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A Comparative Study of Individual Travel Patterns of Urban Fringe Dwellers in Ottawa, Canada; Kuala Lumpur, Malaysia; and, Yogyakarta, Indonesia

BY
NAIRNE CAMERON

A THESIS
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ABSTRACT

A technique for gathering, analyzing and grouping individual travel pattern data is developed and tested in an international case study to compare the travel behaviours of urban fringe dwellers in three cities. The cities are Ottawa, Canada; Kuala Lumpur, Malaysia; and Yogyakarta, Indonesia. The technique makes a contribution to research methodology through implementation of the following elements *in combination*:

(1) an urban fringe, spatial, residential sampling procedure;

(2) a household survey that gathers detailed data on respondents and their travel patterns for three days over the period of a week including both work and non-work time periods; and,

(3) an analysis that decomposes the travel patterns into various dimensions, facilitated by a Geographic Information System (GIS) which is followed by a segmentation of the travel patterns using cluster analysis.

Based on the Ottawa component of the survey, an approach is suggested for collecting spatial familiarity data from urban fringe dwellers. The approach explores relationships involving respondents' previous residential locations in the city region. This evaluates their areal familiarity: a factor which influences their travel patterns.

The comparative study examines empirical relationships by means of comprehensive data analysis and hypothesis testing. The dimensions of travel investigated are: travel activities, modes of travel, distance, time and speed of travel, trip destinations, reasons for travel, frequency of travel, complexity of travel, and, spatial familiarity. Case study results reveal several commonalities and differences between the three field sites:

(a) the car is the dominant mode in Ottawa, compared to a wider diversity of modes operating in the Southeast Asian field sites;

(b) individual respondents in Yogyakarta travelled by a greater number of modes than those in Ottawa and Kuala Lumpur;

(c) car modal share increased on non-work days compared to work days in all sites;

(d) respondents in Ottawa exhibited the highest mean travel distances, travel times and speeds, followed by respondents in Kuala Lumpur and Yogyakarta;

(e) the urban fringe was the destination of over half of all stops in both the Kuala Lumpur and Yogyakarta surveys, compared to less than half in Ottawa; and,

(f) across field sites and survey days, the clusters with the highest mean tours per day have daily destinations concentrated in the urban fringe.

Résumé

Une technique qui a été utilisée pour amasser, analyser et regrouper les données quant aux patterns de transport a été dévelopée et testée à l'intérieur d'une étude de cas international dans le but de *comparer les habitudes de transport* des habitants des zones semi-urbaines et rurales dans trois villes.

Ces trois villes sont la ville d'Ottawa au Canada ensuite la ville de Kuala Lumpur en Malaisie et enfin celle de Yogyakarta en Indonésie.

Cette technique enrichit la recherche méthodologique par le biais de l'application des *éléments combinés* suivants:

(1) une procédure sélective à fin de délimiter les zones résidentielles dans un espace précis et à l'intérieur des espaces semi-urbains et rurales;

(2) un sondage maison qui recueille de l'information sur les répondants et leurs patterns de transport pour trois jours, et ce, sur une période d'une semaine incluant des périodes de travail et de non-travail; et,

(3) une analyse qui décompose le *pattern de transport* dans ces divers aspects grâce à l'utilisation du Système d'Information Géographique. Ensuite, les patterns de transport sont divisés et examinés via une *analyse de groupe*.

Basé sur les données de l'étude de la ville d'Ottawa, une approche est suggérée pour amasser des données sur la familiarité spatiale des habitants des zones semi-urbaines et rurales. Cette approche explore les relations concernant les lieux de résidences antérieures des répondants dans la région de la ville. Ceci évalue leur familiarité avec la région: un facteur qui influence leurs patterns de transport.

L'étude comparative examine les relations empiriques par le biais de l'analyse compréhensive de données et la vérification d'hypothèses. Les aspects du transport qui sont étudiés sont: les activités reliées au transport, les moyens de transport, la distance, le temps et la vitesse de transport, la destination des voyages, les raisons des voyages, la fréquence des voyages, la complexité des voyages et la familiarité de l'espace. Les résultats de l'étude de cas ont révélé certaines ressemblances et différences entre les trois sites:

(a) la voiture est le mode de transport le plus important à Ottawa, comparativement à l'Asie du Sud-Est ou une plus grande diversité de moyens est utilisée;

(b) les répondants individuels de Yogyakarta utilisent un plus grand nombre de moyens de transport que ceux d'Ottawa et de Kuala Lumpur;

(c) l'utilisation de la voiture connaît un pourcentage plus élevé durant les journées de non-travail en comparison aux journées de travail et ce, pour tous les sites;

(d) les répondants d'Ottawa ont démontré le plus haut pourcentage de distances parcourues, de temps de voyages et de vitesse atteinte par rapport aux répondants de Kuala Lumpur et Yogyakarta;

(e) les zones semi-urbaines et rurales étaient la destination de la moitié de tous les arrêts dans les sondages autant pour celui de Kuala Lumpur que celui de Yogyakarta, alors que pour Ottawa elle en était moins que la moitié; et,

(f) dans les divers sites et les différentes journées du sondage, le groupe de répondants avec le plus haut taux de trajets, par jour, ont des *destinations journalières* concentrées dans les zones semi-urbaines et rurales.

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Many individuals in three countries (Indonesia, Malaysia and Canada) have supported this international research project. I especially wish to acknowledge the advice and encouragement of my dissertation supervisor, Dr. Barry Wellar. Dr. Wellar's constant reminders that geography matters made me appreciate why he was awarded the Anderson Medal of Honor in Applied Geography from the Association of American Geographers, and why my investigation into the theoretical and applied aspects of urban fringe trip behaviour in different cities and in different countries is a scientifically and societally significant geographic inquiry.

Also, I wish to acknowledge my thesis committee members: Dr. Ata Khan, Dr. André Langlois and Dr. Léon Ploegaerts, and my external examiner, Dr. Shih-Lung Shaw for their contributions. Dr. Ata Khan, from the Department of Civil and Environmental Engineering at Carleton University, lent his expertise related to transportation modelling methodology to the study. Dr. André Langlois, as an urban and quantitative geographer, offered technical comments regarding the data analysis. Sharing his in-depth knowledge of the National Capital Region, Dr. Léon Ploegaerts made a valuable contribution to the Ottawa portion of the study. Finally, Dr. Shih-Lung Shaw, a GIS and transportation specialist from the University of Tennessee, Knoxville, made many helpful suggestions on the GIS and data analysis aspects of the thesis.

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Nairne Cameron, May, 2003.

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Purpose Statement

In this thesis *a GIS-based approach for modelling travel patterns of individuals in the outer fringes of urban areas* is developed. The approach is tested by case studies in Ottawa, Canada; Kuala Lumpur, Malaysia; and Yogyakarta, Indonesia. The research program has seven components:

1) design a household travel survey instrument that uses an activity analysis approach;

2) pre-test the survey instrument;

3) conduct survey field research in three cities (Ottawa, Kuala Lumpur, Yogyakarta);

4) present research results derived from a GIS-based empirical study conducted in the three field site cities;

5) design an approach for describing and classifying travel patterns;

6) identify the contribution to travel pattern knowledge made by the research;

7) suggest how the travel pattern classification approach could be applied in transportation and land-use policy-making.

1. Research Problem

1.1 Introduction

Urban transportation networks in both mature and developing countries continue to experience major difficulties, including severe congestion and air pollution. The problem to be resolved can be phrased as a research question.

> How can we organize our urban land use and transportation systems in order to accommodate the movement of people and goods without incurring the congestion, greenhouse gas emissions, pollution and other direct and indirect costs of current transportation networks?

Developed and developing countries share similar social, environmental, financial and economic consequences arising from the impact of urban transportation infrastructure expenditure and uses. With a rapidly-developing transportation network, the difficulties in Southeast Asia are particularly acute in mega-urban regions. Traffic congestion, road accidents, environmental pollution (including air quality, noise, and visual intrusion), overloaded public transport, poor conditions for pedestrians and cyclists, and the lack of money to improve those conditions (Rimmer, 1995) are just some of the difficulties.

These same symptoms were identified nearly three decades ago in North America and labelled as being part of the 'urban problem' (Owen, 1966; Meyer et al., 1969; Stegman, 1969; Smith and Wellar, 1992; Wellar, 1982; Wellar, 1994). Now that we have reached the year 2003, and with half of the world's population resident in cities (Laquian, 1995), the 'urban problem' persists and indeed intensifies in developed and developing countries alike (Stren, 1994; Pendakur, 1995; Government of Canada, 2002).

In the maturing transportation environment of North America, the 'urban problem' exists in a slightly different form than in Southeast Asia. In North America, there appear to be two main trends:

a) an increase in suburb-to-suburb travel; and,

b) growth in discretionary (non-work) travel (see Table 1).

As Torrie (1996, p. 38) notes:

> "For nearly fifty years, the weekday morning peak rush-hour has been the focus of urban transportation planning techniques and infrastructure investments. Now it is rapidly spreading out both in space and time as urban origin/destination patterns become increasingly complex."

Table 1: General Trends in North American Urban Traffic Patterns

Traffic Characteristics	Change Over Time (1950's-late 1990's)
Peak Hours	Morning, noon and evening peaks have become longer in duration.
Trip Origin	Suburbs (as opposed to the city core) have become the origin of more trips.
Trip Destination	Suburbs (as opposed to the city core) have become the destination of more trips.
Travel Volumes	Have increased.
Trip Purpose	Growth in non-work travel.

In both Southeast Asian and North American cities, the outer fringes of cities is the area where many new infrastructure decisions are being made – decisions on locations for new housing, retail establishments, high-technology clusters and road developments. For this reason, the urban fringe is the focus of this study.

Most current techniques of transportation modelling were originally developed to forecast demand for major freeways in North America in the 1960's (Wen, 1998) and were adapted for transit planning in the 1970's (Regional Municipality of Ottawa Carleton, 1979). As a result, these "mass flow" techniques are not easily adapted to *heterogeneous* land use or travel environments, such as the outer fringes of large urban regions or areas experiencing increased suburb-to-suburb travel. And, due to the mixed land use and diverse transportation systems in Southeast Asia, this thesis employs an alternative technique emphasizing individual travel behavior.

The technique developed in this research is an accessory to the aggregate four-step model. The traditional four-step process is based on "mass" behavior and is useful for estimating regional and inter-city demand for highways. The technique developed in this thesis does not attempt to estimate demand, but instead examines individuals and households living in a specific part of an urban area (urban fringe) and looks at why, where, how and when travel is undertaken. Such an approach examines household and individual travel, thus deriving information that could be incorporated into aggregate regional models.

A household interview survey approach was selected over other techniques, such as an origin-destination survey. An origin-destination (O-D) survey measures the amount of travel between locations (O'Flaherty, 1986), in an effort to identify mass movement patterns (Morlok, 1978). In this study a detailed household survey of individuals is employed. Respondents are sampled from a particular area of the city (urban fringe). This technique yields detailed data on respondents' travel patterns and lifestyles so that the individuals' and households' travel can be seen in full context.

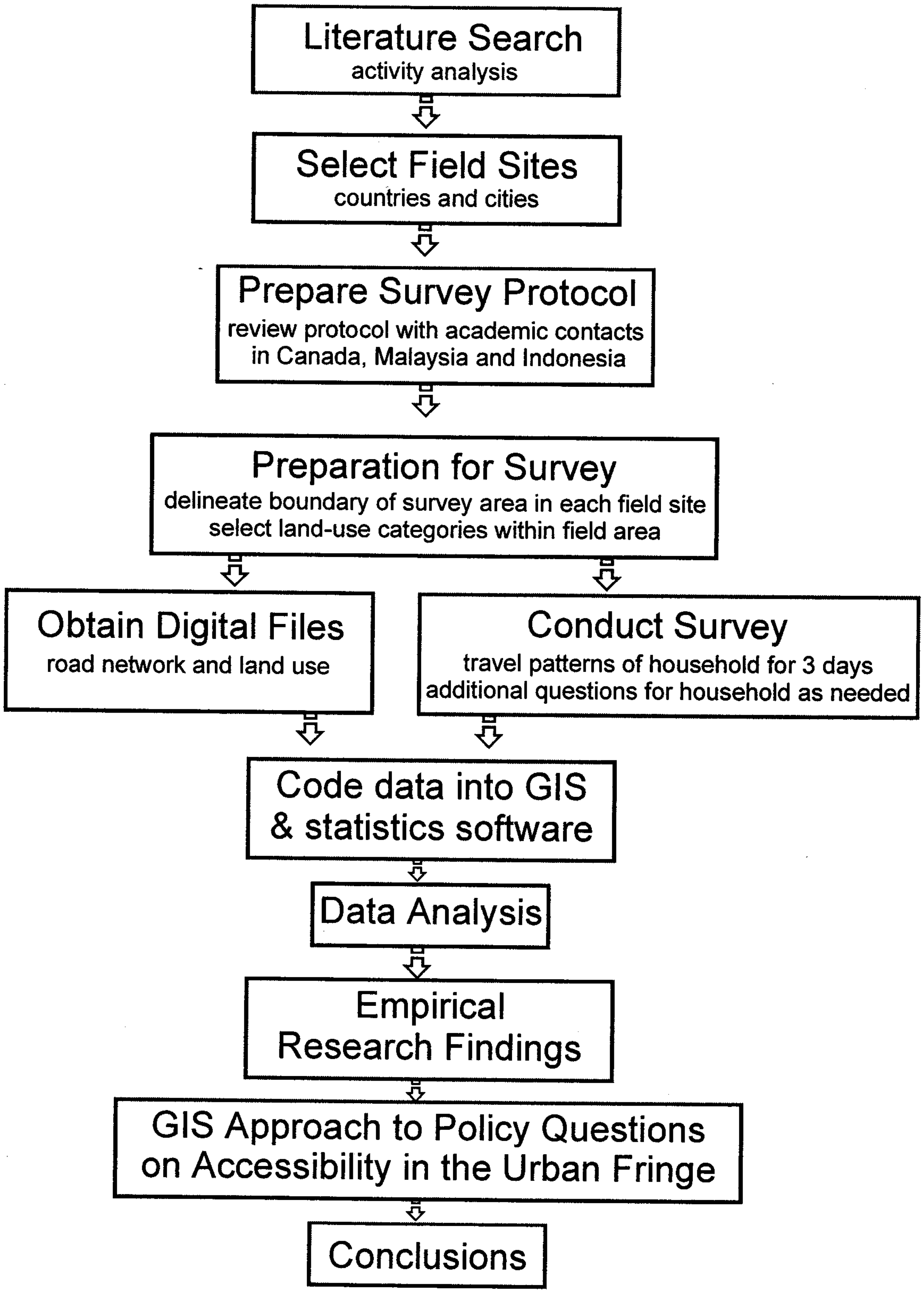
The technique uses a decompositional direct travel/activity pattern approach (Kansky, 1967; Hanson and Marble, 1971; Hanson and Huff, 1986). This approach decomposes travel patterns into component parts and generates measures for each of the parts. Similar travel patterns are grouped together. A benefit of this approach is that conclusions on travel behaviour may be derived from a small sample (Kansky, 1967).

The objective of the research is to develop an approach that models individual travel patterns in the urban fringe. An understanding of *why*, *where* and *when* travel is undertaken by urban fringe dwellers is a basis for better decisions regarding *where* activities should be located or, alternatively, *how* citizens/customers can reach them. This knowledge can point to solutions that reduce the environmental impacts of travel. The research design is presented diagrammatically in Figure 1.

1.2 *ENVIRONMENTAL AND HUMAN HEALTH CONTEXT*

Transportation has negative impacts on the environment and human health, including: loss of ecosystems for organisms and loss of arable farm land to make way for new infrastructure; damage from accidental spills; impacts related to life cycle production, use and disposal of transportation vehicles; and, water pollution from runoff from roads (National Round Table on the Environment and the Economy, 1996; ibid, 1997). In his report on alternative transportation modes, Wellar (1997) included a number of environment and human health consequences associated with reduced urban travel by

Figure 1: Flowchart of Research Design



automobile. The text is reproduced in Table 2 to indicate the potential scope and implications of this research domain.

Table 2: Indicative List of Beneficial Consequences Associated with Reduced Urban Travel by Automobile

Reduced deaths/injuries of vehicle operators and passengers, and vehicle victims (by-standers, pedestrians, cyclists, transit operators and passengers)
Reduced stress on automobile operators and users of other modes
Reduced conflicts between vehicle operators and users of other modes
Reduced levels of air, water, land, noise and light pollution
Reduced depletion of atmospheric ozone layer
Reduced amount of ground level ozone
Reduced global warming
Reduced amount of land lost to roads and parking lots/spaces, and driveways
Reduced extent and cost of urban sprawl
Reduced consumption of fossil fuels
Reduced money spent on car/truck/van insurance and claims
Reduced costs of law enforcement (patrols, ticketing, court time)
Reduced capital and maintenance costs for road infrastructure
Reduced damage to public and private property
Reduced solid waste disposal/junkyard eyesore problems
Increased mental, physical and social well-being of pedestrians, cyclists, transit operators and users
Increased public health (mental, physical, physiological, etc.)
Increased amount of land available for non-transportation uses (agriculture, housing, open/green space, recreation, etc.)
Increased financial health of transportation demand side (individuals, corporations, governments)
Increased economic, social and environmental returns on transportation infrastructure expenditures
Increased sense and reality of neighborhood and community
Increased effectiveness, efficiency and economy of urban regions
Preserved ozone layer
Preserved fossil fuel supplies
Preserved natural resources/habitats

*Source: Wellar (1997). The boxes shown as marked to indicate consequence pertinent to this research.

