning and Anti-planning in Nigeria: Lagos and Ibadan” (1968) 34(6) *Journal of the American Institute of Planners* 374, at pg. 376.

³³⁰ Razia Khan, “From BRICS to BRINCS: Lagos Holds the Key” Presentation made at the 6th Lagos State Economic Summit “Ehingbeti 2012” at Eko Hotel, on April 23-25 2012.

licenses.³³¹ Scholars also note a tendency to centralize import and export licensing, financial markets, and heavy industries in large or primate cities. Lipton who proposed the urban bias theory also argues that resource allocation in less developed countries has reflected urban priorities rather than equity or efficiency considerations, drawing on the glaring disparities in income and capital investments between urban and rural areas to support his theory.³³² Economic policy also tends to centralize import and export licensing and financial markets in primate cities.

Urbanization in Lagos may have been encouraged by national policies that have historically preferred Lagos and that hint at a measure of bias. The major governmental and financial regulators mentioned were located in Lagos, although some have now moved since the administrative capital moved to Abuja. Lagos was also the national administrative capital until 1991. Henderson remarks that the singular fact of a city's being a capital attracts people, and in his estimation, accounts for 25% of its enhanced population.³³³ That fact does seem to explain the influx to Lagos, although the precise percentage that is attributable to that status is not determinable.³³⁴ The concentration of major financial regulators and of industry in Lagos certainly hints as a level of subtle bias. The bias is probably motivated by the city's strategic coastal location, and its former capital status that in combination encouraged industry to concentrate in Lagos, and in consequence the city has grown industrially, making the major national contributions identified earlier.

³³¹ V. Henderson, "Urbanization in Developing Countries" (2002) 17(1) the World Bank Research Observer 89, at pg. 96.

³³² M. Lipton, *Why Poor People stay Poor: Urban Bias in World Development*, (Cambridge, Massachusetts, Harvard University Press 1977).

³³³ V. Henderson, *supra*, note 331, at pg.108.

³³⁴ Yet excessive concentration has a negative impact on economic growth rates as a result of soaring wages, high cost of living, and deteriorating quality of life: V. Henderson, *supra*, note 325. See also D.H Chun, & K.S. Lee, "Changing Location Patterns in Population and Employment in the Seoul Region" Report No. UDD-65, World Bank, Washington D.C. Online: www-wds.worldbank.org.

4.3 The Significance of Lagos

Cities promote industrialization, and ultimately enhance development. Jane Jacobs is the pioneer of theories about cities being engines of economic growth.³³⁵ Writing in the 1960s, she argued that cities are primary economic organs on the following premises: agriculture is only productive after it has incorporated many goods and services that are produced in cities; equipment to improve and change productivity in rural areas, as well as to introduce new work, come from cities; profoundly rural countries demonstrate the most unproductive agriculture, whereas the urbanized ones produce more abundant quantities of food; and agricultural production experiences exponential growth when cities grow. She cited Japan where in spite of farmers' industriousness in the 19th Century, food production was not sufficient, and importations were required to meet the local demand. With the introduction of modern technologies from cities however (fertilizers, refrigeration, and electricity), agricultural production rapidly increased such that by 1960, farms were exceeding the country's food supply needs. In her words, Japan "created rural productivity upon a foundation of city productivity".³³⁶ Scholars have built upon Jacob's formulations over the years.³³⁷ It is ironic that she wrote at a

³³⁵ J. Jacobs, *The Economy of Cities*, (Random House, New York, 1969).

³³⁶ Ibid.

³³⁷ Mabogunje classifies the benefits of cities into technological, social and economic benefits. Duranton opines that a city is not merely a location for economic growth, but the actual engine of growth. Leon also wrote affirmatively that cities, not the countryside, have for hundreds of years been centres and drivers of commercial and cultural life. Hoselitz who discussed primate cities in Asia found that they are the most important centres of cultural change especially in fields that affect economic development: A. Mabogunje, "The Case for Big Cities", supra, note 250; G. Duranton, "Urbanization, Urban Structure, and Growth", in J-M Huriot and J.F. Thisse, eds. *Economics of Cities: Theoretical Perspectives*, (Cambridge, Cambridge University Press, 2000) 290; D. Leon, "Cities, Urbanization and Health" (Editorial) (2008) 37 *International Journal of Epidemiology* 4; B.F. Hoselitz, "Urbanization and Economic Growth in Asia" (1957) 6 *Economic Development and Cultural Change* 42; M. Polese, "Cities and National Economic Growth: A Re-Appraisal" (2005) 42(8) *Urban Studies* 1429; J.M. Quigley, "Urban Diversity and Economic Growth" (1998) 12(2) *Journal of Economic Perspectives* 127.

time of popular agreement about the primacy of agriculture, but this very fact gives weight to her statements.³³⁸

A big city is indeed a sign of development and it facilitates the prudent allocation of resources during earlier stages of industrial growth. Lagos in Nigeria is an affirmation that cities are tools and mediums of economic growth. As a coastal state with sea ports, Lagos has been a natural gateway for international trade, and engages in international commercial transactions and carriage of goods by sea that has generated huge revenues for the country. The larger proportion of Nigeria's trade is routed through the sea, and its economy accounts for 70% of the maritime trade in the West African sub-region. Lagos contributes 40% of the country's non-oil national Gross Domestic Product, and is thus a major contributor to national wealth.³³⁹ According to recent reports, Nigeria is now officially Africa's biggest economy (USD 503bn) on the basis of a revised computation of its Gross Domestic Product that took into account revenues from its newest business sectors, that is, the film industry, music, telecommunications, and e-commerce industries.³⁴⁰ A very large proportion of these industries are located in Lagos. Lagos also contributes directly to Nigeria's economy by being the locus of manufacturing and financial services for the nation, and facilitates trade and human interactions with the rest of the world. The extent of Lagos' contribution to national growth was discussed in Chapter 1. On account of

³³⁸ There is however a dichotomy between economists/historians on one hand, and public health practitioners on the other hand, about the real significance of cities. Whereas economists and historians tend to give credit to cities for contributing in measurable terms to economic development, the rampant and pervasive outbreaks of epidemics in the 19th century particularly led public health practitioners to associate cities with poor sanitation and contaminated water. But it hardly seems fair to blame cities because of a limited understanding of the etiology of disease at this time. See D. Leon, "Cities, Urbanization and Health" (Editorial) (2008) 37 *International Journal of Epidemiology* 4.

³³⁹ B.E.A. Ogbojafor, O.L. Kuye, & G.C. Alaneme. "Concession as a Strategic Tool for Ports Efficiency: An Assessment of the Nigerian Ports" (2012) 1(4) *American Journal of Business and Management* 214. See also Femi Olokesusi, "Lagos: The Challenges and Opportunities of an Emergent African Mega City" Paper Presented at the NISER Seminar Series on 5 July 2011.

³⁴⁰ The Guardian, *Hello Nollywood: How Nigeria Became Africa's biggest Economy Overnight*, Online: <http://www.theguardian.com>

economic activities in Lagos in particular, Nigeria has become a worthy emerging market, according to the United Nations.³⁴¹

Cities are truly engines of economic growth but when they become too big, they are fraught with problems. The myriad of disturbing environmental problems associated with urbanization in many cities, especially pressure on water and the resultant pollution especially in developing nations, appear to challenge the viability of cities as mediums of growth which Jacobs and other scholars discussed earlier argue for. The following discussion elaborates more on the problems.

4.4 Problems of Large Cities

In spite of the demonstrable contributions of cities to economic development, and that of Lagos in particular, the uncontrolled growth of these agglomerations has the potential to cause a horde of social and environmental problems. Large cities often constitute fertile grounds for slum growth, which in turn breed crime and violence. As Harris expresses it, they tend to become concentrations of disorder and deprivation rather than opportunities for economic development, as the urban poor spread epidemics, while street vendors and overcrowded streets deprive owners of the pleasure of using private vehicles.³⁴² They place tremendous pressure on pre-existing infrastructure, especially water.³⁴³

³⁴¹ UNHABITAT, *State of African Cities (2010)* at pg. 16. Angola and Ethiopia are other such emerging markets, whilst South Africa, Ghana, Tanzania, Uganda, and Cote D'Ivoire have demonstrated sustained economic growth with emerging middle classes that create considerable consumer markets in the global economy.

³⁴² N. Harris, "Urbanization, Economic Development and Policy in Developing Countries" (1990) at pg. 16 (Available online).

³⁴³ Henderson also argues that excessive concentration in a city significantly reduces economic growth rates as a result of soaring wages and a high cost of land and infrastructure which is quite apart from a steadily deteriorating quality of life with population increase. Such cities ultimately become unattractive to foreign investment, making it difficult for them to compete favourably in world markets. And as these problems emerge and escalate, resources are

More importantly and significantly for this research, these crowded agglomerations cause “hydra-headed” environmental problems of water scarcity, and inadequate water distribution and transmission, while the populations generate unmanageable quantities of solid waste and sewage.³⁴⁴ These environmental problems are examined in more detail below.

4.4.1 Water Shortage

Water supply shortage is an immediate and evident problem. An ever-increasing mass of people is bound to exhaust the available water supply even where there are spirited efforts to increase sources of water. Foster observes that dwindling and easily exhausted water resources in large cities usually compel a resort to alternative sources of water such as importations from locations that are costly and beyond the urban limits in order to meet the water needs of the growing populations.³⁴⁵

Water supply shortage is a perennial problem for Lagos. Unable to use most of its own surface waters on account of pollution and salinity, as mentioned in Chapter 3, its major surface water source is the Ogun River in Akute, Ogun State, a bordering state. The Water Corporation has consistently but unsuccessfully struggled to increase capacity and to find new water sources to meet the needs of the ever-increasing numbers of residents into that tiny coastal city. In spite of its efforts to increase capacity and to find alternative sources of water however, the city’s ever

increasingly diverted to tackle the unexpected negative results of an uncontrolled urbanization process: V. Henderson, *supra*, note 331, at pgs. 104-105.

³⁴⁴ S.O. Oyegoke, A.O. Adeyemi, & A.O. Sojobi, “The Challenges of Water Supply for a Megacity: A Case Study of Lagos Metropolis” (2012) 3(2) *Int. Journal of Scientific & Engineering Research* 1. See also A.D. Jiboye, “Urbanization Challenges and Housing Delivery in Nigeria: The Need for an Effective Policy Framework for Sustainable Development” (2011) *Int. Review of Social Sciences and Humanities* 176.

³⁴⁵ S.S.D. Foster, “Impacts of Urbanisation on Groundwater”, UNESCO-IHP III International Symposium, URBAN WATER 88: FR Germany- The Netherlands (1988), Available Online.

growing population renders these series of capacity expansions inadequate after a few years and the Corporation currently meets only a fraction of water demand.³⁴⁶

4.4.2 Vast Generation of Waste

Mabogunje observes that the rapid growth of cities and the large population sprawls that ensue are responsible for municipalities' inability to deal effectively with solid wastes and wastewater generated from anthropogenic activities. In particular, the improper handling of toxic wastewater as shown by the loading of water bodies from the municipality, and by permitting industries to eject untreated effluents, are a potential source of health problems in epidemic proportions.³⁴⁷ Speaking within the same context, Foster similarly notes that urbanization, which incorporates the "inseparable" industrial development component with the attendant generation of large quantities of waste and sewage, has severe polluting impacts on the hydrological cycle.³⁴⁸ These statements are typified in Lagos.

4.4.3 Groundwater Pollution by Solid Waste and Wastewater

The effects of urbanization on groundwater quality, which are the most pertinent for this research, are the most devastating. Scholars have both historically and up till the present time affirmed that urbanization alters the natural chemical balance of groundwater, as well as infuses it with harmful bacterial contamination. Eisen & Anderson who researched in Milwaukee, Wisconsin, United States, found that pollution to groundwater occurs from the infiltration of surface water polluted by municipal and industrial wastes, as well as from leakages in sewer

³⁴⁶ A.U. Oteri, "Coastal Groundwater Resource-Abstraction, Quality and Related Environmental Concerns: Lagos State Case Study" Presented at LSWRC Workshop, (2013); Lagos Water Corporation, *Lagos Water Supply Plan 2010-2020* (2012).

³⁴⁷ A.L. Mabogunje, *supra*, note 250, at pg. 25; Foster, *supra*, note 345.

³⁴⁸ S.S.D. Foster, *supra*, note 345.

lines. Graniel et al researched in Merida, Yucatan, Mexico, a city with 100% dependency on groundwater. They sampled wells and boreholes and found that the areas with the highest contamination coincide with urbanization. Carlson et al also tested groundwater wells in Arizona, United States, and established that urban storm runoff (used in recharging groundwater) negatively affects groundwater quality with “anomalously high” concentrations of harmful chemical contaminants.³⁴⁹

In Lagos, pollution is occurring both from wastewater and solid waste generated by the vast population, which is an estimated 350 million gallons daily.³⁵⁰ The large population which is involved in myriad domestic, commercial and industrial activities has combined to degrade the city’s groundwater resource.

Wastewater is generated both from domestic sources by the teeming Lagos residents, and also from industrial facilities. The concentration of industries and their intensive industrial processes give rise to a vast quantum of wastewater daily. Industrial wastewater is a particular culprit because the compounds from normal production processes usually include lubricants, solvents and disinfectants, and also contain heavy metals and chlorinated hydrocarbons in the sewage.³⁵¹ These effluents are non-biodegradable and carcinogenic compounds.³⁵² Industrialists

³⁴⁹ C. Eisen & M.P. Anderson, “The Effects of Urbanization on Groundwater Quality: A Case Study” (1979) 17(5) GROUNDWATER 456; C.E. Graniel, L.B. Morris, & J.J. Carillo-Rivera, “Effects of Urbanization on Groundwater Resources of Merida, Yucatan, Mexico” (1991) 37(4) Environmental Geology 303; M. Carlson, K. Lohse, J. McIntosh & J. McLain, “Impacts of Urbanization on Groundwater Quality and Recharge in a Semi-Arid Alluvial Basin” (2011) 409(1-2) Journal of Hydrology 196.

³⁵⁰ Lagos Wastewater Management Office, *Institutional, Regulatory, and Legal Framework*, supra, note 203.

³⁵¹ A. Cavallaro, C. Corradi, G. de Felice, and P. Grassi, ‘Underground Water Pollution in Milan and Province by Industrial Chlorinated Organic Compounds’, Proceedings of WRC-WHO Conf. *Effects of Land Use on Fresh Waters*, (1985); A.R. Lawrence & S.S.D. Foster, “The Pollution Threat from Agricultural Pesticides and Industrial Solvents” (1987) BGS Hydrogeology Research Report; B.C. Zoetman, E. De Greef, & F.J.J. Brinkmann, “Persistency of Organic Contaminants in Groundwater: Lessons from Soil Pollution Incidents in the Netherlands” (1981) 17 Studies Environ Sci. 465.

³⁵² Ritter et al, “Sources, Pathways and Relative Risks of Contaminants in Surface water and Groundwater: A Perspective Prepared for the Walkerton Inquiry” (2002) 65(1) J Toxicol Environ Health A. 1.

habitually discharge it in its raw untreated state into the environment, a regrettable but prevalent culture within the industrial sector in Lagos. The discharges are considerably high in assorted toxic, caustic, and carcinogenic chemicals and reported to have migrated into groundwater. Empirical findings in Lagos have proved that the first and second aquifers have become so highly polluted in the industrial areas that resort now is now being made to the third aquifer.³⁵³ Details and ramifications of the pollution including the problem of corporate apathy and non-compliance are discussed in the next chapter.

Domestic wastewater or sewage from the large population is ejected by diverse on-site sanitation methods in Lagos. They are mostly not centralized or collected for treatment, and thus pose a risk to groundwater, particularly where disinfectants and deodorants are present in it, as these are generally problematic compounds in sewage.³⁵⁴ The extent of the problem is also elaborated in the next chapter.

The huge population also generates immense amounts of assorted solid wastes that are discharged into open waste dumpsites. The disposal of municipal solid wastes is another problem to groundwater that is aggravated by urbanization. This is particularly so because the waste sites are open sites that are uncontrolled and unsanitary, and contain diverse wastes that are all disposed in the same generic manner. The details and implications of this method of waste disposal form part of the discussion in the next Chapter.

³⁵³ K. Olayinka, & B. Alo, "Studies on Industrial Pollution in Nigeria: The Effect of Textile Effluents on the Quality of Groundwater in Some Parts of Lagos" (2004) 3(1) *Nigerian Journal of Health and Biomedical Sciences*. See also: D. Eni, J. Obiefuna, C. Oko, & I. Ekwok, "Impact of Urbanization on Subsurface Water Quality in Calabar Municipality Nigeria" (2011) 1(10) *International Journal of Humanities & Social Science* 167.

³⁵⁴ K.M. Baxter, "The Effects of the Disposal of Sewage Effluents on Groundwater Quality in the United Kingdom" (1982) 86 *Water Services* 219.

4.5 Summary

In summary, urbanization has a dire environmental impact. In Lagos, the problems that urbanization has created for groundwater as presented in the foregoing discussion have made it necessary for solutions to be thoughtfully conceived to make for a sustainable groundwater resource. It has become apparent that the population is too high and so purposeful regulatory measures need to be configured to safeguard its groundwater. In this regard, it is pertinent to note Barbier's comment that "Rapid population growth *and uneven distribution in some areas* undoubtedly complicates natural resource management..."³⁵⁵

Although the implications of population remains a controversial issue from the perspectives of demographers, agriculturalists, economists and feminists discussed earlier in this chapter, international Conferences have generally agreed that a modest population is required for sustainable development.³⁵⁶ Accordingly, a population policy ought ideally to be an integral part of economic development. Maintaining environmental integrity depends on reducing rates of population growth in the developing world. In an ecological perspective, sustainability must involve limits on population and consumption levels, premised on the finiteness of the planet.³⁵⁷

The Nigerian Policy on the Environment recognizes that "Environmental sustainability will be impossible unless human numbers and resource demands level off within the carrying capacity of the Earth".³⁵⁸ Policies developed at important international Conferences have also

³⁵⁵ E.B. Barbier, "The Concept of Sustainable Economic Development (1987) 14(2) Environmental Conservation 101. The emphasis in italics is the Researcher's.

³⁵⁶ World Commission on Environment and Development, *Our Common Future* (Oxford University Press New York, 1987); Jim McNeill, "The Forgotten Imperatives of Sustainable Development", Paper Presented at Pace University (2006).

³⁵⁷ J.M. Harris, "Sustainability and Sustainable Development", International Society for Ecological Economics, Internet Encyclopaedia of Ecological Economics (available online); See also the international discussions at note 111, *supra*.

³⁵⁸ Federal Environmental Protection Agency, *Policy on the Environment*, at S. 4 (1).

clarified that there is inter connection and a synergistic relationship between demographical trends and sustainable development.³⁵⁹ The United Nations acknowledges that rapid urban population growth and industrialization are placing severe strains on water resources of many affected cities. Large urban agglomerations located around costal zones (like Lagos) cause pollution from municipal and industrial discharges, and this, combined with over exploitation of available water threatens the marine environment and the supply of freshwater resources. Agenda 21 states that in order to tackle these, strategies must be in place to reduce the adverse impact on the environment of human activities and vice versa.³⁶⁰ It urges States to commit to considering population trends and projections in national and urban development strategies and policies. With proactive planning the opportunities presented by demographical change including migration should be seized, as well as the challenges addressed.³⁶¹

Law will play a significant role in this process by establishing and enforcing the appropriate governance structures which include policies and legal rules which aim at reducing the overall impact of human activities on the environment by preventing environmental degradation, as well as ensuring the remediation of any degradation that occurs. Governance also includes installing appropriate institutions and mechanisms for civic compliance with laws. As discussed in Chapter 2, Agenda 21 clarifies that aquifer pollution can be prevented through regulation of toxic substances that infiltrate into the ground and establishing of protection zones in groundwater recharge and abstraction areas.³⁶² The rules will be based on a foundation of legal principles of prevention, precaution, environmental impact assessment, and polluter pays, which were

³⁵⁹ Agenda 21, Article 5

³⁶⁰ Ibid

³⁶¹ Ibid. However, although formulating recommendations to tackle the social phenomena of urbanization and overpopulation in the form of population contraction or industrial de-concentration strategies is desirable, such discourse is beyond the scope of this law thesis. This Chapter has highlighted the problem in order to clarify the social context of the groundwater pollution problem in Lagos as a highly urbanized and over-populated, primate megacity.

³⁶² Agenda 21, Arts 18.35 & 18.40.

discussed in Chapter 2. The likely regulatory measures are discussed in more detail in Chapters 6 and 7.

Urbanization is inevitable within the development process. As John Clos, argues “the only way to avoid urbanization is to avoid development.”³⁶³ And since the world is rapidly urbanizing, cities are where the battle for sustainable development will be either won or lost.³⁶⁴ As the United Nations succinctly wrapped it, “Sustainable urbanization is key to successful development”.³⁶⁵ The challenge is to identify and enforce a regulatory regime which ensures that the effects of human activities do not continue to harm the environment, thus making urbanization sustainable. A rapidly growing city can be well managed so that it overcomes major environmental problems like groundwater pollution.

4.6 Conclusion

The discussion in this chapter clarified that urbanization is essential because it signifies the growth of cities from which many benefits, and ultimately economic development, accrue. Relevant theories of urbanization, population growth, and the economic importance of cities like Lagos were examined to explain the city’s over-urbanization whose population derives both from migration and from natural population increases across the country. It affirmed arguments that cities are the progenitors of development, emphasizing the importance of cities in terms of their contributions to economic development, and highlighted Lagos’s enviable contributions to Nigeria’s development. Through the industrial activities of this large city, Lagos has contributed the most to the national economy, and accomplished an enviable status as the economic nucleus

³⁶³ J. Clos, Comment made at the Seventh Session of the Open Working Group on Sustainable Development (OWG-7). See also A. K. Bujones, “Building Sustainable Cities: A Theme of Convergence in the Post 2015 Debate?” Online: <http://cic.nyu.edu>.

³⁶⁴ Ibid. Co-Chair’s Summary Bullet Point for OWG-7.

³⁶⁵ United Nations, *World Urbanization Prospects, the 2014 Revision*, available online.

of Nigeria, and the country's primate city. It showed that although urbanization is important, it can become antithetical to the very development that it enables when a city's population exceeds its capacity to manage the demographical transition efficiently and sustainably. This happens, as in the case of Lagos, when there is no concomitant development of complementary infrastructure to cope with the upsurge, and a tremendous burden is placed on existing structures, with the ensuing degradation to groundwater.

The next chapter will now review the actual status and implications of groundwater pollution by solid waste and wastewater which is the result of over-urbanization in Lagos.

CHAPTER 5

PROBLEMS CONFRONTING GROUNDWATER IN LAGOS

This chapter aims to highlight the pollution that is occurring to groundwater from municipal solid waste and wastewater as proved both by empirical studies and by field work undertaken by the Researcher in Lagos. Owing to the distinction between the two separate streams of waste that pollute groundwater, the chapter is divided into two parts: the first part will focus on solid waste management and will be preceded by definitions of important terms and a brief overview of solid waste management in more developed countries. It will continue with the summary of the field work undertaken in Lagos on the status of solid waste pollution of groundwater. The second part will review the wastewater problem which issues from both domestic and industrial sources, and the field work undertaken in Lagos on the extent of wastewater pollution of groundwater.

PART I: The Problem of Solid Waste in Lagos

5.1 A Conceptualization of Solid Waste

In very general terms, waste is simply used material that is discarded. The United Nations describes municipal waste as “all domestic refuse and non-hazardous wastes such as commercial and institutional wastes, street sweepings, and construction debris”.³⁶⁶ In view of the many potential reuses of waste, the definition of waste has rightly been described as very subjective, because what represents waste to one person may be a valuable resource to another.³⁶⁷ An

³⁶⁶ United Nations Conference on Environment and Development, (Agenda 21) Rio de Janeiro, Brazil, 3rd - 14th June 1992; G.E. Louis, “A Historical Context of Municipal Solid Waste Management in the United States” (2004) 22 Waste Manage Res 306.

³⁶⁷ P.T. Williams, *Waste Treatment and Disposal* (London: John Wiley & Sons, 2013), at pg. 63. Surprisingly, the European Union defines waste as ‘any substance or object which the holder discards or intends or is required to

acceptable definition should reflect its intrinsic or potential value as a useful material within a future process. Therefore it is more helpful to define solid waste as material that is no longer desirable to the user/generator in its present form.³⁶⁸

Waste generation is a natural part of human life. Historically, the management of solid waste did not present any disposal difficulties. From the early civilizations, human waste was simply buried in the earth in compliance with Mosaic instructions.³⁶⁹ Later, waste management strategies focused on removing waste from habitable areas in order to preserve public health. With a better understanding of the hazards of untreated waste, the sanitary landfill was devised.³⁷⁰ Currently, the problems associated with waste management have arisen on account of population increases, increased density, urban sprawls, and the generation of more complex waste types. The generation, composition, and volume of waste are determined by a number of factors including the level of development, socio-economic indices, climatic and geographical conditions, and the frequency of collection.³⁷¹

discard'. This appears to be a rather simplistic definition that does not acknowledge the intrinsic value in waste, and is baffling, considering the giant strides achieved within Europe and all over the developed world in recognizing wastes as 'hidden' resources. It is even more unexpected within the EU's elaborate waste legislation framework. However, considering the EU's waste hierarchy which emphasizes waste minimization and recycling, and that landfilling of waste should be a last resort for waste that is totally useless, this definition of waste could be understood in the sense of objects that have undergone all treatment and are now totally worthless: EU Directive 2008/98/EC on waste of November 2008.

³⁶⁸ G.E. Louis, *supra*, note 366.

³⁶⁹ The Bible laid out simple instructions to "designate a place outside the camp where you can go to relieve yourself. As part of your equipment have something to dig with, and when you relieve yourself, dig a hole and cover up your excrement": The Holy Bible, (New International Version) Deuteronomy 23, vs. 12-13. Also cited by D.G. Wilson in "A Brief History of Solid Waste Management" (1976) 9 *Int. Journal of Environmental Studies* 123.

³⁷⁰ A.V. Shekdar, "Sustainable Solid Waste Management: An Integrated Approach for Asian Countries" (2009) 29(4) *Waste Management* 1438.

³⁷¹ C. Collivgnarelli, S. Sorlini, & M. Vaccari, "Solid Wastes Management in Developing Countries", ISWA World Congress, October 17th -21st 2004; M.R.A. Moghadam, N. Mokhtarani, & B. Mokhtarani, "Municipal Solid Waste Management in Rasht City, Iran" (2009) 29 *Waste Management* 485.

5.1.1 Sources and Composition of Solid Waste ³⁷²

Sources	Typical Waste Generators	Types of Solid Waste
Residential	Single & multifamily dwellings	Food wastes, paper, cardboard, plastics, textiles, glass, metals, ashes, special wastes (bulky items, consumer electronics, batteries, oil, and tires) and household hazardous wastes
Commercial	Stores, hotels, restaurants, markets, office buildings	Paper, cardboard, plastics, wood, food wastes, glass, metals, special wastes, hazardous wastes
Institutional	Schools, government centers, hospitals, prisons	Paper, cardboard, plastics, wood, food wastes, glass, metals, special wastes, hazardous wastes
Municipal Services	Street cleaning, landscaping, parks, beaches, recreational areas	Street sweepings, landscape and tree trimmings, general wastes from parks, beaches and other recreational areas

Source: Shekdar, (2009), note 370

5.1.2 Move from Landfill-Based to Resource-Based Waste Management

As mentioned earlier, waste management efforts were originally focused on preserving public health, and so it was important to move waste away from human habitations.³⁷³ It has since been understood that there is great utility in the many materials that are recoverable from waste through chemical and biological processes. Technological processes now enable the recovery of useful material from a broad range of used articles including paper, plastics, cans, etc., that would previously have been disposed of as garbage, hence the distinguishing of ‘waste’ from ‘garbage’. The meaning of waste has undertaken a dramatic change/alteration at least in managerial, scientific and scholarly circles with the acceptance of waste as material that is still

³⁷² United Nations Environment Programme, cited by A.V. Shekdar in “Sustainable Solid Waste Management, *supra*, note 370.

³⁷³ *Ibid.*

useful in a different state.³⁷⁴ Thus there has been a major shift away from the policy of moving waste away from human habitations, to policies and strategies aimed at the full recovery of useful materials from all types of waste, as well as to achieve a substantial reduction in the quantity of waste that requires disposal at landfills. This move from landfill-based waste management to resource-based waste management places premium on recycle and recovery, and on the diversion of waste away from landfills. Waste management systems particularly in the developed world have become complex, requiring a full understanding of the composition of waste for proper segregation and diversion to the appropriate unit for recovery.³⁷⁵ Solid waste management now comprises many stages, including waste generation, separation, collection, transfer/transportation, storage/processing, and final disposal.³⁷⁶

5.2 Municipal Solid Waste Management in Lagos

Solid waste management in Lagos is undertaken by the Lagos State Waste Management Authority (LAWMA).³⁷⁷ Open dumping of waste is the official method of waste management in

³⁷⁴ S.J. Burnley, "A Review of Municipal Solid Waste Composition in the United Kingdom" (2007) 10 Waste Management 1274.

³⁷⁵ Ibid.

³⁷⁶ G. Tchobanoglous, H. Theison, & A.S. Vigil, *Integrated Solid Waste Management* (McGraw-Hill International Edition 1993). It is worth mentioning that the advancements that developed countries presently record was preceded by ignorance, and at one point, by an "age of sanitary darkness" about the proper handling of waste, which led to epidemics across Europe and the United States. And although the developed world now has a firm grip on the proper management of waste, crises have sprung up now and again, instigated by increasing quantities and complexities of waste. For instance, in 2008, in Naples, Italy, waste collectors stopped picking up waste when the landfills became full, and this resulted in mountains of solid waste accumulating in the streets for months, and led to fierce protests by residents. Around the world, landfills are reaching their full capacity, and requiring additional land to be sourced from a limited supply. It is thus accurate to say that solid waste management is a continuing challenge for both developed and developing countries. Comparing the past ignorance with the present enlightenment however, there is hope that Lagos will also attain a comparably advanced level of waste management in the future: M. Melosi, *Garbage in the Cities: Refuse Reform and the Environment: 1880-1980* (Texas A. & M. Press 1981); G. Moller, *Solid Waste Management in the Developed and Developing World*, Principles of Sustainability Chapter 3: Culture of Waste. University of Idaho Online: <http://vimeo.com/29337858>; United Nations Human Settlements Programme (UN-HABITAT), *Solid Waste Management in the World's Cities. Water and Sanitation in the World's Cities* (Earthscan Ltd, Dunstan House, London 2010).

³⁷⁷ LAWMA is established and authorized to undertake waste management functions by the Lagos State Waste Management Authority Act 2007. LAWMA was previously known as the Lagos State Refuse Disposal Board, an

Lagos. Lagos operates a basic system of open dumping of its municipal solid waste. The city has three major official waste dumps, the largest and most significant of which is *Olushosun*, which measures 42 hectares and is located in Ojota area within the Kosofe Local Government Area of the Lagos metropolis. The second dump is the *Solous* Dump, which measures three hectares and is located in Igando within Alimosho Local Government area of the state along. The third dump is in Abule Egba, and is 10.5 hectares, and also located in Alimosho Local Government Area.³⁷⁸

The city also grapples with illegal dumpsites which are vacant parcels of land that people have unlawfully converted into dumpsites.³⁷⁹

agency created in 1977 by Lagos State Edict No 9 of 1977, and remained so until 1991 when the present name was configured: A. Lasisi, "Leachate and Groundwater Quality in Lagos State, Nigeria" A Paper presented at a Seminar for Officers of Lagos State Environmental Protection Agency, (Available online).

³⁷⁸ F.B. Olorunfemi, "Land Development and Current Practices in Lagos Metropolis, Nigeria" (2011) 4(12) *Journal of Geography and Regional Planning* 656. Before 1996, Lagos had five waste dumps which were originally open swamps that were reclaimed with the wastes dumped into them. They were located in: Gbagada in Kosofe Local Government; Isolo in Oshodi/Isolo Local Government; Adeniji Adele (Pelewura) in Lagos Island Local Government; Achakpo in Ajeromi/Ifelodun Local Government; and Ojota in Odo Iya Alaro Local Government, all within the Lagos metropolis. They were all closed in 1996: Lasisi, *supra*, note 377.

³⁷⁹ These unofficial or "illegal" dumpsites are located in Ojota, Ijesha, Okota, and Bariga within Lagos metropolis. Some researchers indicate the presence of additional unofficial dumps around the metropolis: Lagos State Waste Management Authority (LAWMA), Correspondence between LAWMA and Lagos State Environmental Protection Agency (LASEPA) on 11th September 2012; O. Adeyemi, O.B. Oloyede & O.T. Oladiji, "Physico-chemical and Microbial Characteristics of Leachate-Contaminated Groundwater" (2007) 2 *Asian Journal of Biochemistry* 34. In previous years, the city had a formidable waste management problem that showed up as mountains of refuse, blocked canals and gutters, and littered streets. Recognizing this problem, the state government sought World Bank assistance to improve its waste management systems. The state inaugurated the Lagos Metropolitan Development Governance Program (LMDGP) whose terms of reference included clearing the backlog of waste. The mountains of waste have since disappeared signifying a better collection system, although indiscriminate dumping persists within the Lagos Island especially, while open dumping is fraught with problems and threatening to groundwater: Lagos State Government, *Lagos Metropolitan Development & Governance Project (LMDGP Report) Solid Waste Management Component Environmental & Social Impact Assessment*, Final Report (2009).

5.2.1 Profile of Lagos State's Waste Dumps

Dumpsite	Size	Depth	Year Commissioned	Scheduled Closure Date	Estimate of Waste at Site (million tons)
Olushosun	42 ha	8-15m	1992	2014	1.7
Abule-Egba	10 ha	12m	1983	2009	1.3
Solous	5ha	9m	1981	2008	1.4

Source: Lagos State Government, *Lagos Metropolitan Development & Governance Project (LMDGP), Solid Waste Management Component Environmental & Social Impact Assessment*, Final Report (2009).

5.2.2 Volume of Waste Generated

Daily	9,000 Metric Tons per Day (MTPD)
Weekly	63,000 Metric Tons per Week (MTPW)
Monthly	279,000 Metric Tons per Month (MTPM)

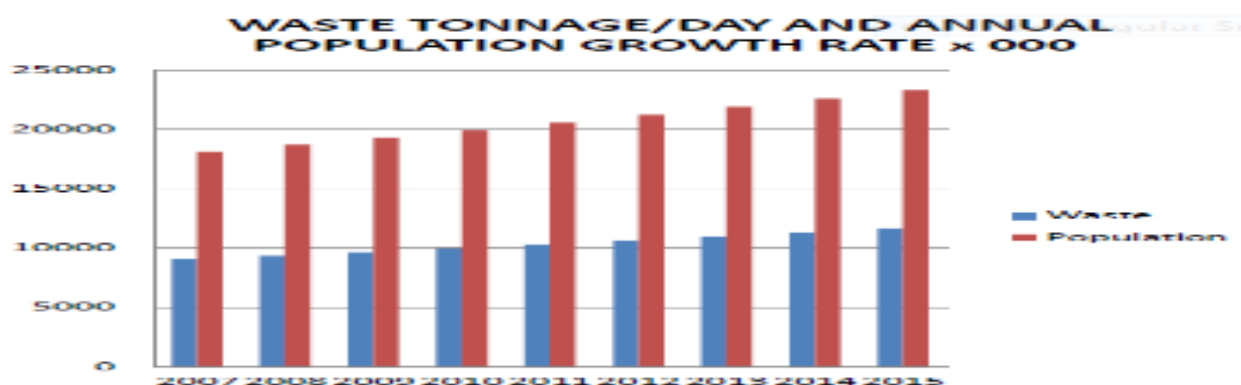
5.2.3 Composition of Waste in Waste Stream:

Waste Type	% of Total Waste
------------	------------------

Organic	60%
Paper	10%
Glass	5%
Metal	5%
Plastic	15%
Other	5%

Source: Correspondence between LAWMA and LASEPA dated 11th September 2012

Lagos residents currently generate 10,000 metric tons of waste daily, at an average rate of 0.5kg of waste per individual.³⁸⁰ Ayodele & Simeon report that in 2012 alone, 2,400 metric tons of solid waste was disposed daily at *Olushosun* waste dump alone.³⁸¹ The quantum of waste is constantly increasing due to a persistent population growth and industrialization.³⁸² The waste is collected via a tripartite arrangement that involves LAWMA-owned trucks, LAWMA contractors, and Private Sector Participation (PSP) trucks. The LAWMA-owned trucks collect waste generated mainly from markets from the highways; the LAWMA contractors handle industrial waste; and the PSP trucks collect domestic/household waste. Waste generation in Lagos has grown proportionately with population increases, as represented in the graph below:



Source: J.O. Olubori, (LAWMA, 2013), note 380

All waste collected is deposited on *platforms* at the official waste dumps after each truck is weighed at the weighbridge which is located at the point of entry. The city previously experienced indiscriminate waste dumping, uncontrolled garbage, and littered pavements, roads,

³⁸⁰ J.O. Olubori, GM Technical Services, Lagos State Waste Management Authority, “The City of Lagos: Solid Waste Management”, Presented at International Solid Waste Association (ISWA) World Congress, Vienna, Austria, (2013). The figure of 9,000 that appeared in LAWMA’s 2012 correspondence cited above seems to have been updated to 10,000 by the General Manager in 2013.

³⁸¹ A. Ayodele & O. Simeon, “Investigating Groundwater Quality Around Olushosun Dumpsite Lagos Nigeria” (2012) 1(9) Indian Journal of Innovations and Development 700.

³⁸² LMDGP Final Report, *supra*, note 379.

and sidewalks.³⁸³ These waste practices led to flooding, and created an aesthetic eyesore at that time. Also, LAWMA could only collect a fraction of the waste in the municipality, which it transferred to its open dumps. The indiscriminate dumping practices have been controlled to a fair extent, although they are still noticeable in parts of the city especially the Lagos Island. Overall, waste collection has improved in recent years, as the mountains of waste on roadsides have disappeared with improved collection and transportation of waste.

5.3 Pollution of Groundwater by Waste Dumps in Lagos

Although waste collection is better and there is improvement in the aesthetics of Lagos, the appropriate and safe handling of the phenomenal quantities of diverse solid wastes in Lagos remains a formidable challenge for LAWMA. Because groundwater is principally recharged by rainfall that infiltrates through the land surface into aquifers below, it follows that the waste disposal activities at this sensitive point affect the quality of groundwater.³⁸⁴ Pollution occurs where the subsurface contaminant load that is generated by human discharges are insufficiently controlled, and in some cases exceed the natural attenuation capacity of the overlying soils. The solid wastes generate leachate which migrates into groundwater and pollutes it, thus preventing its optimal use since the water is suspended in a chemical state that is harmful to use. Researchers have clarified that the tendency toward pollution from subsurface activities is more prevalent in humid regions such as Lagos where large volumes of leachates are generated from

³⁸³ A.G. Onibokun & A.J. Kumuyi, “Governance and Waste Management in Africa”, (Available online).

³⁸⁴ The World Bank, *Groundwater Quality Protection, A Guide for Water Utilities, Municipal Authorities and Environmental Agencies*, (Washington D.C.: 2002) (Available online).

several waste trips. The actual type of contaminant is determined by the origin of the waste and the biochemical reactions that occur within the waste and in the groundwater.³⁸⁵

Leachate from the wastes dumps in Lagos is migrating into groundwater and polluting it. This fact is verified by a stream of empirical research findings by scientists that consistently affirm that pollutants from these open dumps have migrated into wells located near them. The following discussion will highlight the findings of these research efforts.

5.3.1 Empirical Research Findings on Waste Dumps' Pollution of Groundwater

In 2012, Ayodele & Simeon investigated leachate and wells samples located in the vicinity of *Olushosun* dumpsite. They collected water samples from 16 wells and 3 boreholes in the neighborhood, as well as a leachate sample from the waste dump itself. The wells and boreholes were at varying distances of 200 - 800 meters from the dumpsite. The results of the analysis showed the migration of pollutants from the *Olushosun* landfill into all the samples and a very high contamination level. They found further that inhabitants of the area were suffering from many ailments that were attributable to the contaminated water, including cholera, malaria, typhoid, eye irritations, asthmatic attacks, breathing difficulties and pneumonia. This prompted the researchers to urge the government to provide an alternative source of water supply to residents within this area.³⁸⁶

³⁸⁵ R. Gillham & J. Cherry, *Refuse Disposal Sites and their Long-Term Behavior*, (Dusseldorf Germany ENVIREC 1989). See also US-Environmental Protection Agency, *Procedures Manual for Groundwater Monitoring of Solid Waste Disposal Facilities* (1980, Available online); D.S. Macfarlane, J.A. Cherry, R.W. Gillham, & E.A. Sudicky, "Migration of Contaminants in Groundwater at a Landfill: A Case Study 1. Groundwater Flow and Plume Delineation" (1983) 63 *Journal of Hydrology* 1; see also: R. Nicholson, J. Cherry, & E. Readon, "Migration of Contaminants in Groundwater at a Landfill" (1983) 63(1-2) *Journal of Hydrology* 131.

³⁸⁶ A.S. Ayodele & O.O. Simeon, *supra*, note 381. It would have been very helpful if the researchers had included a column showing the World Health Organization's standard for drinking water quality, since that was the parameter that they used.

Ayodele and Simeon's Description of the Type and Location of the Water Samples

Reference Number Used	Coded Number BH = Borehole; WL = Well; LCH = Leachate	Sampling Location Address (No.= Number)
1	BH 09	No. 19, Kujore Street Ojota
2	WL 30	No. 24, Olabisi Street Ojota
3	WL 35	No. Abebi Street Ojota
4	WL 41	No. 15, Ogunleye Street Ojota
5	BH 05	No. 9, Oyebola Street Ojota
6	WL 22	No 7, Ayinde Street, Off Ogudu Road, Ojota
7	WL 10	No. 8, Olushosun Street, Off Oregun Road
8	WL 25	No. 3, Asiata Solarin Crescent, Off Oregun Road, Ojota
9	WL 15	No. 9, Taiwo Street, Off Ogudu Road Ojota
10	BH 07	No. 2A, Oregun Road, Olushosun
11	WL 04	No. 21, Ogunleti Street Ojota
12	WL 64	No. 30 Olatunji Street Ojota
13	WL 40	No. 65 Kujore Street Ojota
14	WL 08	No. 15 Aina Street, Ojota
15	WL 23	No. 3 Taiwo Street, Off Ogudu Road Ojota
16	WL 05	Ojota Mechanic Village
17	WL 43	No. 30 Aina Street Ojota
18	WL 52	No. 3 Emmanuel Street Ojota
19	WL 27	Ojota Bus Garage Adjacent to Total Filling Station

20	LCH Olushosun	Leachate from Olushosun Dumpsite
----	---------------	----------------------------------

Source: Ayodele & Simeon, (2012), note 381

In the same year (2012), Kola-Olusanya investigated both *Olushosun* and *Solous* waste dumps.³⁸⁷ He collected leachate and groundwater samples from them, which he tested in the laboratories of the Lagos State Environmental Protection Agency (LASEPA). Analyses of *Olushosun* samples revealed the presence of fecal coliforms during microbiological testing and indicated that the groundwater in the immediate environment is not fit for human consumption. However the *Solous* samples did not show leachate pollution which suggested that the groundwater from surrounding wells is potable.

In 2011, Aderemi et al conducted a study of groundwater within the vicinity of *Solous* waste dump. Eight sampling points were selected within 0.55 km radius of the waste dumpsite.

Aderemi et Al's Site specifications for Groundwater Samples

Sample	Sampling location	Distance from landfill (km) boundary
GW 1	Abule Onilu Street	0.55
GW 2	Supo Ajayi Apartment	0.37
GW 3	Okooloyun Street	0.28

³⁸⁷ A. Kola-Olusanya, "Impact of Municipal Solid Wastes on Underground Water Sources in Nigeria" (2012) 8(11) European Scientific Journal 1. But his opening statement that there is a pervasive reliance on "sanitary landfills" for disposing of waste is flawed, because it appears to defeat his thesis that the same landfills are causing pollution to groundwater. In the first place, there are probably no landfills in Nigeria. What is common are the open waste dumps, and even though some compaction takes place in them, there is no lining to collect leachates, and so they neither qualify as landfills, nor as sanitary disposal sites. In fact, the damage caused by their unsanitary nature is the motivation for this research, and the subject of several academic research projects, some of which have been discussed in this section. The Researcher notes with regret the pervasive tendency by some Nigerian waste practitioners, academic researchers, and even lawmakers (in the body of existing waste legislation) to use the term 'landfill' as a synonym for waste dumps.

GW 4	John Kay Crescent	0.08
GW 5	Kings Avenue Street	0.26
GW 6	Opposite Lanre Bus stop	0.24
GW 7	Adebayo Odueko Street	0.1
GW 8	Solous Landfill Well	0

Source: adapted from Aderemi et al, 2011, note 388

They found that the leachate generated from the site at that time had a modest impact on the groundwater quality in the locality, which they affirmed to be on account of the largely clayey and lateritic soil which made it naturally non-porous/non-permeable. But they did caution that there is potential for contamination because the elevated levels of chemicals such as lead, cadmium, and zinc in some of the groundwater samples are already above the World Health Organization's (WHO) permissible limits. They pointed out that over time, in the absence of a leachate collection system, the uncontrolled accumulation of leachates at the dumpsite will become a significant threat to the quality of groundwater. They concluded that the groundwater in the study area is unreliable for drinking water, and stressed the importance of improving waste management practices.³⁸⁸

In 2010, Longe & Balogun assessed the level of groundwater contamination through leachate percolation from the *Solous* waste dump. Results showed that the quality of the groundwater underlying the waste dump had become moderately affected by the leachate from the waste site. Some of the chemical parameters used indicated that the levels of chromium, nitrate, and phosphate in the water samples were above the highest permissible level allowed by

³⁸⁸ A. Aderemi, A. Oriaku, G. Adewumi, & A. Otitolaju, "Assessment of Groundwater Contamination by Leachate Near a Municipal Solid Waste Landfill" (2011) 5(11) African Journal of Environmental Science and Technology 933.

Nigerian Standards for Drinking Water Quality and the WHO Standards. They projected that with time, the accumulation of leachate at the base of the dumpsite could break into the groundwater. They did acknowledge that the clayey and silty nature of the site's soil stratigraphy appeared to have slowed the rate of contamination that would otherwise have occurred in a different soil type (consistent with Aderemi's analysis above). But the very same fact, they said, could still enable leachate ponding and outflow into both surface and groundwater. They concluded with recommendations to upgrade the open dump to a sanitary landfill.³⁸⁹

In 2008, in another research project, researchers drilled monitoring boreholes near the dumpsites in Abule Egba and Igando with the objective of evaluating the quality of soil and raw water samples through laboratory analysis. They found that the first borehole investigated at Abule Egba is prone to leachate contamination due to its shallow depth of 30 meters, and the absence of any significant impermeable layer (clay) to protect the groundwater occurring there. They recommended that boreholes constructed in that vicinity should exceed 42 meters in depth in order to avoid infiltration of leachate contaminants. On the other hand in Igando (location of *Solous* waste dump), the aquifers are overlain by multiple layers of clay and laterite which form an impermeable layer that protects the groundwater from surface contamination. They therefore inferred that leachate movement within the clay layers is minimal.³⁹⁰

The same researchers conducted a surface geophysical investigation of *Olushosun* waste dumpsite and a transfer loading station in conjunction with LAWMA in 2008. It was done, *inter alia*, to delineate possible leachate contamination within the dumpsites. Their report indicated that *Olushosun*, as the biggest waste dump in Lagos, has no liners or leachate collection system

³⁸⁹ E.O. Longe & M.R. Balogun, "Groundwater Quality Assessment Near a Municipal Landfill, Lagos, Nigeria" (2010) 2(1) Res. J. Appl. Sci. Eng. Technol. 39.

³⁹⁰ Hydromarine Engineering Co. Ltd., *Report of the Monitoring Boreholes Drilled at Landfill Sites - Abule Egba & Igando, Lagos State* (2008).

and therefore it has the potential to cause groundwater contamination especially within its southern flank.³⁹¹

In 2007, Longe & Enekwechi analysed results from wells within *Olushosun* waste dump site in Lagos. They found a measurable impact of leachate outflows on groundwater quality. Elevated levels of nitrate, chloride and sulphate, and heavy metals iron, manganese, lead, chromium, cadmium and copper in the groundwater body are at levels which are above the safe limits set by the WHO.³⁹²

In the same year 2007, Adeyemi et al investigated the physicochemical and microbial qualities of two wells and two boreholes within a closed waste dump *Odo Iya Alaro* in Kosofe within Lagos metropolis. In terms of physical chemistry, they found that the wells contain very high concentrations of heavy metals such as lead, cadmium, and chromium. In terms of microbial characteristics, they also found that harmful coliform bacteria including *e coli*, salmonella and shigella are also present in the wells.³⁹³

In 2002, Ikem et al monitored wells in the vicinity of a waste dump site in Oworonshoki, Lagos. They found that groundwater from these wells require further purification to make them suitable for human consumption because the levels of contamination in them are higher than levels permitted by WHO Guidelines for drinking water.³⁹⁴

³⁹¹ Hydromarine Engineering Company Ltd., *Report of the Surface Geophysical Investigation Carried out at Landfill Sites- Abule Egba, Igando, & Olushosun and Yaba Transfer Loading Station, Lagos State* (2008).

³⁹² E.O. Longe & L.O. Enekwechi, "Investigation on Potential Groundwater Impacts and Influence of Local Hydrogeology on Natural Attenuation of Leachate at a Municipal Landfill" (2007) 4 Int. Journal of Environ. Sci. Tech. 133.

³⁹³ O. Adeyemi, O.B. Oloyede & O.T. Oladiji, "Physico-chemical and Microbial Characteristics of Leachate-Contaminated Groundwater" (2007) 2 Asian Journal of Biochemistry 343.

³⁹⁴ A. Ikem, O. Osibanjo, M.K.C. Sridhar, & A. Sobande, "Evaluation of Groundwater Quality Characteristics near Two Waste Sites in Ibadan and Lagos, Nigeria" (2002) 140 Water, Air, and Soil Pollution 307. The subject

All the results affirm that pollution has already occurred at *Olushosun* due to the absence of any protection of the surrounding groundwater from the waste dump leachates. In the cases of Solous and Abule Egba which researchers indicate as having non-porous clayey soils that offers some protection to groundwater, although the groundwater does not show significant pollution at those locations, yet the investigators themselves acknowledge that pollution is still imminent but will only take a longer time to occur.

Apart from these empirical studies, the Researcher undertook a field study of Lagos metropolis to clarify her understanding of the extent of groundwater pollution by solid waste.

5.4 Report of Field Trip to Lagos, Nigeria

In view of the pollution that open dumping of waste was reported to have caused to groundwater in Lagos, the Researcher made a field trip to Lagos to discuss the waste management problem, and to understand the underlying reasons for the persistence of this environmental problem. A series of meetings were held with representatives of the responsible government departments. The agencies were: Lagos State Waste Management Agency (LAWMA) and the Lagos State Environmental Protection Agency (LASEPA). Meetings were also held with two senior Professors at University of Lagos who have researched extensively and published on groundwater.

Discussions were based on a set of questions which were organized around major themes. The responses were compared with the independent empirical research findings already discussed here, and were analyzed. The following table represents a summary of findings made:

dumpsite does not appear to be listed in either official or unofficial sites, so the inference is that it is neither an official nor a recognized dumpsite.

Field Work Findings On Waste Dumps in Lagos.³⁹⁵

5.4.1 Summary of Research Findings on Solid Waste Management in Lagos

	Themes	LAWMA	LASEPA	Empirical Scientific Research Literature	Professors' Recommendations
1.	Solid Waste (Open Dumps) Pollution of Groundwater by dumps	Leachate is not migrating into <i>Olushosun</i> dumpsite due to the impermeable clay underlying it	Based on the department's quarterly monitoring reports, leachate is migrating into groundwater wells located around <i>Olushosun</i> dumpsite	Leachate from decaying organic matter and chemical wastes in unlined dumps tends to migrate into groundwater. Leachate migration into surrounding groundwater has been occurring consistently at <i>Olushosun</i> , between 1992 & 2012. Pollution at <i>Solous</i> is not yet significant, but has a potential to intensify in the future	Open dumps wrongly located in dense residential areas; Open dumps are harmful because they pollute groundwater, but the shortage of land in Lagos will soon compel alternatives to open waste dumps
2.	Problems of Open Dumps /Results of Leachate Migration into Groundwater	Since there is no leachate migration, there is no pollution at <i>Olushosun</i> because it is clayey, although cracks may still permit mild percolation of leachates into groundwater	Open dumps are prone to leach into groundwater. Water in <i>Olushosun</i> neighborhood is of poor quality with a cloudy appearance and bad odor. Groundwater of the immediate neighborhood is unfit for human consumption	Polluted groundwater presents environmental and health hazards including water-borne diseases (cholera, typhoid); water-related diseases (cancer, skin diseases, & injury to vital organs) odor	Open dumps cause a horde of environmental problems: Trapped methane and spontaneous fires that occur at waste dumps contribute to depletion of ozone layer, which in turn causes global warming; waste dumps are injurious to waste pickers because they contain a lethal mix of assorted wastes from industrial, medical, and municipal sources; waste dumps are breeding grounds for reptiles and rodents, and emit offensive odors; Leachate from decaying organic waste and chemical waste percolates into surface and groundwater, and cause injuries to human vital parts when the water is consumed
3.	Measures to Abate Problems of Dumping of assorted wastes	Waste sorting is gradually being introduced with LAWMA setting the example by having 3 types of waste bins for organic, plastic, and glass wastes; Atomizer is in place at <i>Olushosun</i> to mitigate odor and dust	Recommend that residential areas should be located farther from dumpsites	Recommend sanitary landfills generally as substitutes to waste dumps; locate dumps far from residential areas; Tyres should be separately disposed at different locations away from other wastes because of the terrible fires that they cause	When situating waste dumps, efforts should be made to prevent seepages (leachate) from migrating into groundwater. Officials should be guided by the hydrogeology in selecting areas where the impact on groundwater can be minimized; treatment should be applied to dumped waste

³⁹⁵ This part of the discussion features only the findings that pertain to solid waste. The report for wastewater will be in the second part of this chapter.

					to reduce harmfulness
4.	Hindrances to Better Waste Management	The surging population is a continuing hurdle to LAWMA’s ability to manage the spiraling waste; Congestion, and increased commercial activities, especially at sea and air ports, compound the problem	Unlawful encroaching on setbacks around dumpsite needs to be addressed; environmental audit of waste sites is necessary to determine the soil type which in turn determines the rate of retention of water, and depth of the well allowable; at night, people dump wastes indiscriminately	The large Lagos population generates enormous wastes that are difficult for LAWMA to competently manage; over use of <i>Olushosun</i> and <i>Abule Egba</i> dumps, but sub-optimal use of <i>Solous</i> dump	There are no facilities for treating waste yet in Lagos; Waste dumps should not be located in densely populated areas; Lagos has a unique population- spiral problem that transforms sparse populations to dense areas in a relatively short time, defeating city-planning efforts
5.	Alternatives to Waste Dumps	Government plans to construct 2 sanitary landfills that incorporate material recovery facilities, recycling of metals, aluminum, plastics and paper, and composting of organic waste.	Sanitary landfills are ideal but may remain futuristic due to enormous cost of separate leachate collection and treatment before discharge into environment. No landfill exists in Lagos	Recommend Sanitary landfills	Recommend Sanitary landfills
6.	Waste Treatment /Recycling Efforts	LAWMA is starting waste treatment initiatives: Car-crushing plant in Epe with proposed scraps resale to iron industries; waste-to-energy pilot scheme to convert organic fruit waste to energy for generation in Ikosi market; 1500 metric tons of waste is converted to compost daily in Ikorodu; Buy-back program encourages sorting of plastics for re-sale to LAWMA	N/A	Research papers generally focus on investigating leachate pollution of groundwater, but do not often evaluate state’s recycling efforts	Government should adopt a systematic approach to the current informal recycling efforts by harnessing the scavengers’ sorting work that goes on at <i>Olushosun</i> ; Recycling may be a problem because of people’s reluctance to spend money on waste.
7.	Longer-term strategies	Integrated Solid Waste Management Policy using the Positive Re-enforcement of Attitude strategy to create awareness of recycling benefits; sanitary landfills in the future; current public enlightenment via radio jingles, seminars, meetings with community development associations; Ikosi organic waste pilot program will be	Having a landfill site is futuristic because it involves a high expenditure; need to address people’s non-compliance with waste guidelines/ laws.	Waste segregation and public sensitization are material to waste management	LAWMA now competently collecting and transporting wastes to dumpsites; Shortcoming is the absence of facilities for treating and properly disposing of wastes; Segregation is key to a successful waste management system; waste management also needs effective legal regulation supported with public sensitization about waste re-use

5.4.2 Analysis and Discussion

5.4.2.1 Waste Pollution of Groundwater:

During interviews at LASEPA, officials confirmed that leachate contamination is occurring at dumpsites, particularly *Olushosun*. LASEPA clarified that it regularly monitors leachate and that it periodically issues a quarterly report of the pollution status known as the ‘Result of Analysis of Leachate from Dumpsites’ to LAWMA. The report indicates that groundwater occurring within the immediate neighbourhood of Olushosun is not fit for human consumption due to its offensive odor and color/turbidity, and that the residents in that neighbourhood require an alternative source of drinking water. LASEPA did not however provide the precise localities at risk from contaminated groundwater to the Researcher, who was also unable to obtain a copy of the Report. Fortunately, Ayodele & Simeon’s research in 2012 discussed earlier (supra, note 381) gives a clearer indication of some of the areas affected. In answer to the Researcher’s question about why people’s residences are located so close to a waste dump, LASEPA said that people have unlawfully encroached on the unsafe areas designated as setbacks from dumpsites (areas of land that are designed to remain uninhabited to safeguard public health), hence the pollution of their groundwater.

LASEPA also observed an improvement in quality of water samples taken from wells located farther away from the dumpsite, thus confirming that a minimum perimeter of safety is required between dumps and residential areas. LASEPA was however unable to give precise statistics based on measured distances from the dumpsite. LASEPA’s information about pollution confirms the various empirical research findings discussed in this section. The solution to the

pollution occurring, they acknowledge, is to install sanitary landfills; however their prohibitive cost will probably make them a matter for future longer-term planning.

It is remarkable that LAWMA denies that pollution is occurring at *Olushosun*. According to the Agency, the site is completely covered in clay which makes it impermeable and enables it to contain any leachate generated from the wastes. In their view, the clayey lining prevents it from percolating into the surrounding groundwater.³⁹⁶ Based on its affirmation, it can be inferred that LAWMA does not agree with either LASEPA, or the scientists' empirical research findings that pollution has occurred at its major dumpsite, *Olushosun*.

LAWMA's disagreement is surprising considering that there are documented reports that confirm the pollution, according to LASEPA's information shared with the Researcher, as well as correspondence between the two agencies that reference the pollution for the last quarter of 2012. Independent empirical reports discussed earlier also confirm the fact of pollution already occurring at *Olushosun*, and the potential for *Solous* to begin to manifest similarly high contamination levels of its surrounding groundwater in the near future. The reason for LAWMA's reticence is not clear.

5.4.2.2 Problems of Open Dumps and Results of Leachate Migration into Groundwater

Apart from LAWMA, all the groups of people spoken to and the findings of scientists agree that waste dumps are a difficult problem generally because of the environmental problems they cause and particularly due to water-borne diseases that result from human consumption of contaminated groundwater. The scientists and Professors agree that prior environmental impact assessment probably did not take place when the waste dumps were originally sited, and as a result, they were located near residential areas and hence the pollution problems that are arising.

³⁹⁶ Personal discussions with LAWMA Recycling Manager on December 10th 2012.

They however note that even if the dumps had been located far from human settlements, the problem of surging population in the city would have neutralized the safety effort, as people would still have encroached on them to erect living quarters around the unsafe zones due to the shortage of housing.

The open dump *Olushosun* has become a specific problem to groundwater in that neighborhood, by making it unfit for human drinking on account of leachate percolation into it. Even where as in *Solous*, the soil is only fairly permeable, cracks and faults occurring within it can still enable migration of pollutants into water as LAWMA itself admitted in a discussion.

5.4.2.3 Measures to Abate Problems of Dumping of Assorted Wastes

It is gratifying that LAWMA is making some efforts towards recycling that will effectually reduce the quantity of waste that leaches into groundwater at the dumpsites. It has also been very relieving to learn recently that medical wastes are no longer dumped together with municipal wastes.³⁹⁷ But although waste sorting is also gradually being introduced as a first step to reduce the diversity of wastes that are placed at waste dumpsites, more enlightenment is needed in waste separation because people do not yet understand the uses of the various bins and still place waste in the wrong bins. The Researcher observed that even within governmental offices that had installed waste bins for different kinds of waste, people were placing wastes in the wrong bins in a clear indication of misunderstanding about the purpose of separation within waste management.

³⁹⁷ LAWMA now works with the Lagos Healthcare Facilities Monitoring and Accreditation Agency to collect and treat medical wastes from 26 general hospitals, 256 public healthcare centers, and 2886 private hospitals: Personal discussion with Principal Environmental Officer, Lagos State Ministry of the Environment on May 19th 2015.

5.4.2.4 Hindrances to Better Solid Waste Management

The large population, which generates huge quantities of waste, is the most difficult and intractable problem for LAWMA because of the large volumes of assorted wastes that end up at the waste dumps daily. The problem is complicated by an acute shortage of housing that compels people to unlawfully encroach on unsafe waste site setbacks. The problem of population spiraling in the city was discussed in the Chapter 4, and the ensuing waste problem indicates that some strategies will have to be devised to tackle it. The Lagos State Environmental Policy also links the waste generation problem to population growth and industrial development in the city, and laments that in spite of enormous resources and efforts committed to waste management, it still defies solution because of the ever-increasing population.³⁹⁸

5.4.2.5 Alternatives to Waste Dumps

In view of the health problems that these dumpsites are causing, it has become necessary to search for alternatives to open dumping of waste. Sanitary landfills are the obvious choice, but their prohibitive cost might mean that they would not be inaugurated for some time, as LASEPA indicated. But since the most urgent problem from these open dumps is leachate migration, a form of leachate collection and containment might offer a realistic mid-term solution.

5.4.2.6 Waste Treatment/Recycling Efforts

The recycling efforts including the proposed car-crushing plant and resale of scraps, 1500 metric tons of waste being converted to compost daily, and the buy-back program that encourages sorting of plastics for re-sale to LAWMA, are still experimental and nascent. It is

³⁹⁸ Lagos State Environmental Protection Agency, *Lagos State Policy on the Environment*.

however evident that the existing informal sector of scavenging operations at the dump sites can be properly harnessed and pruned for a more systematic waste separation system.

5.4.2.7 Longer-term Strategies

LAWMA informed the Researcher that it has set up an integrated waste management facility, and plans that from the 9,000 metric tons of waste generated daily at that time (now 10,000), 1500 tons will hopefully be converted to compost, whilst papers and plastics will go to recycling, leaving only the residue to be sent to the waste dumps. With this plan, it hopes to reduce the pressure on waste dumps. LAWMA narrated its on-going efforts to correct the erroneous and pervasive impression that there is no alternative to waste dumping, through the ‘Positive Reinforcement of Attitude Program’, an enlightenment program about the importance of embracing the recycling culture. The program incorporates beautification of the environment and provision of public toilets in addition to public enlightenment.³⁹⁹ LAWMA has also started a buy-back program at *Olushosun* through which it buys plastic bottles, nylons, and glass from the public as an incentive for people to sort their wastes for recycling.

Overall, LAWMA’s integrated waste management strategies are good, and will hopefully be implemented because solid wastes ought ideally to be properly handled within a structured waste management system that recovers useful materials from them before the residue is sent to waste dumps for final disposal. Such system is consistent with sustainable development principles about the safe handling of solid waste.⁴⁰⁰ In summary, LAWMA needs to re-think its continued

³⁹⁹ Personal Discussions with General Manager, Technical Services, Lagos Waste Management Authority (LAWMA), in Lagos, Nigeria on November 27th 2012; Personal discussions with Manager Recycling, LAWMA on December 10th 2012.

⁴⁰⁰ United Nations Conference on Environment and Development, *Agenda 21*, Arts. 18.58-9. This is modelled within the European Union’s waste management framework which portrays a hierarchy in waste management, as will be discussed in Chapter 6, *infra*.

open dumping of assorted wastes especially at *Olushosun*, as it is apparent that open dumping as the official method of waste disposal in Lagos is harmful to groundwater and portends a serious problem to human health.⁴⁰¹

5.5 Polluted Groundwater and Human Health

The concern about untreated waste being heaped together in open dumps and allowed to leach into groundwater is not merely an academic exercise. The concern is that the assortment of diverse wastes often includes dangerous microbial and chemical contaminants (as Adeyemi et al's research confirms), that together make up a very lethal disease-causing mixture. Biodegradable wastes introduce microbial pathogens such as bacteria, and fungi, while electronic waste is especially hazardous and introduces very harmful elements into the water. Such harmful elements include high levels of nitrate, chloride and sulphate, as well as heavy metals such as lead, chromium, cadmium, manganese, mercury, selenium, and copper.⁴⁰² With the large population in Lagos, the importation and local consumption of electrical and electronic waste has escalated, and with this is the difficulty of finding safe disposal solutions to equipment that are at

⁴⁰¹ Open dumps are also associated with the problem of spontaneous combustion, (fires that erupt when chemicals interact), as well as bacterial decompositions. The fires emit a dangerous combination of chemicals because of the mixed contents of unsorted wastes with chemical and biological compounds: United States Fire Administration, Federal Emergency Management Agency, *Landfill Fires - Their Magnitude, Characteristics, and Mitigation* (TriData Corporation, Arlington, VA, 2002). Tyres are often dumped in Lagos dumps. Their deadly mix of synthetic rubber, carbon black, steel wires, 17 heavy metals and chlorine means that the fires that they ignite have a high heat output and long duration, and are difficult to extinguish. Burning tyres emit carbon monoxide, sulphur dioxide and benzene derivatives which are linked to cancer and reproductive impairments in humans. There is also the additional risk of inhaling these poisonous gases: A. Aderemi & A. Otitoloju, "An Assessment of Landfill Fires and their Potential Health Effects - A Case Study of a Municipal Solid Waste Landfill in Lagos, Nigeria" (2012) 2(2) *International Journal of Environmental Protection* 22; K.A. Aderogba & B.A. Afelumo, "Waste Dumps and their Management in Lagos Metropolis" (2012) *International Journal of Learning and Development* (ISSN 2164-4063) Available online; K. Joseph, R. Nagendran, & L. Palanivelu, "Open Dumps to Sustainable Landfills" Centre for Environmental Studies, Anna University, Chennai India. (Available online).

