"Nature-Based Solutions" and Global Water Shortages: A Political Ecology of The United Nation's World Water Development Report 2018.

Pierre Huns

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Professor Kelly Bronson

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Abstract

The United Nations World Water Development Report of 2018 describes water scarcity as a problem of population growth and climate change. This research paper will challenge this report's hegemonic conception of water scarcity by providing evidence for how there are political explanations for water scarcity other than population growth and climate change. I argue that the report promotes cornucopian and technocentric solutions with the intention of utilizing green infrastructures and water-related ecosystem services for increasing the availability of water. This one-dimensional view of water scarcity prevents a discussion of the important political decision making behind the globally uneven distribution of water. The following analysis uses concepts from political ecology to demonstrate the potential implications of this one-dimensional perspective of water scarcity.

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Introduction

While industrial societies of the western world are grappling with the problem of how to decarbonize the economy without having to sacrifice unprecedented amounts of wealth and freedom, another important issue is flying under the radar. Most of our household goods and services require substantial amounts of water, from cooling the machinery involved in the fabrication of our cellphones, to the mind-boggling amounts of water required for the meat and vegetables that we find in our fridges every day. It is estimated that 80% of the world's water is required for agricultural production while only 16% of it is required for industrial manufacturing (Roth and Warner 2008:259). This uneven distribution of water between industrial development and natural limits as well as between the Global North and the Global South will be one of the most significant socio-environmental challenges of the 21st century (Kumar and Singh 2005:761).

It is important to study water scarcity since, like climate change, this issue is being addressed at the international scale through an uncritical reliance on technological developments and 'green' markets. More researchers are required to critique this reliance and question policymakers on the potential consequences arising from an uncritical faith in technocentric fixes to complex socio-natural problems. Therefore, it makes sense to incorporate a sociological analysis of issues related to natural resources that were once thought to have only technical dimensions and thus solutions (Dunlap and Catton 2002:247). This paper's main research question will be the following: "How does the United Nations World Water Development Report of 2018 describe the problem of water scarcity or shortages and what do the authors propose for fixing this problem?". A related sub question will examine "What are the assumptions behind these proposed solutions?". My rationale for this research question and the research topic in general, is that technology has created unprecedented social and environmental changes, redefining how the natural environment

is perceived, managed and valued. This redefinition is captured best by Neil Smith's (2008) theory of the 'production of nature', described as the innovation or engineering of ecosystems into having more 'productive' value or 'services', which are then deemed useful for the economic and environmental interests of wealthy nations.

The specific data that will be used for this research will consist of the UN's World's Water Development Report (WWDR) of 2018. The report is an annual review of the state of the world's water resources and the provision of development solutions that can be used globally to increase water security. This report will be analyzed and criticized through the theoretical lens of political ecology. The methodology of thematic analysis will be employed to analyze this report. Thematic analysis is a methodology used for identifying, analysing and reporting patterns (themes) within the data (Braun and Clarke 2006:79). Positioned through the lens of political ecology, this paper's central argument is that the 2018 UN water report views "nature-based solutions" as a progressive and technical project for alleviating water shortages without addressing the political causes of this environmental problem. The report's framing of water scarcity as a "technical" problem depoliticizes water scarcity and in turn justifies the use of scientific expertise and technological measures that are water-centric rather than people-centric (Budds and Sultana 2013:276). The paper will start with a brief discussion of the historical context from which this report emerges, followed by a review of the theoretical field of political ecology. I will then proceed with a discussion of the methodology of thematic analysis and a summary of the most relevant chapters of this report. Next, I will present an in-depth analysis of the three major themes found throughout the report followed by a critique of these findings. This paper will end with an elaborate discussion of the research question and argument, followed by a brief conclusion of final thoughts regarding future avenues for research into this specific environmental problem of global water scarcity.

The Contextual Origins of 'Global' UN Conferences and The World Water Development Report (WWDR)

Since its inception in 2003, the United Nations has published annual reports on the state of the world's water resources titled World Water Development Report (WWDR). The global organization published in 2018 its 154-page, report called 'Nature-Based Solutions for Water'. In a nutshell, this report is about demonstrating how nature-based solutions (NBS) mimic natural ecosystems for the management of water. NBS are described throughout this report as promoting greater resource productivity by reducing waste and avoiding pollution. The main UN agencies behind the production of this report consists of The United Nations Educational, Scientific and Cultural Organization (UNESCO), The United Nations Development Programme (UNDP), UN Environment, The Food and Agriculture Organization of the United Nations (FAO), and the United Nations University Institute for Water, Environment and Health (UNU-INWEH). The most recent and shared priority among all of these sub-agencies is to fulfill the UNDP's sixteen goals of sustainable development that are projected to be achieved by the year 2030. The priorities of these agencies are in the interests of eradicating poverty in underdeveloped or developing nations through 'global sustainable development'. The activities of the UN following the second world war, were to ensure world peace and security through international cooperation.

The end of the Second World War led to the development of the UN Educational, Scientific, and Cultural Organization (UNESCO) and the International Union for Conservation of Nature and Natural Resources (IUCN) in 1945 (Caldwell and Weiland 1996:34). Technical assistance to less developed countries was prominent in the FAO agenda in its aims to tackle world food shortages (McCormick 1989:28). UNESCO was founded in 1946 to promote

international cooperation and the promotion of scientific education (McCormick 1989:33). Many of these conferences and treaties were centered around the protection or 'preservation' of nature. UNSCCUR in 1949 organized by FAO and UNESCO, discussed the development of new resources through applied technology (McCormick 1989:37). The development planning of the Green Revolution throughout the 1940s till the 1970s is largely the result of these early conferences organized by the United States.

According to Caldwell and Weiland (1996) The Biosphere Conference of 1968 is the first major international meeting concerned about the global environment (p.34). A predominant theme that arose from this conference declared that air, soil and water pollution in industrial countries could not be corrected by science and technology alone (Caldwell and Weiland 1996:34). The social sciences were also considered to solve resource management problems (McCormick 1989:89). During the 1960s, public environmental awareness expanded from local to national and from national to international horizons (Caldwell and Weiland 1996:36). One of the recommendations of the Biosphere Conference was that conservation of the environment depended not only on better scientific research but also on consideration of the economic, social, and political dimensions of environmental problems (McCormick 1989:90).

The historical context of the WWDR dates to the beginnings of the environmental activist movement during the early 1970s. The United Nations' Stockholm Conference was a landmark event in the growth of international environmentalism. The Stockholm Conference of 1972 had a much greater political impact and looked at the wider political, social and economic questions (McCormick 1989:90). The conference helped provide a framework for the United Nations to solve environmental problems through international cooperation (McCormick 1989:91). The Stockholm conference was organized by industrialized countries who were concerned with the

environmental and developmental problems of the emerging in countries of the Global South (Adams 2001:54). It was the first occasion in which political, social and economic problems related to the global environment were discussed at the international scale (McCormick 1989:88). Nations in the Global South believed that these conferences allowed industrialized economies to wiggle themselves out of this responsibility (Adams 2001:55). The common theme arising from the Stockholm Conference was that many countries of the Global South argued that economic growth should not be curbed by environmental concerns (Adams 2001:56).

The Brundtland Commission's report of "Our Common Future" presented to the UN's General Assembly of 1987, attempted to 'recapture the spirit of Stockholm' (Adams 2001:70). This report, which was also the first to be published as a book, demanded serious attention from politicians arguing that immediate action should be taken to review unsustainable practices in managing natural resources (Gerasimova 2017:35). The Brundtland report is known for popularizing the definition of 'sustainable development' (Duchin and Lange 1994:4). Post-war developed countries were focused on economic growth as the only way to tackle poverty and to achieve environment-development objectives in countries of the Global South (Adams 2001:72). The Brundtland report argued that it is poverty that puts pressure on the environment in the Global South and it is economic growth that will help remove that pressure (Adams 2001:72). Global environmental challenges were presented at the conference as "common challenges" suggesting that international cooperation was required for the management of global natural resources through 'sustainable development' (Gerasimova 2017:37). The Brundtland report disseminated the idea that environmental limits are not set by the environment itself, but by technology (Adams 2001:71).

The UN's Earth Summit of 1992, the UN's Millennium Summit and the Rio +20 Conference of 2012 are also important UN conferences. The Rio +20 conference resulted in the adoption of the Sustainable Development Goals (SDGs), which this report's recommendations aim to accomplish through the introduction of nature-based solutions (Gerasimova 2017:65). However, since the Brundtland report, scholars and activists argue that global environmental governance and policymaking have become market-based with green governance regimes creating markets for environmental goods or services and providing new incentives for green industries (Peet, Robbins and Watts 2011:7). When it comes to UN water and its annual WWDR report, Shah et al (2018:678) and Swyngedouw (2013:829) have both argued that the WWDR continues to advocate for the mobilization of private and market forces to address water scarcity challenges.