For the purposes of this research, the two areas in Table 2 that pose a particular challenge:

- Air pollution and its negative effect on human health; and,
- Impacts of climate change caused by the greenhouse gases that motorized transportation creates.

1.2.1 AIR POLLUTION

In urban areas around the world, air pollution is an issue because of its impact on human health:

> "People in major urban areas of Canada, such as the Lower Fraser Valley of British Columbia and the Windsor-Quebec Corridor, are experiencing the negative health impacts of air pollution. Science has confirmed direct links between transportation, poor air quality, and human health." (National Round Table on the Environment and Economy, 1997, p. 10).

> "A Health Canada study found "strong associations...between premature mortality due to respiratory disease and airborne particulates, COH (coefficient of haze – a measure of visibility), ground-level ozone, and nitrogen dioxide." The same study found that the mortality rate from respiratory disease increased by 2 to 4 percent during periods of poor air quality and that such increases "couid be attributed to the pollutant levels...in the range commonly observed in Toronto. Similar associations were observed for cardiovascular disease..." (National Round Table on the Environment and Economy, 1997, p. 10).

Table 3 presents a selection of quotes from the popular literature which demonstrate that air pollution is a concern in Ottawa (Canada) and Kuala Lumpur (Malaysia).

Table 3: Expressions of Concern about Air Pollution in Ottawa (Canada) and Kuala Lumpur (Malaysia)

Concerns	References
Ottawa: Ontario: "The summer's first wave of smog washed across most of Ontario on the weekend, making the air unfit to breathe from Ottawa to Windsor, and all the way north to Sudbury. The smog began in the southwest Friday, and covered nearly every major city, including Ottawa, by Saturday afternoon and yesterday. It also blanketed the rural spaces in between with colourless ozone gas, the most dangerous component of smog, and one which drifts hundreds of kilometres downwind from the cities, factories, and coal-burning plants where it begins. Smog hits Ottawa for at least a few days every year. But it usually waits until the hot weather of June and July."	"Year's first smog wave hits Ontario." *The Ottawa Citizen.* May 3, 1999, Final Edition, p. A5.
Kuala Lumpur, Malaysia: "a muggy miasma...hangs like a shroud over Kuala Lumpur and most parts of Malaysia. The smog dubbed "the haze" by locals, is raising concerns about health, poor visibility for aircraft and even the quality of rice grown in polluted surroundings....the haze first appeared in 1991 – and never went away. The Indonesian forest fires may have exacerbated it to unpleasant – and in 1994 to downright hazardous levels, but much of the smog is home-made...Kuala Lumpur's woes are aggravated by its location – it sits in a valley...But geography aside, the main culprit is the internal-combustion engine. In April, Bakar Daud, the deputy minister for the environment, told parliament that over the last decade motor vehicles in the city had emitted 2.7 million tonnes of pollutants into the air, or 85% of the city's load."	"Smoke in Your Eyes: Heavy pollution cuts into the quality of life." *Far Eastern Economic Review.* August 14, 1997.

Air quality in Ontario is assessed by measuring for the following contaminants: ground-level ozone[1] (O_3), inhalable particles (PM_{10}), total reduced sulphur (TRS), sulphur dioxide (SO_2), nitrogen dioxide (NO_2), and carbon monoxide (CO) (Ministry of the Environment - Ontario, 1999). Table 4 illustrates that in Ontario (Canada), Kuala Lumpur (Malaysia), and Jakarta (Indonesia), motor vehicles are a main source of urban air pollution.

[1] "Ground-level ozone is not emitted directly into the atmosphere. It results from chemical reactions between volatile organic compounds (VOC's) and nitrogen oxides (NO_x) in the presence of sunlight." (Ministry of the Environment - Ontario, 1999, p. 5)

Table 4: Motor Vehicle Emissions and Air Quality in Ontario (Canada), Kuala Lumpur (Malaysia), and Jakarta (Indonesia)

Contribution of Motor Vehicle Emissions to Overall Emissions	Air Pollutants
In Ontario, road vehicles are responsible for 21 percent of volatile organic compound emissions, 11 percent of inhalable particle emissions, 38 percent of nitrogen dioxide emissions, and 50 percent of carbon monoxide emissions (Ministry of the Environment - Ontario, 1999).	The major components of smog: ground-level ozone and inhalable particles, both of which are created by road vehicles, were the pollutants that most often exceeded the provincial ambient air quality criteria in 1997 (Ministry of the Environment – Ontario, 1999).
In Kuala Lumpur (Malaysia), motor vehicles were found to be the main source of air pollution (Japan International Cooperation Agency, 1993).	Annual and daily inhalable particle, carbon monoxide, and ozone averages regularly exceeded guidelines. Follow-up studies in 1994 showed inhalable particles continued to exceed guidelines. Nitrogen dioxide and inhalable particles were the most common air pollutants (Japan International Cooperation Agency, 1993).
Recent emission inventories prepared by BAPEDAL (Indonesian agency that coordinates environmental impact assessments), indicate that vehicle emissions account for 44% of Total Suspended Particles (TSP), 89% of hydrocarbons (HC), 100% of lead, and 73% of nitrogen oxide (NO_x) pollution in Jakarta. In most Indonesian cities, vehicle emissions constitute the most important source of harmful pollutants (World Bank, 1994; Walsh and Shah, 1997).	In Jakarta, Total Suspended Particles (TSP) are the most common problem followed by sulphur dioxides (SO_2) and nitrogen oxide (NO_x) in areas of heavy traffic. Other major cities in Indonesia with similar weather and topography as Jakarta can be expected to follow the same pattern of pollution. The highest concentrations are along major arteries and overall level a function of population and traffic densities (World Bank, 1994).

There is an air pollution problem in many urban areas around the world and it is particularly acute in developing countries (Lee-Gosselin and Pas, 1997, p. 6). The air pollution in some developing countries in Asia is more severe than in North America. Inhalable particle levels, specifically, are greater in developing nations. This is because industries in developing countries often use outdated technology, and because many vehicles lack emission controls (Wijetilleke and Karunaratne, 1995).

Table 5 compares levels of inhalable particles for cities in various regions of the world. The sample of Asian cities experienced a median number of 153 days in excess of the

World Health Organization standard for particulates, whereas the sample of American and Canadian cities only experienced a median of 0.5 days in excess of the standard.

Table 5: A Comparison of Levels of Suspended Particulate Matter for Cities in Various Regions of the World

Region or Country	Suspended Particulate Matter[1]	
	Number of Cities in Sample[1]	Median Number of Days Over WHO Standard
United States and Canada	10	0.5
South America	2	5.5
Asia	15	153
China	5	219
Europe	5	12
Australia and New Zealand	2	1.5

Source: Adapted from Kingsley et. al., 1994, p. 20.

There are a number of reasons for the high, inhalable particle levels in Asian cities compared to North American cities.

First, in Asia, diesel vehicles such as trucks and buses represent a higher proportion of the vehicle fleet, and are responsible for more total kilometres driven, compared to most highly-industrialized countries (Midgley, 1994). Diesel-fueled vehicles produce large amounts of particulate from unburned fuel and lubricating oil. Even with emission controls, levels of diesel vehicle particulate emissions are much higher than those resulting from comparable gasoline-fueled vehicles (Walsh and Shah, 1997).

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[1] Note: In this table, gravimetrically determined suspended particulate matter measurements are shown and compared with the WHO guidelines of 230 micrograms per cubic meter (Kingsley et. al., 1994, p. 20).

Second, the diesel fuel in Asian cities is often of poor quality (Midgley, 1994), containing larger amounts of sulphur. The sulphur has a tendency to form particulates, which are expelled in the vehicle emissions (Walsh and Shah, 1997).

Third, motorcycles are a more popular mode of transport in Asia than in North America. Many of these motorcycles are powered by two-stroke engines which emit up to ten times more hydrocarbons and smoke per kilometre than 4-stroke engines (Midgley, 1994).

Fourth, Asian countries now produce their own vehicles. Many of these vehicles have no pollution controls (Midgley, 1994). Fifth, many of the vehicles on the road are poorly maintained (Midgley, 1994). Finally, the sheer number of vehicles on the roads adds to the volume of particulates (Kingsley et. al., 1994).

Residents of Asian cities have greater exposure to vehicle emissions on a daily basis than those living in Canada and the United States. Both Indonesia and Malaysia, for example, have a tropical climate. People are outdoors year-round, and they drive more in open vehicles, resulting in greater exposure to vehicle emissions (Midgley, 1994).

While air pollution created by transportation vehicles has a negative effect on human health in all three field site cities (Ottawa, Kuala Lumpur and Yogyakarta), air pollution is of particular concern in Kuala Lumpur and Yogyakarta due in large part to the lack of emission controls on vehicles. This research looks at ways of accommodating the movement of people and goods while seeking solutions to reduce air pollution (and other negative effects) associated with current transportation networks.

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[1] The WHO standard for SPM is 230 micrograms per cubic meter. This figure is the median of the average number of days that measurements of SPM exceeded 230 micrograms per cubic meter at the sample sites in the region or country (Kingsley et. al., 1994, p. 20).

1.2.2 CLIMATE CHANGE

In 1995, approximately 2,500 scientists who formed the Intergovernmental Panel on Climate Change declared that "carbon dioxide remains the most important contributor to anthropogenic forcing of climate change; projections of future global mean temperature change and sea level rise confirm the potential for human activities to alter the Earth's climate to an extent unprecedented in human history... observations suggest *a discernible human influence on global climate*" (Intergovernmental Panel on Climate Change, 1995, preface).

Further, it has been argued, human activity itself is contributing to climate change through increased greenhouse gas[1] emissions: "...since pre-industrial times, the measured concentrations of some of these and other solely human-made, greenhouse gases in the atmosphere have been rising." (Neitzert et. al., 1999, p. xi).

The *transportation sector* was the second largest contributor to Canadian greenhouse gas emissions in 1997, representing 27% of total emissions (see Figure 2) (Neitzert et. al., 1999, p. xi).

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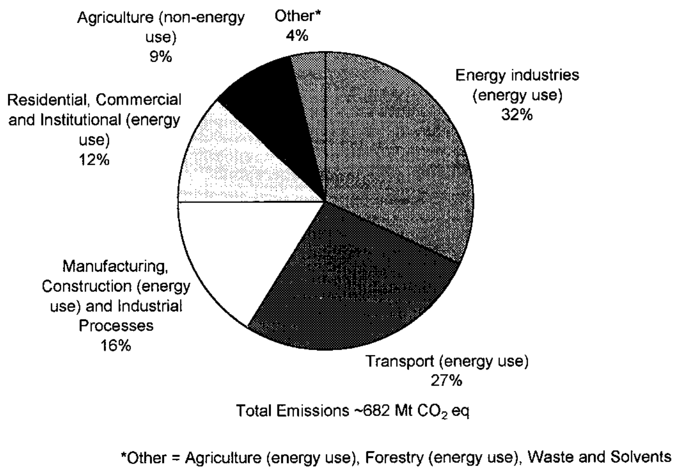
[1] The process by which human-generated greenhouse gases are leading to climate change has been described as follows. Radiation from the sun enters the earth's atmosphere in short wavelengths, the earth absorbs the radiation and then it is radiated back to space in longer wavelengths. The earth's atmosphere contains naturally occurring greenhouse gases. These primary greenhouse gases are water vapour (H_2O), carbon dioxide (CO_2), nitrous oxide (N_2O), methane (CH_4), and ozone (O_3). Increases in the concentration of these greenhouse gases produced through human activity reduces the efficiency with which the heat from the earth is re-radiated back to space. This results in warming of the lower atmosphere and the surface of the earth (Intergovernmental Panel on Climate Change, 1995).

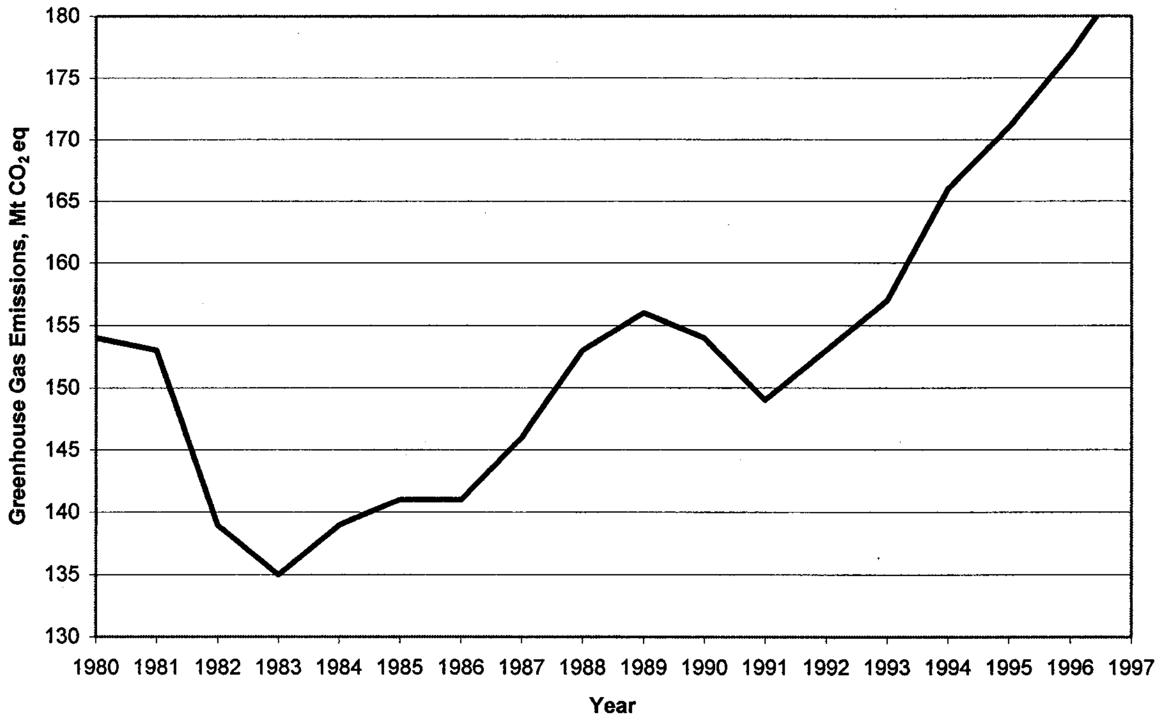
Figure 2: Canada's Greenhouse Gas Emissions by Economic Area for 1997



Source: Neitzert et. al., 1999, p. xi

After a decline in the 1980's brought on by rapid increases in road vehicle efficiency and reduced engine sizes, transportation emissions then increased rapidly in the 1990's (Neitzert et. al., 1999, p. 17) (see Figure 3).

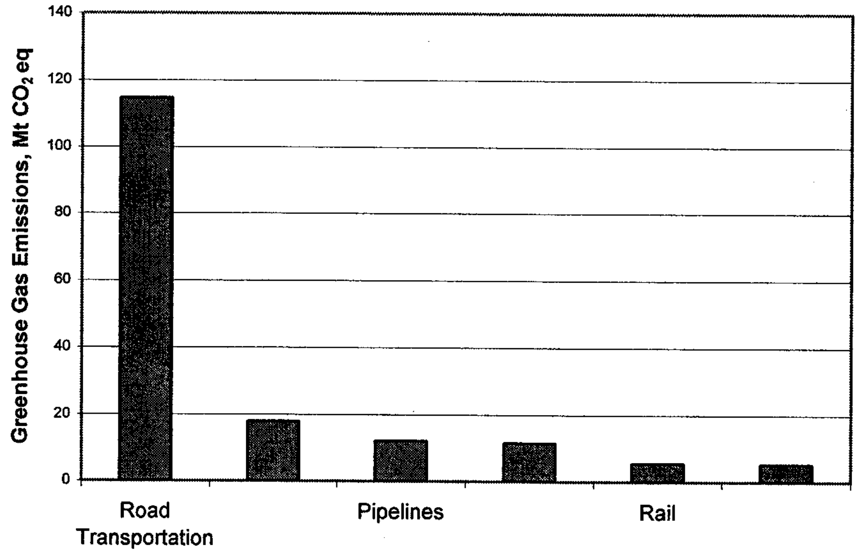
Figure 3: Greenhouse Gas Emission Trends in Transportation



Source: Neitzert et. al., 1999, p. 17.

In 1996, *road transport* was responsible for more than two-thirds of transportation-based greenhouse gas emissions (see Figure 4) (Neitzert et. al., 1999, p. 17).