⁴⁰² Heavy metals are so described because of their high relative atomic mass which persists in nature and can cause damage or death to humans even at low concentrations: Business Dictionary, "Heavy Metal", Online at www.businessdictionary.com/definition/heavy-metal.html.

the end of their lives.⁴⁰³ Scavengers, whose activities, although unauthorized, are part of the informal sector, are also constantly at risk of cuts, wounds, and infection from the wastes that they are in direct contact with. Besides this, smoke from burning wastes does result in respiratory problems, and in the long term, to more serious diseases such as cancers and heart disease.⁴⁰⁴ Therefore leachate-contaminated groundwater in Lagos raises real fears of illnesses from either or both microbial and chemical contaminants.

The problem of groundwater pollution in Lagos would not be as serious or concerning if its use was negligible. But the majority of Lagos residents depend on groundwater exclusively for livelihood, as explained in previous chapters, and hence the concern about its pollution. Experts have confirmed that although essential for life, water also constitutes a very real source of illness because infectious diseases can easily be transmitted by waste-contaminated water.⁴⁰⁵ Pollution in water reduces water quality and facilitates the spread of serious human diseases.⁴⁰⁶ Thus polluted groundwater presents a real risk to life and health which can be both serious and fatal. Developing cities like Lagos are especially vulnerable, because they tend to record increasing cases of infectious intestinal diseases.⁴⁰⁷ A discussion of the usual contaminants in polluted water and their specific impacts on human health is aggregated together with the discussion of wastewater pollution in Part II of this Chapter.

⁴⁰³ Apart from its local consumption, Lagos has become a major entry point for used electronic and electrical equipment, which are refurbished and resold to traders both within and outside Nigeria.

⁴⁰⁴ In spite of their perception as a nuisance with low social status, scavengers do play an important role in waste recycling. Where feasible, can their work be more structured and organized with incentives attached, and their health safeguarded through access to healthcare? Some scholars appear to think so, and the potential for a mutually beneficial waste management relationship is discussed as part of recommendations in the final Chapter: M. Asim, S. Batool, & M. Chaudhry, "Scavengers and their Role in the Recycling of Waste in Southwestern Lahore" (2012) 58 *Resources, Conservation and Recycling* 152.

⁴⁰⁵ F. Jones & J. Watkins, "The Water Cycle as a Source of Pathogens" (1985) *Journal of Applied Bacteriology Symposium Supplement* 27; A. Baba & G. Tayfur, "Groundwater Contamination and its Effect on Health in Turkey" (2011) 183(1-4) *Environ Monit. Assess* 79.

⁴⁰⁶ S.L. Poster, G.C. Daily & P.R. Ehrlich, "Human Appropriation of Renewable Fresh Water" (1996) 271 *Science* 785.

⁴⁰⁷ Jones & Watkins, *supra*, note 405.

5.6 Mitigating Harm at Waste Disposal Sites

Therefore, owing to the pollution hazards associated with open dumping, it is no longer a safe or acceptable method to manage waste. It is important to either find an alternative method of disposing of waste, or at the least, conceive a means of making the dumps less harmful to groundwater. Ordinarily, before selecting a place for the purpose of waste dumping, some preliminary checks and measures ought to be in place. It is crucial to first appraise the hydrogeology of the proposed waste site in case the underlying aquifers have peculiar characteristics that might indicate a propensity to pollution, such as the Recent Sediments aquifer discussed in Chapter 1. Secondly, regardless of the kind of hydrogeology in the area, a system of leachate containment is also necessary since leachate is a well-known source of groundwater pollution. Such measures are consistent with prior environmental impact assessment and the principle of prevention which are both important legal principles that encourage action to be taken to protect the environment at an early stage in order to anticipate damage that may occur and to avert it, as discussed in Chapter 2.⁴⁰⁸ The principles also imply that waste dumps should not be located around actual or potential residential areas for any reason, and that wherever located, they should always incorporate leachate collection systems. Thus, the careful study of proposed sites, determination of the safest locations, installation of secure leachate collection systems, would then be accompanied by proper monitoring for possible seepages.

However, this thesis acknowledges that pollution has already occurred in Lagos, and that it is too late to avert damage by employing these preventive measures. The recommendation however remains valid in case more waste dumps are planned for the future. In this regard law

⁴⁰⁸ See for instance Nigeria's Environmental Impact Assessment Act, which is discussed in the next chapter: Environmental Impact Assessment Act (1992), Cap E Laws of the Federation of Nigeria (2004), Ss. 1& 2.

has a vital role to play. Regulatory efforts would include stipulating that preliminary hydrogeological checks for likely harm to groundwater should be carried out before a site is selected for the dumping of waste in order to safeguard the integrity of groundwater and in the interest of overall public health; it would also require leachate collection systems to be installed in every waste facility; it would disallow waste dumps from being located around actual or potential residential areas for any reason; an appropriate legal system would also drive a policy of minimizing or eliminating waste, and the uncontrolled dispersal of waste materials in the broader environment in a manner that could cause ecological or biological harm. Overall, laws should be designed to reduce the generation of waste and promote or mandate waste recycling. The prior assessment for likely harm to groundwater would also be applicable to the proposed activities of governmental agencies too, including the waste management agency and the wastewater management office that could have a probable harmful impact on groundwater. This thesis will address specific legal responses to the pollution in Lagos in Chapters 6 and 7.

5.7 Probable Alternatives to Open Waste Dumps in Lagos

The safe method of solid waste disposal is the sanitary landfill. A sanitary landfill is a method of controlled disposal of municipal solid wastes. It is a site where waste is isolated from the environment until it is safe. Solid waste is disposed in thin layers, immediately compacted by heavy machinery such as bulldozers, and then covered with a layer of compacted soil to prevent access to rodents and pests, and to minimize odors. The landfill site is sealed with impermeable bottom liners, and a layer of clay or synthetic liners to prevent water entering. Leachate collection and treatment which is a basic requirement, ensures that groundwater is protected from contamination by leachate. Leachate is contained and treated with biological and physico-chemical treatment. Trained personnel are usually based at the landfill to supervise site

preparation and construction, the depositing of waste and the regular operation and maintenance of the site.⁴⁰⁹ Landfills are known to require proper design, planning, maintenance, and operation. They are a vital part of any well designed municipal solid waste management system as the ultimate repository of a city's municipal waste after all other material recovery options have been exhausted. However as mentioned earlier, the sanitary landfill is expensive for Lagos, and for this reason, may remain a matter for possible future use. While a city like Lagos is still employing waste dumps, it is important to mitigate the harmful effects that may occur from it.

Joseph, et al suggest that for cities that plan to relinquish open dumps, a cautionary transition from open dumps to safer and more appropriate methods of waste disposal can be accomplished in a phased manner. This would help reduce the associated costs because the transition to sanitary landfill may be too abrupt and costly and thus necessitate a mid-course.⁴¹⁰ They review and describe various alternative methods of waste disposal from which a suitable intermediate method of waste disposal can be selected depending on the city's economic and social status.

Types of Landfills

Type	Engineering Measures	Leachate Management	Landfill Gas Management	Operation Measures
Open Dumps	None	Unrestricted Contaminant Release	None	Few, Scavenging
Controlled Dumps	None	Unrestricted Contaminant Release	None	Registration and placement/compaction of waste

⁴⁰⁹ Encyclopaedia Britannica, *Sanitary Landfill*, Online: www.britannica.com.

⁴¹⁰ K. Joseph, R. Nagendran & K. Palanivelu, "Open Dumps to Sustainable Landfills" Online: <http://www.swlf.ait.ac.th/UpdData/National/ODSL1.pdf> accessed on March 12th 2014.

Engineered Landfill	Infrastructure and liner in place	Containment and some level of leachate management	Passive ventilation or flaring	Registration and Placement/Compaction of waste; uses daily soil cover
Sanitary Landfill	Proper Siting, infrastructure; liner and leachate treatment in place	Containment and leachate treatment (often biological and physic-chemical treatment)	Flaring	Registration and placement/compaction of waste; uses daily of soil cover, measures for final top cover
Controlled Contaminant Release Landfill	Proper siting infrastructure with low-permeability liner in place. Potentially low-permeability final top cover	Controlled release of leachate into environment based on assessment and proper siting	Flaring or passive ventilation through top cover	Registration and placement/compaction of waste, uses daily soil cover. Measures for final top cover
Landfill Bioreactor	Proper siting, infrastructure, liner and leachate recirculation/generation system	Controlled recirculation of leachates for enhanced degradation and stabilization of wastes and leachates	Landfill Gas recovery	Registration and placement/compaction/daily cover/closure/mining and material recovery

Source: Joseph et al (1999) note 410

From these options, the engineered landfill appears the most feasible, being that it has waste compaction which is already in place in Lagos, and will incorporate leachate containment that keeps groundwater safe from contamination. However, it is advisable that Lagos begins to think in serious terms of making some significant investment in a safer method of waste management

in order to safeguard the health of its residents. Such investment is likely to help the city to save money in the long term by reducing the financial burden that sick people impose on the healthcare system, by reducing mortality and extending lifespans, and by reducing the overall strain on the economy.

5.8 Summary

In conclusion, the open dump is only a basic form of sanitation which is ridden with health hazards and poses a real threat to the precious groundwater resource in Lagos. Whilst in earlier times, open dumps achieved the purpose of separating waste and odors from people, it has since been realized that treatment is necessary and that the dumps are themselves breeding grounds for rodents and harmful microorganisms. Open dumps are therefore neither consistent with environmental protection, nor with sustainable natural systems. Although they are truly an inexpensive method of disposing of waste, they have such unfavorable impacts on the environment that the United Nations summed up their impacts as the “dire consequences of open dumping”.⁴¹¹ Therefore Lagos will need to consider some expenditure on a safer waste management method, which could be a medium-term solution such as an engineered landfill.

International agreements on sustainable development have emphasized the importance of dealing appropriately with solid wastes in order to halt the effects of environmental degradation, and to promote sustainable and environmentally sound development. They particularly emphasize the minimizing of wastes, and maximizing of environmentally sound waste reuse and

⁴¹¹ United Nations Environment Programme (‘UNEP’), *Training Module: Closing an Open Dumpsite and Shifting from Open Dumping to Controlled Dumping and to Sanitary Land Filling* (2005). UNEP describes a range of unfavourable and unmonitored activities at typical waste dumps some of which are true of Lagos dumps. These are: unsorted uncovered waste; no waste compaction; sporadic self-igniting fires; no application of soil cover or minimal cover; scavenging; no or inadequate leachate management; no provision for capturing landfill gas; no engineering measures such as a liner system ahead of waste placement; and a variety of roaming animals.

recycling. The meetings recognize the interrelationship between water on one hand, and solid waste and wastewater management systems on the other hand.⁴¹² Lagos needs to follow these guidelines in the interest of safeguarding its groundwater. As mentioned in Chapter 1, there are indications from newly formulated sustainability policies that there will be less tolerance in the international community for waste dumping in the years to come. This is based on agreements reached at the recent Conferences on Sustainability and Climate Change. According to the Sustainable Development Summit, good water quality, (its sixth goal), will be achieved by eliminating dumping, and by preventing pollution, amongst other measures.⁴¹³ The Climate Change Conference also emphasized a commitment to easing access by African nations to sustainable energy technology.⁴¹⁴ Renewable energy options comprise processed bio-mass, which is biodegradable waste that mostly ends up at waste dumps in Lagos. Lagos would do well to harness the opportunity presented by this policy to process its organic waste into energy, whilst it ought also to be a disincentive to continue its tradition of dumping waste.

Perhaps the real challenge for a developing city like Lagos is that waste management (and environmental protection generally) has traditionally not been considered a priority. Efforts have been directed toward preserving the city's aesthetics, and in this bid, open dumps, which are an easy and relatively affordable option, are used as containers of waste that are removed from view in the municipality. But even if Lagos were to continue using open dumps they require a large area of land, thus the shortage of land in an over-crowded Lagos will likely create an urgent need to find an alternative, less expansive waste disposal method in the near future as a matter of expediency. Land ought to be put to better public use than waste dumping.

⁴¹² United Nations Conference on Environment and Development, *Agenda 21*, Arts. 18.58 - 9.

⁴¹³ United Nations Summit on Sustainable Development, Transforming Our World, Art 6.3

⁴¹⁴ United Nations Climate Change Conference (2015), *Paris Decision*, Preamble.

In the final analysis, the best practice is one where all wastes can be recovered and reused, based on a zero waste policy that is also consistent with sustainable development principles. When this is achieved, groundwater and other precious natural resources as well as the environment in general will no longer be at risk of pollution. Full material recovery is the objective of an integrated solid waste management strategy that imports composting, recycling, re-use, and final disposal and this will be discussed in Chapter 7.

PART II: The Menace of Wastewater to Groundwater in Lagos State

This section deals with wastewater management problems that challenge groundwater in Lagos. It will review the impact of wastewater on groundwater, as well as the findings from the Researcher's field research which will be summarized and analyzed. The discussions will be preceded by some preliminary definitions and background information.

5.9 Definition of Wastewater

Wastewater has been defined as any water whose quality has been adversely affected by anthropogenic activities, and includes liquid waste discharged from domestic, commercial, industrial, and agricultural sources.⁴¹⁵ It has also been described as spent water that has been used for either life support or in commercial/industrial processes and is quite apart from storm

⁴¹⁵ See Wikipedia at <http://en.wikipedia.org/wiki/Wastewater>. The United Nations adopts a very broad sense of the term by defining it to include all the following components: domestic wastewater (black water- excreta, urine and faecal sludge); grey water (kitchen and bathing wastewater); water from commercial establishments; from hospitals; storm water; urban runoff, and agricultural, horticultural, and aqua cultural effluents: E. Corcoran et al, eds., (2010) *Sick Water? The Central Role of Waste Water Management in Sustainable Development*. A Rapid Response Assessment, United Nations Environment Program, UN HABITAT, GRID-ARENDAL ("Sick Water Report") at pg. 15.

water that is simply runoff from precipitation.⁴¹⁶ For the purpose of this thesis, it is used water from domestic, industrial, and commercial sources, but with a distinction between domestic sewage (referring to wastewater from homes), and industrial wastewater which issues exclusively from industrial (manufacturing) activities. The terms ‘wastewater’, ‘effluents’ and ‘sewage’ will be used interchangeably.

Around the world, the discharge of untreated wastewater into water bodies is a distinct problem within the water cycle because of the resultant contamination of water bodies especially in developing nations. As mentioned in Chapter 1, it is accountable for the growing incidence of de-oxygenated dead zones in the world’s seas and oceans that currently extends to 245,000 square km.⁴¹⁷ Pollution, which has assumed “menacing proportions”, is currently a matter of concern for national governments, international organizations, and this research project. With developing nations facing multifarious socio-economic and environmental challenges, predominantly poverty, the World Bank quite rightly infers that their greatest challenge in the water and sanitation sector is the creation of affordable sewage treatment systems that also permit the re-use of effluents in agriculture and industry.⁴¹⁸

5.10 History of Wastewater Management in Lagos

Historically, Lagos did not construct or have any centralized sewerage systems. From the mid-19th century, colonial administrators made very limited investment in water and sanitation, and the case of wastewater was even worse, as there was the “complete absence” of any

⁴¹⁶ F.J. Burian & F.G. Edwards, “Historical Perspectives of Urban Drainage” (Available online).

⁴¹⁷ Sick Water Report, *supra*, note 415, at pg. 5.

⁴¹⁸ M. Jacobsen, M. Webster, & K. Vairavamoorthy, *The Future of Water in African Cities: Why Wastewater?* Directions in Development, Washington D.C The World Bank (2012).

functional sewer system.⁴¹⁹ Lagos residents operated the night soil system to dispose of human waste, which was styled the “Agbepo Night Soil Man Human Waste Collection System”. This involved the use of the pail system whereby human waste was gathered at night into buckets that were collected and emptied by night soil men the next day. Proposals for comprehensive underground sewerage were made in 1902 and at various times after that, but the plans did not materialize. In 1956, another attempt was made but was abandoned partly owing to lack of financial resources, but also due to political manoeuvres by a consortium of anti-sewerage activists who had a financial stake in perpetuating the night soil sewage collection system.⁴²⁰

Later sewage practices evolved including disposal through the use of pit latrines, and the direct discharge of raw sewage into water bodies and farm lands. The unhealthy night soil system was outlawed in 1986.⁴²¹ Subsequently, the popular flush toilet with the accompanying septic tanks was introduced. It became mandatory for owners of any buildings to register suitable sewage disposal systems with the appropriate local government.⁴²² Later, state-funded septic tanks development and construction in households evolved.

5.11 Current Wastewater Management Practices in Lagos

Lagos generates approximately 350 million gallons (1.6 billion liters) of wastewater daily from domestic households, commercial centers, and industries.⁴²³ Domestic wastewater is produced from bathrooms, kitchens, toilets, and laundry wastewater generated by homes,

⁴¹⁹ M. Gandy, “Planning, Anti-Planning and the Infrastructure Crisis Facing Metropolitan Lagos” (2006) 43(2) *Urban Studies* 371, at pgs. 375 & 378.

⁴²⁰ *Ibid*, at pg. 378; B. A. Williams & A.H. Walsh, *Urban Government for Metropolitan Lagos* (Fredrick A. Praeger New York, The Institute of Public Administration: 1968).

⁴²¹ Abolition of Pail Latrine System Law (1986), Laws of Lagos State (2003).

⁴²² *Ibid*.

⁴²³ Lagos Wastewater Management Office, *Institutional, Regulatory, and Legal Framework*; Lagos State Wastewater Management Office, <http://www.lagoswastewater.org/fashola-approves-eight-waste-water-plants/>

hospitals and commercial centers). Industrial wastewater is created from diverse manufacturing and industrial processes. The classification is important because separate agencies oversee the two separate streams: During interviews, it was clarified that LASEPA is responsible for overseeing industrial wastewater, while LASWAMO oversees domestic sewage.⁴²⁴ Both sources of wastewater have an unfavorable impact on groundwater in Lagos.

5.11.1 Domestic Sewage

From the total of 350 million gallons generated daily in Lagos, 300 million gallons is domestic wastewater that is received into individual septic tanks.⁴²⁵ Septic tanks are a form of on-site sanitation (a sanitation system in which wastewater is contained within the plot occupied by the dwelling and its immediate surroundings).⁴²⁶ Every building has its individual septic tanks and soak away pits into which sewage is flushed. Therefore, ejection into the environment is in a diffused, distributed manner rather than a centralized one. The city's original town planning design did not incorporate a plan for centralized sewage collection, and thus the problems associated with individual septic tanks and distributed emissions have begun to manifest. Only a very limited part of the state, 0.04% of the state's population has sewage treatment plants.⁴²⁷ Sewage from households and commercial centres leak from the tanks and is released into the environment with minimal or no treatment. Although the septic tanks are

⁴²⁴ Personal discussions at Lagos Wastewater Management Office on November 16th 2012; Personal Discussions at Lagos State Environmental Protection Agency on November 28th 2012.

⁴²⁵ Lagos State Wastewater Management Office, Online: <http://www.lagoswastewater.org/danger-lagos-faces-drinking-water-pollution-from-waste-discharge/>

⁴²⁶ World Health Organization, *Guidelines for the Safe Use of Wastewater, Excreta and Greywater* (2006) Available online.

⁴²⁷ The few estates that have centralized sewerage include: Abesan, Oke-Afa, Iponri, and Alausa: Personal discussions with LASWAMO Engineer on November 19th 2012; Lagos State Wastewater Management Office, Online: <http://www.lagoswastewater.org/facilities/>

supposed to be equipped for primary sewage treatment which ensure that the wastewater released into the ground is fairly safe, that standard is rarely met.⁴²⁸

The use of on-site sanitation is premised on the scientific understanding that natural soil profiles can be effective mediums for purifying human wastes by eliminating fecal microbes, as well as by breaking down chemical compounds. However this useful soil functionality is dependent on proper designs and the presence of appropriate physical conditions.⁴²⁹ On-site sanitation systems that do not conform to these specifications create the risk of pathogenic bacteria and viruses penetrating into the underlying aquifers, and are proven vectors of pathogenic transmissions in the outbreak of diseases.⁴³⁰

Microbial contamination of groundwater in Lagos is occurring from these on-site sanitation systems, and is compounded by improperly constructed septic tanks, and the haphazard location of wells within pollution zones without an understanding of site hydrogeology.⁴³¹ There is often poor construction of septic tanks in Lagos, and this constitutes the major source of pollution of groundwater. The tanks are sometimes not of good enough quality or design to allow necessary primary biological processes to take place. Such tanks then function as mere holding tanks rather than mediums of primary treatment. Thus human waste is released into the soil without treatment and contaminates groundwater and water wells in the vicinity.⁴³² According to LASWAMO, a well-constructed septic tank ought to function as a

⁴²⁸ Personal discussions with LASWAMO Engineer on November 19th 2012.

⁴²⁹ S.S.D. Foster, "Potable Groundwater Supplies and Low-cost Sanitary Engineering - How Compatible?" (1985) 9(2) Natural Resources Forum 125. Ideal physical conditions, according to his research include the following: the hydraulic loading of the tanks ought to be designed not to exceed 30mm daily; wastewater deposited in them should not exceed 30mm daily; and the groundwater table ought not to be shallow, i.e. should occur at more than 3 metres depth.

⁴³⁰ World Health Organization Guidelines, *supra*, note 426.

⁴³¹ Personal Discussions with LASWAMO Engineer, *supra*, note 428.

⁴³² *Ibid.* See also: F. Obi, "Wastewater Management for a Modern City - The Way Forward' Paper presented at Lagos State Water Regulatory Commission's One-Day Stakeholder Summit on Wastewater, October 3rd 2013, Ikeja,

medium for primary treatment of sewage by having a collection point where it undergoes primary treatment, as well as an exit point from where it enters the ground.⁴³³ Most of the existing septic tanks are mere holding tanks that are not constructed to do the primary treatment of a standard septic tank and thus groundwater is polluted. Many septic tanks are also poorly maintained. A well-maintained septic tank, according to LASWAMO, is one where the waste is held for a maximum of 3 years before being evacuated.⁴³⁴ However, many users of septic tanks hold the waste for as long as 10-15 years. In areas of low water tables like Agege, Alimosho, and Ikeja this puts groundwater at great risk. Additionally, there is overflow into drainages and the environment caused by the unsavory practice of discharging waste water into canals in a bid to save costs. Once it is full, it flows into moving water. When storms occur, storm water flows and carries waste along with it.⁴³⁵

LASWAMO has outlined unhealthy practices within the Lagos metropolis that have the potential to pollute groundwater. These are: septic tanks being piped into the public drainage; pipes leading from ongoing construction of septic tank to a nearby canal; and over-full septic tanks spilling septage into the environment.⁴³⁶ The indiscriminate discharges of untreated wastewater from homes into open drains and water channels has raised fears about underground water pollution in the metropolis.⁴³⁷ These harmful practices are an indication of regulatory failures in controlling wastewater discharges, which are discussed fully in Chapter 6.

Lagos. See also Aliyu Mamman, “Regulating Wastewater Management in Lagos State: How it Affects You! Impacts of Wastewater Mismanagement on Environment, Health, and Water Supply” Paper presented at the same Summit.

⁴³³ Personal discussions with LASWAMO officials, *supra*, note 428.

⁴³⁴ *Ibid.*

⁴³⁵ *Ibid*; K.O. Iwugo, “Aspects of Land Based Pollution of an African Coastal Megacity of Lagos” Presented at Diffuse Pollution Conference (Dublin, 2003), Available online.

⁴³⁶ Lagos State Wastewater Management Office, online: lagoswastewater.org.

⁴³⁷ *Ibid.* The distributed sewage system is fraught with other problems including the need for frequent dislodgment of tanks, arbitrary dumping of raw sewage at illegal points, and dilapidated collection trucks which frequently break

5.11.1.1 Empirical Research Findings on Domestic Wastewater Pollution of Groundwater

Research findings have confirmed that groundwater is being polluted from on-site sanitation. Eruola et al assessed five wells located close to septic tanks within five densely-populated districts in the Lagos metropolis (Ikorodu, Mushin, Shomolu, Itire and Ilasamaja).⁴³⁸ The examination was during the rainy season when groundwater intrusion is normally high, and the sampling points were selected because of their proximity to septic tanks. Results showed that sewage has intruded from the septic tanks into and polluted the surrounding groundwater. They affirmed that water from these wells is unsuitable for domestic use except after treatment, on account of the high levels of bacteria in them that exceeds the World Health Organization's (WHO) limit for drinking water. The writers therefore warn about the looming danger of groundwater pollution from septic tanks on a larger scale.⁴³⁹ Similarly, Balogun et al who evaluated 14 groundwater samples from two districts in Lagos (Amuwo Odofin and Badagry) also confirmed groundwater pollution from urban sewage.⁴⁴⁰

However domestic sewage is considered to be a relatively minor source of groundwater pollution in Lagos compared with industrial wastewater which is a significant and troubling

down an discharge their contents on highways: D. Olanrewaju, "Soakaway Systems and Possible Groundwater Pollution Problems in Developing Countries" (1990) 110(3) *Perspectives in Public Health* 108.

⁴³⁸ A.O. Eruola, R.A. Idowu, I.O. Ogunyemi, & N.A. Adedokun, "Assessment of Effect of Sewage Intrusion from Septic Tanks into The Consumable Hand dug Wells in Lagos State, Nigeria" (2013) 13 *Global Journal of Science Frontier Research* ISSN:2249-4626 &Print ISSN: 0975-5896.

⁴³⁹ Ibid.

⁴⁴⁰ I. Balogun, I.S. Akoteyon & O. Adeaga, "Evaluating Land Use Effects on Groundwater Quality in Lagos-Nigeria Using Water Quality Index" (2012) 4(2) *J. Sci. Research* 397. In 2014, the Lagos State Government started to operate four domestic sewage treatment plants in four areas of the metropolis: Abesan, Oke Afa, Iponri, and the Lagos State Secretariat: Personal Discussion with Principal Environmental Officer, Ministry of the Environment, May 19th 2015. Lagos also planned to construct an additional eight wastewater treatment plants to reduce the constant pollution of groundwater. The plants would be located within Iba Housing Estate, Magodo Estate, Omole Phase I and II, Ogba, Ikeja, and Dolphin Estate: Lagos State Wastewater Management Office, *Fashola Approves Eight Wastewater Plants*, online: www.lagoswastewater.org. The status of construction work was not ascertained at the time of writing this thesis.

phenomenon.⁴⁴¹ Because industries in Lagos also discharge untreated wastewater into the environment, this constitutes the main source of highly toxic chemicals that severely pollute groundwater. The central treatment plant provided in the 1970s for companies within the Ikeja Industrial Estate to process industrial effluents to potable standards ceased to function in the early 1990s and was not replaced, and thus effluents have since been released into the environment in their raw, untreated state.⁴⁴²

5.11.2 Industrial Wastewater

Industries discharge considerably high levels of assorted and dangerous chemical effluents. The combination is dangerous because of the wide range of organic and inorganic chemicals that industries manufacture, use, and dispose. According to experts, industrial effluents are a major source of toxins in groundwater, all with varying characteristics and compositions of carcinogenic and non-bio-degradable elements.⁴⁴³ But while in developed countries, the threats are clearly understood and appropriate standards are established and enforced, the same is not the case for Lagos, a megacity within a developing country, where investigations are not often carried out due to low awareness and inadequate analytical facilities.⁴⁴⁴

Experts have affirmed that in consequence of industrial wastewater being discharged into the environment untreated, the first and second aquifers (Recent Sediments and Upper Coastal

⁴⁴¹ At discussions with LASEPA, the official considered domestic sewage to be overall more benign than chemicals-laced industrial wastewater: Personal Discussion with LASEPA on November 28th 2012.

⁴⁴² Lagos State Wastewater Management Office, *Institutional, Regulatory, and Legal Framework of Lagos Wastewater Management Office* (2012); Personal discussion with LASEPA official, *supra*, note 441.

⁴⁴³ L. Ritter et al, "Sources, Pathways and Relative Risks of Contaminants in Surface Water and Groundwater; A Perspective Prepared for the Walkerton Inquiry" (2002) 65(1) J. Toxicol. Environ Health A. 1.

⁴⁴⁴ O. Sililo, "Groundwater Contamination by Organic Chemicals in Industrializing Countries: An Unseen Threat" Impacts of Urban Growth on Surface Water and Groundwater Quality, Proceedings of IUGG 99 Symposium in Birmingham July 1999.

Plains Sands discussed in Chapter 1) have become severely polluted, and therefore resort is now being made to the third aquifer. LASEPA has standards for industrial effluents, but in spite of these existing legal requirements for industrial wastewater to be treated to specified standards, there is scant compliance.⁴⁴⁵

5.11.2.1 Empirical Research Findings on Industrial Wastewater Pollution of Groundwater

Researchers found that the textile industry in particular is polluting the environment through indiscriminate discharges of untreated effluents. Siyanbola et al collected 5 sample effluents from 5 industries in Lagos state. Their investigation confirms that the effluents being discharged by these industries are not treated before being released into the environment. The companies are not compliant with the Ministry of the Environment's Standards for effluents, and the receiving water bodies are accumulating metal concentrations that are resulting into a serious threat to the aquatic habitat and a major human health hazard to consumers of aquatic animals.⁴⁴⁶ In another research quest, scientists who carried out investigation of fifteen tube wells around the industry confirmed a very high chemical contamination of the wells closest to the mills and that this exceeds the standards set out by the Lagos Ministry of the Environment.⁴⁴⁷

⁴⁴⁵ The current effluent standards for each of the industries are contained in Regulations made between 2009 and 2011 and discussed in Chapter 6.

⁴⁴⁶ T.O. Siyanbola, K.O. Ajanaku, O. James, J. Olugbuyiro, & J. Adekoya, "Physico-Chemical Characteristics of Industrial Effluents in Lagos State, Nigeria" (2011) G. J. P&A Sc and Tech 49.

⁴⁴⁷ K. Olayinka, & B. Alo, "Studies on Industrial Pollution in Nigeria: The Effect of Textile Effluents on the Quality of Groundwater in Some Parts of Lagos" (2004) 3(1) Nigerian Journal of Health and Biomedical Sciences 44. Research in other states within Nigeria also shows the same trend of toxic pollution from industrial sewage: D. Eni, J. Obiefuna, C. Oko, & I. Ekwok, "Impact of Urbanization on Subsurface Water Quality in Calabar Municipality Nigeria (2011) 1(10) International Journal of Humanities & Social Science 167. The potentially harmful effect of industrial wastewater was depicted in an incident in Lagos in November 2013. A photo laboratory which used liquid chemicals with strong odor, discharged the wastewater derived from the process into nearby drains without any treatment. Soon afterwards, 25 students and 2 teachers at a school next door collapsed after inhaling the noxious fumes from the chemical wastes in the drain: Nigeria Weekly Standard, "Toxic Chemical Waste Knocks off 25 Students and 2 Teachers", Online: <http://weeklystandardng.com>.

5.12 Report of Field Trip to Lagos

In view of the problems associated with wastewater in Lagos, the Researcher visited and had discussions with officials in the responsible government departments in Lagos. These are: the Lagos State Environmental Protection Agency (LASEPA); Lagos State Wastewater Management Office (LASWAMO); Lagos Water Corporation (LWC); and the Lagos State Water Regulatory Commission (LASWARC). The Researcher also interviewed two Senior Professors/Researchers at the University of Lagos. The findings are shown in the table below:

5.13 Summary of Research Findings on Wastewater Problems in Lagos, Nigeria

	Theme	LASEPA	LASWAMO	LWC	LASWARC	Professors/Scientists
1.	Reason for Wastewater Pollution of Groundwater By Industrial/ Domestic Sewage	Industrial: Industries are discharging raw effluents into the environment and polluting groundwater; Industrial effluents contains heavy metals and is more toxic than municipal sewage; Domestic: Overall volume of domestic sewage is more than industrial sewage but is fecal and less lethal	Industrial: Toxic industrial emissions from textile companies especially are polluting groundwater. Domestic: Diffuse sewage ejection in the municipality is also polluting groundwater; Districts like Lekki with high water table are wrongly using on-site sanitation instead of sewage treatment plants	There is no pollution of groundwater sourced by LWC for public use due to its extraction from a confined aquifer that is not affected by pollution; Individual exploitations are from an unconfined aquifer that is susceptible to pollution from leaks in septic tanks	Wells are being polluted as individuals exploit groundwater without understanding hydrogeology	The distributed sewage ejection system is causing dangerous pollution of groundwater which is now occurring in Lagos
2.	Extent of Wastewater Pollution	1 st and 2 nd Aquifers are highly contaminated primarily from industrial sewage discharges	1 st and 2 nd aquifers are highly contaminated; areas of high water table that are wrongly using on-site sanitation will probably experience an epidemic in the near future	There is pollution of unconfined aquifers in Lagos	Pollution is occurring as sewage migrates to wells and boreholes	Quality impairment of 1 st aquifer is very high
3.	Underlying Reasons for the pollution problem	Industries are unwilling to incur the high costs involved in treating their wastewater. They consider it to be a waste	Decentralized sewage collection; wrongly constructed septic tanks, & poorly maintained septic	LWC is only able to meet 30% of water demand in the state for many reasons: overpopulation;	LWC's inability to provide adequate water has forced residents to find	Haphazard location of shallow wells and boreholes downstream of septic tanks causes pollution that is

		of valuable resources; domestic sewage is haphazardly discharged into the environment	systems directly cause pollution; intentional piping of domestic wastewater into open drains that directly pollute surface water; old rickety disposal trucks, and periodic overflows of sewage into drains	frequent electricity outages; high cost of diesel to run generators for water pumping; pipe leakages causing unaccounted-for water loss; low tariffs; public perception of water as a social commodity with free access to all causes indiscriminate well construction with resultant pollution	water on their own, without any knowledge of hydrogeology; some wells and boreholes are sunk too close to septic tanks, and become polluted	worsened by flooding; on-site sanitation (septic tanks) is polluting groundwater particularly in areas of high water table; 1 st aquifer is highly prone to pollution; citizens contribute to the pollution by wrongly locating wells and boreholes with inadequate distance from on-site sanitation; insufficient data on wells/boreholes will make enforcement of regulations elusive; housing shortages makes difficult to enforce minimum distances between septic tank and wells
4.	Effects of Wastewater Pollution	High pollution of the 1 st two aquifer horizons has occurred and is forcing a resort to the 3 rd aquifer especially in the industrial areas	1 st and 2 nd aquifers are highly polluted mainly from untreated industrial emissions; Epidemic is imminent from domestic sewage in areas of high water table where septic tanks are wrongly used	Unconfined aquifers are polluted but LWC is unaffected because its water is sourced from the confined aquifers	Aquifer pollution affects a lot more people than the polluter because once polluted, it is impossible to know how far the water would travel	Water in 1 st and 2 nd aquifers is unfit for human consumption
5.	Pollution Abatement Efforts	LASEPA is trying to encourage industry operators to recognize the value in treating and re-using wastewater. Seminars & workshops are being organized to encourage a re-use culture; Companies are required to have primary wastewater treatment plants within their premises	5-year strategic plan in place (2011-2015) for Lagos sewage management. Will revamp existing sewage treatment plants; new constructions are mandatorily required to include sewage treatment plan in the draft building plan for state approval	Laws to regulate the location of domestic boreholes need to be written	Presently compiling data on boreholes to enable a regulatory system that would prescribe location, and distance from on-site sanitation	Government is aware of the pollution problem and has set up a Water Regulatory Commission, and a Committee to tackle it
6.	Possible Solutions/Longer-term strategies	Government is making efforts to repair the central (WEMABOD) wastewater treatment plant that conducts secondary sewage treatment for industries within Ikeja Industrial	Planned de-centralized sewage treatment in areas subject to land availability; Some housing estates now have central sewage treatment plants;	20-year Master Plan in place to improve water supply significantly by 2020; future talks about water conservation will possibly consider recycling of water for	We will try to provide potable water for all residents to reduce individual groundwater exploiting; Water has its	Lagos needs well-designed sewage systems to gather wastewater from homes. Min. of Environment Committee on Water & Sanitation is

		Estate	Draft law prohibits discharge of household sewage into open drains and mandates use of septic tanks; planned acquisition of 10 new treatment plants which are expected to increase coverage of wastewater management to 35% from the current 6% coverage; making efforts to correct the trend of wrongful septic tank usage in areas of high water table because to avoid epidemic	re-use and for cost-savings	hazards, there is environmental impact of abstraction, it is not necessarily cheaper than LWC's water; currently compiling data on boreholes; will be engaging technical experts to write regulations for licensing commercial boreholes	looking into this; There are plans to introduce the sewage system; there must be a perimeter of safety distance between wells and septic tanks both within and across buildings; regulations must be adequately enforced; haphazard groundwater exploitation must be extinguished; limit number of boreholes drilled in an area
--	--	--------	--	-----------------------------	--	---

5.14 Discussion and Analysis

5.14.1 Reasons for Wastewater Pollution of Groundwater:

Untreated wastewater discharged from both industrial and municipal sources is polluting groundwater in Lagos. Happily, groundwater pumped by the Water Corporation for public use is still safe from pollution because it is exploited from the deeper, confined aquifer (Lower Coastal Plain Sands) that is not yet affected by the pollution trend. The inference is that the affected groundwater is that which is exploited by citizens from the shallow aquifer (Recent Sediments).

Industrial activities have raised natural chemical concentrations in groundwater, an alarming trend because of the non-biodegradable nature of heavy metals.⁴⁴⁸ LASEPA stated that industrial wastewater, though a much smaller volume than municipal sewage, is more dangerous to human health because of its lethal mix of toxic chemicals that are both carcinogenic and non-

⁴⁴⁸ O.J. Aderinola, E.O. Clarke, .M. Olarinmoye, V. Kusemij & M.A. Anatekhai, "Heavy Metals in Surface Water, Sediments, Fish Periwinkles of Lagos Lagoon" (2009) 5(5) American-Eurasian Journal of Agric. & Environ. Sci. 609; P.B. Tchounwou, C.G. Yedjou, A.K. Patlolla, & D.J. Sutton, "Heavy Metals Toxicity and the Environment (2012) 101 EXS. 133; G. E. Nwajei & P.O. Gagophien "Distribution of Heavy Metals in Sediments of Lagos Lagoon" (2000) 43(6) Pakistan Journal of Scientific and Industrial Research 338.

bio-degradable. Domestic sewage on the other hand is milder, usually fecal, and typically composed of black and grey water from kitchens and bathrooms. However, this thesis affirms that the harmfulness of wastewater from either source should not be minimized; both streams of wastewater are equally dangerous because of their potentially dire effects on human life and health, as the discussion of the health effects following this analysis will elaborate. Therefore measures to correct the wrongful wastewater emissions from both sources should be equally firm, especially in view of reports that domestic sewage contamination has been causing illnesses in the metropolis.⁴⁴⁹

A factor which compounds the pollution problem is indiscriminate groundwater exploitation, which is a pervasive trend. Due to limited regulation of private well use especially, there is unrestricted liberty to construct and use wells and boreholes. These are erected haphazardly by practically anyone with little or no understanding of site hydrogeology, or of the interactions between wastewater and groundwater. In consequence, wrongful locations close to septic tanks or to waste dump sites place such wells at risk of pollution which has begun to occur. Although there are rules governing the locations of septic tanks in terms of minimum location specifications from wells and other potable water supplies, there does not appear to be significant compliance.⁴⁵⁰ The problem is thus partly that of inadequate regulation of well use, and also non-compliance with rules for septic tanks' location. A fuller discussion of the regulatory framework in Chapter 6 incorporates this finding.

⁴⁴⁹ Reports in 2014 indicate that domestic sewage contamination of groundwater has begun to result in illnesses within the metropolis, although precise details were not available at the time of writing this thesis: *Fashola Approves Eight Wastewater Plants*, supra, note 440.

⁴⁵⁰ The rules are contained in: National Environmental (Sanitation and Wastes Control) Regulations, Federal Republic of Nigeria Official Gazette, (2009) No. 60, Vol. 95, S. 10 and Schedule IV.

5.14.2 Extent of Pollution

The relevant agencies (LASEPA, LASWAMO, & LWC) and scientific investigations are unanimous that the first and second aquifers in some parts of Lagos are now polluted predominantly from industrial wastewater. Although the city's extraction for public use is from the uncontaminated, confined groundwater, LWC's supply is extremely limited, and thus individual extractions are prone to be from polluted sources because of the ease of access due to their relative proximity to the surface. People are generally uninformed about site hydrogeology, and are unaware about groundwater pollution that is happening, and thus locate wells at any convenient location which is sometimes in unsafe zones or too close to sources of pollution. Yet it is well known that aquifer pollution is extremely difficult to redress in spite of their natural attenuation capabilities of aquifer discussed in Chapter 3 which may be inadequate to mitigate severe pollution that is already occurring.⁴⁵¹

5.14.3 Underlying Reasons for Pollution: Distributed Wastewater Ejection/Industrial Apathy

In the case of domestic sewage, LASWAMO told the Researcher that it is planning to put together de-centralized sewage treatment plants in some of the developed residential areas. The system will collect and treat sewage to a quality that can be safely discharged into surrounding bodies of water.⁴⁵² It cited a waste water treatment plant at Ojota that has been approved for construction. Collection will be privatized, meaning that the households will initiate collection, and also pay for it. Clusters of treatment plants will be installed subject to availability of land that is provided by property owners. For newly developing areas LASWAMO affirmed that it

⁴⁵¹ The imminence of water-borne diseases that result from domestic pollution has prompted the government to plan for eight domestic wastewater treatment plants in addition to the current four that are now in operation: see Lagos Wastewater Management Office, *Fashola Approves Eight Wastewater Plants*, supra, note 440.

⁴⁵² Ibid. The plants are now underway, according to the report.

will henceforth disallow decentralized sewage systems and require centralized sewage treatment plants. Prospective builders will be required to include their plans for sewage treatment in the building plans for prior approval from LASWAMO.

LASWAMO's plan is a laudable, well-intentioned plan to tackle a problem in the context of a fully developed metropolis where it is difficult to lay communal sewerage pipes. However some impediments are immediately evident. The sustainability of a plan for developed areas that is subject to the willing participation of home owners in a system of pervasive apathy may be difficult to implement. The plan is also subject to availability of land, so, for a city like Lagos that is particularly short on land the viability of this plan seems doubtful.

In the case of industrial wastewater, LASEPA's indication of industry unwillingness to treat their water, and the derelict treatment plant meant for secondary treatment now have to be firmly addressed. LASWAMO's strategic plan to invest in repair of moribund treatment plants may be costly and probably not worth the effort. New treatment plants are preferable for their likely durability and functionality. Industry operators may be offered incentives to treat their wastewater, but their culture of discharging toxic wastewater should no longer be allowed in the interest of public health.

5.14.4 Effects of Wastewater Pollution:

The city's groundwater is suffering extensive pollution with two aquifers now highly polluted. Due to the extensive pollution, the health of residents is at risk. As mentioned earlier,

reports are emerging about outbreaks of illnesses.⁴⁵³ A fuller discussion of the effects of polluted groundwater on human health will be presented in the next section.

5.14.5 Pollution Abatement Efforts

For industrial wastewater, efforts to repair the central wastewater treatment plant that fell into disrepair since the 1990s needs to be either firmed up, or, in the alternative, a new treatment plant should be purchased. In terms of domestic wastewater, as mentioned earlier, reports have indicated that four wastewater treatment plants are already in use, while the state government has approved the construction of eight additional treatment plants.⁴⁵⁴ This is consistent with its planned decentralized sewage treatment in some developed areas mentioned earlier. However the Researcher was unable to confirm the actual construction of the additional eight, nor assess their positive impact on groundwater quality, if any.

5.14.6 Longer-term Strategies:

The culture of industries' discharging raw effluents into waterways is an unacceptable practice that needs to be halted immediately before more serious results emerge than those already reported. It will be necessary to increase enlightenment about the re-use of waste water, and the cost savings that may thereby accrue to industry operators. LASWAMO's new requirement for sewage treatment plans to be included in building plan applications for its approval is commendable, and its effectiveness will be known over time. For the future, industries should ideally be located only after proper hydrogeological studies have determined that the location is not close to a sensitive aquifer.

⁴⁵³ Supra, note 440.

⁴⁵⁴ Ibid.

A report indicates that the city is gradually introducing more advanced treatment methods to its domestic sewage that will comprise physical, chemical, and biological processes. The report shows that at pre-treatment plants located at Abesan, Maryland, Amuwo Odofin, Lekki and Iddo, sewage collected by evacuation trucks is being discharged into the grill chamber which separates solid waste items out of the sewage. Its objective is to produce a treated effluent for discharge or reuse back into the environment as well as sludge, (a natural fertilizer waste residue).⁴⁵⁵ This development is a very welcome one, and if sustained, its full impacts will hopefully be quantifiable over time.

The first part of this chapter discussed the problem of migration of leachates from solid waste into groundwater and the ensuing contamination. The second part discussed wastewater pollution from domestic and industrial sources. Whether from leachates or sewage, contaminants which may be either chemical or microbial in nature, are very harmful to human health. It is now worth describing the likely implications of these contaminants.

5.15 Description of Chemical and Microbial Contaminants in Waste Dump Leachates and Wastewater

The effects of polluted groundwater on human health depend on the type of chemicals or microorganisms that have been released into the environment. Both are relevant for Lagos owing to the diversity of wastes at dumps that habitually comprise both biodegradable waste and chemical wastes, and the complexity of chemicals and microbes in industrial and domestic wastewater. Whether the source is sewage or leachate from solid waste dumps, the effect on human health is serious.

⁴⁵⁵ The Punch Newspapers, "How Sewage is Treated in Lagos State" November 7th 2013 Online: <http://www.punchng.com>.

5.15.1 Chemical Contaminants

Chemical wastes feature an assortment of elements and heavy metals. As mentioned in Chapter 1, water bodies in their natural form contain small amounts of naturally-occurring dissolved gases and solids. These chemical compounds such as bicarbonates, nitrates, chlorides, and sulphates, as well as heavy metals occur naturally throughout the earth's crust.⁴⁵⁶ However anthropogenic activities may contribute to their accumulation at high levels that are dangerous to human health.⁴⁵⁷ Collectively, heavy metals, which are unaffected in the process of bio-degradation of organic materials, have toxic effects on humans. Writers discuss the toxicity and effects of humans ingesting harmful compounds into their bodies through contaminated water. According to Florea & Busselberg, heavy metals such as arsenic, lead, mercury, platinum, and tin are metal species to which humans easily get exposed, and which may interfere with the central nervous system. Because the exposure to heavy metals may cause blood and bone disorders, they recommend that this should be addressed before compost from municipal solid waste is used as fertilizers.⁴⁵⁸

Lead is one of the oldest known and most widely studied occupational and environmental toxins.⁴⁵⁹ It enters the environment from industry, and is used in the production of ammunition, batteries, electrical and electronic equipment, and X-ray shields. Sources of occupational exposure include lead mining, refining, smelting, construction work, paint removal, demolition, maintenance of bridges and water towers, car repair, and recycling.⁴⁶⁰ It affects red

⁴⁵⁶ C.W. Fetter, *Applied Hydrogeology*, (New Jersey: Prentice-Hall, 2001) at pg. 346.

⁴⁵⁷ E.O. Longe & A.O. Ogundipe, "Assessment of Wastewater Discharge Impact from a Sewage Treatment Plant on Lagoon Water, Lagos Nigeria" (2010) 2(3) Research Journal of Applied Sciences, Engineering and Technology 274.

⁴⁵⁸ A.M. Florea & D. Busselberg, "Occurrence, Use and Potential Toxic Effects of Metals and Metal Compounds" (2006) 19 BioMetals 419.

⁴⁵⁹ D.A. Gidlow, "Lead Toxicity" (2004) 54 Occup Med 76.

⁴⁶⁰ A. Pizent, B. Tariba & T. Zivkovic, "Reproductive Toxicity of Metals in Men" (2012) 1 Arh Hig Rada Toksikol 35.

blood cell chemistry by delaying normal physical and mental development in babies and children. It causes deficits in attention span, hearing, and learning in children. It can also cause increased blood pressure in adults, and is regarded as a probable carcinogen.⁴⁶¹

Chromium enters the environment from the runoff in mining operations leaching into groundwater, and also from waste incineration. Chromium is toxic and causes liver and kidney damage, internal haemorrhaging, respiratory damage, dermatitis and ulcers on the skin at high concentrations. When chromium and lead are combined (often used in pesticides) they may cause permanent and irreversible damage to the brain, nervous system, and kidneys.⁴⁶²

Cadmium enters the environment from industrial discharges, water pipes, batteries, and landfill leachate. It is usually extracted as a by-product in the process of making other chemicals such as zinc, lead, or copper, and is also recovered from used batteries. It is employed in the production of nickel-cadmium batteries and stabilisers for plastics.⁴⁶³ Exposure of human populations to cadmium through air, food and water may produce negative effects in organs such as the kidneys, liver, lungs, cardiovascular, immune and reproductive systems. It replaces zinc in the body and causes high blood pressure, liver and kidney damage and anaemia.⁴⁶⁴ It destroys testicular tissue and red blood cells. It has also been identified as a human carcinogen.⁴⁶⁵ Studies conducted on wells around waste dumpsites, which confirmed the presence of high concentrations of the heavy metals lead, cadmium, and chromium in groundwater, also affirmed that they may lead to impaired renal function and probably cancer.⁴⁶⁶

⁴⁶¹ Ibid.

⁴⁶² A.M. Florea & D. Busselberg supra, note 458.

⁴⁶³ United States Department of Health and Human Services, Agency for Toxic Substances and Diseases Registry, *Toxicological Profile for Cadmium*, (2012) Available online.

⁴⁶⁴ B.A. Fowler, "Monitoring of Human Populations for Early Markers of Cadmium Toxicity: A Review" (2009) 238 *Toxicology and Applied Pharmacology* 294.

⁴⁶⁵ Ibid.

⁴⁶⁶ A.M. Florea & D. Busselberg, supra, note 458.

Benzene: human activities that use petroleum lead to benzene exposure, and these activities include processing of petroleum products, and use in industrial and consumer products. Benzene has been associated with a range of acute and long-term diseases especially cancer and aplastic anaemia. It has been shown to lead to higher incidences of leukemia, neuromuscular and kidney damage, and excessive or long term exposure to it can lead to death.⁴⁶⁷

Nitrates enter the environment from fertilizers, sewage, and human waste.⁴⁶⁸ Toxicity arises from the body's natural break down of nitrate to nitrite. Nitrite inhibits the blood's oxygen-carrying capacity, and is particularly dangerous for infants because they cause *methemoglobinemia*, or "baby blue" disease, a condition which inhibits the blood from carrying oxygen, and results in digestive and respiratory problems.⁴⁶⁹

Arsenic: Although occurring naturally in water, arsenic can become deadly at a high level of concentration, at which it becomes a carcinogen. Dangerous levels of arsenic enter the environment from industrial activities and industrial waste, and cause acute and chronic toxicity, liver and kidney damage, and decreased blood haemoglobin.⁴⁷⁰ Dogan et al observed skin disorders in 153 individuals who had consumed arsenic-contaminated drinking water.⁴⁷¹ In a second study, the scientists collected blood and hair samples from participants who were exposed to arsenic in groundwater. The results proved that exposure to arsenic in drinking water causes

⁴⁶⁷ World Health Organization, *Exposure to Benzene: A Major Health Concern*, Online: <http://www.who.int/ipcs/features/benzene.pdf>

⁴⁶⁸ M. McCasland, N.M. Trautmann, R.J. Robert, & K.S. Porter, "Nitrate: Health Effects in Drinking Water" (2007) Centre for Environmental Research and Natural Resources (Cornell University Cooperative Extension) available online: <http://psep.cce.cornell.edu/facts-slides-self/facts/nit-heef-grw85.aspx>.

⁴⁶⁹ Ibid.

⁴⁷⁰ M. Dogan, A.U. Dogan, C. Celebic & Y.I. Baris, "Geogenic Arsenic and a Survey of Skin Lesions in the Emet Region of Kurahya, Turkey" (2005) 14(6) *Indoor and Built Environment* 533.

⁴⁷¹ Ibid.

serious DNA damage.⁴⁷² Arsenic poisoning is linked to skin, lung and bladder cancer. High levels of arsenic also lead to cardiovascular damage, and lowered immune system functions.⁴⁷³

Mercury: Mercury enters the environment from industrial waste, electrical equipment such as batteries lamps, switches, municipal solid waste incineration, hazardous waste and sewage sludge. It targets the kidneys, causes acute and chronic toxicity, and can cause nervous system disorders.⁴⁷⁴

Platinum: Platinum is a chemical element that is largely resistant to corrosion, and thus termed a noble metal.⁴⁷⁵ Short-term exposure to platinum salts may cause irritation of the eyes, nose, and throat, while long-term exposure may cause both respiratory and skin allergies.⁴⁷⁶ Studies conducted on animals showed kidney shrinkage, DNA damage, and enlargement of white pulp in the spleen.⁴⁷⁷ This result demonstrates a potential for human susceptibility to the same illnesses.

Manganese: Manganese is a chemical element that usually combines with others such as iron.⁴⁷⁸ According to a study, a higher level of exposure to manganese in drinking water is associated with increased intellectual impairment and reduced intelligence quotients.⁴⁷⁹

⁴⁷² Ibid; See also: Sardars, S. “Risk Assessment in Arsenic Exposure, in *Medical Geology workshop* (2009) pp. 138–144), Turkey, 30 October - 1 November.

⁴⁷³ Ibid.

⁴⁷⁴ United Nations Environment Program, *Global Mercury Assessment- Sources, Emissions, Release and Environmental Transport* (2013), Online: <http://www.unep.org/PDF/PressReleases/GlobalMercuryAssessments2013>; United States Geological Survey, *Contaminants Found in Groundwater*, online: <https://water.usgs.gov/edu/groundwater-contaminants.html>

⁴⁷⁵ Wikipedia, Online: <http://en.wikipedia.org/wiki/Platinum>.

⁴⁷⁶ Ibid.

⁴⁷⁷ Z. Gagnon, C. Newkirk, & S. Hicks. “Impact of Platinum Group Metals on the Environment: A Toxicological Genotoxic and Analytic Chemistry Study” (2006) 41 *Journal of Environmental Science and Health Part A* 397

⁴⁷⁸ Wikipedia, Online: http://wikipedia.org/wiki/Manganese#manganese_in_drinking_water.

⁴⁷⁹ M.F. Bourchard, S. Sauve, B. Barbeau, M. Legrand, M. Brodeur, T. Bouffard, E. Limoges, D.C. Bellinger & D. Mergler, “Intellectual Impairment in School-Age Children” (2010) 119 (1) *Environmental Health Perspectives* 138.

The proof of the serious impacts of diverse pollutants in groundwater to human health is demonstrated by the following studies:

5.15.1.1 International Case Studies

Esakku et al studied an open dumpsite at Perungudi, an Indian city which generated 3,500 tons of waste daily at the time. They found that unorganized dumping of diverse wastes (including electronic waste) caused a slow leaching of heavy metals into groundwater. Mercury, chromium, and lead exceeded the limits of Indian drinking water standards. The case demonstrates that open dumps can be responsible for chemical leachates in groundwater, and they are not merely containers of organic biodegradable materials.⁴⁸⁰

Dolk et al studied the births of mothers who resided around waste sites. The study showed an elevated risk of congenital anomalies in babies whose mothers lived closer to landfill sites that handled hazardous chemical wastes. The anomalies included malformations of the cardiac septa and anomalies of great arteries and veins. On the other hand, they noted a fairly consistent decrease in risk with distance away from the sites, thus prompting them to recommend a safety perimeter of 7 km from a landfill site for residences.⁴⁸¹

⁴⁸⁰ S. Esakku, K. Palanivelu, & K. Joseph, "Assessment of Heavy Metals in a Municipal Solid Waste Dumpsite" Workshop on Sustainable Landfill Management, 3rd -5th December 2003, Chennai, India. See also K. Aurangabadkar et al, "Impact of Municipal Solid Waste Dumpsite on Groundwater Quality in Chennai, India" (2001) 5 Environmental Pollution Control 41. See also J. Ciba, T. Korolewicz, & M. Turek, "The Occurrence of Metals in Composted Municipal Wastes and their Removal" (1999) Water, Air, Soil Pollution 159.

⁴⁸¹ H. Dolk, M. Vrijheid, B. Armstrong, L. Abramsky, F. Bianchi, E. Garne, V. Nelen, E. Robert, J.E. Scott, D. Stone & R. Tenconi, "Risk of Congenital Anomalies Near Hazardous-Waste Landfill Sites in Europe: the EUROHAZCON Study" 1998 352(9126) Lancet 423.

Kerndoff et al identified 1200 organic contaminants/chemicals in groundwater pollution plumes at waste disposal sites in Germany.⁴⁸² Other researchers also tied impaired locomotion and reduced spleen weight to groundwater contaminated by leachate.⁴⁸³

5.15.2 Microbial Contaminants

Microbial pollution of groundwater is potentially dangerous to health because of possible outbreaks of water-borne diseases. Microbial contaminants in groundwater include pathogens such as bacteria, fungi, and viruses that cause infectious diseases such as polio, cholera, typhoid fever, dysentery, and hepatitis. From studies conducted on wells, writers found that coliform bacteria including e coli, salmonella and shigella were present in them.⁴⁸⁴ E coli cause kidney failure and bloody diarrhea, while salmonella and shigella are known causes of infectious diarrhea.⁴⁸⁵ Other studies showed that leachate contaminated groundwater can cause bladder cancer and leukemia.⁴⁸⁶

The reality that groundwater can become polluted and severely affect human health was illustrated in Walkerton, Canada in 2000. In that case, microorganisms migrated into an aquifer that supplied drinking water to the Walkerton community and polluted it. This metamorphosed into a large-scale epidemic with tragic consequences as 2300 residents fell ill and seven people died.⁴⁸⁷

⁴⁸² Sililo discussed these cases in O.T.N. Sililo, "Groundwater Contamination by Organic Chemicals in Industrializing Countries: The Unseen Threat" *supra*, note 436. See also S. Esakku et al, *supra*, note 472.

⁴⁸³ L.M. Radi, D.J. Kuntz, G. Padmanabham, I.E. Berg, & A.K. Chaturvedi, "Toxicological Evaluation of Leachate from a Closed Urban Landfill" (1987) 38(2) *Bull. Env. Contam. Toxicol.* 337.

⁴⁸⁴ O. Adeyemi, O.B. Oloyede, & O.T. Oladiji, "Physico-Chemical and Microbial Characteristics of Leachate-Contaminated Groundwater (2007) 2 *Asian Journal of Biochemistry* 343.

⁴⁸⁵ H.R. Stutman, "Salmonella, Shigella and Campylobacter, Common Causes of Diarrhoea" (1994) 23(10) *Pediatr. Ann.* 538.

⁴⁸⁶ G.M. Albion "Landfill Waste Pollution and Control" in B. Abbob, ed., *Hazardous Waste Detection Control and Treatment, Part B* (Elsevier Science Amsterdam 1995) 1199.

⁴⁸⁷ Ontario Ministry of the Attorney-General, *Report of the Walkerton Commission of Inquiry: A Strategy for Safe Drinking Water* (Queen's Printer, Ontario 2002).

The discussions above confirm that drinking water from contaminated wells and borehole without a prior treatment will continue to expose the public to dangerous heavy metals and other lethal chemicals.⁴⁸⁸ A summary of the profile of the usual contaminants in groundwater is presented below:

5.15.3 Profile of Hazardous Chemical and Microbial Contaminants in Groundwater

No.	Name	Symbol	Impact on Human Health
1.	Lead	Pb	Delays normal physical and mental development in babies and children, causes deficits in attention span, hearing, and learning in children. A probable carcinogen
2.	Chromium	Cr	Liver and kidney damage, internal haemorrhaging, respiratory damage, dermatitis and ulcers on the skin
3.	Cadmium	Cd	High blood pressure, liver and kidney damage and anemia. It also destroys testicular tissue and red blood cells
4.	Benzene	C ₆ H ₆	Cancer and aplastic anaemia are probable diseases caused by benzene
5.	Nitrates	NO ₃ ⁻	<i>Methemoglobinemia</i> , inhibits blood from carrying

⁴⁸⁸ A.M. Taiwo, “Source Identification and Apportionment of Pollution Sources in Groundwater Quality in Major Cities in Southwest Nigeria (2012) 29 GEOFIZIKA available online; A.M. Taiwo, S.O. Ige, & O.O. Babalola, “Assessments of Possible Gonadotoxic Effect of Lead on Experimental Male Rabbits”, (2010) 5 Global Veterinaria, 282; A.M. Taiwo, S.O. Ige, and O.O. Babalola, “Investigations into the Teratogenic Potentials of Lead in Pregnant Rabbit” (2010), 4 Int. J. Biol. Chem. Sci., 809.

			oxygen, causes digestive/respiratory problems
6.	Arsenic	As	Liver and kidney damage, decreased blood haemoglobin
7.	Mercury	Hg	Acute and chronic toxicity, nervous system disorders
8.	Tin	Sn	
9.	Platinum	Pt	Short-term exposure: irritation of the eyes, nose, and throat; long-term exposure: respiratory and skin allergies
10	Manganese	Mn	Causes learning impairments
11.	Microbiological Contaminants (Pathogens		Bacteria, viruses, and parasites cause polio, cholera, typhoid fever, dysentery, and hepatitis

All these studies are compelling proofs that consumption of leachate-contaminated or sewage-polluted groundwater is extremely hazardous to human health. They emphasize the importance of having appropriate regulatory safeguards including regular monitoring of water quality on a regular basis in Lagos since the increase in concentration of these harmful contaminants will increase the threats to man's health and life.

Lagos residents are at risk from microbial and chemical pollutants from both dumpsites (due to mixed wastes) and sewage. But groundwater contamination is one of the least recognized problems because groundwater problems are not easily detected, and because pathways to

contamination are not easily traceable.⁴⁸⁹ But wastewater ought not to constitute such a problem in view of the opportunities to convert it into useful material as the following discussion will illuminate.

5.16 The Usefulness of Wastewater

Although wastewater was originally viewed as pure waste, this has changed dramatically as the world has embraced it as a potential resource.⁴⁹⁰ With pressures on water supply from increasing populations and climatic vagaries described in Chapter 1, the value of re-using wastewater and its nutrient contents particularly in arid and water-stressed regions is becoming apparent, necessary, and even viable.

5.16.1 Treating Wastewater

Wastewater in its untreated state is odious, toxic, and dangerous to health. But this apparent enemy that causes so much discomfort and disease can be transformed into a valuable resource by means of appropriate treatment. The objective of wastewater treatment is now not merely to produce a disposable effluent without causing harmful pollution to the environment, but also to retrieve good water, and produce a useful solid residue (sludge). Wastewater treatment is therefore the process of removing contaminants from wastewater using physical, chemical, and biological processes to remove physical, chemical and biological contaminants.

A particularly interesting and potentially viable method for treating and purifying industrial wastewater in Lagos is by phytoremediation. Phytoremediation is the use of plants to purify contaminants in wastewater, groundwater, soil and surface water. The method employs a

⁴⁸⁹ Adeyemi et al, *supra*, note 484.

⁴⁹⁰ S. Jhansi & S. Mishra, “Wastewater Treatment and Reuse: Sustainability Options” (2013) *Consilience: The Journal of Sustainable Development* 1. See also *Benefits of Investing in Wastewater: An OECD Perspective* (2011) hereafter ‘OECD Report’.

variety of plant biological processes and characteristics to aid the purification.⁴⁹¹ Researchers, Ajayi & Ogunbayo demonstrated that through the process of phytoremediation, water hyacinths can be employed to remove contaminants in chemically-polluted wastewater at a very low cost.⁴⁹² Their application of water hyacinth to three wastewater samples from three industries (a textile mill, a metallurgical company, and a pharmaceutical company) showed that the water hyacinths effectively removed most of the chemical contaminants in them.⁴⁹³ This demonstrates the potential for freeing up used water that would otherwise have remained in an unfavorable chemical condition and unfit for human or other use. It also portrays the interesting paradox that the water hyacinth which is ordinarily a difficult and hazardous product of pollution, can be very helpful in curing waste. The phytoremediation option forms part of recommendations in the final chapter.

Treated wastewater may be used for agricultural and landscape irrigation, industrial processes, and groundwater recharge. It also effectually reduces pressure on both surface and groundwater sources, as well as the nutrient loads from wastewater discharges into waterways, thereby preventing pollution.⁴⁹⁴ Additionally, not only can wastewater be treated and then reused, it is usable even in its raw form, as the following discussion elaborates.

⁴⁹¹ Bruce E. Pivetz, "Phytoremediation of Contaminated Soil and Groundwater at Hazardous Waste Sites" (United States Environmental Protection Agency: Office of Research and Development, 2001).
Online: http://www.epa.gov/superfund/remedytech/tsp/download/epa_540_s01_500.pdf

⁴⁹² Water hyacinths are rapidly-growing weeds that occur in waters that have a high level of nutrients, so their presence signifies the presence of harmful nutrients in water. They grow at a phenomenal rate, depleting oxygen in water. Adebayo et al reported that they can reproduce 600,000 more of their plants within 8 months, and these can completely cover the surface of an area of natural freshwater, thereby interfering with the many uses of water. They are very harmful because they obstruct navigation, deplete oxygen in water and thereby kill off fish and other aquatic animals: A.A. Adebayo, E. Briski, O. Kalaci, M. Hernandez, S. Gbabooli, & B. Beric (2011) "Water Hyacinth (*Eichhornia Crassipes*) and Water Letuce (*Pistia Stratiotes*) in the Great Lakes: Playing with Fire?" (2011) 6(1) *Aquatic Invasions* 91.