Similar to the critique of the WWDR's hegemonic focus on markets, I have situated my critique among Shah et al (2018) and Swyngedouw (2013) who have both argued that the kind of influence that UN level reports have had on governance is largely technical, based on the natural sciences and economics. Shan et al (2018) highlight in their analysis of the 2016 edition of the WWDR that its policy recommendations rely primarily on economic and technological 'expert knowledge' (p.679). The common theme among these reports seems to be that water scarcity is treated as a 'technical problem' and an emphasis on the managerial terminology of competition, efficiency and productivity (Shan et al 2018:679). Earlier editions of the WWDR were focused on achieving the Millennium Development Goals of the UN Millennium Summit of 2000 but since the Rio+20 conference of 2012, this report's objectives have been concentrated on fulfilling the Sustainable Development Goals (SDGs). Yet still, Shah et al (2018:685) and Swyngedouw (2013:827) have both argued that the 2012 and 2016 editions of this report fail to recognize that water management involves political struggles for water control. These authors argue that the

WWDR understands and describes issues of water scarcity apolitically by avoiding discussion of uneven allocation practices and resulting conflicts (Swyngedouw 2013:827; Shah et al 2018:685). As such, the report's objectives are in alignment with the goals of previously influential UN conferences, which assume that economic growth and development will be good for the environments of third-world nations (Shah et al 2018:686).

The 2016 and 2018 versions of the WWDR both propose increasing water supply through more infrastructures and new technologies (Shah et al 2018:688). Unsurprisingly, the report promotes the mainstream economic and engineering view of managing and supplying water (Shah et al 2018:683; Swyngedouw 2013:829). The existing analyses of the 2012, 2016 and 2018 versions of the WWDR, have all pointed out that the common idea is that freshwater withdrawals have increased globally due to growing demand in developing countries. The report continuously and implicitly implies that governments in the Global South are wasteful of water due to the inefficiencies of their current infrastructures (Shah et al 2018:684). The WWDR has impacted global environmental governance by recommending that national policies be oriented towards employing scientific, technical, economic and managerial strategies rather than more complex social and political approaches for managing water.

Theoretical Framework

The theoretical framework of political ecology will be employed to analyze the WWDR. Political ecology is defined by Watts (2000) as an approach "to understanding the complex relations between nature and society through a careful analysis of what one might call the forms of access and control over resources and their implications for environmental health and sustainable livelihoods" (Robbins 2012:16). Robbins (2015) refers to political ecology as a field of study that "combines the concerns of ecology and a broadly defined political economy" (Perreault 2015:90). This field of research is interested in finding causes rather than symptoms of problems and the more general conditions of inequity, where some social actors exploit other people and their environments for limited gain at a collective cost (Robbins 2012:20). Political ecology challenges dominant approaches to understanding the links between human action and environmental change (Adams 2001:251). Political ecology will be used in this paper to interrogate the relationship between political power and ecological knowledge and provide an analysis of the WWDR (2018) which argues that damaged environments can be "repaired" through technocentric and managerial solutions that can then be used to solve other environmental problems.

Political ecology conceptualizes environmental change as a result of power relations that cause highly variable access to resources, and it is a framework which rejects neo-Malthusian explanations of human impacts on the environment (Brannstrom 2013). Neo-Malthusians take the position that population growth is the single greatest driver of environmental degradation (Robbins, Hintz, Moore 2014:18). Political ecology is an analysis of environmental problems as a result of political decision-making that favors the control of natural resources by one group over another, which inevitably leads to conflicts and other social and environmental issues. According to Neumann (2005), technocratic and managerial approaches to environmental degradation are

closely associated with neo-Malthusianism (p.27). Neumann (2005) points out that technocentric and managerial solutions ignore the social relations, economic constraints and political power structures that shape resource use (p.28). Political ecology examines political and social factors to explain resource struggles and does not examine the "natural" mechanisms of population pressures (Moore 1996:125). The main premise of the theoretical field of political ecology emerging during the 1980s was that complex social, economic and political problems, rather than simple technical or managerial problems, were at the core of most environmental issues (Neumann 2005:5). Adams (2001) argues that conventional analyses of environmental issues tend to draw heavily on scientific explanations, with social and political dimensions often ignored (p.252).

I will also draw on Neil Smith's (2008) theory of the 'production of nature', which describes how the innovation or engineering of ecosystems leads to more 'productive' values or 'services', which is then deemed useful for the economic and environmental interests of wealthy nations. The engineering of ecosystems is the process through which scientific advances in the understanding of the productive functions of ecosystems is used by capitalists to continue their treadmill of production and to bypass the environmental limits of their activities. The production of nature through the introduction of ecosystem services can capitalize on nature more creatively and intensively than the conventional extractive resource industries of early capitalism (Dempsey and Robertson 2012:762).

Political ecology and the perspective of environmental realism both complement each other by demonstrating that environmental problems are not simply for science and technology to provide cornucopian solutions but are fundamentally social and political problems that wealthier societies need to address (Neumann 2005:44). Environmental realists are concerned with studying the intersection of environment, politics and the economy (Young 2015). Environmental realism

examines the complex historical, political and economic context that makes up the "solutionist" thinking behind environmental problems (Cockerill 2017:8). Murphy's (2002) critique against social constructivism is that "nature cannot be reduced to what people think it is" (p.317). Nature 'strikes back' through earthquakes, fires, floods and droughts and their impacts intensify when societies place increasing pressure on its finite supply. Murphy (2002) argues that "it is more reasonable to speak of the manipulation of nature than its social construction" since Murphy also believes that this manipulation will lead to a proliferation of new risks, which are either environmental or social (p.316).

Environmental realist also examine how "solutions" are commonly understood as implying that a problem has been "fixed", usually through technical means and therefore will no longer require any attention (Cockerill 2017:5). The common worldview of "solutionism" is a quest for certainty and stability without recognizing the complexity of environmental problems (Cockerill 2017:5). Reducing this complexity will inevitably prevent an examination of the more complex political and social origins of these environmental problems. Cornucopian theorists usually deny environmental problems of either pollution or resource depletion and advocate for market mechanism and technological innovations that will always find new sources for extraction (Murphy 2006:188). Cornucopian thinking and the ideology of solutionism both seem to emphasize that technological innovations coupled with market mechanisms will always allow societies to bypass the messier and more complicated aspects of environmental problems.

Environmental realism focuses on the environmental problem first before examining how society is constrained by this environmental concern (Young 2015). For realists, the dynamic stability of many natural processes constrains our ability to socially construct the world (Newton 2007:92). Environmental realists argue that society is constrained by the biophysical limits of

nature and that surpassing these limits will result in nature's dynamics striking back against society's abuse of nature (Young 2015). Realists have emphasized the concept of the ecological footprint to support their claims that production and consumption need to be left under the control of planetary limits in order to avoid ecological disasters (Young 2015). This is one particular weakness of environmental realism since it may side more with natural scientists than with social scientists and uncritically adopt the findings of natural scientists (Newton 2007:98; Young 2015).

Lastly, many environmental realists in recent years have employed the concepts of the "water footprint" or "virtual water". The relationship between food production and water consumption can be examined through the concept of virtual water (Roth and Warner 2008:259). Virtual water is described by Carolan (2014) as "water used during the growing, making, or manufacturing of a given commodity" (p.83). Water-scarce countries such as India and China are the highest net exporters of virtual water through the export of rice and wheat while water-abundant countries such as Switzerland are the lowest importers of virtual water (Boelens and Vos 2012:24). Agricultural production accounts for 80% of the total amount of virtual water traded internationally (Roth and Warner 2008:259). The concept of virtual water is more complex than having water-scarce countries import water-intensive agricultural products from water-abundant nations. North African countries import the largest amounts of virtual water while they still face serious water scarcities (Kumar and Sigh 2005:760). The relevance of this concept to this research is that "nature-based solutions" do not take into consideration the global political decision making that evaluates the economic wealth of countries in the Global South based on their production and trade of agricultural commodities, without taking into consideration the substantial amounts of water that is required for the accumulation of this national wealth.

Given the centrality of the ecosystem services concept to my central argument, this concept is defined by Daily (1997) as "the conditions and processes through which natural ecosystems, and the species that make them up, sustain and fulfill human life" (p.3). Ecosystem services provide goods and benefits to humans from the underpinning ecological processes within ecosystems (Mace, Norris and Fitter 2012:20). Ecosystem services, such as forests, perform fundamental human life support services through the purification of air and water, while the human economy also depends on these ecosystem services performed "for free" for the production of pharmaceutical and agricultural goods that are then traded in global economic markets (Daily et al. 2003). In a nutshell, the services provided by these ecosystems produce most of the goods that support the prosperous economies of countries in the Global North. Newton (2007) reminds us that it is currently impossible to reverse environmental degradation and many of our present attempts through the use of ecosystems as carbon sinks or offsets, have their biophysical limitations (p.99).

This research will employ political ecology and environmental realist perspectives to analyze how the WWDR's progressive presentation of this nature-based project leaves out an examination of the political causes of this ecological problem. Political causes should be thought of as the result of important decisions that allow the uneven possession or management of a natural resource by one particular group, which then often results in ecological problems, such as water scarcity. Many scholars are beginning to recognize that these cornucopian "solutions" are leading to new ecological problems (Cockerill 2017:5). Agricultural technologies of the past, such as pesticides, fertilizers and high-yielding seeds have increased the productivity and intensification of agriculture but would many decades later result in the growth of a multiplicity of unpredictable environmental problems (Guthman 2011:53). Advanced fish-finding technology has led to the

industrialization of fisheries and due to overfishing, this resulted in the collapse of many small-scale fisheries during the 1980s (Mansfield 2011:84-86). But technology alone was not the ultimate culprit, the broader political economy of fishing since the 1950s was focused on political decisions that would allow for the pursuit of profits by externalizing costs (Mansfield 2011:93).