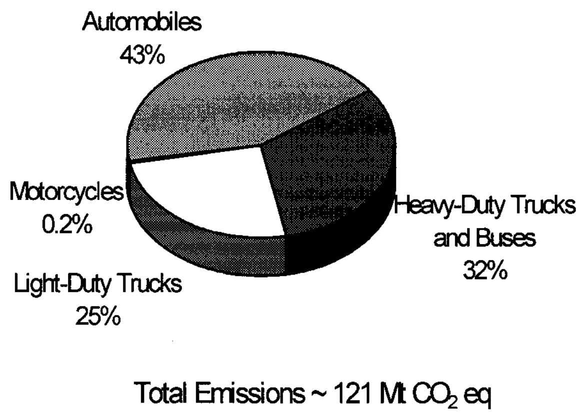
Figure 4: 1996 Transportation Category Greenhouse Gas Sources



Source: Neitzert et. al., 1999, p. 17

Light vehicles consisting of automobiles and light trucks are responsible for close to three-quarters of all emissions from the road category in 1996 (see Figure 5) (Neitzert et. al., 1999, p. 20).

Figure 5: 1996 Road Transportation Greenhouse Gas Emissions



Source: Neitzert et. al., 1999, p. 20

As Table 6 shows, the number of *light trucks on Canadian roads grew by 24%* between 1990 and 1996. At the same time the number of cars declined. "Both the documented lower efficiency of light trucks and their higher greenhouse gas emission rate imply that this trend is resulting in greater greenhouse gas emissions." (Neitzert et. al., 1999, p. 23). Despite the threat of climate change, the North American public continues to purchase light trucks, vans and four-wheel drive vehicles (Neitzert et. al., 1999), which points to a continuing increase in greenhouse gas emissions.

Table 6: Significant Indicators: Light-Duty Gasoline and Diesel Vehicles

	1990		1996	
	Automobiles	Light-Duty Trucks	Automobiles	Light-Duty Trucks
Vehicle Population	11 200 000	3 530 000	10 800 000	4 740 000
Average Fuel Consumption Ratio (1/100 km)	11.5	15.4	10.4	14.3
Greenhouse Gas Emission Rate (g CO_2 eq/km)	280	390	260	370

Source: Adapted from Neitzert et. al. (1999, p. 23).

Table 7 shows that between 1990 and 1996 carbon dioxide (CO_2) emissions followed fuel use patterns, methane (CH_4) emissions remained relatively stable over the period, while nitrous oxide (N_2O) emissions from both automobiles and trucks grew.

> "These trends underscore the effect of emission controls on greenhouse gases. Carbon dioxide releases are not technology-dependent – emissions simply follow fuel use patterns. However methane and nitrous oxide emission levels are affected by changes in emission-control equipment." (Neitzert et. al., 1999, p. 24).

It should be noted from Table 7 that the level of carbon dioxide emitted from both automobiles and trucks is much higher than the level of methane and nitrous oxide.

The Ballard fuel cell is thought by some to be able to minimize the impact of motorized transportation on the environment and its contribution to climate change. However, the current working model of the Ballard cell requires hydrogen and oxygen as inputs and produces electricity, water and heat as outputs. While the fuel cell is two to three times more efficient than a traditional internal combustion engine, "there is no significant environmental advantage in using hydrogen as a fuel for fuel cells in

Table 7: Detailed Greenhouse Gas Emission Trends for Automobiles and Light Trucks[1]

Year	Automobiles (Gasoline, Diesel, Natural Gas and Propane) CO_2 Mt	CH_4 Mt CO_2 eq	N_2O Mt CO_2 eq	Total Greenhouse Gases Mt CO_2 eq	Light-Duty Trucks (Gasoline and Diesel) CO_2 Mt	CH_4 Mt CO_2 eq	N_2O Mt CO_2	Total Greenhouse Gases Mt CO_2 eq
1990	53.9	0.24	2.0	56.2	21.0	0.08	1.3	22.3
1991	51.4	0.22	2.1	53.7	21.1	0.08	1.5	22.7
1992	51.5	0.22	2.4	54.1	22.5	0.09	1.8	24.4
1993	51.8	0.22	2.6	54.6	23.7	0.09	2.1	26.0
1994	52.2	0.24	2.8	55.2	25.2	0.09	2.5	27.8
1995	51.2	0.27	2.8	54.3	26.1	0.09	2.6	28.9
1996	50.4	0.26	2.6	53.3	27.4	0.09	2.6	30.1

Source: Neitzert et. al., 1999, p. 23.

regards to reducing the carbon dioxide that is emitted into the air. This is because the hydrogen would be made from natural gas and so the carbon dioxide would be produced at the hydrogen manufacturing plant. Carbon dioxide is not a local pollution problem, but a global one." (Wiens, 1999). Even if a fuel cell that runs on methanol is successfully developed it will not solve the carbon dioxide problem, since methanol is also currently made mainly from natural gas (Wiens, 1999).

The carbon dioxide problem could be alleviated by using renewable energy[2] or possibly another fuel source yet to be developed (Wiens, 2002). However, Wiens (2002) notes

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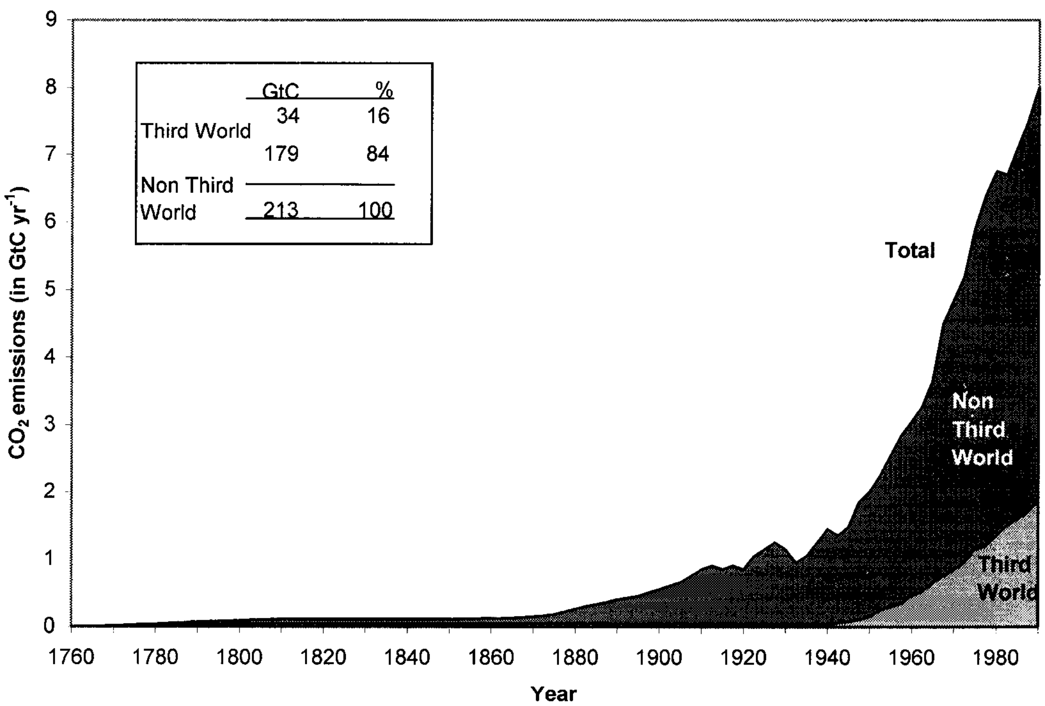
[1] Methane and nitrous oxide emissions in Table 6 are expressed as "CO_2 eq". This abbreviation stands for "carbon dioxide equivalence". It means that the masses of methane and nitrous oxide emissions are multiplied by specific factors (termed Global Warming Potentials) in order that their respective abilities to trap heat in the atmosphere can be compared to carbon dioxide (Neitzert et. al., 1999).

[2] For example, greenhouse gases are not considered to be directly emitted by hydro, wind, solar and tidal electricity generation (Neitzert et. al., 1999).

that "...it will be difficult for society to find the vast amounts of renewable energy needed to power automobiles".

While the bulk of the increase in carbon dioxide and some other greenhouse gases was generated by *developed nations* in the time period 1765 and 1990 (Whyte, 1995), a shift is forecast in future decades. As Whyte (1995, p. 69) notes "...In 1988, the less developed countries only contributed 15 percent of the additional carbon dioxide released that year from the burning of fossil fuels but their input has been rising by around 5 percent per annum against 0.7 percent for the developed nations" (Figure 6).

Figure 6: Comparison of Historical Carbon Dioxide Releases from Third World and Non Third World Countries



Source: Mintzer, 1992.

With large populations and the increased demand for personal mobility in developing areas of the world, there is a concern that carbon dioxide emissions may reach even higher levels.

Automobiles and light trucks are a major source of greenhouse gas emissions in Canada. With increased desire for greater personal movement and hence greater motor vehicle ownership in developing countries, and the sheer number of people involved, global greenhouse gas emissions from motor vehicles could increase dramatically in the future.

1.3 ACCESSIBILITY

The preceding sections outlined how increasing vehicular traffic and congested transportation networks affect air pollution and the global climate. Despite these concerns, however, the fact remains that the movement of people and goods is a necessary part of the urban condition, which brings us to the matter of access. In this section, the term *accessibility* is defined and ways in which it can be measured are outlined. By measuring accessibility one can assess the degree of ease or difficulty by which people and goods can be moved between points. Such an assessment can lead to understanding ways in which an urban transportation system can be modified to promote or discourage access as the case may be. Put simply, *accessibility* refers to how easy or difficult it is to get from one point to another.

The term *accessibility* is differentiated from the concept of *mobility* which is defined as "...the ease with which a person can move about or the amount of movement he performs" (Hensher, 1979, p. 120). Thus *mobility* refers to the availability of, access to, and use of travel routes and transport modes by an individual with little consideration of the destination of a trip (Cameron, 1995), whereas *accessibility* as defined by Vickerman (1974, p. 676) acknowledges the destination aspect: "...location on a surface relative to suitable destinations."

Accessibility of people to places is of current interest for both the public and private sectors, as well as for ordinary citizens, for a number of reasons. In North America, the freedom and ability to move is seemingly taken for granted. With a maturing transportation network, a large percentage of the North American population can afford vehicles. This ease of movement has positive economic benefits by allowing the exchange of goods and services. It can also have positive social benefits, allowing spatially-separated friends and family to visit each other. And, for a segment of the population such ease of movement allows those who live in rural areas to commute to places of employment that are located in urban areas.

However, the negative side-effects of the movement of people and goods on society are becoming more and more evident. First, and as several major literature reviews have shown, the lack of a solution to the 'urban problem' has resulted in the misuse of space and loss of time as a result of urban sprawl and congestion (Wellar, 1996; Wellar, 1998; Wellar, 2000). Further, safety concerns about highways continue to increase as a result of the Just-in-Time (JIT) delivery and other measures to minimize transshipment, warehousing and storage costs (Delaney, 1991; Arbeit, 1993; Wellar, 1993; Oliver, 1994; Gleckman et al., 1994), which put more and larger trucks on roads, which in turn raises the level of conflict between trucks (carrying goods) and cars (carrying people) (see Table 8).

Table 8: Headlines from Ontario (Canada) Newspapers Illustrating Conflict between Trucks and Cars.

"Wheels fly off government tractor-trailer: Charges pending as disastrous accident narrowly avoided."	Mercer, J. *The Ottawa Citizen.* April 1, 1998, Final Edition, p. B1.
"Quebec trucker charged in latest 'Carnage Alley' pileup: OPP officer fighting for her life after five-car crash."	McCrindle, K. *The Ottawa Citizen.* June 9, 2000, Final Edition, p. A4.
"One dead after wheel flies off truck and smashes into Toronto minivan."	Carmichael, A. *Canadian Press Newswire.* June 28, 2001.
"'All I saw was grille': Geoff Moon says the image is still there: A view in the mirror of a tractor-trailer running towards the rear-end of his car. Every 15 hours, someone dies in a truck-related crash on Canadian roads..."	Singer, Z. *The Ottawa Citizen.* June 26, 2001, Final Edition, p. A6.

Until recently in North America, and still strong in many developing countries, is the general expectation of car mobility as a "right". Promotion of car mobility over pedestrian mobility was the impetus for the Walking Security Index Project (Wellar, 1997), as a means to challenge transportation policies biased towards the automobile mode.

On the one hand, then, there are increasing expectations and demands with regard to means and barriers of access. And, on the other hand, there are concerns about the undesirable consequences associated with decisions that affect access levels. This conflict lends itself to expression as a research question, that is:

> How can we organize our urban land use and transportation systems in order to accommodate the movement of people and goods without incurring the congestion, greenhouse gas emissions, pollution and other direct and indirect costs of current transportation networks?

Accessibility is a concept that may be useful in examining this question. The geographic concept of accessibility combines locations of people and activities and the links joining them. In more formal terms, *accessibility* is defined as, "...a combination of two elements: location on a surface relative to suitable destinations, and the characteristics of the transportation network or networks linking points on that surface" (Vickerman, 1974).

There is increased real-world interest by organizations in accessibility as demonstrated by Table 9, which presents a selection of statements that further elaborate accessibility as a practical and research concern.

Table 9: A List of Reasons Supporting the Study of Accessibility: Organization Perspective

Reasons or Concerns Supporting Research on Accessibility	References
"Municipal land use policy documents should also establish goals and objectives and specific policies on the following transit-related issues...A policy indicating that a significant majority of residences, jobs, and other activities/uses should be located within 400m walking distance of a transit stop."	Ministry of Transportation and Ministry of Municipal Affairs, Ontario (1992), p. 76.
"Region's transportation vision is for a balanced role for many modes of transportation that are safe, effective, *accessible*, and efficient."	Peter Clark (Regional Municipality of Ottawa-Carleton) (Clark, P., October 1, 1994).
TAC calls for future transportation systems "...that are more *accessible* and increase mobility." Also, "urban transportation systems will have to be very productive, efficient, cost effective and *accessible* to allow cities to generate the wealth needed for quality of life improvements, social services, infrastructure, environmental protection, and transportation itself."	Transportation Association of Canada (TAC) (1993), p. 1.
"Public streets and places used by the public will be planned to meet the needs of pedestrians and be designed to be safe, vibrant, and *accessible* to all, including the disabled."	Commission on Planning and Development Reform in Ontario (1993), p. 31.

In addition to organizations, 'ordinary citizens' are also concerned with accessibility. Table 10 presents quotes from the popular literature that illustrate a sampling of the concerns of 'ordinary citizens' related to accessibility such as road quality, congestion and land development.

Table 10: A Sample of Newspaper Article Headlines Reflecting the 'Ordinary Citizen' Perspective on Accessibility

Citizens' Concerns about Accessibility	References
"U.S. Motorists see red, come up shooting" "As the roads in the United States deteriorate and congestion increases, flashes of anger are turning to rage and fatal violence."	Globe and Mail (Toronto, Canada) (Mar. 3, 1997, p. A7).
"Open letter to members of the West Carleton Township Council." "West Carleton has approximately 1,400 building lots. We do not have an influx of people clamouring for housing in our municipality. Would it not make more sense to wait till some of the already severed and zoned lots are purchased and developed before we approve more development? The snowploughs, road maintenance vehicles, garbage trucks and fire protection are already servicing these areas."	Carp Valley Press (Carp, Ontario) (Feb. 28, 1997, p. 13).
"Worsening traffic flow along Jalan Genting Kelang." "I would be lucky if I can reach the traffic light junction to Jalan Titwangsa in 30 minutes after the traffic light junction at Jalan Usahawan!...I hope the police will help smoothen traffic flow so as to make our morning trip to the office less strenuous and less stressful."	New Straits Times (Kuala Lumpur, Malaysia) (Feb. 9, 1996a, p. 13).
"Hoping for a Jam-Free Subang Jaya." "Twelve years ago, Subang Jaya was acclaimed as one of the most modern self-contained housing estates in the country with recreational and sporting facilities to cater to the needs of the residents as well as the business community...By 1984, the 30,000-odd residents in the housing estate had come to realise that they were living in a large 580-ha site, with only one exit...As one of them put it then, should there be any calamity or disaster in Subang Jaya, at least 80,000 cars would have to squeeze through only one exit to the Federal Highway. Every morning there would be a jam and cars going to Shah Alam and Klang would be held up because traffic was congested at that stretch."	New Straits Times (Kuala Lumpur, Malaysia) (Feb. 9, 1996b, p. 25).

Table 11 contains some recommendations brought forward at the Transportation Research Board's (1995a) *Forum on Future Direction in Transportation R&D*. The recommendations support using accessibility for travel modelling and performance measurement.

Table 11: Transportation Research Board's (1995) Recommendations in Support of Accessibility for Travel Modelling and Performance Measurement

Recommendations	Page Number
"It is important to use accessibility instead of mobility to measure performance."	p. 74
"Much work must be done to integrate modelling of land use and transportation, specifically the linkages."	p. 74
"Policy research of all sorts, but especially environmental policy research. Technology R&D tends to favour supply-side solutions to transportation demand. Policy-based solutions that focus on the demand side deserve equal attention. how much transportation (mobility is enough)?"	p. 54-55

Source: Transportation Research Board (1995a).