⁴⁹³ T.O. Ajayi & A.O. Ogunbayo. "Achieving Environmental Sustainability in Wastewater Treatment by Phytoremediation with Water Hyacinth (2012) 5(7) *Journal of Sustainable Development* 80.

⁴⁹⁴ S. Jhansi & S. Mishra, *supra*, note 490.

5.16.2 Using Raw Wastewater

Wastewater could be used in its raw form, and since the ancient civilizations, raw domestic sewage was applied directly to agricultural irrigation.⁴⁹⁵ Although Chadwick is credited with proposing a system that took out effluents to public sewers for agricultural land treatment, this practice had been in existence since the ancient civilizations. Once it was realized that sewage made a more productive agricultural yield, organized formal use of it grew with creative design ideas for the sewage transport systems. The drawback at this time was the large volume of water that accompanied the sewage, which caused over logging of the land, and difficulty in achieving hygienic standards. Subsequent chemical and biological processes however eliminated the difficulties with sewage use.⁴⁹⁶

In more recent times, researchers have confirmed the use of domestic sewage by extracting the urine component for agricultural application, with some startling results. Tettey-Lowor reports many studies across the world where urine is successfully used to irrigate agricultural fields.⁴⁹⁷ Apparently, urine contains sodium chloride, urea, potassium, calcium, phosphorus, and sulphate, a composition that, according to experts, is in good levels and balance for intake by plants, and for use as a unique biologic fertilizer.⁴⁹⁸

⁴⁹⁵ The ancient civilizations of Egypt, Mesopotamia, Greece and Rome had unprecedented mastery of sewerage in general. Their sophisticated sewage technologies prompted Gray to express disappointment that there has been little advancement since those times. Angelakis et al also referred to his comment: H.F. Gray, "Sewerage in Ancient and Mediaeval Times" (1940) 12(5) *Sewage Works Journal* 939.; A. Angelakis, D. Koutsoyiannis, & G. Tchobanoglous, "Urban Wastewater and Storm Water Technologies in Ancient Greece" (2005) 39 *Water Research* 210

⁴⁹⁶ P.F. Cooper, "Historical Aspects of Wastewater Treatment" in P. Lens, B. Zeeman, & G. Letting, eds., *Decentralized Sanitation and Reuse: Concepts, Systems and Implementation* (IWA Publishing, 2007) 11, at pgs. 17 – 22.

⁴⁹⁷ F. Tettey-Lowor, *Closing the Loop Between Sanitation and Agriculture in Accra, Ghana* (Master's Thesis, Wageningen University, Netherlands, 2008) (Available Online)

⁴⁹⁸ H.K. Upreti, P Shrestha & P Paudel, "Effect of Human Urine as Fertilizer on Crop Production" (2011) 2 *Agronomy Journal of Nepal* 168.

Thus in Sweden, Johansson recorded a higher yield of spring barley in plots that were fertilized with urine than those fertilized with mineral fertilizers.⁴⁹⁹ Similarly, Winblad & Simpson-Hebert carried out a number of experiments in which they used urine to fertilize a selection of vegetables in Zimbabwe. They demonstrated that by adding three parts of water to a part of urine, crop yield increases significantly compared to cases where water alone is applied as shown in the table below.⁵⁰⁰

Plant Name and Growth Period	Weight at Cropping (water application only) Grams net weight	Weight at Cropping (3:1 water urine application 3 x week) Grams net weight
Lettuce - 30 days	230	500
Lettuce - 33 days	120	345
Spinach - 30 days	52	350
Covo - 8 weeks	135	545
Tomato - 4 months	1680	6084

Source: Winblad & Simpson-Hebert (2004)

⁴⁹⁹ M. Johanssen, *Urine Separation - Closing the Nutrient Cycle, Final Report of the R & D Project: Source Separated Human Urine - A Future Source of Fertilizer for Agriculture in the Stockholm Region* (2000), Available online; H. Kirchmann & S. Pettersson, "Human Urine Chemical Composition and Fertilizer Use Efficiency (1995) 40 Fertilizer Research 149.

⁵⁰⁰ U. Winblad & M. Simpson-Hebert, *Ecological Sanitation* (Stockholm, Sweden: Stockholm Environment Institute, 2004). But Larson & Gujer advise caution in using urine: T.A. Larson & W. Gujer, "Separate Management of Anthropogenic Nutrient Solutions (Human Urine)" (1996) 34(3-4) *Water Science & Technology* 87. See also Hoglund, *Evaluation of Microbial Health Risks Associated with the Reuse of Source Separated Human Urine*, PhD. Thesis, Dept. of Biotechnology, Royal Institute of Technology, Stockholm, Sweden, ISBN91-7283-039-5.

Ghana reportedly uses raw wastewater for agriculture. About 90% of Accra's vegetable needs are produced from irrigated agriculture whose water is sourced from raw wastewater.⁵⁰¹

5.17 Summary

In view of the problems that wastewater is causing to groundwater, Lagos needs to direct some significant investments into this sector, as the benefits appear to be worth some expenditure and a concerted effort. Investing in sound wastewater management systems and sanitation may be expensive in the short term, but it certainly has many advantages. As illustration, when thirteen states within the United States introduced water chlorination and filtration in the 20th Century, mortality reduced significantly.⁵⁰² Apart from obviously improving the quality of water by removing disease - causing pollutants, treated wastewater provides nutrients for application in agriculture and frees up good water for re-use in irrigation, thus conserving water and reducing the pressures on water sources, both surface and groundwater.⁵⁰³ It is also a stimulant of economic growth, for where good quality water is available for recreational uses, it indirectly enhances tourism (and employment) which is an excellent source of foreign exchange earnings for many national economies. Good quality water has also been credited with enhancing the values of properties that lie alongside properly treated streams of

⁵⁰¹ O.O. Cofie, G. Cranjac, & P. Drechsel, "The Use of Human Waste in Peri-Urban Agriculture in Northern Ghana" (2004) 20(2) *Renewable Agriculture & Food Systems*; World Bank, *Future of African Cities: Why Wastewater?* at pg. 7. Melissa Scanlan highlights that bio solids in wastewater can be subject to a process of anaerobic digestion to produce biogas, and that there is therefore a hidden potential for urban sewage to be a source of renewable energy. On the other hand, because the process of wastewater treatment itself is an energy-intensive process, some leading wastewater treatment facilities are charting a new direction with sewage-based renewable energy that harnesses the inherent renewable energy whilst reducing the greenhouse gas emissions from the treatment process: Melissa K. Scanlan, "Sustainable Sewage" (Available online).

⁵⁰² In 2003, 13 U.S. cities experienced reduced mortality and a savings in cost per person of USD 500: OECD Report, *supra*, note 490.

⁵⁰³ *Ibid.*

water, in sharp contrast to others that are not so strategically situated.⁵⁰⁴ For Lagos, just as the case of waste management, such investment in appropriate wastewater infrastructure will likely save money in the long term by limiting expenditure on sick people and thus reducing healthcare costs, by reducing mortality and extending lifespans, and by reducing the overall strain on the economy.

More importantly for this study, treating wastewater will insulate groundwater from pollution from wastewater emissions, and safeguard the health of residents. International policy forums on sustainable development have clarified that the goals of sustainable development can only be achieved in the absence of a high level of debilitating diseases, and where human populations can attain a minimal state of physical, mental and social wellness.⁵⁰⁵ They particularly acknowledge that because some very debilitating diseases are caused by polluted water, every effort should be put into averting such crises.⁵⁰⁶ The goal of improved management of chemicals and wastes is also premised on the finding that a third of the deaths in the Third World are caused by food and water that is contaminated with human or industrial waste.⁵⁰⁷ It is thus imperative for Lagos as a megacity in the developing world to center its efforts on countering the probable serious health effects of wastewater-polluted groundwater on human life.

Improved sanitation and wastewater management are at the heart of poverty reduction and improved human health.⁵⁰⁸ Sanitation is indeed at the heart of a nation's health and well-being, and a contributor to economic development. Improperly managed wastewater has rightly

⁵⁰⁴ Ibid. On the other hand, poor sanitation has negative impacts on the economy. For instance, poor sanitation in Cambodia, Indonesia and the Philippines in South East Asia accounts for financial costs of USD 2 billion yearly, as well as economic losses of USD 9 billion yearly: *OECD Report*, supra, note 490.

⁵⁰⁵ *The Future We Want*, Art. 138.

⁵⁰⁶ Ibid.

⁵⁰⁷ *The Future We Want*, Art. 213; Agenda 21, Chapter 21.

⁵⁰⁸ *The Future We Want*, Art. 119-121.

been described as a major challenge to development and a cause of poverty because it generates healthcare costs and lost labor productivity.⁵⁰⁹

The objective of this thesis, which is to tackle and offer recommendations aimed at resolving groundwater pollution by solid waste leachates and wastewater in Lagos, aligns with the important policy statements and agreements reached at these international Conferences. As noted earlier, Agenda 21 clarifies that sound and long-term development of freshwater requires a holistic management of resources, and a proper understanding of the interconnection of the elements that determine its quality. The meetings particularly underline the importance of protecting water resources and water quality from inadequately treated domestic sewage, and insufficient control over the discharges of industrial wastewater.⁵¹⁰ The Sustainable Development Goals, whilst affirming the importance of improving water quality, outlines the specific measures that need to be taken to accomplish it. These are: reducing pollution, eliminating dumping, minimizing the release of hazardous chemicals in the environment, and halving the proportion of untreated wastewater.⁵¹¹ The Dublin Statement is especially accurate in observing that sustainability of urban growth is threatened by termination of supplies due to degradation caused by past extravagance. Following generations of excessive water use and of careless discharge of municipal and industrial wastes, water scarcity is forcing the development of costly and distant new water sources.⁵¹² The case of Lagos where careless disposal of waste is gradually destroying the valuable source of water and putting millions of lives at risk, affirms this warning. The problem is due primarily to wrongful wastewater disposal practices, but

⁵⁰⁹ Sick Water Report, *supra*, note 415.

⁵¹⁰ Agenda 21, Art.18.35; Dublin Statement, Principle 1.

⁵¹¹ United Nations Summit on Sustainable Development, *Transforming Our World: the 2030 Agenda for Sustainable Development*, Goal No. 6

⁵¹² Dublin Statement on Water and Sustainable Development, 'Sustainable Urban Development'.

considerably enhanced by urbanization and industrialization which characterize development in Lagos, as discussed in Chapter 4. Therefore both aspects of the problem have to be tackled with appropriate recommendations.

Access to good quality water is an indispensable basic need for human dignity. The United Nations recognizes this in the Millennium Development Goal which requires governments to halve the proportion of their populations without sustainable access to safe drinking water and basic sanitation and especially to halve the proportion of the population without sustainable access to an improved water source by 2015.⁵¹³ Nigeria adopted this resolution and also accepted in *Gbemre's* case discussed in Chapter 1 that its citizens have a right to a healthy environment, which, this thesis argues, includes good uncontaminated groundwater.⁵¹⁴ Sadly however, it has not met the Millennium Development Goal.⁵¹⁵ Further, with the Lagos Water Corporation meeting only 30% of residents' water needs to date, it has similarly failed to meet the 2015 deadline. Lagos' inability to meet this goal merely re-reflects the federal difficulties at the level of a state. Further, with aquifer pollution proceeding at the current rate in which two of the four aquifers are polluted, the Lagos government is not only failing to meet water needs, but is allowing pollution that threatens the further loss of use of groundwater, and that denies the right to a healthy environment.

⁵¹³ Millennium Development Goal, Target 7c.

⁵¹⁴ *Gbemre v Shell Petroleum Development Company Ltd* (2005) AHRLR 151, (Available online).

⁵¹⁵ Nigeria is one of the 189 countries which signed the United Nations Millennium Declaration and committed themselves to eradicating extreme poverty in all its forms by 2015. The Declaration incorporates Goal No. 7, which is a commitment to environmental sustainability and specifically, to providing water. In a 2013 Report, the Nigerian President indicated that there were "enormous" challenges with meeting the environmental target due to increased terrorism and the global economic shutdown. The Report further stated that the progress towards access to an improved source of water had been irregular. Although acknowledging a modest national increase in water overall water provision from 49.10% to 57.40% between 2007 and 2013, it indicated that the 20% gap that was expected to be achieved by 2015 was unlikely to be accomplished: President Goodluck Ebele Jonathan, *Nigeria: Millennium Development Goals* (2013). Online: http://www.ng.undp.org/content/dam/nigeria/docs/MDGs/UNDP_NG_MDGsReport2013.pdf

Although the United Nations reports that the goal of improving access to safe drinking water by halving the number of those without access has been achieved (2.3 billion people now have access to improved drinking water source), Lagos remains on the negative side of the divide since groundwater in Lagos is fast becoming an unsafe drinking source which the same report references as the continuing resort of 748 million people in the world.⁵¹⁶ Assuring water access is intricately woven into environmental sustainability without which development in Lagos cannot in all earnestness be maintained.

5.18 Conclusion

This Chapter has portrayed the problems of solid waste and wastewater management that are causing pollution to groundwater in Lagos. It has shown that the current practices of open dumping of waste and wastewater in the environment are very damaging to groundwater, to human health, and constitutes a threat to life in the city. The city's industrial processes that are continually discharging untreated wastewater into the waterways are damaging groundwater resources, which is a critical component of the natural environment that sustains life. The distributed domestic sewage system with unmonitored septic tanks are overflowing and also polluting surface and groundwater. Waste dumps with their assorted wastes and without lining or leachate collection systems are percolating into, and polluting groundwater and making it unfit for consumption. These practices are destroying the natural resource that sustains life, and exceeding nature's ability to attenuate or repair. The waste problems in Lagos are therefore an embodiment of unsustainable development, because a degraded environment undermines the very economic development that a city is working to achieve. Since it is understood that the integrity and stability of life depends on natural resources especially water, well-planned and

⁵¹⁶ The United Nations, *The Millennium Development Goals Report* (2014), at pg. 43 (Available online).

safe waste and water management systems are imperative to sustainable development and must be worked out in Lagos.

As a general summation, the previous chapters have reviewed two aspects of the three - dimensional problems affecting groundwater: the direct environmental problem of wrongful waste and sewage handling; and the indirect problems of over-urbanization into Lagos and a resultant precipitous population increase. The next chapter will evaluate the laws and the environmental institutions which constitute the third aspect of the problems confronting groundwater in Lagos, followed by a comparison with the European Framework, and extraction of best legal provisions for better management of groundwater.

CHAPTER 6: A REVIEW OF LEGAL AND INSTITUTIONAL FRAMEWORKS FOR GROUNDWATER IN LAGOS

This chapter reviews the framework for groundwater management in Lagos, and will also include a comparison with the European Union's framework in order to draw out best practices for application in Lagos. In order to understand the status of the legal framework for groundwater management in Lagos, it is important to appreciate the evolution of environmental law in the country. Like many developing countries, Nigeria has struggled to maintain a balance between its economic development and sustainability of its environmental resources. The non-resolution of this dichotomy reflects in the contamination of groundwater in Lagos. The history and evolution of the existing legal framework for environmental resources especially groundwater within the economic climate of Nigeria is explained in the following section.

6.1 History of Environmental Regulation in Nigeria

Environmental regulation in Nigeria did not start out as a systematic effort to provide a progressively inclusive framework for managing its natural resources. For a considerable number of years after the country's independence in 1960, the national preoccupation was with providing basic social amenities, and with advancing national economic development.⁵¹⁷ Therefore concerns about the environment were not in purview at this time, but were rather regarded as luxurious or esoteric preoccupations that posed a threat to advancing industrialization.⁵¹⁸ In

⁵¹⁷ This experience is not unique to Nigeria however, as some economically advanced countries such as the United States share some similarities in the evolution of their environmental regulatory systems. Both the United States and Nigeria experienced crises that necessitated the establishment of their respective environmental protection agencies. The U.S. had a long history of air, water and land pollution before it "... awakened to the seriousness of its environmental pollution problem" by establishing the environmental Protection Agency in 1970: Phil. Wisman, *EPA History (1970-1985)* Online: <http://www2.epa.gov/aboutepa/epa-history-1970-1985>.

⁵¹⁸ A. Adegoroye, "The Challenges of Environmental Enforcement in Africa: The Nigerian Experience" Third International Conference on Environmental Enforcement, Proceedings of the 3rd Environmental Conference at Oaxaca, Mexico, 25-28 April 1994, (Available online).

consequence, Nigeria's environmental resources were sadly neglected. It is an interesting paradox however, that since the 1960s, Nigeria had been participating with other African nations in environment-focused meetings where admirable corporate statements about important environmental issues such as water quality, erosion control, and the protection of forestry and wildlife were made, but apparently doing little else to address environmental problems.⁵¹⁹ In spite of these regional efforts, Nigeria, together with many African nations, still experiences serious and diverse environmental problems which a scholar describes as "staggering".⁵²⁰ Eventually, an environmental crisis that occurred in southern Nigeria in the 1980s was the trigger to environmental regulation, as it forced Nigeria to start to view environmental matters more seriously.⁵²¹

A study of the trajectory of Nigeria's environmental legislation reveals a growth pattern that this thesis classifies into four distinct stages: the Colonial Period (1900 - 1956), a time generally known for its dearth of environmental legislation except for brief provisions in public health legislation, torts and nuisance; Petroleum-focused sectorial environmental legislation (post 1956 –early 1970s), a period following the discovery of crude oil, its subsequent commercialization, and sector-specific legislations that indicated the national preoccupation; Rudimentary and Perfunctory legislation (1970s - pre 1987 crisis); and the Contemporary Period

⁵¹⁹ Its historical apathy towards environmental protection is comparable to that of other developing African countries who experienced severe and diverse environmental problems, but who lacked significant environmental legislation for a long time. Ironically, as mentioned earlier, African nations have since the 1960s acknowledged the importance of the environment to life, by meeting severally and issuing statements intended for further action by nation states. See for instance: African Convention on the Conservation of Nature and Natural Resources (Algiers, 1968); Convention for Cooperation in the Protection and Development of the Marine and Coastal Environment in West and Central African Region (Abidjan, 1981); Convention for the Protection Management and Development of the Marine and Coastal Environments of the Eastern African Region (New York, 1985); and Convention on the Ban of Import into Africa and the Control of Trans boundary Movement and Management of Hazardous Wastes within Africa (Bamako, 1991).

⁵²⁰ William Andreen, "Environmental Law and International Assistance: The Challenge of Strengthening Environmental Law in the Developing World" (2000) 25 Colum J. Int. L. 17.

⁵²¹ The case is discussed a little later in Paragraph 6.14, *infra*.

(Post 1987 until now), a period that has seen the start of serious legislation owing to an environmental crisis, and is characterized by increasing environmental awareness and sophistication, although with some difficulties.

6.1.1 The Colonial Period (1900 - 1956)

Nigeria was a British colony starting from 1861 with the British annexation of Lagos, continuing until 1900 with colonization of the entire country, and lasting until its independence in 1960.⁵²² During this period, the British were occupied with trading activities. As described in Chapter 4, historical accounts show that the early European settlers found Lagos to be particularly convenient for trade because of its strategic location on the only permanent break on the eastern West African coastline, as well as for the Lagos Island's frontage which was also found suitable for piers and wharves that received ships.⁵²³

During this time, there seemed an overall disinterest in, or lack of awareness about, environmental issues. The colonial administrators who were involved in national governance between 1861 and 1960 did not pursue or prioritize environmental protection, but were rather preoccupied with their political and economic interests. Harris notes that colonial regions functioned primarily to supply imperial powers with raw materials and cheap labor, and so the structures of imperial and colonial power which dominated the world in the nineteenth and early twentieth centuries made little provision for either economic or social advancement of the

⁵²² T. Falola & M. Heaton, *A History of Nigeria* (Cambridge, New York: Cambridge University Press, 2008). Nigeria derived a system of laws as her colonial heritage from the British: The Received English Law (English Common Law and Doctrines of Equity) and the English Statutes of General Application in force in England on the 1st of January 1900. The High Court laws of the various states contain provisions that directly import these English laws into the Nigerian legal system, with some limitations in the case of former Western Region. Many of the English statutes have been replaced by local laws, a situation foreseen by the conditional wording of the receiving laws that makes them subject to local legislations.

⁵²³ A. Mabogunje, "The Evolution and Analysis of the Retail Structure of Lagos, Nigeria (1964) 40(4) Economic Geography 304.

developing world.⁵²⁴ Takang also writes that colonial administrators convened environmental meetings that were ostensibly aimed at natural resource protection, but were in fact meant to promote trade and enhance the economic growth of their countries.⁵²⁵ Nnadozie, in summing up this commercial preoccupation in Nigeria, conjectures that any laws that might have restricted economic activities or imposed additional responsibilities on the colonial government in form of environmental requirements would probably have been considered counter-productive.⁵²⁶ Thus there were no laws directed at either protecting the environment or the natives from the polluting effects of their activities.⁵²⁷ Cases that arose with a bearing on the environment were classed under the English common law rules of torts and nuisance, as well as under the local public health legislation, and dealt with accordingly.⁵²⁸ The Criminal Code Law of 1916 and the Public Health Act of 1917 were the notable laws at this time.⁵²⁹

⁵²⁴ J.M. Harris, “Basic Principles of Sustainable Development” (Global Development and Environment Institute, Tufts University 2000), available online.

⁵²⁵ J.M. Takang “From Algiers to Maputo: The Role of the African Convention on the Conservation of Nature and Natural Resources in the Harmonization of Conservation Policy in Africa” (2014) 17 *Journal of International Wildlife Law and Policy* 165. Thus, for instance, the Parties to the *Convention on the Preservation of Wild Animals, Birds and Fish in Africa* were Germany, France, Spain, Great Britain, Portugal and Italy. A main objective was to ensure a seamless supply of wild life resources for ivory traders, trophy hunters, and skin dealers. The Convention classified animals as either “useful to man”, or “harmful” or “harmless” Consequently the welfare of the local inhabitants was subjugated to the overriding economic interests of these countries.

⁵²⁶ K. Nnadozie, “Pollution Control in Nigeria: The Legal Framework” Paper presented at a Workshop at Lagos Sheraton Hotel (April 1994).

⁵²⁷ Providing even basic environmental facilities for ‘natives’ sometimes proved difficult. Gandy records that in the Lagos colony in the early 1900s, provision of good potable water to residents was sometimes resisted because of the perceived high infrastructural cost involved. Limited investment in water infrastructure meant that only 10% of residents in metropolitan Lagos were directly connected to the municipal water system, and the rest of the city had to rely on wells and creeks. Apart from that the colonial administrators did not address overcrowding and disease: M. Gandy, “Planning, Anti-planning and the Infrastructure Crisis Facing Metropolitan Lagos” (2006) 43(2) *Urban Studies* 371.

⁵²⁸ O. Fagbohun, “Mournful Remedies, Endless Conflicts, and Inconsistencies in Nigeria’s Quest for Environmental Governance: Rethinking the Legal Possibilities for Sustainability” 4th Inaugural Lecture, Nigerian Institute for Advanced Legal Studies. Online: www.nials-nigeria.org.

⁵²⁹ The Public Health Act is no longer in force, but the Criminal Code remains a valid federal law. A 1914 Mineral Oils Ordinance written to “regulate the right to search for, win and work mineral oils”, indicates that early efforts were on-going to locate crude oil at that time. The later Minerals Ordinance of 1916 was concerned with ownership of oil, as was the supervening Minerals Act of 1945. Other laws made during this period were: Quarantine Act (1926), CAP Q2, Laws of the Federation of Nigeria (2004). Others were: Hides and Skins Act (1942), CAP H3, Laws of the Federation of Nigeria (2004); the Forest Ordinance (1937); and the Water Works Act 1915: S.I. Ibaba,

The 1916 Criminal Code which is still in force briefly addresses some aspects of public health contraventions.⁵³⁰ The law prohibits the selling of noxious food or drink and the adulteration or poisoning of any article of food or drink meant for sale. It also criminalizes the carrying of dead animals into slaughter houses, and the corrupting or fouling of water in any water source that makes it unfit for use. Other provisions criminalize the burying of corpses in houses, premises, or within a hundred yards of such, or in any open space situated within a township. The vitiation of atmosphere in any place that makes it noxious to the health of persons in the neighborhood, or the carrying out of any act likely to spread infectious diseases that are dangerous to human or animal life, are also prohibited. Finally, the use of white (yellow) phosphorus in the manufacture of matches is disallowed.⁵³¹ The provisions are actually focused on public health, not environmental issues, and can hardly be regarded as serious environmental legislation.⁵³²

In the absence of specific environmental laws, cases at that time that bordered on environmental violations were premised on the torts of negligence, strict liability, public nuisance, and trespass. Claimants tended to rely on negligence and strict liability to redress damages for personal injury resulting from environmental pollution, while resorting to actions in trespass and nuisance to redress invasions and environmental harm to property interests.⁵³³ As illustration, the renowned 1868 English case of *Rylands v. Fletcher* established *strict liability*, a no-fault liability where responsibility is imposed for damage caused by a defendant's action

“Environmental Protection Laws and Sustainable Development in the Niger Delta” (2010) *Africana*, cited by J. L. Oyefara, “Good Governance and Environmental Sustainability in Lagos State, Nigeria: Can the State Achieve Goal Seven of Millennium Development Goals (MDGS)?” (2013) 9(5) *European Scientific Journal* 41.

⁵³⁰ Criminal Code Act 1916, CAP C38, Laws of the Federation of Nigeria (2004). The Criminal Code has remained the federal criminal law that applies in all Nigeria except Northern Nigeria where the Penal Code applies.

⁵³¹ Criminal Code Act, (1916) CAP C39, Laws of the Federation of Nigeria (2004), Sections 243-248.

⁵³² All efforts to retrieve a copy of the defunct 1917 Public Health Act for analysis did not yield results in spite of a rigorous search of the compendium of national environmental laws and published legislative reviews

⁵³³ O. Fagbohun, *supra*, note 528.

regardless of there being no actual fault.⁵³⁴ That principle has provided an important precedent in subsequent Nigerian cases, including *Umudje vs. Shell British Petroleum* where the plaintiffs successfully relied on it to have the defendants ruled liable for their crude oil waste that escaped on to the plaintiff's land, polluting their ponds and killing their fish.⁵³⁵ Similarly the 1932 English case of *Donoghue v. Stevenson* provided a major precedent in *negligence* that is premised on a duty of care.⁵³⁶ The case has been adopted as a binding precedent in subsequent Nigerian cases.⁵³⁷

These common law principles were not designed for environmental cases, however, and did not address any particular natural resources. Other laws made at that time were not meant for natural resource protection and any imputations to environmental protection in the wordings of the enactments seem entirely accidental. This 'accidental' nature of environmental legislation was the status until the discovery of petroleum in later years.⁵³⁸

6.1.2 Petroleum-focused Sectorial Environmental Legislation (1956 - early 1970s)

In 1956, Nigeria discovered petroleum (crude oil) in commercial quantities at Oloibiri within the Niger Delta region of Nigeria. The country's economy which had previously been agro-based switched its focus to petroleum exploration. The discovery resulted in a national preoccupation with petroleum exploitation, as oil exports became the country's major source of foreign exchange earnings. A pervasive national engagement with "the newly industrializing"

⁵³⁴ *Rylands v. Fletcher* (1868) UKHL 1; (1868) LR 3HL 330 (Available online).

⁵³⁵ *Umudje & Anor v. Shell-BP Petroleum Development of Nigeria Ltd.* (1975) 9/11 S.C. 155. Being a 1975 case, it falls outside the time frame in this classification; however it demonstrates the direction of judicial thinking at this time. The case is being used as illustration due to the unavailability of reported cases for this specific period.

⁵³⁶ *Donoghue v. Stevenson*, (1932) All ER 1; (1932) UKHL 100; (1932) AC 562.

⁵³⁷ *Osemobor v. Niger Biscuit* (1973) 1 CCHCJ 71. See also *Nigerian Bottling Co. v. Ngonadi*, (1985) 1 NWLR (PT. 4) 739.

⁵³⁸ A rigorous search of the compendium of federal laws for any laws that had a bearing on environmental resources at that time did not yield any other environmental laws.

economy and with the new wealth that the foreign exchange earnings translated into characterized this period.⁵³⁹ A slew of petroleum-focused environmental enactments for this emerging sector, followed.⁵⁴⁰ It appears that legislators erroneously believed that only the petroleum sector required close environmental monitoring. The laws focused on the many facets of petroleum exploration activities, and aimed at reducing the pollution that resulted from them.⁵⁴¹ Naturally, this created a very limited ‘sectorial’ legislative framework centered solely on “economically important natural resources”.⁵⁴² However, later in 1964, a law was made to regulate the importation of articles in an effort to control the spread of plant diseases and pests. Amongst other provisions, it required that imported sand, seeds, soil, containers, and straw that were suspected to be infected with any plant disease or pest, could be destroyed by an authorized officer who could also direct that they should not be imported until treated to a satisfactory standard.⁵⁴³ But apart from this law and the petroleum enactments, the few laws with a bearing on the environment were peripheral, disunited and very varied in subject matter. They covered such disparate subjects as “sanitation”, “national parks”, “domestic personal hygiene”, and “wild animals”.⁵⁴⁴

⁵³⁹ Gozie Ogbodo, “Environmental Protection in Nigeria: Two Decades after the Koko Incident” (2009) 15.1 Annual Survey of International and Comparative Law 1.

⁵⁴⁰ They include: Oil Pipelines Act 1956, CAP O7 Laws of the Federation of Nigeria (2004). (later complemented by the Oil and Gas Pipelines Regulations S.I.14 of 1995); Oil in Navigable Waters Act 1968 CAP O6 Laws of the Federation of Nigeria (2004); Petroleum Act 1969 CAP P10, Laws of the Federation of Nigeria (2004, and 20 Regulations and Amendments made thereafter); Nigerian Mining Corporation Act 1972, CAP N120, LFN (2004); Hydrocarbon Oil Refineries Act 1965, CAP H5, LFN (2004, and later amended by Hydrocarbon Oil Refineries Regulations 1965); Exclusive Economic Zone Act 1978 CAP E17 LFN (2004); Territorial Waters Act 1967 CAP T5, LFN (2004 and later amended by Territorial Waters Amendment Act 1998).

⁵⁴¹ See Olusegun Ogunba, “EIA Systems in Nigeria: Evolution, Current Practice and Shortcomings” (2004) 24 Environmental Impact Assessment Review 643. See also Isichei, “Environmental Impact Assessment and Environmental Evaluation Reports” Paper Presented at Workshop of the Nigerian Corrosion Association, Warri, Nigeria (2000).

⁵⁴² A. Adegoroye, *supra*, note 518.

⁵⁴³ Agricultural (Control of Importations) Act 1964, CAP A13, LFN 2004, Ss. 1 & 6.

⁵⁴⁴ Gozie Ogbodo, *supra*, note 539. Ogolla notes that this was common to African nations which inherited the legacy of sector-specific environmental laws from colonial administrators. Since their concern was for extraction and

6.1.3 Rudimentary and Perfunctory (1970s and pre 1987 crisis)

Although environmental legislation commenced after the discovery of petroleum, there was limited public awareness about the dimensions of the environment that required development. Technical issues like effluent limitations, pollution abatement and the overall modalities for the sustainable development of Nigeria's environmental resources were not well understood and did not form part of the general public discourse, or of regulations at this time. Most of the laws that were not petroleum-related had only a minor bearing on the environment, with slight provisions that protected some aspects of the environment. In other words, they were “accidental” or “incidental” environmental legislation. These fragmented sectorial enactments provided what is at best rudimentary environmental regulation, and notable amongst these is the Factories Act.

The Factories Act 1987 (which remains a valid law) was made primarily to provide for the registration of factories, and for the safety of workers exposed to occupational hazards. Its provisions cover: cleanliness, overcrowding, ventilation, lighting, drainage of floors, and sanitary conveniences. Other provisions relate to staff welfare, first aid, and the supply of drinking water. Penalties are also provided in case of breach of these provisions.⁵⁴⁵

The Act requires that sanitary conveniences must be available for workers of both sexes, and an inspector is designated to report any default in relation, inter alia, to water supply to the local government council for remediation.⁵⁴⁶ More specifically the Act states that “an adequate supply of drinking water shall be provided and maintained at suitable points conveniently

allocation, laws were equally devoted to licensing and rights rather than management. They did not address the unpleasant environmental effects of resource exploitation: B.D. Ogolla “Environmental Law in Africa: Status and Trends” (1995) *International Business Lawyer* 412, at pg. 413.

⁵⁴⁵ Factories Act (1987), CAP F1, Laws of the Federation of Nigeria (2004), Sections 7-11.

⁵⁴⁶ *Ibid*, Ss. 12 & 13.

accessible to all persons employed”.⁵⁴⁷ The water must be contained in suitable vessels, duly designated by a written notice, and renewed daily, while all steps should be taken to preserve the water and its vessels from contamination. Further, the Act requires separate locations for drinking water and water that is meant for washing up. Interestingly however, it permits the Director of factories to exempt any factory from the duty to provide and maintain adequate suitable facilities for washing where there is difficulty in obtaining an adequate supply of water.⁵⁴⁸

In spite of the scanty environmental profile at this time, a few important environmental laws were made during this period. These are: the Land Use Act; Endangered Species (Control of International Trade and Traffic) Act 1985; Sea Fisheries Act 1990 (later repealed by Sea Fisheries Decree 1992); the Energy Commission of Nigeria Act 1979; and the River Basins Development Authorities Act (1986). Due to their importance, they are briefly reviewed below.

The Land Use Act 1978 (promulgated as a Decree during a military administration) is a major subsisting law which radically altered the system of land holding across the country. Before British colonial rule started, the country operated multiple land tenure systems that were based on diverse customary laws. In southern Nigeria, families acquired land under various systems of customary land ownership either by inheritance, conveyance, gift, outright purchase, or long possession. Landowners were only required to obtain the consent of Government when rights were being conveyed to aliens. In the absence of a proper registration system, abuse was likely, and the practice of multiple sales of the same land to different buyers by land-owning families was especially notorious. With the coming of the British and the enactment of the *Native*

⁵⁴⁷ Ibid, S. 40.

⁵⁴⁸ Ss. 40(1- 3), & 41.

Lands Acquisition Proclamation in 1900, interests in land were legally vested in Nigerians in freehold. In northern Nigeria on the other hand, the land tenure system differed due to agreements reached with colonial rulers, a subsequent *Land and Native Rights Ordinance*, and later the Land Tenure Law that effectively granted mere rights of occupancy to the northern land holders, a system which contrasted sharply with the freehold estates in the south.⁵⁴⁹

Thus a dual system of land holding operated in the country, to the dissatisfaction of legal scholars who clamored for a revision, for uniformity, and for an explicit statement on land use policy across the country.⁵⁵⁰ The calls culminated in the enactment of the Land Use Act in 1978. The Land Use Act vests all land in the state government to be held in trust for the use and common benefit of all Nigerians.⁵⁵¹ A very important provision in the law is the ownership of all improvements on the land by holders of rights of occupancy, and this impliedly includes the groundwater flowing underneath their land.⁵⁵²

⁵⁴⁹ A. Mabogunje, "Land Reform in Nigeria: Progress, Problems and Prospects" Online: <http://siteresources.worldbank.org>; B. Oseni, *Summary of the Land Use Act 1978* (Available online); V.C. Uchendu, "State, Land and Society in Nigeria: A Critical Assessment of Land Use Decree No. 6 of 1978" (1979) 6(2) *Journal of African Studies* 62. Park argued that the introduction of English law by colonialists did not cancel customary land tenure, but rather made it possible for dealings in land to cause English titles to arise: A.E.W. Park: "A Dual System of Land Tenure: The Experience of Southern Nigeria" (1965) 9 *Journal of African Law* 1, at pg. 10.

⁵⁵⁰ T.O. Elias wrote that there was "...a great need for the early introduction of uniform legislation about land rights throughout Nigeria". H. O. Oluwasanmi also expressed the view that due to the change in the country's economy, the old land tenure system had become too slow and ineffective for bringing about the changes needed in agricultural practices. See: T.O. Elias, *The Nigerian Legal System* (London, 1963) at pg. 329. See also: H.O. Oluwasanmi, "Land Tenure and Agricultural Improvement in Tropical Africa" (1957) 39(3) *Journal of Farm Economics* 735.

⁵⁵¹ Land Use Act (1978), CAP L5, Laws of the Federation of Nigeria (2004). But though intended to usher in land reform however, the Act has created many problems of interpretation and application. Attempts to amend it are extremely difficult because the Act is incorporated into the Nigerian Constitution, and thus any amendment requires a constitutional amendment. Difficulties with the Act prompted the Federal Government to set up a Presidential Technical Committee in April 2009 to make proposals for the reform of the Land Use Act: Mabogunje, *supra*, note 549.

⁵⁵² Land Use Act, *supra*, note 551, S. 15. The Water Resources Act (1993) complements this provision. In S. 3, it authorizes every holder of a right of occupancy to use groundwater within his/her premises without charge for domestic purposes, to water livestock, and for personal irrigation purposes: Water Resource Act (1993) CAP W2, Laws of the Federation of Nigeria (2004). The Water Resources Act is discussed in detail later as part of the framework for managing groundwater in Lagos.

The River Basins Development Authorities Act 1986 established 11 river basin development authorities across Nigeria to undertake comprehensive development of surface and groundwater resources, and with particular focus on providing irrigation infrastructure and the control of floods and erosion. Each Authority is required to supply water from completed storage schemes to all users, and to identify all water resources requirements within the Authority's area of operation.⁵⁵³

The Sea Fisheries Act which was later replaced by the Sea Fisheries Decree provides for the regulation and protection of sea fisheries in the territorial waters of Nigeria and the licensing of motor fishing boats.⁵⁵⁴

In 1979, the Energy Commission of Nigeria Act established the Energy Commission to strategically plan and coordinate national policies and to systematically develop the various energy resources in all its ramifications in Nigeria. Its membership is from Ministers in the following departments: Mines, Power and Steel, Petroleum Resources, Agriculture, and Water Resources and Rural Energy, (amongst others).⁵⁵⁵

In 1985, the Endangered Species (Control of International Trade and Traffic) Act was enacted for the purpose of prohibiting the hunting or trade in wild animals and to regulate via permits and certificates, the export and import of specified animals.⁵⁵⁶

⁵⁵³ River Basins Development Authorities Act (1986) CAP R9, LFN (2004). An earlier River Basins Development Authorities Act had been made in 1979 but was repealed by this Act. It is interesting to note that this Act was synchronized with the Land Use Act by actual reference, i.e. all the River Basin Authorities' powers to acquire land for their purposes are limited by the Land Use Act's requirement of Governor's consent within their respective areas of operation. A similar limitation is placed on every person in the country within the new ownership structure stipulated by the Land Use Act thus demonstrating the primacy of the Act.

⁵⁵⁴ Sea Fisheries Act, CAP 404, LFN (1990), later repealed by Sea Fisheries Decree (1992), CAP S4, LFN 2004

⁵⁵⁵ Energy Commission Act (1979), CAP E10, LFN 2004.

⁵⁵⁶ Endangered Species (Control of International Trade and Traffic) Act (1985), CAP E9, LFN 2004. Other laws made at this time with some bearing on the environment are: Associated Gas R-Injection Act 1979, CAP A25 Laws

The preceding discussion has portrayed the meager profile of Nigeria's environmental laws during the period before 1987. In spite of the paltry profile of the environmental enactments however, Nigeria participated in both regional and international conferences that aimed at improving environmental governance. The meetings aired and analyzed burning critical issues of multi-national dimensions, and proposed definitive steps for member countries to follow up on. Within the African Region, as mentioned at the start of this chapter, Nigeria participated in four meetings between 1968 and 1991 that resulted in some important agreements.⁵⁵⁷

On the international sphere, starting from 1972, Nigeria participated in the United Nations Stockholm Conference on the Human Environment. Following this Conference, a federal ministry charged solely with responsibility for the environment and environment-related issues was created. Egunjobi surmises that this step indicated a higher level of environmental awareness. Subsequently, the Third National Development Plan (1975-1980) attempted to reverse the previous status of environmental unawareness by incorporating a deliberate policy to enhance the quality of life for all citizens as development progressed.⁵⁵⁸ Nigeria created an Urban Development and Environment Division within its Federal Ministry of Economic Development in 1975. In the aspect of environmental impact assessment, Nigeria stipulated in the Fourth National Development Plan (1981-1986) that feasibility and viability studies for all

of the Federation of Nigeria; Animal Diseases Control Act 1988, CAP A17, LFN 2004; Bees (Import Control and Management) Act 1970, CAP B6, LFN 2004; Civil Aviation Act 1965 CAP 51, later repealed by Civil Aviation Act No. 6 of 2006; Pest Control of Produce (Special Powers) Act 1968, CAP P9, LFN 2004; Agricultural (Control of Importation) Act 1964, CAP 13, LFN 2004; Explosives Act 1967, CAP E18, LFN 2004; Live Fish (Control of Importation) Act 1965 CAP L14, LFN 2004; and Quarries Act 1969, later repealed by Mineral and Mining Decree 1999, CAP M12, LFN 2004; Food and Drugs Act 1976, CAP F32, LFN (2004); Standards Organization of Nigeria Act 1970, CAP S9, LFN (2004); National Water Resources Institute Act 1985, CAP N83 LFN (2004); Nigerian Atomic Energy Commission Act, 1976, CAP N91, LFN (2004); Exclusive Economic Zone Act 1978 CAP L17, LFN (2004), later amended by Exclusive Economic Zone Amendment Decree No. 42 of 1998.

⁵⁵⁷ See note 519, *supra*.

⁵⁵⁸ Federal Republic of Nigeria, Third National Development Plan: 1975-1980 (Lagos, Nigeria); L. Egunjobi, "Issues in Environmental Management for Sustainable Development", (1993) 13(1) *the Environmentalist* 33.

projects both public and private should be accompanied by environmental impact assessments.⁵⁵⁹ However, modalities to achieve the Plan's objective of heightening environmental consciousness were not detailed, and no formal legislation complemented it at that time.⁵⁶⁰

In 1982, Nigeria also hosted the Inter-Parliamentary Union Spring Meeting. At this meeting, its Committee on Education, Culture and Environment adopted a draft resolution on the "State of the World Environment Ten Years after the UN Conference on the Human Environment".⁵⁶¹ There were also a number of national workshops and conferences that focused on environmental issues. For instance in 1983, the Nigerian Institute of Social and Economic Research (NISER) organized a national conference with the theme: "Development and the Environment" where 29 papers were presented and published. In 1985 also, the Department of Geography and Regional Planning of the University of Benin collaborated with the Federal Ministry of Works and Housing to organize a national seminar with the theme: "Environmental Issues and Management in Nigerian Development" and 35 papers were selected and published.⁵⁶²

6.1.4 Contemporary Period (Post 1987 Koko Crisis until the Present)

More serious efforts at environmental legislation were triggered by a catastrophic environmental incident. In August 1987, an Italian company imported several tons of toxic industrial waste and deposited them in Koko, Delta state within Southern Nigeria. The waste

⁵⁵⁹ M. Okorodudu-Fubara, "The Law of Environmental Protection" (Ibadan: Caltop Publications, 1988).

⁵⁶⁰ T. Agbola, "A Review of Environmental Components in Nigeria's National Development Plans: 1946-1985", in P.O. Sada & F.O. Odermerho, eds., *Environmental Issues and Management in Nigerian Development* (Evans Brother, Ibadan, Nigeria 1988) 47.

⁵⁶¹ Olusegun Ogunba, *supra*, note 541.

⁵⁶² O. Adeniyi & I.B. Bello-Imam, *Development and the Environment: Proceedings of a National Conference*, (Nigerian Institute of Social and Economic Research, Ibadan, Nigeria, 1986). See also: P.O. Sada & F.O. Odemerho, *Environmental Issues and Management in Nigerian Development* (Ibadan, Nigeria: Evans Brothers, 1988).

leaked into the surrounding environment and resulted in the tragic deaths of some residents of that community.⁵⁶³ Such an unprecedented incident forced the Federal Government to react by enacting the Harmful Waste (Special Criminal Provisions, etc.) Act.⁵⁶⁴ The Act criminalizes activities involving the sale, purchase, transportation, importation, deposit or storage of harmful waste either singly or in conjunction with others on Nigeria's soil, air, or sea.⁵⁶⁵ Harmful waste is defined as injurious, poisonous, noxious or toxic substances, particularly nuclear waste that emits any radioactive substances.⁵⁶⁶

In the same year, the governing federal military government promulgated the Federal Environmental Protection Agency (FEPA) Act that established a Federal Environment Protection Agency with broad powers to manage and protect environmental resources and to develop environmental research technology. The Act also empowered states within the federation to set up their respective state environmental protection agencies primarily to maintain good environmental quality in relation to pollutants within their control.⁵⁶⁷ Three important subsidiary regulations made under this Act directly stipulated standards for the discharge of harmful effluents from industries, the management of solid and hazardous wastes, and for pollution abatement in industries and in facilities generating wastes.⁵⁶⁸

⁵⁶³ M. Okorodudu – Fubara, *supra*, note 559.

⁵⁶⁴ Harmful Waste (Special Criminal Provisions, etc.) Act (1988), Cap H1, Laws of the Federation of Nigeria Revised Ed. (2004) (Nigeria).

⁵⁶⁵ *Ibid*, Ss. 1-3.

⁵⁶⁶ *Ibid*, S. 15 (Interpretation).

⁵⁶⁷ The Decrees are now designated as 'Acts' within civilian administrations. Federal Environmental Protection Agency Act (1988), CAP F10, Laws of the Federation of Nigeria, (2004). Later in 1989, a Natural Resources Conservation Act 1989 was enacted to complement this law, but was repealed by Federal Environmental Protection Amendment Decree No. 59 of 1992. In 1999, the Agency's functions were taken over by the Federal Ministry of the Environment. See Section 25 that empowered states to establish respective environmental protection agencies.

⁵⁶⁸ These were: National Environmental Protection (Effluent Limitation) Regulations (1991); National Environmental Protection (Management of Solid and Hazardous Waste) Regulations (1991); National Environmental Protection (Pollution in Industries and Facilities Generating Waste) Regulations (1991).

The law establishing the Agency authorized it to prescribe national guidelines, criteria and standards for water quality, air quality and atmospheric protection, noise levels, gaseous emissions and effluent limits; and to monitor and control hazardous substances, supervise and enforce compliance. It also gave the Agency broad enforcement powers, even without warrants, to gain entry, inspect, seize and arrest offenders who obstructed the enforcement officers in the discharge of their duties.⁵⁶⁹ FEPA Act is now repealed by the National Environmental Standards Regulations and Enforcement Agency Establishment Act, which is the major environmental legislation in Nigeria, and which forms a very significant part of the framework for groundwater that is discussed in the next section.

In 1989, the Federal Environmental Protection Agency formulated the current National Policy on the Environment. Egunjobi describes the Policy as “perhaps the most positive achievement Nigeria has ever recorded in the area of environmental management”.⁵⁷⁰ Its overarching objective is sustainable development based on proper management of the environment in order to meet the needs of the present and future generations. It aims at securing for all Nigerians a quality of environment adequate for their health and well-being; to raise public awareness and promote understanding of the essential linkages between the environment and development; and to encourage individual and community participation in environmental

⁵⁶⁹ A number of peculiar socio-political factors hampered FEPA’s efforts: inadequate waste disposal facilities within industrial estates; inadequate funding for FEPA; powerful political groups that countered its efforts; a negative public perception of FEPA; and political instability. Thus it performed sub-optimally in spite of its impressive staff list of academics, and of its spirited efforts to make a positive impact. In consequence, groundwater pollution from untreated industrial sewage continued. In 1999, Federal Ministry of the Environment took over FEPA’s functions but was also not effective enough owing to bureaucracy, and a dearth of Regulations and Standards : A. Adegoroye, *supra*, note 518; A. Adeyemo, *Assessing Environmental Protection and Management Systems in West Africa: A Case Study of Nigeria* (Ann Arbor, U.S.: Proquest LLC, 2008).

⁵⁷⁰ L. Egunjobi, *supra*, note 558, at pg. 37.

protection and improvement efforts.⁵⁷¹ The Policy is also an important component of the present framework for groundwater management that is discussed in the next section.

In 1999, the Federal Ministry of the Environment took over the functions of the Federal Environmental Protection Agency. From that time and until now, the scope of environmental legislation has become progressively more sophisticated and demonstrates increasing awareness of the importance of environmental resources.

The Harmful Waste Act and FEPA laws, although reactive, were a good development in view of the relative obscurity of environmental regulation at this time. It has even been argued that they place Nigeria on “equal” footing with some developed countries on environmental protection, a statement that is however an overstatement.⁵⁷²

In 1993, the major federal law on water, the Water Resources Act was written.⁵⁷³ The Act provides the main framework for water resources management including groundwater that is discussed in the next section of this chapter. Its purpose is to promote the optimum planning, development and use of Nigeria's water resources. The law provides that for the purpose of water planning and development, the right to the use and control of all surface and groundwater and of any water course affecting more than one State, is vested in the Federal Government, with some qualifications.⁵⁷⁴

⁵⁷¹ Federal Environmental Protection Agency, National Policy on the Environment, Online: <http://www.nesrea.org/images/National%20Policy%20on%20Environment.pdf>

⁵⁷² A. Adegroye, *supra*, note 518, at pg. 43.

⁵⁷³ Water Resources Act (1993), CAP W2, Laws of the Federation of Nigeria, (2004)

⁵⁷⁴ The Act authorizes the conjunctive management of ground and surface water, but this does not appear to be taking place as groundwater is not integrated into the national water resources development plan: M.E. Offodile, “The Development and Management of Ground Water for Water Supply in Nigeria” Presented at the 2nd Fellow’s Workshop of NMGS, Jos, Nigeria. (2000). Online: <http://www.uneca.org/awich/The%20Development%20and%20Management%20of%20Ground%20Water%20for.pdf>.

Since 1956, petroleum exploration activities have caused very severe consequences that have required a steady stream of laws and subsidiary regulations that strive to address them. In the earlier years of oil exploration and right into the 1990s, oil spillages were reported to have been of such great magnitude as to adversely affect agricultural and fishing activities of the local communities. Between 1976 and 1988, 2000 reports of spillages causing an estimated loss of two million barrels of oil, were recorded nationwide.⁵⁷⁵ In 1999, in response to the concerted efforts to compensate the affected communities, the Niger-Delta Development Commission Act established the Niger Delta Commission to tackle ecological problems that arose from the exploration of oil minerals within the Niger Delta.⁵⁷⁶

Several other environmental laws have since been made: the National Agency for Food and Drugs Administration and Control Act which has had 2 amendments and 39 subsidiary Regulations, and the Merchant Shipping Act which has 60 subsidiary legislations made under it. The volume of regulations underscores their importance within the national agenda.⁵⁷⁷

In 1992, the Environmental Impact Assessment (EIA) Act was enacted. For the first time, the country could claim to have a law of general application that mandates the prior appraisal of likely environmental impacts of intended projects.⁵⁷⁸ The law requires that projects of both the

⁵⁷⁵ C.O. Ikporukpo, "Managing Oil Pollution: Towards an Interactive Approach" in P.O. Sada & F.O. Odemerho, eds., *Environmental Issues and Management in Nigerian Development* (Evans Brothers, Ibadan, 1988). See also: C.T.I. Odu, "Oil Pollution and the Environment" in N.O. Adedipe & L.C. Nwoboshi, eds., *Environmental Problems in Nigeria* (Nigerian National Committee of SOPE 1977).

⁵⁷⁶ Niger-Delta Development Commission Act (2000), CAP N86, Laws of the Federation of Nigeria (2000) Petroleum-related laws made prior to this period were discussed in the earlier section. This is however a wholly different field of research and an aspect of environmental regulation that is not within the scope of the present research work.

⁵⁷⁷ National Agency for Food and Drugs Administration and Control Decree No. 15 of 1993, CAP N1, LFN (2004) and 38 subsidiary legislations; Inland Fisheries Decree 1992, LFN I10, Nuclear Safety and Radiation Protection Act 1995, CAP N142, LFN (2004); Nigerian Meteorological Agency (Establishment) Act No. 9 of 2003; Nigerian Urban and Regional Planning Decree no 88 of 1992, CAP N138, LFN (2004); Merchant Shipping Act CAP M11, LFN (2004) plus 60 subsidiary legislation; Consumer Protection Act 1992, CAP C25, LFN (2004).

⁵⁷⁸ Environmental Impact Assessment Act (1992), CAP E12, Laws of the Federation of Nigeria (2004).

public and the private sectors must be subjected to an initial early appraisal in case of resulting harm to the environment.⁵⁷⁹ The Environmental Impact Assessment Act is also part of the framework for groundwater management that is discussed in the next section of the chapter.

Finally, in 2007, the National Assembly enacted the National Environmental Standards and Regulations Enforcement Agency (Establishment) Act (NESREA) to take over the functions of the Federal Environmental Protection Agency. The Act has been described as “a new dawn in environmental compliance and enforcement” in Nigeria on account of its efforts to address all aspects of the environment.⁵⁸⁰ NESREA is now the major federal environmental law, and incorporates provisions that are intended to safeguard groundwater in Lagos.

Having reviewed the evolution of environmental laws in Nigeria, it is now appropriate to examine the institutions and laws that govern groundwater in Lagos. The discussion will include a consideration of the laws and the institutions that relate to waste and wastewater management because of their intersection with groundwater.

6.2 Environmental Management Institutions in Lagos

The departments responsible for managing water, solid waste and wastewater in Lagos which are core to this thesis, are listed below and discussed serially:

- Lagos State Ministry of the Environment

⁵⁷⁹ Prior to the EIA Act, projects had to undergo appraisals under two separate laws: the Petroleum Act, and the Urban and Regional Planning Act. With the making of the Environmental Impact Assessment Act, have scholars criticised the simultaneous use of 3 independent and unrelated EIA systems, complaining of a lack of coordination between them, of unnecessary replications in efforts, preparations, and of substantial costs in time and money. They argue that there are considerable overlaps between them, and multiple authorities designated for the EIA approval process, leaving permit seekers with no option but to seek approval from all three agencies. But they do acknowledge however, that the proactive provisions under the EIA Act are preferable to that under the Petroleum Act which is largely reactive: Olusegun Ogunba, *supra*, note 541.

⁵⁸⁰ M.T. Ladan, “Review of NESREA Act 2007 and Regulations 2009-2011: A New Dawn in Environmental Compliance and Enforcement in Nigeria” (2012) 8(1) *Law, Environment and Development Journal* 116.

- Lagos State Environmental Protection Agency (LASEPA)
- Lagos State Waste Management Authority (LAWMA)
- Lagos Water Corporation (LWC)
- Lagos State Wastewater Management Office (LASWMO)
- Lagos State Water Regulatory Commission (LASWARC)

6.2.1 Lagos State Ministry of the Environment:

The Ministry of the Environment was carved out of the former Ministry of Works and Transport in 1979 and upgraded to a full ministry in 2003.⁵⁸¹ It has overall responsibility for environmental security in Lagos in terms of waste management, pollution control, drainage services, sewage management, and evaluation of environmental impact assessments.⁵⁸² Its mandate is to secure a clean, healthier and sustainable environment that is conducive for tourism, economic growth and well-being of its citizens.⁵⁸³ Based on its overarching responsibilities, the Lagos State Environmental Protection Agency, the Lagos State Waste Management Authority, and Lagos State Wastewater Management Office are directly accountable to the Ministry of the Environment.⁵⁸⁴

6.2.2 Lagos State Environmental Protection Agency (LASEPA)

The Lagos State Environmental Protection Agency (LASEPA) is an agency of the Ministry of the Environment.⁵⁸⁵ It was established in 1996 as the environmental regulator and monitor for Lagos, and has broad monitoring powers in respect of raw water, wastewater, solid

⁵⁸¹ Lagos State Government, Ministry of the Environment, Online: <http://moelagos.gov.ng>

⁵⁸² Ibid.

⁵⁸³ Ibid .

⁵⁸⁴ Personal Discussions with the Chief Scientific Officer of the Ministry of the Environment on January 10th 2013

⁵⁸⁵ Ministry of the Environment website, *supra*, note 581.

waste, and groundwater.⁵⁸⁶ It has responsibility for determining the acceptable standards in order to control water pollution, and prescribes standards for effluent discharges. It regulates industrial wastewater discharges in particular, as well as the quality of drinking water produced by private companies for public consumption.⁵⁸⁷ LASEPA is directly accountable to the Ministry of the Environment.

6.2.3 Lagos State Waste Management Authority (LAWMA)

The Lagos State Waste Management Authority (LAWMA) is responsible for managing solid waste in Lagos.⁵⁸⁸ Before its creation, the Lagos State Refuse Disposal Board performed waste management functions, as mentioned in Chapter 5.⁵⁸⁹ In 1981, its name was changed to Lagos State Waste Disposal Board. In 1991, the name was further amended to Lagos State Waste Management Authority, which it now bears.⁵⁹⁰

6.2.4 Lagos Water Corporation (LWC)

Although the Lagos Water Sector Law ostensibly established the Lagos Water Corporation, in fact, the Water Corporation pre-existed that law. When Lagos State was created in 1967, it took over the responsibility for water provision that had hitherto been the function of the Federal Ministry of Works.⁵⁹¹ To carry out this responsibility, Lagos set up a Water Board that was later designated the Lagos State Water Corporation in 1980. It was upgraded in 1985 to

⁵⁸⁶ Lagos State Environmental Protection Agency Law, Laws of Lagos State (1996) Ss. 7 & 8; Lagos State Environmental Protection Agency, Online; <http://www.lasepa.gov.ng>; Lagos State Water Sector Law (2004) S. 112(2).

⁵⁸⁷ Lagos State Environmental Protection Agency Law, *supra* note 577, Ss. 7-9; Personal discussions with Chief Scientific Officer, *supra* note 584.

⁵⁸⁸ Lagos State Waste Management Authority Law (2007) Ss. 1- 4.

⁵⁸⁹ A. Lasisi, "Leachate and Groundwater Quality in Lagos State, Nigeria" A Paper presented at a seminar for Officers of Lagos State Environmental Protection Agency, (Available online).

⁵⁹⁰ Lagos State Waste Management Authority Law (2007); A. Lasisi, *supra*, note 589.

⁵⁹¹ Lagos Water Corporation, *Organization History*, online http://www.lagoswater.org/about_us.php

the status of a parastatal that could handle major water extension projects as well as funding from major donors including the World Bank.⁵⁹² LWC is accountable directly to the State Governor.⁵⁹³ The Corporation is statutorily responsible for providing potable water to Lagos residents. It owns all water services assets, and has power to develop all water and sewerage services assets, and to control all water treatment plants and groundwater.⁵⁹⁴

6.2.5 Lagos State Wastewater Management Office (LASWAMO)

The Lagos State Wastewater Management Office (LASWAMO) was carved out of the former Sewage Department of the office of Drainage Services in the Ministry of the Environment, and incorporated into the LWC in September 2010.⁵⁹⁵ The Office was required as part of efforts at institutional reform in wastewater management.⁵⁹⁶ Its functions are: to provide and maintain a system of public sewers to all properties, domestic, commercial, agricultural, medical or industrial; to regulate the construction, operations and maintenance of these wastewater systems in the state; and to properly manage wastewater generated from all premises through public sewers, emptying of septic tank, cesspools and any other wastewater containment.⁵⁹⁷ Although the Office's terms of reference require it to provide sewerage systems to all properties, it clarified during interviews that its responsibility is limited to sewage from domestic sources, i.e., wastewater from bathrooms, kitchen, and toilets from households,

⁵⁹² Ibid. See also the Lagos Water Corporation, *Lagos Water Supply Plan 2010 - 2020* (2012).

⁵⁹³ Personal Discussions with the Chief Scientific Officer, *supra*, note 584.

⁵⁹⁴ Lagos State Water Sector Law (2004), Ss. 6-7.

⁵⁹⁵ Lagos State Wastewater Management Office, online: <http://www.lagoswastewater.org>

⁵⁹⁶ Ibid.

⁵⁹⁷ Ibid.

hospitals and commercial centers but excluding industrial sources.⁵⁹⁸ LASWAMO is accountable directly to the Ministry of the Environment.⁵⁹⁹

6.2.6 Lagos State Water Regulatory Commission (LASWARC)

Lagos State has no Ministry of Water Resources. The Lagos State Water Regulatory Commission was established in 2012 to oversee and regulate the water sector, that is, the water provision and wastewater management responsibilities of the Water Corporation and the Wastewater Management Office respectively.⁶⁰⁰ Both the Water Corporation and the Wastewater Management Office are accountable to it, and it has predominantly regulatory responsibilities over them. The Commission clarified that the water sector is structured as a tripod: The Ministry of the Environment is responsible for making policies in environmental management generally; the Water Commission has regulatory or law-making functions, while the Water Corporation and Wastewater Management Office are for service delivery. LASWARC regulates the Water Corporation on water quality, and enforces and monitors it. The Commission is accountable directly to the State Governor.⁶⁰¹

6.3 Current Legal Framework for the Management of Groundwater in Lagos

The legal framework for managing groundwater consists of federal and state laws. The Nigerian Constitution authorizes the federal legislature to make laws that “protect and improve

⁵⁹⁸ Personal Discussions with officials of Lagos Wastewater Management Office on 16th November 2012.

⁵⁹⁹ Personal Discussions at Lagos Ministry of the Environment on January 10th 2013.

⁶⁰⁰ Lagos State Water Sector Law, Laws of Lagos State (2004) Ss. 48- 53.

⁶⁰¹ Personal Discussions at Lagos Water Regulatory Commission on January 10th 2013. As a fairly new establishment, the Commission has undertaken measures to sensitize the public and institutions about its responsibilities, and to address problems of water quality and sewage handling. In 2013, it organized a workshop themed “Groundwater Abstraction in Lagos State: Environmental and Health Impacts”. A second workshop titled “Regulating Wastewater in Lagos State: How it Affects You” took place later the same year. Presentations made at both seminars are relevant to this study and are cited in this thesis.

the environment and safeguard the water, air and land, forest, and wild life of Nigeria”.⁶⁰² It also empowers the federal legislature to make laws on water that is *from such sources as may be declared by the National Assembly to be sources affecting more than one state*.⁶⁰³ By interpretation this includes groundwater that is national in scope. The two provisions set the tone for federal regulation of water, which includes groundwater.

The Constitution similarly empowers the state legislatures to make laws for the ‘peace, order and good governance of the state...’ on any matter included in the concurrent legislative list, and any matter excluded from the exclusive legislative list.⁶⁰⁴ That, coupled with the right to make laws on any matter not included in the exclusive legislative list is an implied state power to legislate on groundwater which is also a water source that does not affect any other state. Thus the federal laws provide an overarching frame of laws and standards to guide all states, and also devolve power to them to manage environmental and water resources that occur within their territories. Following from these constitutional authorizations, federal laws, as well as laws made by Lagos itself regulate groundwater in Lagos.

There is however no single law written exclusively for groundwater either at the federal or the state levels. Provisions pertaining to groundwater management have been extracted from a combination of environmental and water laws at the federal level, as well as water and environmental laws at the state level. As mentioned earlier, due to the intersection of solid waste

⁶⁰² Constitution of the Federal Republic of Nigeria, (1999), CAP C23 Laws of the Federation of Nigeria (2004) S. 20

⁶⁰³ Ibid, 2nd Schedule, Part I “Exclusive Legislative List”.

⁶⁰⁴ The Constitution, supra, note 602, at S. 4(7). The Exclusive Legislative List refers to matters that are reserved solely for the federal legislature, whilst both the federal and the state legislatures may make laws on matters in the concurrent list. The concurrent list does not mention water or groundwater specifically, but the wording of S. 4(7) confers broad legislative powers on state houses of assembly that are wide enough to include water and groundwater occurring within each state.

and sewage with groundwater, the discussion will also include laws governing their management.

6.3.1 The Federal Framework for Groundwater Management

The federal laws include:

- i. The National Policy on the Environment 1989
- ii. The Water Resources Act 1993
- iii. Environmental Impact Assessment Act 1992
- iv. The National Environmental Standards and Regulations Enforcement Agency (Establishment) Act 2007 (and Regulations made under it).

Each will be described in turn in order to extract their relevant provisions.

6.3.1.1 National Policy on the Environment 1989

Although the National Policy on the Environment does not specifically mention groundwater within the water section, it addresses wastewater as a potential source of groundwater pollution.⁶⁰⁵ The Policy defines its water management strategies to include establishment of adequate controls and enforcement procedures to prevent contamination of water resources, and the control of point and non-point sources of pollution.⁶⁰⁶ It directs states to establish a system of improved water management technology that incorporates a safe disposal of waste water, waste-water reuse and recycling.

⁶⁰⁵ Federal Environmental Protection Agency, *National Policy on the Environment* (1989). Although there is only direct mention of groundwater in relation to industry sustainability, this guideline appears broad enough to include it.

⁶⁰⁶ Ibid, S. 4.8(g).

A direct reference to groundwater appears later within the section on mining and mineral resources, where the Policy requires states to minimize the degradation effect of mining exploitation.⁶⁰⁷ An important aspect of the Policy is that industries must monitor effluents from factories and other non-point sources as well as leachate from approved industrial waste disposal sites.⁶⁰⁸ Provisions also pertain to monitoring of groundwater quality in areas that are prone to pollution from oil and gas exploration activities.⁶⁰⁹ The aspect of industrial pollution abatement and waste management are important because they constitute a major source of pollution to groundwater which is core to this research.