Political ecology is a field of study that is ideal for critically examining environmental problems as a result of technological innovations being uncritically placed into the hands of the market to increase the productivity of the global economy. Political ecology as a branch of environmental realism is evidently a critique of cornucopian and solutionist theories related to environmental concerns. Environmental realists argue that overlaps in how human societies use the earth as a living space, supply depot and waste repository, frequently results in social conflicts (Young 2015). A current example of this conflict is the introduction of ecosystem services into developing nations, which allows developed nations to extend their ecological limits and to continue expanding their supply depot of ecosystem goods, such as pharmaceutical and agricultural products, which overlaps with the living space of the people in developing nations who depend on these ecosystems for their own subsistence. Developed nations often use the ecosystem services of developing nations to sustain their current consumption levels while despoiling the latter’s living spaces and the biodiversity of their ecosystems (Dunlap 2010:19).

Methodology

Thematic Analysis is a method for identifying, analysing and reporting patterns (themes) within qualitative data (Braun and Clarke 2006:79). The data or dataset for this research paper will consist of United Nations' intergovernmental policy report titled "The World Water Development Report (WWDR)". Thematic analysis is a useful methodology for organizing and describing in rich detail the data found in this report (Braun and Clarke 2006:79). Thematic analyses move beyond counting explicit words or phrases and focuses on describing both implicit and explicit themes found within the dataset (Guest, Macqueen and Namey 2012). A theme in this research paper will be defined as a sentence, phrase and even word, that identifies what a unit of data is about (Saldana 2013:139). This research started with inductively finding key themes by coding text from the WWDR and then I used ideas from the existing political ecology literature to analyze and criticize the data found in this report (Braun and Clarke 2018:58).

The three major codes that emerged from the WWDR are; nature-based solutions (NBS), green infrastructure and water-related ecosystem services. Using NVivo software, text indicating each of these three codes were catalogued from the 154-page report. Textual excerpts (words, phrases) related to NBS were mentioned 797 times; while even though 'green infrastructure' or 'ecosystem services' are not heavily mentioned throughout this report, they are closely related to the concept of NBS. Based on the extraction of key phrases or sentences which employs or describes each of these three concepts from this dataset, I then deduced what these extracts might imply. These codes were then theoretically critiqued by employing the findings of existing research. I have deemed the first three chapters of the WWDR 'Nature-based solutions (NBS) and water', 'NBS For Managing Water Availability' and 'NBS For Managing Water Quality' as the most relevant chapters for this paper's research question and topic.

Summary of the first three chapters of this report

Chapter one in the WWDR is titled 'Nature-based solutions (NBS) and water'. The goal of this chapter is to provide the reader with an elaborate depiction of what is essentially ecosystem services and the multiple benefits that can be derived by employing these natural processes to improve the current management of water. The chapter is predominantly a discussion of what an NBS is, the different types of ecosystems that NBS consists of, and some of the benefits that could be acquired by employing these solutions. What this chapter of the report attempts to accomplish is to represent NBS as arising from nature by stating that NBS are an innovative response that have been around for thousands of years (UNESCO 2018:iv). A majority of this chapter is a discussion about the multiple functions of these different types of ecosystems regarding the management of their local hydrology. The authors of the WWDR dedicate one whole section to describing how NBS also support biodiversity conservation measures. The chapter ends with a description of green infrastructures and how NBS can achieve many of the sustainable development goals (SDG) outlined by the United Nations General Assembly in 2015.

The second chapter of the WWDR is called 'NBS For Managing Water Availability'. The goal of this chapter is to demonstrate how NBS can address issues of water scarcity by increasing the quality of water. This chapter starts off by describing that agriculture is by far the largest global consumer of freshwater and therefore NBS regarding conservation agriculture can improve water use efficiency in irrigation. This chapter is about how green infrastructures in conjunction with traditional grey infrastructures can be used to increase the availability of water. This chapter goes on to describe that vulnerable or minority populations living in developing nations, will benefit the most from these implementations. Urban green infrastructures in cities, such as Nairobi, can be used to combat the effects of decreasing water scarcity due to population growth in urban cities

and the threats of drought and floods due to climate change. This chapter also describes that there are institutional, political and technical constraints for employing NBS to increase the availability of water. This chapter, like the previous one, restates that NBS can make promising contributions to several SDG.

The third chapter called ‘NBS For Managing Water Quality’ starts out by describing how population growth, agriculture and climate change are contributing to the global deterioration of water. A large section of this chapter is dedicated to describing how modern agriculture has a significant impact on the deterioration of water quality. This chapter goes on to describe how the adoption of green infrastructures, such as constructed wetlands, can act as wastewater treatments, increasing the quality of water and therefore increasing the supply of water. The chapter goes on to describe the environmental and socio-economic co-benefits and limitations of NBS. This chapter, as in the previous two chapters, ends with a discussion of how the potential for NBS to improve the quality of water, contributes to achieving a multiplicity of goals outlined in the SDG.

Analysis

Theme 1. "Green infrastructure": The first theme which emerged from the inductive coding of the WWDR is biodiversity as a form of "green infrastructure" that can help serve human needs while securing them against the "natural" threats of drought. Green infrastructure is described by the authors of this report as *"the use of natural or semi-natural systems to provide benefits that are equivalent or similar to conventional grey water infrastructures"* (UNESCO 2018:4). This report further goes on to describe green infrastructure solutions as *"the deliberate and conscious effort to utilize ecosystem services to provide primary water management benefits"* (UNESCO 2018:31). *"Forests, wetlands, grasslands, soils and crops when managed properly, provide high-value 'green infrastructure' for enhancing source water protection"* (UNESCO 2018:53). Green infrastructures are described in this report as reducing significant risks (UNESCO 2018:5). The report is not clear in distinguishing what kind of risks are involved. But the report also goes on to highlight that there remain many uncertainties about the function of green infrastructures (UNESCO 2018:6). Green infrastructure is described as becoming increasingly important for addressing the complex challenges of water management (UNESCO 2018:31).

The report goes on to state that technocratic and grey infrastructure approaches have tended to dominate water resources management and that domination can be more balanced by introducing the contribution of ecosystems (UNESCO 2018:23). The report then goes on to provide the technocratic concept of ecohydrology as having been implemented for alleviating the effects of water scarcity in the developing world. Ecohydrology is defined within this policy document as an *"integrative science that focuses on the interaction between hydrology and biota"* (UNESCO 2018:23). The report states that economic development in developing countries will be

stagnant in nations that will be *"held hostage to their hydrology"* due to the lack of investments in current grey infrastructures (UNESCO 2018:31).

The report uses managerial terms such as, 'high-value green infrastructures', used to describe ecosystems for increasing the supply of water in drought prone areas, which connotates that ecosystems ought to be engineered as a new form of green infrastructure that delivers critical services for human communities and economies (Carse 2012:2). What seems to be implicit is that green infrastructures facilitate a more inconspicuous and less controversial treatment of ecosystems as infrastructure to serve insatiable human demands. Within the report's notion of green infrastructure lies the economic belief that the benefits of nature are measured by its worth to humans (Raymond et al 2013:540). The description of green infrastructures as reducing significant risks but also leaving many uncertainties, leaves more questions than answers, such as how can green infrastructures be utilized for reducing the risks of droughts, if there still remain many uncertainties regarding the functioning of green infrastructures? The report also provides the controversial argument that *"the predicted longer duration and severity of droughts can be alleviated by more water storage, which requires upscaling of infrastructure investments that can have significant trade-offs for society and the environment"* (UNESCO 2018:17). This quote does not outline the kind of trade-offs for society these investments would entail or whom would reap the benefits. The report goes on to state that the impacts of droughts will be worsened by increasing withdrawals in response to increasing water demand but goes on to emphasize that green infrastructures must be part of the solution since they are beneficial for increasing water storage in the environment.

Green infrastructures are described as important for addressing complex issues of water management but Mehta (2011) argues that managerial, technical and popular understandings of

water scarcity tend to be simplistic (p.372). Mehta's argument is certainly useful in analyzing this WWDR, as the report continuously provides case study examples in developing nations of how constructing ecosystems as technical, 'green infrastructures', can be quickly introduced as a band-aid solution for political factors that have contributed to the water scarcity challenges of developing nations. For instance, this report provided the case of Zimbabwe where the use of 'sand dams' were described as a technology and a 'simple' means to increase the storage capacity of water, reducing the risk of drought during dry season and therefore 'productive' for farmers to allow them to harvest a second cash crop (UNESCO 2018:39). The employment of this low-cost, water harvesting technology will not completely solve water scarcity in developing nations since the core causes of this problem are grounded in political and economic reforms.