1.4 *TRANSPORTATION MODELLING*

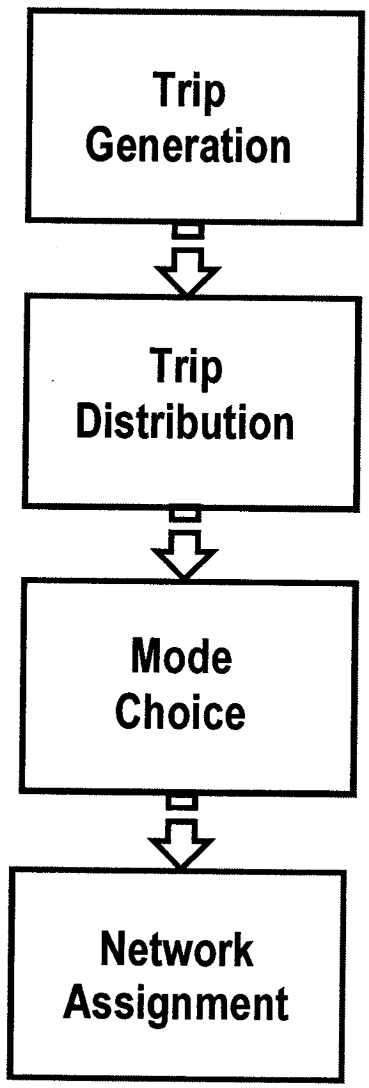
Current techniques of transportation modelling were originally developed to forecast demand for major freeways in North America in the 1960's. Based on "mass behaviour", the traditional four step process is useful for estimating the performance of future regional and intercity wide transportation demand. The four-step process (Figure 7) consists of the following procedures:

- trip generation,
- trip distribution,

- mode competition; and,
- route choice.

A fifth step "land use forecasting" is sometimes undertaken prior to the four steps pictured in Figure 7 (Morlok, 1978).

Figure 7: Four-Step Transportation Demand Model



The four-step approach involves dividing the study region into zones (Morlok, 1978). It then predicts the number of person trips beginning from/ending in each zone, estimates the trip volumes between all zones in the region, predicts each tripmaker's choice of travel mode and, finally, forecasts the tripmaker's choice of route between pairs of zones. Travel characteristics required for the model are obtained from an origin-destination survey. An origin-destination survey can be conducted through several methods[1]. The survey gathers socioeconomic data and travel data such as trip start location, trip end location, trip frequency (per week, per month), trip purpose, and number of persons travelling together (O'Flaherty, 1986; Khan, 1996).

All methods, even the home-interview method which accommodates more detailed data collection, normally involve gathering travel data for only one day (usually a work day) (O'Flaherty, 1986). By contrast, the technique implemented in this thesis collects travel data over a three day period including both work and non-work time periods.

Origin-destination surveys for traffic planning emphasize motorized trips (O'Flaherty, 1986), whereas this research measures travel made by both motorized and non-motorized means. As the name of the origin-destination technique implies, the main origins and destinations of travel are emphasized (O'Flaherty, 1986), compared to examination of the whole tour, including secondary stops made along the journey, in this study. Since origin-destination surveys seek to quantify mass movement between points, origins and destinations of trips are analyzed by zones with all trips assumed to originate and terminate at zone centroids (O'Flaherty, 1986). By contrast, the

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[1] Origin-destination methods include: roadside interview, mail-return survey, registration number method, tag or sticker method, and home interview method (O'Flaherty, 1986).

approach presented in this thesis analyzes all travel patterns individually and is based on actual travel points.

This thesis does not use an "aggregate" approach since the study's purpose is not to forecast mass flows (between zones) across a region. Instead, a more detailed approach is adopted in order to examine the accessibility or the ability, and ease, by which people can reach the places they need to go. By using a household survey interview technique, in contrast to an origin-destination survey, individual travel patterns are examined in detail. Also, households are sampled from a specific area of the city (urban fringe), as opposed to respondents being randomly intercepted while travelling, such as in a roadside interview O-D survey.

1.5 *Activity Analysis*

In many transportation studies, travel is not considered to be the direct result of spatially separated home, employment, goods/services and recreational activities. Over the past few years there has been a trend towards collecting activity or time-use data (Transportation Research Board, 1995b), in comparison to the most commonly used transportation modelling framework. This framework, the four-step transportation model (composed of generation, distribution, modal split and assignment steps) does not treat travel as a derived demand (Transportation Research Board, 1995b), meaning that the model does not recognize travel as simply a necessity in order to reach activities.

Activity analysis is the data collection technique chosen for this research because of its focus on how an individual uses space and time. In the Proceedings from the Conference on Travel Demand Analysis held at Oxford in 1981, Goodwin (1983, p.

470) defines *activity analysis* as "consideration of revealed travel patterns in the context of a structure of activities, of the individual or household, with a framework emphasising the importance of time and space constraints".

There is a trend towards collecting activity data for several reasons (Transportation Research Board, 1995b, p. 139).

> First, if travel is to be understood as a necessity in order to move from point A to an activity at point B, greater emphasis needs to be placed on activities rather than trips.
>
> Second, respondents recall activities better than trips.
>
> Third, in-home substitution of travel by information technologies and couriers/delivery services can be considered in such a framework.
>
> Fourth, an activity approach recognizes that trip-chaining or multiple activity stops may result in response to locational change.
>
> Fifth, the activity-based approach can consider a wide range of adjustments in travel and related behaviour, which may take place in response to changes in transport services and/or societal service systems, for example, land use patterns and hours of operation.

Household activity data can be collected through a household travel survey. Such a survey can be conducted by telephone, mail, personal interview or a combination of these methods (Lawton and Pas, 1995). The (personal) home interview retrieval method (Lawton and Pas, 1995) was chosen as the best way of collecting the data. Research contacts in Kuala Lumpur (Malaysia) and Yogyakarta (Indonesia) also recommended a home interview technique as the preferred method because a face-to-face meeting is more personal, and the interviewer can gain the trust of the respondent and thereby obtain more details about activities.

In trial tests during the Ottawa field research, most respondents lost motivation when asked to do self-reporting or they forgot to complete their surveys. Although a few respondents asked to be surveyed by telephone, the home interview technique was found to be more effective. Also, having more than one household member present during the interview meant that the travel patterns recorded for the household were more accurate and comprehensive. Even for households that agreed to do self-reporting, in most cases a home interview was conducted to collect and review the completed survey.

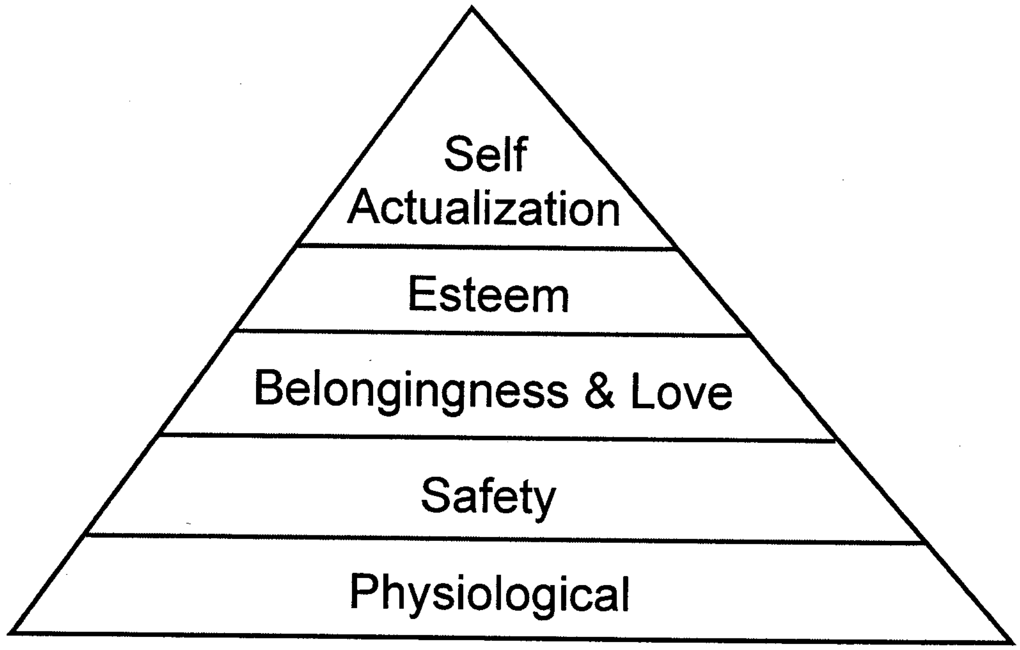
1.5.1 MOTIVATION FOR ACTIVITIES AND TRAVEL

Before describing the technique of activity analysis, the underlying question of what causes humans to participate in activities and travel to opportunities is addressed. Maslow (1970) developed a framework to explain the motivations behind the actions of humans.

Maslow classifies needs into five hierarchically organized categories starting with the most basic: physiological, safety, belongingness and love, esteem, and self actualization as shown in Figure 8.

Physiological refers to needs of the body such as hunger and thirst. These needs are the most basic. Once man's physiological needs are satisisfied, he yearns for *safety*, security, and structure and order in daily life. When physiological and safety needs have been met, he will seek *love* and will strive to belong to a group. Following the need for love,

Figure 8: Maslow's Hierarchy of Needs



esteem needs are the next in Maslow's hierarchy. Through mastering skills, achieving goals and acquiring prestige and recognition, greater self-esteem can be realized.

At the top of Maslow's hierarchy is *self actualization*. Self actualization is the ability of an individual to do what he is fitted for. "A musician must make music, an artist must paint, a poet must write, if he is to be ultimately at peace with himself. What a man can be, he must be. He must be true to his own nature." (Maslow, 1970, p. 46).

Applying Maslow's hierarchy to activity participation and travel behaviour (Wen, 1998), an individual's participation in certain activities might satisfy basic physiological needs, whereas other activities and travel might be undertaken to satisfy higher order self-actualization needs.

1.5.2 Early Activity Pattern Studies

Studies on activity patterns first appeared in the early 1970's. Their general objective was to examine travel from a wider perspective than just measuring the amount of vehicular movement between points in a city. Two influential studies were produced by Chapin (1974) and Hagerstrand (1970).

Chapin's research perspective emphasized people's choices, and was based on investigating activity patterns as the means by which people satisfied their needs. Chapin identified two broad groups of human needs (Chapin, 1974, p. 39):

a) Subsistence needs:

   Motivated by: need for sleep, food, shelter, clothing and health care.

   Means of satisfying: earning income from vocational training, education, medical care, social service etc. (assumes institutionalized system and economic organization for production and distribution of goods).

b) Cultural, social, and individual needs:

   Motivated by:

   - felt needs for security, status, achievement, affection, and social contact;
   - outlets for exercise of personal talents;
   - need for mental and emotional release; and,
   - need for physical release

   Means of satisfying:

   - seeing other people;
   - participating in civil life (for example, church and community groups); and,
   - engaging in recreation and hobbies.

Hagerstrand's (1970) research perspective, on the other hand, was concerned with constraints on decisions or choices. He identified three types of constraints:

a) *Capability constraints:* human capability is limited by biological factors and the capacity of the tools man commands (e.g. means available for travel or communication).

b) *Coupling constraints:* arising from the need for certain people, tools, and materials to come together at prescribed locations for given periods of time (e.g. work).

c) *Authority constraints:* which limit and control access to activity and travel facilities in space and time.

"The contrasting approaches adopted by Chapin and Hagerstrand reflect their different perspectives: Hagerstrand is interested in understanding the operation of constraints so that planning can relax them, whereas Chapin is concerned with people's preferences so that as a planner he can provide for them. Taken together, these two perspectives provide a powerful basis for understanding activity patterns: choice in the context of constraints." (Jones et. al., 1983, p. 266).

Since Chapin's and Hagerstrand's work in the early 1970's, the field of activity analysis has broadened substantially to include such topics as time budget studies (Forer, 1998). For the purposes of this research, however, the focus of the literature review is limited to the field of activity analysis of travel. Since several authors (Wen, 1998; Kitamura, 1988a; and Jones et. al., 1990) recently reviewed the activity analysis literature comprehensively, their work forms the basis of the summary.

1.5.3 ACTIVITY ANALYSIS TECHNIQUES

Wen's (1998) framework is used to structure the literature review. Activity analysis is categorized as follows:

- daily travel/activity pattern analysis;
- activity participation and duration;
- activity participation and travel patterns;
- activity scheduling;
- direct travel/activity patterns;
- day-to-day variability in travel/activity analysis; and,
- dynamic aspects of travel behaviour.

These various activity analysis techniques are listed in Table 12 to provide an overview. The purpose of using activity analysis is to collect and analyze travel patterns of individuals, and compare different aspects of the travel patterns between the field sites over a three-day period that includes both work and non-work days. The main technique chosen for this investigation was the decompositional direct travel/activity pattern technique, since it allows for the collection, analysis and comparison of different aspects of the individual travel patterns. Day-to-day variability in the travel patterns as it relates to work versus non-work travel is also discussed.

In the next several paragraphs, the techniques which are not pertinent to this study are identified and briefly discussed. The purpose of the critique is to address questions that could arise about their suitability. Following the brief overview of the techniques not selected for the study, the selected technique (decompositional direct travel/activity pattern) is then examined.

Table 12: A Typology of Activity Analysis Techniques

Technique	References for Examples
Activity participation and duration	Damm and Lerman (1981); Kitamura (1984); Mannering et al. (1994).
Activity participation and travel patterns	Golob and McNally (1997); Hamed and Mannering (1993).
Activity scheduling	Jones et al. (1983); Recker et al. (1986a, 1986b).
Trip chaining and tour based analysis	Adler and Ben-Akiva (1979); O'Kelly (1981); Kitamura and Kim (1981); Kitamura (1983); Borgers and Timmermans (1986); Goulias et al. (1990); Stratham et al. (1994).
Day-to-day variability in travel/activity analysis	Hanson and Huff (1982, 1986, 1988); Huff and Hanson (1986, 1990); Pas (1986, 1987, 1988); Jones and Clarke (1988); Hirsh et al. (1986).
Dynamic aspects of travel behavior	Golob and Meurs (1987); Kitamura (1988b); Kitamura and Bovy (1987); Golob and van Wissen (1988); Golob (1990a, 1990b); Jones et. al. (1983).
Direct travel/activity patterns	*Holistic:* Burnett and Hanson (1982); Koppelman and Pas (1985); Pas (1983); Recker et al. (1983, 1985); Golob (1985). *Decompositional:* Kansky (1967); Hanson and Marble (1971); Hanson and Huff (1986).

Source: Adapted from Wen, 1998.

Activity Analysis Techniques Not Selected for Study

Activity participation and duration activity analysis techniques focus on the timing and location of participation, and not directly on travel patterns, and therefore are not considered for use in this research project. While *activity participation and travel patterns* techniques do include travel behaviour, they are not considered here since mode and destination choices are not generally included in these models. *Activity scheduling techniques* are not employed since these techniques focus on the decision-making process preceding travel that determines which activities will be performed and in which order, the locations for each activity, the beginning and end of activities, and the modes of travel (Wen, 1998). These models use combinatorial programming or simulation techniques, and they do not allow examination of real travel patterns.

The focus of *trip chaining and tour-based analysis* is solely on activity selection and trip sequencing, without taking a broader view of travel (for example, residential location and socio-economic characteristics of the individual traveller), which is reason to eliminate this technique from consideration.

The techniques of *day-to-day variability in travel/activity analysis* and *dynamic aspects of travel behaviour* focus on day-to-day variability and changes in travel behaviour over time. As such, these techniques do not lend themselves to comparing general time and space characteristics of individual travel patterns collected over a week, which is a design requirement of this study. While not employing a formal technique, day-to-day variability comparing work and non-work travel patterns is included in this thesis.

Activity Analysis Technique Selected for Study

The technique which is pertinent to this study, the *direct activity/travel pattern* approach, has two sub-approaches: *holistic* and *decompositional*. The holistic version was not considered since it doesn't allow for analysis of individual aspects of the travel patterns. The decompositional direct travel/activity pattern was selected because a comparative study of different aspects of actual travel patterns is being undertaken. The direct travel/activity pattern allows *spatial* aspects of actual travel to be studied. This approach decomposes travel patterns into component parts, and generates measures for each of the dimensions. Factors creating differences between travel patterns are identified, and then similar travel patterns are grouped together. Conclusions on travel behaviour may be derived in this way from a small sample (Kansky, 1967).

1.6 GEOGRAPHIC INFORMATION SYSTEMS (GIS)

Most current techniques of travel demand analysis are not based on individual travel patterns (Transportation Research Board, 1995a). The study of aggregate travel patterns between *zones* in an urban area is useful for estimating overall volume flows, but it masks details of individual *point-to-point* travel behaviour (why, where, how and when trips are made). The technique proposed here models individual travel behaviour, a process that was constrained in the past because of the inability to manipulate and represent the required data.

Some recommendations derived from the Transportation Research Board's (1995b) *Conference on Household Travel Surveys: New Concepts and Research Needs* in support of the use of GIS for transportation planning, are presented in Table 13.

Table 13: Recommendations from the Transportation Research Board (1995) Supporting the Use of GIS for Transportation Planning

Recommendations	Page Number
"GIS technology adds a dimension to samples drawn for household surveys. Typical samples are stratified by household demographic characteristics, such as number of people in and number of autos owned by a household, or by income, as a variable of wealth. Only recently have metropolitan planning organizations (MPOs) considered drawing samples by specific area and/or are type."	p. 69-70
"GISs offer many benefits in the conduct of household travel surveys. These benefits include more effective and efficient data collection, improved data quality, and reduced survey costs. In addition, GISs provide a platform for data integration and provide more flexible output products to better interpret survey results."	p. 74
"The process of translating travel survey data to final analysis format is generally recognized as labor-intensive and time-consuming. The ability of a GIS to manipulate spatial information and create new information can be valuable for processing travel survey data. Some especially useful capabilities are aggregation and overlay, routing, and statistical analysis."	p. 176

Source: Transportation Research Board, 1995b.