The Policy has a statement of ‘sustainable industrial development strategies’, which is apparently an acknowledgement of the connection of industrial activities with water quality. The statement directs that industries are not to be located close to ecologically sensitive areas such as natural lakes, swamps, and wetlands; industries must write Industrial Master Plans that demonstrate methods for phased pollution abatement and waste management; sufficient space is to be provided on industrial sites for solid waste storage and primary effluent treatment; production processes are to incorporate waste minimization; and industries must establish specialized facilities for the handling and disposal of toxic and hazardous wastes.⁶¹⁰ Industries are to provide on-site solid waste storage and primary effluent treatment systems; they must also ensure the establishment of specialized facilities for the handling and disposal of toxic and

⁶⁰⁷ Ibid, S. 4.11(c).

⁶⁰⁸ Ibid S. 4.12(v).

⁶⁰⁹ Ibid, S. 4.14. Lagos is not yet an oil-producing state, but reports indicate that it expects to begin exploration activities from late 2015, following the March 2014 approval of its plans to develop the first phase of the Aje shallow water oil fields: The Punch Newspapers, *Lagos to Join Oil Producing States in 2015*, Online: <http://www.punchng.com/business/business-economy/lagos-to-join-oil-producing-states-in-2015/>

⁶¹⁰ Ibid.

hazardous wastes from industries.⁶¹¹ From these provisions, it is arguable that the Policy has groundwater protection in its broad contemplation of water resources.

The Policy is obviously well-thought out and well-intended. It recognizes the intersection of waste practices with water quality, which is consistent with Agenda 21 which directs attention to be given to the interconnectedness of the elements related to freshwater quality, and best practices for water management.⁶¹² However there is little indication of compliance, as industries continue to release untreated wastewater into the environment, as discussed in Chapter 5.

6.3.1.2 The Water Resources Act 1993

The Nigerian Water Resources Act is the major federal water enactment which regulates water use, management and protection.⁶¹³ It provides that for the purpose of water planning and development, the right to the use and control of all surface and groundwater and of any water course *affecting more than one State*, is vested in the Federal Government of the Federation.⁶¹⁴

6.3.1.2.1 Groundwater Abstraction under the Water Resources Act

Although the Act vests the right to the use and control of groundwater in the Federal Government, this does not affect private use of groundwater, for the same law clarifies that every holder of a statutory or customary right of occupancy to any land may take and use groundwater without charge for domestic purposes, watering livestock, and personal irrigation schemes.⁶¹⁵ The Act thus acknowledges the rights of private citizens to draw groundwater for their private

⁶¹¹ Policy on the Environment, *supra*, note 605, S. 4.12 (k & l).

⁶¹² Agenda 21, Art. 18.35.

⁶¹³ Water Resources Act (1993), Cap W2, Laws of the Federation of Nigeria Revised Ed. (2004) (Nigeria). This law was written by the Federal Military Government whilst Nigeria was under military rule in 1993. Originally styled 'Decree', this and other laws made during military rule are now referred to as 'Acts', as explained earlier in note 558, *supra*.

⁶¹⁴ *Ibid*, S. 1.

⁶¹⁵ *Ibid*, S 2(iii).

needs.⁶¹⁶ But this proprietary right of citizens is subject to the Minister of Water Resources' power to control the exploitation of groundwater resources in the following ways: determining the place, manner, and quantum of water that may be withdrawn in times of actual or anticipated water shortage; revoking a right to use or take water if inconsistent with the public interest; requiring examination or licensing of any person undertaking the work of drilling for water; regulating the place, depth, manner of construction or mode of operation of any bore-hole or well; and defining the times at which water may be taken from such borehole or well.⁶¹⁷

6.3.1.2.2 Groundwater Quality Safeguards under the Water Resources Act

In terms of groundwater quality, the Act empowers the Minister to either temporarily or permanently prohibit water withdrawals from any groundwater source if it would be hazardous to public health.⁶¹⁸ The Minister must make adequate provision for the supply of water for drainage, the safe disposal of sewage, effluent, and water-borne wastes and the control and prevention of pollution.⁶¹⁹ The Act further provides that the Minister may not license the commercial manipulation of groundwater (diversion, pumping or storage) if it has a likelihood of interfering with groundwater quality at that location.⁶²⁰ The Minister's power to regulate the

⁶¹⁶ Ibid S. 2. This abstraction right is consistent with provisions of the Land Use Act as mentioned earlier in this Chapter, and a qualification of the Federal Government's general ownership of land. A certificate of occupancy is a 99-year lease granted to qualified citizens by virtue of the Land Use Act 1978. The Act made monumental changes to the country's land tenure law which had hitherto been based on the English land tenure system of the 'fee simple' estate in perpetuity. The Land Use Act vested ownership of all lands occurring within the territory of a state in the state governments, only permitting the holding of leases for a maximum period of 99 years: Land Use Act, CAP 202, Laws of the Federation of Nigeria, (2004) S. 1.

⁶¹⁷ Water Resources Act (1993), S. 4(a-e).

⁶¹⁸ Ibid, S. 4.

⁶¹⁹ Ibid, S. 5(b).

⁶²⁰ Ibid, S. 11.

place, depth, manner of construction or mode of operation of any bore-hole or well is arguably a provision to safeguard groundwater quality.⁶²¹

The provisions set the tone for possible interventions in cases of emergency, but since the Minister's power is predominantly over interstate waters, the interference with private exploitation within a particular city, like Lagos, is improbable or at least very limited.

6.3.1.3 Environmental Impact Assessment Act 1992

As described earlier, the Environmental Impact Assessment Act (EIA Act) was written in 1992 as part of the series of responses to the 1987 toxic waste incident in Koko, South West Nigeria.⁶²² The Act's purpose is to forestall environmental harm by requiring the assessment of projects that might significantly damage the environment, before their execution.⁶²³ It authorizes the Environmental Protection Agency to prescribe mitigation measures where a proposed project is likely to cause some adverse environmental effect. It may also prohibit projects that may have significantly adverse effects that cannot be mitigated. Any decision to be taken by any public or private person, authority corporate body or unincorporated body including the Government of the Federation, State or Local Government is subject to prior environmental impact assessment.⁶²⁴

The EIA Act provides that "environment" means "...land, water and air, including all layers of the atmosphere..."⁶²⁵ That being so, "environment" includes groundwater, and so it is

⁶²¹ Ibid S. 4(f).

⁶²² Environmental Impact Assessment Act (1992), CAP E12, Laws of the Federation of Nigeria (2004).

⁶²³ Ibid, S.1.

⁶²⁴ Ibid, Ss. 2 & 14.

⁶²⁵ Ibid, S. 63.

safe to infer that before any activities are carried out, the likely impact on groundwater ought to be assessed and dispensed with if potentially harmful to it.

However, the portion of the Act that gives the Agency power over harmful projects is surprisingly wordy and vague. It reads thus:

“Where, in the opinion of the Agency, the project is likely to cause significant adverse environmental effects that cannot be mitigated...*the Agency shall not exercise any power or perform any duty or function conferred on it by or under any enactment that would permit the project to be carried out in whole or in part*” (italics is the Researcher’s).⁶²⁶

It would have been more helpful to simply state that the Agency can prohibit any project that may significantly harm the environment, or that it can require its promoters to find alternative methods to execute their project in a less harmful way, or similarly clear wording to that effect.

Nevertheless the Act’s provisions are consistent with Prevention and Precautionary Principles discussed in Chapter 1, which require that action be taken to avert harm to environmental resources. But it is regrettable that there has not been enough compliance even by environmental management agencies in terms of preventing harm to groundwater by safely locating or securing the city’s waste dumps in Lagos. Dumps have been located around residential estates, without lining or leachate collection systems, as described in Chapter 5, which also pointed out that preliminary investigation of the hydrogeology of the proposed waste dumps locations was probably not undertaken before locating them. Industries have also been situated

⁶²⁶ Ibid, S. 39.

around vulnerable aquifers, in violation of the national environmental policy, and in consequence, groundwater pollution has ensued.⁶²⁷

But in spite of vagueness, superfluity, or past non-compliance however, it is reassuring to have a major federal law that has groundwater resources in contemplation, although indirectly. Even though groundwater pollution has already occurred in Lagos, the provisions remain useful as a preventive tool for ensuring prior assessments for likely harm to groundwater in case of future constructions and activities of either private citizens or of governmental agencies.

6.3.1.4 National Environmental Standards and Regulations Enforcement Agency (Establishment) Act (NESREA) 2007

The National Environmental Standards and Regulations Enforcement Agency (Establishment) Act is Nigeria's principal federal environmental law.⁶²⁸ Before NESREA came into being, its predecessor (FEPA) made three Regulations that targeted toxic waste and wastewater emissions from industries.⁶²⁹ But FEPA did not address groundwater directly, and was also not very effective, with industrial compliance ranging between 20 - 40% in spite of a 5-year moratorium given to industry operators to install pollution abatement facilities.⁶³⁰ Minimal compliance has had dire consequences on groundwater, with severe contamination occurring

⁶²⁷ Chapter 5 clarified that the problem of waste dumps polluting groundwater is likely due in part to a failure by waste management authorities to appraise the hydrogeology of proposed waste dump sites prior to locating them. Appropriate studies would have determined the propensity of aquifers in that location to pollution, and probably drawn attention to the need to have a form of leachate collection or other groundwater safety measures there.

⁶²⁸ National Environmental Standards and Regulations Enforcement Agency (Establishment) Act, Federal Republic of Nigeria Official Gazette 2007 No 92, Vol. 94 ("NESREA Act").

⁶²⁹ They were: National Environmental Protection (Effluent Limitation) Regulations (1991); National Environmental Protection (Management of Solid and Hazardous Waste) Regulations (1991); National Environmental Protection (Pollution in Industries and Facilities Generating Waste) Regulations (1991).

⁶³⁰ M.A. Ajomo & O. Adewale, *Environmental Law and Sustainable Development in Nigeria*, (Lagos: Nigerian Institute of Advanced Legal Studies, 1994); M.T. Ladan, *supra*, note 580.

over the years, as described in Chapter 5. This fact is very important, as industrial wastewater pollution of groundwater forms a significant part of this thesis.

In 2007, the National Environmental Standards and Regulations Enforcement Agency (Establishment) Act (NESREA) repealed the Federal Environmental Protection Agency (FEPA) Act.⁶³¹ It established a new Agency, the National Environmental Standards and Regulations Enforcement Agency (NESREA), with broad powers to protect and develop the environment, and to oversee the sustainable development of Nigeria's natural resources.⁶³² NESREA enforces compliance with local laws and guidelines relating to water quality, pollution abatement, and environmental health and sanitation.⁶³³ NESREA's additional power to enforce compliance with the provisions of international agreements, protocols, conventions and treaties on the environment, including hazardous wastes, pollution, and sanitation enables the application of international agreements as a standard for groundwater management in this thesis.⁶³⁴

6.3.2 A Review of NESREA Regulations on Groundwater

NESREA has written twenty four Regulations regarding various aspects of the environment in Nigeria.⁶³⁵ Ten of these Regulations relate broadly to groundwater and waste management. Whilst one of the Regulations has a section that is devoted to groundwater, another controls waste disposal, which intersects with groundwater quality. The remaining eight Regulations are directed at industries, and are meant to control their wastewater discharges, which also intersects with groundwater quality. Due to similarities between the eight regulations,

⁶³¹ NESREA Act, *supra*, note 628, Ss. 1 & 38.

⁶³² *Ibid* S. 2.

⁶³³ *Ibid* Ss. 2(a) & 7.

⁶³⁴ *Ibid* S. 7(c).

⁶³⁵ *Ibid*, Ss. 23 & 24.

the Electronics Regulation will be employed as a sample that is reflective of provisions for other industries. The Regulations are discussed in the following sections:

6.3.2.1 Groundwater Quality Protection under NESREA

6.3.2.1.1 Industrial Effluents and Leachates:

Two Regulations provide broad rules concerning industrial and commercial sewage emissions. These are the Surface and Groundwater Regulation, and the Sanitation and Wastes Control Regulation.

The Surface and Groundwater Regulation

The second part of the Surface and Groundwater Quality Control Regulation addresses groundwater with the objective, *inter alia*, of protecting it from any substance having the potential to contaminate it.⁶³⁶ The relevant sections refer mainly to hazardous waste fluids within mineral extraction processes. Later references to ‘landfills’ and ‘burrow pits’ in which waste is buried require that the physico-chemical makeup (assumed to refer to groundwater) must comply with parameters outlined in the accompanying fourth Schedule. The fourth Schedule clarifies that the chemical micro pollutants in groundwater must not exceed the limits set out for each chemical element listed. Also, pathogenic organisms and coliform bacteria in groundwater at these locations are not to exceed limits set out in the sixth Schedule. The sixth Schedule then details microbiological limits for groundwater quality.⁶³⁷

Industrialists are required to obtain NESREA permits before discharging sewage into groundwater. NESREA determines the applicable treatment for individual dischargers as well as

⁶³⁶ National Environmental (Surface and Groundwater Quality Control) Regulation, Federal Republic of Nigeria Official Gazette, (2011) No. 49, Vol. 98. S. 19.

⁶³⁷ *Ibid*, Ss. 21 (1-2); Schedules IV & VI.

limits discharges in order not to compromise the quality of the receiving waters.⁶³⁸ Industrial operators are prohibited from installing or operating landfills for industrial waste disposal where such waste would allow pollutants into groundwater.⁶³⁹ NESREA may conduct tests or analyses of groundwater or effluent samples to determine the compliance of sewage, industrial waste or other discharges with the requirements of the Regulation.⁶⁴⁰

An important provision is the Agency's power to disallow an aquifer from remaining a source of drinking water if it becomes so contaminated that it endangers human health, and if it is economically or technologically impractical to make it fit for human consumption.⁶⁴¹ This provision is relevant for Lagos and may be invoked soon since some of its aquifers are already highly contaminated.

Although made to protect groundwater from pollution, the Regulation appears to have omitted an important factor or premise in waste pollution of groundwater, which is the leachate that is generated from waste dumping. The Regulation refers directly to physico-chemical parameters for chemicals, as well as microbiological limits for pathogenic organisms in groundwater, but ignores waste leachate which is the reason for the presence of these elements in groundwater. There is no mention of waste dumping or of the leachate which migrates into, and pollutes groundwater. In fact, there is no single mention of "open dumps" or any form of control of dumping activities that pose such a worrisome problem to groundwater, even though it does restrict discharges of sewage into groundwater.

⁶³⁸ Ibid. Ss. 22(1-4).

⁶³⁹ Ibid, S. 23(7).

⁶⁴⁰ Ibid. S. 31.

⁶⁴¹ Ibid, S. 27 (1) (ii).

Another difficulty with this Regulation is that it dwells a lot more on surface water than groundwater.⁶⁴² There is also a lot of detail on underground injection of hazardous wastes and fluids used for extraction of minerals and fossil fuels energy, but these are not core to the problems confronting groundwater in Lagos. The section on “Landfills and Burrow Pits” is odd since landfills did not exist at the time of enacting the Regulations nor has any become operational even at the present time.⁶⁴³

The Sanitation and Wastes Control Regulation

The Sanitation and Wastes Control Regulation aims at achieving sustainable sanitation and waste management practices at all levels, (domestic, commercial, and industrial) of both solid waste and wastewater.⁶⁴⁴ Although primarily meant for wastes, the Regulation controls some aspects of wastewater management, and this is important because of its intersection with groundwater in Lagos. It requires commercial enterprises and industries to treat their effluents to standards that are specified in the tenth Schedule.⁶⁴⁵ Generators of toxic and hazardous waste must treat them with methods that are acceptable to the Agency.⁶⁴⁶ Further provisions state that no person shall *abstract groundwater* or carry out any activity near it that would probably have an adverse effect on it without an environmental impact assessment statement.⁶⁴⁷

The measures are important because they aim at ensuring that waste released into the environment is safe, and this ultimately safeguards groundwater. However, the aspects relating to

⁶⁴² Ss. 1-18 deal exclusively and in considerable detail with surface water.

⁶⁴³ Ibid, S. 20(2); see also Personal Discussions held with a University of Lagos Prof on January 9th 2013 in Lagos, Nigeria.

⁶⁴⁴ National Environmental (Sanitation and Wastes Control) Regulations, Federal Republic of Nigeria Official Gazette, (2009) No. 60, Vol. 95.

⁶⁴⁵ Ibid., S. 35.

⁶⁴⁶ Ibid, Ss. 44-48.

⁶⁴⁷ Ibid, S. 38.

industrial effluent standards, as well as to groundwater abstraction should ideally be located within the Groundwater Regulation. Their presence within the Sanitation Regulation contributes to a fragmented framework.

6.3.2.1.2 Control of Manufacturing Wastewater Emissions

Apart from the general provisions for commercial and industrial effluents already discussed, eight NESREA Regulations specifically address industrial operations in terms of their wastewater emissions. The industries addressed are: Chemicals, Base Metals and Iron, Plastics and Rubber, Electronics, Mining, Food and Beverages, Textiles, and Chemicals and Soap Manufacturing industries. All the Regulations contain similar provisions, and so, as mentioned earlier, the Electronics Regulation will be employed as a sample that is reflective of provisions in all the others.⁶⁴⁸

NESREA's Electrical/Electronics Sector Regulation has rules within the following subcategories; Effluent Limitation Standards; Restriction on the Release of Toxic Effluents; Treatment of Effluent; and Sludge Disposal.⁶⁴⁹

Effluent Limitation Standards: Chemical effluents are required to be within the standards specified in the tenth Schedule for chemicals such as arsenic, chromium, cadmium, lead, mercury and tin. Any effluent in excess of the specified limits, and discharges without pre-treatment are regarded as non-compliant.

⁶⁴⁸ National Environmental (Electrical/Electronics Sector) Regulations (2011), Federal Republic of Nigeria Official Gazette, No. 50, Vol. 98.

⁶⁴⁹ Ibid, Ss. 15-19.

Restriction on the Release of Toxic Effluents: Corporate organizations are prohibited from discharging effluents into a water body except the effluent parameters are properly observed.

Treatment of Effluent: All organizations must ensure that toxic components of both effluents and sludge are treated in an environmentally sound manner. Short cuts, such as diluting effluent in order to give the impression of compliance, are particularly prohibited.

Sludge Disposal: toxic organics within sludge must be removed. Sludge must not be directly discharged into any water body, unless with a permit.

Regulations for the other industries contain similar provisions with minor variations in the particular standards for chemical components of effluents.⁶⁵⁰ In combination, they set guidelines for industrialists' discharges of polluting substances into the environment. They prohibit discharges without required permits and require mitigating facilities (waste treatment plants and surface impoundments). They also require each industrial organization to periodically self-report its effluent discharges to the Agency including periodic audits by accredited environmental experts.⁶⁵¹

⁶⁵⁰ National Environmental (Chemical, Pharmaceutical, Soap and Detergent Manufacturing Industries) Regulations, Official Gazette No. 68, Vol. 96 (2009); National Environmental (Food, Beverages and Tobacco Sector) Regulations, Official Gazette No. 65, Vol. 96 (2009); National Environmental (Textile, Wearing Apparel, Leather and Footwear Industry) Regulations, Official Gazette No. 66, Vol. 96 (2009); National Environmental (Mining and Processing of Coal, Ores and Industrial Minerals) Regulations, Official Gazette No. 63, Vol. 96 (2009); National Environmental (Base Metals, Iron and Steel Manufacturing/Recycling Industries Sector) Official Gazette No. 41, Vol. 98 (2011); National Environmental (Domestic and Industrial Plastic, Leather and Foam Sector) Regulations (2011); National Environmental (Non-metallic Minerals Manufacturing) Regulations, Official Gazette No 48, Vol. 98 (2011).

⁶⁵¹ See for instance: Ss. 37-39, Chemicals and Pharmaceuticals Regulations; Ss. 52-53, Electrical and Electronics Sector Regulations; Ss. 35-37, Food Beverages and Tobacco Sector Regulations; Ss. 47-49, Non-Metallic Minerals Manufacturing Regulations.

The provisions regarding the heavy metals listed above are important because they are known to pollute groundwater when they occur in high concentrations. This special attention to heavy metals is gratifying because of the dire consequences that they have on human health, as studies have shown, and as discussed in Chapter 5.

Overall, the provisions endeavor to minimize wastes generated during industrial production processes, and to control environmental pollution at the sources of their emissions. The Polluter-pays principle which is incorporated into all these Regulations, places a responsibility on industries concerned for clean-up, remediation and compensation to affected persons.⁶⁵²

6.3.2.1.3 Domestic Effluents

Domestic sewage management is regulated by the Groundwater Regulation, and the Sanitation and Wastes Control Regulation.⁶⁵³

The Groundwater Regulation provides that chemical elements in groundwater within domestic areas must not exceed the limits set out in the fifth Schedule, which details the limits of concentration.⁶⁵⁴

The Sanitation and Wastes Control Regulation provides that the construction and maintenance of septic tanks must comply with the fourth Schedule, which requires owners to ensure that their septic tanks comply with minimum location specifications, at a safe distance

⁶⁵² See for instance S. 5, National Environmental (Chemical, Pharmaceutical, Soap and Detergent Manufacturing Industries) Regulation 2009; S. 7, National Environmental (Electrical/Electronic Sector) Regulation 2011

⁶⁵³ Sanitation and Wastes Control Regulations.

⁶⁵⁴ National Environmental (Surface and Groundwater Quality Control) Regulation, S. 21.

away from potable water supplies sourced from wells.⁶⁵⁵ Septic tanks must be located at least 15 meters from any potable water supply, well or spring; Owners must ensure that the septic tanks or other on-site sanitation facilities are regularly maintained; They must provide drains for wastewater and ensure that untreated sewage is not piped or discharged into public drains or roads; and ensure regular dislodgement and safe disposal of the contents of the septic tank.⁶⁵⁶ Sadly, however, there are no known standards for the design of these facilities as prescribed, and neither does there appear to be any serious enforcement of these rules.

Two important provisions deserve a special mention. First, the prohibition of open sewage drains as a method of domestic sewage disposal recognizes its potential danger to groundwater. As discussed in Chapter 5, open drains constitute one of the problems encountered in domestic sewage management in Lagos. Secondly, the requirement that septic tanks must comply with detailed minimum location specifications is also designed to protect groundwater from pollutants that might migrate from sewage into groundwater. But it is apparent that neither provision is being enforced since there is a proliferation of wrongful domestic sewage disposal methods as well as wrongful siting of septic tanks as discussed in Chapter 5.

Further provisions prohibit any activities that can directly or indirectly cause groundwater pollution: The Regulation expressly disallows anyone to release poisonous or toxic matter, radioactive waste, or other pollutants into the natural environment, or into water bodies.⁶⁵⁷ No one may abstract groundwater or conduct activities near surface waters that are likely to have an adverse effect on the quality of water without an EIA statement.⁶⁵⁸

⁶⁵⁵ Sanitation and Wastes Control Regulations, S. 10, & Schedule IV.

⁶⁵⁶ Ss. 10(c-g) & 35.

⁶⁵⁷ Ibid., Ss. 36 & 39.

⁶⁵⁸ Ibid., S. 38.

But it is deplorable that the Sanitation and Waste Regulation does not deal with the effect of solid waste leachates on groundwater. Since the Groundwater Regulation did not address this effectively as mentioned above, it was naturally assumed that the Sanitation and Wastes Regulation would do, but that is not the case.

Some of the Regulation's provisions are rather vague while others do not appear feasible. For instance the requirement that owners of septic tanks should ensure the "regular maintenance of the structure" is vague without precise guidelines. There are also no specific guidelines for the design of septic tanks that would enable them to perform the primary treatment that is expected of a standard septic tank, as described in Chapter 5. This allows the varied types of septic tanks in use in Lagos to remain a major threat to groundwater quality. Also the duty of waste generators to "apply sustainable practices to minimize pollution" needs to be clarified.⁶⁵⁹ Besides these, the twelfth Schedule prescribes central on-site sewage treatment plants for high density residential and commercial areas, but the language makes it unclear if the provision is intended for new or pre-existing structures. If for the latter, it is rather doubtful that this can be implemented because of the common use of the diffuse method of ejecting sewage described in Chapter 5, and also because of the difficulty of having this within a substantially built up environment that Lagos is.

Finally, although it is good to find the detail about groundwater abstraction in S. 38 which is missing from the Surface and Groundwater Regulation, the appearance of this fragment within this Regulation is unexpected since it is clearly marked for "sanitation and wastes control". It is natural to assume that prospective abstractors of groundwater would look to the Surface and Groundwater Quality Control Regulations, and not the Waste provisions to

⁶⁵⁹ Ibid, Ss.10 & 15.

determine their legal obligations. This provision underlines the fragmented nature of groundwater regulation in Lagos.

6.3.3 General Appraisal of Federal Laws Relating to Groundwater

As mentioned earlier, the EIA Act is wordy and vague, although that should not detract from its important objective of preventing harm to groundwater. Despite the perceived non-compliance with its provisions when siting waste dumps and industries discussed in Chapter 5, and granted that it is a little late to prevent groundwater pollution which has already occurred, it remains extremely valuable for safeguarding groundwater in terms of future projects.

The NESREA Act appears to be a firmer effort by the Federal Government to address perceived gaps in the previous law, especially pertaining to groundwater. Its Regulations addressing septic tanks and industrial effluents are two major sources of groundwater pollution in Lagos.

However, some of its provisions are fragmented, as mentioned above. For instance, various provisions within the Waste Regulation regarding septic tanks, industrial effluent treatment, and groundwater abstraction should ideally be in the Surface and Groundwater Regulation, or better still, in a law that is dedicated to groundwater in Lagos, as will be discussed a little later in this chapter. More fragmentation is evident as one has to review so many federal laws and Regulations in order to glean the framework for groundwater, and this clearly underscores a very fragmented federal regulatory framework indeed.

Provisions relating to domestic sewage are surprisingly detailed, even though there do not appear to be actual design guidelines or standards for septic tanks. But the troubling persistence of the haphazard domestic sewage structures in the metropolis and especially of untreated industrial wastewater discussed in Chapter 5 raise questions about the efficacy of the rules, and

also indicates a larger problem of non-compliance. There is a pervasive problem of industrial non-compliance with effluent limitation standards that preceded NESREA and its Agency. As discussed in Chapter 5, field research findings confirmed that industry operators consider the cost of treating effluents to be prohibitive and unnecessary. Non-compliance is a serious problem with dire consequences for groundwater and for the health and lives of Lagos residents.⁶⁶⁰

Happily, NESREA has power to enforce compliance with international environmental agreements on pollution and sanitation.⁶⁶¹ In the meantime the enabling section provides a sound basis to use the agreements as a benchmark for the purpose of this study.

In addition to the federal framework, Lagos has a number of environmental laws from which provisions regarding groundwater management will be extracted. As mentioned earlier in this Chapter, based on the constitutional authorizations, laws made by Lagos state complement the federal laws on groundwater, and these will now be examined.

6.4 State Regulation of Groundwater in Lagos

Lagos State does not have a single law that deals exclusively with groundwater, but it has a collection of environmental laws and an environmental policy that address groundwater.⁶⁶²

They are:

1. Lagos State Policy on the Environment
2. Lagos State Water Sector Law

⁶⁶⁰ Personal Discussions at Lagos State Environmental Protection Agency on November 28th 2012 in Lagos, Nigeria.

⁶⁶¹ NESREA Act, S. 7. NESREA will presumably enforce the agreements by enacting into law those environmental agreements which Nigeria has ratified. For instance it has a draft Agenda 21 that is in the process of enactment: <http://www.nesrea.org/environmentalpolicies.php>.

⁶⁶² The Federal Constitution which empowers states to make laws is silent on groundwater. But section 4(7) confers power on the State Houses of Assembly to make laws for the 'peace, order and good governance of the State or any part thereof'. That, coupled with the right to make laws on any matter not included in the exclusive legislative list is an implied power to legislate on groundwater which is also a water source that does not affect any other state.

3. Lagos State Environmental Protection Agency Law

In addition, the following laws dealing with waste management are relevant:

4. Lagos State Waste Management Authority Law
5. Environmental Pollution Control Law
6. Environmental Sanitation Law

6.4.1 Lagos State Policy on the Environment

Lagos State Environmental Protection Agency (LASEPA) wrote the Policy on the Environment, which provides guiding principles for environmental protection.⁶⁶³ The Policy laments that the status of Lagos as the national economic hub with a large concentration of industrial and trading activities has exposed it to environmental pollution and ecological problems where water is being polluted, and natural resources are being over-exploited, all of which have profoundly degraded the environment.⁶⁶⁴ Therefore, it emphasizes the preservation and maintenance of renewable and non-renewable natural resources. The Policy is committed to promoting awareness about balancing environmental management with development.⁶⁶⁵ It acknowledges the important intersections of waste management, population growth and industrial activities on a healthy environment.⁶⁶⁶ Although not actually mentioning groundwater, it does state that every economic activity must be conducted in a manner that minimizes the pollution of the environment.⁶⁶⁷ This is very important to sustainable development particularly in the context of persistent industrial pollution.

⁶⁶³ Lagos State Environmental Protection Agency, *Policy on the Environment* (1999).

⁶⁶⁴ Ibid, S. 2.

⁶⁶⁵ Ibid, S. 4.

⁶⁶⁶ Ibid, S. 6.6.

⁶⁶⁷ Ibid, at page 5.

6.4.2 The Lagos Water Sector Law

The Lagos State Water Sector Law is the major enactment governing water resources in Lagos and for this reason is a fundamental and central element of current groundwater management arrangements.⁶⁶⁸ It creates the agencies that govern water resources described earlier in this chapter, and also set out their responsibilities.

By virtue of this law, the Lagos Water Corporation (LWC) has control and management of all groundwater.⁶⁶⁹ LWC is responsible for the following: potable water supply throughout Lagos state, control of all water treatment plants (water works) and groundwater, development of existing and new water works and sewerage systems; identification and implementation of projects for providing water services; and preparation of plans for maintenance and development of water services.⁶⁷⁰ The relevant sections of the law read thus:

“The functions of the Corporation shall be to:

- (a) Develop all water services assets, new water services and sewerage service assets;
- (b) Prepare on behalf of the State, plans for the maintenance and development of water services, water services assets and new water services assets in the State...
- (c) Identify and implement projects for the provision of water services which may be undertaken with private sector participation, pursuant to consultation with the relevant authorities in order to fulfill the water service obligations of the State
- (d) Ensure the supply of potable water in the State, either pursuant to project agreements with private participants, or by raising necessary funds through the capital market

⁶⁶⁸ Lagos State Government, *Lagos State Water Sector Law*, Official Gazette No. 24, Vol. 37 (2004).

⁶⁶⁹ Ibid. S. 6(e).

⁶⁷⁰ Ibid, Ss. 6-7.

(e) Control and manage all waterworks and ground water in the State’’⁶⁷¹

Further, the law provides further that LWC owns all water services assets:

“The Corporation shall...own all water services assets, new water services assets and sewerage services assets’’⁶⁷²

6.4.2.1 Groundwater Abstraction under the Water Sector Law

As part of its ownership of water services assets, LWC has the power to abstract water from any groundwater source for potable water supply throughout the state. Its powers of ownership and control over groundwater abstraction are expressed thus:

“The Corporation shall... control the sinking and operation of boreholes and the abstraction from underground water forming part of State water and making appropriate regulations relating thereto’’⁶⁷³

Except for domestic users, LWC must approve and license all boreholes meant for abstracting groundwater.⁶⁷⁴ Private individuals may also abstract groundwater without license by constructing wells and boreholes within their residential premises for domestic purposes, and this is consistent with the Water Resources Act as mentioned earlier.⁶⁷⁵

⁶⁷¹ Ibid, S. 6 (a) - (e). ‘Waterworks’ refers to water treatment plants which are at locations where water is abstracted from the ground, processed, stored and distributed through channels to the metropolis. New waterworks means new treatment plants that are constructions from time to time. As mentioned in Chapter 3, Lagos currently has 48 treatment plants which abstract groundwater exclusively which the LWC categorize as mini/micro waterworks. ‘Water services’ refers to water supply and all its incidents including abstraction, treatment and distribution.

⁶⁷² Ibid, S. 7(a).

⁶⁷³ Ibid, S. 7(m).

⁶⁷⁴ Ibid, S. 115(2).

⁶⁷⁵ Ibid, Ss. 43 & 115 Water Sector Law; S. 2 Water Resources Act.

6.4.2.2 Groundwater Quality Preservation under the Water Sector Law

Under the Water Sector law, maintenance of groundwater quality is the collective responsibility of the LWC, LASWARC, and private individuals.

Lagos Water Corporation: The law requires LWC to periodically examine groundwater to know if any pollution exists, and to ascertain its causes.⁶⁷⁶ It can also determine that any borehole that is hazardous to health will be temporarily prohibited from being supplied for consumption.⁶⁷⁷ LWC may enter into any premises to examine, repair or remove any pipes belonging to it.⁶⁷⁸

Where water in a pipe is likely to be contaminated by the return of any substance from certain premises to the water pipe, LWC has power to either disconnect a service pipe or cut off water supply, or serve notice on the owner/consumer to take appropriate steps. In these cases LWC will specify steps that the consumer is to take before water is restored. The steps are intended to see that the damage, contamination or waste does not reoccur when the water supply is restored.⁶⁷⁹

Additionally, LWC has power to carry out in any street any work to prevent pollution of its water treatment plants. Such work may include: breaking or opening up a street; tunneling or boring under a street; breaking up or opening a sewer drain or tunnel; or moving or removing earth or other materials.⁶⁸⁰ LWC may construct drains or sewers for intercepting, treating or disposing of foul water arising from or flowing on any land that it owns or has a right to work

⁶⁷⁶ Ibid, S. 7(l).

⁶⁷⁷ Ibid, S. 115(3).

⁶⁷⁸ Ibid, S. 7(n).

⁶⁷⁹ Ibid, S. 128.

⁶⁸⁰ Ibid, S. 130(1) a.

on. It may also carry out this work in order to prevent pollution of groundwater that belongs to it, or from which it is permitted to take water, or underground strata that it is authorized to abstract water from.⁶⁸¹ The law requires that the quality of drinking water supplied to the public must be equivalent to that of the World Health Organization.⁶⁸²

The law also empowers LWC to provide a system of public sewers, to clean and maintain them, and to ensure that the area is continually drained. It must empty these sewers when necessary by means of sewage disposal works, and make provision for the emptying of on-site sewage collection systems.⁶⁸³ LWC's regulatory power allows it to prevent wastage and leakage by regulation, while through licensing procedure it may also monitor wastewater and sewerage operators.⁶⁸⁴

Private Individuals: Private individuals who construct wells or boreholes must comply with rules that require boreholes to be sited in a hygienically conducive environment and protected from pollution.⁶⁸⁵ Any person who pollutes water that is meant for human consumption or for manufacturing edible items is guilty of an offence.⁶⁸⁶ The law also forbids the discharge of waste by any person into any water bodies. It states that:

⁶⁸¹ Ibid, S. 130.

⁶⁸² Ibid, Ss. 112 & 115(4). The Lagos Water Regulatory Commission has a draft "Lagos State Regulations for Drinking Water Quality" which is being made under the enabling provisions of Ss. 52 and 53 of the Water Sector Law, and is published on its website, but is not yet law. When it becomes law, it will be applicable to everyone including LWC, manufacturers in food processing, water sellers and private individuals. In the meantime the World Health Drinking Water Standard is the benchmark for public drinking water quality: <http://www.lagoswastewater.org>.

⁶⁸³ The sewerage function is now that of Lagos Wastewater Management Office: S. 95

⁶⁸⁴ Lagos Water Sector Law, Ss. 7(n), & 26.

⁶⁸⁵ Ibid, S. 115. The rule is consistent with, and complements NESREA's Sanitation and Waste Control Regulation S. 10 discussed in the previous section.

⁶⁸⁶ Ibid, S. 125.

“No person shall discharge or cause or permit the discharge of ... hazardous or toxic substances beyond the limits approved by the law”⁶⁸⁷

Lagos Water Regulatory Commission: The Lagos State Water Regulatory Commission (LASWARC) has some regulatory responsibilities in respect of water quality. It may make regulations to prevent water in a water pipe from contamination, and to safeguard its quality and suitability for its particular purpose in case of any substance returning into its pipes from any premises; it may also make regulations to prevent waste and misuse of water after it has left the LWC’s pipes.⁶⁸⁸

Although the monitoring measures required of LWC are intended to secure water quality, they are not adequate. The measures would be sufficient if supported by multi-barrier protection at all points of groundwater management from source until delivery to consumers, (which is not apparent from these provisions). “Multi-barrier” is a figure of speech to denote an unbroken string of protective measures that addresses all potential sources of water pollution at every point of water occurrence from abstraction to supply and “bars” them. This entails protection at source, treatment, distribution, monitoring and response.⁶⁸⁹ For Lagos, the requirement for monitoring would be adequate if it were a part of the total measures that shield groundwater. In particular, there is no mention of preventive measures in respect of the real sources of pollution which are solid waste dumps and wastewater, and does not indicate an appreciation of likely sources of pollution. Indeed, the monitoring provisions are largely reactive.

⁶⁸⁷ Ibid, S. 118(1) c.

⁶⁸⁸ Ibid, S. 127.

⁶⁸⁹ Hrudey et al, “A Fatal Waterborne Disease Epidemic in Walkerton, Ontario: Comparison with Other Waterborne Outbreaks in the Developed World” (2003) 47(3) Water Science and Technology 7.

It is noteworthy that there is still limited regulation of domestic boreholes/wells under either present or proposed laws, as these are expressly excluded from the provisions of the various laws. Apart from generic provisions that prohibit pollution of water bodies mentioned above, the laws exclude wells that are intended for domestic use from direct regulation or licensing.⁶⁹⁰ This is concerning because the object of this study is protection of groundwater sources from pollution. If private citizens are free to continue exploiting the resource without complying with construction, maintenance or other standards, then that might well defeat current efforts to safeguard the valuable resource. As discussed in Chapter 5, the problem of groundwater pollution is aggravated by limited regulation of private well use, which appears to have conferred a license on practically anyone to indiscriminately exploit groundwater.

Overlaps in regulatory and other powers are evident within the law. Both agencies are conferred with power to make regulations on groundwater exploitation in terms of the sinking and operation of boreholes, and for groundwater extraction. Similarly, both have power to fix the rate and scale of charges payable for water supply. The relevant sections are extracted below:

“The **Corporation** shall ...**control the sinking and operation of boreholes and abstraction** from underground water ...and making appropriate regulations relating thereto”

“The functions of the **Commission** shall be to:

(a) Regulate the **production, distribution, supply and use of water...**”

The **Corporation** may

⁶⁹⁰ Water Sector Law, S. 115(2). Also, the controversial draft Borehole Licensing Law also excludes domestic boreholes from its requirement for licensing.

“...make regulations...fixing the **rate and scale of charges** payable for the water supplied by meter or otherwise within the State”

“The functions of the **Commission** shall be to

(a) regulate the production, distribution, supply and use of water...

(b) Approve from time to time the **rates and scales of charges** payable for water supply...”⁶⁹¹

(Emphasis is the Researcher’s)

Overlapping regulatory powers and functions result in a multiplicity of legal instruments, duplication of provisions, and confusion to users. It can also cause inter-agency disputes over lines of authority. A demonstration of the functional overlap between both agencies is the draft borehole licensing law made by LWC but which LASWARC declared to be outside its jurisdiction, yet both Agencies were evidently acting within their powers under Lagos Water Sector Law.⁶⁹² Overall, it can worsen the already existing fragmentation and ultimately adversely affect implementation of the rules and the safeguarding of groundwater which was the intention of the drafters.

Finally, stipulations of fines and imprisonment for non-compliance with its rules do not seem adequate in the context of environmental regulation, as they neither prevent nor resolve the pollution occurring to groundwater.⁶⁹³

6.4.3 The Lagos State Environmental Protection Agency Law

⁶⁹¹ S. 7(m) & S. 52 (1)(a); S. 26(a) &(f), & S.52(1)(b), Lagos Water Sector Law.

⁶⁹² The draft law is titled: *Lagos State Water Sector (Rates and Charges) Regulations (2012)*. Personal discussions with Lagos Water Corporation on November 29th 2012; Personal discussions with Lagos Water Regulatory Commission on January 10th 2013.

⁶⁹³ Lagos Water Sector Law, Ss. 124-126.

As mentioned earlier in this chapter, the Lagos State Environmental Protection Agency Law created the Lagos State Environmental Protection Agency (LASEPA) in 1996 with powers to regulate effluent emissions in the state.⁶⁹⁴ LASEPA adopted NESREA's Effluent Standards for industries which have already been discussed.

LASEPA has monitoring responsibilities for groundwater quality. LASEPA Law authorizes LASEPA to survey and monitor groundwater in order to determine pollution levels in it.⁶⁹⁵ It determines pollution levels, collects baseline data, and is required to work in conjunction with other agencies. LASEPA has responsibility to see that facilities generating waste put in place proper abatement plants that treat generated wastewater to prescribed standards.⁶⁹⁶ However, LASEPA does not appear to have had a positive effect on the quality of groundwater in view of the escalating pollution and industrial non-compliance with standards for wastewater emissions.⁶⁹⁷

Due to pollution also occurring from waste dumps, it is important to also examine the legal provisions for waste management in Lagos in order to understand the contributory problems. The next section will review the laws that govern the waste dumping practices which constitute a problem to groundwater in Lagos.

6.5 Laws Relating to Solid Waste Management in Lagos

⁶⁹⁴ Lagos State Environmental Protection Agency Law, (1996).

⁶⁹⁵ Ibid, S. 7. This is consistent with the Water Sector Law which makes LASEPA the monitoring body for raw water, waste water, liquid wastes, groundwater, land and soil in the state: S. 112(2). However, during field work, it was clarified that LASEPA only oversees industrial wastewater, while domestic sewage is the responsibility of Lagos Wastewater Management Office. See personal discussions at Lagos State Environmental Protection Agency of November 28th 2012. See also personal discussions at Lagos Wastewater Management Office of November 16th 2012.

⁶⁹⁶ Lagos State Environmental Protection Agency Law, Ss. 8(d) & 9(c).

⁶⁹⁷ In the *Final Draft Report of Lagos State Effluent Limitation Standards and Guidelines (1999)*, drafters lamented a paltry 20% compliance by industrial manufacturers in requirements to install appropriate pollution abatement facilities. Discussions with officials at LASEPA discussed in Chapter 5 also affirmed a low industrial compliance rate.

Solid waste management in Lagos is governed mainly by the Lagos Waste Management Authority (LAWMA) Law, the Environmental Pollution Control Law, the Environmental Sanitation Law, and the NESREA Sanitation and Waste Regulation.

6.5.1 Lagos State Waste Management Authority Law (LAWMA)

The Lagos State Waste Management Authority (LAWMA) Law authorizes LAWMA to collect and dispose of domestic, commercial, and industrial waste, and to make provision for all waste management services in the state.⁶⁹⁸ Waste disposal is to be only at designated waste disposal sites, and vehicles conveying waste must be covered to prevent littering roads or highways.⁶⁹⁹ The law empowers LAWMA to set standards relative to waste collection and waste disposal system.⁷⁰⁰ The law does mention the establishment and management of “an organizational structure for recycling activities in the state” but little else.⁷⁰¹ LAWMA law does not prohibit the use of open waste dumps, but rather authorizes waste dumping which is a notorious problem to groundwater as discussed in Chapter 5.⁷⁰² It also does not give guidelines about any acceptable or healthy methods of waste disposal and treatment.

Interestingly, it provides that LAWMA should designate a place as a ‘sanitary landfilled area’ where collected waste would be dumped, whilst giving LAWMA the sole right to design and operate such designated ‘sanitary landfilled’ site.⁷⁰³

⁶⁹⁸ Lagos Waste Management Authority Law (2007), Lagos State Official Gazette, No. 27, Vol. 40

⁶⁹⁹ Ibid, Ss. 4, 5, 14, & 15.

⁷⁰⁰ Ibid, S4 (Supplementary Provisions); The Researcher was told that there was no revision or subsidiary legislation that details the permissible or safe methods of waste.

⁷⁰¹ Ibid, S. 5(h).

⁷⁰² Ss. 14(b) & 16.

⁷⁰³ Ibid, S. 16. In earlier chapters, the Researcher has regretted the pervasive tendency by practitioners to mix up terminology by referring to open dumps as landfills or even as sanitary landfills.

6.5.1.1 The Environmental Pollution Control Law

The Environmental Pollution Control Law was made to control pollution and to protect the environment from being abused due to poor waste management.⁷⁰⁴ It set up an Advisory Committee and Sub-committee within the Ministry of the Environment to collectively formulate policies on environmental sanitation, pollution, environmental conservation, and related programs. The Committees have power to recommend recycling of waste as a management method for industries and state government agencies; establish and recommend the basic requirements for solid, liquid, gaseous or toxic wastes management in the state; and to establish and recommend acceptable safe methods for collecting and disposing of hazardous and toxic waste.⁷⁰⁵ They may enter into any manufacturing premises to collect samples in order to determine environmental pollution. They may also apply adequate enforcement measures to combat environmental pollution.⁷⁰⁶ The law also empowers the Ministry to control the siting and management of waste dumpsites, although this is a function of LAWMA.⁷⁰⁷

6.5.1.2 The Environmental Sanitation Law

The Environmental Sanitation Law is another law dealing with some aspects of waste and general sanitation. It requires cleanliness of restrooms in hotels, the mandatory use of sanitary

⁷⁰⁴ Environmental Pollution Control Law (1989).

⁷⁰⁵ Ss. 5(c) - (e).

⁷⁰⁶ Ibid, S. 8.

⁷⁰⁷ Ibid, S. 7(n). At the time of writing this thesis, it was unclear if the Ministry was taking any definitive steps to control toxic effluents from manufacturing industries, or to control groundwater pollution. Neither was it possible to ascertain if any new recommendation or policies had been made regarding waste recycling in industries, or for municipal solid waste management. However, according to recent news reports in August 2015, the Ministry has been sealing up commercial premises that fail to treat their wastewater to required standards in order to prevent further groundwater pollution. The same efforts are in place for noise and air pollution: *Churches, Companies, Strip Clubs Shut Down By Lagos Government* (27th August 2015), Online: <http://www.tori.ng/news/7516/churches-companies-strip-club-shut-down-by-lagos-g.html>; Channels Television, *LASEPA Seals Hotels, Religious Houses*, (4th August 2015), Online: <http://www.channelstv.com/2015/08/04/lasepa-seals-hotels-religious-houses/>; the Punch Newspapers, *LASEPA Seals Kanu Nwankwo's Hotel, Worship Centres*, Online: <http://www.punchng.com/news/lagos-seals-kanu-nwankwos-hotel-worship-centres/>

litter bins, and the proper disposal of garbage.⁷⁰⁸ An unexpected provision pertaining to waste management that would ordinarily be within the LAWMA law occurs within this law: it prohibits anyone from disposing of domestic waste except through the use of Private Sector Participation Operators. It also has a stipulation for the maintenance of drains, septic tanks, and sewage (similarly found in the Sanitation and Wastes Control Regulation) earlier, and which would likely also fit better within either the Groundwater Regulation or the Water Sector Law.⁷⁰⁹

Finally, NESREA's Sanitation and Wastes Control Regulation provides some Federal rules for solid waste management. It places responsibility on everyone (individuals, food vendors and traders) to maintain hygiene and to dispose of wastes appropriately.⁷¹⁰ Industrial operators are to ensure sorting and segregation of wastes at source, provide receptacles for recyclable materials in accessible locations; and keep drains litter free. Commercial and industrial operators are required to minimize pollution by reducing, re-using and recycling waste.⁷¹¹ Healthcare facilities generating healthcare waste must be properly registered, and ensure that waste is segregated at source, and then treated according to measures outlined in the sixteenth and seventeenth schedules.⁷¹²

In spite of confusing terminology that references 'landfills' instead of 'waste dumps', LAWMA law's provisions authorize waste dumping. However, when all the laws are read together, it may be inferred that they slightly ameliorate the effects of waste dumping by prohibiting indiscriminate littering and by restricting disposal to official dump sites only. It is also arguable that they endeavor to promote better waste management practices amongst

⁷⁰⁸ Environmental Sanitation Law (2000), Laws of Lagos State (2004)

⁷⁰⁹ Ibid Section 1-7, & 12.

⁷¹⁰ Sanitation and Waste Control Regulation, Ss. 3, 6 & 7.

⁷¹¹ Ibid, S. 24.

⁷¹² Ibid, Ss. 54-59.

commercial and industrial operators by requiring them to minimize and recycle waste. But the efforts are evidently rudimentary and ineffective since there is scant sorting except for the activities of scavengers described in Chapter 5. Waste is mixed also, as industrial and domestic wastes have traditionally been disposed together, with the ensuing aggregation of toxic biological and chemical leachates described in Chapter 5.⁷¹³ There are also many overlaps in functions which are visible within the provisions.

6.5.2 Appraisal of Lagos Framework for Groundwater

The discussions above represent the framework for managing groundwater at the level of Lagos state. The absence of a single law that addresses groundwater exclusively has meant searching through many laws on water and waste in order to discover what Lagos has to provide for the resource. The overall framework is characterized by fragmentation, vagueness, inadequacy, and by legal provisions that create functional overlaps. Within this frame, there is no mention of preventive measures in respect of the real sources of pollution which are solid waste dumps and wastewater. Also, there is still no regulation for domestic boreholes/wells, which also constitute a threat to groundwater's integrity. Thus the resource continually suffers escalating pollution occurring from a range of anthropogenic activities as discussed in Chapter 5.

6.5.3 Addressing the Difficulties within the Overall Federal and Lagos Legal Frameworks

In summary, problems of pluralism of laws, fragmentation, overlaps, vagueness, gaps, wordiness and non-compliance attend the federal and Lagos legal framework for groundwater which intersects with solid waste and wastewater management. Vagueness and confusion are regrettable especially in the case of the Environmental Impact Assessment Act which is a critical

⁷¹³ But recent reports mentioned in Chapter 5 indicate that LAWMA is now operating a medical waste treatment plant for all the wastes emanating from all medical facilities in Lagos.

law for preventing activities that could potentially degrade groundwater. The collection of laws provides at best a fragmented framework.

The aggregation of laws is thus insufficient and does not adequately reflect the international agreements that incorporate the best practices for managing environmental resources generally and groundwater in particular. As discussed in Chapter 2, the sustainable development principles on water have been well enunciated at the various international Conferences including the Rio Meeting (Agenda 21), continued with the Dublin Principles, and re-iterated in the Future We Want. The Rio meeting stresses the importance of enacting effective environmental legislation, standards and priorities which reflect the developmental contexts to which they apply. Agenda 21 requires protection of water quality, and demands that pollution which gradually destroys freshwater should be addressed. It recognizes that inadequately treated effluents and insufficient control over industrial wastewater discharges are known sources of pollution. In order to prevent pollution, these should be controlled by reducing pollution at source, and by implementing standards for point source discharges. It also provides guidelines for the strengthening of managerial elements, that is, legal instruments. The Rio + 20 Conference reiterated in *The Future We Want*, the importance of managing water efficiently, and of realizing the human right to safe drinking water.⁷¹⁴ In addition, the Sustainable Development Goals affirm the importance of tackling water pollution and improving water quality, and importantly, it stresses the essential role of legislation in accomplishing this objective.⁷¹⁵

For groundwater, it is necessary to eliminate the legal pluralism. Since no particular law is dedicated to groundwater, rules concerning its exploitation have had to be searched out from

⁷¹⁴International Conference on Water and the Environment, *Dublin Principles* (1992), Principles 1-4; Agenda 21, Arts. 5(a-c), (e), 6, 23, & 35; United Nations Conference on Sustainable Development (Rio +20), *The Future We Want* (2012) Arts. 119-124.

⁷¹⁵United Nations Summit on Sustainable Development, *Transforming Our World: the 2030 Agenda for Sustainable Development*, Goal 6, Arts. 33 & 45.

the numerous federal and state enactments, as was done in the preceding sections. This has effectually created a very unwieldy patchwork of laws that all have to be perused in order to ascertain the relevant provisions. In view of groundwater's importance to residents, it is necessary that Lagos devotes a law exclusively to groundwater management. Since groundwater has no dedicated law, it has not garnered the level of interest and attention to its ramifications that it probably would have done if a law were exclusively devoted to it. As a result of the superficial attention given to it so far, groundwater is still substantially unprotected. It is probable that the drafters of a law that is solely committed to groundwater will have a chance to address all the incidents of groundwater extraction, well/borehole maintenance, and groundwater quality protection, and thus offer a fuller framework that contributes to its sustenance. The new law should ideally build upon the relevant provisions of the NESREA Surface and Groundwater Regulations by incorporating important provisions about specific standards for the construction and maintenance of wells and boreholes into it.

Due to the intersection of waste and wastewater disposal practices with groundwater, and in order to further safeguard it, the law should harness provisions which affect groundwater that are spread out between the Sanitation and Wastes Control Regulation and the Groundwater Regulation that is, licensing and permissible limits of chemical compounds in wastewater discharges from industries may be extracted and combined in the new groundwater law. Requirements for the proper location of boreholes in hygienic environments, and the treatment of wastewater to approved standards before discharge that are contained in the NESREA's Sanitation and Wastes Control Regulation should be similarly extracted and included in this new law.⁷¹⁶ The law should outlaw the use of open drains to discharge wastewater since they transmit untreated effluents that flow directly into surface waters that ultimately migrate into

⁷¹⁶ NESREA Sanitation and Wastes Control Regulation, Ss. 35-36, 39-40; 40-41, & Schedules 11 & 12.

groundwater. Current offenders should be given a moratorium to install safer disposal systems in their buildings. Public education and information over a period of time will communicate this to the residents. The groundwater law will complement the eight NESREA Regulations that govern wastewater emissions from the Manufacturing sector, which were discussed earlier.⁷¹⁷

Other pertinent groundwater provisions spread around the other legislations should be extracted and incorporated into the proposed law. For example, provisions in the Water Sector Law about the location of boreholes, licensing of non-domestic boreholes, and prohibition of waste discharges into water bodies should be extracted for incorporation into the proposed groundwater law.⁷¹⁸ Suggestions from this thesis that LWC should working closely with LAWMA, LASWAMO and LASEPA to monitor leachates from waste dumps, and to ensure that wastewater discharges from domestic and industrial activities do not damage groundwater would also be desirable.

The matter of limited regulation of private boreholes which is enabled by both the Water Resources Act and the Water Sector Law that both guarantee private citizens the unregulated private right to exploit groundwater needs to be addressed as it is an indirect enabler of domestic sewage pollution of groundwater. As mentioned in Chapter 5 and earlier in this chapter, limited regulation of private well use has meant that people erect structures for exploiting groundwater without any form of control in terms of licensing, and thus, wastewater contamination of wells has begun to cause illnesses in the metropolis.⁷¹⁹ The Water Sector Law's specific statement that private persons do not require a license arguably removes private groundwater exploitation from

⁷¹⁷ Being federal enactments, Lagos does not have the jurisdiction to amend them, but may extract useful sections that can be incorporated into a separate law for its groundwater.

⁷¹⁸ Water Sector Law, Ss. 115, & 118.

⁷¹⁹ As discussed in Chapter 5, reports in 2014 affirmed contamination of groundwater within the metropolis, although precise details were not available at the time of writing this thesis: *Fashola Approves Eight Wastewater Plants*, Online: <http://www.lagoswastewater.org>

legal control. However, NESREA's Sanitation and Wastes Control Regulation prescribes minimum distances between septic tanks and wells, so if read together, it may be inferred that private wells are not entirely unregulated and that the law provides at least a standard for well location. LWC explained this non-regulation of private wells on the basis that its inability to provide water for all residents forecloses its right to prevent them from sourcing for water on their own.⁷²⁰ But this has enabled indiscriminate exploitation, and wrongful well locations that have increased the propensity to pollution as is presently occurring. There should therefore be some effort to regulate private borehole exploitation that would not deny residents their right to secure water, since the LWC is presently unable to provide enough water for all. Such regulations should also form a part of the new groundwater law.

The proposed new law should also emphasize the intersection of solid waste and wastewater with groundwater and stress the importance of coordination of all the waste and water management efforts. In addition, it should contain a stipulation for prior environmental impact assessment of any activities with likely impacts on groundwater. Environmental impact assessment would include prior evaluation of the hydrogeology to determine the presence of sensitive aquifers at sites proposed for waste management, or for locating industries that generate substantial effluents. Finally, the new law should not prioritize provisions like punishment by imprisonment which are found within the various enactments, but rather see to it that its provisions incorporate the time-tested principles of prevention, precaution and remediation, i.e. polluter pays. Provisions concerning private borehole exploitation within the Sanitation and Waste Control Regulation and the Water Sector Law should be included in the new groundwater

⁷²⁰ Personal discussion with LWC's Legal Adviser on November 25th 2012.

law. The new law may also draw additional best management practices from mature systems such as the European Union, which will be discussed in the next section of this Chapter.⁷²¹

In respect of solid waste management, it is ideal that the fragmented provisions within the current LAWMA Law should be merged with the Environmental Sanitation Law and the Environmental Pollution Control Law in order to create one cohesive instrument for solid waste management. Separate sections may be created to deal with municipal solid waste, and industrial waste respectively. Fragments appearing in the Sanitation and Waste Control Regulation pertaining to waste management may also be extracted and combined in the single new law. There is also a need to incorporate specific provisions regarding a gradual, phased progression from waste dumping to sanitary landfilling. A single cohesive document would make waste management rules easily discernible, and the monitoring of waste management activities that intersect with groundwater easily ascertainable in order to ease the detection of groundwater pollution.

It is recommended that all the existing laws should undergo detailed screening and fine-tuning to remove all superfluity and duplications of powers. Due to the fact that the NESREA Act and its Regulations are federal enactments that provide the overarching frame for environmental management, they cannot be touched. Neither should the Water Sector Law, which is also a critical enabling document that creates the major agencies, within the water

⁷²¹ Provisions laying down punishments are in: NESREA (Sanitation and Wastes Control) Regulations, Ss. 80 & 85; NESREA (Surface and Groundwater) Regulations, Section 34(2); and Lagos Water Sector Law, Ss. 124 & 125. The disputed Water Sector (Rates and Charges) Regulation mentioned earlier is a draft law that represents emerging efforts to start direct regulation of groundwater. However it is concerned mainly with abstraction and is directed towards commercial users of groundwater, stipulating the obtaining of licenses for a fee. It excludes domestic users who make up a significant proportion of overall use. The provisions also appear to be more revenue-driven than motivated by a compelling need to address problems of degradation, thus it totally omits this important issue: Draft Lagos State Water Sector (Rates and Charges) Regulations 2012.

sector. For this reason it needs to be retained albeit with the modifications suggested to remove the functional overlaps that presently exist between the water sector operators.

Apart from the legal difficulties discussed, the matter of institutions also needs to be addressed.

6.6 Tackling Institutional Difficulties

Due to the fact that Lagos does not have a Ministry of Water Resources, the government established the Lagos Water Regulatory Commission in an effort to bridge the gap that the lack of a Water Ministry created. The idea of a Regulatory Commission is thus a noble one. Sadly however, the Lagos Water Sector Law which also established the Lagos Water Corporation creates difficulties in form of functional overlaps that arise from the wording of the enactment. Overlaps also exist between other agencies as the following examples will illustrate:

6.61 Regulatory Commission and LWC

The Water Sector Law permits both LWC and LASWARC to make regulations on the same matters. It gives both agencies power to make regulations on tariffs for water services, as mentioned earlier.⁷²² LWC may make regulations with respect to “fixing the rate and sale of charges payable for the water supplied by meter or otherwise within the state” and “fees payable for services rendered by the Corporation together with the time and place of payment of such fees”. LASWARC may “regulate the production, distribution, supply and use of water, the quality of service and the tariff and charges payable to ensure the financial stability of the water

⁷²² See *supra*, note 690.

sector...” and “approve from time to time the rates and scales of charges payable for water supply.”⁷²³

Also, the Water Sector Law gives LASWARC broad regulatory powers “to regulate the production, distribution, supply and use of water...” over the water sector, but also empowers LWC to “make appropriate regulations” to control the sinking and operation of boreholes and abstraction of groundwater.⁷²⁴ The sinking and operation of boreholes and the abstraction of groundwater should ordinarily come within production or supply of water. LASWARC’s power to regulate water quality overlaps with LWC’s similar power. Similarly, LWC’s power to regulate waste and leakage overlaps with LASWARC’s broad regulatory functions.⁷²⁵

A consequence of the overlap between these two key players in the water sector is the matter of the borehole law which the Water Corporation’s legal department drafted, but which the Regulatory Commission rejected as being outside its jurisdiction.⁷²⁶ Both Agencies were evidently acting within their powers under Lagos Water Sector Law.

6.62 The Ministry and LAWMA

Apart from the two key players in the water sector discussed above, there are functional overlaps within the waste management sector as illustrated by the following two examples. Although not dealing with water, their activities in waste management indirectly affect groundwater, as the pollution from waste dumps attests. The Environmental Pollution Control Law allows its Committee to control the location and management of waste dump sites, and to

⁷²³ S. 26(a) & (f), & S.52(1)b, Lagos Water Sector Law.

⁷²⁴ S. 7(m) & S. 52(a) Water Sector Law.

⁷²⁵ Ss. 7 (m –n); 26, 52, 127, & 128 Lagos Water Sector Law.

⁷²⁶ The draft law titled: *Lagos State Water Sector (Rates and Charges) Regulations (2012)* was mentioned in note 692, supra. Personal discussions with the Legal Adviser Lagos Water Corporation on November 29th 2012, and personal discussions with Lagos Water Regulatory Commission on January 10th 2013, both affirmed this state of affairs.

prohibit the dumping of waste without permission, but this is clearly the function of LAWMA.⁷²⁷

The Environmental Pollution Control Law also empowers the Ministry's Subcommittee to do all the following: examine and recommend recycling of waste as a management method for industries and state government agencies; establish and recommend the basic standard requirements for solid, liquid, gaseous or toxic wastes management in the state; and establish and recommend acceptable safe methods for collecting and disposing of hazardous and toxic waste.⁷²⁸ But this is in fact a LAWMA responsibility.

LAWMA Law, the Environmental Pollution Control Law, and the Environmental Sanitation Laws, contain waste management provisions that suggest that these should all be synchronized into one document and the functions contained within one agency, LAWMA, as suggested earlier.

6.6.3 The Ministry and LASEPA

Three examples illustrate the overlap between the Ministry and LASEPA. First, the Environmental Pollution Control Law allows the Ministry's Sewage Department to enter and inspect any *manufacturing premises* to collect samples and to ascertain environmental pollution at all times. But LASEPA law gives the same power to LASEPA to apply enforcement measures to combat environmental degradations in *manufacturing premises*.⁷²⁹

Secondly, the Environmental Pollution Control Law also empowers the Ministry's Committee to control industrial pollution at point source; establish effluent discharge standards;

⁷²⁷ Ss. 7, 8, & 18 Environmental Pollution Control Law and Section 7, Lagos State Environmental Protection Agency Law; Lagos Waste Management Authority Law, Ss. 5(j) and (m).

⁷²⁸ Ss. 5 (c) - (e), 7(n) Environmental Pollution Control Law; Ss. 2-7, Environmental Sanitation Law; section 12-15 LAWMA Law.

⁷²⁹ Environmental Pollution Control Law, S. 7(a); Lagos State Environmental Protection Agency Law, S. 8(d).

and issue effluent discharge permits. This is a clear overlap with LASEPA's oversight responsibilities over industrial effluents. LASEPA Law states that it may make regulations on acceptable standards to control water, air and noise pollution as well as standards for effluents.⁷³⁰

Again, the Environmental Pollution Control gives powers to the Ministry to monitor and control the discharges and disposal of solid, liquid and gaseous industrial wastes. Similar provisions in LASEPA law give LASEPA power to monitor and control disposal of solids, gaseous and liquid wastes generated by governmental and private facilities.

6.6.4 LASEPA and LWC

The Environmental Protection Law authorizes LASEPA to survey and monitor groundwater to determine pollution levels in them and collect baseline data. This appears to be very similar to the Lagos Water Sector Law that gives LWC power to examine groundwater to determine pollution.⁷³¹

6.6.5 Effects of Overlaps and Fragmentation

Functional overlaps mean that efforts are being replicated and this leads to waste and confusion. It also means a lack of coordination and continuity in managerial efforts and as a result an important resource such as groundwater suffers. It has been argued that in such a fragmented and unwieldy patch work of separate controls arising from lack of inter-institutional cohesion and cooperation, governing agencies end up competing rather than complementing one

⁷³⁰ See S. 7(a) Environmental Pollution Control Law, and Ss. 8(d) & 9, LASEPA Law.

⁷³¹ Ss. 7 & 8, Environmental Protection Law; S. 7(f) LASEPA Law; S. 7(l) Water Sector Law. Some heartening cohesiveness is however apparent in the laws. For instance, the Water Sector Law states that LASEPA is the monitor of raw water, wastewater and groundwater. LASEPA law confirms this by providing that LASEPA is to monitor and control the disposal of solids and liquid waste generated by both governmental and private facilities in Lagos: Lagos State Water Sector Law, S. 112(2); Lagos State Environmental Protection Agency Law, S. 7(6).

another.⁷³² During discussions, LASWARC admitted that a number of functional overlaps do exist between the environmental agencies.

In conclusion, difficulties in the management of groundwater have been caused by a multiplicity of fragmented laws, gaps in regulation, as well as functional and regulatory overlaps. Overlaps are occurring especially in the regulatory powers currently shared by LWC and LASWARC, in the functions between the Ministry and LAWMA, between the Ministry and LASEPA, and between LASEPA and LWC. It is thus evident that these governing structures have not helped to alleviate the problem of groundwater pollution. Evidently, a good amount of synchronizing, refining, and streamlining of environmental laws as well as functional overlaps needs to be carried out.

6.6.6 Probable Solutions to the Institutional Difficulties

In view of legal provisions that have created functional overlaps, these overlaps need to be resolved in clear legal drafts. LASWARC's exclusive regulatory powers can be clarified in an amendment to the Water Sector Law, while the Water Corporation should retain its exclusive powers of sourcing and distribution of water and ownership of water infrastructure in the state. For waste management, it is recommended that waste management functions should be exclusively LAWMA's. This, coupled with the amalgamated waste management law recommended in the previous section, would ease the burden of ascertaining the waste management activities that affect groundwater in Lagos.