It is interesting to note that the concept of green infrastructure is heavily advocated to be implemented in developing nations while rarely even implemented in developed countries. Norgaard (2010) notes that a significant reason why there are so few ecosystem service or green infrastructure projects in the developed world is the conflict from the diversity of ecological ways of knowing make almost any such approach to ecosystems, too controversial and extremely difficult to implement (p.1222). It is also interesting to note that green infrastructure projects are not being advocated to resolve water shortages in developed countries, such as in the American Midwest, where the over-extraction of ground water has led to longer drought seasons.

The report also states that ecohydrology is an 'integrative' science that has been implemented to alleviate the effects of water scarcity but does not attempt to provide explanations for how political factors have an effect on hydrology. This concept has actually been criticized for excluding social, cultural, political and even economic explanations for water conservation (Hiwasaki and Arico 2007:8). This concept has also been criticized as a largely expert-driven and

technocratic approach to water conservation (Rodina 2019). The report mentions *"that socio-economic development is curtailed in countries that have insufficient grey infrastructure to manage water, that many developing countries are consequently 'held hostage to their hydrology'"* (UNESCO 2018:31). But the report had also mentioned early on that the *"The vast majority of the growing demand for water will occur in countries with developing economies"* (UNESCO 2018:3). Even earlier in the report, it is mentioned that *"With a rapidly growing global population, demand for water is expected to increase by nearly one-third by 2050"* (UNESCO 2018:v). To argue that nations are "held hostage to their hydrology" due to growing populations, is to adopt a neo-Malthusian argument that overpopulation and urbanization in developing nations is one of many root causes of water scarcity. This way of defining water scarcity makes it more amendable to technical solutions (Jarosz 1996:148). This is also an active social construction of hydrology that is separated from social and political-economic processes (Swyngedouw 2013:828).

The report goes on to state that *"water use is expected to continue increasing at the global level, as a function of population growth, economic development and changing consumption patterns, among other factors"* (UNESCO 2018:10). This report does not go into further detail about what changing consumption patterns entails. This statement and many others found in this report consists of what Swyngedouw (2013) would call conflict-avoiding jargon (p.826). Does 'changing consumption patterns' mean making the substantial societal and political changes to reduce consumption levels in countries of the Global North? Such a significant and necessary change would surely cause conflicts among people in the wealthy nation-states of the Global North. Neo-Malthusian explanations employed throughout this report also conveniently help underplay the role that governments in the Global North play in contributing to the global shortages

of water (Jarosz 1996:152). Water scarcity is an imminent environmental concern due to the uneven global distribution of freshwater resources (Moran, Petersone, and Verones 2019). Technical solutions will allow governments not to make political or economic decisions that force significant changes in the consumption patterns of their citizens. The failure of this report not to address issues of freshwater overuse in the countries of the Global North, reveals the extent to which the historical origins of anthropogenic water scarcity are predicated on highly inequitable global processes from the start (Hornborg 2015:59). This report goes on to state that *"Green infrastructure is the application of an NBS"* (UNESCO 2018:31), which leads me to discuss the second and more prevalent theme of this report.

Theme 2. "Nature-based solutions": The report describes NBS as the instrumental use of water-related ecosystems, such as wetlands, to help increase the performance of traditional grey infrastructures, such as hydropower dams, for increasing the availability of water and reducing the threat of scarcity. This predominant theme is evident in the following quote *"Some of the best examples of the deployment of NBS are where they improve the performance of grey infrastructure"* (UNESCO 2018:4). The report goes on to argue that utilizing NBS to improve the operation efficiency of hydropower dams is represented as one of many examples of the benefits of combining grey and green infrastructures (UNESCO 2018:45). *"An NBS approach has been advocated partly because of the adverse environmental and social impacts associated with large-scale grey infrastructure"* (UNESCO 2018:33). NBS is described as *"working with nature instead of against it"* and is further described as fueling *"social, economic and hydrological efficiency gains in water resources management"* (UNESCO 2018:2).

The value of nature in this report is also measured on the basis of managerial terms such as circular economy, natural capital, green growth, and cost-effectiveness. A simple example of this argument is provided in the following quote. *"An often-overstated assumption about NBS is that they are 'cost-effective'"* (UNESCO 2018:6). The report goes on to describe that some small-scale application of NBS can be of low cost, while other applications may require larger investments (UNESCO 2018:6). The report goes on to highlight that there is an emerging "green bond" market, which is described as good for the finance of NBS and could help it perform well *"when assessed against rigorous standardized investment performance criteria"* (UNESCO 2018:6). In this instance, NBS are constructed and transformed into a product that would be competitive for the emerging 'green economy'. NBS when coupled with these managerial terms, constructs ecosystems as investments to be competitive on the open and growing green market. NBS is further described as supporting a 'circular economy', which includes 'greater resource productivity' along with 'green growth' promoting sustainable natural resource use (UNESCO 2018:23). The report then goes on to recognize NBS as a form of 'natural capital', which is described as plants, animals, air, water, soils and minerals that provide a variety of benefits for people (UNESCO 2018:23).

The report also argues for a combination technical and managerial solutions to NBS for increasing water availability. The report starts out by stating that NBS is often neglected in policy proposals regarding development planning due to what they believe is insufficient research in NBS, specifically in terms of their cost-benefit and hydrological performance in conjunction with grey infrastructure (UNESCO 2018:6). Therefore, the report argues that in order for NBS and the hydrological functions of natural ecosystems to become better understood in policy arenas, they propose that they are paired with the technical guidance and tools of current grey-infrastructures

(UNESCO 2018:6). This pairing would allow for a better understanding of the 'performance' of natural ecosystems, through the technical guidance of grey infrastructures, which would then allow it to be more credible in policy arenas and could be used for more 'productive' purposes.

NBS is then described as a means for addressing water scarcity through 'supply-side management' as the main solution for achieving sustainable water levels (UNESCO 2018:38). In a clearer context, NBS or 'supply-side management', is then described as increasing the quantity of water through various land management practices through either ecosystem conservation or rehabilitation (UNESCO 2018:39). The report states that where the performance of NBS does not meet the expectations of cost-benefit analysis, more knowledge of NBS will be required through more science-based evaluations of their performance (UNESCO 2018:47). This report further goes on to claim that these NBS concepts and tools are related to ecological engineering, ecosystem-based disaster risk reduction, green or natural infrastructure and climate adaption ecosystem services (UNESCO 2018:23). NBS is also described in this report as inspired by nature's natural processes for the management of water and the defining feature of an NBS is described as not whether an ecosystem used is 'natural' but whether natural processes are used to achieve water related objectives (UNESCO 2018:22). The report has identified NBS with many win-win outcomes across many different sectors, in which it is deemed to deliver increased sustainable agricultural productivity and profitability along with other benefits, such as improved water availability (UNESCO 2018:5).

The suggestion of implementing NBS to improve the performance of traditional grey infrastructures, such as the operation efficiency of hydropower dams, is based on the implicit economic outlook in this report's statements is that the value of nature should be based on how much it helps with the improvement and performance of grey infrastructures. The advocation for

an NBS approach to reduce environmental and social problems associated with large-scale grey infrastructures, is certainly beneficial but does not enable a discussion of the social and political causes behind the unequal global distribution of freshwater that continues to provide developing countries with the threat of water scarcity. Boelens and Vos (2012) argue that 'efficiency' discourses may justify policies and projects that will interfere with existing local water management practice and local livelihoods (p.16).

The report's description of NBS as providing 'hydrological efficiency gains' reduces the complexity of ecosystems without highlighting the crucial fact that they are much less understood since they are much more complicated than traditional grey infrastructure. Terms such as productivity, efficiency, and hydrological functions are all managerial terms that evaluate the basis of nature based on its instrumental value to humans. The problem with the managerial conceptions of ecosystems as contributing to the circular economy and promoting green growth is that the possibilities of new technologies for releasing new environmental services leads to a conception that we are consuming 'natural capital' rather than consuming it for human needs (Norgaard 2010:1223).

Advocating for NBS as addressing water scarcity challenges through supply-side management without addressing the more difficult question of how social, political and even economic factors might be causing these environmental problems is what Swyngedouw (2013) argues "language caught up in conflict-avoiding jargon that often obfuscates more than it reveals" (p.826). What this report does not mention is that the lack of water in global hotspots is a result of the inefficient governance or management of water, soils and crops and not necessarily the result of poor supply management (Rockstrom et al 2010:543). There are conflicts over the dwindling availability of water due to the introduction of agricultural technologies, such as high-yielding,

water-intensive seeds and the agrochemicals of pesticides and fertilizers that increase nitrate pollution in groundwater and surface water (Bhushan 2018). The use of terms like ‘cost-effective’ and ‘supply-side management’, diverts attention away from deeply uneven political, social and economic power relations that ultimately decides who has access to the distribution and management of water (Swyngedouw 2013:826). Within many developing and developed nations, water is mostly distributed to and managed by agrochemical industries supplying the increasing global demand for food, while reducing the availability of freshwater for the people supplying that demand.