The strength and widespread appeal of GIS is their capacity to manipulate point, line and polygon representations (Wellar, 1993). For the travel pattern research in this study, a GIS is employed to manage and manipulate the large and complex database.

1.7 COMPARATIVE INTERNATIONAL CASE STUDY

A case study approach was selected as the research sought to conduct an in-depth survey of individual travel patterns. As Simon (1969, 1978, p. 206) notes: "The case study...is the method of choice when you want to obtain a wealth of detail about your subject. You are likely to want such detail when you do not know exactly what you are looking for. The case study is therefore appropriate when you are trying to find clues and ideas for further research..." In other words, case studies are useful in exploratory research for producing "ideas". However, as Simon (1969, 1978) and Wellar (2001a) also indicates, it should be borne in mind that confirmatory research is necessary to test case study findings.

Another reason for selecting the case study approach is as Sax (1968, p. 289) notes: "It is often less expensive and simpler to select a limited number of cases which exhibit the phenomenon."

In designing a case study Sax (1968) recommends selecting cases that capture the main dimensions of the research problem. Also, "often the most useful cases in helping to generate hypotheses are those that clearly represent some extreme position" (Sax, 1968, p. 290). In effect, Sax is advocating a *comparative* approach in conducting a case study. This research study follows the recommendation of Sax, and examines individual travel patterns of urban fringe dwellers in three different cities (one city in North America and two cities in Southeast Asia).

As noted in Section 1.1, urban transportation networks in both mature and developing countries are currently experiencing numerous difficulties, particularly those of congestion and air pollution. While the same general patterns might be revealed in a study of a single country, this research is conducted in three countries – one in North America and two in Southeast Asia – which allows for the results to be compared and contrasted between field sites.

And, as Lane (1990, p. 196) notes:

> "The comparative method aims at the analysis of the genus and differentia specifica of a social system: that is, similarities and differences. A model is searched for that may explain *why* and *how* there are similarities and differences between spatial entities by a number of independent factors."

In comparing developed with developing countries, "luxuries" of development may be revealed. As Øyen (1990, p. 2) observes: "The globalization of problems is another key concept…An understanding of poverty in the Third World cannot be isolated from a consideration of the wealth accumulated in the rich countries."

The International Development Research and Policy Task Force (1996, p. 8) notes that:

> "...in many respects, Canada confronts development problems that are not greatly different from those faced by 'developing' countries (management challenges, urbanization...)"

Also, in comparing travel in three different cultural settings, the research may yield unique features of one field site (such as a particular transportation service) which may have possible application in other urban areas.

> "While some cultural differences are diminishing, others are becoming more salient. Comparative research may have to shift its emphasis from seeking uniformity among variety to studying the preservation of enclaves of uniqueness among growing homogeneity and uniformity." (Sztompka, 1988, p. 215).

In other words, differences as well as commonalities in transportation between and among field sites can be highlighted.

To gain a greater understanding of travel behaviour, Lee-Gosselin and Pas (1997) recommend that research be conducted to compare high and low income countries:

> "More than ever before, the role of researchers should include bringing together balanced inferences from a wide variety of existing situations in both the high- and low-income regions of the world. A new forum for examining and discussing our best predictions of the global consequences of strategic choices at the societal level may be appropriate as an extension of the series of international travel-behaviour conferences." (Lee-Gosselin and Pas, 1997, p. 24).

At the general level, there are a number of substantive reasons to undertake a comparative, international study of activity travel patterns. As for the selection of two cities in Southeast Asia to compare with Ottawa (Canada), there are three reasons to support such a design decision.

First, the sheer number of people in Southeast Asia and the rapidly rising level of motorization make the urban problem more pronounced in Southeast Asian cities (compared to other less populated and less affluent areas of the world). Increased motor vehicle use in Southeast Asia could cause a dramatic rise in health problems and global greenhouse gas emissions. With this possibility looming, significant societal questions arise about whether there are any ways that greenhouse gas emissions and other negative effects from motor vehicles could be reduced, while accommodating the movement of people. Examination of current land use and the transportation system and resultant travel patterns in Southeast Asian field sites may provide insights.

A second reason for studying Southeast Asia involves urban fringe land use patterns and population densities, and their effects on travel patterns. Yogyakarta, one of the field sites, has an extremely high agricultural population density (among highest in the world) (see Section 2.1.1.6) in the city's urban fringe. The population density in Kuala Lumpur is intermediate between that of Yogyakarta (high) and Ottawa (low in relative terms) (see Table 14). Current land use patterns in Southeast Asia may point to ways of accommodating movement of people and goods while limiting the negative effects of transportation.

A third reason for the selection of Southeast Asia as a study location is the prevalence of paratransit (mini-buses in particular), which appears to offer effective transportation service. Lessons learned from Kuala Lumpur and Yogyakarta may demonstrate how paratransit can be applied to Ottawa's urban-fringe area to aid movement of people and goods, while reducing congestion, pollution and other negative effects of transportation.

In summary, this research presents a comparative case study of individual travel patterns of urban fringe dwellers. The field sites for the study are located in three different countries – Canada, Malaysia and Indonesia. The next chapter provides an overview of the field site countries, details the field site city selection and then proceeds to describe the field site cities.

2. Field Site Selection and Description

This research is based on a comparative study of travel patterns in Ottawa (Canada), Kuala Lumpur (Malaysia) and Yogyakarta (Indonesia). The purpose of Chapter 2 is to provide a detailed explanation for the selection of the field site countries and cities, and to outline background material on the field site countries and cities referenced in subsequent chapters.

2.1 *Selection of Field Site Countries*

Canada was selected for pragmatic reasons, being the home country of the author. It represents the "developed" nation in this study. Malaysia and Indonesia were chosen for several reasons. In conducting previous research (January-March 1996), several field research contacts were developed in these two countries. However, these countries were chosen primarily because of their level of development, population density and transportation modes.

Malaysia is making a transition from being a developing country to becoming a developed nation (Neher, 1999) and represents the "intermediate" developed country in the study. Indonesia represents the "developing" country (CIA, 2000b; Neher, 1999) (see Section 2.1.1.4).

Java, the island on which the field site city of Yogyakarta is located, has one of the highest agricultural population densities in the world (see Section 2.1.1.6). The population density in Kuala Lumpur's urban fringe is also high compared to Ottawa (low in relative terms) (see Table 14). Contrasting individual travel patterns from the three field sites, each with different land use patterns and population densities, may

Table 14: Comparison of Key General Characteristics of Canada, Indonesia and Malaysia

Characteristic	Canada	Indonesia	Malaysia
Population[1,2,3] (millions) (July 2000, est.)	31,281,092	203,456,005	21,793,293
Demographics: Population aged 65 and above (1998) (% of total)[4]	12.5%	4.5%	4.0%
Population Growth Rate[1,3,5]	1.02% (2000 est.)	1.63% (2000 est.)	2.01% (July 2000 est.)
Land area[1,3,5] (km^2)	9,976,140	1,919,440	329,750
Climate[1,3,5,6,7]	Varies from temperate in the south to subarctic and arctic in the north.	Tropical, hot, humid; annual monsoons (timing differs across archipelago)	Tropical, hot humid; annual southwest (May-September and northeast (November-March) monsoons
Seasonality Dictated by	Temperature	Rainfall	Rainfall
Religion[1,5,8]	Catholicism 42% Protestantism 40% Other religions 18%	Islam 87% Protestantism 6% Catholicism 3% Buddhism 2% Hinduism 1%	Islam 52% Buddhism 17% Taoism 12% Hinduism 8% Christianity 8% Tribal 2%
Ethnic Groups[1,9,10]	British, Scottish, Irish 28% Mixed background 26% French 23% Other European 15% Other 6% Indigenous 2%	Indonesian 97%[11] Chinese 3%	Malay 47% Chinese 25% Indigenous 11% Other 10% Indian 7%
Languages[1,3,5]	English (official) French (official) Other	Bahasa Indonesia (official) Local languages (most common is Javanese) English Dutch	Bahasa Melayu (official) English Chinese dialects Other (Tamil, Telugu, Malayalam, Punjabi, Thai, Indigenous)
Government Type[1,3,5,12]	Constitutional monarchy (in form). Confederation with parliamentary democracy (in practice).	Republic	Constitutional monarchy
GDP[1,3,5] (billion US$) (1999 est.)	722.3	610	229.1
GDP per capita[1,3,5] (US$) (1999 est.)	23,300	2,800	10,700
Development Status	Developed	Developing	Newly Industrialized Country
Main Former Colonizer and Date of Independence[1,3,5]	Britain (1867)	Netherlands (1949)	Britain (1963)
Concentration of population	90% within 160 km of border with US	66% of Indonesia's population is on Java	Western part of Peninsular Malaysia
Country Urbanization (1998)[13]	76.9%	38.3%	55.8%

[1] CIA, 2000a; [2] BPS Indonesia, 2001a; [3] CIA, 2000c; [4] UNDP, 2000; [5] CIA, 2000b; [6] Mantra, 1981; [7] Malaysian Meteorological Service; [8] Lonely Planet, 2000; [9] Rigg, 1991; [10] U.S. State Department, 2000; [11] main sub-groups: Javanese, Sundanese, Madurese, Coastal Malay; [12] Eggleston, 1961; [13] UNDP, 2000.

point to ways of accommodating the movement of people and goods while limiting the negative effects of transportation. Also, the prevalence of paratransit and the lack of economy-of-scale facilities in Malaysia and Indonesia may offer lessons to Ottawa.

To provide a general context, the following section contrasts the three countries (Canada, Malaysia and Indonesia) where the field sites are located. Since this research is designed as a comparative study, each aspect – political, religious, language, economy, climatic, geographical, population and geological – that could affect land use planning and transportation development is considered. Finally, each aspect of the field site countries that could affect the design and implementation of the travel survey is also mentioned.

2.1.1 OVERVIEW OF FIELD SITE COUNTRIES

2.1.1.1 Politics

The region of Southeast Asia is made up of ten countries: the mainland countries of Burma[1], Cambodia, Laos, Thailand and Vietnam, and the island states of Brunei, Indonesia, Malaysia, Philippines and Singapore. (Rigg, 1991) (see Figure 9).

These ten countries fall into two groups, based on their political orientation. In the first group are the countries of Indochina. In 1975, the governments of Cambodia, Laos and Vietnam adopted a Communist philosophy and aligned themselves with the Soviet Union or China (Rigg, 1991). Burma also falls into the first group because of its (politically) controlled economy.

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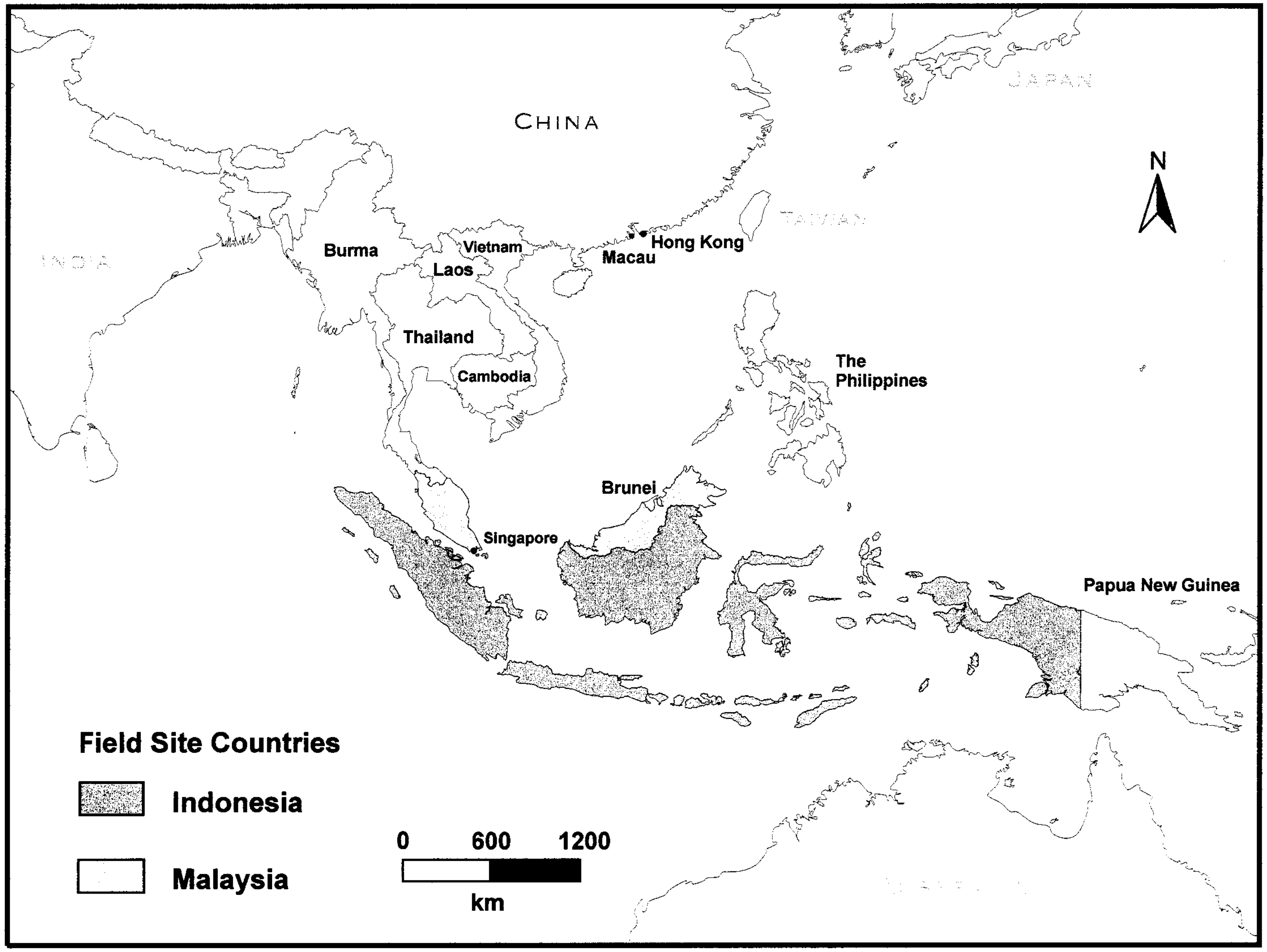
[1] In 1989 Burma was changed to "Myanmar" by the country's martial law governments. Scholars believe that the new name is temporary, and will be changed back to Burma when the current regime is overthrown (Neher, 1999). For the purposes of this research, the premartial law name, Burma, is used.

Figure 9: Countries of Southeast Asia



The second political group is made up of the six remaining countries: Indonesia and Malaysia (countries in this study) and Brunei, Philippines, Singapore and Thailand. These six countries form the Association of Southeast Asian Nations (ASEAN). As Rigg (1991, p. 2) notes "these are market economies following outward-looking, export-oriented strategies of economic development. They have also aligned themselves, to varying degrees, with the USA and the west."

Since Canada and Malaysia were both colonized by the British, they both have a similar form of government, a constitutional monarchy. (CIA, 2000a,c; Eggleston, 1961). While Indonesia experimented with parliamentary democracy between 1950 and 1957 following independence in 1949 (CIA, 2000b), it did not fit well with traditional Indonesian culture which "...placed little value on representation, group formation and majority plus one governance." (Neher, 1999, p 100).

Between 1959 and 1965, Indonesia's President, Sukarno, oversaw the country's transition to a "guided democracy" (Neher, 1999). However in 1965, a group of army officers attempted a coup d'état of Sukarno's government. General Suharto assumed control of the army and captured the coup leaders. In 1967, Suharto instituted a republican form of government (CIA, 2000b) known as the "New Order" which has prevailed until the present.

Since 1972, Malaysia's parliament has been skewed in favour of the majority ethnic group, the Malays. A legacy of British colonial rule in Malaysia is a population comprised of three distinct ethnic groups: native Malays (47%), Chinese (25%) and Indian (7%) [the remainder is indigenous (11%), non-Malaysian citizens and others (10%)] (U.S. State Department, 2000). During the colonial era, the British allowed some 16 million Chinese and Indians to immigrate to Malaysia between 1909 and 1940 to assist in developing the colony by working in cities, factories, tin mines and rubber plantations (Rigg, 1991).

Although Canada has a mixed population like Malaysia's, composed of citizens having roots in the British Isles (Britain, Ireland and Scotland) (28%), mixed background (26%), France (23%), other European (15%), other nations (mostly Asian, African, Arab) (6%) and indigenous (2%) (CIA, 2000a), Canada's ethnic groups, with the exception of the French in Quebec, are not as distinct as those in Malaysia. Canada is a nation of immigrants in contrast to Malaysia, where the indigenous Malays make up 47% of the population. In Canada, indigenous people only make up 2% of the country's population. Unlike Malaysia and Canada, Indonesia's population is indigenous for the most part, with the exception of the Chinese who constitute approximately 3% of the population. (Rigg, 1991).

Ethnic population segmentation had to be taken into account when devising the sampling strategy for the Kuala Lumpur household survey. For example in Malaysian towns, Malay, Chinese and Indian households are often spatially segregated from each other. To examine a full range of the travel behaviour of the town's residents, one must be aware of this segregation and, where possible, sample from the different ethnic areas of the town.