⁷³² O. Fagbohun, "Mournful Remedies, Endless Conflicts, and Inconsistencies in Nigeria's Quest for Environmental Governance: Rethinking the Legal Possibilities for Sustainability" 4th Inaugural Lecture, Nigerian Institute of Advanced Legal Studies, at page 52. Online: <http://nials-nigeria.org>.

It is very important to have cohesiveness within the institutions. The intersection of solid waste and wastewater with groundwater makes it necessary that all responsible managerial agencies should work well together in the interest of safeguarding groundwater integrity. The government needs to adopt necessary measures to encourage cooperation, to promote goodwill, and to eliminate any resentment, while encouraging alignment in the interest of the city's groundwater. It should encourage institutional cooperation between the waste and water management institutions, that is, LASWARC, LWC, LAWMA and LASWAMO. By working with LASWAMO and LAWMA to observe, monitor and control waste management, LWC will be equipped to anticipate and control aquifer pollution from wastewater and solid waste leachates. LASWARC would support it with regulations from time to time. LWC also needs to make a more diligent effort to protect groundwater from pollution by monitoring the wastewater and solid waste sources which this study has identified.

6.7 Summary of Section Recommendation:

The summary of recommendations in this section is as follows:

Lagos needs to streamline and resolve the functional overlaps within its agencies, as well as eliminate the fragmentation, pluralism and superfluity that plague its environmental legislation. A single law at the level of Lagos should be enacted for groundwater, whilst the various fragments on waste management contained within the three laws - Environmental Pollution Control Law, the Environmental Sanitation Law, and the LAWMA Law - should be consolidated into a single waste management law for ease of reference and monitoring, with LAWMA having exclusive responsibility for managing all forms of solid waste.

LASWARC should have exclusive regulatory functions, whilst the Water Corporation takes exclusive charge of water abstraction, supply, distribution, and ownership of water infrastructure. Lagos should write a law that is dedicated to all the ramifications of groundwater management. It should build on NESREA's Surface and Groundwater Regulation, extract relevant provisions that are presently spread across the other environmental laws, and also extract best practices from mature jurisdictions such as the European Union whose environmental management frameworks are discussed in the next section.

Proper cohesiveness and inter-institutional cooperation needs to be encouraged in the interest of safeguarding the city's groundwater. Strong institutions are an important prerequisite for sustainable development.⁷³³ Governing institutions should not feature overlaps, fragmentation, or duplication of efforts, but rather be firm enough to respond effectively to current and future challenges. Where they fall short of the standard, they have to be strengthened and reformed as a requirement to achieve sustainable development. Strengthening institutions by implementing these measures would result in an overall stronger legal framework for groundwater as a tool for achieving sustainable development in Lagos.

The preceding discussions have identified problems within the laws and the institutions governing groundwater, analyzed them and offered ideas on tackling them. In order to further strengthen the proposed framework, it is useful to examine the laws in a mature system that has had more experience in environmental management. The study will now review the legal frameworks of the European Union in respect of groundwater, and (due to their intersection) of solid wastes and wastewater, and compare with Lagos in order to draw best practices from them for application in Lagos.

⁷³³ The United Nations Conference on Sustainable Development, (Rio + 20) *The Future we Want*, S. 75 - 76.

6.8 An Examination of the EU Legal Frameworks

Reference to an exogenous legal framework is supported by international agreements which encourage networking and experience-sharing amongst national governments because it helps countries to learn from one another in order to identify appropriate sustainable development policies. These may be expressed through legal instruments.⁷³⁴

The European Union's frameworks have been selected for review and comparison, as a matured system with a firm understanding of the interactions of waste and wastewater with groundwater, and also because the Union has through its Directives, progressively achieved adequate protection of groundwater within its Member States. In its quest for sound environmental management, the European Union has employed a wide range of strategies, recommendations, directives, and agreements that have shifted away from sector-based management to more holistic, ecosystem-based environmental management.⁷³⁵ The frameworks for wastewater, solid waste, and groundwater will be reviewed in turn, and their salient provisions will be compared with corresponding provisions within Lagos. The most appropriate and most adaptable provisions will be extracted from the European Union to address perceived gaps within Lagos, and recommended for the city.

6.9 The European Union Urban Wastewater Treatment Directive

The Urban Wastewater Treatment Directive has the overall objective of protecting the environment from the adverse effects of wastewater, (especially industrial wastewater)

⁷³⁴ Ibid, *The Future We Want*, S. 64.

⁷³⁵ S. Apotz, M. Elliott, M. Fountain, and T. Galloway, "European Environmental Management: Moving to an Ecosystem Approach" (2006) 2(1) *Integrated Environmental Assessment and Management* 80.

discharged into it.⁷³⁶ It recognizes the potential for harm that untreated industrial effluent discharges can have on the environment. Its most important sections provide that:

- All agglomerations with populations of 15,000 and more must have collecting systems for conducting urban wastewater to treatment plants, and such wastewater must undergo secondary treatment before discharge;⁷³⁷
- Where a collecting system is not practicable, individual collecting systems that achieve the same level of environmental protection are permitted. Discharges that do not enter urban waste water treatment plants must be subject to appropriate requirements;⁷³⁸
- Biodegradable industrial wastewater discharges which do not enter urban wastewater treatment plants before discharge to receiving waters must be subject to specific prior authorizations by competent authorities in each Member State that would be determined by the nature of the industry concerned;⁷³⁹
- Sensitive water bodies must be identified. A water body is sensitive if it is a natural freshwater lake, an estuary, or coastal water that is eutrophic or showing a propensity to become eutrophic unless preemptive action is taken. Discharges into sensitive areas are to be subject to more stringent treatment standards than the secondary treatment required for regular discharges;⁷⁴⁰

⁷³⁶ European Union Council Directive 91/271/EEC of 21st May 1991, as amended by the Commission Directive 98/15/EC of 27th February 1998, and Regulations made in 2003 and 2008.

⁷³⁷ Ibid, Art. 4.

⁷³⁸ Ibid, Art. 1.

⁷³⁹ Ibid, Art. 13. The industries are listed in Annex III as: Milk processing, fruit/vegetable manufacturing; soft drinks manufacturing, potato processing, meat industry, breweries, alcohol/alcoholic beverages production, fish processing, animal feed manufacturing, malt houses and gelatin/glue manufacturing.

⁷⁴⁰ Ibid, Art. 5, & Annex II of the Schedule.

- Sludge, which is the residue of treated wastewater, is to be recycled as much as possible, and the former practice of disposal in surface waters by dumping from ships and pipelines should be phased out;⁷⁴¹
- Wastewater treatment plants must comply with standards for their design and construction, and must be operated and maintained to ensure sufficient performance under all normal local climatic conditions;⁷⁴²
- Treated wastewater should be re-used whenever possible.⁷⁴³

6.91 Comparison with Lagos Framework

There are similarities between the provisions of this Directive and those regulating wastewater discharges in Lagos. Lagos requires its industries to be licensed to discharge effluents, and they must comply with standards laid out in the respective schedules for their effluents before discharge into the environment.⁷⁴⁴ The laws stipulate permissible limits of chemical compounds contained in wastewater discharges, and also standards for the disposal of industrial effluents.⁷⁴⁵ Groundwater quality is monitored to ensure compliance.⁷⁴⁶ Apart from these general provisions, eight additional NESREA Regulations that focus on specific industries establish standards for their respective effluent discharges, restrict the release of toxic effluents, require treatment of effluents, emission standards, and sludge disposal. The provisions aim at minimizing wastes generated during the respective production processes, and to controlling environmental pollution at the sources of their emissions. The Polluter-pays principle which is

⁷⁴¹ Ibid, Art. 14.

⁷⁴² Ibid, Arts. 4, 7, & 10.

⁷⁴³ Ibid, Art. 12.

⁷⁴⁴ National Environmental (Sanitation and Wastes Control) Regulations, Ss. 40-41, Schedules 11 & 12; National Environmental (Surface and Groundwater Quality) Regulations, S. 22.

⁷⁴⁵ National Environmental (Sanitation and Wastes Control) Regulation, Ss. 39, 40, 41, 44, 47 and Schedules X & XI; Water Sector Law, S. 118.

⁷⁴⁶ National Environmental (Surface and Groundwater Quality) Regulation, S. 31; LASEPA Law, S. 7; Lagos Water Sector Law, S. 112.

incorporated into all these Regulations, places a responsibility on industries concerned for clean-up, remediation and compensation to affected persons.⁷⁴⁷ However the legal framework is fragmented, as demonstrated by fractional provisions spread across numerous laws, a difficulty that was highlighted earlier in this chapter.

By contrast, the EU's provisions are together in a single enactment and are comprehensive. The Directive's requirement of treatment of wastewater that enters collection systems in sensitive areas is a proactive and sensible precaution to safeguard groundwater quality from domestic sewage. Although this particular provision may not be fully applicable in Lagos because of the dearth of central collection systems, the Directive offers an alternative in the form of individual treatment plants that may be substituted for centralized plants, (it anticipates that centralized treatment is not always feasible), and these would then be subject to the same standards that are applied to centralized systems.

The EU's requirement for the delineation of sensitive bodies of water, although directed at surface water bodies, is a provision that is consistent with the principle of Prevention and prior environmental impact assessment, and is very instructive for managing groundwater in Lagos. It could serve as a guide for water managers to map out areas that overlie aquifers, and to distinguish particularly sensitive groundwater zones based on scientific criteria. As discussed in Chapter 1, Lagos is underlain by various sedimentary rocks of varying depths, structure and sensitivity which make up the aquifer horizon, of which the Recent Sediments, which is the most

⁷⁴⁷ See for instance: National Environmental (Chemical, Pharmaceutical, Soap and Detergent Manufacturing Industries) Regulations, Official Gazette No. 68, Vol. 96 (2009), S. 5; National Environmental (Food, Beverages and Tobacco Sector) Regulations, Official Gazette No. 65, Vol. 96 (2009); National Environmental (Textile, Wearing Apparel, Leather and Footwear Industry) Regulations, Official Gazette No. 66, Vol. 96 (2009); National Environmental (Mining and Processing of Coal, Ores and Industrial Minerals) Regulations, Official Gazette No. 63, Vol. 96 (2009); National Environmental (Base Metals, Iron and Steel Manufacturing/Recycling Industries Sector) Official Gazette No. 41, Vol. 98 (2011); National Environmental (Domestic and Industrial Plastic Leather and Foam Sector) Regulations (2011); National Environmental (Electrical/Electronics Sector) Regulations (2011), S.7; National Environmental (Non-metallic Minerals Manufacturing) Regulations (2011).

accessible, is also the most prone to pollution. But although aquifers are distributed across the Lagos metropolis, they do not however exist in every available space underground. Thus the concept of delineation of sensitive water bodies would require the prior determination of the precise locations of such sensitive groundwater/aquifers within the vicinity of proposed activities where significant effluent discharges are foreseen. Identifying the sensitive areas would therefore be the starting point in determining the locations and protecting aquifers from pollution. A new policy for Lagos can prohibit the location of industries in particularly sensitive areas, and be incorporated into the new groundwater law that is being proposed for Lagos. Where industries are already situated in such sensitive zones, it can henceforth stipulate and enforce stringent standards for wastewater discharges, and also have a scientific basis for insisting that such industries remediate the environmental damage that their toxic emissions have already caused.

Another provision that is relevant for Lagos is the stipulation of secondary treatment as a mandatory minimum legal standard for wastewater discharged to fresh water bodies. Secondary treatment involves biological treatment with a secondary settlement process, and this is in addition to prior primary treatment which is a simpler physical or chemical process involving settlement of suspended solids. The mandatory high standard ensures that water released into the environment is always safe for human use.

Interestingly, the Directive allows for wastewater treatment to be downgraded to primary treatment for less sensitive areas, provided that such discharges do not adversely affect the environment.⁷⁴⁸ This is a realistic provision where there is no serious risk, and where it is unnecessary for industrialists to incur high treatment costs. Operators can then tailor their water treatment to that standard, thus avoiding the high costs associated with higher treatment levels.

⁷⁴⁸ Ibid, Art. 6.

This aligns with the ‘water fit’ concept that will be discussed as one of the recommendations in Chapter 7.

The Directive is holistic, having not just environmental harm in view, but also the safety of every contact with waste water. It provides measures to safeguard the health and safety of its staff; the protection of waste water treatment plant and equipment from damage; secures the unimpeded operation of the wastewater treatment plant and the sludge treatment plant; and provides for sludge to be disposed of in an environmentally safe manner.⁷⁴⁹ Overall, it provides good standards and information for regulators.

6.9.1 Section Recommendation:

In summary, the useful lessons extracted from the EU Directive on Urban Wastewater Treatment for application in Lagos are: First, hydro-geologists in Lagos should immediately identify areas in which sensitive aquifers are located which occur within industrial discharge zones, and that they be properly so designated for the application of stringent industrial wastewater discharge standards. Secondly, the absence of centralized sewage treatment systems should not impede the application and enforcement of adequate treatment standards. These can be properly enforced in Lagos. Thirdly, the holistic approach taken to wastewater management in which attention is also paid to health and safety of staff, the protection of waste water treatment plant and equipment from damage, unimpeded operation of the wastewater treatment plants, and the safe disposal of sludge residues is admirable and may be emulated in Lagos. This may be done by including such provisions in the proposed groundwater law. Also, Lagos may stipulate that wastewater treatment plants and septic systems must comply with standards for design, construction and operation which it presently lacks. Finally, the Directive also encourages the enactment of a single document for groundwater management, which is recommended for Lagos.

⁷⁴⁹ Ibid, Art. 11, & Annex IC.

The next section reviews the EU Framework for managing solid waste.

6.10 European Union Framework on Solid Waste Management

Solid waste management in Europe has evolved over the years, and now involves a complex interconnection of technological alternatives, economic instruments, and regulatory frameworks. These have helped to shape the paradigm of global sustainable development. Following the Earth Summit in 1992, the EU adopted the first EU Sustainable Development Strategy with the objective of supporting and promoting actions that would enable its Member States to achieve sustainable communities with efficient resource management. The current EU Waste Directive written in 2008 was in furtherance of this goal, as it has, more than ever before, challenged waste managers to devise more sustainable methods of managing solid waste.⁷⁵⁰

An elaborate assortment of laws has over the years made up the framework for waste management within the EU. Although some of these have since been repealed, a good number still remain.⁷⁵¹ The most relevant for this study are: the Waste Directive, the Landfill Directive and the Packaging and Packaging Waste Directive. They are reflective of the advancements in waste management and of the high level of environmentally safe management that is now required within the European community.⁷⁵²

⁷⁵⁰ A. Pires, G. Martinho, & N. Chang, “Solid Waste Management in European Countries: A Review of Systems Analysis Techniques” (2011) 92 *Journal of Environmental Management* 1033.

⁷⁵¹ The following Directives were repealed from 2010: Directive 75/439/EEC on the disposal of waste oils; Directive 91/689/EEC on hazardous waste; and Directive 2006/12/EC on waste management.

⁷⁵² The European Union is currently reviewing its waste legislations and investigating how new markets and better recycling can contribute to economic growth. The review is premised on the firm belief that the EU economy can be more innovative and productive by using fewer resources and minimizing environmental damage whilst retaining its competitiveness: European Commission Online Resource and Efficiency Platform, online at http://ec.europa.eu/environment/resource_efficiency/news/up-to-date_news/010213

6.10.1 The Waste Directive

The current Waste Directive was written in 2008.⁷⁵³ It repealed the former waste management Directive “in the interests of clarity and readability”.⁷⁵⁴ It aims to minimize the environmental impact of waste generation and management on human health and the environment.

A number of significant policies informed the need for a revision of the former waste legislations: First, a broad policy to minimize the negative effects of the generation and management of waste on human health and the environment, and of reducing the use of resources was found to be imperative towards the goal of sustainable development.⁷⁵⁵ Therefore the idea of a ‘Waste Hierarchy’ that sets out the priority in which waste should be managed which constitutes the best overall environmental option in waste legislation and policy, was devised. The hierarchy is in the order of Prevention, Preparing for re-use, Recycling, Other Recovery, and Disposal, and is intended to move the European Community closer to a recycling society that minimizes waste generation and that re-uses its waste as a resource.⁷⁵⁶ The Directive however allows for a departure from a strict prioritization of the waste hierarchy when necessary or justifiable, if alternative measures can result in the best overall environmental outcome.⁷⁵⁷

At the time of writing the Directive, Member states were required to establish waste prevention programs and to write these into a Waste Management Plan, or into environmental policy programs by December 2013. The Plan is an analysis of the current waste management situation and of measures to be taken to improve environmentally sound waste management according to the waste hierarchy. It should also include waste types and quantities, sources of

⁷⁵³ Directive 2008/98/EC of the European Parliament and of the Council on Waste and Repealing Certain Directives

⁷⁵⁴ Ibid, Art. 41 & Preamble 8.

⁷⁵⁵ Ibid, Art. 13.

⁷⁵⁶ Ibid, Preambles 6, 28, 31 & Art. 4.

⁷⁵⁷ Ibid, Art 4(2).

waste, and an evaluation of the development of waste streams in the future; existing waste collection schemes and major disposal and recovery installations, including any special arrangements for hazardous waste; and an assessment of the need for new collection schemes, and the closure of existing waste installations.⁷⁵⁸

Another principle, the re-conceptualizing of waste management on the basis of the entire life cycle of products and materials, was formulated.⁷⁵⁹ The life cycle approach is a principle intended to strengthen waste prevention. Member States are required to develop waste prevention programmes that concentrate on key environmental impacts and that take into account the whole life-cycle of products and materials and not only the waste phase.⁷⁶⁰ Following from the life cycle approach, the Directive introduces the concept of extended producer responsibility on manufacturers of all products to take into full account and facilitate the efficient use of resources during their whole life-cycle including their repair, re-use and recycling.⁷⁶¹ The purpose of this provision is to strengthen the re-use, prevention, recycling and recovery of waste. To this end, the Directive urges Member States to take appropriate measures to ensure that manufacturers' product designs reduce their environmental impacts, reduce the waste generated in the course of production and subsequent use, and enables the proper recovery and disposal of waste.⁷⁶² The responsibility further requires manufacturers to design products to be technically durable, and to be capable of multiple uses and safe disposal. It also obliges them to accept returned products and their waste and to be responsible for their safe disposal.⁷⁶³ By adopting this approach, the Directive expresses an expectation that the economic value of waste will be

⁷⁵⁸ Ibid, Arts. 1, 4, 28 & 29.

⁷⁵⁹ Preamble 27.

⁷⁶⁰ Ibid, at Preambles 8 & 40.

⁷⁶¹ Ibid, Art 8, & Preamble 27.

⁷⁶² Ibid, Art 8(2).

⁷⁶³ Ibid, Art 8(1) & 8(2).

strengthened.⁷⁶⁴ Further, it requires separation and separate treatments of various types of hazardous waste and of biodegradable waste (by composting and digestion).⁷⁶⁵

An important environmental management principle within the Directive is the obligation to consider the environmental impact of waste and waste management. This means that the process of developing or revising waste management plans should integrate the environmental impacts of the generation and management of waste.⁷⁶⁶ Of particular note is the provision for care to environmental resources including water, and recognition of the intersection of waste with water. The Directive provides that:

“Member States shall take the necessary measures to ensure that waste management is carried out without endangering human health, without harming the environment and, in particular:

(a) without risk to water, air, soil, plants or animals”.⁷⁶⁷

In addition, the Directive stipulates that Member States should make provision for a network of cooperation as regards disposal installations and installations for the recovery of mixed municipal waste collected from private households, taking into account geographical circumstances and the need for specialised installations for certain types of waste.⁷⁶⁸

It is evident from the Directive’s policies and provisions that the overriding preference in the waste hierarchy is waste prevention, whilst on the other hand, disposal such as landfilling is meant to be the last resort. Overall, the Directive aims at moving the EU to a recycling society in which waste generation is avoided as much as possible, while waste is continually re-used.

⁷⁶⁴Ibid, Preamble 8.

⁷⁶⁵ Ibid, Arts., 3, 17, 18, 22.

⁷⁶⁶ Ibid, Arts 1, 4(2), 13, & Preamble 37.

⁷⁶⁷ Ibid, Art 13, & Preamble 37.

⁷⁶⁸ Ibid, at Preamble 12.

6.10.11 Comparisons with Lagos Framework

In Lagos, NESREA's Sanitation and Waste Control Regulation, the Lagos State Waste Management Authority (LAWMA) Law, the Environmental Pollution Law and the Environmental Sanitation Law provide the framework for waste management, as discussed earlier in this chapter.

The Sanitation and Waste Control Regulation requires industries and every waste-generating facility to minimize pollution by sorting, reducing, re-using and recycling waste.⁷⁶⁹ LAWMA is authorized to establish and manage "an organizational structure for recycling activities in the state".⁷⁷⁰ In furtherance of this provision, LAWMA has a Recycling Department as well as a number of recycling and recovery efforts that are in place in Lagos, as described in Chapter 5. There are also efforts to collect methane gas from the *Olushosun* waste dump.⁷⁷¹

NESREA's waste Regulation has general provisions on sanitation that require every waste generator to segregate waste by placing recyclables in plastic bags, and separating hazardous from non-hazardous waste as well as requirements that hazardous waste should be secured, marked, labelled, and treated.⁷⁷² The provisions mention reducing, re-using and recycling of waste, and its collection and transportation by licensed waste managers, but there is no detail of the modalities for these waste management processes. The Regulation's delving into extraneous matters like effluent discharge, the maintenance of septic tanks, and groundwater

⁷⁶⁹ National Environmental (Sanitation and Wastes Control) Regulations, Official Gazette, No. 60, Vol. 96 (2009), Ss. 8(h) & 24.

⁷⁷⁰ Lagos State Waste Management Authority Law, Ss. 5-6.

⁷⁷¹ Personal Discussions with LAWMA Recycling Manager in November 2012; Personal Discussions with LAWMA official during the Researcher's tour of *Olushosun* Dump site on January 18th 2013.

⁷⁷² National Environmental (Sanitation and Wastes Control) Regulations, Ss. 11, & 44-47.

abstraction, have been discussed as indicative of the problem of fragmentation that plagues the environmental management framework in Lagos.⁷⁷³

Interestingly, NESREA's Waste Regulation has a brief provision on extended producer responsibility which requires manufacturers to incorporate environmental concerns in the design, process and disposal of their products.⁷⁷⁴ This is apparently an additional duty on industries to remove harmful materials within the waste stream which could potentially contaminate waste sites and groundwater sources in particular. However, there is no further explanation, definition, information or detail given about this, and no indication of compliance or even awareness of the provisions within industries.

Unhappily, the law authorizes the open dumping of waste which is a notorious problem to groundwater in Lagos, while neither it nor any of the other laws offer guidelines about the acceptable or healthy alternative methods of waste disposal and treatment. Although a provision in the LAWMA Law empowers the state government to designate a place as a 'sanitary landfilled area' where collected waste would be dumped, this does not appear to have been done. The confusing mix of terminology in the interchangeable use of "landfill" to mean "waste dumps" gives the erroneous impression that the city operates a safe or acceptable method of waste disposal.⁷⁷⁵

The Directive's requirement for States to take the necessary measures to ensure that waste management is carried out without endangering human health, without harming the environment and, in particular water, is an important note for Lagos where official waste

⁷⁷³ Ibid, Ss. 24, & 35-40.

⁷⁷⁴ Ibid, S. 16.

⁷⁷⁵ LAWMA Law, S. 16. Chapter 5 argued that the term 'landfill' that occurs within the laws has unfortunately been used inaccurately to refer to waste dumps in Nigeria.

disposal activities contribute significantly to groundwater pollution, and so have evidently not paid much attention to their environmental impact. Such a waste disposal method is harmful to an important natural resource, and ultimately to human health, and thus denies an important objective in waste management which is to minimize the negative effects of waste and waste management on human health and environment

The idea of a Waste Management Plan for strategic medium to long term waste management plans in the Directive would be a good start for Lagos to begin to address its biggest source of groundwater pollution.⁷⁷⁶

An interesting provision is the Directive's stipulation of a network of cooperation as regards disposal installations and installations for the recovery of mixed municipal waste collected from private households. In this regard, it is arguable that the policy thinking underlying this provision, which is that some linkages are necessary in the interest of environmental protection, may be extended to harnessing scavengers' waste sorting activities.

The difficulties within Lagos' framework which include fragmentation, vagueness, gaps, and overlapping provisions within numerous demonstrate that, Lagos has a long way to go in safely disposing of waste, needing elaborate public education about sorting from households, waste minimization and waste re-use. Drawing valuable lessons from the European Waste Directive on a waste hierarchy is very useful for Lagos because it lays down a priority order of what constitutes the best overall environmental option (waste prevention) in waste legislation and policy as well as guiding principles that would contribute to securing groundwater.

⁷⁷⁶ As mentioned in Chapter 5, during interviews, LAWMA mentioned to the Researcher an on-going 'Positive Reinforcement of Attitude' program which seems like a waste management plan, but it is not clear if it incorporates all the important details that contribute to sound waste management, which would in turn safeguard groundwater. But even if it does have such a plan in place or under construction, it can benefit from additional measures that make for a safe waste management system, in the interest of securing its groundwater.

6.10.2 The Landfill Directive

The Landfill Directive is another component of the European Union's solid waste management framework.⁷⁷⁷ It was written following a resolution that only safe landfill activities should be carried out throughout the European Union Community. It specifies technical standards for the landfilling of wastes that includes the location, conditioning, management, control, and closure of landfills. Member States are to implement national strategies to reduce biodegradable waste which is taken to landfills by adopting recycling, composting, biogas production, or materials/energy recovery. The Directive prescribes a phased 15-year plan for reducing bio-degradable waste that ends up at the landfills: within 5 years, Member States must have reduced the proportion of biodegradable waste going to landfills by 75%; within 10 years, the waste must have reduced to 50%, and by the 15th year, the proportion must have reduced to 35%.⁷⁷⁸

The Directive classifies landfills into three types: hazardous, non-hazardous, and inert. For waste to be safely accepted at landfills it must meet requirements for safe acceptance of waste in a landfill, and also be carefully assigned to the appropriate landfill.⁷⁷⁹ Careful and detailed prerequisites for accepting waste at landfills are provided, and certain wastes are not acceptable under any circumstance (liquid/flammable waste, explosive/oxidizing waste, corrosive, hospital/infectious waste, and used whole tyres). Landfill sites have to be so well controlled and monitored that their contents react only in foreseeable ways.⁷⁸⁰ The Directive also specifies landfill closure and after-care procedures.⁷⁸¹

⁷⁷⁷ Council Directive 1999/31/EC on the Landfill of Waste.

⁷⁷⁸ Ibid, Art. 5(2), paragraphs (a) – (c).

⁷⁷⁹ Ibid, Arts. 4, 5, & 6. The EU Council Decision No 2003/33/EC of 10th December 2002 established criteria and procedures for the acceptance of waste at landfills as directed by Article 16 of the Landfill Directive 1999/31/EC

⁷⁸⁰ Council Directive 1999/31/EC, Arts. 5, 6, & 11, and Paragraph 7 of the Preamble.

⁷⁸¹ Ibid, Art. 13.

6.10.21 Comparison with Lagos Framework

The Landfill Directive complements the Waste Directive because it is consistent with the waste hierarchy's objective of prioritizing waste minimization, and requiring landfilling to be the last resort after all other options have been optimally explored. In the case of Lagos, despite the loose use of 'landfill' within the environmental laws, there are no known functional landfills in operation in Lagos. In view of the pollution that open dumping of waste has caused to groundwater, a more sanitary form of waste disposal is being proffered for Lagos, as discussed in Chapters 3 and 5 even if this entails a phased, progressive transition to a sanitary landfill. Prohibitive construction and maintenance costs would likely require a gradual transition to that ideal status. Whilst transitioning to the sanitary landfills, Lagos may extract from this Directive the safe processes for accepting waste at its waste sites, and bear in mind that in an ideal waste management system, disposal should be the last option after all preventive and re-use options have been explored.

The Directive's classification of landfills into three types is also very useful in the Lagos context because it underlines the importance of segregating different waste types in order that appropriate treatment technologies may be applied to them separately.

The requirement for Member States to progressively reduce the proportion of biodegradable wastes that are sent to landfills from 75%, to 50% and then to 35% over a period of 15 years is also very instructive. It emphasizes the policy that landfilling is the least desirable, and therefore the last option in waste management. It also implicitly encourages maximum recycling and re-use of waste, which are useful lessons for Lagos.

6.10.3 The Packaging and Packaging Waste Directive

Still within the EU's waste management framework, the Packaging and Packaging Waste Directive further complements the Waste Directive.⁷⁸² Its overall goal is to reduce the quantum of waste that is disposed of at all levels. It aims first at minimizing packaging waste that is generated within domestic or commercial processes, recovering packaging waste through recycling and other methods of waste recovery, and then at reducing the quantity of packaging waste that is disposed of. Its scope extends to all packaging placed on the market in the EU, and all packaging waste at all levels (industrial, commercial, and household levels), regardless of the material use. Packaging means all products made of any materials used for the containment, protection, handling, delivery and presentation of goods, from raw materials to processed goods, and from the producer to the consumer.⁷⁸³

It is quite remarkable that the EU found it necessary to dedicate an entire Directive to the management of packaging waste alone. That is probably because packaging waste is a huge study area, and is a testament to the massive scale of diverse manufacturing processes, of waste produced within them, and recognition of their potential value as reusable resources. Whilst it might not be ideal that Lagos should adopt the same approach of devoting an entire law to packaging waste (in order not to further fragment the existing framework), it could draw some useful practices from the provisions and probably include pertinent provisions in the amended waste management law that has been recommended for Lagos.

6.10.4 Summary of Recommendation for Waste Management

Solid waste management in Lagos is still extremely rudimentary, and the fragmented legislative provisions have not improved the situation. Many valuable practices may however be

⁷⁸² The EU Packaging and Packaging Waste Directive No. 94/62/EC.

⁷⁸³ Arts. 1, 2, & 3.

extracted from the European model, in order to enhance the superficial nature of solid waste management framework in Lagos, that would in turn protect groundwater.

The Directive's caution that waste management must not endanger human health or the environment including water recognizes the critical connection between waste and water. It should also place waste managers on alert about proper preventive and precautionary measures to precede the waste management processes. Lagos may adopt this as a policy.

The waste hierarchy places premium on waste prevention and aims at zero waste, and this is expected to contribute to sustainability of development based on achieving environmental preservation concurrently with development. Adopting a waste hierarchy that is similar to that of the European Union would reduce waste that reaches the waste dumps in Lagos, and ultimately of the volume and assortment of waste that has the potential to leach into groundwater. Closely linked to this, the extended producer responsibility that requires manufacturers to be responsible for the entire product life cycle in waste management is an excellent concept. Although mentioned in Lagos' waste Regulation, it requires a lot more than a few words in the law for full understanding and implementation. The life cycle approach makes manufacturers responsible for the entire life-cycle of a product and especially for the take back, recycling and final disposal.

Further, in compliance with the packaging waste directive, a stipulation for manufacturers to reduce the material used in packaging designs would likely reduce the waste that requires disposal. Waste reduction is important for groundwater in Lagos because it means there is less waste that can potentially leach into groundwater (for as long as Lagos operates waste dumps). International policy agreements endorse the life cycle approach to waste management within a global mandate to manage the majority of global waste in an environmentally sound manner, and as a resource, calling for the development of comprehensive

national waste management policies, strategies, and laws.⁷⁸⁴ They also require fundamental changes in the way that societies produce and consume goods, and in particular, changing unsustainable production patterns.⁷⁸⁵ Since a root cause of environmental degradation is unsustainable production processes and consumption patterns described in Chapter 3, it follows that successfully countering this will require inter alia, the involvement of core private sector participants. The private sector (especially manufacturing) has a significant impact on environmental trends on account of its investment and technology decisions. According to the United Nations, “a greater commitment by the private sector should be pursued to engender a new culture of environmental accountability...this approach must be linked to the development of cleaner and more resource efficient technologies for a life-cycle economy and efforts to facilitate the transfer of environmentally sound technologies”.⁷⁸⁶ Therefore controlling and minimizing waste from industry which is a major waste generator potentially secures the environment generally. Adopting a waste management framework that requires corporate responsibility from the world of business would be in tandem with the international policy which supports national regulatory and policy frameworks that enable business and industry to advance sustainable development initiatives.⁷⁸⁷ For Lagos, minimizing industrial waste that is disposed of at dump sites reduces the materials which have a potential to leach into groundwater. However consumer protection is still at its infancy in Lagos, with hardly any serious policies or laws on product returns, and therefore some aspects of extended producer responsibility including product return may not be immediately feasible.

⁷⁸⁴ *The Future We Want*, Arts. 218 & 220.

⁷⁸⁵ United Nations Summit on Sustainable Development, *Transforming Our World*, Art. 28; Agenda 21, Art 21.4; *The Future we Want*, Arts. 58(o) & 61.

⁷⁸⁶ Global Ministerial Environment Forum, Sixth Special Session of the Governing Council of the United Nations Environment Programme (2000) Online: <http://www.unep.org/malmo/malmo2.pdf>.

⁷⁸⁷ *The Future we Want*, Art 46.

More serious efforts need to be made to reduce and re-use overall waste in the city. It is not desirable that the larger proportion of 10,000 metric tons of waste generated daily in Lagos should end up at the waste dumps with the potential to leach into and pollute groundwater. As discussed in Chapter 5, groundwater is principally recharged by rainfall which infiltrates through the land surface into aquifers below; therefore the waste disposal activities at this sensitive subsurface adversely affect the quality of groundwater. As a humid region with substantial rainfall and with large volumes of waste and leachates generated, groundwater in Lagos has a greater tendency toward pollution from subsurface activities because the greater the volume of waste at dumpsites, the greater is the tendency for migration of leachates into groundwater. Minimizing the volume of waste that is dumped at waste sites would thus be in the overall best interest of securing groundwater quality. Were it not for the waste sorting and reselling activities of scavengers at dump sites, the waste management problem would be a much bigger one than the city currently faces. The example of the EU in first preventing and minimizing waste, and then sorting is necessary, and needs to be rigorously pursued in Lagos.

Lagos may also adopt the Waste Directive's stipulation for a network of cooperation which can be employed to harness the work of its scavengers. Finally, Lagos also needs to properly define the important components and principles of a practicable waste hierarchy in order to clarify its scope, and to avoid ambiguity in its amended waste management law. Such terms would include Prevention, Reuse, Recycle, and waste hierarchy.

Collectively, the EU Frameworks for waste management are ideal for a city that aspires towards sustainability. Admittedly, it might be a bit ambitious for a developing city like Lagos to accomplish the level of EU Waste management standard, and the European Community itself

arrived at this comparatively higher level gradually. But it represents standards that Lagos can at least aspire to attain in the medium and longer terms.

Having discussed the frameworks for managing sewage and solid waste, the next section will now review the EU's water frameworks which incorporate groundwater management.

6.11 The European Union Water Framework Directive

In examining the framework for groundwater within the European Union, it is appropriate to start with the EU's Water Framework Directive.⁷⁸⁸ The Directive is the broad or major frame within which groundwater is conjunctively managed with surface water.⁷⁸⁹ It was necessitated by the need for action to prevent long-term deterioration of freshwater quality and quantity. It therefore embodies holistic management that combines natural and social science methods that are consistent with the goal of achieving sustainable development as agreed at international meetings over the years.⁷⁹⁰

The core objective of the Directive is to achieve sustainable management and protection of surface and groundwater, and the management and restoration of aquatic systems to good ecological quality.⁷⁹¹ Following analysis, the Researcher classified the core provisions into the

⁷⁸⁸ Directive 2000/60/EC of the European Parliament and the Council Establishing a Framework for Community Action in the Field of Water Policy. Amended by: Decision 2455/2001/EC; Directive 2008/32/EC; Directive 2008/105/EC; Directive 2009/31/EC, and Directive 2013/64/EU.

⁷⁸⁹ Both the Water and Groundwater Directives are interconnected, as borne out by several references to the Water Framework Directive throughout the Groundwater Directive. See for instance paragraphs 3 & 6 of the Groundwater Framework's Preamble that reiterate the Water Framework's emphasis on the importance of protecting groundwater by preventing pollution in order to reduce the purification needed. Similarly, paragraphs 13, 14, 15, 17, & 22 restate the Water Directive's resolutions on the repeal of Directive 80/68/EEC, on groundwater pollutants, groundwater monitoring, and prior authorization of sewage discharges. Other references continue throughout the Directive on substantive issues of assessment criteria and procedures, identification of pollution trends, and measures to limit pollutants.

⁷⁹⁰ The Earth Summit (1992): D. Hering, A. Borja, J. Carstensen, L. Carvilho, M. Elliott, C. Feld, A. Heiskanen, R. Johnson, J. Moe, D. Pont, A. Solheim, & W. Van Der Bund, "The European Water Framework Directive at the Age of 10; A Critical Review of the Achievements with Recommendations for the Future" (2010) 408 *Science of the Total Environment* 4007.

⁷⁹¹ Water Framework Directive, *supra*, note 788, Art 1.

following sub categories: Quality Safeguards, Monitoring and Restoration, Integrated Management, and Reporting.

6.11.1 Water Quality Safeguards

At the core of this legislation is the aim of achieving quality control of surface and groundwater. The Directive provides that water pollution prevention and control strategies should involve pollution control at source through setting of emission limit values. Very importantly, it recognizes that on account of the time lag in groundwater formation and renewal, it is critical to employ early pre-emptive action, and stable long-term planning of protective measures to safeguard the good status of groundwater. These factors should be taken into account when formulating measures for achieving good status of groundwater, and for reversing significant and sustained upward trends in groundwater pollution. Member States must implement emission controls and emission limits stipulated in a number of enactments, particularly the Urban Wastewater Treatment Directive discussed earlier.⁷⁹²

The Water Directive contains detailed guidelines for the EU Parliament to adopt strategies against water pollution which is caused by either individual or groups of pollutants, and which represent a major risk to the aquatic environment. The analyses should include groundwater characteristics, a review of the impact of human activities on the status of groundwater, and an economic analysis of water use. The analysis of characteristics, using either hydrological or geological data, should determine the location and boundaries of groundwater bodies and the pressures to which the groundwater bodies are susceptible (point/diffuse pollution sources). It should also give information about abstraction and artificial recharge rates, and surface water ecosystems that depend directly on groundwater bodies. The characterization should include geological and hydrogeological characteristics, an inventory of linked surface

⁷⁹² Ibid, Arts. 4 & 10, & Preamble 28.

systems, and details of the chemical compositions. The analysis of human activity impacts on groundwater bodies that are at risk must be identified. Following this analysis, a program of measures which incorporates the analyses must be drawn up with the objective of achieving good groundwater quality status. The European Parliament, after considering these analyses, is to adopt specific measures to prevent and control groundwater pollution with the objective of achieving good groundwater chemical status. These measures will include criteria for assessing good groundwater chemical status, for identifying significant and upward pollution trends, and for defining the starting point for trend reversal.⁷⁹³

The Directive further allows for less stringent environmental objectives for groundwater bodies when they are so affected by human activity, or their natural condition makes the prescribed standard impracticable to achieve. Furthermore, failure to achieve good groundwater status or to prevent deterioration on account of changes in physical characteristics is not a breach of responsibility in cases of unforeseen natural causes or of force majeure.⁷⁹⁴

6.11.2 Water Quality Monitoring and Restoration:

The Directive stipulates that the input of pollutants into groundwater must be limited, with efforts made to prevent the deterioration of the status of all bodies of groundwater. Member States have until 2015 to achieve good groundwater status by protecting, enhancing, and restoring all bodies of groundwater, and by balancing extraction and recharge. They must implement measures to reverse any sustained upward trend in concentration of pollutants that result from human activity, and should combine these with periodical analyses and monitoring

⁷⁹³ Ibid, Arts. 4, 5, 11, 17, and Annex II of the Schedule.

⁷⁹⁴ Ibid, Arts. 4(6) & 4(7).

programs. Programs to monitor chemical and quantitative status of groundwater are to be established.⁷⁹⁵

6.11.3 Integrated Water Resources Management:

The Directive contemplates a unified system of managing waters. It integrates surface and groundwater management through a system of river basins for proper monitoring of both quality and quantity aspects of surface and groundwater. All groundwater is required to be assigned to a river basin as much as possible, and groundwater that does not fully follow a particular river basin should be identified and assigned to the nearest or most appropriate river basin district. Each river basin is to be analyzed for characteristics, impact of human activity on groundwater, and economic analysis of water use.⁷⁹⁶

Implementation of this framework provision has changed the scope of water management from local to basin level, and often resulted in trans-boundary management.⁷⁹⁷ Therefore two or more EU Member States have often taken charge of an individual river basin.⁷⁹⁸

6.11.4 Reporting on the Status of Waters

Reporting provisions require that Member States should submit summaries of the analyses required as well as monitoring programs designed. They are also to send copies of river basin management plans and updates to the Commission within three months of publication.⁷⁹⁹

Analysis:

⁷⁹⁵ Water Framework Directive, Arts. 4(b), 5, & 8.

⁷⁹⁶ Ibid, Arts 3 & 5.

⁷⁹⁷ S. Apitz, M. Elliott, M. Fountain, & T. Galloway, "European Environmental Management: Moving to an Ecosystem Approach" (2006) 2(1) Integrated Environmental Assessment and Management 80.

⁷⁹⁸ For instance out of the ten river basins delineated in Germany (Danube, Rhine, Maas, Ems, Weser, Ode, Elbe, Eider, Warnow-Peene & Schlei-Trave), eight extend across at least one international border, such that only the Weser and Warnow-Peene are confined within Germany: German Federal Ministry for the Environment, Nature Conservation and Nuclear Safety, Water Framework Directive: The Way Toward Healthy Waters, Berlin, Germany (2010) available online.

⁷⁹⁹ Water Framework Directive, Arts. 5, 8 & 15.

The Water Framework Directive provides holistic protection for water, and significantly complies with policy agreements reached at international Conferences about the best options for safeguarding water discussed in Chapter 2. The agreements call for a set of measures to protect water by increasing water quality and reducing water pollution. This includes water resources assessment which entails appraising the sources, extent, dependability, quality, and especially human activities that affect water, as the practical basis for its sustainable management.⁸⁰⁰

The Directive is a very detailed document that was prompted by concerns about the negative effects of strong economic interests which were pitted against the public's interest in having good environmental quality.⁸⁰¹ Thus it deliberately adopted concerted measures to ensure water security including setting water quality standards, implementing discharge controls, and minimizing the effects of anthropogenic pressures on surface water quality. Its core measures to achieve good groundwater status which include preventing pollution, restoring groundwater bodies, and reversing upward trends of pollution from human activity, are in tandem with time-tested environmental principles on prevention, precaution, and polluter pays (remediation).⁸⁰² The Directive's provisions are evidently not theoretical measures, but rather demonstrate seriousness especially in its stipulation for a three-tier analysis of characteristics, and of human activity impacts on groundwater.⁸⁰³ When read together, the Directive's provisions come across as a tightly-knit continuum of measures to safeguard water (and groundwater) from every imaginable pollution source, and falling that, to remediate it. The Directive's innovativeness is apparent in its employment of biological parameters as a benchmark to measure water quality.⁸⁰⁴

⁸⁰⁰ Agenda 21, Arts. 18.23 & 18.35; *The Future We Want*, Art. 124; Sustainable Development Goal No. 6.

⁸⁰¹ Apitz et al, *supra*, note 797.

⁸⁰² *Ibid*, Art. 4(b) & Preamble 11.

⁸⁰³ *Ibid*, Art. 5 and Annex II of the Schedule.

⁸⁰⁴ D. Hering et al, *supra*, note 790, at pg. 4008.

Moss describes it as offering an “unprecedented” opportunity to improve the quality of fresh and marine water systems.⁸⁰⁵

A striking feature of the Directive is the conjunctive management framework for both groundwater and surface water, a desirable state of affairs that experts have been clamoring for in Nigeria for many years.⁸⁰⁶ The two streams of water are after all just one water resource based on the hydrological continuum, as experts have clarified.⁸⁰⁷ This conjunctive management system prevents the “hidden” groundwater resource from being overlooked as has historically been the case with the resource in Nigeria generally and Lagos in particular, until more recent efforts began to draw attention to it. It also ensures that the same care, precaution, and protection are accorded both components of the water resource. Had conjunctive management been practiced from the onset with adequate regulation devolving from the federal to state legislatures, it is probable that the pollution problems confronting groundwater in Lagos would not have occurred.

Another interesting provision is the Water Directive’s allowing for less stringent environmental objectives for groundwater bodies when they are so affected by human activity, or their natural condition makes the standard objective unfeasible. It is a useful note for Lagos where two of its aquifers are polluted, in case remediating them to the ideal standard is unrealistic. It can similarly be applied to other areas that are heavily impacted by human activities. Reducing quality standards should however not become a threat to either the environment or human health.

⁸⁰⁵ B. Moss, “Shallow Lakes, the Water Framework Directive and Life: What Should it all be About? (2007) 584 *Hydrobiologia* 381.

⁸⁰⁶ M.E. Offodile, The Development and Management of Groundwater for Water Supply in Nigeria, Presented at the 2nd Fellows Workshop of the Nigerian Mining and Geosciences Society (NMGS) (2000).

⁸⁰⁷ United States Geological Survey, *Groundwater and Surface Water - A Single Resource* U.S. Geological Survey Circular 1139, Available online; Akujieze et al, “Groundwater in Nigeria - A Millennium Experience- Distribution, Practice, Problems, and Solutions” (2003) 11 *Hydrogeology Journal* 259.

Finally, the Directive requires public information to users of river basin management plans that includes an overview of significant water management issues. Member States are to periodically report on analyses and monitoring programs conducted. The public is to be allowed to participate via comments from them.⁸⁰⁸ The reporting and information requirements create responsibility, accountability, and follow up, and are poised to see that the concerted measures are actually carried out in the interest of water security. They are also consistent with the Rio Principles that recommend participation of all concerned citizens in environmental issues.⁸⁰⁹

Having reviewed the broader water framework, the framework for groundwater specifically will be discussed next.

6.12 The European Union Groundwater Framework

This Directive recognizes groundwater as the largest and most sensitive body of water within the European Union.⁸¹⁰ Its salient provisions are that pollution of groundwater which is intended for drinking should be prevented in order to reduce purification treatment costs, according to the guideline of the Water Framework Directive. It reiterates that groundwater bodies must be protected and conserved by employing specific measures to prevent and control pollution. This includes: providing criteria for assessing good chemical status by establishing threshold values for pollutants and indicators of pollution that take into account the inter-relationship with associated surface waters, ecosystems and wetlands; establishing criteria to

⁸⁰⁸ Water Framework Directive, Arts. 5, 8, 14 & 15.

⁸⁰⁹ Rio Declaration on Environment and Development, (1992) Principle No 10.

⁸¹⁰ The Directive 2006/118/EC of the European Parliament and of the Council on the Protection of Groundwater Against Pollution and deterioration. Amended by Commission Directive 2014/80/EU of June 20th 2014.

identify significant and sustained upward trends, and to define the start points for trend reversals; and measures to prevent or limit inputs of pollutants into groundwater.⁸¹¹

These provisions form the core of the Directive, and are consistent with the provisions of the Water Framework Directive. The Groundwater Directive implements the Water Directive's requirement that Member States should formulate criteria for assessing groundwater's chemical status, and strategies to prevent and control pollution of groundwater.⁸¹² It offers procedures for assessing groundwater chemical status, and details threshold values for groundwater pollutants and indicators of pollution. It also affirms that the assessment for determining the chemical status of a body of groundwater must take into account the information required by the Water Directive.⁸¹³

It is arguable that the Groundwater Directive is superfluous because it reenacts several of the Water Directive's provisions and thus identical provisions appear in both of them. But retention of the Groundwater Directive is justifiable because it allows an exclusive dedication to groundwater protection. As mentioned earlier, this is important because the drafters of a law that is committed to groundwater entirely have the opportunity to address all the incidents of groundwater extraction, maintenance and protection, and thus contribute to safeguarding the important resource.

6.12.1 Comparison of the Water Directives with Lagos Framework

Collectively, both the Water Framework Directive and the Groundwater Directive are very detailed and comprehensive documents that aim at identifying and analyzing all possible sources of pollution to groundwater and averting them.

⁸¹¹ Groundwater Directive, Arts 3-6. It incorporated the Water Framework Directive's Arts. 17 (1 – 2).

⁸¹² Water Framework Directive, Arts. 17(1) & (2); Art. 2.3 of Annex V. Groundwater Directive, Art. 3, and Annex II

⁸¹³ Ibid, Art. 5 & Annex II; Groundwater Directive, Art. 4(2)c & Annex III.

The Water Directive addresses the security of groundwater in as much detail as it does surface water. It is realistic in allowing Member States to have a phased implementation of the program of measures in order to spread the implementation costs to achieve the Directive's objectives, and with possibilities of extending the timescale.⁸¹⁴ Also very realistic is its understanding that human activities sometimes have a very high impact on bodies of water, and that such waters may not be required to have the same high quality as other bodies of water, although measures should be taken to avoid further deterioration. There are also requirements to report to customers on its overall performance, a provision that encourages a measure of accountability.⁸¹⁵

By contrast, the framework for groundwater in Lagos is much less structured or comprehensive. NESREA Regulations and the Water Sector Law make provisions concerning water sources generally. They prohibit the discharge of hazardous or toxic substances, and of any waste type that cannot be purified to satisfactory standards from domestic and commercial/industrial sources, into "any water body..." Generators of solid waste and sewage require sewage discharge permits, whilst industrial operators must dispose of hazardous chemicals safely.⁸¹⁶ Boreholes (wells) are required to be situated in hygienic environments that are free from pollution. Failure to treat hazardous waste to acceptable standards constitutes offences with penalties attached.⁸¹⁷

Groundwater protection under Lagos framework is mostly indirect, because its management framework has had to be inferred, drawn out, and extracted from several laws that regulate solid

⁸¹⁴ Water Framework Directive, Preambles 29 & 30.

⁸¹⁵ Ibid, Arts 14 & 15.

⁸¹⁶ Lagos State Water Sector Law, Ss. 115 & 118. NESREA (Sanitation and Wastes Control) Regulations, Ss. 39-41, 44, 47, & 53.

⁸¹⁷ NESREA (Sanitation and Wastes Control) Regulations, Ss. 80 & 85; NESREA (Surface and Groundwater) Regulations, S. 34(2); Lagos Water Sector Law, Ss. 124 & 125.

waste and wastewater. Besides, the groundwater quality safeguards are mainly restricted to commercial and industrial boreholes, i.e. non-domestic boreholes, with only scant regulation of private wells. Yet domestic wells form the vast majority of the wells and boreholes that are employed in groundwater exploitation in Lagos, as private citizens increasingly search for water; thus they are haphazardly located often without knowledge of hydrogeology, and situated dangerously close to on-site sanitation, hence resulting in groundwater pollution as discussed in Chapter 5.⁸¹⁸ Although private well users are required to comply with standards for septic tank locations, this is not even enforced.

The Water Sector Law focuses rather less on measures to secure the quality and integrity of water, but more on licensing and tariffs for water use, as well as on detailing rights, powers, and functions of the water management departments that it creates, with the result that many functional overlaps have occurred, as described earlier. It is arguable, though, that its comparatively smaller attention to the actual details of water security can probably be excused since it is predominantly an enabling instrument that sets up the water sector operators. The Lagos framework offers peripheral protection for groundwater, with provisions occurring haphazardly and spread out across the various legislations. Even within the Water Sector Law, these provisions are scattered across the four sections of the Law that creates the agencies that manage water within the state. The framework for groundwater is evidently still nascent with much work to do. The inadequacies strengthen the present call for a law that is dedicated to groundwater exclusively.

⁸¹⁸ NESREA (Surface and Groundwater) Regulations, Section 24; Lagos Water Sector Law, S. 115(2).

The EU's Water Framework Directive is not a perfect legal framework, and has been criticized as being unduly complex, unrealistic, and for giving rise to uncertain assessments.⁸¹⁹ But there is overall utility in its provisions that Lagos could extract. For instance, its policy that was prompted by concerns about water quality being sacrificed in favor of economic advancement resonates in the case of Lagos, where the Government similarly drives economic growth at the expense of environmental security with the result that groundwater is now highly polluted by untreated industrial wastewater.

Groundwater legislation in Lagos needs to emulate the EU Framework in its detail, serious mindedness, inter-referencing, connection of the laws, a holistic approach to water management, realism about water pollution and remediation, and in technical knowledge of hydrogeology, toxicology and ecology. It ought also to demonstrate a scientific understanding of the impact of interactions between various streams of water in the water cycle, as well as comprehension of the impact of human activities on water. Lagos can benefit from such in-depth, holistic drafting that demonstrates both the importance of groundwater and the seriousness of the issues facing it, as well as a scientific understanding of the diverse measures that can prevent and redress the myriad of quality issues that may trouble it.

⁸¹⁹ For instance, Hering et al (supra, note 790, at pg. 4008) criticize the ecological parameters used for measuring water quality as presenting a huge problem to ecologists who have to quantify complex and dynamic biological communities into a single numeric score in measuring the degree of change. Apart from that, whereas grouping water bodies together according to physical/morphological attributes is helpful for water managers and the public to understand their differences, the reality is that many disparate environmental parameters influence community compositions. Again, the simple assessment system assumed by the drafters to be applicable across Europe is not realistic because stress elements that affect ecosystems vary between regions, and also the effects of these elements cannot be assessed with the same metrics. Similarly Moss (supra, note 805) suggests that drafters had a simplistic approach to determining ecological quality and thus used parameters that were out-dated, and this prompted him to infer that they had probably combined 21st century environmental idealism with mid-20th Century limnology (pgs. 382-383). In spite of these criticisms however, the same experts acknowledge the immense benefits of the Framework. For instance, implementing it has greatly increased knowledge of the ecology of European surface water especially in regions that had hitherto been unexplored. Besides this, its use of biological parameters has been more holistic than if it had employed the limited chemical quality parameter.

Rather than Lagos merely creating offences and attaching fines for con-compliance with regulations directed at protecting groundwater sources, it is more useful to require offending persons to remediate the damage that they have caused, failing which they could then be liable to fines in addition to correcting the wrongful acts. This would be consistent with the Polluter Pays principle, while punishments would continue to serve as a deterrent to future offenders. On the other hand, limiting environmental enforcement measures to punishment alone does not indicate a proper understanding of the polluter pays principle which the law claims to adopt in its sections.⁸²⁰ In addition to fines, specific remediation and cleanup will have to be stipulated, in compliance with standards for some industries that require remediation where pollution has occurred.⁸²¹

Reversing upward trends of pollution from human activity is a remedial strategy that Lagos may now have to formulate for the industrial regions in which two components of its aquifer horizon have become polluted. The remedial measures should progressively reduce the pollution and return the water to fitness for human use, and thus restore the affected groundwater bodies. This would be consistent with the principle of polluter pays.

Therefore for Lagos, a combination of strategic forward-looking measures to achieve/maintain good groundwater quality status, as well as remedial measures for groundwater that is already polluted, may be extracted from the collective EU Water Frameworks. The preventive measures would be consistent with environmental law principle of prevention, whilst the remedial measures would be in tandem with polluter pays.

⁸²⁰ NESREA (Surface and Groundwater) Regulations, S. 1.

⁸²¹ See for instance National Environmental (Chemical, Pharmaceutical, Soap and Detergent Manufacturing Industries) Regulations (2009), S. 5. It might be argued that fines and punishments alone create a strong incentive to comply with the required standards, but the persistence in activities that pollute groundwater in spite of these provisions denies that claim.

6.13 Directive on the Protection of Groundwater against Pollution Caused by Certain Dangerous Substances

The Directive on the protection of groundwater against pollution by certain dangerous substances is an additional legislation that may be useful for Lagos.⁸²² Although now repealed, it contains pertinent provisions for this research study that are worth mentioning.⁸²³ It was written to address “toxic, persistent and bioaccumulatable substances”.⁸²⁴ It aims at outright prohibition of certain extremely toxic discharges (List I), whilst limiting the discharge of some other substances (List II). All wastewater discharges must be subject to prior authorizations that can only be given after a survey of the receiving environment except in cases of groundwater that is permanently unsuitable for any other use. Prior surveys of the receiving environment must precede the prior authorization before discharge of sewage into groundwater; there is prohibition of certain dangerous chemicals and restriction of others; and prior investigations must include examination of the hydrogeological conditions of the area concerned, and of the possible purifying powers of the soil and subsoil and the risk of pollution and alteration of the quality of the groundwater.⁸²⁵

This Directive provides additional safeguards for groundwater from substances that are too dangerous to permit in the environment, and those that should be properly monitored and

⁸²² Directive 80/68/EEC of 17 December 1979 on the Protection of Groundwater against Pollution Caused by Certain Dangerous Substances.

⁸²³ The Directive is now repealed by the Water Framework Directive 2000/60/EC with effect from December 2013. It has been mentioned earlier that the EU has deemed it necessary to repeal some environmental laws from time to time. These repealed laws are neither inappropriate nor irrelevant, but are cancelled out of a need to streamline, avoid superfluity, and create a coherent body of laws within the Community. Their provisions remain relevant and useful for researchers who seek ideal frameworks for managing vital natural resources. Directive 80/68/EEC is a good example because it contains critical provisions on toxic emissions which this thesis has identified as a major threat to groundwater in Lagos, and offer additional protection to groundwater. Further, the Groundwater Directive recognized the importance of continuing the protection that it offered in spite of its repeal: Paragraph 13 of the Preamble.

⁸²⁴ Ibid, Preamble.

⁸²⁵ Ibid, Arts. 4, 7, 8, & 9.

treated before discharge. The stipulations on substances that must be either limited or totally prohibited are helpful in the context of the varying levels and toxicity of industrial wastewater that is discharged in Lagos. Total prohibition should be prescribed for dangerous chemicals that are too harmful to be released into the environment under any circumstance. The requirements for prior investigation and authorizations of proposed disposals and survey of the hydrogeological conditions of receiving environment complements the Wastewater Directive discussed earlier and is important for Lagos, as it would disclose more sensitive areas underlain by aquifers whose subsoil have limited purification powers, and at which discharges should not take place, or take place only after adequate treatment level has been certifiably carried out. These additional safeguards may be factored into the new groundwater law that is being proposed for Lagos.

6.14 Summary of the EU Directives on Water and Groundwater

The drafting of the EU Directives especially the Water Directives are instructive pieces of legislation in terms of informing Lagos' laws for many reasons. The Directives reflect environmental legal principles as well as the best practices which international Conferences agreed on concerning paths to sustainable development. They carefully detail the policies that explain their provisions and clarify their intentions. The Directives are interconnected, with frequent references to one another. Mutual incorporations and frequent references to one another indicate that the legal drafters are aware and abreast of all subsisting regulations, do not lose sight of any single enactment, and know when legislation becomes repetitive, superfluous, or obsolete. As the environmental legislation has evolved over the years, EU legal drafters have consistently streamlined by repealing laws to avoid superfluity, overlaps, and an unwieldy or confusing network of enactments. Still, the useful provisions in the cancelled laws are not

discarded, but consolidated with existing enactments, as the case of the former and present Water Directives demonstrates. This shows seriousness, attention to detail, and continuity, and is a good legislative model that is worthy of emulation in Lagos where functional and legal overlaps in the city's environmental management structures abound as described in Chapter 5. Finally, a reasonable window of time is usually given to Member States to comply with various provisions, and this allows time to transit or to phase out existing structures that are incompatible with the new directives. The provisions which were identified as useful for Lagos are recommended for inclusion in the new law proposed for groundwater.

6.15 Conclusion

This chapter has reviewed the framework for groundwater management in Lagos by first tracing the evolution of environmental legislation in Nigeria which started out historically as very superficial, and slowly evolved to the present firmer frame. It evaluated the current laws governing groundwater and (due to their intersection), of wastewater and solid waste in Lagos. It identified the shortcomings in them, including fragmentation, pluralism, inadequacy, gaps, vagueness, and as enabling functional overlaps within the governance structures. It also appraised the functional overlaps between governing institutions, and proposed measures to improve the status. The chapter also reviewed the relevant EU legal frameworks, and compared them with provisions within the Lagos framework, drawing out the best practices for possible application in Lagos.

The preceding discussions across all the chapters have covered the three dimensions of the problems confronting groundwater in Lagos, as described in the Statement of the Problem of this thesis: environmental, social, and legal/institutional. The environmental problem reflects as enormous quantities of waste and wastewater; the waste generated is amplified by social factors,

namely, a vast population caused by steady urbanization into Lagos, resulting in an over-populated primate city working hard towards economic prominence, but greatly polluting groundwater through its manufacturing processes; this is complicated by apathy and non-compliance with laws and standards; the population overwhelms water supply and compels people to self-help by over-exploiting groundwater. Finally, legal and institutional failings have not improved the status, and groundwater has suffered in consequence. This thesis has demonstrated that the groundwater pollution problem is due to this complex network of direct and underlying root causes which have been discussed and analyzed throughout this study.

In spite of these complex interconnections and overall dysfunction, it is still necessary to secure groundwater through a governance frame that addresses all the issues. In its generic definition, governance comprises laws and standards, but in the context of a developing city with peculiar socio-economic circumstances such as Lagos, the implications of governance are more involved, and require factoring these different elements into a suitable regulatory and governance framework. It is no wonder that experts remark that the challenge in water management is “governing water wisely”.⁸²⁶ A wise and competent governing framework would have to address the intersection of all these factors. Having discussed and proposed appropriate legal revisions, the concluding chapter will endeavor to put together recommendations that address each of the underlying problems, for inclusion in policy and law.

⁸²⁶ Second World Water Forum, *Ministerial Declaration of the Hague on Water Security in the 21st Century*, available online.

CHAPTER 7: RECOMMENDATIONS FOR ACHIEVING SUSTAINABLE GROUNDWATER MANAGEMENT IN LAGOS

This final chapter aims at providing a set of recommendations to be incorporated into a legal framework for the sustainable management of groundwater in Lagos, and to thereby answer the research questions of this study. In order for a comprehensible presentation of all the issues, the chapter will summarily discuss each segment of the problems that previous chapters have narrated, follow up with probable solutions, and end with recommendations in each section.

Subsequent discussions will be under the following categories:

1. Overcoming Chronic Water Shortage to Reduce Pressures on Groundwater;
2. Alternative Solid Waste and Wastewater Management Options to Protect Groundwater;
3. Balancing Environmental and Economic Policies to Safeguard Groundwater;
4. Tackling Industrial Apathy towards Groundwater Security.

7.1 Overcoming Chronic Water Shortage to Reduce Pressure on Groundwater

Measures to maximize existing water supplies are being formulated as a probable solution to water shortage in a halfway measure to address groundwater pollution; whilst not fully resolving the pollution problem itself, this thesis argues that increasing overall water availability will ease the pressures on groundwater, and thus the pollution problem will become less urgent. This will allow enough time to find and implement remedial measures for the polluted groundwater, even as citizens have adequate and safe supplies from other sources. The discussion will thus examine measures to maximize available water, and to increase the water supply from sources other than groundwater.

As mentioned in earlier chapters, water and sewerage difficulties started during the British colonial rule in Lagos when the administrators did not address the problems of water shortage and poor sanitation. Administrators failed to establish a fully-functional metropolis through investment in the built environment or the construction of integrated technological networks.⁸²⁷ Chapter 5 discussed the limited investment in water and the preferential treatment of the colonial enclaves which meant that a mere 10% of Lagos residents were connected to the municipal water system, resulting into wide disparities in water supply access. Although LWC's coverage is presently 30%, the seeds of this current dysfunction were sowed a long time ago, and continue to manifest in water supply difficulties. In consequence, residents have "perfected self-help survival strategies in the face of the urban water supply crisis", including exploiting groundwater haphazardly.⁸²⁸ Pervasive resort to groundwater has thus given it a special place in Lagos.

The problem of chronic water inadequacy questions the water supply policy that has been adhered to for very long, but which has not been successful in meeting the needs of an ever-expanding population. This suggests that alternatives might be worth exploring and the next section elaborates on these probable alternative options to water supply.

7.1.1 Changing Conventional Approaches to Water Management: Soft versus Hard Approaches

The problem of chronic water inadequacy in Lagos presents an opportunity for a thoughtful reappraisal of the conventional approach to water management in the quest for an enduring solution. It questions the traditional policy that focuses on the supply side of water management

⁸²⁷ A. Aderibigbe, *Expansion of the Lagos Protectorate, 1863-1900*, (Ph.D. Thesis, University of London, 1959) [unpublished]; A.O. Ilesanmi, "Urban Sustainability in the Context of Lagos Mega-city" (2010) 3(10) *Journal of Geography and Regional Planning* 240.

⁸²⁸ M. Gandy, "Planning, Anti-planning and the Infrastructure Crisis Facing Metropolitan Lagos" (2006) 43(2) *Urban Studies* 371, at 378. See also: Olukoju, *Infrastructure Development and Urban Facilities in Lagos, 1861-2000*, Occasional Publication No. 15, Institut Français de Recherche en Afrique, (Ibadan, Nigeria: 2003), at Chapter 3.

where efforts are continuously made to find new water sources in order to increase the overall volume of water. It challenges water managers to think about an alternative approach by paying attention to maximizing available water supply, and optimizing water use, in other words, the demand-side of water management. These alternative policy options will be examined in turn.

A supply-sided water policy represents the traditional approach to water management. Water managers make their best efforts to increase sources of water to meet projected increases in the water demands of their populations. Because the drivers of additional water use (especially population) have usually increased over the years, traditional water planners have invariably assumed that water demand will always rise and eventually surpass water supplies, and that it is therefore necessary to continually find new water sources. Such planners believe that the shortfall will be met by “taming” even more of the hydrologic cycle, and by building more dams and more water storage infrastructure.⁸²⁹

Consequently, enormous water projects and dramatic alterations to the hydrologic cycle through unprecedented constructions of massive engineering projects for flood control, water supply, hydro power, and irrigation” prevailed in the 19th Century. The construction of dams, aqueducts, pipelines, sophisticated water treatment plants and other “large scale manipulations of water” to meet increased water demands characterized the water supply investments of the 19th Century, with undeniable benefits.⁸³⁰ The 20th-century water development paradigm was also

⁸²⁹ P.H. Gleick, “The Changing Water Paradigm: A Look at Twenty-First Century Water Resources Development” (2000) 25(1) *Water International* 127.