This report’s approach to fill a void left by the incomplete information of an ecosystem’s functions by adopting a ‘more science-based evaluation’, is a plea for the economic and scientific conversion of previously natural ecosystems into more ‘productive’ green infrastructures (Adger and Luttrell 2000:76). In this line of thinking, demonstrating the economic value of these technological and managerial functions will increase the chances of ‘cost-effective’ or ‘cost-benefit’ utilization (Adger and Luttrell 2000:76). This is also an example of Murphy’s (2002) recombinant nature which is described as technology being used for rearranging or manipulating the dynamics of nature in ways not found in its virgin state to accomplish the goals of “cornucopian thinking (p.325). “Cornucopian thinking” is played out in this example, through an overreliance on NBS as a scientific, technological and managerial “solution” for converting degraded ecosystems into more productive green infrastructures that will help increase the supply of water. This “solution” is perceived by cornucopian thinkers as circumventing the ecological limits of water scarcity without having to tackle the more complex political decision making at the root of this problem.

NBS has been described in this report as natural while employing scientific, managerial, economic, technological approaches without mentioning any social, cultural and political approaches for water management. This report states early on that *"NBS are also consistent with, if not essential to, numerous religious, cultural or totemic beliefs that emphasize conceptions about nature rather than management decisions driven by a technocratic approach. Among other things, this can make religious, cultural and totemic leaders powerful allies in the deployment of NBS"* (UNESCO 2018:23). Although this report has declared that NBS includes a plurality of views on water conservation, as I have shown, it is primarily a technocentric and managerial approach for the preservation of water, but this report does not address the political factors behind the global unequal distribution of water.

This report has described NBS as associated with many 'win-win' benefits, one of them being improved water availability. Adger et al (2001) argue that 'win-win' policies are a key concept of managerial discourses (p.702). This report described NBS as being able to deliver groups of ecosystem services and usually offering "co-benefits" beyond water-related ecosystem services (UNESCO 2018:22). Such a win-win solution is institutionalized through technological solutions (Adger et al 2001:702). This report goes on to highlight an example of a constructed wetland used for wastewater treatment as also providing biomass for energy production (UNESCO 2018:33). The prevalent theme is that an NBS approach to water scarcity allows for addressing issues related to climate change adaption technology, inefficiencies in grey infrastructure and ecosystem services. In other words, more efficient technologies in a competitive marketplace provides the illusion that it will be able to avoid water scarcity by enlarging planetary limits (Murphy 2006:192). NBS is constructed as a 'multiple win' green technology and contributing to many goals outlined in the UN's sustainable development goals. This dominance of 'multiple

wins' provided by nature-based solutions conceals the political complexity of environmental problems (Norgaard 2010:1226). NBS and ecosystem services, as they will be discussed in the following section, are heavily criticized as working against the inherent complexity of nature.

Theme 3. "water-related ecosystem services": The third major theme arising from this report, is the highly controversial employment of ecosystem services as an economic panacea for the environmental issue of water scarcity. Ecosystem services are described in this report as 'solutions' that make investments more cost-effective over time (UNESCO 2018:6). In simpler terms the report describes ecosystem services as *"The water-related processes and functions of ecosystems that can be managed to deliver benefits to people as 'ecosystem services'"* (UNESCO 2018:29). "Water-related ecosystem services" are described as related to the movement of water, the storage of water (in soils, groundwater and wetlands) and the improvement of the quality of water (UNESCO 2018:29). In other words, water-related ecosystem services are the employment of wetlands and other water-relevant ecosystems for servicing human needs in terms of improving the quality and supply of water. The report goes on to state that the growing negative impacts on land and water due to the intensification of agricultural production, could be avoided if it would involve ecosystem services that would help reduce the detrimental impacts of agricultural intensification (UNESCO 2018:11). This is an example of employing ecosystem services as a quick economic fix for attempting to solve land and water damages without having to reduce the increased intensification of agricultural production that will be required in the decades to come.

The ecosystem services discourse has argued for an economic and managerial perspective on biodiversity (Turnhout 2013:156). Since ecosystem services are often regarded as scientific and economic, we tend to forget that they are also highly political. From a political ecological

standpoint, the issue with the economic concept of ecosystem services is that it has been conceptualized by economists in developed countries and often used in developing nations, where it is less controversial to implement. The concept of ecosystem services is also useful for masking the politics behind water conservation issues in many developing countries. The introduction of ecosystem services is instrumentally useful as a quick scientific and economic fix for not having to force industrialized countries to reduce their direct and indirect over-consumption of water. The other issue with ecosystem services is that they tend to simplify the complexity of water scarcity and mask the political processes that drive this environmental issue. We should also not forget that new avenues for capital accumulation are increasingly accomplished through the intensification of production via technological innovations (Smith 2008:27).

Without specifying what those drivers may be, this report is in other words stating that we need to understand those drivers in order to plan and develop a replacing ecosystem service that will adapt to the increasing drivers or demands that are placed on current ecosystems. The report goes on to state that UN-Water has stressed that the impacts of climate change will mostly be on the hydrology of ecosystems but goes on to imply that 'ecosystem-based management' should be the primary means of climate change adaption, which largely involve the use of NBS for water (UNESCO 2018:35). What this report seems to imply is that climate change, which is largely driven by social and political factors, is reducing the availability of water. But rather than employing methods to reduce the effects of water scarcity through climate change, we will adapt through a better scientific understanding of water-related ecosystem services.

The report goes on to argue that it is essential to first understand the direct and indirect drivers that led to the loss of previous ecosystems before restoring them with more 'effective' ecosystems that can provide even more services and adapt to the effects of climate change

(UNESCO 2018:31). In other words, what this unrealistic expectation of ecosystems signifies, is a viewpoint that ecosystems now need to be engineered to be more 'productive' in being able to 'service' our growing demands, while also being more 'cost-effective'. This report provides an interconnected set of technocentric, economic and managerial themes that promote a perspective that celebrates the principles of 'efficiency' and 'cost-effectiveness' that in turn contributes to an impoverished understanding of water-related ecosystems (Turnhout, Neves, and Lijster 2014:594).

Herbert Marcuse provides an important argument that is at the basis of my own argument that this 'one-dimensional, technical thinking' has taken over how we think of nature and led into policies for tackling environmental degradation (Feenberg 1996:47). Science might as well be compared to a wolf in sheep's clothing since science, especially in the era of global neoliberalism, has become a means for production (Katz 1998:50). The economic notion of a 'service' involves the territorial economy of non-consumptive exchange-values with a certain distance from traditionally more controversial primary resource exploitation (Dempsey and Robertson 2012:764). I share a similar observation with Swyngedouw (2013) that the overwhelming share of cited literature comes from either other UN sources or from ecological engineering literature, leaving critical theoretical research on water struggles in countries of the Global South not receiving the attention they deserve (p.826). In practice, ecological economists need to resist using current dominant ways of thinking to reach short-term, partial solutions and favor both emerging and the multiplicity of less dominant ways of analyzing problems to promote a rich understanding of the complexities of society and nature (Norgaard 2010:1225).

The report goes on to emphasize that *"Land degradation is linked with impaired ecosystem services and low water productivity"* (UNESCO 2018:19). Land degradation should not be the only factor that is linked with impaired ecosystem services that are not able to provide

unsustainably high levels of water. What prevents ecosystems from being more 'productive', especially in developing countries of the Global South, is the over-extraction of water for the production of food and household goods that are mostly exported to the developed countries of the Global North. Mehta (2011) argues that a dimension to anthropogenic scarcity is the overexploitation of groundwater aquifers (p.377). Quite surprisingly, this report goes on to emphasize that tapping underexploited water in landscapes, as a form of small-scale grey infrastructure, have at times been presented as NBS (UNESCO 2018:39). Marcuse (1964) argues that science has become technological rationality since it organizes matter as a possible object of human manipulation (p.159). Many political ecologists would agree with Marcuse that the domination of nature by instrumental and technological rationality is increasingly evident with concepts such as ecosystem services, and potentially disastrous (Atkinson 1991:62). Prevalent throughout this report, is the idea that ecosystems should be defined mathematically as 'ecosystem services' now makes it possible for natural science and ecological engineering to treat ecosystems instrumentally and rationally as an object for the technocrat's ability to get them out of the troubles they created in the first place.

From an ecological or scientific perspective, this concept has also been subject to criticism for obscuring certain important ecological functions and leading to dangerous simplifications (Kull 2015:123). The treatment of ecosystems favoring one particular function is potentially disastrous since ecosystems are extremely complex and there are still many uncertainties regarding their functions. Uncertainties surrounding climate change or the role of upstream forests in the functioning of down-stream catchment basins, are one of many examples of uncertainties inherent in any research pertaining to the function of ecosystems (Barnaud and Antona 2014:114). What this report seeks to accomplish through the concept of ecosystem services, is to simplify the

complexity of water scarcity issues. The baseline is that water scarcity, as a complex social and political issue cannot be addressed with a simple technical fix.