2.1.1.2 *Religion*

In both Malaysia and Indonesia, religion is an important part of daily life for much of the population, with Islam as the dominant faith in both countries. Canada, on the other hand, is a secular state with no official religion. In Malaysia the following religions are practiced: Islam (52%), Buddhism (17%), Taoism (12%), Hinduism (8%), Christianity (8%) and tribal (2%) (Lonely Planet, 2000), with Islam being the official religion of the country.

Indonesia recognizes five different religions, which the population observes in the following proportions: Islam (87%), Protestantism (6%), Catholicism (3%), Buddhism (2%) and Hinduism (1%) (CIA, 2000b). Canadians observe two main religions: Catholicism (42%) and Protestantism (40%) [other religions make up 18%] (CIA, 2000a). However, many Canadians are only passively religious and do not attend church on a regular basis. Of the three countries, Indonesia is the most unified in religious faith – almost 90% of Indonesians are Muslim.

Religion and the role it plays in daily and weekly routines has important implications for travel patterns. In particular, religion in Indonesia permeates daily lives of many, and as a result substantial travel is associated with participation in religious activities. Muslim religious observance on Fridays was taken into account while conducting the travel survey. Interviews were not conducted on Friday afternoons in Malaysia and Indonesia.

2.1.1.3 *Language*

Multilingualism is the norm among Indonesians. Currently, over 400 different languages are spoken in Indonesia, making it "one of the world's sociolinguistic giants" (Nababan, 1979). The most widely spoken local language is Javanese (CIA, 2000b). Bahasa Indonesia, based on Malay, has been adopted as the national language in the aims of unifying the country. The most important foreign language in Indonesia was at one time Dutch, but now it is English.

The official language of Malaysia is Bahasa Melayu which is very similar to Bahasa Indonesia. Other languages spoken in Malaysia include: English, Chinese dialects, Tamil, Telugu, Malayalam, Punjabi, Thai and indigenous languages (CIA, 2000c).

Since the founding peoples of Canada were the British and French, it is understandable that English and French are the most widely spoken languages in Canada. Although many residents in the Ottawa field site are bilingual, English is the predominant language.

Understanding the languages used in each of the field sites is a key consideration when conducting a household survey. In Yogyakarta, for example, a local language (Javanese) was the most effective means of communicating with some of the respondents.

2.1.1.4 *Economy*

Comparing the economies of Indonesia, Malaysia and Canada, it is clear that the three countries differ greatly in their level of development (see Table 15).

While Indonesia has the largest economy (GDP) in Southeast Asia (US$610 billion), it has a low GDP on a per capita basis (US$2,800) (CIA, 2000b). This is because the gross GDP must be divided by over 200 million Indonesians. Since 1965, the Indonesian economy has grown steadily, averaging 6% growth every year (Neher, 1999) (except during the 1997 Asian crisis). Agriculture is the slowest growth sector in the Indonesian economy, accounting for 21% of GDP, yet employing the greatest number of persons – approximately 45% of the population (CIA, 2000b). With a low GDP per capita, with almost half (45%) of the population employed in agriculture (CIA, 2000b), and with the low standard of living that many Indonesians lead, Indonesia remains a developing country.

In contrast to Indonesia, Malaysia has achieved the status of a newly industrialized country (NIC) (Neher, 1999). Malaysia has a GDP per capita of US$10,700 – much higher than Indonesia (see Table 15) (CIA, 2000c). Malaysia's current prime minister, Datuk Seri Mahathir bin Mohamad, came to power in 1981. The continued economic

Table 15: Gross Domestic Product (GDP) for Indonesia, Malaysia and Canada in 1998-1999 and Development Status

Country	GDP (Billion US$) (1999 est.)	GDP per capita (US$) (1999 est.)	GDP Composition by Sector (1998)[1]	Development Status
Canada	722.3	23,300	Agriculture: 3% Industry: 31% Services: 66%	Developed
Indonesia	610	2,800	Agriculture: 20% Industry: 45% Services: 35%	Developing
Malaysia	229.1	10,700	Agriculture: 12% Industry: 46% Services: 42%	Newly Industrialized Country

Source: CIA 2000a, b, c.; World Bank, 2000.

growth and an increased standard of living for all classes of people has enabled Mahathir to hold on to power (Neher, 1999). However, there is still poverty in the country. Mahathir plans to reduce the remaining poverty over the next 20 years through the "Vision 2020" plan, and have Malaysia become a developed nation by 2020 (Neher, 1999).

Indonesia's President Suharto, like Malaysia's Prime Minister Mahathir, was able to hold the country's leadership for so long, in large part, because of the country's strong economy. However, the recent financial crisis (1997-1998) in Asia has been a factor in pushing Indonesia towards a more open political system (Neher, 1999). Indonesia turned to the International Monetary Fund (IMF), World Bank, Asian Development Bank and industry for financial aid during the Asian crisis. The terms of the IMF financial aid dictated that the Suharto family give up monopoly control over certain key businesses (Neher, 1999).

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[1] The statistics for GDP composition by sector for Indonesia are from World Bank, 2000.

Canada has the largest economy of the three nations, with a GDP of US$722 billion in 1999 (CIA, 2000a). Canada's economy is tied tightly to its closest neighbour and largest trading partner – the United States. The citizens of Canada enjoy a high standard of living with a GDP per capita of US$23,300. Services of all types are now the basis of Canada's economy, making up 66% of the GDP (CIA, 2000a). Compared to Indonesia and Malaysia, agriculture makes up only a small proportion of Canada's economy (3% of GDP) (CIA, 2000a).

Canada, Indonesia and Malaysia are similar in that they are all aligned economically with a superpower. Canada (along with Mexico) is aligned economically with the United States through the North American Free Trade Agreement (NAFTA) of 1994. The agreement eliminated trade tariffs between the three countries. Similarly, Indonesia and Malaysia are informally aligned with Japan. In fact, all of Southeast Asia "…is economically dependent upon Japan as a major source of imports, market for exports, aid provider and foreign investor." (Neher, 1999, p. 11).

In summary, the field site countries of Canada, Malaysia, and Indonesia have been chosen to examine travel patterns from three different *economic* development scenarios (developed, newly industrialized, and developing), since the full range of the dimensions of the urban problem may be revealed by studying the problem in both developed and developing countries. In less-developed countries, however, an automobile is not affordable for many citizens (Freund and Martin, 1993), so transport modes other than the automobile are used. As a result, alternative modes of transport and the land use structure that supports these modes are investigated as part of the inquiry into ways and means of improving movement of people and goods, while limiting the negative effects of transportation.

2.1.1.5 *Climate*

All of Southeast Asia lies in the humid tropics. The temperature at sea level is relatively constant throughout the region and over the year. The only differences in temperature are produced as a function of altitude – with cooler temperatures at higher altitudes. The seasonality in Southeast Asia is created by the spatial pattern and timing of rainfall. Rainfall, therefore, influences the patterns of natural vegetation (Rigg, 1991). In contrast to Southeast Asia, seasons in Canada are mainly determined by changes in temperature and hours of sunlight.

In Yogyakarta (Indonesia) there are two main seasons. The dry season lasts from April to September, and the wet season from October to March (Mantra, 1981). The pattern of rainfall in Kuala Lumpur (Malaysia) is more complex than that of Yogyakarta. Four seasons are created by two periods of maximum rainfall (brought by monsoons), separated by two periods of minimum rainfall. In Kuala Lumpur, the southwest monsoon lasts from late May or early June to September, while the northeast monsoon occurs early November to March (Malaysian Meteorological Service, 2000).

Canada's climate varies from temperate in the south to subarctic and arctic in the north (CIA, 2000a). Ottawa is in the temperate zone of Canada and has four seasons created mainly by changes in temperature. Winter in Ottawa is from December to February (below 0°C temperatures, with precipitation mainly in the form of snow and freezing rain). Spring is from March to May, summer is from June to August (above 15°C temperatures, with precipitation in the form of rain), and fall lasts from September to November.

Climate was an important consideration in deciding when to conduct the Canadian household survey. The Canadian survey was undertaken during the spring, summer, and fall seasons, as the snow and ice conditions in the Canadian winter were hypothesized to influence travel patterns (see Wellar, 2001b), thereby potentially limiting comparability with the Southeast Asian results. The Southeast Asian monsoons did not pose any restrictions in conducting the travel survey.

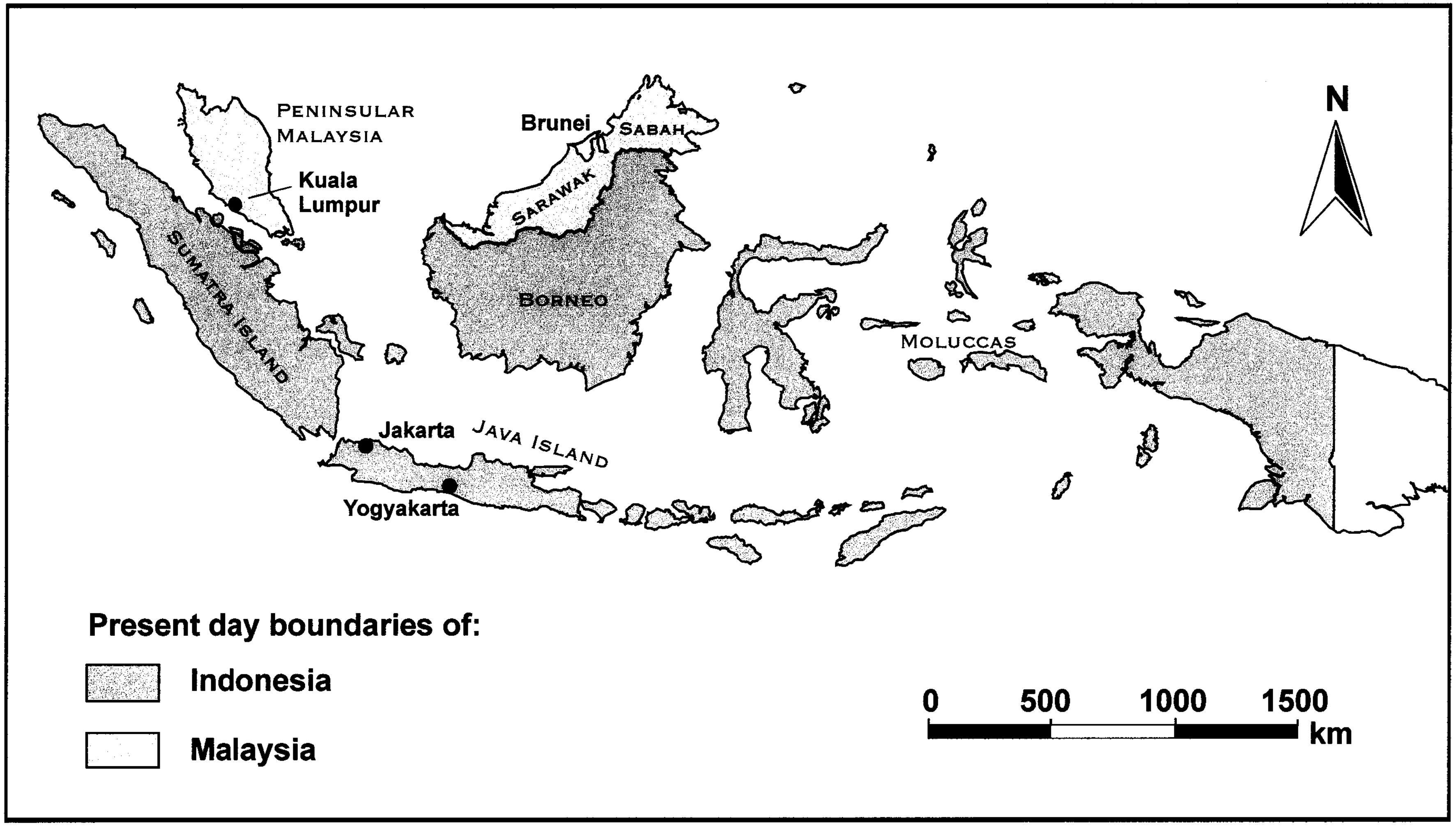
2.1.1.6 Geography and Population

The Southeast Asian region straddles the equator in the eastern hemisphere. Indonesia is the southernmost part of the region (see Figure 10), with a land area that makes it the world's sixth largest nation. Like Indonesia, Canada is a large country. Canada's land area is only exceeded by that of: Russia. Malaysia, by comparison is much smaller in land area (Table 14).

Indonesia is the world's fourth most populous nation, with over 200 million people. Canada and Malaysia (31 and 22 million respectively), by contrast, have much smaller populations (Table 14). Indonesia has had success in reducing its population, with a current growth rate of 1.63% (2000 est.). Malaysia, by comparison, has a population growth rate of 2.01% (2000 est.) and is actually trying to increase its size. Malaysian Prime Minister Mahathir has a saying "Go for five (children)" so that the population of Malaysia can eventually reach 70 million. Malaysia and Indonesia have young populations with only four to five percent of the population 65 and above, compared to Canada where 12.5% of the population is 65 and above (UNDP, 2000).

The Indonesia archipelago is the world's largest, and is made up of 13,677 islands (Apa Productions, 1985). Jakarta, the capital of Indonesia, is located on the northwestern coast of Java. Yogyakarta, the Indonesian field site, is also on Java, but to the east of Jakarta on the south coast of the island (Figure 10). To give an

Figure 10: Places in Indonesia and Malaysia



indication of size, Java is as large as England or New York State (Apa Productions, 1985).

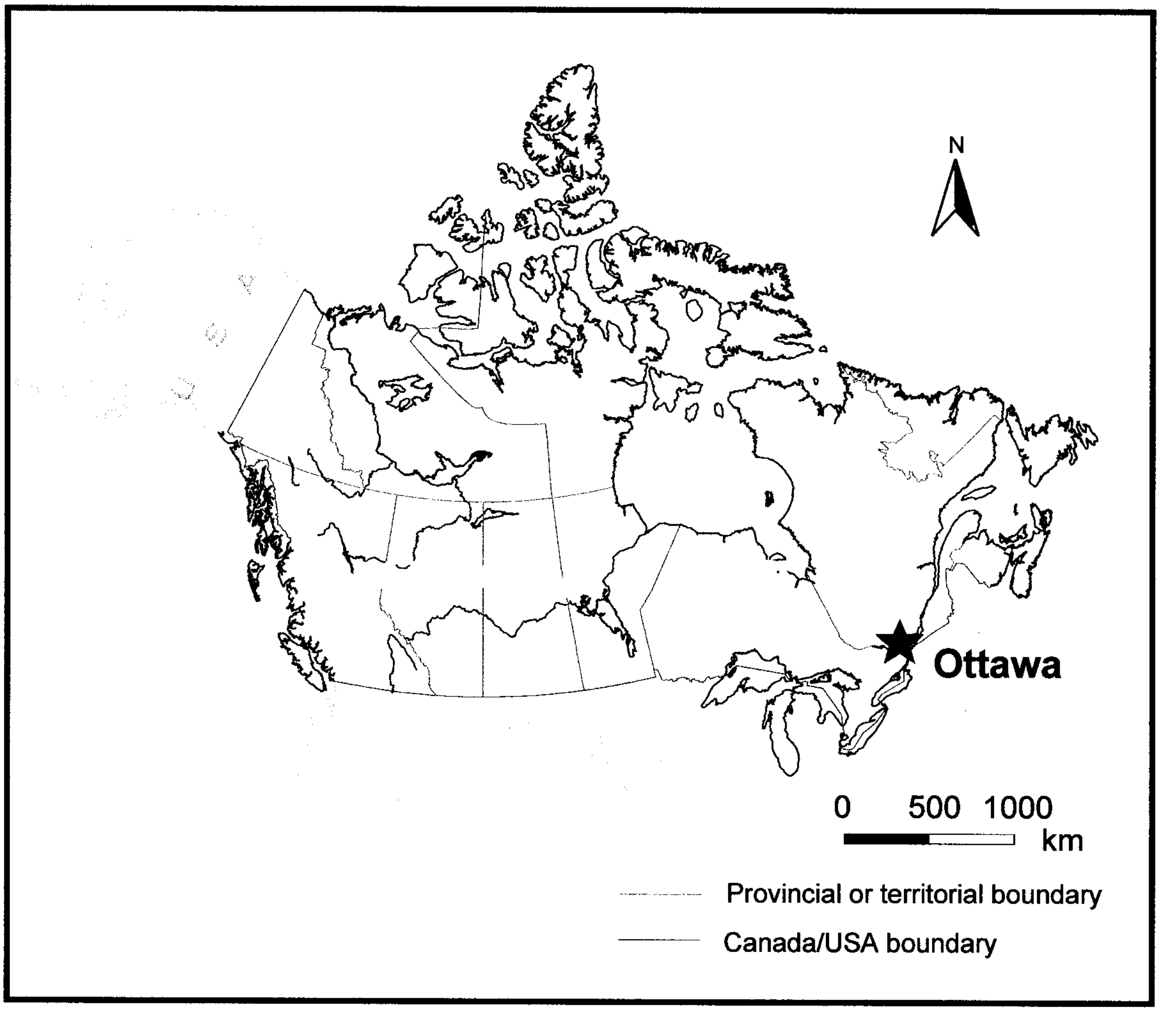
> "Java today supports 100 million people, two-thirds of Indonesia's population, on only seven per cent of the nation's total land area. This represents an average of over 750 persons per km^2... – more than twice that of densely populated industrial nations like Japan and Holland. And in many areas of Java, average rural population densities actually soar to an incredible 2,000 persons per km^2..." (Apa Productions, 1985, p. 65).