⁸³⁰ K. Conca, *Governing Water: Contentious Transnational Politics and Global Institution Building* (Massachusetts: The MIT Press, 2006) at 76. See also P.H. Gleick, “The Changing Water Paradigm” *supra*, note 829. Gleick describes the immense benefits of these large scale water developments which include vastly increased food production, hydroelectric power generation that reduced greenhouse gas emissions, and clean, reliable water supplies in developed countries that ended the water-related diseases that were prevalent in Europe and North America in the 1800s.

characterized by an ethic of growth that was powered by continued expansion of water supply infrastructure.⁸³¹

The limitation of this method of water management, however, is that efforts have to be continually made to find additional sources of water, even when there are none, and to increase water supply at all costs. In view of emerging global water scarcity, this presents a difficulty, particularly as climate change and ever-increasing populations are combining to diminish water sources all over the world. A policy of striving to find more sources of water needs to be reviewed in the face of these new realities. This is really pertinent for Lagos which has for long been constrained to find new sources of water outside the borders of the state, as described in Chapter 3. Since 1915 when the Lagos Water Corporation started a structured system of sourcing for water for mass use, it has consistently sought for additional water sources to increase water supply, and also to increase the generation capacities of its water treatment plants. But in spite of the best efforts of the Water Corporation, it has never met the city's water demand, and it has continued to struggle, and even resorting to seeking for funding from the World Bank to find yet more and costlier sources of water.⁸³²

On the other hand is the demand-sided approach to water management. Gleick recognizes the limitations of the traditional supply-sided approach to water management, and argues for a change from that overly consumptive method of managing water resources. He suggests that policies aimed at providing greater supplies of water should be subjugated to those that focus on economizing and conserving available water. This alternative method prefers to focus on demand rather than supply because the potential for reducing demand is significant and generally easier

⁸³¹ P.H. Gleick, "Water in Crisis: Paths to Sustainable Water Use (1998) 8(3) Ecological Applications 571.

⁸³² Lagos Water Corporation, *Lagos Water Supply Plan 2010-2020* (2012).

to achieve than further increments of supply. He describes the demand approach as the ‘soft path’, in contrast to the ‘hard path’ that represents physical devices to manipulate water in the diverse ways described above. In apparent confirmation of the costliness of the supply approach, the large-scale water developments have imported severe environmental problems over the decades, including the contamination of water sources, dislocation of human populations, and destruction of ecosystems. Finding new sources of water and building new water systems is also very expensive.⁸³³ Therefore for practical, environmental, and economic reasons, the traditional way of managing water truly appears to be failing.

Arguments in support of a soft path to water management as an alternative and more realistic approach are justifiable, as they aim to increase the productivity of available water rather than encourage an unending struggle to increase water sources. Within this alternative method, water is efficiently used and the water saved can be re-allocated amongst other users for more efficient use. Rather than merely delivering water, the approach motivates the provision of water services and quality that are matched with the user’s requirement. Gleick argues further that applying market tools and pricing optimizes the efficient use of water, sees to its equitable distribution, and achieves a long-term sustainable system operation.⁸³⁴ Brooks & Brandes support this soft policy approach in stressing that to achieve a sustainable future for fresh water, institutions and

⁸³³ Gleick underlines the importance of changing this traditional philosophy of new water developments because of their increasing economic and environmental costs. Conca similarly attributes trans-boundary environmental problems to the damming, draining, diverting, and other large-scale manipulations of water: Gleick, *supra*, note 829; P.H. Gleick, “Getting it Right: Misconceptions about the Soft Path”, in: D.B. Brooks, O.M. Brandes and S. Gurman, eds., *Making the Most of the Water We Have: The Soft Path Approach to Water Management* (London: Earthscan 2009) 49-60; Conca, *supra*, note 818.

⁸³⁴ Gleick, *supra*, note 829; P. Gleick, “Global Freshwater Resources: Soft Path Solutions for the 21st Century”, (2003) 302 *Science* 1524.

technologies are needed to collectively work at water efficiency and water conservation in both anthropogenic and ecological terms.⁸³⁵

The soft approach to water management has two components. The first is the drive to increase **water use efficiency** through better equipment that minimizes water loss. As illustration, water losses that are due to poorly maintained distribution pipes can be overcome with appropriate equipment, and water supply will benefit from a policy of stringent and sound expert maintenance. The second component is **reducing the quantum of water actually used** through alternative technology, as for instance, in the United States, toilets were re-configured to low flush systems based on a policy that requires them to use a third of the water they previously used (1.6 gallons per flush).⁸³⁶ The technological innovation reduced toilet water use by 75%. Such innovation may be extended to re-design household appliances such as washing machines, toilets, showerheads, and dishwashers to use water more efficiently. It can also be extended to an assortment of technologies that reduce water use in commercial and industrial settings that collectively add up to the total water savings.⁸³⁷

Overall, the soft path relies on human ingenuity to solve water problems rather than simply increasing the physical resources to generate additional water. It is a management strategy that frees up water by curbing wasteful water use. The benefits in managing water use this way are

⁸³⁵ D.B. Brooks & O.M. Brandes, “Why a Water Soft Path, Why Now and What Then?” (2011) 27(2) *International Journal of Water Resources Development* 315.

⁸³⁶ U.S. Energy Policy Act, (1994) Public Law 102-486. The law became effective in 1994 for residential buildings, and in 1997 for commercial buildings.

⁸³⁷ P.H. Gleick, “Doing More with Less: Improving Water Efficiency Nationwide” (2009) 8(1) *Southwest Hydrology* 20; P. Gleick, “The Changing Water Paradigm, A Look at Twenty-First Century Water Resources Development” (2000) 25(1) *Water International* 127.

apparent: eliminating wasteful uses, reducing water use per person, and reducing overall water use.⁸³⁸

Analysis:

As the population in Lagos continues to expand, and having unsuccessfully explored demand-sided water management for very long, the Lagos Water Corporation will find it worthwhile to explore the alternative soft approach, as it has become apparent that another approach is now required to solve a chronic water problem. LWC's focus on increasing supply has hitherto overlooked opportunities to maximize its existing water, and thereby increase the amount of water that becomes available. Rather than incessantly trying to find new water sources or of increasing supply to meet new demands, a strong case may be made that the Corporation should explore its options in improving efficiency. Moreover, Lagos is situated within Africa, a region in which water supply is shrinking due to a combination of population growth, competing water uses, deteriorating water quality and over-exploitation, and complicated further by the vagaries of climate change that seem determined to reduce water sources even further.⁸³⁹ These facts make an even stronger case for the city to consider alternative water supply practices.

In terms of increasing water use efficiency through better equipment, LWC, as a preliminary measure, needs to eliminate leakages from old and faulty pipes that cause water loss during distribution, and that results in lost or unaccounted-for water, as discussed in Chapter 5. This measure will increase the volume of water available and accessible for residents. Funds required for better equipment are likely to be less than the massive expense of purchasing added

⁸³⁸ D. Brooks. O. Brandes & S. Gurman, eds., *Making the Most of the Water We Have: The Soft Approach to Water Management* (Earthscan Books, London 2009). Brookes adapted his experience from applying the soft approach in the energy sector to water.

⁸³⁹ M. Jacobsen, M. Webster, & K. Vairavamoorthy, *The Future of Water in African Cities: Why Wastewater?* Directions in Development, (Washington, D.C.: the World Bank, 2013).

infrastructure and of finding and processing new sources of water. LWC might also require leakage detection and control systems, and plan for replacement of old pipes with good quality corrosion-resistant materials. In implementing this measure, LWC may draw valuable lessons from the successes recorded in other cities.⁸⁴⁰ A change in water policy that focuses on reducing waste and improving efficiency can also be implemented within its industrial sector where industrialists wastefully and continually take in fresh water rather than treat and re-use their wastewater. Maximizing water efficiency would be consistent with international policies that urge efficient water use by improving technology and eliminating waste.⁸⁴¹

7.1.2 More Unconventional Methods to Increase Water Supply

Apart from increasing the efficiency of water systems and reducing overall water use, it is arguable that the scope of a soft policy can be extended to include various measures that aim at optimizing water to achieve overall water security. This thesis argues that a change in thinking about water supply means not only judiciously managing available water, but also includes optimizing the use of all water available within the water cycle, even where it does not fall strictly within ‘soft’ water parameters. Agreements reached at international Conferences support this thinking by emphasizing that all components of water are valuable and useful, and that all water has inherent value, and thus the components of urban water supply can all be integrated and efficiently used.⁸⁴² The meetings have also urged the development of new and alternative sources of water supply.⁸⁴³

⁸⁴⁰ Lost or unaccounted- for water is not a unique problem to Lagos. For instance, experts estimate that in Mexican cities in the 1990s, urban water loss reached 45%: A.S. Adams & A. N. LutzLey, “An Empirical Study of Factors Affecting Water Loss in Mexican Cities” (2012) 2(3) Journal of Water Sustainability 167, at pg. 169

⁸⁴¹ *The Future We Want*, Arts. 119-121; Dublin Statement, Principle 4; Agenda 21, Art. 6.

⁸⁴² Ibid.

⁸⁴³ *Agenda 21*, Art. 18(12).

Following from this premise, water management methods that include wastewater recycling and re-use, storm water and rainwater harvesting, and desalination of seawater are some options for managing available water that, if adopted and properly implemented in Lagos, will probably have a very beneficial outcome. The methods will contribute to guaranteeing a sufficient supply of water and most importantly, reduce civic pressures on groundwater. Specifically, by reducing demand for continuing access to increased supplies of groundwater, these initiatives offer significant progress towards sustainability in the following ways: fewer random boreholes exposing groundwater to contamination; more time to study and understand the hydrogeology of the respective aquifers and to develop guidelines for groundwater exploitation; a greater allowance of time for legislators to draw up a practicable framework for groundwater use; and more time for restoration/ rehabilitation of contaminated groundwater and abandoned wells.

The various options are discussed further below.

7.1.2.1 Wastewater Recycling and Re-use

Water scarcity and teeming population pressures have spurred communities and nations around the world to find additional ways to maximize the utility of existing water, and in particular, to re-use wastewater. In Europe, water stress in terms of scarcity and quality deterioration since the 1980s compelled thinking about the diverse ways in which water may be re-used, thus prompting a greater acceptance of water re-use practices. In 1991, the EU Urban Wastewater Treatment Directive discussed in the previous chapter incorporated a recommendation for the reuse of treated wastewater “whenever appropriate”.⁸⁴⁴ Thereafter, from

⁸⁴⁴ Council Directive Concerning Urban Wastewater Treatment No. 91/271/EEC, Art. 12.

a few instances in the early 1990s, treatment and re-use of wastewater across Europe has grown into major water re-use projects since the early 2000s.⁸⁴⁵

Individual cities are also exerting efforts to maximize water utility. When Windhoek city in Namibia exhausted its potable water sources while continuing to experience population expansion, it started to reclaim wastewater from two sources that ultimately accounts for 36% of its water supply. The water reclaimed is used both for drinking and for the irrigation of parks, golf courses, and cemeteries. Windhoek is reportedly one of the few world systems that recycle treated wastewater for drinking.⁸⁴⁶ The city's approach to wastewater reuse is consistent with the Dublin Principles which encourage a close-looped water management method in which resources in wastewater are collectible for beneficial use.⁸⁴⁷ As Bixio et al aptly remark, the reuse of wastewater is now “an essential and reliable water supply option” for many municipalities.⁸⁴⁸ The many wastewater re-use options are discussed in more detail later in this chapter within the section on alternative wastewater management options.

Analysis: As discussed in Chapter 5, Lagos generates 350 million gallons of wastewater daily. This is a vast amount that can be put to good re-use, and for this reason wastewater treatment and reuse in Lagos is highly recommended. The United Nations predicts that in

⁸⁴⁵ Reclaimed water is applied to different uses between the two European regions: in southern Europe, reclaimed wastewater is reused predominantly for agricultural irrigation (44% of the projects) and for urban or environmental applications (37% of projects). In northern Europe, the uses are mainly for urban or environmental applications (51% of projects) or industrial (33% of projects).

⁸⁴⁶ J. Lahnsteiner, G. Lempert, I.S. Kim, J. Cho, and S. Kim, “Water Management in Windhoek, Namibia” (2007) 55 (1-2) *Water Science and Technology* 441; Van Der Merwe “Integrated Water Resources Management in Windhoek Namibia (2000) 18(1) *Water Supply: The Review Journal of the International Water Supply Association* 376.

⁸⁴⁷ *Dublin Statement on Water and Sustainable Development*, supra, note 841.

⁸⁴⁸ D. Bixio, C. Theoye, J. de Koning, D. Joksimovic, D. Savic. T. Wintgens, and T. Melin, “Wastewater Reuse in Europe” (2006) 187 *Desalination* 89.

African cities like Lagos, wastewater will soon represent the main water source of the future.⁸⁴⁹ Lagos does not presently have a systematic wastewater treatment and re-use program, in spite of the huge quantity of sewage that it generates every day.⁸⁵⁰ This large volume of water provides a very viable water resource base and a potentially large source of ‘free’ water that is suitable for re-use once treated, particularly if the water-fit idea (treating water to specific intended use) discussed a little later in this chapter, is applied. Therefore, incorporating the treatment and reuse of wastewater from these sources must somehow become a main part of water policy.

7.1.2.2 Storm Water and Rain Water Harvesting

Apart from wastewater, storm water is another good source of water supply. It is that part of runoff that is generated by human activities when land developments alter the natural water balance.⁸⁵¹ Storm water runoff volume increases in proportion to hard, non-absorbent surfaces in developed areas like Lagos because these cannot absorb water. Roofs and paving areas create more runoff than areas of absorbent soils and forest cover. When vegetation and soils are replaced with roads and buildings, less rainfall infiltrates into the ground, less gets taken up by vegetation and more becomes surface runoff.⁸⁵² Poorly managed storm water resulting from land use changes can cause flooding, which is a sad waste of water that can otherwise be put to good use.

⁸⁴⁹ M. Jacobsen et al, *The Future of Water in African Cities: Why Wastewater*, supra, note 827. D. Bixio et al also recommend that maximizing wastewater will require clear institutional arrangements, dedicated economic instruments, water re-use guidelines, and technological innovation.

⁸⁵⁰ But as mentioned in Chapter 5, there are now a few decentralized sewage treatment plants in four areas within the metropolis, with a plan to install eight additional ones, although this latter fact could not be confirmed at the time of writing this thesis.

⁸⁵¹ J.M. Alcamo, C.J. Vorosmarty, R.J. Naiman, D.P. Lettenmaier, & C. Pahl-Wostl, “A Grand Challenge for Freshwater Research: Understanding the Global Water System (2008) 3(1) Environmental Research Letters 010202; P.H. Gleick, “Doing More with Less: Improving Water Efficiency Nationwide” (2009) 8(1) Southwest Hydrology 20.

⁸⁵² K.A. Stephens, P. Graham, & D. Reid, *Stormwater Planning: A Guidebook for British Columbia (British Columbia, Ministry of Water, Land, and Air Protection, Victoria B.C. 2002).*

Analysis: Lagos has an annual average rainfall of 1657mm (65 inches).⁸⁵³ With such a high volume of rainfall in a built-up city, Lagos perennially suffers from severe flooding during the rainy season on account of faulty drainage. Rather than allow such a large volume of water to waste, the city can explore storm water collection on a very large scale as a viable and substantial source of good quality, “free” water for its teeming citizens. Although the city will need to learn the technical processes of incorporating storm water management as a water supply source, it may extract useful lessons from other cities that have institutionalized storm water collection and are seeking ways to improve on technologies to maximize yields from storm water.⁸⁵⁴

7.1.2.3 Desalination of Seawater

Another potential source of water for Lagos is desalinated sea water.⁸⁵⁵ It is a time-tested solution that water-stressed countries with limited water supply options have historically resorted to. Whereas water conservation methods described earlier are excellent measures to improve existing water supplies, they only serve to augment existing water systems, and do not create new water supply sources. Desalinated saltwater on the other hand provides a virtually ‘new’, yet pre-existing source of water that is normally unavailable to mankind. Experts concur that it is one of the few options for increasing water supply beyond what is normally available for use from the hydrological cycle.⁸⁵⁶ The process has not always been popular, however, because of its

⁸⁵³ Lagos State Ministry of the Environment, *State of the Environment Report- Lagos* (2010), at pg. 24.

⁸⁵⁴ Canada is a good system to learn from. With rapid urban expansion, climatic variability, increased traffic, ageing infrastructure and a need to enhance urban water supplies, the country’s conventional storm water management systems are stressed, and are compelling new and more sustainable methods. Regional conferences to review new approaches have been held in succession: J. Marsalek & H. Schreier “Innovation in Storm Water Management in Canada: The Way Forward” Water Quality Research Journal of Canada (available online).

⁸⁵⁵ Desalination is not strictly one of the methods included within a soft water management approach, but it is supported by international agreements mentioned above which recommend harnessing and optimizing available water sources, including non-conventional sources.

⁸⁵⁶ R. Engelman & P. LeRoy, “Sustaining Water: Population and the Future of Renewable Water Supplies” (Population Action International, Washington D.C. US: 1993).

costliness. The *Economist* observes that because the desalination process requires large amounts of energy and also costs much more than treating surface or groundwater, its use was previously confined to the oil rich nations of the Middle East (Saudi Arabia, Kuwait and Bahrain), who opted for this method because of their severe water shortages. But times have now changed with global stresses to water occurring from a combination of climate change, growing populations, droughts, and increasing industrial demands. Desalination of oceans is now becoming more acceptable as a process that provides an apparently inexhaustible water supply, and desalination plants presently exist around the world.⁸⁵⁷

Seawater desalination is a significant source of water because seawater accounts for 97% of all the water on earth.⁸⁵⁸ Therefore developing the capacity to use even a fraction of seawater will have a huge impact on water supplies. The desalination process releases water that would otherwise not be available for use, and appears to offer a “seemingly unlimited” supply of water.⁸⁵⁹ It involves transporting water to desalination plants, pre-treatment of the water intake, and disposal of the effluent “brine”. Elimelech & Philip report a rapid increase in the installation of seawater desalination facilities in the past decades as a method of augmenting water supplies in water-stressed countries. As of 2008, there were 13,080 desalination plants around the world, and it has been projected that by 2016 global water production by desalination would exceed 38

⁸⁵⁷ The Economist, “Tapping the Oceans” (2008), Online: <http://www.economist.com/node/11484059>. The Economist cites former President John Kennedy’s comment that if fresh water can cheaply and competitively be extracted from salt water, it will be ...”in the long range interest of humanity and would really dwarf any other scientific accomplishment”.

⁸⁵⁸ P. Gleick, “Making Every Drop Count” (2001) 284(2) *Scientific American* 28. See also Peter Gleick & Meena Panaliappan, “Peak Water Limits to Freshwater Withdrawal and Use” (2010) 107(25) *PNAS* 11155.

⁸⁵⁹ M.E. Elimelech & W.A. Philip, “The Future of Seawater Desalination: Energy, Technology and the Environment” (2011) 333 *Science* 712.

billion cubic meters yearly, which would amount to double the quantum produced from the same process in 2008.⁸⁶⁰

The thermal method of desalination was historically employed by gulf countries during earlier efforts to appropriate the water resource. That method is heat-based, employing a process in which seawater is heated, evaporated, and condensed to produce freshwater. Due to the high level of energy (from either petroleum oil or electricity) that is required to boil and extract salt from the water, experts describe it as capital and energy intensive.⁸⁶¹ Apart from the high energy consumption, it also results in emissions of a large amount of greenhouse gases. And although half of the processed saline water produces freshwater, the residue of concentrated saline water and pre-treatment chemicals are returned into the ocean/sea. This concentration of chemicals is potentially harmful to marine organisms, and has prompted a scholar to recommend that desalination should be a last resort in favor of water conservation, re-use, and water transfers from other regions.⁸⁶²

The alternative method that some countries such as Spain and Israel have employed is known as *seawater reverse osmosis*, a method in which seawater is pressurized against a semi-permeable membrane that allows water to pass through but retains the salt.⁸⁶³ According to Fritzmann et al, reverse osmosis has gained a wider acceptance in Europe because of its comparatively lower energy consumption.⁸⁶⁴ Desalination of seawater has steadily increased in Spain, particularly in the Mediterranean because the pressures of irregular river flows, excessive

⁸⁶⁰ Ibid; see also the Economist, *supra*, note 857.

⁸⁶¹ M. Shannon, P. Bohn, M. Elimelech, J.G. Georgiadis, B.J. Marinas, & A.M. Mayes, "Science and Technology for Water Purification in the Coming Decades (2008) 452 Nature 301.

⁸⁶² M. Elimelech, Department of Chemical Engineering, Yale University; Interview by T. Miller "Can Seawater Solve our Water Woes?" Online: <http://www.pbs.org/newshour/rundown/can-seawater-solve-our-water-woes/> (2011).

⁸⁶³ Reverse osmosis is a separation process that uses pressure to force a solution through a membrane that retains the solute on one side and allows the pure solvent to pass to the other side. <http://idahowatersolutions.com>

⁸⁶⁴ C. Fritzmann, J. Lowenberg, T. Wintgens, & T. Melin "State of the Art Reverse Osmosis Desalination" (2007) 216 Desalination 1.

groundwater exploitation, and groundwater pollution from agricultural activities necessitates alternative water sources to meet the water demands of the tourist populations and of irrigated agriculture. Spain currently has 950 desalination plants, and is reportedly the country with the 4th largest desalination capacity in the world.⁸⁶⁵ The Economist also cites Perth in Australia as deriving nearly 17 percent of the area's drinking water from desalinated sea water that comes from a reverse osmosis plant.⁸⁶⁶

But although desalination releases ocean water that would otherwise be unavailable for human consumption, extracting salt from seawater is expensive and also polluting to the environment as the process uses non-renewable fossil fuels. Shannon et al rightly observe that addressing the worsening problem of water quality and inadequate potable water requires a tremendous amount of research to be conducted to identify robust new methods of purifying water at lower cost, using less energy, and with a minimal use of chemicals.⁸⁶⁷ Happily, with advancing technology however, the cost and energy consumption of desalination is being reduced. Thus in Perth, Australia, the desalination plant now runs on renewable energy from a wind farm located close by. The city also minimizes the impact of seawater-intake and waste-discharge systems on local marine life, a system that has “set a benchmark for other plants in Australia.”⁸⁶⁸

⁸⁶⁵ P. Palomar & I.J. Losada, “Desalination in Spain: Recent Developments and Recommendations” (2010) 255 *Desalination* 97. The first plants were built in the 1960s on the Canary Islands that bordered the Atlantic Ocean, and where desalination was the only “reasonable” option for water supply to the population. The first plant started production in 1964, and desalination grew from then until the present time.

⁸⁶⁶ The Economist, *supra*, note 857.

⁸⁶⁷ M. Shannon, P. Bohn, M. Elimelech, J.G. Georgiadis, B.J. Marinas, & A.M. Mayes, “Science and Technology for Water Purification in the Coming Decades (2008) 452 *Nature* 301; Y. Zhou, & R.S.J. Tol, “Evaluating the Costs of Desalination and Water Transport” (2005) 41 *Water Resources* 1; S. Veerapaneni, B. Long, S. Freeman, & R. Bond, “Reducing Energy Consumption for Seawater Desalination” (2007) 99 *J. Am. Water Works Assoc.* 95.

⁸⁶⁸ The Economist, *supra*, note 845. The Magazine cites comments made by Jason Antenucci, deputy director of the Centre for Water Research at the University of Western Australia in Perth.

Analysis:

Desalination is an attractive and a potentially viable option for Lagos, which, being a coastal city, has easy access to the adjoining Atlantic Ocean with its boundless salt water supply. However, the high energy input in thermal desalination makes it a problem for Lagos as a city within a developing country whose erratic power supply will frequently hinder the intricate processes involved.⁸⁶⁹ Since electricity supply in the city is sporadic at best, the thermal option with its high level of energy dependence may be unrealistic.⁸⁷⁰ Reverse osmosis would probably be a more realistic option that would be worth exploring. Desalination is attractive for Lagos because it will eliminate the dual problems of water scarcity as well as reduce pressures on groundwater.⁸⁷¹ This thesis acknowledges that either method of desalination remains a costly venture for a city in a developing country that grapples with many infrastructural problems, but believes that with access to adequate finance it could be a realistic option for the future.

7.1.3 Section Recommendation

This section has explored many options to boost water supply in Lagos, and to achieve water security through a diversity of sources. The options are consistent with agreements reached at international Conferences which encourage the adoption of measures including both conventional and non-conventional water resources to combat water scarcity and to address the

⁸⁶⁹ Frequent power outages interrupts water pumping and contributes to the systemic difficulties that LWC encounters in water supply, according to the Director of Hydrogeology in personal discussions during the field research trip, as discussed in Chapter 5.

⁸⁷⁰ Thermal desalination could be undertaken privately in small communities that have access to saline lakes and aquifers, as Shannon et al suggest.

⁸⁷¹ Interestingly, the Lagos Water Corporation has a medium-term plan to begin exploring desalination of its saline waters, and to supply water from them by 2019: Lagos Water Corporation, *Lagos Water Supply Plan 2010-2020* (2012).

balance between water supply and demand.⁸⁷² It is now necessary for Lagos to adopt a new policy approach to water management, in view of its chronic water problems. This approach will focus on optimizing available water sources, and on efficiently using the water that is available for distribution. Lagos should devise better technology that eliminates water losses that occur during transportation of water for distribution. Further, Lagos should endeavor to optimize water supplies by adopting a form of comprehensive water management that involves all the major components of the urban water cycle discussed here. It should explore storm water and rainwater harvesting, desalination of saline water sources (using the reverse osmosis method), and wastewater recycling and re-use. Industrialists should also be re-orientated to discontinue their wasteful water practices and urged to start treating and re-using their wastewater. The new approach should significantly reduce pressure on the Lagos Water Corporation to find more water sources.⁸⁷³ It is expected that this collection of measures will provide enough water for use in the metropolis, and reduce pressures on, and pollution of groundwater, thereby increasing prospects for its sustainability. This new soft policy approach to water management, and the

⁸⁷²The Dublin Statement, supra, note 829; United Nations Conference on Sustainable Development, *The Future We Want*, Art. 123.

⁸⁷³ In case a proposed change in water policy encounters resistance from water users, it would be important for water managers to anticipate the likely points of resistance that might operate as barriers to change. Attachment to previous attitudes can be difficult to change because, according to experts, change necessitates significant psychological reform by the person or group that hold them, and because of the unfamiliarity of the new ideas. In Canada for instance, pre-conceived ideas about water abundance amongst others, has been difficult to change. S. Jordaan, C. Stevens, & D. Brooks, "Removing Institutional Barriers to Water Soft Paths: Challenges and Opportunities", in D. Brooks, O. Brandes & S. Gurman, eds., *Making the Most of the Water We Have: The Soft Path Approach to Water Management* (Earthscan, London, U.K., 2009) 147. For Lagos, water managers themselves might insist that population will always outweigh water supply in spite of best efforts, and that therefore new water sources must continually be sought for. Also, industrialists already present a problem of resistance to wastewater reuse. Thus, Jordaan et al suggest that new education and regular evaluation and feedback could be helpful to tackle these.

specific components of the urban water cycle to be exploited should be incorporated into the water sector policy and law.⁸⁷⁴

Having discussed the options for optimizing existing water supplies in Lagos, the next section examines ways to protect groundwater from solid waste and wastewater by finding other methods to safely dispose of them as the worrisome, direct source of groundwater pollution in Lagos.

7.2 Alternative Solid Waste and Wastewater Management Options to Protect Groundwater

As discussed throughout this thesis, the large population in Lagos overburdens water supplies, and has also drastically increased the amount of solid waste and wastewater generated to 10,000 metric tons and 350 million gallons respectively.⁸⁷⁵ Chapter 5 clarified that solid waste and wastewater are the direct sources of groundwater pollution, and that their improper disposal threatens the sustainability of groundwater. Although from separate streams and sources they are the most critical problem confronting groundwater. The legal review in Chapter 6 found that the legal framework authorizes open dumping of waste which is demonstrably harmful to groundwater. Having identified that the current waste disposal methods and practices are damaging to groundwater, this section examines the options to handling both waste types within the socio-economic context of Lagos.

⁸⁷⁴ Scholars have argued that African cities are particularly suitable for integrated water resources management because, owing to their evolving infrastructure, these can be designed from the start using integrated management principles: M. Jacobsen et al, *The Future of Water in African Cities: Why Wastewater*, supra, note 849.

⁸⁷⁵ LAWMA Report (2013), supra, note 380; Lagos Wastewater Management Office, *Five-Year Strategic Investment Plan for Sewage* (2011-2015).

7.2.1 Solid Waste Management

7.2.1.1 The Engineered Waste Dump

Chapter 5 reviewed many research studies which demonstrate that the improper or inadequate disposal of solid waste results into harmful leachate that percolates into, and pollutes the surrounding groundwater. Empirical findings in Lagos confirm that leachate from waste deposited at the major waste dump, *Olushosun*, have migrated into the surrounding groundwater and made it unfit for human consumption, while other sites indicate that pollution may be imminent. The chapter also discussed the likely adverse effects on human health of these chemical and microbial elements in groundwater. Therefore it is now important that the open dumps method of disposing of solid waste should be either modified or replaced with a safer method in the interest of preserving the integrity of the groundwater, and of safeguarding health in Lagos.

Sanitary landfills are evidently the time-tested and safe method of solid waste disposal where waste is isolated from the environment until safe. Solid waste is disposed in thin layers, compacted by heavy machinery, and then covered with a layer of soil to prevent access to rodents and pests, and to minimize odors. The landfill site is sealed with impermeable bottom liners, and a layer of clay or synthetic liners which collect leachates and prevent them from infiltrating into groundwater. Leachate collection is a basic requirement of landfills because it ensures that groundwater is safe from contamination.⁸⁷⁶

However, as discussed in Chapter 5, although the proposal for a sanitary landfill is an evident and desirable one, such system is costly and amounts to a drastic transition for Lagos, a megacity within a developing country that is already over-burdened with the astronomical costs of

⁸⁷⁶ United States Environmental Protection Agency, *Landfills*, Online: <http://www.epa.gov/solidwaste/nonhaz/municipal/landfill.htm>.

providing infrastructure for its massive population. To cushion the high cost for Lagos, a gradual transition from open dumps to a safer form of waste disposal can be put in place as part of a phased plan until the full-scale sanitary landfill can be achieved. This mid-course could be in form of an engineered dump, as Joseph et al proffer, where there is waste compaction, and some measure of leachate containment and control.⁸⁷⁷ Leachate containment is an urgent requirement for Lagos because of groundwater pollution that is already occurring.⁸⁷⁸

Joseph et al's suggestion on a pathway for transiting from open dumps to sustainable sanitary which is outlined below will be useful for Lagos:

- i. Waste to be deposited in thin layers of 50cm and compacted;
- ii. Surfaces of newly deposited waste to be covered at the end of each day with 15cm of soil or similar material;
- iii. Installation of landfill gas collection and rainwater diversion systems;
- iv. Access roads to be in good condition to allow quick disposal of wastes at designated places;
- v. Conduct of environmental monitoring either by simple visual inspection or complex chemical analysis;
- vi. Proper site management by competent staff.

⁸⁷⁷ K. Joseph, R. Nagendran & K. Palanivelu, "Open Dumps to Sustainable Landfills" Online: <http://www.swlf.ait.ac.th/UpdData/National/ODSL1.pdf> accessed on March 12th 2014.

⁸⁷⁸ In other studies, experts recommend the development of a leachate-monitoring program that includes routine measurement of the likely chemicals known or suspected to be present at the dumpsites. Leachate management can be in form of containment (treatment on site) or attenuation (leachate degradation, dilution and dispersion). Containment minimizes the production of leachate by restricting rainwater access to waste, thus preventing its migration from the landfill. Attenuation allows leachate to migrate outwards from the landfill and takes advantage of the natural subsurface process of biodegradation and filtration to attenuate the contaminants in the leachate. It is based on the 'dilute and disperse' principle of leachate management: R.K. Rowe, "Design Options for Hydraulic Control of Leachate Diffusion", in T.H. Chistensen, R. Cossu & R. Stegmann, eds., *Landfilling on Waste: Barriers* (F.N. Spon, London 1994) 101; D.A. Gray, J.D. Mather, & I.B. Harrison, "Review of Groundwater Pollution from Waste Disposal Sites in England and Wales with Provisional Guidelines for Future Site Selection" (1974) 7 Quart. J. Eng. Geol., 181.

When standard landfilling is eventually in place, serious and concerted monitoring will be essential for early apprehension of leachate contamination. Therefore it is recommended that to safely manage its solid waste henceforth, Lagos should urgently explore a feasible alternative to open dumping of waste by electing the engineered waste dump as a mid-course while planning for the full-fledged sanitary landfill. Although it is conceded that the standardized sanitary landfill is costly to establish and maintain, nevertheless, it is in the interest of human health and Lagos' economic development to invest in more sanitary urban waste management in order to secure both its water resources, as well as its position as the economic giant in Nigeria. This would be consistent with principles about sustainable water management which urge protection of water resources from pollution and degradation.⁸⁷⁹ As a longer-term plan, and as mentioned in Chapter 5, such investment will ultimately be beneficial in terms of reducing healthcare costs, reducing mortality, extending lifespans, and reducing the overall strain on the economy. Recent policy agreements reached at international forums strongly suggest that in the years to come, there will be considerably less support for, or tolerance of open waste dumping, owing to its significant threat to water resources amongst other environmental ills.⁸⁸⁰

However, the disposal of waste at dump sites presumes that such waste cannot be put to any other use, hence the requirement for disposal. It is well known that since gaining a mastery of the waste cycle after the health crises of the 19th Century, environmental management in mature systems have focused on policies that aim at re-using waste as much as possible, and at minimizing waste generated such that only waste that is absolutely useless ends up at landfills. For example, the European Union's framework for waste management (discussed in the previous chapter), aims at the safest and most beneficial uses of waste, employing a waste hierarchy that

⁸⁷⁹ Agenda 21, Art. 18.59.

⁸⁸⁰ Sustainable Development Goals, Art 6.3; United Nations Climate Change Conference, *Paris Decision*, Preamble.

focuses on minimizing and re-using waste. Beyond that, a policy of zero waste in which all waste is re-used is the current standard being rigorously promoted in more developed nations.⁸⁸¹ The recent Climate Change Summit laid emphasis on promoting access to sustainable energy especially in developing African countries.⁸⁸² As biomass is a good source of renewable energy, it will be important for Lagos to begin reviewing methods for harnessing the vast quantities of solid waste that presently go to its dumps for renewable energy. It may find precedence and encouragement in nations which, by adopting the policy of maximizing the utility of waste, have recorded phenomenal accomplishments in energy production. For instance, through its waste-to-energy policy, Sweden gets between 10-15% of its municipal district heating from waste incineration.⁸⁸³ The employment of a proper hierarchy for solid waste treatment measures is also consistent with the United Nations' agreement at the Rio + 20 Conference that strongly recommends the sustainable management of waste.⁸⁸⁴

Lagos has not yet advanced to the level of waste minimization and reuse, although it has some pilot schemes in place to test its evolving waste management proposals under the description 'waste to wealth' which were discussed in Chapter 5. Examples include the Ikosi Fruit Market, which has an organic waste composting project which converts waste fruit into energy to run turbines. A plastics-recycling program is in place at *Olushosun* dumpsite in which plastic water sachets and bottles are bought from the public, are recycled and converted into black bin liners. The program encourages residents to sort, collect and bring used plastics in

⁸⁸¹ El Hagggar advocates zero pollution by means of the 7Rs – Reduce, Reuse, Recycle, Recover, Rethinking, Renovation, and Regulation: S. El-Hagggar, *Sustainable Industrial Design and Waste Management: Cradle-to-Grave*, (London, U.K.: Elsevier Academic Press, 2007) at pg. 13. The new approach was first developed at the American University as the 6Rs approach, and excluded 'Regulation'. Hagggar's latest model includes 'Regulation', without which nothing can be legally done.

⁸⁸² United Nations Climate Change Conference, *Paris Decision*, Preamble (available online).

⁸⁸³ G. Finnveden, M. Reich, O. Eriksson, & A. Sorbom, "Flexible and Robust Strategies for Waste Management in Sweden" (2007) 27 *Waste Management* 1.

⁸⁸⁴ *The Future We Want*, Art. 135.

return for compensation. There is some compacting and compression of waste (without lining covers) at *Olushosun*.⁸⁸⁵ Some waste is also processed into fertilizers at Odogunyan in Ikorodu, although it is not clear if such waste is properly tested for suitability as manure/fertilizer.⁸⁸⁶ There is also a measure of waste sorting carried on unofficially and facilitated by scavengers who work daily at the dumpsite.

But besides these nascent, evolving schemes, not much else appears to have been done to recover useful materials from waste. Therefore waste management in Lagos in general may rightly be described as still being at a basic, rudimentary level. It is time for the city to begin more serious waste management efforts that aim at minimizing waste that is generated, and at re-using waste as much as possible. Lagos should also begin a structured system to recover as much as possible from waste before the residue is taken for disposal because this will minimize waste that has a potential to leach into groundwater. These measures would align with Agenda 21 which stresses that waste management should be founded on a hierarchy of objectives that focus on minimizing waste, adopting environmentally sound waste reuse and recycling and promoting environmentally sound waste disposal and treatment.⁸⁸⁷

7.2.1.2 Optimizing Benefits of Scavenging Activities

An important social phenomenon associated with waste management in Lagos that ought to be properly harnessed is scavenging. Scavenging is an unsolicited social service by

⁸⁸⁵ Personal Discussions with LAWMA representative during a tour of *Olushosun* dumpsite on January 18th 2013.

⁸⁸⁶ Personal Discussions with LAWMA Recycling Manager on December 8th, 2012. Scholars have recommended that before the compost from waste dumpsites is used as manure, it should be properly tested for heavy metals, after which if suitable, the waste should ideally be used only for non-edible crops: S. Esakku, K. Palanivelu, & K. Joseph, “Assessment of Heavy Metals in a Municipal Solid Waste Dumpsite” Workshop on Sustainable Landfill Management, 3-5 December 2003 in Chennai, India.

⁸⁸⁷ Agenda 21, Art. 21.5.

impoverished waste pickers that provides beneficial waste sorting services at dumpsites.⁸⁸⁸

Waste scavengers are part of the informal sector in solid waste management, with other participants being itinerant buyers of discarded products.⁸⁸⁹ In spite of their apparent nuisance value and low social status, scavengers play an important economic and environmental role. They encourage waste sorting, and their efforts reduce the overall volume of waste that remains at the dumpsites. They in fact supply secondary materials to some companies, all at relatively low cost. Authors have rightly argued that scavengers in the informal sector are effectively subsidizing the formal sector, by significantly reducing the amount of waste that the formal service providers are managing.⁸⁹⁰ In effect, they contribute to preserving natural resources by diverting waste from dumpsites back to material cycle. It has also been argued that promoting materials recovery will not only benefit waste scavengers at dumpsites and the informal recycling sector as a whole, but contribute to better solid waste management.⁸⁹¹ Asim et al describe scavengers' activities as positive both economically and environmentally.⁸⁹²

As a partial solution to the waste management problem in Lagos, the government should explore methods of enhancing the value of scavengers' activities by organizing them, and providing them with incentives to sort and dispose of all waste that arrives at disposal sites. Scavengers' sorting activities will effectively reduce the amount of waste that produces leachates that are harmful to groundwater at dumps sites. There is an opportunity to build on the existing recycling networks and increase the current recycling rates in a cost-effective way through co-

⁸⁸⁸ R. Moreno-Sanchez, J. Maldonado, & I. Sheldon, "The Role of Scavengers in a Dynamic Model of Solid Waste Disposal and Recycling in Developing Countries" Presented at First Latin American and Caribbean Congress on Environmental and Resource Economics, Colombia (2003), available online

⁸⁸⁹ L. Rodic-Wiersma, D.C. Wilson & D. Greedy "Waste Scavenging at Dumpsites in Economically Developing Countries" (available online).

⁸⁹⁰ Ibid.

⁸⁹¹ Ibid.

⁸⁹² M. Asim, as. Batool, & M. Chaudhry, "Scavengers and their Role in the Recycling of Waste in Southwestern Lahore" (2012) 58 Resources, Conservation and Recycling 152.

operation with the scavengers. If treated as a valuable business partner, waste scavengers can significantly increase their contribution to the protection of the urban environment and sustainable management of groundwater in Lagos.

7.2.1.3 Remediating Waste Dumps

Lagos may also explore the remediation of its waste dumpsites through a process known as phytoremediation (plant treatment of waste) that was briefly discussed in Chapter 5 as a probable measure to treat industrial wastewater. Phytoremediation is the use of plants to purify contaminants in wastewater, groundwater, soil and surface water. The method employs a variety of plant biological processes and characteristics to aid the purification. It is a sequence of processes, with different processes occurring to different degrees for different conditions, media, contaminants and plants.⁸⁹³ The system is also acquiring significance in the rehabilitation of contaminated municipal solid waste dumpsites. Scientists who explored the rehabilitation of municipal solid waste dumpsites by using a selection of planted vegetation on a landfill, confirm its ability to remove contaminants and to treat leachate.⁸⁹⁴ The actual selection of plants and the type of phytoremediation process depend on the type of contaminants to be treated and the nature of the site.⁸⁹⁵ Although experts caution that the precise mechanism by which plants stimulate the disappearance of hazardous organics from soil in waste dumps is not fully understood, phytoremediation is a very attractive option for Lagos.⁸⁹⁶ The attractiveness of phytoremediation

⁸⁹³ Bruce E. Pivetz, "Phytoremediation of Contaminated Soil and Groundwater at Hazardous Waste Sites" (United States Environmental Protection Agency: Office of Research and Development, 2001).
Online: http://www.epa.gov/superfund/remedytech/tsp/download/epa_540_s01_500.pdf.

⁸⁹⁴ R. Nagendran, A. Selvam, K. Joseph, & C. Chiemchaisri, "Phytoremediation and Rehabilitation of Municipal Solid Waste Landfills and Dumpsites: A Brief Review" (2006) 26 Waste Management 1357.

⁸⁹⁵ Ibid.

⁸⁹⁶ Ibid. Researchers have also explored phytoremediation in treating landfill leachates by means of spray irrigation of untreated leachate onto vegetated land, as a potential remediation option. This is very good news for solid waste

is its low startup cost, low capital and maintenance costs, non-invasiveness, high public acceptance, and the pleasant, aesthetically appealing landscape that emerges.⁸⁹⁷ Phytoremediation as an option for wastewater treatment is also elaborated within the next section on wastewater management.

Lastly, urgent measures to remediate groundwater that has already been polluted by leachates from dumpsites must be taken. This may involve a number of interim measures including notices to the public about the status of the waters, and issuing of “boil water” advisories. It may also require finding scientific methods to clean up the polluted waters. In order to allow time for these measures to take place, while being able to supply a reasonable amount of water to residents, Lagos may consider immediately implementing the alternative water options discussed earlier.

7.2.2 Wastewater Management

Untreated effluents from both industrial and domestic sources are the other major cause of groundwater pollution in Lagos, as discussed in Chapter 5.

7.2.2.1 Industrial Wastewater

Presently, the most significant and dangerous pollution is from manufacturing processes. Industrialists in Lagos are discharging dangerous levels of assorted chemicals into the environment, and causing groundwater to be severely polluted. The toxicity of these emissions and the resultant harm to groundwater has made it clear that this practice cannot continue. The toxic industrial emissions have polluted groundwater up to the second aquifer, such that

management, and worthy or exploration in Lagos: D.L. Jones, K.L. Williamson, & A.G. Owen, “Phytoremediation of Landfill Leachate’ (2006) 26 Waste Management 825.

⁸⁹⁷ M.J. Sadowsky, “Phytoremediation: Past Promises and Future Practices”, in C.R. Bell, M. Brylinsky, & P. Johnson-Green, eds., *Proc. of 8th International Symposium on Microbial Ecology, Atlantic Canada Society for Microbial Ecology*, Halifax, Canada, (1999).

groundwater exploitation is now required to be from the third aquifer in the affected industrial areas, for safety.⁸⁹⁸ It is concerning that there do not appear to be measures to remediate this harmful trend. The inference from the advanced state of pollution is that nature has not been able to attenuate this particular level of pollution; the pollution has exceeded its ameliorative ability, and therefore the industrial wastewater problem is a classic case of economic development that is ecologically unsustainable in the long term.

Yet there is no justification for wastewater emissions to constitute such a hazard in Lagos, considering all the treatment options that are currently available. Truly, it was originally considered to be a public health hazard and the sole objective of earlier wastewater treatment efforts was solely to safeguard human health and the health of receiving bodies of water, as discussed in Chapter 5. The prevalent idea of urban sanitation in earlier times was to avoid direct contact with wastewater and to flush away the harmful components in it. The treatment methods focused on producing environmentally safe effluents and sludge that were suitable for disposal. To avoid negative ecological and economic impacts to the receiving water bodies, wastewater treatment technology was developed with the main objective of converting pollutants into less problematic substances prior to discharge into any surface water body.⁸⁹⁹

But over the past decades, experts have recognized the potential utility of the nutrients and other contents of wastewater, both domestic and industrial. Cornell et al affirm that wastewater is a multi-substance mixture containing probably several hundreds of different substances in extreme dilution that are potentially very valuable.⁹⁰⁰ Energy, phosphorus, nutrients and the water itself are recoverable after treatment. Wastewater has thus become a

⁸⁹⁸ Personal Discussions with Engineer at Lagos Wastewater Management Office on November 16th, 2012.

⁸⁹⁹ P.A. Wilderer, "Sustainable Water Management in Rural and Peri-urban Areas: What Technology do we Need to Meet the UN Millennium Development Goals?" (2005) *Water Science and Technology* 51 (10) 1.

⁹⁰⁰ P. Cornell, A. Meda, & S. Bieker, "Wastewater as a Source of Energy, Nutrients and Service Water" (2011) 4 *Water Quality Engineering* 337.

valuable resource rather than pure waste, even as the primary goal of safeguarding human and ecological health has not been obscured.⁹⁰¹

7.2.2.1.1 Phytoremediation of Industrial Wastewater

Phytoremediation can effectively treat industrial wastewater.⁹⁰² The process uses plants to instigate waste breakdown, and to both remove and control wastes. Plants stimulate the degradation of organic contaminants in soil, and also sequester heavy metals, thus reducing the heavy metal contamination in wastewater. The process draws its inspiration from the diversity of physical, chemical and biological interactions between plants and the environment.⁹⁰³ It is inexpensive, being primarily powered by solar energy.⁹⁰⁴ Phytoremediation is reputed to be a powerful tool in waste management, and a potential great cleanser and healer of the earth at an affordable cost.⁹⁰⁵ This is surely a very welcome discovery for waste managers and regulators and also for industrialists that regularly generate considerable quantities of wastewater in Lagos.

Research carried out in Lagos has confirmed the scholarly findings that phytoremediation can purify wastewater by using water hyacinths.⁹⁰⁶ As mentioned in Chapter 5, Ajayi & Ogunbayo successfully used water hyacinths (the harmful products of nutrients in polluted water) to purify industrial wastewater in Lagos. Their empirical research demonstrates that water

⁹⁰¹ M. Morales & G. Oberg, *The Idea of Sewage as a Resource: An Integrated Study of Knowledge and Decision Making in Liquid Waste Management in Metro Vancouver, B.C. Canada*, (Institute of Resources, Environment and Sustainability, 2012).

⁹⁰² McCutcheon & Schnoor note that the term 'phytoremediation' was first used by Raskin et al (1993) and Raskin (1996) in a 1991 proposal that was funded by the United States Environmental Protection Agency's Superfund Program: S. C. McCutcheon and J.L. Schnoor, "Overview of Phytoremediation and Control of Wastes", in S.C. McCutcheon, C. Steven, & J.L. Schnoor, eds., *Phytoremediation: Transformation and Control of Contaminants* (John Wiley and Sons Inc., New York) 1987.

⁹⁰³ R. Nagendran, et al, *supra*, note 894.

⁹⁰⁴ S. C. McCutcheon & J.L. Schnoor, *supra*, note 902.

⁹⁰⁵ *Ibid*.

⁹⁰⁶ Water hyacinths are rapidly-growing weeds that occur in waters that have a high level of nutrients. Their presence signifies the presence of nutrients. Hyacinths are very harmful because they obstruct navigation, and deplete oxygen in water and thereby kill off fish and other aquatic animals.

hyacinths effectively remove most of the chemical contaminants in industrial wastewater.⁹⁰⁷ It is a pleasant irony that water hyacinths that are a problematic product of waste are also a tool for water treatment, and a vehicle for nutrient and water recovery that yields an environmentally safe effluent. Although this finding has not been tested on an industrial scale, it presents an excellent opportunity for Lagos, in collaboration with scientists, to explore further as a probable solution to the troubling matter of untreated industrial wastewater in the environment.

Apart from employing phytoremediation to purify wastewater, there are many other methods of releasing good quality water that is trapped in unfavorable biological or chemical states. Experts have discussed some methods that are suitable for cities of developing countries, although this thesis argues that phytoremediation still remains the ideal process for Lagos.⁹⁰⁸ Wastewater recovery is indeed a key to solving water problems both in present and future terms, and an important index in sustainable development. As Karmann succinctly wraps it, “sustainable development requires sustainable wastewater management (SWM)”.⁹⁰⁹

Lagos can no longer justify its subsisting, harmful tradition of ejecting all wastewater into the environment, while continually taking in fresh water for its many users, yet complaining

⁹⁰⁷ T.O. Ajayi & A.O. Ogunbayo. “Achieving Environmental Sustainability in Wastewater Treatment by Phytoremediation with Water Hyacinth (2012) 5(7) *Journal of Sustainable Development* 80. See also: A. Adeniran, “Alternative Sewage Treatment Option: The Effect of Use of Water Hyacinth (*Eichhornia Crassipes*) in the Treatment of Domestic Sewage”, (Available online).

⁹⁰⁸ Jhansi & Mishra propose three “sustainable wastewater treatment” options for urban cities in the developing world. These are: Lagoons and Wetlands; Anaerobic Digestion; and Soil Aquifer Treatment technology. The Lagoons and wetlands system uses shallow ponds as stabilization lagoons in which water hyacinths recover heavy metals. This allows for total resource recovery, but is not ideal because of large amounts of land needed, and the resultant concentration of algae and suspended solids. Anaerobic digestion is suggested where land is limited, and is a process in which anaerobic bacteria degrade organic matter without oxygen and produce methane and carbon dioxide. The methane is reusable as biogas whilst the resultant sludge is good for use in agriculture. In the soil aquifer system method, wastewater is treated by having it percolate through the soil into groundwater, a method that was found to achieve an excellent reduction of suspended solids, biochemical oxygen demand and fecal coliform with a 90% recovery rate: S.C. Jhansi & S.K. Mishra, “Wastewater Treatment and Reuse: Sustainability Options” (2013) 10 *Consilience: The Journal of Sustainable Development* 1. See also: S. Kaur & M. Singh, “Soil Aquifer System: A Case Study” (2002) 44(3) *Indian Journal of Environmental Health* 23.

⁹⁰⁹ E. Karmann, “Strategies towards Sustainable Wastewater Management” (2001) 3 *Urban Water* 63. He recommends four strategies for handling wastewater: separating nutrient-containing sewage from other sewage; recycling nutrients and using energy efficiently; preventing contamination of sewage flows; and finally placing unavoidable pollution on landfills.

about the difficulty of finding new water sources to boost supplies for its teeming population. It is necessary for the city's water managers and regulators to start to diligently explore a range of feasible wastewater treatment options.

7.2.2.2 Domestic Sewage Treatment

In respect of domestic sewage, Lagos needs to have and enforce standards for the design of septic tanks that will enable them to function as a medium of primary sewage treatment. It will however need to allow residents a reasonable moratorium for compliance. This is in addition to having decentralized sewage treatment plants, since most areas cannot accommodate centralized systems due to their being fully built up. The decentralized plants will serve individual houses or groups of houses. Happily the decentralized plants are gradually being provided in the metropolis, as discussed in Chapter 5.

7.2.3 Wastewater Re-use

Wastewater is a “multi-substance mix” of valuable materials that consists not only of assorted chemicals including detergents and disinfectants, but even noble metals such as gold, silver and platinum. The diversity of the contents of sewage prompted Kroiss to say that “the only compounds which can reliably be prevented from wastewater “... are those which are not produced”.⁹¹⁰ It has therefore been beneficial to explore its re-use, and over the years, many countries and municipalities have discovered the usefulness following treatment, of the valuable compounds and nutrients that can be extracted from it, and the many diverse uses to which recovered wastewater and nutrients can be put, all of which can be useful lessons for Lagos.

⁹¹⁰ H. Kroiss, “What is the Potential for Utilizing the Resources in Sludge?” (2004) 49(10) Water Science and Technology 1.

Following treatment, the re-use of wastewater has become an acceptable practice around the world. Originally, reuse was limited to regions experiencing extreme water shortage or unusual effluent disposal constraints. That thinking has now totally changed as reclaimed water has become an increasingly strategic water management option for growing communities. It provides a new source of water, minimizes the volume of effluents discharged into the environment, and conserves freshwater resources for the highest quality need, i.e. drinking water.⁹¹¹ According to Asano, “Water reuse is particularly attractive in the situation where available water supply is already overcommitted and cannot meet expanding water demands in a growing community. Increasingly, society no longer has the luxury of using water only once”.⁹¹²

Currently researchers in both developed and developing countries are finding good uses for both domestic and industrial sewage. Chapter 5 discussed case studies in which untreated domestic sewage was applied in agriculture with startling results, as well as prospects for harnessing the bio-energy contained in wastewater.⁹¹³

Cornell et al remark that in large cities where drinking water demands far exceed the locally available water resources, the demand for potable water can be significantly reduced by reclaiming waste water. This is because drinking water supply can only be assured with large-scale efforts and occasionally with severe impacts on the environment. They state that dire consequences attend the adoption of a strict supply-focused water supply strategy. These include: excessive exploitation of existing water resources, lowering of groundwater levels, and energy-

⁹¹¹ B. Durham, M.M. Bourbigot, & T. Pankratz, “Membrane as Pretreatment to Desalination in Wastewater Reuse: Operating Experience in the Municipal and Industrial Sector” (2001) 138 *Desalination* 83.

⁹¹² T. Asano, *Water Reuse Issues, Technologies, and Applications* (New York: McGraw-Hill, 2007).

⁹¹³ M. Johanssen, *Urine Separation - Closing the Nutrient Cycle Final Report on the R & D Project Source Separated Human Urine - A Future Source of Fertilizer for Agriculture in the Stockholm Region?* (2000) Available online; H. Kirchman & S. Pettersson, “Human Urine Chemical Composition and Fertilizer Use Efficiency” (1995) 40 *Fertilizer Research* 149; Melissa Scanlan, “Sustainable Sewage” (Available online).

intensive and costly water transportation over many hundreds of miles.⁹¹⁴ It is thus reasonable to infer that water re-use saves numerous resources by reducing the energy demand of the water cycle, and by contributing to reducing related emissions of greenhouse gases.

Treated wastewater has been applied to both potable and non-potable uses, including agricultural and landscape irrigation, flushing, industrial re-use, groundwater recharge, recreational and environmental uses, and drinking.⁹¹⁵ Naturally, the quality requirements for potable use are significantly higher than that for non-potable use, and the required energy for treatment is higher as well. The direct consequence of properly treating sewage are numerous: a healthy and thriving community of people, a healthy ecosystem and aquaculture, mitigation of climate change on global water resources, and an adequate potable water supply.⁹¹⁶

7.2.4 Section Recommendation

Lagos should rigorously embrace a culture of wastewater reuse by exploring the many options for its reuse both in its raw form and after treatment. As a viable option for treating its industrial wastewater and waste dumps, Lagos should explore phytoremediation because it frees up good water, making it available for re-use, and also remediates solid waste dumpsites. As a solar-powered process, it is inexpensive to set up and maintain, and so the combination of low costs and solar-energy use make it an attractive and sustainable option for Lagos with its tropical climate. Based on the research findings about phytoremediation of both wastewater and solid waste discussed above, it is apparently a very important option that Lagos should immediately

⁹¹⁴ P. Cornell, A. Meda, & S. Bieker, “Wastewater as a Source of Energy, Nutrients, and Service Water” in P. Wilderer, ed., *Treatise on Water Science* (New York: Oxford Academic Press 2011) 337.

⁹¹⁵ J. Lahnsteiner et al discuss both potable and non-potable uses of treated wastewater in Namibia: J. Lahnsteiner, G. Lempert, I.S. Kim, J. Cho, and S. Kim, “Water Management in Windhoek, Namibia” (2007) 55 (1-2) *Water Science and Technology* 441.

⁹¹⁶ Aliyu Maigari Mamman, “Regulating Wastewater Management in Lagos State: How it Affects You! Impacts of Wastewater Mismanagement on Environment, Health and Water Supply” Paper presented at the 1st Lagos Wastewater Summit 2013 organized by the Lagos State Water Regulatory Commission on 3rd October 2013.

begin to explore for both its sewage and solid waste management systems. Phytoremediation is particularly important for managing wastewater in Lagos because the city is unable to undertake centralized sewage collection due to the limitations of a largely built-up place, paucity of land to house sewage pipes, and water shortage. Centralized sewerage would have to be confined to new developments.⁹¹⁷ On the other hand, phytoremediation processes can probably be carried out within individual industries, and so the limitations of land and water shortages should not matter, since industries might conduct the process within their respective premises. Phytoremediation presents an incredible opportunity to solve a thorny waste management problem in Lagos. A stipulation that waste managers should explore all available methods of scientific wastewater treatment including phytoremediation can be incorporated into law or policy in Lagos.

In respect of domestic sewage across the municipality, Lagos will also need to consider if the present diffuse system of flushing domestic sewage that uses a large amount of water is sustainable in view of the city's chronic water shortage. Writers have argued in the negative, saying that the large volume of water involved is unsustainable, and because it tends to blow up an ordinarily domestic problem into a regional one. They also argue that the water systems are transplanted from western countries without consideration of their appropriateness to the culture, land, and climate.⁹¹⁸

⁹¹⁷ The United Nations rightly observes that although centralized sewage treatment plants are desirable, lack of adequate and regular water supply and funds for infrastructural development of sewage systems work against introducing the centralized system for the present. For this reason the best option remains the use of septic tanks with soakage pits.

⁹¹⁸ S. Jhansi & S. Mishra, *supra*, note 908. An alternative option might be the ECOSAN sanitation toilet that diverts urine and recycles water and nutrients contained in human waste back into the environment. An ECOSAN perspective views waste and sewage as an opportunity by either recovering nutrients in it and returning these to the soil, or by converting solid waste to biofuel. The technology is in use in some states in the U.S., for instance in South Royalton, Vermont.

In terms of solid waste management, a safer waste disposal method such as an engineered landfill with a leachate collection system is urgently needed. The waste dumps may also be remediated by phytoremediation, which should be explored. Scavengers' activities should be harnessed in order to enhance their waste sorting activities both for material recovery and to reduce the volume of materials that have a potential to leach into, and pollute, groundwater. Finally, polluted groundwater in the metropolis needs to be remediated.

Collectively, the measures proposed within this section are compliant with international agreements that urge concerted measures to significantly reduce water pollution and increase water quality, to significantly improve wastewater treatment and water efficiency and to reduce water losses.⁹¹⁹

The preceding discussions have addressed the direct problems of water shortage and pressures on groundwater, sewage and solid waste management. The next section looks closer into the underlying reasons for manufacturers' apathy towards environmental protection, particularly the problem of untreated wastewater emissions in the environment.

7.3 Overcoming Industrial Apathy towards Groundwater Protection

Chapters 3, 5 and 6 discussed the apathy and reluctance by industrialists to treat their effluents to required standards in spite of regulations under past and present legal frameworks. Industry operators are apathetic, and view the cost of sewage treatment as a pointless waste of resources. The history of non-compliance with effluent limitation standards makes it likely that the problem might not be resolved by making more laws, or by imposing additional standards on

⁹¹⁹ *The Future We Want*, Art. 124.

industries. A selection of extra measures is required to address the perceived apathy and non-compliance.

7.3.1 Education about the Usefulness of Wastewater

The first issue to address in wastewater treatment is that industrialists do not appear to recognize the utility of wastewater as a resource, and only see it as waste, and this accounts for their reluctance to incur expense over pure waste. But the reality of wastewater as a valuable resource that is ideal for treatment and reuse is well known and has been discussed in Chapter 5 as well as in earlier sections of this chapter. Therefore the first measure would be to address this wrong perception through education about the usefulness of wastewater, which can be treated and reused by industrialists within their processes. Industrialists can be enlightened that rather than requiring new and costly water, they can treat and reuse their wastewater, and thereby save costs. The idea of savings in production costs ought to be appealing to them, and serve as a motivator to embrace a culture of wastewater re-use.

7.3.2 The ‘Water Fit’ Concept in Wastewater Treatment

The second issue is for industrialists to be properly informed about the idea of ‘Water Fit’. The concept means that water should be treated to fit its intended purpose only. Industrialists need to understand that their wastewater need only be treated to the standard of the reuse to which it is intended, which in many cases may not require potable water quality standards. This should resolve any misconceptions that all wastewater treatment is too costly simply because it has to be treated to the same high standard. Lower treatment standards may be applied to non-potable uses like industrial washing, flushing, and gardening. Treating all wastewater to potable standards would certainly amount to an inefficient use of water, energy,

and money.⁹²⁰ The idea of spending minimally on treatment costs, while having the treated effluent available for their reuse should be attractive to them.

Industrial re-orientation is absolutely critical to groundwater sustainability in Lagos, as wastewater that would otherwise have been ejected untreated into the environment can be re-directed into manufacturing processes. Re-orientation confirms the scholarly view that achieving substantive sustainable development requires significant changes in socio-cultural beliefs, attitudes and behavior.⁹²¹ The incentive for industrialists in wastewater treatment is that treating and re-using water will free up water for their own re-use, reduce the cost of fresh intakes of water at all times, and reduce their overall production costs. Because less water is abstracted overall, it will also reduce the growing gap between water demand and supply in the metropolis because more water would be freed up for other uses. Learning about lower water treatment costs means that water can be treated at lower cost and re-used for non-potable purposes. The environment also benefits from reduced wastewater discharges, since treating wastewater and reusing it reduces the total amount expelled.⁹²² The National Policy on the Environment supports environmental education in its provision which reads thus:

“In order to secure the involvement of the citizenry and assure its commitment to the principle of sustainable development, action will be undertaken to enlighten various levels of society on the essential linkages between environment and development”.⁹²³

⁹²⁰ M. Jacobsen, M. Webster, & K. Vairavamoorthy, *The Future of African Cities: Why Wastewater* (2013), supra, note 849.

⁹²¹ W. Rees, “The Ecology of Sustainable Development” (1990) 20(2) *Ecologist* 18, at pgs. 18-19.

⁹²² D.C.Y. Foo, “Water Cascade Analysis for Single and Multiple Impure Fresh Water Feed” (2007) 85(8) *Chemical Engineering Research and Design* 1169; Muller, “Fit for Purpose: Taking Integrated Water Resource Management Back to Basics” (2010) 24(3-4) *Irrigation and Drainage Systems* 161.

⁹²³ *Nigerian National Policy on the Environment*, S. 6.6.

7.3.3 Social Factors Influencing Environmental Behavior

Apart from the measures discussed above, other methods may be adopted to influence environmental behavior within the industrial community. These include community pressure and environmental reputation. Researchers have identified these social factors as determinants of industrial behavior and as effective measures even in the absence of specific laws. In one case, in response to community pressure in India, manufacturers reduced their wastewater emissions by installing new treatment facilities. They also compensated the community by providing drinking water, blankets, and new facilities such as temples and community halls.⁹²⁴ For Lagos, the government could increase community awareness, which could then bring pressure to bear on industries to be more environmentally friendly.

Closely linked to community pressure is environmental reputation. The willingness of industries to behave in an environmentally friendly manner may sometimes depend on reputational factors. Evidence from the United States suggests that large polluters have a strong incentive to improve their environmental reputations through participation in voluntary cleanup programs. Arora & Cason found that large plants with high toxic releases are more likely to participate in the US Environmental Protection Agency's voluntary and highly publicized environmental programs.⁹²⁵

7.3.4 Incentives to Induce Environmental Compliance

Finally, incentives may be employed to further induce positive environmental behaviour and industrial compliance. Economic instruments encourage compliance with regulations and

⁹²⁴ R. Khator, *Environment, Development and Politics in India* (Lanham, MD: University Press of America, 1991)

⁹²⁵ Arora and Cason, "An Experiment in Voluntary Environment Regulation: Participation in EPA's 33/50 program (1995) 28 *Journal of Environmental Economics and Management* 271. H. Hettige, M. Huq, S. Pargal, & D. Wheeler, "Determinants of Pollution Abatement in Developing Countries; Evidence from South and East Asia (1996) 24(12) *World Development* 1891. S. Dasgupta, H. Hettige, & D. Wheeler, "What Improves Environmental Compliance? Evidence from Mexican Industry" (2000) 39 *Journal of Environmental Economics and Management* 39.

address the perceived unwillingness to incur costs of processing wastewater treatment. Incentives could be in the nature of tax breaks, import duty concessions, grants, subsidies or other reward measures.