From a political ecological perspective, this technocentric concept has been critiqued on the basis that it avoids a consideration of crucial social, political and contextual factors (Kull 2015:123). Turnhout et al. (2013) argue that technocentric approaches to biodiversity selectively privilege certain aspects of scientific knowledge while ignoring the diversity of knowledges in relation to biodiversity (p.154). Focusing on one service provided by an ecosystem can also hide many other functions that are important for local livelihoods (Kull 2015:129). Natural scientists tend to view the concept of ecosystem services as describing the functioning of an ecosystem and disconnects this description from its social context (Barnaud and Antona 2014:118). Behind every ecosystem service there are individuals who either benefit from these services or actors contributing to the production, degradation or protection of these services (Barnaud and Antona 2014:118). Ecosystem services were introduced by the western scientific community, which views nature as the supplier of services for society (Barnaud and Antona 2014:117). Through the innovation of technology to gain a greater understanding of the functions of ecosystems, this science allows us to have increased mastery of nature in order to serve our needs.

The central argument of this report is that ecosystem services are good for increasing the supply of water through the construction of ecosystems to store water, which is then deemed beneficial in reducing the likelihood of water shortages. This report may see ecosystem services as a solution to water scarcity challenges in countries of the Global South, but this report does not address the political factors of water shortages. Scarcity is a concept that can provide explanations for a wide range of phenomena over which humans have no control while science and technology are evoked as panaceas (Mehta 2011:373). Mehta (2011) instead argues that there is an urgent

need to link water scarcity with wider socio-political processes (p.372). Hornborg (2015) argues that the dominant narratives and consensus around climate change are that it is derived from human activities, but rather than examine their social and political drivers as factors that can be transformed, the narrative tends to represent them as natural and inevitable traits of human biology (p.62). There has also been a tendency to direct attention to the lack of water supply due to natural forces rather than examine human-induced land and water use practices (Mehta 2011:372). One example in this report is that investments in 'urban green infrastructure' with examples consisting of reforestation and the construction of wetlands, will increase urban water storage and act as a buffer against water scarcity (UNESCO 2018:45). This regulation of urban water flows particularly increases urban water storage and therefore resilience to variations in water availability, whether for flood management or to act as a buffer against water scarcity (UNESCO 2018:45).

Mehta (2011) argues that in popular discourses promoted in the media and by politicians, the anthropogenic dimension of water scarcity is often obscured (p.377). The water problem is portrayed as "natural", something beyond human agency (Mehta 2011:377). The report states that water availability (particularly scarcity) is influenced by water quality but goes on to argue that disastrous floods and droughts are represented as the only two factors related to affecting water availability (UNESCO 2018:38). These two extreme factors are those most often attributed to the effects of climate change but not stated explicitly as such, but more importantly, they represent the water scarcity problem as a cause of the 'natural' side effects of climate change. This problem is described as not beyond the agency of humanity since NBS can help address these water availability challenges by being more resilient to the effects of climate change on water availability. The hidden reality is that scarcity is socially and politically constructed to meet certain

ends, but it is constructed by these powerful discourses as ‘natural’ and to be left to the control of technocrats (Mehta 2011:383). Powerful discourses of scarcity have largely served the interests of powerful people (Mehta 2011:382). Swyngedouw (2013) argues that scarcity is socially and politically constructed and expressive of unequal power relations (p.828).

Another example of this report failing to direct attention to human elements of water scarcity, is in its advocacy that policy environments need to promote the adoption of NBS where it is warranted (UNESCO 2018:48). They go on to argue that ‘warranted’ refers to water shortages caused by extreme floods and droughts, without addressing any social or political factors that are the cause for the unequal global distribution of freshwater. This is interesting considering that extreme floods and droughts are often associated as major effects of climate change. The report also notes that NBS are committed to the thirteenth goal within the UN’s Sustainable Development Goals (SDG), which would contribute significantly to resiliency against the impacts of climate change by increasing carbon storage through ecosystem services (UNESCO 2018:49). In other words, what this commitment means, is that this technocentric understanding of nature, is useful for mitigating the effects of climate change, without significantly reducing our over consumption of fossil fuel intensive goods and services in nations of the Global North. This instrumental and technocentric understanding of nature can now also be used to mitigate the effects of drought, without significantly reducing our consumption of water-intensive goods in countries of the Global North.

Hornborg (2015) highlights an important fact, which is that an average American today emits as much carbon dioxide as 500 average citizens of Africa, yet climate change is presented as a ‘global’ environmental problem (p.61). I question whether this is not the same reality with the global issue water scarcity? This report is focused on how to implement nature-based technologies

to increase water availability in developing countries, which use most of their water supplies to help support the water-intensive consumption lifestyles of people in countries of the Global North. The introduction of wetland ecosystems to help alleviate the effects of water scarcities in developing countries, signifies that this report is not interested in addressing the uneven distribution of water, which is leading to conflicts over the control of this limited resource. Water scarcity in developing countries are beyond the horizons of natural science and environmental engineering, because they require analytical tools that natural scientists and ecological engineers are not equipped with (Hornborg 2015:62). This is also not simply a problem of natural scientists ignoring the social and social scientists ignoring the natural (Norgaard 2010:1220).

The problem is an uncritical enthusiasm for ecosystem services that has not addressed the more important fact that we are eventually going to have to make the substantial societal and political changes to significantly reduce human demands and pressures on ecosystems, especially by the wealthy. Through the implementation of carbon offsets and now the optimization of water-related ecosystem services in poorer countries, this cornucopian thinking of being able to continue the detrimental cycle of overuse is being sustained in rich countries of the Global North (Norgaard 2010:1219). This dominant way of thinking could substantially reduce scientific understanding of the true complexities of ecosystems that will lead to narrow management and future crises (Norgaard 2010:1222). The problem is that we have become accustomed to the understanding and deployment of technologies that have facilitated high levels of individual consumption patterns that have been destroying the natural systems that support these unsustainable lifestyles (Norgaard 2010:1225).

This report fails to address that these nature-based technologies enables some groups of people at the global scale to exert power over other groups of people at the local scale. For example,

this report uses mainstream methods from ecological engineering to obscure the fact that there is an unequal global exchange of water. The lack of understanding of this unequal exchange is the result of our obsession with ‘technological progress’ and the displacement of the global focus on environmental issues (Hornborg 2015:65). The treatment of ecosystems by valuing one particular function, is potentially disastrous since all functions work interdependently to support a healthy ecosystem. Favoring one particular function over all other functions of an ecosystem, will surely lead to its quick demise. This leads me to my main argument that a technocentric construction of problems related to water scarcity, without an investigation of the political causes of this environmental problem, may potentially lead to the increased uneven development of these artificial ecosystems or ‘green infrastructures’, leading to severe social conflicts. An emphasis on interpreting and responding through an ecosystem service perspective sets other patterns of understanding to the margins and increases the likelihood of making serious mistakes (Norgaard 2010:1220). Assuming away the complexity of socio-ecological systems and the diverse ways of understanding that complexity, is a recipe for ineffective and disastrous outcomes (Norgaard 2010:1221).

Discussion

I have argued throughout my analysis, that this report consists to be a highly technocentric document by depoliticizing the ecological problem of water scarcity. I now embark on providing an answer for the infamous 'so-what?' question. What is this report saying about water scarcity and how does it propose to solve this issue? I found that this report's description of water scarcity is still influenced by the policy outcomes of early UN conferences, which describe water shortages as requiring technocentric, scientific and managerial solutions. I also found that this report fails to acknowledge the deep-rooted political causes of social and environmental problems in the developing countries where these 'nature-based solutions' are implemented. My findings are similar to Shah et al's (2018) who found that this report failed to recognize that water management involves political struggles for water control (p.685). One significant and undiscussed cause of water scarcities that the report's technocentric outlook fails to address, is the growing academic recognition that in many developing nations around the world, such as in India and Chile, water scarcities are rooted in water controlled by global agribusiness and extractive industries, which support the growing wealth of nations in the Global North (Shah et al 2018:685). These social as well as environmental problems are often not visible to people in countries of the Global North since they are distant from the political power and environmentally destructive activities of these industries in countries of the Global South. The site where these green infrastructures or nature-based solutions are implemented, is also thousands of miles away from the daily sights of people in the Global North, which makes it easier to deepen the uneven development of these green infrastructure solutions or ecosystem services and to intensify conflicts over scarce natural resources in countries of the Global South (Smith 2008:19).

The unaddressed concern with this report, is that these "cornucopian" solutions may potentially led to the uneven development of ecosystems to preform services that are likely only to benefit the wealthy countries that have implemented them in order to extend their ecological limits. Ecosystem services is described within the context of this report as 'solutions' that make investments more cost-effective over time (UNESCO 2018:6). Ecosystem services are also described in the WWDR as *"The water-related processes and functions of ecosystems that can be managed to deliver benefits to people as 'ecosystem services'"* (UNESCO 2018:29). Secured ecosystem services in most cases comes from northern governments in developing countries where there is little infrastructure and capital to make the necessary payments (Dempsey and Robertson 2012:771). The growing academic concern, especially among political ecologists, is that ecosystem services are displacing many people and leading to unforeseen ecological and social problems, which is continuously outside the scope of the UN's world water reports. A focus on ecosystem services also negates a discussion of how changes in human behaviors can be achieved to address the causes of widespread ecological degradation (Bullock et al. 2011:546). The analysis should act as a caveat for the recognition that the conversion of ecosystems into single services, is risking the emergence of social and ecological problems.