Malaysia is located north of Indonesia. The country is made up of Peninsular Malaysia which is part of the mainland, plus the states of Sabah and Sarawak which are located on the island of Borneo (Borneo is divided between Malaysia, Indonesia, and Brunei). Kuala Lumpur, the capital and field site for this study, is located on the west coast of Peninsular Malaysia (see Figure 10). Malaysia's population is concentrated along this west coast.

Canada is located in the northwestern hemisphere (Figure 11). Ottawa, the capital and field site for this study, is located in south central Canada. Most (almost 90%) of Canada's population is situated within 160 kilometres of the border with the United States (CIA, 2000a). Canada's population is the most urbanized of the three countries with 76.9% of the nation living in urban areas. Malaysia is the next most urbanized with 55.8%, followed by Indonesia with 38.3% of its citizens living in urban areas (UNDP, 2000).

Population, population growth, and density of population are important factors to consider when planning for transportation infrastructure and services. Java, the island on

Figure 11: Canada



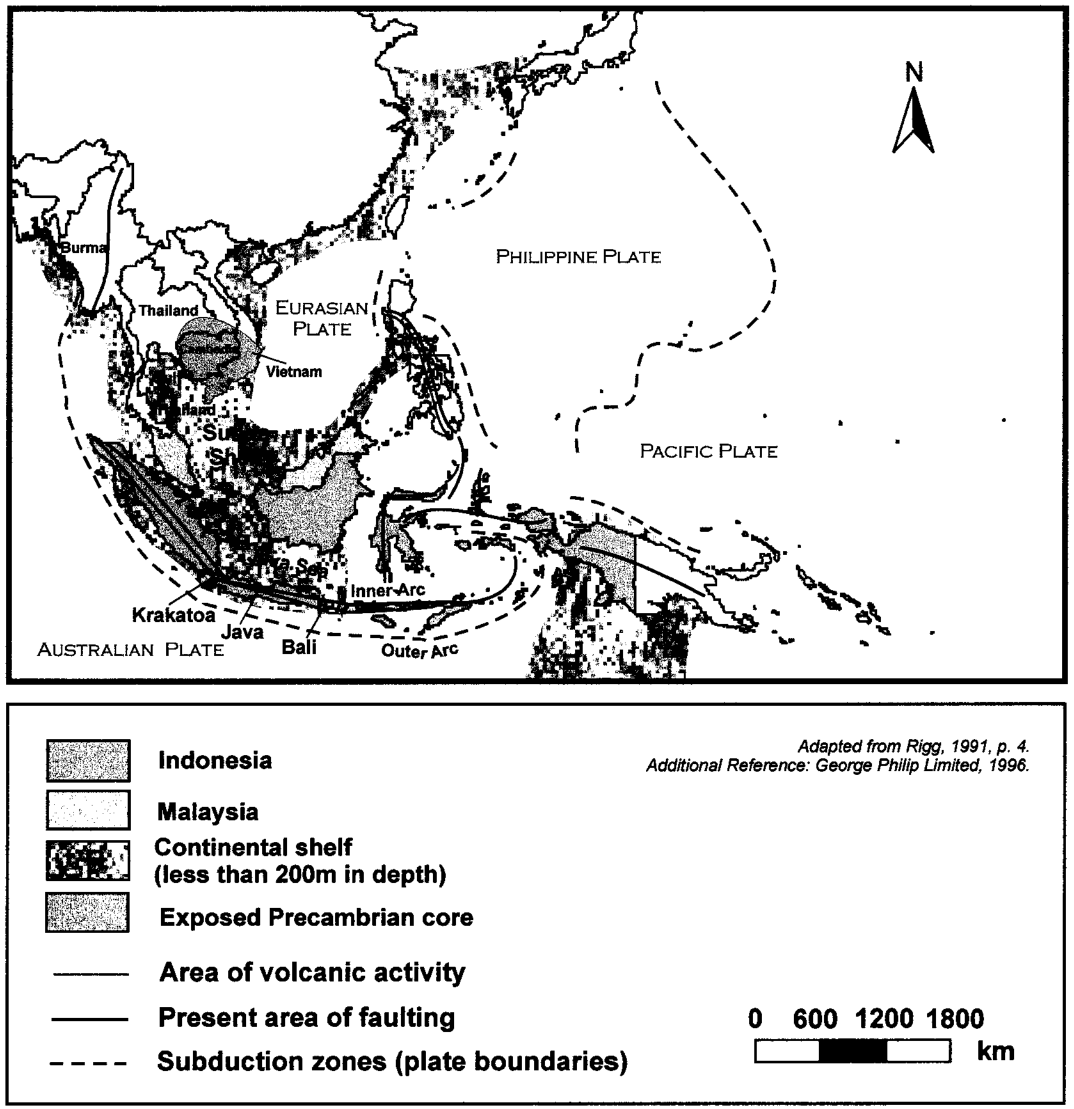
which the field site city of Yogyakarta is located, has one of the highest agricultural population densities in the world (see page 78). The population density in Kuala Lumpur is also high compared to Ottawa (low in relative terms). Contrasting individual travel patterns from the three field sites, each with different land use patterns and population densities may point to ways of allowing the movement of people and goods, while limiting the negative effects of transportation. The sheer number of people in Indonesia and the growing population in Malaysia underline the potential for the urban problem to become worse in this area of the world (increase in air pollution and greenhouse gas emissions) if current motorization trends continue (see Section 1.2).

2.1.1.7 *Geology*

Canada's geology consists of two main parts, the ancient *Precambrian Shield* dating from 570 to 4,600 million years ago (George Philip Limited, 1996) forming the central core of the country, and the younger mainly stratified *Borderlands* which surround the north, west and south edges of the Shield in two concentric rings. The field site city of Ottawa, is located within the sedimentary rock-based *St. Lawrence Lowlands* region, but is bounded to the west and north by the Precambrian Shield (Bostock, 1970). Agricultural land is found south of the Precambrian Shield in Central Canada (inferred from maps provided in Warkentin, 1997).

Compared to Canada, Southeast Asia is much younger geologically. The Southeast Asian region situated on the Eurasian Plate and is bounded by a series of deep-sea trenches where the Australian, Pacific and Phillippine plates plunge beneath the Eurasian Plate. These trenches consist of an outer, earlier (19 million years ago) arc and an inner, later (3 million yrs ago) arc. The inner arc is a zone of intense volcanic activity, as evidenced by the explosion of Krakatoa in 1883 (Simkin, Fiske et. al., 1983) (Figure 12).

Figure 12: Geology of Southeast Asia



The Malay Peninsula has a range of mountains that form a spine along its whole length. West Malaysia's land area consists of heavily forested mountains, with very little flat land except in narrow strips along the coast where the population is concentrated. Only a few roads have been developed between the east and west coasts of Malaysia due to an interior mountain range (Major, 1991). Agricultural land is found along the west coast of Malaysia where the nation's population is concentrated.

All the islands in the Indonesian archipelago are relatively young geologically with the earliest one dating from 15 million years ago (Apa Productions, 1985). Since the islands' creation there has been much volcanic activity. This activity has produced the "most spectacularly fertile tropical soils in the world." (Apa Productions, 1985, p. 60), Java and Bali not only have excellent soils for agriculture, but they also experience sufficient rainfall and sunshine over alternating half-year long dry and wet seasons making excellent conditions for agriculture (Apa Productions, 1985).

Geology and topography have influenced population density and location of urban settlements at all three field site countries. In general, population is concentrated in areas of good agricultural land. The volcanic activity on Java has produced fertile soils allowing agriculture to support Java's population. The forested mountain areas in Peninsular Malaysia have been a barrier to settlement and as a result the population is concentrated along the western part of the Malay Peninsula where agriculture is possible. In Canada, the Canadian Shield dominates a large part of the country, and while the Shield provides mineral wealth, it is not productive for agriculture. The agricultural lands to south of the Canadian Shield in central Canada are where population is concentrated.

2.1.1.8 *Urban Transportation Systems*

The majority of annual motorized travel[1] by individuals in major urban areas in all three field site countries is done by private vehicle. Indonesia is the least oriented towards private transport with 62.4% of 1990 annual motorized travel by private vehicle (motorcycle: 32%, car and taxi: 30%), and 37.6% by public transportation (Newman and Kenworthy, 1998; Kenworthy and Laube et. al., 1999) (Table 16). In Malaysia, approximately 80% of 1990 annual motorized travel is by private vehicle (motorcycle: 17%, car and taxi: 63%), compared to ~20% by transit (Newman and Kenworthy, 1998; Kenworthy and Laube et. al., 1999). Of the three countries, Canada is the most dependent on private transportation with 90.3% of annual travel by private vehicle (mainly car) and only 9.7% by transit (Newman and Kenworthy, 1998; Kenworthy and Laube et. al., 1999).

Canada has the highest number of vehicles per person (1.7 persons per vehicle) compared to fewer vehicles per person in Malaysia and Indonesia (9.0 and 21.3 persons per vehicle respectively) (United Nations, 1993).

The vehicle mix differs among the three countries. In Canada in 1994 only 1.9% of motor vehicles were motorcycles (Statistics Canada, 2001). Motorcycles made up a far larger proportion of the motor vehicle fleet in 1993 in Indonesia (68.4%) and Malaysia (55.8%) (United Nations, 1999). Automobiles are still not affordable for many Malaysians and Indonesians. Since these statistics on vehicle mix were collected (1993), many more Malaysians now own cars. Malaysia has developed its own automotive industry. Two

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[1] Annual total motorized passenger km of travel (total per capita occupant km) as collected by Newman and Kenworthy, 1998 and Kenworthy and Laube et. al., 1999 from local transportation agencies in each city.

Table 16: Comparison of Key Transportation Characteristics of Canada, Indonesia and Malaysia

Characteristic	Canada	Indonesia	Malaysia
Private transportation (% annual motorized travel 1990)[1]	90.3%[2]	62.4%[3] consisting of: motorcycle: 32.0% car and taxi: 30.4%	80.3%[4] consisting of: motorcycle: 16.9% car and taxi: 63.0%
Public transportation (% annual motorized travel 1990)[1]	9.7%[2]	37.6%[3]	20.1%[4]
Persons per vehicle (1991)[5]	1.7	21.3	9.0
Motorcycles (% in motor vehicle fleet) (1993, 1994)	1.9%[6]	68.4%[7]	55.8%[7]
Motor cars (% in motor vehicle fleet) (1993, 1994)	77.4%[6]	16.4%[7]	33.9%[7]

[1] Newman and Kenworthy, 1998 and Kenworthy and Laube et. al., 1999 (per capita occupant km); [2] Average for 7 Canadian cities (Calgary, Winnipeg, Edmonton, Vancouver, Toronto, Montreal and Ottawa); [3] Average for 2 Indonesian cities (Jakarta and Surabaya); [4] For Kuala Lumpur; [5] United Nations, 1993; [6] Statistics Canada, 2001 (data for 1994) (motorcycle category includes mopeds); [7] United Nations, 1999 (data for 1993).

national car makers, Perusahaan Otomobil Nasional Bhd. (Proton) and Perusahaan Otomobil Nasional Kedua (Perodua), dominate the Malaysian market. In October 1998 the two car companies together had 70% of vehicle sales in Malaysia (The Financial Express, 1998).

Indonesia's automotive industry, despite being supported for 30 years by government, has not performed very well. The import of motor vehicles was banned until 1993, when the ban was replaced by tariffs of 175%-275%. These high tariffs against imports led to an inflow of foreign assemblers who imported most of their parts and components, and assembled the vehicles in Indonesia. These foreign establishments now dominate the Indonesian market (Okamoto and Sjöholm, 1999). Canada is similar to Indonesia in the sense that its automobile industry is dominated by foreign assemblers with branch plants in Canada.

A comparison of key general and transportation characteristics of Canada, Indonesia and Malaysia is presented in Table 14 (page 66) and Table 16.

2.2 SELECTION OF FIELD SITE CITIES

Ottawa was chosen as the Canadian field site, being the home base for the author (see Figure 13 and Figure 14). Ottawa's growing population was 748,981 in 1997 (estimated population) (Statistics Canada, 2002a). The three main income generators in Ottawa's economy are: services (includes tourism), government (capital of Canada) and advanced technology (Ottawa Carleton Economic Development Corporation, 2000) (Table 17).

To match the characteristics of Ottawa, the criteria for selecting a city in Malaysia and Indonesia were as follows: population size of greater than 0.7 million, but less than 5 million (larger population differential might reduce comparability); city experiencing growth in its population; government, tourism or other service activities comprising a major part of the local economy; and, presence of a recognized institute/university specializing in transportation or human geography research.

In doing work abroad, and especially in conducting a cross-national study, it is advantageous for the foreign researcher to be in close contact with a research institute or university ideally specializing in both the subject and methodological aspects of the research. As Øyen (1990, p. 16) notes "...there is a widespread understanding legitimated ethically as well as methodologically that cross-national studies profit from being conducted in close cooperation with researchers based in the respective countries, and collaborating during all the phases of the project." Interaction with local researchers is important in order to obtain assistance in recruiting field surveyors, to ask the local researchers to review the research and provide suggestions, and also to obtain a letter of reference for conducting the research.