Existing environmental policies and agreements support the idea of formulating incentives to encourage good environmental behaviour. The National Policy on the Environment endorses a scheme of incentives to reward industries that devise viable programs for environmental remediation, and those with facilities for waste management.⁹²⁶ The Policy prescribes economic incentives such as tax holidays, soft loans, and outright grants.⁹²⁷ International agreements also recommend the use of economic instruments as a means of discouraging harmful environmental behavior. For instance, the United Nations in Agenda 21 recommends incentives to reduce unsustainable patterns of production and consumption.⁹²⁸ It prescribes incentives that encourage citizens (including industry) to choose to recycle waste rather than dispose of it. Local and municipal authorities that recycle the largest amount of wastes are to be rewarded with incentives.⁹²⁹

It is instructive to note that NESREA Regulations provide parameters to reward industries for complying with environmental protection.⁹³⁰ They prescribe a Flag Award in which companies are to be rated and the best awarded the NESREA Green Mark representing the best performing company, while the information is disseminated to the public. It is an effort at using public perception to encourage environmental behaviour. But although public perception could affect a corporate behaviour as discussed above, it does not seem to be adequate in the case

⁹²⁶ *Nigerian National Policy on the Environment*, supra, Ss. 4.12(p).

⁹²⁷ *Ibid.*

⁹²⁸ Agenda 21, Chapter 21, Art. 21.24.

⁹²⁹ *Ibid.*

⁹³⁰ An example is the National Environmental (Chemical, Pharmaceutical, Soap and Detergent Manufacturing Industries) Regulations (2009), Section 53 and Schedule XIII.

of industry in Lagos. In view of these local provisions, it is puzzling that there is still a very low rate of industrial compliance, but explainable on the basis that the incentive schemes are probably not attractive enough, or have simply not been implemented. Whatever the case may be, a more concerted effort is required in view of the seriousness of groundwater pollution and the urgency of remedial action needed at this point.

The collection of measures discussed in this section, that is, industrial education about the usefulness of wastewater, the idea of ‘water-fit’ treatment, community pressure, environmental reputation, and incentive schemes are measures that are likely to change the mode of operation of industrialists, and may be written into law and policy. They are consistent with Agenda 21 which recommends the provision of incentives to reduce unsustainable patterns of production and consumption, and that such incentives and penalties which motivate economic behavior must be reoriented to become a strong force for sustainability.⁹³¹ When these measures are coupled with enforced legal standards for industrial effluents, they ought to be effective in assuring better industrial co-operation with efforts at safeguarding groundwater in Lagos. Education about ‘water fit’, understanding that untreated wastewater is a valuable ‘hidden’ resource, and that their overall production costs will reduce should be attractive to industrialists.

7.4 Balancing Environmental and Economic Policies to Safeguard Groundwater

Lagos is a hub of commercial and industrial activities, and a city whose industrial development contributes significantly to Nigeria’s national economy. Over the past two decades, Lagos grew in stature to solidify its position as the commercial capital of the country and even propelled Nigeria into becoming Africa’s strongest economy, as discussed in Chapter 5. Unfortunately that laudable economic accomplishment has taken place at a huge environmental

⁹³¹ Agenda 21, Art 21.10.

cost. Its development is occurring at a serious cost to the precious environmental resource, groundwater, thus affirming the theory that the processes of industrialization exert a great toll on the environment.⁹³² It also raises questions about a likely imbalance between the economic policy and the policy on the environment.

It is arguable that the apathy from industrialists discussed earlier stems from the drive by Lagos government to achieve a very high level of economic growth. The manufacturing industry is particularly at the core of economic growth, and therefore the biggest culprit in groundwater pollution. The state's Economic Development Plan clarifies that the overall economic goal is to achieve "a dynamic expanding economy".⁹³³ It aims at creating an annual gross domestic product (GDP) growth that exceeds both the rate of inflation and the rate of population growth, by building on the current rate of 7% to accomplish 10% by 2020. Of particular note is the objective of achieving a maximal output from the manufacturing sector which is expected to begin operating at 40% of Lagos GDP by 2020.⁹³⁴ The goal of increasing the manufacturing sector's contribution to the GDP over the 13 year period between 2012 and 2025 is particularly important because it helps to understand that there is presently a very intense effort at economic development in Lagos with emphasis on the manufacturing sector. And research studies have demonstrated that a major culprit in toxic emissions polluting groundwater in Lagos is the manufacturing sector, especially the textiles industry.⁹³⁵

On the other hand, its Environmental Policy laments that the status of Lagos as the economic hub, with a large concentration of industrial, commercial and trading activities, has

⁹³² See generally, discussions on the evolution of sustainable development in Chapter 2.

⁹³³ Lagos State Government, *Lagos State Development Plan (2012-2025)* (Ministry of Economic Planning and Budget: 2013).

⁹³⁴ Ibid.

⁹³⁵ See earlier discussions in Chapter 5.

exposed it to “various environmental pollution and ecological problems” where water is being polluted, and natural resources are being over-exploited”.⁹³⁶ The Policy stresses the importance of promoting *the awareness of citizens in the State on the need to balance environmental management with development*.⁹³⁷ This principle underlies the sustainability of development, which, if observed, pollution problems ought not to be occurring.

Ironically, the Economic Development Plan also has a “*Sustainable Environment Pillar*” written into it, which contains statements about improving solid waste management and pollution control. One of the expected outcomes, “*sanitation that meets the needs of all without polluting groundwater*”, sounds very promising even though it is the only reference to groundwater, and does not explain further.⁹³⁸ The Plan also recognizes that manufacturing tends to be environmentally polluting, and that compliance with “*sustainable environmental principles*” would be required. But what constitutes these principles and how they should in fact be implemented are not explained. Besides, the vital interconnection between industry processes and groundwater pollution is not adequately addressed.⁹³⁹ What is being done practically about environmental sustainability? Do manufacturing industries have similar environmental statements written into their corporate statements? Are the likely environmental impacts of manufacturing prepared for, and factored into their production processes? Even if they do have environmental mission statements, the fact of continuing discharges of untreated toxic wastewater into the environment denies any real commitments to protecting the environment in the pursuit of business goals.

⁹³⁶ Lagos State Environmental Protection Agency, *Policy on the Environment*.

⁹³⁷ Ibid.

⁹³⁸ *Lagos State Development Plan (2012-2025)*, supra, note 933.

⁹³⁹ Ibid, at Chapter 10, pg. 195.

The fact that groundwater is continually being degraded largely on account of industrial development is enough feedback from the environment to the economy about the lack of harmony and balance between the natural systems and the economic system. Unless otherwise proved, Lagos does not appear to have been integrating environmental imperatives with developmental goals in real terms by reconciling its development with environmental objectives. This conflicts with the state's Environmental Policy that says that citizens must be made aware of the need to balance environmental management with development.⁹⁴⁰

The apparent absence of balance between development efforts and environmental protection creates a dangerous conflict that will likely make any attempts at protecting groundwater from pollution and ensuring its sustainability, illusory. It will also make any elaborate institutional or regulatory measures to protect groundwater of little effect. It is thus arguable that the economic policy is unwittingly causing the degradation of groundwater, and encouraging a decline in water quality. In the interest of a sustainable Lagos city, and of a realistic sustainable development, the two goals must somehow be synchronized.

It is understandable that as Lagos is the economic hub of Nigeria, it must drive economic growth. But the government seems to be driving optimal economic growth without enough attention to the environmental implications of this growth. The core of ecologically sustainable development is to achieve a balance between economic advancement and environmental security. The absence of this critical balance is played out in Lagos where, in the drive toward economic development, the industrial wastewater emissions from manufacturing industries have greatly polluted the city's groundwater and placed it in such a precarious condition that has

⁹⁴⁰ Lagos State Environmental Protection Agency, *Policy on the Environment*, pg. 3, S.

required the present intervention.⁹⁴¹ Yet, as clarified in Chapter 3, groundwater is critical to industrial growth, thus making it important for Lagos to be concerned about its pollution. Therefore a number of measures need to be taken to correct the apparent imbalance in the interest of securing groundwater, and these are discussed below.

7.4.1 Corporate Environmental Awareness

First, the government in Lagos needs to drive environmental security in equally strong terms as it drives economic development. To this end, it would be extremely useful to have a representative of the Ministry of Environment present at the yearly forums where the state's economic policies are being rigorously driven to see that environmental security is equally rigorously driven.

7.4.2 Corporate Responsibility for Environmental Protection

Secondly, corporate citizens, more than anyone else, need the education that environmental management and industrial development must be balanced, and must implement this understanding within their industrial processes. The industries in particular need to be mandated to include environmental aspects within their industrial procedures and processes. In this regard, they can be encouraged to adopt 'industrial ecology' within their processes. Frosch & Gallopoulos proposed the industrial ecology model.⁹⁴² Their thesis is premised on the observation of symbiosis in ecological systems in which there is no material depletion, but rather full re-use. Biological systems optimally use energy and materials, generate minimal waste, and the effluents of one process serve as the raw material for another process. By adopting this

⁹⁴¹ Caldwell makes a good argument that it is important to place greater premium on long-range ecological considerations rather than on short-range considerations: L.K. Caldwell, *Political Aspects of Ecologically Sustainable Development* (1984) 11(4) *Environmental Conservation* 299, at pg. 305.

⁹⁴² R.A. Frosch & N.E. Gallopoulos, "Strategies for Manufacturing" (1989) 189 (3) *Scientific American* 152.

system, manufacturers should find innovative uses for materials previously considered to be waste, because waste can serve as raw material for the same or another related process. The result is a closed industrial ecosystem with fewer incidences of decreasing supplies of raw materials, waste and pollution. This, according to them is the ‘industrial ecosystem’ approach.⁹⁴³ The incentive to them is the achievement of self-sustenance, operating with minimized costs and a sustained ability to remain competitive.

7.4.3 Instituting Environmental Impact Assessment within Industrial Processes

Thirdly, environmental impact assessment as a form of precaution should be firmly implemented within economic strategies in Lagos. Environmental Impact Assessment (EIA) is a consciously planned method of exercising control over the adverse impacts on the environment consequent upon various development projects. Industrialists should be required to ensure that each manufacturing process is environmentally friendly, and that their emissions cease to ruin the city’s groundwater. Since EIA helps to determine ahead whether a particular policy, program, or action should be executed, modified, or completely abandoned (precaution), it is arguable that this is very necessary and desirable for Lagos. It can be very persuasively argued that a consistent EIA should be done right through every economic process in Lagos. This would be in the spirit of Nigeria’s National Environmental Policy that compulsorily requires that EIA be mandatorily carried out before any major development project is embarked on or proposed activities which may affect the environment or the use of natural resources.⁹⁴⁴ It would also be in tandem with Lagos state’s environmental policy that stipulates that “every economic activity (industrial, commercial, services e.t.c.) shall be conducted in a way to minimize the pollution of

⁹⁴³ Ibid.

⁹⁴⁴ National Policy on the Environment, Introduction, pg. 1; S 4.13.

the environment” and that “degradation arising from pollution of any component of the ecosystem (air, land and water) from any human activity shall be controlled”.⁹⁴⁵

The manufacturing sector also needs to be aware that it plays a big part in achieving sustainable development.⁹⁴⁶ The Rio + 20 Conference clarified that industry as a sector has a responsibility to contribute to sustainable development by developing sustainability strategies.⁹⁴⁷ Agreements reached at the international Conferences recognize that in tackling environmental sustainability, urgent action is needed to address unsustainable patterns of production and consumption. Overall, a change is called for in the way industry has hitherto carried on its production activities.⁹⁴⁸ The United Nations clarified the role of industry when it said that “guaranteeing a water secure world will require the full engagement of all actors, not least the world of business.”⁹⁴⁹ Groundwater contamination from toxic industrial effluents cannot continue unattended in Lagos. As the Dublin Statement aptly expresses it, “Residual contamination of water is no longer acceptable as a reasonable trade-off for the prosperity brought by industrial growth”.⁹⁵⁰

In addition, to the measures outlined above Lagos may also

- Monitor and encourage industrial compliance;
- Ensure environmental training for technical industrial personnel to encourage better environmental management effort and compliance

⁹⁴⁵ Lagos State Environmental Protection Agency, *Policy on the Environment* (1999), at pg. 5.

⁹⁴⁶ Industries’ contribution to severe environmental pollution is perhaps due to its lacking a sense of responsibility for environmental protection and public health, whereas they do have a corporate social responsibility in this regard: *The Future We Want*, Arts. 46, 58(o), 61, 69, & 71.

⁹⁴⁷ *The Future We Want*, Ss. 61, 69 & 224.

⁹⁴⁸ *Ibid.*

⁹⁴⁹ Remarks made at the 2013 Water Summit in Budapest, Hungary, October 8th 2013. Online: UN News Centre. See similar statements made in *The Future We Want*, Article 119, (Available online).

⁹⁵⁰ Dublin Statement, Action Agenda, pg. 3.

Finally, Lee and Goodland's statement that sustainable development requires "... policies, regulations, and incentives to induce economic behavior that is environmentally rational" infers the propriety of incorporating this combination of measures which are aimed at securing the cooperation of industry operators whose actions adversely affect groundwater, into law and policy.⁹⁵¹ Further deterioration of groundwater cannot be allowed to continue.

7.5 Conclusion of Discussion about Problems Confronting Groundwater in Lagos

The best practices identified in the EU Legal frameworks for managing groundwater, wastewater and solid waste, as well as needed reforms within the relevant laws and institutions in Lagos that were discussed at length in chapter 6 are the major recommendations made in this thesis for implementation and application in Lagos. This thesis summarizes its recommendation for law reform by reiterating that a law dedicated to groundwater management should be written in Lagos. In order to strengthen the law, it should draw valuable lessons from the EU Framework. The lessons include: attention to detail; resoluteness to address every conceivable aspect of groundwater; recognition and address of the interconnection of waste and wastewater management with groundwater; addressing the identified gaps in regulation; inter-referencing between laws that are interconnected; a holistic approach to water management; realism about water pollution and remediation; and in technical knowledge of hydrogeology, toxicology and ecology. The lessons also include demonstration of scientific understanding of the impact of the interactions between various streams of water in the water cycle, as well as comprehension of the impact of human activities on water.

⁹⁵¹ J. Lee & R. Goodland, "Economic Development and the Environment" (1986) 23(4) Finance and Development 36.

In addition, the recommendations made within the present chapter are urged for exploration and incorporation into law and policy wherever possible, as probable complementary solutions to alleviate groundwater pollution. Together, the combination of measures ought to contribute to a sturdy and secure groundwater resource.

The discussion of the many components of the problems facing groundwater in the various categories is now concluded. As promised at the start of the Chapter, all the recommendations which have been made will now be extracted and pooled together for policy and law review:

7.6 SUMMARY OF RECOMMENDATIONS FOR POLICY AND LAW

Following from all the discussions within the preceding sections, recommendations that should collectively assure a sustainable framework for managing groundwater are presented in the tables below:

7.6.1 Resolving Fragmented Legal frameworks and Institutional Difficulties

1.	Lagos should enact a single law that addresses all groundwater issues by building on the provisions of NESREA's Surface and Groundwater Regulation, and incorporating important elements within the other laws on wastewater and waste to show an understanding of the interaction of these elements with groundwater
2.	Lagos should adopt useful lessons identified within the European Union's frameworks for groundwater, wastewater, and solid waste management to enhance the proposed new law for groundwater
3.	The proposed groundwater law should incorporate environmental principles including EIA, and especially Polluter Pays as consistent with sustainable development principles
4.	Lagos needs to find a means of regulating private groundwater exploitation in order to safeguard groundwater without impinging on proprietary rights to exploit groundwater
5.	In the interest of groundwater security, eliminate vagueness and pluralism of laws by merging the three existing waste laws (Environmental Pollution Control Law, the Environmental Sanitation Law, and the LAWMA Law)
6.	Hydro-geologists in Lagos need to immediately identify sensitive areas in which susceptible aquifers are located. For areas determined to be sensitive, zoning regulations

	that make it impossible for economic activities to take place within aquifer zones should be written
7.	Where industrial activity is already being carried out in a sensitive area, such area needs to be labeled as a sensitive area to which stringent standards for wastewater discharged by industrial operators should henceforth be strictly applied
8.	Lagos must streamline and resolve the functional overlaps between the governing institutions, as well as overlaps and superfluity in the wordings of its environmental legislations
9.	Inter-Institutional cohesiveness and cooperation should be rigorously promoted in the interest of groundwater preservation
10.	LWC needs to work with wastewater and solid waste managers (LASEPA, LAWMA, and LASWAMO) in order to monitor and prevent further pollution to groundwater
11.	Overall, stricter regulation, monitoring and enforcement must be employed to raise the cost and the consequences of pollution (non-compliance) Periodic evaluation and reviews, updating and streamlining of environmental legislations, will be necessary

7.6.2 Water Shortage and Pressures on Groundwater

1.	Lagos should adopt an alternative soft approach which focuses on the efficient use of available water and on conserving water, in order to boost its water supply
2.	The soft approach will enhance both the reliability and security of water supply which is much needed in Lagos, and in consequence, reduce the current pressure on groundwater
3.	Lagos should maximize water efficiency through better equipment which eliminate waste especially unaccounted-for water losses during distribution
4.	As a medium term-strategy, Lagos should reduce the quantum of overall water used in the municipality through alternative technology
5.	As far as practicable, it should also endeavor to optimize water supplies by harnessing all forms of water within the urban cycle, i.e., wastewater treatment and reuse, storm water and rainwater harvesting, and later, seawater desalination when affordable
6.	In the case of industries, manufacturers should be encouraged to redesign systems to get more from using less water especially by treating and re-using their wastewater

7.6.3 Alternative Solid Waste and Wastewater Management Options to Protect Groundwater

7.6.3.1 Solid Waste Recommendation

1.	To halt further groundwater pollution, Lagos should urgently move away from open dumping of solid waste and elect to transition to an engineered waste dump with leachate
----	---

	containment as a safer medium-term waste disposal method. Later, investment in sanitary landfills will be advisable
2.	Phytoremediation to rehabilitate the waste dumpsites should be explored
3.	Measures to remediate groundwater that has already been polluted by leachate from waste dumps need to commence immediately in the interest of public health
4.	A waste management policy similar to the EU's Waste Hierarchy is necessary, and public education is needed about proper waste management at all levels
5.	Industry operators should be thoroughly knowledgeable about the life cycle of products, and incorporate this in product design, and also be responsible for disposing of their wastes
6.	A structured system that involves waste sorting and recycling in order to reduce waste at dumpsites is necessary. Lagos should concertedly explore the processing of biomass into energy
7.	Lagos should harness the sorting efforts of scavengers on its waste dumpsites as a means of reducing the overall volume of waste that remains at the dumpsites and that can potentially leach into groundwater, as a prelude to more structured system for waste minimization
8.	Legislation should promote investment in more sanitary urban waste management

7.6.3.2 Wastewater Recommendation

1.	In compliance with the principle of Polluter Pays, concerted efforts to halt the groundwater pollution trend, identify polluters, and to remediate polluted groundwater should start immediately in accordance with guidelines of the EU Water Framework
2.	Lagos should start a deliberate policy effort at re-using wastewater, as a key to solving water problems both in present and future terms. It should also research into the realistic potable and non-potable uses of treated wastewater in Lagos
3.	Lagos should explore Phytoremediation as a realistic means of treating industrial wastewater. Research should be commissioned to confirm or deny studies about the utility of water hyacinths within the process
4.	In respect of domestic sewage emissions, Lagos should devise and enforce standards for septic tanks' construction, allowing residents a reasonable time for compliance
5.	Lagos should explore safer domestic sewage disposal through a decentralized system of wastewater treatment since this is more practicable for a built up city. It should also re-appraise the long-term sustainability of its current flushing system which uses a large amount of scarce water

7.6.4 Tackling Industrial Apathy and Pollution from Manufacturing

1.	Lagos should enlighten its industrialists about the usefulness of wastewater, as this is a valuable resource which may be subject to reuse. They should embrace a culture of wastewater treatment, and find uses for wastewater generated within their processes
----	--

2.	Education is necessary for industrialists to understand the concept of ‘Water Fit’, i.e. that wastewater need only be treated to the standard for which it is to be re-used, thus saving high treatment costs
3.	Industries must use water more efficiently by minimizing water used, minimizing fresh intakes of water, and minimizing the wastewater produced
4.	Attractive incentive including tax breaks, import duty concessions, grants, and subsidies should be in place to encourage industrialists in environmentally friendly industrial practices and to reward compliance
5.	A combination of community pressure and environmental reputation may be brought to bear on industrialists in order to arrest their apathetic environmental behavior
6.	Remediation of groundwater polluted by industrialists in their manufacturing activities on the basis of the principle of Polluter pays is now mandatory. Lagos should put in place a system to identify polluters and make them remediate polluted waters. Industrialists should work with regulators on measures to remediate groundwater that has already been polluted by wastewater discharges in the interest of public health
7.	A change in water policy that focuses on reducing waste and improving efficiency could also be implemented within the industrial sector so that industrialists will be required to eliminate wasteful water practices by treating and re-use their wastewater

7.6.5 The Problem of Balancing Environmental and Economic Policies

1.	The Government needs to drive environmental security in equally strong terms as it drives economic development
2.	Industrialists need to be educated about their contributory responsibility in attaining sustainable development, and the importance of integrating environmental considerations into their processes
3.	Industrial ecology should be driven and implemented in industries, and industry operators required to find uses for every waste produced within their manufacturing processes
4.	Industrialists should be legally required to critically examine every aspect of their manufacturing processes and to ensure that the processes are environmentally friendly, and not hurtful to groundwater. For this purpose, environmental impact assessment needs to be incorporated into their processes

7.7 The Role of Legislation in Sustainable Groundwater Management in Lagos

The recommendations require incorporation into law in order to have the frame, the authority, legality and the enabling environment for their enforcement. Both national and Lagos state’s environmental policies authorize the incorporation of these measures into law. The National Policy on the Environment provides that the legal framework should continuously drive

policy in a way that recognizes the organic nature of the environment and the need to manage it in an effective and efficient manner. To this end, environmental laws should be periodically evaluated, updated, and streamlined into a holistic and integrated compact.⁹⁵² Similarly Lagos state's environmental policy provides that laws should periodically be reviewed and amended whenever necessary.⁹⁵³

Law is an extremely powerful tool that may be employed to streamline and redirect important national activities. The United Nations acknowledges that each country faces specific challenges to achieve sustainable development, and so each government has to adopt the particular approach and tools in accordance with its peculiar national circumstances and priorities that make sustainable development possible. For this purpose, it encourages experience-sharing between countries.⁹⁵⁴ It also encourages national governments to establish effective legal and regulatory frameworks that enhance national capacities to respond to the challenges of sustainable development. The laws and regulations must be suited to country-specific conditions as a critical instrument for transforming environment and development policies into action. The laws should be properly integrated, not piecemeal, and be supported by adequate *institutional machinery and authority* for enforcement and timely adjustments.⁹⁵⁵ The international policy forums acknowledge that developing countries in particular have sometimes been affected by faulty legislation; to integrate environment and development in policies and practice, it is important to formulate laws that are based on social, ecological, economic, and scientific principles. They encourage compliance incentives, recognizing that although environmental law is important, it cannot alone deal with the problems of environment and

⁹⁵² National Policy on the Environment, S. 8.

⁹⁵³ Lagos State *Policy on the Environment*, S. 5.

⁹⁵⁴ *The Future We Want*, Arts. 32 & 64.

⁹⁵⁵ *Agenda 21*, Art. 8.13.

development. It has to be complemented with governmental economic policies and incentives because they also determine civic attitudes and conduct towards the environment.⁹⁵⁶ On the basis of these enabling provisions, the collective legal and other measures identified as necessary to ensure groundwater sustainability in Lagos can be justified.

In Nigeria, environmental security has been elevated to constitutional status by the incorporation of a right to healthy environment in the 1999 Nigerian Constitution. Gbemre's case discussed in Chapter 1 amplified the constitutional guarantee of a right to life to include the right to a healthy environment. This certainly makes it more imperative and gives more inspiration to urge a firmer framework for managing groundwater in Lagos. The right to a healthy environment is a constitutional promise that is owed to citizens within a broader federal responsibility to doggedly pursue the sustained protection of the environment and to avoid deterioration and depletion of critical natural resources, especially groundwater. Since the Constitution is preeminent in the hierarchy of national laws, priority must accordingly be given to its promise of environmental protection, which in this context pertains to groundwater security.⁹⁵⁷

It is gratifying that environmental legislation in Nigeria has progressed in the right direction from a state of virtual non-existence, to its present status of environmental laws and institutions, with centralization of environmental management in environmental protection agencies.⁹⁵⁸ But this progression or advancement is not enough if there is degradation of a vital natural resource such as groundwater in Lagos. Securing groundwater in Lagos will need the aggregation of all the recommendations made which need the force of law to be implemented.

⁹⁵⁶ Ibid, Arts. 8.14, 8.16, 8.27, & 8.28.

⁹⁵⁷ Constitution of the Federal Republic of Nigeria (1999), S. 1. However, the matter of environmental rights is a full subject in itself, and is beyond the scope of this thesis. Therefore it has not been elaborated beyond a mention of the status that a right to water now has in Nigeria.

⁹⁵⁸ B. Ogolla, *Environmental Law in Africa: Status and Trends* (1995) International Business Lawyer 412.

They would be part of the strong governance at national and local levels that is required for sustainable development.

7.8 Achieving Sustainable Groundwater Management in Lagos

Economic growth, industrialization, and urbanization that collectively make up the city's development are proceeding at rates that are hardly sustainable. The dynamics of urbanization, a very high rate of population growth, and high levels of industrialization and toxic wastewater discharges into the environment are destroying the city's groundwater, and must be re-configured. An attempt to achieve sustainable development based on these prevailing patterns is hard to conceive. As the Rio Principles express it, "to achieve sustainable development and a higher quality of life for all people, States should reduce and eliminate unsustainable patterns of production and consumption and promote appropriate demographic policies."⁹⁵⁹

The important place of groundwater for industrial growth in Lagos cannot be stressed enough. Securing the sustainability of groundwater will mean that the many industries which rely predominantly on it will have an unimpeded and safe supply that contributes to guaranteeing continuity of their production processes. Water scarcity hinders production, or compels it to carry on at incredibly high costs. Poor quality infrastructure including water shortage is also a discouragement to foreign investments which would otherwise enhance business development. But if Lagos addresses its water challenges, it will greatly maximize the economic growth that it so determinedly pursues. And if it truly aspires to join the league of leading world economies, and to become "Africa's model megacity and global, economic and financial hub that is safe secure, functional and productive", then the groundwater must be better secured than it presently

⁹⁵⁹ Rio Principle No. 8.

is.⁹⁶⁰ In that event, the growth that it plans over the next 13 years on the magnitude projected and which emphasizes manufacturing growth, will have a chance of attainment and also be sustainable both economically and ecologically. Lagos will effectually be eliminating the developmental trend of damaging an important natural (groundwater) resource at a faster rate than nature's limits to remediate it. Securing groundwater in Lagos will also safeguard the health of its residents who depend in it exclusively, for as the United Nations succinctly expresses it, "...of all things in the world, people are the most precious. It is the people that propel social progress, create social wealth, develop science and technology and, through their hard work, continuously transform the human environment." ⁹⁶¹

In this spirit, as a megacity within a developing nation, Lagos should strive to accomplish ecologically sustainable development by adopting a more enduring method and paths to development, learning from the costly errors of its developed counterparts, and avoiding irreversible damage to its groundwater resources particularly. Fresh water after all is a finite and vulnerable resource that is essential to sustain life, development and the environment.

Achieving sustainable development is a process. As the Brundtland Commission expressed it, sustainable development is "a process of change" in human activities so that the natural resource base upon which current and future generations of humanity depend for the satisfaction of their needs and aspirations is not undermined.⁹⁶² The process needs to start now.

It has been argued that many environmental problems in developing countries originate from the lack of development, that is, from the struggle to overcome extreme conditions of poverty,

⁹⁶⁰ Ministry of Economic Planning and Budget, *Lagos State Development Plan 2012-2025*, (2013).

⁹⁶¹ Declaration of the United Nations Conference on the Human Environment, (Stockholm, 1972) Art. 5

⁹⁶² World Commission on Environment and Development, *Our Common Future*, at pg. 46.

and that effective environmental protection is determined by a nation's wealth.⁹⁶³ But if indeed this is so, and that the solution will only materialize when a country becomes developed and wealthy, then that creates the impression of a vicious, difficult, and hopeless cycle, and assumes the impossibility of resolving a critical environmental problem such as Lagos has. It is also unnecessarily defeatist since it is apparent that man has the capability and the responsibility to determine and guide the future course of his environment through corrective action.⁹⁶⁴ Indeed, "Man is both creature and molder of his environment".⁹⁶⁵

7.9 CONCLUSION OF THESIS

At the start of this thesis, the following research questions were posed:

1. What are the direct environmental problems, and the underlying social, and institutional threats that contribute to groundwater degradation in Lagos, and how can they be solved?
2. How can law address the current fragmented and cursory legal regime and frame a comprehensive one that takes into account the direct and indirect problems that confront groundwater in Lagos State and that safeguards groundwater sustainability?

In answering the first question, this thesis identified the direct environmental threats as leachate from improperly managed solid waste, and wastewater generated from domestic and

⁹⁶³ Stockholm Declaration, *supra*, note 946, Art. 4; Founex Report on Environment and Development, Ch. 1.4, 1.5, 1.8; See also: P. Bartelmus, *Environment and Development* (Allen and Unwin, London, England, 1986), cited by E. Barbier IN "The Concept of Sustainable Economic Development". Barbier elaborates by using the illustration that poor people often have no option but to choose immediate economic benefits at the cost of the longer term sustainability of their livelihoods. He cites Pearce's example of people using dung as fuel instead of as fertilizer, resulting in a decline in soil fertility, low levels of production, and loss of future economic welfare: Pearce, *The Sustainable Use of Natural Resources in Developing Countries*. See also D. Tarlock, "Ideas Without Institutions: The Paradox of Sustainable Development" (2001) 9(1) *Indiana Journal of Global Legal Studies* 35.

⁹⁶⁴ The Intergovernmental Conference for the Rational Use and Conservation of the Biosphere, *Conclusions*, (Available online).

⁹⁶⁵ Declaration of the United Nations Conference on the Human Environment, (1972), Art. 1. (Available online)

industrial activities that, in combination, are polluting groundwater. The indirect problems are over urbanization that has led to over-population, and industrial apathy.

To resolve the direct problems, this study recommended alternative methods for managing solid waste, preferably engineered dumpsites with leachate collection and control. It also recommended a waste management policy that prioritizes waste minimization, and that emphasizes recycling and reuse. In the process of transitioning to better waste management, the useful role of scavengers may be properly harnessed. In the case of industrial wastewater, industrialists are urged to explore phytoremediation to rehabilitate their wastewater, as well as explore wastewater re-use generally. In terms of domestic sewage, it recommended that a moratorium be given to residents to acquire standard septic tanks which function as primary treatment, whilst the efforts to have decentralized treatment plants continue. The study also found that the current pressure on groundwater, which has contributed to its degradation, is caused by inadequate water supplies. It thus urged that the pressure can be reduced by optimizing existing water, and exploring the use of alternative, existing sources of water.

In order to tackle the indirect problems, this thesis proffered a number of measures to address industrial apathy, and these include: education about the ‘water fit’ concept that is expected to significantly reduce wastewater treatment costs; the employment of community pressure based on environmental reputation to be brought to bear on industrialists in order to change their apathetic environmental behavior; and incentives including tax breaks, environmental awards with pecuniary benefits attached, and other measures to encourage good environmental behavior should be worked at. A system of incentives was recommended for inclusion in law and policy, with realistic details to be worked out and implemented. In order to address the adverse effects of over-urbanization on groundwater, the thesis recommended remediating polluted groundwater,

achieving a substantial reduction in untreated wastewater, and reducing pressures on groundwater through adoption of the soft approach to water management.

To answer the second research question, this thesis recommended that a single law be written for groundwater management. The new law should build upon existing provisions of the Federal NESREA Regulations, and go much further by incorporating safe wastewater and solid waste management practices that intersect with groundwater. It should also adopt best practices identified within the European Union's legal framework. Additionally, in order to further safeguard groundwater, it proposed a streamlining of the three waste management laws in Lagos into a single document for ease of access. It proposed the strengthening of institutions by cooperation and the elimination of functional overlaps.

The thesis urged the incorporation of all the proposed recommendations into law and policy in Lagos. This thesis firmly believes that if Lagos should adopt all the recommendations in this thesis, it would lead to a safe, secure and sustainable groundwater resource.

BIBLIOGRAPHY

SECONDARY MATERIALS: MONOGRAPHS

1. Adeniyi, O. & I.B. Bello-Imam. *Development and the Environment: Proceedings of a National Conference*, (Ibadan, Nigeria: Nigerian Institute of Social and Economic Research, 1986).
2. Adeyemo, A. *Assessing Environmental Protection and Management Systems in West Africa: A Case Study of Nigeria* (Ann Arbor, U.S.: Proquest LLC, 2008).
3. Angotti, Thomas. *Metropolis 2000-Planning, Poverty and Politics* (London, U.K: Routledge, 1993).
4. Asano, T. *Water Reuse Issues, Technologies, and Applications* (New York: McGraw-Hill, 2007).
5. Bairoch, P. *The Economic Development of the Third World Since 1900* (Berkeley, California: University of California Press, 1975).
6. Bartelmus, P. *Environment and Development* (London, U.K.: Allen and Unwin, 1986).
7. Brooks, D.B., O. Brandes & S. Gurman, eds., *Making the Most of the Water We Have: The Soft Approach to Water Management* (Earthscan Books, London 2009).
8. Carson, R. L. *Silent Spring*, (New York: Houghton Mifflin Company, 1962).
9. Cech V.T., *Principles of Water Resources - History, Development, Management, and Policy* (USA: Wiley, 2003).
10. Cole, A.J. & E.M Hoover, *Population Growth and Economic Development in Low Income Countries* (Princeton, NJ: Princeton University Press, 1958).
11. Conca, Ken. *Governing Water: Contentious Transnational Politics and Global Institution Building* (Massachusetts: The MIT Press, 2006).
12. de Villiers, Marq. *Water: The Fate of Our Most Precious Resource* (New York, U.S.: Houghton Mifflin Co., 2001).
13. Dhawan, B.D. *Studies in Irrigation and Water Management* (New Delhi, India: Commonwealth Publishers, 1989).
14. Dike, K.O. *Trade and Politics in the Niger Delta, 1830-1885: An introduction to the Economic and Political History of Nigeria* (Oxford: Clarendon Press, 1956).
15. El-Haggag, S. *Sustainable Industrial Design and Waste Management: Cradle-to-Grave*, (London, U.K.: Elsevier Academic Press, 2007).

16. Elias, T.O. *The Nigerian Legal System* (London, U.K: Routledge & Kegan Paul, 1963).
17. Falola, T. & M. Heaton, *A History of Nigeria* (Cambridge, New York: Cambridge University Press, 2008).
18. Fetter, C.W. *Applied Hydrogeology*, (N.J, U.S.: Prentice-Hall, 2001).
19. Fisher, D. *The Law and Governance of Water Resources: The Challenge of Sustainability*, (Cheltenham: Edward Elgar Publishing, 2009).
20. Flint, R.W. & W.L. Houser, *Living a Sustainable Lifestyle for our Children's Children*, (California, U.S.: Authors Choice Press, 2001).
21. Fisher, D. *The Law and Governance of Water Resources: The Challenge of Sustainability*, (Cheltenham, U.K.: Edward Elgar Publishing, 2009).
22. Gleick, Peter. *The World's Water Volume 7: The Biennial Report on Freshwater Resources* (Washington D.C: Island Press, 2011).
23. Glennon, Robert. *Water Follies: Groundwater Pumping and the Fate of America's Freshwaters* (Washington D.C.: Island Press, 2002).
24. Hibbs, D. *Mass Political Violence: A Cross-National Causal Analysis* (New York, U.S.: Wiley and Sons, 1973).
25. Jacobs, Jane. *The Economy of Cities*, (New York, U.S.: Random House, 1969).
26. Kaplan, R.D. *The Coming of Anarchy: Shattering the Dreams of the Post Cold War* (New York, U.S.: Random House, 2000).
27. Khator, R. *Environment, Development and Politics in India* (Lanham, U.S.: University Press of America, 1991).
28. Lipton, M. *Why Poor People stay Poor: Urban Bias in World Development*, (Cambridge, Massachusetts: Harvard University Press, 1977).
29. Melosi, M. *Garbage in the Cities: Refuse Reform and the Environment: 1880-1980* (Texas: A. & M. Press, 1981).
30. Myrdal, G. *The Challenge of World Poverty* (New York, U.S.: Pantheon Books, 1970).
31. Novotny, Vladimir. *Water Quality: Diffuse Pollution and Watershed Management* (Hoboken, New Jersey: John Wiley & Sons Inc., 2003).
32. Odemerho, F.O. eds., *Environmental Issues and Management in Nigerian Development* (Ibadan, Nigeria: Evans Brothers, 1988).

33. Offodile, M.E. *Groundwater Supply and Development in Nigeria* (Ibadan, Nigeria: University of Ibadan Press, 2002).
34. Okorodudu-Fubara, M. *The Law of Environmental Protection* (Ibadan, Nigeria: Caltop Publications, 1988).
35. World Commission on Environment and Development, *Our Common Future*, (Oxford & New York: Oxford University Press, 1987).
36. Norgaard, R. B. *Development Betrayed* (London: Routledge, 1994).
37. Sada, P.O. & F.O. Odemerho, *Environmental Issues and Management in Nigerian Development* (Ibadan, Nigeria: Evans Brothers, 1988).
38. Shah, Tushar, D. Molden, R. Sakthivadivel, & D. Seckler, *The Global Groundwater Situation: Overview of Opportunities and Challenges* (Sri Lanka: International Water Management Institute, 2000).
39. Simon, J.L. *The Ultimate Resource* (Princeton, NJ: Princeton University Press, 1981).
40. Stephens, K.A., P. Graham, & D. Reid, *Stormwater Planning: A Guidebook for British Columbia* (British Columbia, Victoria B.C: Ministry of Water, Land, and Air Protection, 2002).
41. Swanson, Peter. *Water: The Drop of Life*, (Chanhassen, U.S.: Northword Press 2001).
42. Tolba, M. *Development without Destruction* (Dublin, Ireland: Tycooly International, 1982).
43. Tchobanoglous, G., H. Theison, & A.S. Vigil, *Integrated Solid Waste Management* (McGraw-Hill International Editions: 1993).
44. Umoh, B.D. *Population Studies for Nigeria: A New Perspective*, (Enugu, Nigeria: Institute for Development Studies, 2001).
45. Williams, B. A. & A.H. Walsh, *Urban Government for Metropolitan Lagos* (New York: Fredrick A. Praeger Institute of Public Administration, 1968).
46. Williams, P.T. *Waste Treatment and Disposal* (London: John Wiley & Sons, 2013).
47. Winblad, U. & M. Simpson-Hebert, *Ecological Sanitation* (Stockholm, Sweden: Stockholm Environment Institute, 2004).

SECONDARY MATERIALS: ARTICLES

1. Adams, A.S. & A. N. LutzLey, “An Empirical Study of Factors Affecting Water Loss in Mexican Cities” (2012) 2(3) *Journal of Water Sustainability* 167.
2. Adebayo A.A., E. Briski, O. Kalaci, M. Hernandez, S. Gbabooli, & B. Beric “Water Hyacinth (*Eichhornia Crassipes*) and Water Letuce (*Pistia Stratiotes*) in the Great Lakes: Playing with Fire?” (2011) 6(1) *Aquatic Invasions* 91.
3. Adelana, S.M.A, P.I. Olasehinde, R.B. Bale, P. Vrbka, A.E. Edet & I.B. Goni. “An Overview of the Geology and Hydrogeology of Nigeria” in *Applied Groundwater Studies in Africa*, (London, U.K.: Taylor & Francis Group, 2008) 171.
4. Adepelumi, A.A., B.D. Ako, T.R. Ajayi, O. Afolabi, & E.J. Omotosho. Delineation of Saltwater Intrusion into the Freshwater Aquifer of Lekki Peninsular, Lagos, Nigeria, (2009) 56 *Environ Geol.* 927.
5. Aderemi, A., A. Oriaku, G. Adewumi, & A. Otitoloju, “Assessment of Groundwater Contamination by Leachate Near a Municipal Solid Waste Landfill” (2011) 5(11) *African Journal of Environmental Science and Technology* 933.
6. Aderemi, A., & A. Otitoloju, “An Assessment of Landfill Fires and their Potential Health Effects- A Case Study of a Municipal Solid Waste Landfill in Lagos, Nigeria” (2012) 2(2) *International Journal of Environmental Protection* 22.
7. Aderogba, K.A. & B.A. Afelumo, “Waste Dumps and their Management in Lagos Metropolis” (2012) *International Journal of Learning and Development* (ISSN 2164-4063).
8. Aderinola, O.J., E.O. Clarke, O.M. Olarinmoye, V. Kusemiju & M.A. Anatekhai. “Heavy Metals in Surface Water, Sediments, Fish Periwinkles of Lagos Lagoon” (2009) 5 (5) *American-Eurasian J. Agric. & Environ. Sci.* 609.
9. Adewuyi, G.O. O.U. Oputu & M.A. Opasina, “Assessment of Groundwater Quality and Saline Intrusions in Coastal Aquifers of Lagos Metropolis” (2010) 2 *Journal of Water Resources and Protection* 849.
10. Adeyemi, O., O.B. Oloyede & O.T. Oladiji, “Physico-chemical and Microbial Characteristics of Leachate-Contaminated Groundwater” (2007) 2 *Asian Journal of Biochemistry* 343.
11. Agbola, T. “A Review of Environmental Components in Nigeria’s National Development Plans: 1946-1985”, in P.O. Sada & F.O. Odermerho, eds., *Environmental Issues and Management in Nigerian Development* (Evans Brother, Ibadan, Nigeria 1988) 47.
12. Agunwamba, J. C. “Solid Waste Management in Nigeria: Problems and Issues” (1998) 22(6) *Environ Management* 849.

13. Ajayi T.O. & A.O. Ogunbayo. "Achieving Environmental Sustainability in Wastewater Treatment by Phytoremediation with Water Hyacinth" (2012) 5(7) *Journal of Sustainable Development* 80.
14. Akoteyon, I.S. "Evaluation of Groundwater Quality Using Water Quality Indices in Parts of Lagos - Nigeria" (2013) 6(1-2) *Journal of Environmental Geography* 29.
15. Akoteyon, I.S. "Evaluation of Groundwater Quality Using Contamination Index in Parts of Alimosho, Lagos Nigeria" (2012) 4(4) *American Academic & Scholarly Research Journal* 1.
16. Akhtar, M.A., S.A. Batool, & M.N. Chaudhry, "Scavengers and their Role in the Recycling of Waste in Southwestern Lahore" (2012) 58 *Resources, Conservation and Recycling* 152.
17. Alabi, A.A., R. Bello, A.S. Ogungbe & H.O. Oyerinde, "Determination of Groundwater Potential in Lagos State University, Ojo Using Geoelectric Methods (Vertical Electrical Sounding and Horizontal Profiling)" (2010) 2(5) *Report and Opinion* 68.
18. Albion, G.M. "Landfill Waste Pollution and Control" in B. Abbob, ed., in *Hazardous Waste Detection Control and Treatment, Part B* (Amsterdam: Elsevier Science, 1995) 1199.
19. Alcamo, J.M., C.J. Vorosmarty, R.J. Naiman, D.P. Lettenmaier, & C. Pahl-Wostl, "A Grand Challenge for Freshwater Research: Understanding the Global Water System ." (2008) 3(1) *Environmental Research Letters* 010202.
20. Andreen, W. "Environmental Law and International Assistance: The Challenge of Strengthening Environmental Law in the Developing World" (2000) 25 *Colum J. Int. L.* 17.
21. Angelakis, A. D. Koutsoyiannis, & G. Tchobanoglous, "Urban Wastewater and Storm Water Technologies in Ancient Greece" (2005) 39 *Water Research* 210.
22. Akujieze, C. N. S.J.L. Coker & G.E. Oteze. *Groundwater in Nigeria - A Millennium Experience - Distribution, Practice, Problems and Solutions* (2003) 11 *Hydrogeology Journal* 259.
23. Alonso, W. "Five Bell Shapes in Development", (1980) 45 *Papers of the Regional Science Association* 5.
24. Amadi, A.N. "Effects of Urbanization on Groundwater Quality: A Case Study of Port-Harcourt, Southern Nigeria" (2010) 11(2) *Natur. Appl. Sci. J.* 143.
25. Apotz, S. M. Elliott, M. Fountain, & T. Galloway, "European Environmental Management: Moving to an Ecosystem Approach" (2006) 2(1) *Integrated Environmental Assessment and Management* 80.

26. Arora, Seema & Timothy N. Cason, "An Experiment in Voluntary Environment Regulation: Participation in EPA's 33/50 Program" (1995) 28 *Journal of Environmental Economics and Management* 271.
27. Asim, M., S. Batool, & M. Chaudhry, "Scavengers and their Role in the Recycling of Waste in Southwestern Lahore" (2012) 58 *Resources, Conservation and Recycling* 152.
28. Asubiojo, O.L. et al, (1997) "Trace Elements in Drinking and Groundwater Samples in Southern Nigeria" 208 (1-2) *The Science of the Total Environment* 1.
29. Aurangabadkar, K., S. Swaminathan, S. Sandya & T.S. Uma. "Impact of Municipal Solid Waste Dumpsite on Groundwater Quality in Chennai, India" (2001) 5 *Environmental Pollution Control* 41.
30. Aworemi, J.R., A. Adegoke, & N. Opoola, "An Appraisal of the Factors Influencing Rural-Urban Migration in Some Selected Local Government Areas of Lagos State Nigeria" (2011) 4(3) *Journal of Sustainable Development* 136.
31. Ayodele, A. & O. Simeon, "Investigating Groundwater Quality Around Olushosun Dumpsite Lagos Nigeria" (2012) 1(9) *Indian Journal of Innovations and Development* 700.
32. Baba, A. & G. Tayfur. "Groundwater Contamination and its Effects on Health in Turkey" (2011) 183 *Environ Monit. Assess* 77.
33. Balogun, I.I., I.S. Akoteyon & O. Adeaga. "Evaluating Land Use Effects on Groundwater Quality in Lagos-Nigeria Using Water Quality Index (2012) 4(2) *J. Sci. Res.* 397.
34. Barbier, E.B., "The Concept of Sustainable Economic Development" (1987) 14(2) *Environmental Conservation* 101.
35. Batabyal, Armitrajeet "Developing Countries and Environmental Protection: The Effects of Budget Balance and Pollution Ceiling Constraints" (1997) 54 *Journal of Development Economics* 285.
36. Baxter, K.M. "The Effects of the Disposal of Sewage Effluents on Groundwater Quality in the United Kingdom" (1982) 86 *Water Services* 219.
37. Biswas, A.K. "Water for Sustainable Development in the 21st Century: A Global Perspective" (2007) *International Journal of Water Resources Development* 219.
38. Biswas, M.R. & A.K. Biswas, "Complementarity Between Environment and Development Processes" (1984) 11(1) *Environmental Conservation* 35.

39. Bixio, D., C. Theoye, J. de Koning, D. Joksimovic, D. Savic. T. Wintgens, & T. Melin. "Wastewater Reuse in Europe" (2006) 187 *Desalination* 89.
40. Blanchet, Didier. "On Interpreting Observed Relationships between Population Growth and Economic Growth: A Graphical Exposition" (1991) 17 *Population and Development Review* 105.
41. Bourchard, M.F., S. Sauve, B. Barbeau, M. Legrand, M. Brodeur, T. Bouffard, E. Limoges, D.C. Bellinger & D. Mergler, "Intellectual Impairment in School-Age Children" (2010) 119 (1) *Environmental Health Perspectives* 138.
42. Brockerhoff, M. "Fertility and Family Planning in African Cities: The Impact of Female Migration" (1995) 27 *Journal of Biosocial Science* 347.
43. Brooks, D.B. & O.M. Brandes. "Why a Water Soft Path, Why Now and What Then?" (2011) 27(2) *International Journal of Water Resources Development* 315.
44. Brundtland, G.H. "Population, Environment, and Development" (1993) 19(4) *Population and Development Review* 893.
45. Burke, E.J., S.J. Brown, & N. Christidis. "Modeling the Recent Evolution of Global Drought and Projections for the Twenty-first Century with the Hadley Centre Climate Model" (2006) 7 *Journal of Hydrometeorology* 1113.
46. Burnley, S.J. "A Review of Municipal Solid Waste Composition in the United Kingdom" (2007) 10 *Waste Management* 1274.
47. Caldwell, Lynton K. "Political Aspects of Ecologically Sustainable Development" (1984) 11(4) *Environmental Conservation* 299.
48. Calow, R.C., A.M. MacDonald, A.L. Nicol, & N.S. Robins. "Groundwater Security and Drought in Africa: Linking Availability, Access and Demand" (2010) 48 *Ground Water* 246.
49. Calow, R. C., N. S. Robins, A. M. Macdonald, D. M. J. Macdonald, B. R. Gibbs, W. R. G. Orpen, P. Mtembezeka, A. J. Andrews & S. O. Appiah, "Groundwater Management in Drought-prone Areas of Africa" (1997) 13(2) *International Journal of Water Resources Development* 241.
50. Carlson M., K. Lohse, J. McIntosh & J. McLain, "Impacts of Urbanization on Groundwater Quality and Recharge in a Semi-Arid Alluvial Basin" (2011) 409(1-2) *Journal of Hydrology* 196.
51. Clark, D. "Interdependent Urbanization in an Urban World: An Historical Review" (1998) 164 *the Geographical Journal* 85.

52. Ciba J, T. Korolewicz, & M. Turek, "The Occurrence of Metals in Composted Municipal Wastes and their Removal" (1999) *Water, Air, Soil Pollution* 159.
53. Cofie O.O., G. Cranjac, & P. Drechsel, "The Use of Human Waste in Peri-Urban Agriculture in Northern Ghana" (2004) 20(2) *Renewable Agriculture & Food Systems*.
54. Cohen, B. "Urbanization in Developing Countries: Current Trends, Future Projections, and Key Challenges for Sustainability" (2006) 28 *Technology in Society* 63.
55. Cohen, B. "Urban Growth in Developing Countries: A Review of Current Trends and a Caution Regarding Existing Forecasts" (2004) 32 *World Development* 23.
56. Cornell, P. A. Meda, & S. Bieker, "Wastewater as a Source of Energy, Nutrients, and Service Water" in P. Wilderer, ed., *Treatise on Water Science Vol. 4* (New York: Oxford Academic Press, 2011) 337.
57. Davis, J.W., N.J. Klier & C.L. Carpenter. "Natural Biological Attenuation of Benzene in Groundwater Beneath a Manufacturing Facility" (1994) 32(2) *GROUNDWATER* 215.
58. Dan-Hassan, M.A., P. I. Olasehinde, A. N. Amadi, J. Yisa & J. O. Jacob "Spatial and Temporal Distribution of Nitrate Pollution of Groundwater of Abuja Nigeria" (2012) 4(3) *Int. Journal of Chemistry* 104.
59. Dasgupta, S., H. Hettige, & D. Wheeler, "What Improves Environmental Compliance? Evidence from Mexican Industry" (2000) 39 *Journal of Environmental Economics and Management* 39.
60. Davis, M. "Planet of Slums" (2004) 26 *New Left Review* 5.
61. Drakkakis-Smith, D. *Third World Cities* (London and New York: Routledge, 2000).
62. De Loe, Rob & Reid Kreutzweiser, "Closing the Groundwater Implementation Gap" (2005) 36(2) *Geoforum* 241.
63. Dellapenna, J. W. & J. Gupta. "The Challenges for the Twenty-First Century: A Critical Approach", in J.W. Dellapenna & J. Gupta, eds., *The Evolution of the Law and Politics of Water* (Springer: 2009) 391.
64. Dogan, M., A.U. Dogan, C. Celebic & Y.I. Baris, "Geogenic Arsenic and a Survey of Skin Lesions in the Emet Region of Kurahya, Turkey" (2005) 14(6) *Indoor and Built Environment* 533.
65. Dolk H., M. Vrijheid, B. Armstrong, L. Abramsky, F. Bianchi, E. Garne, V. Nelen, E. Robert, J.E. Scott, D. Stone & R. Tenconi. "Risk of Congenital Anomalies Near Hazardous-Waste Landfill Sites in Europe: the EUROHAZCON Study" (1998) 352(9126) *Lancet* 423.

66. Duranton, G. "Urbanization, Urban Structure, and Growth", in J-M Huriot & J.F. Thisse, eds. *Economics of Cities: Theoretical Perspectives*, (Cambridge: Cambridge University Press, 2000) 290.
67. Durham, B., M.M. Bourbigot, & T. Pankratz, "Membrane as Pretreatment to Desalination in Wastewater Reuse: Operating Experience in the Municipal and Industrial Sector" (2001) 138 *Desalination* 83.
68. Dunn, R. "In Retrospect Silent Spring", (2012) 485 *Nature* 578.
69. Egboka, B.C.E., G.I. Nwankwor, I.P. Orajaka, & A.O. Ejiofor. "Principles and Problems of Environmental Pollution of Groundwater Resources with Case Examples from Developing Countries" (1989) 83 *Environmental Health Perspectives* 39.
70. Egunjobi, L. "Issues in Environmental Management for Sustainable Development in Nigeria" (1993) 13 (1) *The Environmentalist* 33.
71. Ehrlich, Paul & Anne Ehrlich. "The Population Explosion: Why We Should Care and What We Should Do About It" (1997) *Environmental Law* 1187.
72. Ehrlich, I. & F. Lui. "The Problem of Population Growth: A Review of the Literature from Malthus to Contemporary Models of Endogenous Population and Endogenous Growth" (1997) 21 *Journal of Economic Dynamics and Control* 205.
73. El-Shakhs, S. "Development, Primacy and Systems of Cities" (1972) 7(1) *J. Dev. Areas* 11.
74. Eisen, C. & M.P. Anderson. "The Effects of Urbanization on Groundwater Quality: A Case Study" (1979) 17(5) *GROUNDWATER* 456.
75. Elimelech, M.E. & W.A. Philip. "The Future of Seawater Desalination: Energy, Technology and the Environment" (2011) 333 *Science* 712.
76. Engelman R. & P. LeRoy. "Sustaining Water: Population and the Future of Renewable Water Supplies" (Population Action International, Washington D.C. US: 1993).
77. Eni, D. & J. Obiefuna, C. Oko, & I. Ekwok. "Impact of Urbanization on Subsurface Water Quality in Calabar Municipality Nigeria" (2011) 1(10) *International Journal of Humanities & Social Science* 167.
78. Eruola, A.O. R.A. Olowu, I.O. Ogunyemi, & N.A. Adedokun. "Assessment of Effect of Sewage Intrusion from Septic Tanks into the Consumable Hand dug Wells in Lagos State, Nigeria" (2010) 13(1)b *The Global Journal of Science Frontier Research* ISSN:2249-4626 & Print ISSN: 0975-5896.

79. Faisal, I.M., M. Parveen, & M.R. Kabir. "Sustainable Development through Groundwater Management: A Case Study of the Barind Tract" (2005) 21 Int. J. of Water Res. Dev. 425.
80. Finnveden, G., M. Reich, O. Eriksson, & A. Sorbom, "Flexible and Robust Strategies for Waste Management in Sweden" (2007) 27 Waste Management 1.
81. Florea, A.M. & D. Busselberg, "Occurrence, Use and Potential Toxic Effects of Metals and Metal Compounds" (2006) 19 BioMetals 419.
82. Foo, D.C.Y. "Water Cascade Analysis for Single and Multiple Impure Fresh Water Feed" (2007) 85(8) Chemical Engineering Research and Design 1169.
83. Fowler, B.A. "Monitoring of Human Populations for Early Markers of Cadmium Toxicity: A Review" (2009) 238 Toxicology and Applied Pharmacology 294.
84. Freestone, D. "The Precautionary Principle" in R. Churchill and D. Freestone, eds., *International Law and Global Climate Change* (London: Graham and Trotman, 1991).
85. Foster, S.S.D. "Potable Groundwater Supplies and Low-cost Sanitary Engineering - How Compatible?" Natural Resources Forum (1985) 9(2) Natural Resources Forum 125.
86. Fritzmann, C., J. Lowenberg, T. Wintgens, & T. Melin. "State of the Art Reverse Osmosis Desalination" (2007) 216 Desalination 1.
87. Frosch, R.A. & N.E. Gallopoulos, "Strategies for Manufacturing" (1989) 189(3) Scientific American 152.
88. Gaines, S.E. "The Polluter Pays Principle: From Economic Equity to Environmental Ethos" (1991) 26 Tex. Int. Law J. 463.
89. Gandy, M. "Planning, Anti-Planning and the Infrastructure Crisis in Metropolitan Lagos (2006) 43(2) Urban Studies 371.
90. Gagnon Z, C. Newkirk, & S. Hicks. "Impact of Platinum Group Metals on the Environment: A Toxicological Genotoxic and Analytic Chemistry Study" (2006) 41 Journal of Environmental Science and Health Part A 397.
91. Gbadebo, A.M. & A.M. Taiwo, "Geochemical Characterization of Phreatic Aquifers in areas of Sango, Southwestern Nigeria, (2011) 12 J. World Appl. Sci. 815.
92. Gidlow, D.A. "Lead Toxicity" (2004) 54 Occup Med 76.
93. Gillham, R. & J. Cherry. *Refuse Disposal Sites and their Long-Term Behavior*, (Dusseldorf Germany ENVIREC 1989).

94. Gleick, P.H. "Water in Crisis: Paths to Sustainable Water Use" (1998) 8(3) *Ecological Applications* 571.
95. Gleick, Peter. "Making Every Drop Count", (2001) 284(2) *Scientific American* 28.
96. Gleick, P.H. "Doing More with Less: Improving Water Efficiency Nationwide" (2009) 8(1) *Southwest Hydrology* 20.
97. Gleick, P.H. "Getting it Right: Misconceptions about the Soft Path", in: D.B. Brooks, O.M. Brandes and S. Gurman, eds., *Making the Most of the Water We Have: The Soft Path Approach to Water Management* (London: Earthscan, 2009) 49.
98. Gleick, P.H. "Global Freshwater Resources: Soft Path Solutions for the 21st Century", (2003) 302 *Science* 1524.
99. Gleick, P.H. "The Changing Water Paradigm: A Look at Twenty-First Century Water Resources Development" (2000) 25(1) *Water International* 127.
100. Gleick Peter. "Water and Terrorism" (2006) 8 *Water Policy* 481.
101. Gleick, P. & M. Panaliappan. "Peak Water Limits to Freshwater Withdrawal and Use" (2010) 107(25) *PNAS* 11155.
102. Gorre-Dale, E. "The Dublin Statement on Water and Sustainable Development" (1992) 19(2) *Environmental Conservation* 181.
103. Graniel, C.E., L.B. Morris, & J.J. Carillo-Rivera, "Effects of Urbanization on Groundwater Resources of Merida, Yucatan, Mexico" (1991) 37(4) *Environmental Geology* 303.
104. Gray, D.A., J.D. Mather, & I.B. Harrison, "Review of Groundwater Pollution from Waste Disposal Sites in England and Wales with Provisional Guidelines for Future Site Selection" (1974) 7 *Quart. J. Eng. Geol.*, 181.
105. Gugler, J. "Overurbanization Reconsidered" (1982) 31 *Econ. Dev. Cult. Change* 173.
106. Gullet, W. "Environmental Impact Assessment and the Precautionary Principle: Legislating Caution in Environmental Protection" (1998) 5(3) *Australian Journal of Environmental Management* 146.
107. Harris J.R. & M.P. Todaro. "Migration, Unemployment and Development: A Two-Sector Analysis" (1970) *American Economic Review* 126.
108. Hayton, R. & A. Utton. International Transboundary Resources Center, "Transboundary Groundwaters: The Bellagio Draft Treaty" (1989) 29(3) *Natural Resources Journal* 663.

109. Henderson, V. "Cities and Development" (2009) 50(1) *Journal of Regional Science* 515.
110. Henderson, Vernon. "Urbanization in Developing Countries" (2002) 17 *The World Bank Research Observer* 89.
111. Hering, D. A. Borja, J. Carstensen, L. Carvilho, M. Elliott, C. Feld, A. Heiskanen, R. Johnson, J. Moe, D. Pont, A. Solheim, & W. Van Der Bund, "The European Water Framework Directive at the Age of 10: A Critical Review of the Achievements with Recommendations for the Future" (2010) 408 *Science of the Total Environment* 4007.
112. Hettige, H., M. Huq, S. Pargal, & D. Wheeler, "Determinants of Pollution Abatement in Developing Countries; Evidence from South and East Asia" (1996) 24(12) *World Development* 1891.
113. Hiscock, K.M., M.O. Rivett & R.M. Davison. "Sustainable Groundwater Development", in Hiscock et al, eds., *Geological Society London Special Publications* (London: Geological Society of London, 2002) 1.
114. Hoselitz, B.F. "Urbanization and Economic Growth in Asia" (1957) 6(1) *Economic Development and Cultural Change* 42.
115. Hrudey, S.E., P. Payment, P.M. Hulk, R.W. Gilham, & E.J. Hrudey. "A Fatal Waterborne Disease Epidemic in Walkerton, Ontario: Comparison with Other Waterborne Outbreaks in the Developed World" (2003) 47(3) *Water Science and Technology* 7.
116. Hulme, M.R. T. Doherty, T. Ngara, M. Mew, and D. Lister, "African Climate Change: 1900-2000" (2000) *Climate Research* 145.
117. Ibaba, S.I. "Environmental Protection Laws and Sustainable Development in the Niger Delta" (2010) 2(2) *Africana* 56.
118. Ikem, A. O. Osibanjo, M.C.K. Sridhar & A. Sobande. "Evaluation of Groundwater Quality Characteristics Near Two Waste Sites in Ibadan and Lagos, Nigeria" (2002) 140 *Water, Air and Soil Pollution* 307.
119. Ikporukpo, C.O. "Managing Oil Pollution: Towards an Interactive Approach" in P.O. Sada & M.A. Ajomo & O. Adewale, *Environmental Law and Sustainable Development in Nigeria*, (Lagos: Nigerian Institute of Advanced Legal Studies, 1994).
120. Ilesanmi, A.O. "Urban Sustainability in the Context of Lagos Megacity" (2010) 3(10) *Journal of Geography and Regional Planning* 240.

121. Iwejingi, S.F. "Population Growth, Environmental Degradation, and Human Health and in Nigeria" (2011) 8(4) Pakistan Journal of Social Science 187.
122. Jahan, M. "Impacts of Rural Urban Migration on Physical and Social Environment: the Case of Dhaka City" (2012) Int. Journal of Development and Sustainability 186.
123. Jefferson, M. "The Law of the Primate City" (1939) 29(2) Geographical Review 262.
124. Jhansi, S.C. & S.K. Mishra, "Wastewater Treatment and Reuse: Sustainability Options" (2013) 10 Consilience: The Journal of Sustainable Development 1.
125. Jiboye, A.D. "Urbanization Challenges and Housing Delivery in Nigeria: The Need for an Effective Policy Framework for Sustainable Development" (2011) Int. Review of Social Sciences and Humanities 176.
126. Jones, D.L., K.L. Williamson & A.G. Owen, "Phytoremediation of Landfill Leachate" (2006) 26 Waste Management 825.
127. Jones, F. & J. Watkins, "The Water Cycle as a Source of Pathogens" (1985) Journal of Applied Bacteriology Symposium Supplement 27.
128. Jordaan, S., C. Stevens, & D. Brooks, "Removing Institutional Barriers to Water Soft Paths: Challenges and Opportunities", in D. Brooks. O. Brandes & S. Gurman, eds., *Making the Most of the Water We Have: The Soft Path Approach to Water Management* (Earthscan, London, U.K., 2009) 147.
129. Karmann, E. "Strategies towards Sustainable Wastewater Management" (2001) 3 Urban Water 63.
130. Kasarda, J. & E. Crenshaw. "Third World Urbanization: Dimensions, Theories and Determinants" (1991) 17 Annual Review of Sociology 467.
131. Kaur, S. & M. Singh. "Soil Aquifer System: A Case Study" (2002) 44(3) Indian Journal of Environmental Health 23.
132. Kirchmann, H. & S. Pettersson. "Human Urine Chemical Composition and Fertilizer Use Efficiency" (1995) 40 Fertilizer Research 149.
133. Kola-Olusanya, Anthony. "Impact of Municipal Solid Wastes on Underground Water Sources in Nigeria" (2012) 8(11) European Scientific Journal 1.

134. Kokole, O. H. "The Politics of Fertility in Africa" (1994) 20 Population and Development Review 73.
135. Kroiss, H. "What is the Potential for Utilizing the Resources in Sludge?" (2004) 49(10) Water Science and Technology 1.
136. Ladan, M.T. "Review of NESREA Act 2007 and Regulations 2009-2011: A New Dawn in Environmental Compliance and Enforcement in Nigeria" (2012) 8(1) Law, Environment and Development Journal 116.
137. Lahnsteiner, J., G. Lempert, I.S. Kim, J. Cho, & S. Kim, "Water Management in Windhoek, Namibia" (2007) 55 (1-2) Water Science and Technology 441.
138. Larson, T.A. & W. Gujer, "Separate Management of Anthropogenic Nutrient Solutions (Human Urine)" (1996) 34(3-4) Water Science & Technology 87.
139. Leon, D. "Cities, Urbanization and Health" (2008) 37(4-8) International Journal of Epidemiology (Editorial) 4.
140. Linsky, A. "Some Generalizations Concerning Primate Cities" (1965) 55(3) Annals of the Association of American Geographers 506. Also Available online: <http://onlinelibrary.wiley.com/doi/10.1111/j.1467-8306.1965.tb00531.x/epdf>
141. Llamas, M.R. & P. Martinez-Santos. "Intensive Groundwater Use: A Silent Revolution that Cannot be Ignored?" (2005) 8 Water Science and Technology 167.
142. Longe, E.O., S. Malomo & M.A. Olorunniwo. "Hydrogeology of Lagos Metropolis" (2007) 6(2) African Journal of Earth Sciences 163.
143. Longe, E.O. "Groundwater Resources Potential in the Coastal Plain Sands Aquifers, Lagos, Nigeria" (2011) 3(1) Research Journal of Environmental and Health Sciences 1.
144. Longe, E.O. & M.R. Balogun, "Groundwater Quality Assessment Near a Municipal Landfill, Lagos, Nigeria" (2010) 2(1) Res. J. Appl. Sci. Eng. Technol. 39.
145. Longe, E.O. & L.O. Enekwechi, "Investigation on Potential Groundwater Impacts and Influence of Local Hydrogeology on Natural Attenuation of Leachate at a Municipal Landfill" (2007) 4 Int. Journal of Environ. Sci. Tech. 133.
146. Longe, E.O. & A.O. Ogundipe, "Assessment of Wastewater Discharge Impact from a Sewage Treatment Plant on Lagoon Water, Lagos Nigeria" (2010) 2(3) Research Journal of Applied Sciences, Engineering and Technology 274.