In terms of social conflicts, the introduction of water-related ecosystem services into developing nations, will allow wealthier nations to expand their ecological limits by extending their water supply depot into developing nations, which overlaps with the living space of people who have traditionally depended on the land for subsistence. The technocrats of wealthier nations continuously refuse to accept the fact that the overuse of ecosystems will always lead to ecological disruptions, which then become ecological and social problems (Dunlap and Catton 2002:245). The technocentric and cornucopian thinking of wealthy westerners that ecosystems can just be

constructed in developing nations as 'green infrastructures', to be overused for their "productivity" and not expect new ecological problems to emerge, is profoundly cyclical. This cornucopian and one-dimensional thinking does not take into account the functions of ecosystems and does not question the root causes of why water scarcities keep re-emerging in developing nations. This thinking also allows for the continued treadmill of production for agricultural commodities to be exported to wealthier nations without any regard for environmental repercussions. Neither is this thinking forcing nations of the Global North to encourage international discussions around how political factors play a crucial role in this growing environmental concern.

I have found that NBS otherwise described as green infrastructures or ecosystem services are to act as a water supply depot, without a discussion of how developed countries can reduce their reliance on the importation of agricultural commodities from developing nations. There is academic consensus that agriculture is a significant contributor to clean water shortages, as it is evident in the following anecdote. *"An NBS approach is a key means for addressing overall water scarcity through supply-side management, not least because the approach is recognized as the main solution for achieving sustainable water for agriculture"* (UNESCO 2018:38). I also found that these nature-based solutions will act as a waste-repository site for carbon sequestration in the global fight against climate change as illustrated in the following quote. *"As most NBS involve improving system resilience, and in many cases increasing carbon storage (notably through soil and vegetation management), they also contribute significantly to SDG 13* (*"Take urgent action to combat climate change and its impacts"*)" (UNESCO 2018:49).

The provision of a specific ecosystem service for the functions of carbon sequestration or water storage, will also lead to social conflicts for access to natural resources (Bullock et al. 2011:543). I therefore argue that these two particular environmental functions of water-related

ecosystem services to be implemented into developing nations, will create fewer living spaces for the people where these ecosystem services are implemented and lead to conflicts between local people and the global forces implementing these services. The conversion of ecosystems into single purpose services will no longer function as a supply depot for food and other needs that the local people have always been dependent on. Environmental preservation projects require that a particular patch of nature be rendered off limits to future habitation and these cordoned off landscapes are often constructed and overseen by non-residents whose livelihood is not dependent on the enclosed environment (Katz 1998:54).

Morgan Robertson (2004) provides an example of how wetland mitigation has become an opportunity for the private sector by illustrating how a 120-acre piece of land on the outskirts of Chicago, was bought by a residential development firm that was not planning to plant corn but planned to convert into a wetland to produce and sell ecosystem services (p.361). The reason for converting land into ecosystem services is that with offset credits emphasized as a solution by the Millennium Development Goals for solving global environmental problems, such as climate change, it is becoming increasingly more profitable to invest in the conversion of ecosystems into servicing specific needs, such as the reduction of carbon in the atmosphere. The desire of wealthier nations to use recent technological innovations called green infrastructures, to buy themselves out of environmental problems, is potentially conflicting with the interests of the people where these ecosystem services are being developed. As more people require places to live, use resources and produce waste, especially in developing nations with higher population growth rates, ecological problems will worsen, and new ones will continue to emerge (Dunlap and Catton 2002:245).

Water-related ecosystem services in the future will face huge demands for a multitude of uses, which can potentially lead to ecological conflicts between conservation of a specific service

and biodiversity loss. Wetlands are signified as important for biodiversity conservation, which then constrains them to single uses. This results in a situation where a complex natural ecosystem supporting multiple uses is now transformed into a greatly simplified system for increasing the availability of water (Adger and Luttrell 2000:82). A simplified ecosystem could lead to detrimental impacts for the biodiversity of an ecosystem, which then affects its ability to provide other services (Bullock et al. 2011:546). With the help ecological engineering experts gaining a greater knowledge of the hidden functions of ecosystems, nature in itself is going through what Katz (1998) calls an "involution" process (p.45). The involution process is that as science and technology is used to gain a greater understanding of the hidden dynamics of nature, the biodiversity of nature is shrinking as technological innovations are used to manipulate the earth's limited resources to cater to the insatiable consumption demands of countries in the Global North.

Murphy (2018) argues that the impoverishment of biodiversity has its origin in the monopolization of resources through the technological manipulation of nature (p.240). The cornucopian thinking of the mastery of nature by humans leads to the monopolization of nature's resources by the human species and the destruction of biodiversity (Murphy 2006:192). The cornucopian mastery of nature is provided in this report as the implementation of green infrastructures to extend the ecological limits of water scarcity in developing nations, caused by the extractive industries of wealthy, industrialized nations. Due to dramatic reductions in biodiversity resulting from industrial development in Europe and North America, many biodiversity battles are now being fought in developing countries throughout Latin America, Asia and Africa (Katz 1998:48). The monopolization of these ecosystem services and the resources it produces, is monopolized by wealthier nations and potentially leading to the destruction of

ecosystems in the Global South where generations of poorer, local people have conserved its biodiversity. The intensified poverty of the local inhabitants surrounding these mitigation sites often leads to significant if not accelerated environmental degradation (Smith 2008:20). The greater mastery of nature through technological advancements in countries of the Global North has allowed for 'the production of more nature' through the introduction of ecosystem services. This finding is at the heart of my argument, that this manipulation of nature through the production rather than the traditional extraction of more natural resources, alters how natural resources will be managed by wealthier nations but not without the introduction of new risks regarding ecological and social problems in countries of the Global South.

I will argue that the increased governance of ecosystems through the market is facilitated by what Neil Smith (2008) calls the "production of nature". This new form of nature, which is characterized in this report as 'green infrastructure' was engineered to be more productive and is now deemed to be 'improved'. The production of nature is the innovation or the construction of ecosystems into having more 'productive' value, which is then deemed as useful for the economic and environmental interests of wealthy nations. There is currently a lucrative market in the preservation or restoration of these ecosystems and the current transnational political ecological relations are there to ensure that the eventual benefits will flow north (Katz 1998:49). The production of nature is evident in this report as the process of transforming ecosystems into green infrastructures by engineering them to be as productive, if not more productive, than traditional grey infrastructures. Smith (2008) argues that this concept is not about questioning to what extent nature is controlled, but the question is really about how nature is being produced and who controls this production of nature (p.89). This transformation is deemed to make them more cost-effective and productive for increasing the availability or supply of water and therefore increasing the

economic value of these constructed ecosystems since they are helpful in extending the ecological limits of affluent nations who overuse the world's limited resources.

The concern with the production of natural wetlands into "services" for the sequestration of carbon and for increasing the supply of water, is that it will reduce the amount of land that is available for the local people to depend on for their own needs. This cornucopian discourse marginalizes social explanations for why water scarcity prevails despite technological advancements. This marginalization in turn leads to social problems through the displacement of local people from their natural wetlands in order to enclose these ecosystems for the "services" they provide to alleviate the effects of water scarcities that are caused by the industries of developed nations. The enclosure of wetlands to act as a supply depot and waste-repository for affluent nations is veiled in the language of nature-based solutions, green infrastructures and ecosystem services.

I share a similar argument with Smith that emerging market-based environmental policies, such as the argument for ecosystem services for water purification that appears in the WWDR (2018), will exacerbate existing inequalities. An overemphasis on the technical concerns of this problem at the expense of examining the political factors, will most likely favor the increased enclosure of wetlands and continue to exacerbate the uneven global distribution of water and land. This alternative framing of global environmental problems examines political decisions in developing nations that have blindly favoured technological innovations of the Green Revolution that have many decades later resulted in numerous environmental problems. The current capitalist economic system requires that the high-consumption lifestyles of people in countries of the Global North remains unabated and therefore global development will always be uneven in order to sustain these lifestyles (Robbins, Hintz, Moore 2014:110). Katz (1998) argues that putting such

properties aside in the name of global environmental protections is a form of luxury consumption in itself (p.48).

The production of nature is not simply the mastery of nature through technological innovations for the increased extraction of the earth's limited resources. The production of nature through ecosystem services or green infrastructures can capitalize on nature more creatively and intensively than the conventional extractive resource industries of early capitalism (Dempsey and Robertson 2012:762). What is interesting about Smith's (2008) conception of the production of nature is that the accumulation of nature no longer traditionally occurs on a top-down scale, in which nature was traditionally perceived as an "open frontier" for corporations to extract raw materials from. The accumulation of nature is now performed on a bottom-up scale by 'improving' nature through technological innovations and then claiming its 'improved ecosystem services' can be used to alleviate environmental problems as a result of having exhausted ecological limits.

This conversion will likely serve the interests of a select few in countries of the Global North at the exclusion of local people in countries of the Global South. During the first half of the twentieth century, technical advancements were used for the increased extraction of natural resources. In the second half of the twentieth century, science and technology has led to a greater understanding of the complex functions of nature permitting the 'production' of natural resources, which is the increased supply of water through ecosystems services. The difference between these two time periods in terms of resource management is that the former was based on extraction and the latter was based on production. What has not changed, is the social issue of local people being displaced for the development of ecosystem services, that primarily serve the interests of nations in the Global North. These recent technological innovations or 'fixes' allow for the conversion of the traditional and controversial extraction of natural resources into the production of new

ecosystems for increasing the supply of water and extending the ecological limits of water scarcity. This recent conversion, which is emphasized as a nature-based and progressive project in this report, has supported my central argument that this cornucopian and technocentric fix has not addressed the complex political causes at the root of this environmental problem. The historical spread of post-war Green Revolution agricultural science and technology throughout countries of the Global South is a significant political factor behind the uneven distribution of water and water shortages for human needs in developing nations today. Western India is a recent example of how political decisions concerning water allocation has been heavily skewed towards food production and transnational agribusinesses (Roth and Warner 2008:266).

The post-war Green Revolution was first coined in 1968 as a political strategy of the US government to counter the rise of communist revolution sweeping through the developing world, particularly in Mexico and India (Kilby 2019:9). The post-war Green Revolution in countries of the Global South was mostly funded by the US government policies and the Rockefeller foundation, which resulted in the export of Green Revolution technology ignoring local farming systems in favour of scientific knowledge (Kilby 2019:10). This government had also pushed for the promotion and sponsor of research in agricultural science and technology for resolving the imminent social problem of population growth and widespread famine in nations of the Global South. These social problems were perceived by westerners as making countries of the Global South more susceptible to communist influences and therefore local farming systems were to be replaced with a simple scientific and technocentric fix. This report does highlight that *"Traditional or local-community knowledge of ecosystem functioning and the nature-society interaction can be a significant asset"* (UNESCO 2018:7). But this report does not tie this important fact back to the political decision to replace local agricultural knowledge systems with 'Green Revolution science

and technology' that have today resulted in significant soil and water degradation problems in the western Indian state of Punjab.

The Green Revolution's agrochemical technologies of chemical fertilizers and pesticides have contaminated significant amounts of ground and surface water, therefore reducing the global availability of freshwater. The spread of the Green Revolution in Punjab is synonymous with the spread of the intensive use of water (Shiva 2016:168). Future increases in crop production will now have to come from rainfed farming as a result of the significant ecological and social damages of these technologies (Hunt 2004:79). The report does briefly acknowledge this fact, *"By far the greatest potential for NBS to improve water availability, compared to other options, is in agriculture, through efficiency gains in rainfed and irrigate system"* (UNESCO 2018:49). The problem is that in a place like India, where rainfall is unreliable, rainfed farming is certainly not possible (Tripathi, Mishra, Verma 2016:52). This specific case study example poses as a significant challenge to the report's technological 'expert knowledge' and policy recommendations, which are assumed to be applied universally (Shah et al 2018:682).

The foreign political actions of the past to reduce social problems of rising communism and famine, have now resulted in serious environmental problems for India. Punjab was at the epicenter of the Green Revolution in the late 1960s (Tripathi, Mishra, Verma 2016:49). The environmental concern in Punjab since the Green Revolution has been groundwater overexploitation and depletion resulting in many concerns for local ecosystems and human needs (Tripathi, Mishra, Verma 2016:49). The overexploitation of groundwater for the irrigation of agriculture in Punjab is an example of Mehta's (2011) argument that a significant dimension of water scarcity is the overexploitation of groundwater aquifers (p.377). Water shortages in western India is a result of what Bhushan (2018) elaborately calls "Intensified and productivity-enhancing

Green Revolution technology-based agriculture" (p.185). The intensity of monocropping for increased productivity with increased reliance on chemical fertilizers, decreases nutrients in the soil resulting in the degradation of soil quality and therefore affecting its ability to store water. The intensive monocropping of wheat and rice with the heavy use of fertilizers and pesticides has resulted in the degradation of soil and water quality of these water-intensive and soil-exhaustive crops (Tripathi, Mishra, Verma 2016:52). The degradation of soil and water quality in a state that has irregular rainfall patterns has forced it to be reliant on the over-exploitation of groundwater for irrigation.

Another significant finding of the WWDR 2018 in relevance to concerns of water insecurity in the northwestern Indian state of Punjab, is that there is no mention of the concept of 'virtual water', despite growing academic research and applications of this concept. This is even more surprising considering that in 2003, the first edition of the report was launched at the international World Water Forum (WWF), at the same time that India was paying close attention to the concept of virtual water when it was also first introduced at the WWF in 2003 (Shah et al 2018:680). The western Indian state of Punjab, exports most of its agricultural products from an already dry place to relatively wetter regions of the northern world (Vos and Boelens 2018:284). Environmental realists employing the concept of virtual water will tend to argue that a nation like India can deal with water scarcity through the import, rather than the export of staple foods like wheat and rice (Roth and Warner 2008:259).

Resolving these environmental problems in a developing country like India, that cannot rely on rainfall farming and faces increasing demands for food due to population and economic growth, will be much more complex than just replacing Green Revolution induced agriculture with the implementation of 'nature-based solutions' for increasing the supply of water. The problem of

water scarcity in a developing nation like India, will require serious global political discussions with wealthier northern countries on how to feed and support the economy of a growing number of people, without having to reduce the availability of water for the producers and exporters of these soil and water intensive crops. When many poor rural farmers in Punjab are worried that crop diversification will reduce their incomes (Roth and Warner 2008:265), policy leaders need to listen to the concerns of the most vulnerable and ask themselves if it is even possible to balance economic growth with environmental 'sustainability'? The current discussion that policy makers should be engaged in at the international scale is how to avert these imminent water scarcity problems in a place like India, without having to wait for technical solutions.

Conclusion

To recap, this paper's central research question was "How does the United Nations World Water Development Report of 2018 describe the problem of water scarcity or shortages and what do the authors propose for fixing this problem?". I have answered that question by arguing that water shortages or scarcity is described in this report, not as a social or political problem, but as an economic and technical problem with 'nature-based solutions' grounded in 'more science and technology'. I have argued throughout this paper that this report does not direct enough attention to the social and political elements of water scarcity. The report presents water scarcity as influenced by the quality of water that is available for human consumption but goes on to argue that disastrous floods and droughts are represented as the only two factors that have a detrimental impact on the availability of water (UNESCO 2018:38). Water scarcity is described early on in this report as the "natural" causes of climate change and population growth. The lack of a discussion of anthropocentric effects of water scarcity has made this environmental problem more amendable to solutions provided by the natural sciences and ecological engineering.

Another important finding regarding this research question is that NBS, otherwise described as green infrastructures or ecosystem services, are to act as a water supply depot, without a discussion of how developed countries can reduce their reliance on the importation of agricultural commodities from developing nations where there is academic consensus that agriculture is a significant contributor to clean water shortages, as it is evident in the following anecdote. "*An NBS approach is a key means for addressing overall water scarcity through supply-side management, not least because the approach is recognized as the main solution for achieving sustainable water for agriculture"* (UNESCO 2018:38). I also found that these nature-based solutions will act as a waste-repository site for carbon sequestration in the global fight against climate change as

illustrated in the following quote. *"As most NBS involve improving system resilience, and in many cases increasing carbon storage (notably through soil and vegetation management), they also contribute significantly to SDG 13* (*"Take urgent action to combat climate change and its impacts"*)" (UNESCO 2018:49).

The impact of these findings is that political ecology in the twenty-first century should concentrate more of its academic efforts on how technological advancements in the coming years may mean that technological innovations, coupled with market forces, will be more frequently adopted to solve environmental issues at the expense of examining social and political solutions. This research could be a starting point for explaining why in certain parts of the world, these green infrastructures may be implemented, but may not reduce scarcity in places where there are still many conflicts as a result of national and international policies that favor the virtual control of water by agribusinesses. This research could also be potentially referenced in the near future as an example of how a highly technocentric understanding of ecosystems tends to invite unforeseen social and ecological problems.

I first discussed the historical and current context from which this report emerged from. I then provided a general outlook of the theoretical field of political ecology. Next, I provided a brief summary of what I found were three of the most relevant chapters to the topic of this research, which was the environmental problem of water scarcity. I then provided an in-depth analysis of the three most common and prevalent themes or keywords found through these three chapters. In the discussion section, I then provided an elaborate answer for my research question by arguing that this report's examination of water scarcity through a "nature-based" and technocentric lens does not address political factors grounded in this ecological problem, which could then potentially lead to a proliferation of new social and ecological problems.

The significant limitation of this study is that it did not provide an in-depth case study of the effects that a water-related ecosystem service, such as a constructed wetland, can have on the local populations where these services are implemented. This limitation is actually an opportunity to discuss further areas of research. These three common themes, especially the theme of ecosystem services, could inform a case study where these water-related ecosystem services would be implemented and how they would affect the local livelihoods of these people. Such a case study would demonstrate the real-life and distant effects that such an influential and hegemonic report has on the people where some of these green infrastructure developments might take place. My analysis and critique of this report should also encourage political ecologists to do more research into how technological innovations have an impact on people of the developing world. This research relates to existing political ecological literature that critiques the development of carbon offsets projects for Clean Development Mechanism (CDM) credits introduced by the Kyoto protocol.

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