147. Louis, G.E. "A Historical Context of Municipal Solid Waste Management in the United States" (2004) 22 Waste Manage Res 306.
148. Mabogunje, Akin. "The Case for big Cities" (1983) 7(5) HABITAT INTL 21.
149. Mabogunje, Akin. "Reconstructing the Nigerian City: The New Policy on Urban Development and Housing" in D. Amole, A. Ajayi & A. Okewole, eds., *The City in Nigeria: Issues, Challenges and Strategies*, (Ile-Ife, Nigeria: Obafemi Awolowo University, 2002).
150. Mabogunje, Akin. "Urbanization in Nigeria: A Constraint on Economic Development" (1965) 13(4) Economic Development and Cultural Change 413.
151. Mabogunje, A. "The Evolution and Analysis of the Retail Structure of Lagos, Nigeria" (1964) 40(4) Economic Geography 304.
152. MacNeill, J., "Strategies for Sustainable Economic Development" (1989) 261(3) Scientific American 154.
153. MacDonald, A.M. & R.C. Calow. "Developing Groundwater for Secure Water Supplies in Africa" (2009) 248 Desalination 546.
154. MacDonald, A. M., H.C. Bonsor, B.E.O. Dochartaigh, & R.C. Taylor. "Quantitative Maps of Groundwater Resources in Africa" (2012) 7 Environmental Research Letters 024009.
155. Macfarlane, D.S., J.A. Cherry, R.W. Gillham, & E.A. Sudicky, "Migration of Contaminants in Groundwater at a Landfill: A Case Study 1. Groundwater Flow and Plume Delineation" (1983) 63 Journal of Hydrology 1.
156. Magraw, D. B. & L.D. Hawke, "Sustainable Development", in D. Brodansky, J. Brunnee & E. Hey, *The Oxford Handbook of International Environmental Law* (Oxford: Oxford University Press, 2007) 613.
157. Moghadam, M.R.A., N. Mokhtarani, & B. Mokhtarani, "Municipal Solid Waste Management in Rasht City, Iran" (2009) 29 Waste Management 485.
158. Moir, H. "Relationships Between Urbanization Levels and the Industrial Structure of the Labor Force" (1976) 25 Economic Development and Cultural Change 123.
159. Moss, B. "Shallow Lakes, the Water Framework Directive and Life: What Should it all Be About? (2007) 584 Hydrobiologia 381.

160. Muench L.H., & C.Z. Muench. "Planning and Antiplanning in Nigeria: Lagos and Ibadan" (1968) 34(6) *Journal of the American Institute of Planners* 374.
161. Muller, Mike. "Fit for Purpose: Taking Integrated Water Resource Management Back to Basics" (2010) 24(3-4) *Irrigation and Drainage Systems* 161.
162. Nagendran, R. A. Selvam, K. Joseph, & C. Chiemchaisri. "Phytoremediation and Rehabilitation of Municipal Solid Waste Landfills and Dumpsites: A Brief Review" (2006) 26 *Waste Management* 1357.
163. Nicholson, R., J. Cherry, & E. Readon, "Migration of Contaminants in Groundwater at a Landfill" (1983) 63(1-2) *Journal of Hydrology* 131.
164. Nijkamp, P. & F. Soetaman. "Ecologically Sustainable Economic Development: Key Issues for Strategic Environmental Management" (1988) 15(3-4) *Int. Journal of Social Economics* 88.
165. Nnorom, I. & O. Osibanjo. "Electronic Waste (E-Waste): Material Flows and Management Practices in Nigeria" (2008) 28 *Waste Management* 1472.
166. Nwajei, G. E. & P.O. Gagophien "Distribution of Heavy Metals in Sediments of Lagos Lagoon" (2000) 43(6) *Pakistan Journal of Scientific and Industrial Research* 338.
167. Nyenje, P.M. "Eutrophication and Nutrient Release in Urban Areas of Sub-Saharan Africa- A Review" (2010) 408 *Science of the Total Environment* 447.
168. Obiora, D.N. & O. S. Onwuka. "Groundwater Exploration in Ikorodu, Lagos-Nigeria: A Surface Geophysical Surface Contribution" (2005) 6(1) *the Pacific Journal of Science and Technology* 86.
169. Odu, C.T.I. "Oil Pollution and the Environment" in N.O. Adedipe & L.C. Nwoboshi, eds., *Environmental Problems in Nigeria* (Nigerian National Committee of SOPE, 1977).
170. Oghojafor, B.E.A., O.L. Kuye, & G.C. Alaneme. "Concession as a Strategic Tool for Ports Efficiency: An Assessment of the Nigerian Ports" (2012) 1(4) *American Journal of Business and Management* 214.
171. Ogbodo, Gozie. "Environmental Protection in Nigeria: Two Decades after the Koko Incident (2009) 15.1 *Annual Survey of International and Comparative Law* 1.
172. Ogolla, B.D. "Environmental Law in Africa: Status and Trends" (1995) *International Business Lawyer* 412.

173. Ogunba Olusegun. "EIA Systems in Nigeria: Evolution, Current Practice and Shortcomings" (2004) 24 Environmental Impact Assessment Review 643.
174. Olanrewaju, D. "Soak-away Systems and Possible Groundwater Pollution Problems in Developing Countries" (1990) 110 Perspectives in Public Health 108.
175. Olayinka, K. & B. Alo. "Studies on Industrial Pollution in Nigeria: The Effect of Textile Effluents on the Quality of Groundwater in Some Parts of Lagos" (2004) 3(1) Nigerian Journal of Health and Biomedical Sciences.
176. Olorunfemi, F.B. "Land Development and Current Practices in Lagos Metropolis, Nigeria" (2011) 4(12) Journal of Geography and Regional Planning 656.
177. Olufemi, A. "Assessment of Groundwater Quality and Saline Intrusions in Coastal Aquifers of Lagos Metropolis, Nigeria" (2010) 2(10) Journal of Water Resource and Protection 849.
178. Oluwasanmi, H.O. "Land Tenure and Agricultural Improvement in Tropical Africa" (1957) 39(3) Journal of Farm Economics 735.
179. Onwuka, E.C. "Another Look at the Impact of Nigeria's Growing Population on the Country's Development" (2006) 21(1) African Population Studies.
180. O'Riordan, T. & A. Jordan, "The Precautionary Principle in Contemporary Environmental Politics" (1995) 4(3) Environmental Values 191.
181. O'Riordan, T., & A. Jordan. "The Precautionary Principle: A Legal and Policy History", in M. Martuzzi and J. Tickner, *The Precautionary Principle: Protecting Public Health, the Environment and the Future of our Children* (World Health Organization, 2004).
182. Oyegoke, S.O., A.O. Adeyemi, & A.O. Sojobi. "The Challenges of Water Supply for a Megacity: A Case Study of Lagos Metropolis" (2012) 3(2) Int. Journal of Scientific & Engineering Research 1.
183. Park, A.E.W. "A Dual System of Land Tenure: The Experience of Southern Nigeria" (1965) 9 Journal of African Law 1.
184. Palomar P. & I.J. Losada. "Desalination in Spain: Recent Developments and Recommendations" (2010) 255 Desalination 97.

185. Pimentel, D., B. Berger, D. Filiberto, M. Newton, B. Wolfe, E. Karabinakis, S. Clark, E. Poon, E. Abbett & S. Nandagopal. "Water Resources: Agricultural and Environmental Issues" (2004) 54(10) Bio Science 909.
186. Pires, A., G. Martinho, & N. Chang, "Solid Waste Management in European Countries: A Review of Systems Analysis Techniques" (2011) 92 Journal of Environmental Management 1033.
187. Pizent A., B. Tariba & T. Zivkovic, "Reproductive Toxicity of Metals in Men" (2012) 1 Arh Hig Rada Toksikol 35.
188. Polese, M. "Cities and National Economic Growth: A Re-Appraisal" (2005) 42(8) Urban Studies 1429.
189. Poster, S.L., G.C. Daily & P.R. Ehrlich. "Human Appropriation of Renewable Fresh Water", (1999) 271 Science 785.
190. Quigley, J.M. "Urban Diversity and Economic Growth" (1998) 12(2) Journal of Economic Perspectives 127.
191. Radi, L.M., D.J. Kuntz, G. Padmanabham, I.E. Berg, & A.K. Chaturvedi, "Toxicological Evaluation of Leachate from a Closed Urban Landfill" (1987) 38(2) Bull. Env. Contam. Toxicol. 337.
192. Rees, W. "The Ecology of Sustainable Development" (1990) 20(2) Ecologist 18.
193. Ritter, L., K. Solomon, P. Sibley, K. Hall, P. Keen, G. Mattu & B. Linton "Sources, Pathways and Relative Risks of Contaminants in Surface Water and Groundwater; A Perspective Prepared for the Walkerton Inquiry" (2002) 65(1) J. Toxicol. Environ Health A. 1.
194. Rowe, R.K. "Design Options for Hydraulic Control of Leachate Diffusion", in T.H. Chistensen, R. Cossu & R. Stegmann, eds., *Landfilling on Waste: Barriers* (London: F.N. Spon, 1994) 101.
195. Sangodoyin, A.Y. & O.M. Agbawhe. (1992) "Environmental Study on Surface and Groundwater Pollutants from Abattoirs Effluents" (1992) 41 Bioresource Technology 193.
196. Satterthwaite, D. G. McGranahan & C. Tacoli. "Urbanization and its Implications for Food and Farming" (2010) 365 Philosophical Transactions of the Royal Society B. 2809.

197. Shandra, J.M., B. London, & J.B. Williamson, "Environmental Degradation, Environmental Sustainability, and Overurbanization in the Developing World: A Quantitative, Cross-National Analysis" (2003) 46 *Sociological Perspectives* 309.
198. Shannon, M., P. Bohn, M. Elimelech, J.G. Georgiadis, B.J. Marinas, & A.M. Mayes, "Science and Technology for Water Purification in the Coming Decades" (2008) 452 *Nature* 301.
199. Shekdar, A.V. "Sustainable Solid Waste Management: An Integrated Approach for Asian Countries" (2009) 29(4) *Waste Management* 1438.
200. Sinding, S. "The Great Population Debates: How Relevant Are They for the 21st Century?" (2000) 90 *American Journal of Public Health* 1841.
201. Siyanbola, T.O., K.O. Ajanaku, O. James, J. Olugbuyiro, & J. Adekoya. "Physico-Chemical Characteristics of Industrial Effluents in Lagos State, Nigeria" (2011) *G. J. P&A Sci. & Tech* 49.
202. Stutman, H.R. "Salmonella, Shigella and Campylobacter, Common Causes of Diarrhea" (1994) 23(10) *Pediatr. Ann.* 538.
203. Taiwo, A.M., S.O. Ige, & O.O. Babalola, "Assessments of Possible Gonadotoxic Effect of Lead on Experimental Male Rabbits" (2010) 5 *Global Veterinaria* 282.
204. Taiwo, A.M., S.O. Ige, and O.O. Babalola, "Investigations into the Teratogenic Potentials of Lead in Pregnant Rabbit" (2010) 4 *Int. J. Biol. Chem. Sci.*, 809.
205. Takang, J.M. "From Algiers to Maputo: The Role of the African Convention on the Conservation of Nature and Natural Resources in the Harmonization of Conservation Policy in Africa" (2014) 17 *Journal of International Wildlife Law and Policy* 165.
206. Tarlock, Dan "Ideas without Institutions: The Paradox of Sustainable Development" (2001) 9 *Ind. J. Global Legal Stud.* 35.
207. Tarlock, & S. Deutsch, "Symposium on Prevention of Groundwater Contamination in the Great Lakes Region- Foreword" (1989) 65 *Chi.-Kent L. Rev.* 345.
208. Timberlake M. & J. Kentor, "Economic Dependence, Overurbanization, and Economic Growth: A Study of Less Developed Countries" (1983) 24 *the Sociological Quarterly* 489.
209. Trainer, Maria. "Goals, Gaps and Governance: The Holy Grail in Preserving Canada's Liquid Gold" (2010) 380 *Journal of Hydrology* 1.

210. Turner, Allyn. "The Federal Groundwater Regulation and Policy: Improvements Under the Horizon?" (2008) 10 J. Nat Resources & Envtl. Law 323.
211. Uchendu, V.C. "State, Land and Society in Nigeria: A Critical Assessment of Land Use Decree No. 6 of 1978" (1979) 6(2) Journal of African Studies 62.
212. Ufoegbune, G.C., K.I. Lamidi, J.A. Awomeso, A.O. Eruola, O.A. Idowu & C.O. Adeofun. "Hydro-geological Characteristics and Groundwater Quality Assessment in Some Selected Communities of Abeokuta, Southwest Nigeria" (2009) 1(1) Journal of Environmental Chemistry and Ecotoxicology 010.
213. Ukpolo, Victor "Population Growth and Economic Growth in Africa" (2002) 18(4) Journal of Developing Societies 315.
214. Upreti, H.K., P. Shrestha & P. Paudel, Effect of Human Urine as Fertilizer on Crop Production" (2011) 2 Afronomy Journal of Nepal 168.
215. Varis, O. A. Biswas, C. Tortajada, & J. Lundqvist. "Megacities and Water Management" (2006) 22(2) Water Resources Development 377.
216. Weiss, E. "In Fairness to Future Generations and Sustainable Development" (1992) 8(1) American University Int. Law Review 19.
217. Wilson, D.G. "A Brief History of Solid Waste Management" (1976) 9 Int. Journal of Environmental Studies 123.
218. van Braun, J. "Towards a Renewed Focus on Rural Development" (2004) 11(2) Agriculture & Rural Development.
219. van Der Merwe "Integrated Water Resources Management in Windhoek Namibia (2000) 18(1) Water Supply: The Review Journal of the International Water Supply Association 376.
220. Veerapaneni, S., B. Long, S. Freeman, & R. Bond. "Reducing Energy Consumption for Seawater Desalination" (2007) 99 J. Am. Water Works Assoc. 95.
221. Wellisz, S. "Economic Development and Urbanization" in L. Jacobsen and V. Prakash, eds. *Urbanization and National Development*, (Beverly Hills: Calif. Sage Publications, 1973).
222. Wheaton, W.A. & H. Shusido, "Urban Concentration, Agglomerative Economics and the Level of Economic Development" (1981) Econ. Dev. Cult. Change 17.

223. Wilderer, P.A. "Sustainable Water Management in Rural and Peri-Urban Areas: What Technology Do We Need to Meet the UN Millennium Development Goals?" (2005) 51(10) *Water Science and Technology* 1.
224. Yusuf, K.A. "Evaluation of Groundwater Quality Characteristics in Lagos-City" (2007) 7(13) *Journal of Applied Sciences* 1780.
225. Zaporozec, A. "Ground-Water Pollution and its Sources", (1981) 5.5 *GeoJournal* 457.
226. Zhou, Y. & R.S.J. Tol, "Evaluating the Costs of Desalination and Water Transport" (2005) 41 *Water Resources* 1.
227. Zoetman, B.C., E. De Greef, & F.J.J. Brinkmann, "Persistency of Organic Contaminants in Groundwater: Lessons from Soil Pollution Incidents in the Netherlands" (1981) 17 *Studies Environ Sci.* 465.

CONFERENCE PAPERS

1. Adegoroye, A. "The Challenges of Environmental Enforcement in Africa: The Nigerian Experience" Third International Conference on Environmental Enforcement, Proceedings of the 3rd International Conference on Environmental Enforcement.
2. Banire, Muiz. "The Adverse Effects of Over-Exploitation of an Aquifer on the Environment". Paper presented at a workshop organised by the Lagos Water Corporation in Ikeja, Lagos, Nigeria. (December 2007).
3. Cavallaro, A., C. Corradi, G. de Felice, and P. Grassi, 'Underground Water Pollution in Milan and Province by Industrial Chlorinated Organic Compounds', Proceedings of WRC-WHO Conf. *Effects of Land Use on Fresh Waters*, (1985).
4. Collivgnarelli, C. S. Sorlini, & M. Vaccari, "Solid Wastes Management in Developing Countries", ISWA World Congress, October 17th -21st 2004.
5. Esakku, S., K. Palanivelu, & K. Joseph. "Assessment of Heavy Metals in a Municipal Solid Waste Dumpsite" Workshop on Sustainable Landfill Management, 3-5 December 2003 in Chennai, India.
6. Isichei, "Environmental Impact Assessment and Environmental Evaluation Reports" Paper Presented at Workshop of the Nigerian Corrosion Association, Warri, Nigeria, (2000).
7. Iwugo, K.O. "Aspects of Land Based Pollution of an African Coastal Megacity of Lagos" Presented at Diffuse Pollution Conference (Dublin, 2003), Available online.

8. Khan, Razia “From BRICS to BRINCS: Lagos Holds the Key” Presentation made at the 6th Lagos State Economic Summit “Ehingbeti 2012” at Eko Hotel, on April 23-25 2012.
9. Kurukulasuriya L. “The Role of the Judiciary in Promoting Environmental Governance and the Rule of Law” Prepared for Global Environmental Governance: the Post-Johannesburg Agenda Yale Center for Environmental Law and Policy, New Haven (October 2003).
10. Lasisi, A. “Leachate and Groundwater Quality in Lagos State, Nigeria” A Paper presented at a Seminar for Officers of Lagos State Environmental Protection Agency.
11. Longe, E.O. “Groundwater Resource in Water Supply: Lagos State Case Study” (2013) LSWRC Groundwater Workshop June 4th 2013.
12. MacNeill, J., “The Forgotten Imperative of Sustainable Development” Presented at Pace University on April 20th 2006.
13. Mamman, Aliyu Maigari. “Regulating Wastewater Management in Lagos State: How it Affects You! Impacts of Wastewater Mismanagement on Environment, Health, and Water Supply” Paper presented at Lagos State Water Regulatory Commission’s One-Day Stakeholder Summit on Wastewater, October 3rd 2013, Ikeja, Lagos.
14. Moreno-Sanchez, R., J. Maldonado, & I. Sheldon, “The Role of Scavengers in a Dynamic Model of Solid Waste Disposal and Recycling in Developing Countries” Presented at First Latin American and Caribbean Congress on Environmental and Resource Economics, Colombia (2003).
15. Nnadozie, K. “Pollution Control in Nigeria: The Legal Framework” Paper presented at a Workshop at Lagos Sheraton Hotel (April 1994).
16. Obi, F. “Wastewater Management for a Modern City - The Way Forward’ Paper presented at Lagos State Water Regulatory Commission’s One-Day Stakeholder Summit on Wastewater, October 3rd 2013, Ikeja, Lagos.
17. Olokesusi, O. “Lagos: The Challenges and Opportunities of an Emergent African Megacity” Presented at the Nigerian Institute of Social and Economic Research (NISER) Seminar Series (2011).
18. Offodile, M.E. “The Development and Management of Ground Water for Water Supply in Nigeria” Presented at the 2nd Fellow’s Workshop of NMGS, Jos, Nigeria (2000).
19. Olubori, J.O. GM Technical Services, Lagos State Waste Management Authority, “The City of Lagos: Solid Waste Management”, Presented at International Solid Waste Association (ISWA) World Congress, Vienna, Austria, (2013).

20. Oteri, A.U. "Coastal Groundwater Resource- Abstraction, Quality and Related Environmental Concerns: Lagos State Case Study" LSWRC Workshop on Groundwater, June 2013.
21. Oteri, A.U., & F. P. Atolagbe, "Saltwater Intrusion into Coastal Aquifers in Nigeria" (2003), the 2nd Intl. Conf. on Saltwater Intrusion and Coastal Aquifers - Monitoring, Modelling, and Management. Mérida, Yucatán, México, available online.
22. Oyefara, J. L. "Good Governance and Environmental Sustainability in Lagos State, Nigeria: Can the State Achieve Goal Seven of Millennium Development Goals (MDGS)?" (2013) 9(5) European Scientific Journal 41.
23. Sadowsky, M.J., "Phytoremediation: Past Promises and Future Practices", in C.R. Bell, M. Brylinsky, & P. Johnson-Green, eds., Proc. 8th *International Symposium on Microbial Ecology*, (Halifax, Canada: Atlantic Canada Society for Microbial Ecology, 1999).
24. Sililo O. "Groundwater Contamination by Organic Chemicals in Industrializing Countries: An Unseen Threat" Impacts of Urban Growth on Surface Water and Groundwater Quality, Proceedings of IUGG 99 Symposium in Birmingham July 1999.

LEGISLATION: CANADA

Water Opportunities Act, SO 2010, c 19

LEGISLATION: EUROPEAN UNION

1. European Union Council Directive 91/271/EEC Concerning Urban Wastewater Treatment.
2. European Council Directive 1999/31/EC on the Landfill of Waste.
3. European Directive 2008/98/EC of the European Parliament and of the Council on Waste and Repealing Certain Directives.
4. European Union Packaging and Packaging Waste Directive No. 94/62/EC.
5. Directive 2000/60/EC of the European Parliament and the Council Establishing a Framework for Community Action in the Field of Water Policy.
6. Directive 2006/118/EC of the European Parliament and of the Council on the Protection of Groundwater Against Pollution and Deterioration.

7. Directive 80/68/EEC of 17 December 1979 on the Protection of Groundwater against Pollution Caused by Certain Dangerous Substances.

LEGISLATION: NIGERIA

1. Abolition of Pail Latrine System Law (1986), Laws of Lagos State (2003).
2. State Creation and Transitional Provisions Decree (1967).
3. Agricultural (Control of Importations) Act 1964, CAP A13, Laws of the Federation of Nigeria (2004).
4. Constitution of the Federal Republic of Nigeria, (1999), CAP C23 Laws of the Federation of Nigeria (2004).
5. Criminal Code Act 1916, CAP C38, Laws of the Federation of Nigeria (2004).
6. Environmental Impact Assessment Act (1992), CAP E12, Laws of the Federation of Nigeria (2004).
7. Environmental Pollution Control Law (1989), Laws of Lagos State.
8. Environmental Sanitation Law (2000), Laws of Lagos State.
9. Factories Act (1987), CAP F1, Laws of the Federation of Nigeria (2004)
10. Federal Capital Territory Act, Cap F128, Laws of the Federation of Nigeria, (2004).
11. Harmful Wastes (Special Criminal Provisions, etc.) Act (1988), Cap H1, Laws of the Federation of Nigeria (2004).
12. Lagos State Environmental Protection Agency, *Policy on the Environment* (1999).
13. Lagos State Environmental Protection Agency Law, (1996), Laws of Lagos State.
14. Lagos State Government, Lagos State Water Sector Law, Official Gazette No. 24, Vol. 37 (2004).
15. Lagos Waste Management Authority Law (2007), Lagos State Official Gazette, No. 27, Vol. 40.
16. Land Use Act (1978), CAP L5, Laws of the Federation of Nigeria (2004).
17. National Environmental (Surface and Groundwater Quality Control) Regulation, Federal Republic of Nigeria Official Gazette, (2011) No. 49, Vol. 98.

18. National Environmental (Sanitation and Wastes Control) Regulations, Federal Republic of Nigeria Official Gazette, (2009) No. 60, Vol. 95.
19. National Environmental (Electrical/Electronics Sector) Regulations (2011), Federal Republic of Nigeria Official Gazette, No. 50, Vol. 98.
20. National Environmental Standards and Regulations Enforcement Agency (Establishment) Act, Federal Republic of Nigeria Official Gazette 2007 No 92, Vol. 94.
21. National Environmental Protection (Effluent Limitation) Regulations (1991).
22. National Environmental Protection (Management of Solid and Hazardous Waste) Regulations (1991).
23. National Environmental Protection (Pollution in Industries and Facilities Generating Waste) Regulations (1991).
24. River Basins Development Authorities Act (1986) CAP R9, Laws of the Federation of Nigeria (2004).
25. Water Resources Act (1993), Cap W2, Laws of the Federation of Nigeria Revised Ed. (2004).

LEGISLATION: UNITED STATES

1. Energy Policy Act, (1994) Public Law 102 - 486.

INTERNATIONAL LEGAL AGREEMENTS/DECLARATIONS/INSTRUMENTS

1. Founex Report on Development and Environment, (1971).
2. International Conference on Water and the Environment, *Dublin Principles* (1992).
3. Millennium Summit of the United Nations, United Nations Millennium Declaration (2000), *Millennium Development Goal* No. 6 to Combat HIV/AIDS and other Diseases.
4. United Nations Climate Change Conference (2015)
5. United Nations Conference on Sustainable Development, *The Future We Want*, (2012).
6. United Nations Conference on Environment and Development, *the Rio Declaration* (1992).

7. United Nations Conference on Environment and Development (Earth Summit) *Agenda 21*.
8. United Nations Conference on the Human Environment (1972).
9. United Nations Summit on Sustainable Development, 2015 (Transforming Our World)
10. Convention for the Preservation of Wild Animals, Birds and Fish in Africa (London in 1900).
11. Convention Relative to the Preservation of Fauna and Flora in their Natural State (1933).
12. African Convention on the Conservation of Nature and Natural Resources in (Algiers, 1968).

JURISPRUDENCE

1. Donoghue v Stevenson (1932) All ER 1; (1932) UKHL 100; (1932) AC 562.
2. Gbemre v Shell Petroleum Development Company Nigeria Ltd. & Anor (2005) AHRLR 151.
3. Osemobor v Niger Biscuit (1973) 1 CCHCJ 71.
4. Nigerian Bottling Co. v. Ngonadi, (1985) 1 NWLR (PT. 4) 739.
5. Oposa v Factoran, GR No. 101083 (30 July 1993) Supreme Court, Republic of the Philippines.
6. Rylands v. Fletcher (1898) UKHL 1; (1898) LR 3HL 330.
7. Umudje & Anor v Shell-BP Petroleum Development of Nigeria Ltd. (1975) 9/11 S.C. 155.

GOVERNMENT AND OTHER REPORTS

1. *Benefits of Investing in Wastewater: An OECD Perspective (2011)*.
2. Coode Blizzard Ltd, *Hydrogeological Investigation of Lagos State*, Final Report, Vol. 1, (1997).
3. Corcoran, E., C., C. Nellesmann, E. Baker, R. Bos, D. Osborn, & H. Savelli (eds.) "Sick Water? The Central Role of Wastewater Management in Sustainable Development,

- (2010) A Rapid Response Assessment” United Nations Environment Program, UN-HABITAT, GRID-Arendal. Online: www.grida.no/publications/rr/sickwater/.
4. Food and Agriculture Organization of the United Nations, *Law for Water Management, A Guide to Concepts and Effective Approaches*, (Rome: Electronic Publishing and Support Branch, 2009).
 5. Food and Agriculture Organization of the United Nations, *Monitoring Agricultural Water Use At Country Level: Experiences of a Pilot Project in Benin and Ethiopia* (2011).
 6. Lagos State Ministry of Economic Planning and Budget, *Digest of Statistics* (2011).
 7. Lagos State Ministry of Economic Planning and Budget, *Digest of Statistics*, (2012).
 8. Hydromarine Engineering Co. Ltd., *Report of the Monitoring Boreholes Drilled at Landfill Sites - Abule Egba & Igando, Lagos State* (2008).
 9. Hydromarine Engineering Company Ltd., *Report of the Surface Geophysical Investigation Carried out at Landfill Sites- Abule Egba, Igando, & Olushosun and Yaba Transfer Loading Station, Lagos State* (2008).
 10. Jacobsen, M., M. Webster, & K. Vairavamoorthy. *The Future of Water in African Cities: Why Wastewater?* Directions in Development, (Washington, D.C.: the World Bank, 2013).
 11. Lagos State Government, *Final Report on Effluent Limitations Standards and Guidelines* (1999).
 12. Lagos State Government, *Lagos State Development Plan 2012 – 2025* (Lagos: Ministry of Economic Planning and Budget, 2013).
 13. Lagos State Government, *State of the Environment Report- Lagos 2010*.
 14. Lagos State Government, *Lagos Metropolitan Development & Governance Project (LMDGP Report) Solid Waste Management Component Environmental & Social Impact Assessment*, Final Report (2009).
 15. Lagos State *Policy on the Environment* (1989).
 16. Lagos Wastewater Management Office, *Five-Year Strategic Investment Plan for Sewage* (2011-2015).
 17. Morris, B.L, A.R.L Lawrence, P.J.C. Chilton, B. Adams, R.C. Calow, & B.A. Klinck. *Groundwater and its Susceptibility to Degradation: A Global Assessment of the Problems and Options for Management*. Early Warning and Assessment Report Series, RS. 03-3. (Nairobi, Kenya: United Nations Environment Programme, 2003).

18. Natural Resources Defence Council, *The Story of Silent Spring*, Online:
<http://www.nrdc.org/health/pesticides>.
19. Nigeria *National Policy on the Environment* (1999).
20. SEDEC Associates, *2008 State of the Nigerian Environment Report*, (Abuja, Nigeria: Federal Ministry of the Environment, 2008).
21. UN Habitat, *State of the World's Cities 2006/7 Urbanization*. Online:
http://www.unhabitat.org/documents/media_centre/sowcr2006/SOWCR%202.pdf.
22. United Nations, Department of Economic and Social Affairs Population Division, *World Urbanization Prospects: the 2014 Revision, Highlights* (available online).
23. United Nations Environment Programme ('UNEP'), *Training Module: Closing an Open Dumpsite and Shifting from Open Dumping to Controlled Dumping and to Sanitary Land Filling* (2005).
24. United Nations Human Settlements Programme (UN-HABITAT), *World Urban Forum III, Urbanization Facts and Figures* (2006). Available online.
25. United Nations Human Settlements Programme (UN-HABITAT), *Solid Waste Management in the World's Cities. Water and Sanitation in the World's Cities* (Earthscan Ltd, Dunstan House, London 2010).
26. United Nations Human Settlements Programme (UN HABITAT), *State of the World's Cities 2006-2007*, Available online.
27. United States Environmental Protection Agency, *DDT - A Brief History and Status*, Online: <http://www2.epa.gov/ingredients-used-pesticide-products/ddt-brief-history-and-status>.
28. United States Department of Health and Human Services, Agency for Toxic Substances and Diseases Registry, *Toxicological Profile for Cadmium*, (2012) Available online.
29. United Nations Environment Program, *Global Mercury Assessment- Sources, Emissions, Release and Environmental Transport* (2013) Online:
<http://www.unep.org/PDF/PressReleases/GlobalMercuryAssessments2013>
30. United States Geological Survey, *Groundwater Availability in the United States*, Circular 1323 (2008). Online: www.usgs.gov.
31. United States Geological Survey, *Groundwater and Aquifers FAQs*, online:
<http://www.usgs.gov/faq/categories/9812/2776>.
32. United States Geological Survey, *Contaminants Found in Groundwater*, online:
<https://water.usgs.gov/edu/groundwater-contaminants.html>.

33. United States Geological Survey (USGS), *Groundwater and Surface Water - A Single Resource*, U.S. Geological Survey Circular 1139, Available online.
34. United States Geological Survey, *Definitions*, (2014) Online: http://toxics.usgs.gov/definitions/natural_attenuation.html
35. United States Geological Survey, *Natural Attenuation Strategy for Groundwater Cleanup Focuses on Demonstrating Cause and Effect* (2014) Online: <http://toxics.usgs.gov/pubs/eos-v82-n5-2001-natural/>
36. United States Fire Administration, Federal Emergency Management Agency, *Landfill Fires - Their Magnitude, Characteristics, and Mitigation* (TriData Corporation, Arlington, VA, 2002).
37. U.S. Environmental Protection Agency, *Procedures Manual for Groundwater Monitoring of Solid Waste Disposal Facilities* (1980, Available online).
38. UNHABITAT, *State of African Cities* (2010).
39. UNHABITAT *The State of African Cities* (2014).
40. Walkerton Inquiry, reported in *Ontario, Report of the Walkerton Inquiry Part I* (Toronto: Ministry of the Attorney General 2002).
41. World Energy Council, *World Energy Resources: 2013 Survey*, (2013).
42. World Savvy Monitor, *Water as Key to Economic Development*, Online: <http://worldsavvy.org>
43. World Water Council, Second World Water Forum, Ministerial Declaration of the Hague on Water Security.
44. World Bank, *Sustainable Groundwater Management Concepts and Tools, Utilization of Non Renewable Groundwater: A Socially-Sustainable Approach to Resource Management* (2005). Online: <http://un-igrac.org>.
45. World Bank, *Developing Countries Need to Harness Urbanization to Achieve the MDGs: IMF-World Bank Report*, Online: <http://www.worldbank.org/en/news/press-release/2013/04/17/developing-countries-need-to-harness-urbanization-to-achieve-mdgs-imf-world-bank-report>.
46. World Bank, *Urbanization and Economic Growth*.
47. World Bank, *Groundwater Quality Protection, A Guide for Water Utilities, Municipal Authorities and Environmental Agencies*, (Washington D.C.: 2002).

48. World Health Organization, *Water Quality Assessments-A Guide to Use of Biota, Sediments and Water in Environmental Monitoring* (London, England: F & FN Spon 1996).
49. World Health Organization, *Exposure to Benzene: A Major Health Concern*, online <http://www.who.int/ipcs/features/benzene.pdf>

THESES

1. Aderibigbe, A. *Expansion of the Lagos Protectorate, 1863-1900* (Ph.D. Thesis, University of London: 1959) [unpublished]
2. Tettey-Lowor F. *Closing the Loop Between Sanitation and Agriculture in Accra, Ghana* (Master's Thesis, Wageningen University, Netherlands, 2008), available online.
3. Hoglund, Caroline. *Evaluation of Microbial Health Risks Associated with the Reuse of Source Separated Human Urine*, (PhD. Thesis, Dept. of Biotechnology, Royal Institute of Technology, Stockholm, Sweden, 2001) ISBN91-7283-039-5. Available online

WEB-BASED MATERIALS

1. Adeniran, A. "Alternative Sewage Treatment Option: The Effect of Use of Water Hyacinth (*Eichhornia Crassipes*) in the Treatment of Domestic Sewage", Online: <http://www.slideshare.net/engrae/alternative-sewage-treatment-option-for-developing-countries>.
2. Agboje, I.A., A. Adetola & B.O. Irhivben, "Performance Assessment of Solid Waste Management following Private Partnership Operations in Lagos State, Nigeria" (2014) *Journal of Waste Management*, Online: <http://dx.doi.org/10.1155/2014/868072>.
3. Bartlett, A. "Laws of Sustainability": <http://www.resilience.org/stories/2009-11-06/dr-albert-bartletts-laws-sustainability>.
4. Biswas, A. J. Lunqvist, C. Tortajada, & O. Varis, "Water Management for Megacities" Online: http://www.researchgate.net/profile/Asit_Biswas/publication/228886418_Water_management_for_megacities/links/09e41509e53f9b33a1000000.pdf.
5. Bezemer, D. J. & D. Heady, "Agriculture, Development and Urban Bias", MPRA Paper No. 7026. Online: <http://mpra.ub.uni-muenchen.de/7026/1/MPRApaper7026.pdf>
6. Burian, F.J.& F.G. Edwards, "Historical Perspectives of Urban Drainage" Online: <http://unix.eng.ua.edu/~rpitt/Class/International%20urban%20water%20systems/M1%20Burian%20paper.pdf>

7. Chen, M. H. Zhang, W. Liu, W. Zhang. "The Global Pattern of Urbanization and Economic Growth: Evidence from the Last Three Decades" (2014) Online:
<http://journals.plos.org/plosone/article?id=10.1371/journal.pone.0103799>.
8. Chun, D.H, & K.S. Lee, "Changing Location Patterns in Population and Employment in the Seoul Region" Report No. UDD-65, World Bank, Washington D.C.:
<http://documents.worldbank.org/curated/en/1985/04/1554190/changing-location-patterns-population-employment-seoul-region>.
9. Cooper, P.F. "Historical Aspects of Wastewater Treatment" in P. Lens, B. Zeeman, & G. Letting, eds., *Decentralized Sanitation and Reuse: Concepts, Systems and Implementation* (IWA Publishing, 2007):
<http://www.personal.leeds.ac.uk/~cen6ddm/History/HistSewTreat.pdf>.
10. Ebomhe, S.E. "Environmental Legislation Changes in Nigeria: What Impact on Foreign Investment?" (2006): <http://geplaw.com/wp-content/uploads/2014/11/Environmental-Legislation-Changes-in-Nigeria.pdf>.
11. Elimelech, M. Department of Chemical Engineering, Yale University; Interview by T. Miller "Can Seawater Solve our Water Woes?" (2011) Available online:
<http://www.pbs.org/newshour/rundown/can-seawater-solve-our-water-woes/>
12. European Environment Agency, Environmental Terminology and Discovery Service:
<http://glossary.eea.europa.eu/>
13. Fagbohun, O. "Mournful Remedies, Endless Conflicts, and Inconsistencies in Nigeria's Quest for Environmental Governance: Rethinking the Legal Possibilities for Sustainability" 4th Inaugural Lecture, Nigerian Institute for Advanced Legal Studies:
[http://www.elri-ng.org/Inaugural%20Paper%20-%20Prof%20Fagbohun%20\(NIALS\).pdf](http://www.elri-ng.org/Inaugural%20Paper%20-%20Prof%20Fagbohun%20(NIALS).pdf)
14. Foster, S.S.D. "Impacts of Urbanisation on Groundwater", UNESCO-IHP III International Symposium, URBAN WATER 88: FR Germany- The Netherlands (1988):
http://hydrologie.org/redbooks/a198/iahs_198_0187.pdf.
15. Galiani, S. & S. Kim. "Political Centralization and Urban Primacy: Evidence from National and Provincial Capitals in the Americas" in D.L. Costa & N.R. Lamoreaux, eds., *Understanding Long-Run Economic Growth: Geography, Institutions, and the Knowledge Economy* (University of Chicago Press, U.S. 2011) 121:
<http://www.nber.org/books/cost10-1>
16. Grossman, M.R. "Agriculture and the Polluter Pays Principle" Netherlands Comparative Law Association. Online:
http://heinonline.org/HOL/Page?handle=hein.journals/oklr59&div=7&g_sent=1&collection=journals

17. Harris, J.M. “Basic Principles of Sustainable Development” (Global Development and Environment Institute, Tufts University 2000):
<http://econwpa.repec.org/eps/dev/papers/0106/0106006.pdf>
18. Harris, J.M. “Sustainability and Sustainable Development”, International Society for Ecological Economics, Internet Encyclopaedia of Ecological Economics:
<http://isecoeco.org/pdf/susdev.pdf>.
19. Harris, Nigel. “Urbanization, Economic Development and Policy in Developing Countries” (1990):
<https://www.bartlett.ucl.ac.uk/dpu/publications/latest/publications/dpu-working-papers/WP19.pdf>
20. Henderson, J.V. “Urbanization in China: Policy Issues and Options” (2009):
www.econ.brown.edu
21. Jedwab, R. L. Christiaensen, & M. Gindensky, “Demography, Urbanization and Development: Rural Push, Urban Pull and ... Urban Push?” (2014) Online:
<http://www.parisschoolofeconomics.eu/IMG/pdf/pse-rues-juin2014-jedwab.pdf>.
22. Johanssen, M. *Urine Separation - Closing the Nutrient Cycle Final Report on the R & D Project Source Separated Human Urine - A Future Source of Fertilizer for Agriculture in the Stockholm Region?* (2000) Online: <http://www.sswm.info/library/1340>
23. Joseph, K., R. Nagendran, & L. Palanivelu. “Open Dumps to Sustainable Landfills” Centre for Environmental Studies, Anna University, Chennai India: http://www.researchgate.net/publication/228737059_OPEN_DUMPS_TO_SUSTAINABLE_LANDFILLS
24. King, Russell. “Theories and Typologies of Migration: An Overview and a Primer”, Willy Brandt Series of Working Papers in International Migration and Ethnic Relations (2012) Online:
<https://www.mah.se/upload/Forskningscentrum/MIM/WB/WB%203.12.pdf>
25. Mabogunje, A. “Land Reform in Nigeria: Progress, Problems and Prospects” online:
<http://siteresources.worldbank.org/EXTARD/Resources/336681-1236436879081/5893311-1271205116054/mabogunje.pdf>
26. Malthus, Thomas “An Essay on the Principle of Population” (1798):
<http://www.esp.org/books/malthus/population/malthus.pdf>
27. Marsalek, J. & H. Schreier “Innovation in Storm Water Management in Canada: The Way Forward” Water Quality Research Journal of Canada:
http://www.mcgill.ca/files/water2010/Article-Marsalek_and_Schreier.pdf

28. McCasland, M., N.M. Trautmann, R.J. Robert, & K.S. Porter, "Nitrate: Health Effects in Drinking Water" (2007) Centre for Environmental Research and Natural Resources (Cornell University Cooperative Extension) available online:
<http://psep.cce.cornell.edu/facts-slides-self/facts/nit-heef-grw85.aspx>
29. McCutcheon, S. C. & J.L. Schnoor, "Overview of Phytoremediation and Control of Wastes", in S.C. McCutcheon, C. Steven, & J.L. Schnoor, eds., *Phytoremediation: Transformation and Control of Contaminants* (New York: John Wiley & Sons Inc.,1987): <http://onlinelibrary.wiley.com/doi/10.1002/047127304X.ch1/summary>
30. Moller, G. Solid Waste Management in the Developed and Developing World, Principles of Sustainability Chapter 3: Culture of Waste. University of Idaho Online:
<http://vimeo.com/29337858>
31. Moench, M. "Groundwater and Poverty: Exploring the Connections": http://new-test.fundacionbotin.org/89dguuytdfr276ed_uploads/Observatorio%20Tendencias/PUBLICACIONES/LIBROS%20SEM%20INTERN/intensive%20use%20groundwater/cap21-intensiveuse.pdf
32. Morales, M. & G. Oberg. *The Idea of Sewage as a Resource: An Introductory Study of Knowledge and Decision Making in Liquid Waste Management in Metro Vancouver, B.C. Canada*, (British Columbia, Canada: Institute of Resources, Environment and Sustainability, 2012): <http://watergovernance.ca/wp-content/uploads/2012/03/Gunilla-Oberg-Sewage-as-a-resource-10April2012.pdf>
33. Onibokun, A.G. & A.J. Kumuyi. "Governance and Waste Management in Africa": <http://dspace.africaportal.org/jspui/bitstream/123456789/15357/4/Chapter%201.pdf?1>
34. Oseni, B. "Summary of the Land Use Act Decree No. 6 of 1978 in Nigeria": <http://nigeriaenvironment.blogspot.ca/2012/11/summary-of-land-use-act-decree-no-6-of.html>
35. Peng, X., X. Chen, & Y. Cheng. "Urbanization and its Consequences", Online:
<http://www.eolss.net/sample-chapters/c04/e6-147-18.pdf>
36. Pivetz, Bruce E., United States Environmental Protection Agency: Office of Research and Development (2001) "Phytoremediation of Contaminated Soil and Groundwater at Hazardous Waste Sites" :
http://www.epa.gov/superfund/remedytech/tsp/download/epa_540_s01_500.pdf
37. Puckett Jim, L. Byster, S. Westervelt, R.Gutierrez, S.Davis, A. Hussain, & M. Dutta. *Exporting Harm: The High-Tech Trashing of Asia*. (2002)The Basel Action Network (BAN). Online: <http://www.ban.org/E-waste/technotrashfinalcomp.pdf>
38. Rodic-Wiersma, L., D.C. Wilson & D. Greedy. "Waste Scavenging at Dumpsites in Economically Developing Countries" (Available online)

39. Scanlan, Melissa, K. "Sustainable Sewage" http://www-assets.vermontlaw.edu/Assets/directories/FacultyDocuments/Scanlan_Sustainable%20Se wage%20IUCN%20chapter%203-23-15.pdf
40. Taiwo, A.M., "Source Identification and Apportionment of Pollution Sources in Groundwater Quality in Major Cities in Southwest Nigeria (2012) 29 GEOFIZIKA : http://geofizika-journal.gfz.hr/vol_29/No2/29_2_Taiwo.pdf
41. Tchounwou, P.B., C.G. Yedjou, A.K. Patlolla, & D.J. Sutton, "Heavy Metals Toxicity and the Environment (2012) 101 EXS. 133
42. The Economist, "Tapping the Oceans" (2008), Online: <http://www.economist.com/node/11484059>
43. The Guardian, *Hello Nollywood: How Nigeria Became Africa's biggest Economy Overnight*, Online: <http://www.theguardian.com>
44. Tolley, G.S. "Urbanization and Economic Development", Online: <http://www.rrojasdatabank.info/econurb87/econurbp27-43.pdf>
45. Toth, J. "Groundwater in Igneous, Metamorphic and Sedimentary Rocks": <http://www.eolss.net/sample-chapters/c07/e2-09-01-02.pdf>
46. World Savvy Monitor, *Water as Key to Economic Development* , Online: <http://worldsavvy.org>

OTHER MATERIALS

1. Aganga, O. (Lagos Commissioner for Trade and Investment) "Investment Climate and Competitiveness in Nigeria: Lagos State Holds the Key" Presentation made at the 6th Lagos State Economic Summit "Ehingbeti 2012" April 23-25 2012.
2. Fashola, Raji. (Lagos State Governor) Keynote Address Presented at the 6th Lagos State Economic Summit "Ehingbeti 2012" at Eko Hotel on April 23-25, 2012.
3. Khan, R. "From BRICS to BRINCS: Lagos Holds the Key" Presented at the 6th Lagos State Economic Summit "Ehingbeti 2012" at Eko Hotel, April 23-25 2012.
4. Lawrence, A.R. & S.S.D. Foster. "The Pollution Threat from Agricultural Pesticides and Industrial Solvents" Hydrogeology Research Report of the British Geological Survey No. 87/2 (Oxfordshire, 1987).
5. Nigeria Weekly Standard, "Toxic Chemical Waste Knocks off 25 Students and 2 Teachers", Online: <http://weeklystandardng.com>.

6. Olukoju, *Infrastructure Development and Urban Facilities in Lagos, 1861-2000*, Occasional Publication No. 15, Institut Français de Recherche en Afrique, (Ibadan, Nigeria: 2003).
7. The Holy Bible. (New International Version).

APPENDIX

COMPENDIUM OF INTERVIEW QUESTIONS

Graduate Studies in Law, Faculty of Law, University of Ottawa

Doctor of Philosophy (PhD Law) Program

Research Topic: Sustainable Groundwater Management in Lagos, Nigeria: The Regulatory Framework

Candidate: **Adebola Ogunba**

Respondent: **Water Officials, Lagos Water Corporation**

1. For a long time there have been water shortages across the state and this has compelled citizens to source for water by themselves.
 - a. What are the problems that account for these water shortages?
 - b. What proportion of the population's water needs is the water Corporation servicing?
 - c. What problems are you encountering in the supply of water to residents?
 - d. Are there any particular social or other impediments to an uninterrupted supply of water in the state?
 - e. How do you think these problems can be tackled?
 - f. What measures are in place to address these problems and to ensure a sustainable water provision for citizens?
2. Does the state source for water from surface sources or from groundwater for municipal supply?
 - a. Can you please refer me to the state's current statistics on water sourced from surface water compared with water sourced from groundwater by citizens?
 - b. What is accountable for the preference for or reliance on surface/groundwater by the state?
 - c. Please give us an update about the Micro groundwater projects that is currently on.
3. Research shows that citizens have overwhelmingly resorted to exploiting groundwater for domestic uses. What is responsible for citizens' resort to groundwater?
4. The River Basins Development Authority Act envisaged a national conjunctive management of surface and groundwater. How practicable is it to integrate ground and surface water management?
5. Who has responsibility for groundwater management?
 - a. Who has responsibility for intra-state groundwater?
 - b. Who is responsible for inter-state groundwater management?
 - c. Are there overlaps in allocation of responsibilities?
 - d. If yes, has this caused hitches or bottlenecks or other problems in water administration?
6. Is a conjunctive management of groundwater and surface water desirable?

- a. Is it feasible? If no, why is it not feasible?
 - b. If yes, how soon can this be practicably implemented?
7. Is groundwater adequately protected by regulation in the state?
8. What impediments are there to enforcement of the regulations for groundwater?
 - a. What impediments are there to pollution-free groundwater?
9. Research shows that distributed sewage ejection poses a particular threat to groundwater quality. What is the solution to this pervasive culture of distributed wastewater disposal?
 - a. Within the varied users and uses of water in the State, which do you perceive as the most significant?
 - b. What conflicts, if any, are presented by these water uses?
 - c. Does any particular use of water present any special challenges?
10. Research has shown that the location of wells close to waste dumps is presently polluting groundwater. How do you address this problem?
11. The haphazard exploitation of groundwater is another related problem posed to sustainable groundwater. How can this be tackled?
12. How adequately have the varied users/uses of water managed the wastewater from their activities?
 - a. Is waste water properly disposed of in the municipality and by the varied water users?
13. It is clear that there are very adverse effects of improperly disposed waste and waste water on groundwater in the state. Have there been any recent significant adverse impacts on groundwater?
14. How do you think that groundwater may be protected from harmful effects of the varied water uses?
15. In December 2007, Lagos Water Corporation organized a workshop on the need for borehole licensing in the state.
 - a. What is the Corporation's objective in this licensing drive?
 - b. Has licensing now taken place?
 - c. If yes, what has the experience been like? What are the accomplishments? What are the medium to long term expectations from that project?
 - d. What impacts would the project have on protecting the quality of groundwater?
 - e. What impacts is the project expected to have on sustainable groundwater provision in the state?
 - f. Please describe the division of responsibilities between Water Corporation and Wastewater Management Office. Has this enhanced protection of the groundwater or surface water resources?
16. Can you refer me to any helpful sources of information?

Graduate Studies in Law, Faculty of Law, University of Ottawa

Doctor of Philosophy (PhD Law) Program

Research Topic: Sustainable Groundwater Management in Lagos, Nigeria: The Regulatory Framework

Candidate: Adebola Ogunba

Respondent: Lagos State Environmental Protection Agency (LASEPA)

1. LASEPA has oversight responsibility to protect the natural resources of Lagos state's environment: air, land, and water resources. This project is concerned about the groundwater resource which is threatened by pollution from waste and sewage. Please describe your agency's efforts to address the pollution problems from these 2 sources.
2. Lagos Water Corporation has direct responsibility for water provision and protection. How does LASEPA share this responsibility with the Corporation? Are there any overlaps or omissions in the allocation of functions?
3. Can you give figures for the quantum of waste from commercial centres, from households and other sources? Which waste from what source presents the biggest challenge?
4. Open dumps are the approved method of solid waste disposal in the State. But researchers have demonstrated that this method is prone to problems of leaching into underground water, and that open dumps serve as a breeding ground for harmful rodents
 - a. In view of these problems, are there realistic alternatives to the open dumps method of waste management?
 - b. Please describe these alternatives?
 - c. Is your agency working at implementing some of these alternative methods?
 - d. Are there any social or political impediments to implementing these alternative waste treatment methods?
 - e. Which is the most feasible and the most probable alternative waste disposal method?
 - f. When is it likely to be implemented?
5. In the state, people have traditionally dumped waste indiscriminately in gutters, canals, on the streets, and in streams and rivers.
 - a. What is the cause of this indiscriminate waste disposal in the state?
 - b. Are there any social, economic, or other reasons responsible for the people's haphazard dumping of waste?
 - c. How is your agency addressing/how has your agency addressed this peculiar problem?
6. The problem with wastewater is related to the distributed ejection method that research shows is now encroaching on groundwater. This is apart from wastewater being generally untreated. How is LASEPA addressing this wastewater problem in the municipality?

7. LASEPA has direct responsibility for wastewater from industries. Presently we learnt that companies are not treating their wastewater to acceptable/legal standards. How is LASEPA addressing this? Are there plans to re-instate the central treatment plant provided by WEMABOD in the 1980s so that treated wastewater released back into the environment is safe?
8. A related problem confronting groundwater is the haphazard exploitation of groundwater for wells and boreholes. Does your agency have any policies or strategies in place to correct this?
9. Research has shown that the haphazard location of wells close to waste dumps has caused them to become highly polluted due to leachate from the waste. What measures are in place to correct this error? (2 perspectives: waste managers and water managers)
10. Why is there yet no formal sorting & recycling? Plastics, garbage, metals, etc are still being dumped together. When will sorting from source, re-use, & recycling start in earnest like in countries that are aware of the harmful impacts on the environment and in order to safeguard the environment? Do people need public enlightenment?
11. Whilst walking towards the Ikeja bus stop, I observed a stench from the gutters that is caused by haphazard dumping of waste and sewage into surface waters and open drains by citizen. The same awful stench applies to the Lagos lagoon. The hydrological link between surface and groundwater means that this contamination eventually reaches groundwater. What measures are in place to alter this regrettable attitude and to clean up the surface water?
12. Can you please make available the current laws on groundwater in the state?
13. In your opinion and with your experience, how can groundwater in the state be sustainably managed, free from pollution and haphazard exploitation?
14. Can you please refer me to other sources of information including useful documents?

Graduate Studies in Law, Faculty of Law, University of Ottawa

Doctor of Philosophy (PhD Law) Program

Research Topic: **Sustainable Groundwater Management in Lagos, Nigeria: The Regulatory Framework**

Candidate: **Adebola Ogunba**

Respondent: **Wastewater Management Officials**

1. The Lagos Wastewater Management Office is fairly new in creation. It was carved out of the erstwhile Sewage Department of the Office of Drainage Services in 2010 to oversee wastewater management in the state, and was incorporated into the Lagos Water Corporation

b. It was not possible to get a copy of your policies or laws or regulations online. What is the enabling law? How can copies be obtained?

c. Can you please direct me to regulations made under the enabling law, or any made so far?

2. There are diverse sources of wastewater: households, commercial centers, hospitals, and industries, to mention the obvious ones. Please describe the efforts that your department is making to treat wastewater from each and all these sources.

3. Industrial waste particularly from textiles companies and other companies using lots of chemicals are presenting a particular pollution problem to aquifers, and there are reportedly cases of aquifers becoming of extremely high temperature and unfit for human use as a result. How is your department addressing this serious problem?

4. Hospital wastewater is particularly hazardous to human health. Are there any special ways designed by your department to treat this?

5. Regulations made under FEPA had specific rules about the treatment of industrial wastewater. However, FEPA was concerned almost exclusively with wastewater from industries. How is your department tackling sewage from the municipality (households, commercial centers, hospitals)?

6. Has NESREA and the Regulations made under it had any impact on your work?

7. Who owns groundwater in the state? Is it the Federal Government or Lagos state government? The water act stipulates that the Federal Government owns all inter-state groundwater. What impact does this ownership of water have on your work?

8. Let's assume that Lagos State has responsibility for groundwater running across its territory. At the moment groundwater is threatened by sewage and solid waste from diverse sources. What measures are in place to tackle this? As your department is a part of Lagos Water Corporation, what specific measure do you have in place to protect groundwater?

9. Whilst walking towards the Ikeja bus stop, I observed a stench from the gutters that is caused by waste and wastewater into these and other open drains/surface waters. The same awful stench applies to the Lagos lagoon. The hydrological link between surface and groundwater means that this contamination eventually reaches groundwater. What measures are in place to alter this regrettable attitude?

b. Of course the problem of indiscriminate waste disposal is due to more fundamental ones. Do you identify any?

10. Distributed wastewater ejection is a major threat to groundwater, particularly because in the state and indeed the country it is untreated. Yet it is difficult to alter to a centralized collection and treatment system at this stage because the areas are developed.

- a. What do you think that your department can do at this stage to treat wastewater and curtail its threat to groundwater?
- b. Are there any plans for a centralization of wastewater collection and treatment?
11. Research has shown that the haphazard location of wells close to waste dumps has caused them to become very polluted. What measures are in place to correct this error?
12. How does your department streamline its work with that of the Water Corporation to avoid duplications or omissions in coverage of the various responsibilities for water supply and waste water treatment?
13. In your opinion and with your experience, how can groundwater in the state be sustainably managed, free from pollution and haphazard exploitation?
14. Can you refer me to any helpful sources of information?
15. It may be necessary for another meeting based on issues arising from this one. Will that be ok?

Graduate Studies in Law, Faculty of Law, University of Ottawa

Doctor of Philosophy (PhD Law) Program

Research Topic: **Sustainable Groundwater Management in Lagos, Nigeria: The Regulatory Framework**

Candidate: **Adebola Ogunba**

Respondent: **Water Professors/Scientists**

1. Scientific research findings reveal the migration of pollutants into groundwater from diverse sources. Please describe your understanding about the current and most consistent sources of groundwater pollution?
 - b. What are the current likely impacts on human health of these contaminants?
2. What are the underlying reasons behind these causes of pollution?
 - a. Are there social or other factors responsible for the pollution?
3. Based on your empirical work, what is the current status of aquifer degradation across the Lagos state?
 - a. Where are the aquifers at special risk located?
 - b. What is responsible for their being at risk?
 - a. Can you please summarize the status of degradation of aquifers in Lagos?
 - b. Would you say the problem is getting resolved, or is worsening?
 - c. If worsening, what are the immediate causes of the deterioration?

- d. I would like to visit one of these aquifer sites for a hands-on understanding of the problems posed. When can we schedule this visit?
4. **Distributed sewage disposal** is the accepted form of disposal in the state. Research shows that groundwater is at risk from this system because the discharge of sewage is not centrally collected and treated. The problem is pronounced/urgent in areas of high water table and saltwater, with an epidemic imminent. Yet in these developed areas, the problem cannot easily be corrected with central collection/treatment. How do you think that this problem can be addressed?
5. **Waste dumps** have been found to constitute a real pollution problem and a significant threat to groundwater. It has been shown that some residences in the neighborhood of waste dumps have found their groundwater to be contaminated beyond human use. How do you think this pollution problem can be effectively corrected?
6. How can the research findings that reveal extensive and continuing pollution of groundwater from anthropogenic activities be reflected in groundwater policies, and translate to effective measures for groundwater protection?
7. As groundwater and surface water connected in the hydrological cycle, can you describe how groundwater interacts with surface water in the hydrological cycle?
8. Can the two water resources be managed conjunctively?
 - a. What benefits are there to a conjunctive management?
 - b. How can the conjunctive management be realistically implemented?
 - c. What benefits are there in a separate management?
9. Research indicates that the management of groundwater is not as adequate as the surface counterpart, and that the groundwater resource has largely been overlooked.
 - a. What is responsible for this?
 - b. How can it be corrected?
10. In your expert opinion and experience, why is groundwater so important for Lagos?
 - a. What special considerations should be in contemplation to manage this special resource?
 - b. How should these peculiarities be addressed so that the management of groundwater is effective?
11. Can you refer me to any helpful sources of information and publications?

Graduate Studies in Law, Faculty of Law, University of Ottawa

Doctor of Philosophy (PhD Law) Program

Research Topic: **Sustainable Groundwater Management in Lagos, Nigeria: The Regulatory Framework**

Candidate: **Adebola Ogunba**

Respondent: **Officials of the Lagos State Waste Management Authority (LAWMA)**

17. Open dumps are the approved method of solid waste disposal in the State. But some researchers have demonstrated that this method is prone to problems of leaching into underground water, and that open dumps serve as a breeding ground for harmful rodents
 - g. In view of these problems, are there realistic alternatives to the open dumps method of waste management?
 - h. Please describe these alternatives?
 - i. Is your agency working at implementing some of these alternative methods?
 - j. Are there any social or political impediments to implementing these alternative waste treatment methods?
 - k. Which is the most feasible and the most probable alternative waste disposal method?
 - l. When is it likely to be implemented?
18. In the state, people have traditionally dumped waste indiscriminately in gutters, canals, on the streets, an in streams and rivers.
 - d. What is the cause of this indiscriminate waste disposal in the state?
 - e. Are there any social, economic, or other reasons responsible for the people's haphazard dumping of waste?
 - f. How is your agency addressing/how has your agency addressed this peculiar problem?
19. Sewage has historically been disposed of in a de-centralised manner. Research shows that this method is prone to problems including a need for frequent dislodgment, and also constitutes a serious health risk to drinking wells located nearby.
 - a. How is your agency addressing this problem?
20. Hospital waste is particularly hazardous to human health. Are there any special ways designed by your agency to treat this?
21. May I have your updated figures on the population in Lagos State to compare with mine?
22. In view of augmenting population what is the current quantum of waste generated daily/weekly/monthly in the state?
 - a. What impact does the population have on waste generated in the state?
 - b. Does the population pose any significant or additional challenges to your Agency's ability to manage waste in the state?
 - c. If yes, how may these challenges be addressed?
23. Apart from population increases, are there any or other causes of increased waste generated in the state?
 - a. How can these problems be addressed?
24. Research indicates that the waste problem is rooted in other underlying problems in the society, including apathy by citizens to environmental protection. Are there any social, cultural, economic or other factors accountable for the waste problem?
 - a. How can these be addressed?
25. The National Environmental Standards and Regulations Enforcement Agency Act (NESREA), Nigeria's major federal environmental law replaced the Federal

Environmental Protection Agency Act (FEPA) Act in 2007, and attempted a more structured and comprehensive federal framework for waste management, amongst other efforts.

- a. What impact has the NESREA had on waste management in Lagos state?
26. Why is there yet no formal sorting & recycling? Plastics, garbage, metals, etc are still being dumped together. When will sorting from source, re-use, & recycling start in earnest like in countries that are aware of the harmful impacts on the environment and in order to safeguard the environment? Do people need public enlightenment?
27. What do you do with residue of waste from wastewater treatment?
28. Research has shown that the haphazard location of wells close to waste dumps has caused them to become highly polluted due to leachate from the waste. What measures are in place to correct this error?
29. Can you refer me to other relevant sources of information?

Graduate Studies in Law, Faculty of Law, University of Ottawa

Doctor of Philosophy (PhD Law) Program

Research Topic: Sustainable Groundwater Management in Lagos, Nigeria: The Regulatory Framework

Candidate: **Adebola Ogunba**

Respondent: **Lagos State Water Regulatory Commission**

1. The Lagos State Water Regulatory Commission is newly created. Can you please direct me to the enabling law and to any regulations made so far? What Ministry is it responsible to?
2. What are the terms of reference of your Commission? What are its specific responsibilities?
3. There are reported overlaps in functions of water management officials across the government's department. Also the Wastewater Management Office is designed to be accountable to the Lagos Water Corporation and to coordinate its functions with the LWC. Please describe the division of responsibilities between Water Corporation and Wastewater Management Office. Has this enhanced protection of the groundwater or surface water resources? Are there any functional overlaps in water management?
4. Have you made any new regulations regarding groundwater?
5. How will the Commission handle the sporadic and inadequate supply of water that compels citizens to source for water from groundwater sources?
6. The state government has the responsibility to protect water resources and to provide drinking water for its citizens. For Lagos state, the Water Corporation has that responsibility under the

enabling law. However, there is sporadic water supply in the state. What is responsible for this, and how do you think that law can address this challenge better?

7. Four major problems confront groundwater in Lagos state and threaten its sustainability. These are:

- i. Distributed sewage
- ii. Waste dumps and improperly disposed waste
- iii. Haphazard exploitation of groundwater
- iv. Improper location of wells, and a rudimentary regulation

What measures will the new Regulatory Commission adopt to tackle these problems?

8. Can you refer me to any helpful sources of information?



Université d'Ottawa
Bureau d'éthique et d'intégrité de la recherche

University of Ottawa
Office of Research Ethics and Integrity

Ethics Approval Notice

Social Science and Humanities REB

Principal Investigator / Supervisor / Co-investigator(s) / Student(s)

<u>First Name</u>	<u>Last Name</u>	<u>Affiliation</u>	<u>Role</u>
Jamie	Benidickson	Law / Law	Supervisor
Adebola	Ogunba	Law / Others	Student Researcher

File Number: 09-12-10

Type of Project: PhD Thesis

Title: Sustainable groundwater management in Nigeria: The regulatory framework

Approval Date (mm/dd/yyyy)	Expiry Date (mm/dd/yyyy)	Approval Type
10/15/2012	10/14/2013	Ia

(Ia: Approval, Ib: Approval for initial stage only)

Special Conditions / Comments:

N/A

**Université d'Ottawa**

Bureau d'éthique et d'intégrité de la recherche

University of Ottawa

Office of Research Ethics and Integrity

This is to confirm that the University of Ottawa Research Ethics Board identified above, which operates in accordance with the Tri-Council Policy Statement and other applicable laws and regulations in Ontario, has examined and approved the application for ethical approval for the above named research project as of the Ethics Approval Date indicated for the period above and subject to the conditions listed the section above entitled "Special Conditions / Comments".

During the course of the study the protocol may not be modified without prior written approval from the REB except when necessary to remove subjects from immediate endangerment or when the modification(s) pertain to only administrative or logistical components of the study (e.g. change of telephone number). Investigators must also promptly alert the REB of any changes which increase the risk to participant(s), any changes which considerably affect the conduct of the project, all unanticipated and harmful events that occur, and new information that may negatively affect the conduct of the project and safety of the participant(s). Modifications to the project, information/consent documentation, and/or recruitment documentation, should be submitted to this office for approval using the "Modification to research project" form available at: <http://www.research.uottawa.ca/ethics/forms.html>.

Please submit an annual status report to the Protocol Officer four weeks before the above-referenced expiry date to either close the file or request a renewal of ethics approval. This document can be found at: <http://www.research.uottawa.ca/ethics/forms.html>.

If you have any questions, please do not hesitate to contact the Ethics Office at extension 5387 or by e-mail at: ethics@uOttawa.ca.

Signature:

Kim Thompson

Protocol Officer for Ethics in Research

For Barbara Graves, Chair of the Social Sciences and Humanities REB