Figure 13: Location of Three Field Site Cities

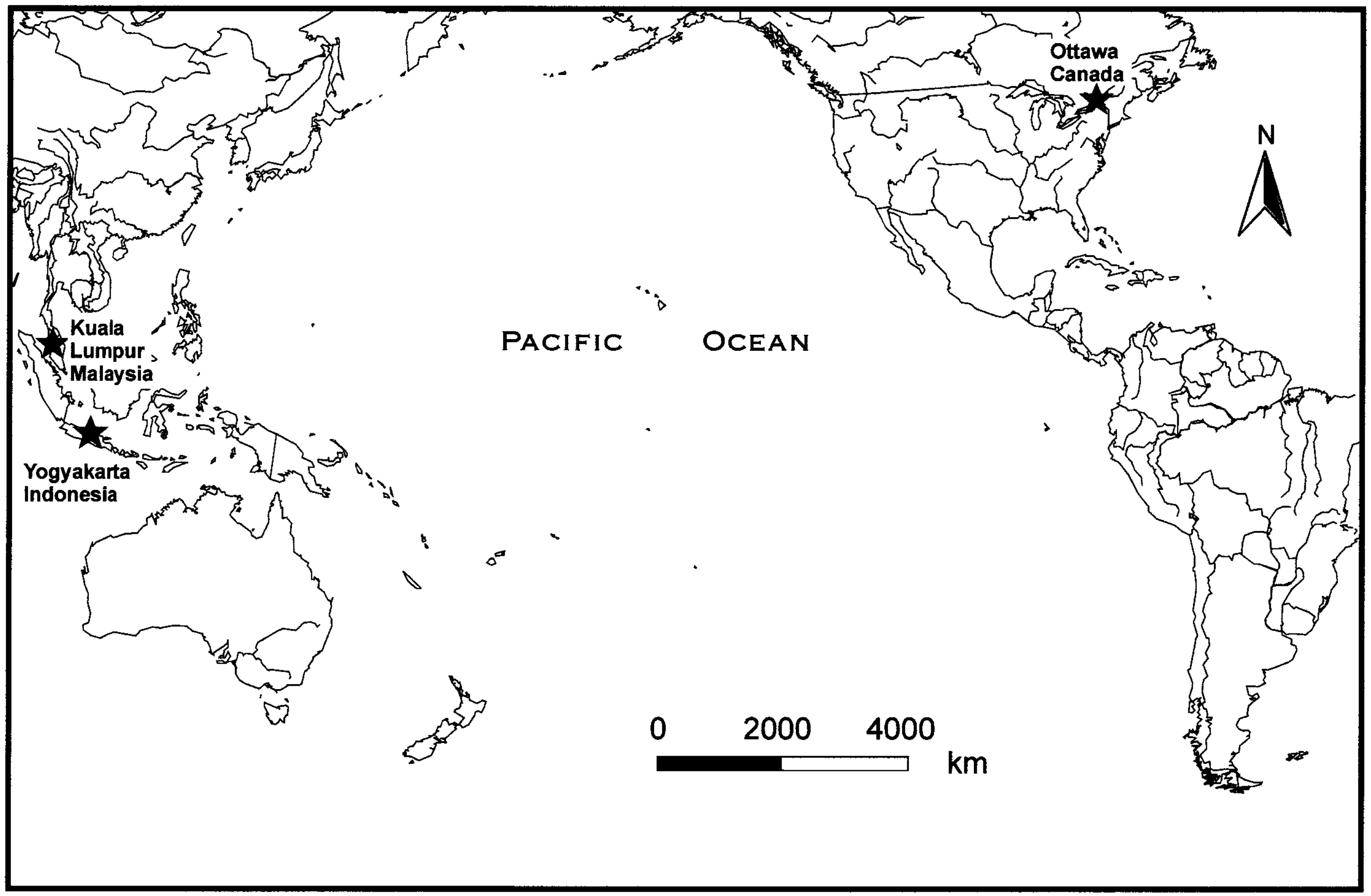

Figure 14: Location of Ottawa, Canada

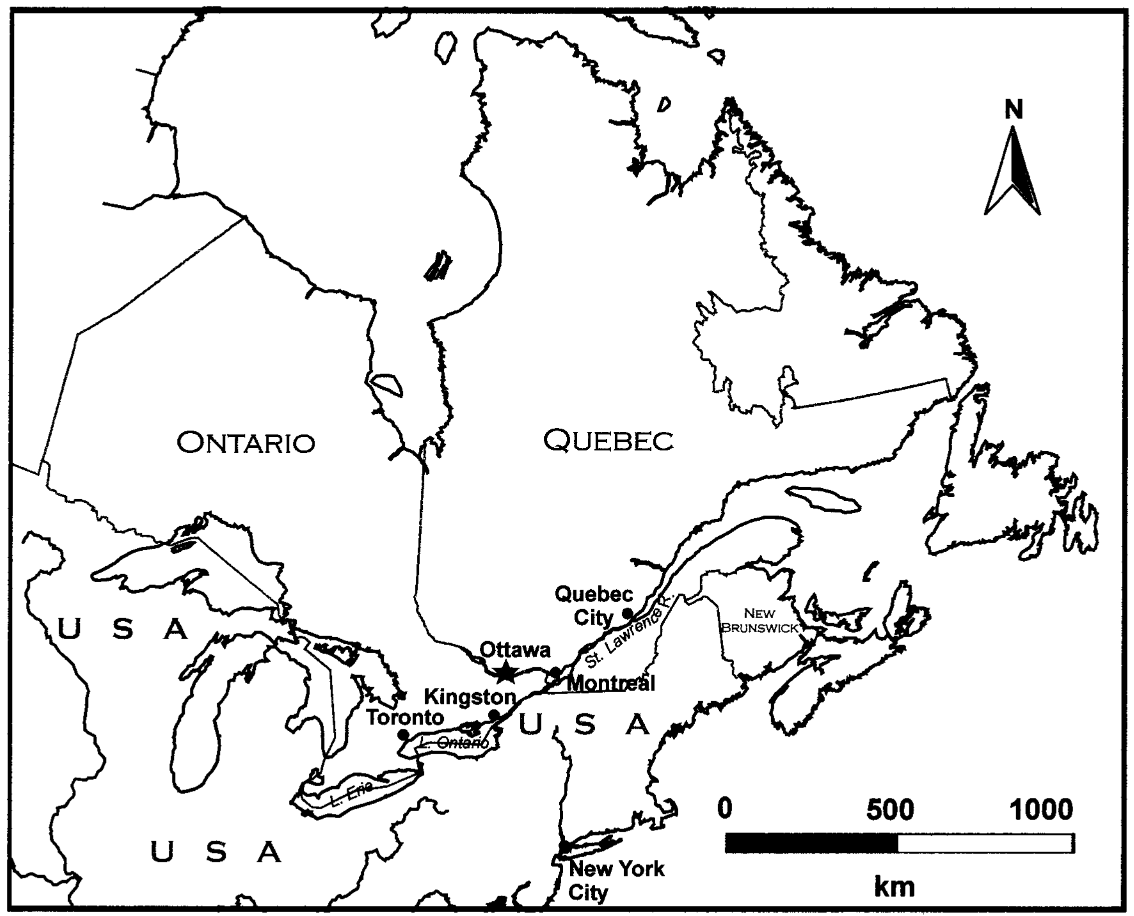

Table 17: Key General Characteristics of Field Site Cities

Characteristic	Ottawa, Canada[1]	Kuala Lumpur, Malaysia[1]	Yogyakarta, Indonesia[1]
Population (million)	0.75 (1997 est.)[2]	3.78 (1997 est.)[3]	2.98 (1997 est.)[4]
Population density[5]	272 persons/square km	1,337 persons/square km	937 persons/square km
Urban/rural population classification[6,7,8]	90% urban, 10% rural	91% urban, 9% rural	54% urban, 46% rural
Age (percentage of population within specified age brackets (in years))[9,10,11]	0-14: 20.6% 15-24: 13.1% 25-34: 17.1% 35-44: 17.9% 45-54: 13.4% 55-64: 7.8% 65+: 10.2%	0-14: 29.2% 15-24: 19.5% 25-34: 20.8% 35-44: 15.4% 45-54: 8.4% 55-64: 4.0% 65+: 2.7%	0-14: 24.5% 15-24: 19.8% 25-34: 15.4% 35-44: 12.5% 45-54: 9.8% <u>55-59</u>: 4.1% <u>60+</u>: 13.8%
Income (average)[12,13]	$30,993 (1995 Canadian $)	n/a	n/a
Ethnic or language groups[14,15]	English: 65.4% French: 14.5% Other[16]: 20.0%	Chinese: 44.7% Malay: 38.4% Indian: 11.8% Other: 5.1%	Mostly Javanese[1]. Exact statistics not available.

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[1] Ottawa is defined as the former Regional Municipality of Ottawa Carleton. Kuala Lumpur is defined as the Klang Valley including four districts in the State of Selangor (Selangor Darul Ehsan) (Gombak, Klang, Petaling and Hulu Langat) and the Federal Territory of Kuala Lumpur (DBKL). Yogyakarta is defined as the Yogyakarta Special Region.

[2] Exact population figure: 748,981. Estimated population based on post-censal adjustments. Statistics Canada. (2002a). Internet site. (http//ceps.statcan.ca/english/profil) (profile for Ottawa Carleton Public Health Unit).

[3] Exact population figure: 3,784,000. Selangor Darul Ehsan. (2001) and DBKL. (2001). Internet sites. (http://www.selangor.gov.my and http://www.jbtdbkl.gov.my).

[4] Exact population figure: 2,984,300. BPS Indonesia. (2002a). Internet site. (http://regional.bps.go.id//~yogya/sosduk/pop_tables.htm#table5).

[5] Calculated from populations and land areas presented in above footnotes and table.

[6] Data for 1997. City of Ottawa. (2002a). Data provided directly from City of Ottawa (Robert Calladine).

[7] Data for DBKL and Selangor. Department of Statistics Malaysia (2002b). Eight Malaysia Plan National Data. *Key Summary Statistics by State, Malaysia, 2000.* Internet site. (http://www.statistics.gov.my/English/pageks.htm).

[8] Data for 1997. Calculated by interpolation of data provided for 1990 and 2000, assuming a constant annual rate of change. BPS Indonesia. (2002a). Internet site. (http://regional.bps.go.id//~yogya/sosduk/pop_tables.htm#table3).

[9] Ottawa data for 1996. Ottawa Carleton Economic Development Corporation (2000). Ottawa 1991 and 1996 Census and Planning Projections (under review).

[10] Data <u>only</u> for Selangor (Gombak, Klang, Petaling and Hulu Langat). Selangor Darul Ehsan (2002). Internet site. (http://www.selangor.gov/my/final/subfigure.htm).

[11] Indonesian data for 1996. BPS Indonesia. (2002b). Number of Population by Age Group in D.I. Yogyakarta, 1996-1997. Data provided directly from BPS Indonesia Yogyakarta.

[12] Average total income of persons reporting income. Statistics Canada. (2002a). Internet site. (http//ceps.statcan.ca/english/profil) (profile for Ottawa Carleton Public Health Unit).

[13] Comparable data for Kuala Lumpur and Yogyakarta are unavailable. For a comparison of income on a country level, please refer to Section 2.1.1.4.

[14] Data for Ottawa is for 1996. Population by mother tongue (language first learned and still understood). Statistics Canada. Internet site. (2002a). (http://ceps.statcan.ca/english/profil) (profile for Ottawa Carleton Public Health Unit).

[15] Data for Kuala Lumpur is for DBKL in 1998. DBKL. (2002). Internet site. (http://www.dbkl.gov.my/info/eng_frm_maklumatkl.htm).

[16] Other languages and multiple responses.

Characteristic	Ottawa, Canada[1]	Kuala Lumpur, Malaysia[1]	Yogyakarta, Indonesia[1]
Land area	2,757 square km[2]	2,830 square km[3]	3,186 square km[4]
Economy[5,6,7,8,9,10] (employment (1996) composition by sector)	Services: 87.8% Manufacturing: 11.2% Agriculture: 1.0%	Services: 50.4% Manufacturing: 42.8% Agriculture: 6.5%	Services: 42.9% Manufacturing: 21.0% Agriculture: 36.0%

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[1] Mantra, 1981.

[2] Statistics Canada. (2002a). Internet site. (http://ceps.statcan.ca/english/profil) (profile for Ottawa Carleton Public Health Unit).

[3] Data for 1997. Selangor Darul Ehsan. (2001) and DBKL. (2001). Internet sites. (http://www.selangor.gov.my and http://www.jbtdbkl.gov.my).

[4] BPS Indonesia. (2002a). Internet site. (http://regional.bps.go.id//~yogya/sosduk/pop_tables.htm#table4).

[5] Data for Selangor Darul Ehsan. DBKL not included. Selangor Darul Ehsan (2001). Internet site. (http://www.selangor.gov.my).

[6] Statistics Canada. (2002a). Internet site. (http://ceps.statcan.ca/english/profil) (profile for Ottawa Carleton Public Health Unit).

[7] BPS Indonesia. (2001b). Labour Force Sample Survey for Yogyakarta. Provided directly from BPS Indonesia Yogyakarta.

[8] Services in Kuala Lumpur and Yogyakarta include: wholesale trade, retail trade, restaurant and hotels; transportation, storage and communications; electricity, gas and water supply; financing, insurance, real estate and business services; community, social and personal services; government and other services.

[9] Manufacturing in Ottawa, Kuala Lumpur and Yogyakarta includes manufacturing and construction.

[10] Agriculture in Kuala Lumpur and Yogyakarta includes agriculture, forestry, hunting, fishery, livestock, mining and quarrying. Agriculture in Ottawa includes agriculture and other resource based industries.

Since *Kuala Lumpur* is the only city in Malaysia with a population above 0.7 million[1], it was selected by default (see Figure 13 on page 86 and Figure 15). Kuala Lumpur is similar to Ottawa in that its population is growing. As the capital of Malaysia, government is an important part of its economy and, also like Ottawa, tourism is a major income generator. Kuala Lumpur is home to one of Malaysia's oldest and foremost universities, the University of Malaya. The university has both a Transportation Research Centre and a Human Geography Department.

A decision matrix (see Table 18) was prepared for selecting the Indonesian field site city. Ten major cities in Indonesia were considered candidates: seven on the island of Java (Jakarta, Bandung, Semarang, Yogyakarta, Surakarta, Malang and Surabaya); two on the island of Sumatra (Medan and Palembang) and one on Sulawesi (Ujung Padang) (see Figure 16).

Applying the first decision criterion, four of the ten cities were eliminated from further consideration. Jakarta, the nation's capital, was ruled out due to its population size. With a population of 8 million, Jakarta is too large to be comparable to Ottawa and Kuala Lumpur. Bandung was dismissed because it is strongly influenced by Jakarta. The western urban fringe of Bandung is merging with the Jakarta Metropolitan Region (Ida Ayu Indira Dharmapatni et. al., 1995). Surakarta was not suitable for the field study due to its small population (0.5 million).

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[1] Other major urban areas in Malaysia have the following populations (preliminary count report for 2000): Johor Bahru (384,613); Kota Bharu (233,673); Melaka (Bandaraya Bersejarah) (369,222); Seremban (246,441); Kuantan (283,041); Ipoh (566,211); Kota Kinabalu (354,153); and, Kuala Terengganu (250,528). Department of Statistics Malaysia. (2002a). Internet site. (http://www.statistics.gov.my/English/precensus2k.htm).

Figure 15: Location of Kuala Lumpur, Malaysia and Yogyakarta, Indonesia

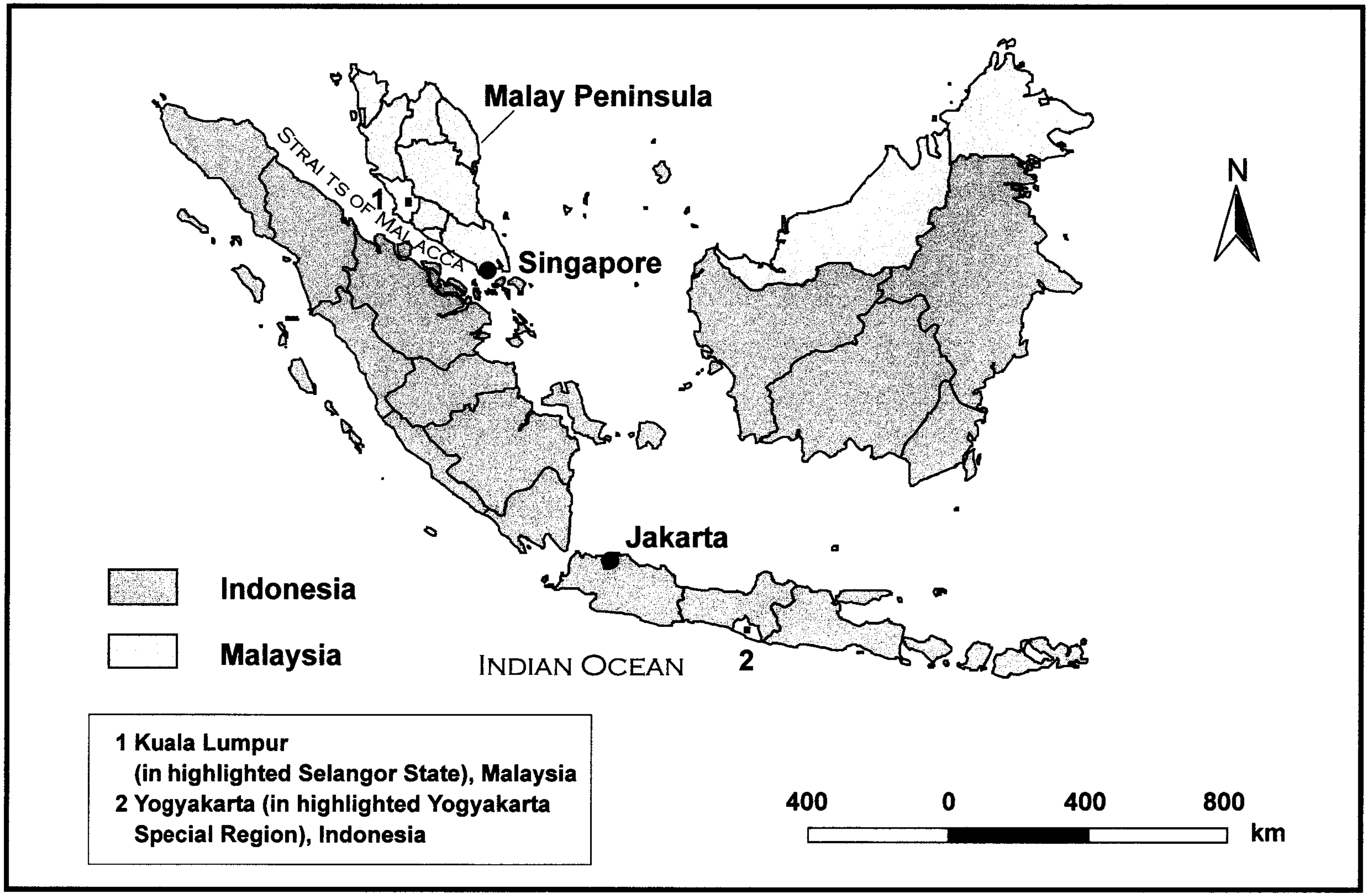

Table 18: Decision Matrix for Selecting Indonesian Field Site City

City	Island	Size[1] (>0.7 million but <5 million)	Urban Growth[2]	Recognized Institute or University[3]	Economy of city[4]	Notes
Jakarta	Java	8.4 million (1998 est.[5])				Nation's capital. Large mega-city – too large to be comparable.
Bandung	Java	2.4 million (1996)				Capital of West Java. Western urban fringe merging with Jabobatek.[6]
Semarang	Java	1.4 million (1997)	Yes	Diponegoro University	Government. Important commercial centre. Port.	Capital of Central Java. North coast port.
Yogyakarta	Java	3.0 million (1997)	Yes	Gadjah Mada University; Institut Seni Indonesia	Tourist centre. Government. Exports[7]: leather, silver, ceramics, tile.	Special Territory.
Surabaya	Java	2.3 million (1994)	Yes	Surabaya University; Sekolah Tinggi Teknik Surabaya; Institute of Technology Sepuluh Nopember; STIKOM Surabaya; Airlangga University.	Port. Important industrial and manufacturing centre. Industries[8]: ship building, manufacturing, petrochemical and cement.	Indonesia's second largest city. Second in commerce to Jakarta.
Malang	Java	0.7 million (1994)				Population borderline. Eliminated due to personal safety concerns (see text).
Surakarta	Java	0.5 million (1997)				Population too small to be comparable.

[1] BPS (Bureau Pusat Statistik) Indonesia. (2001c). Internet site. (http://www.bps.go.id).

[2] Interpolated on the basis of provincial data (BPS Indonesia, 2001c). All Indonesian provinces show positive growth rates for the period 1980-1990.

[3] Indonesian Embassy, Ottawa, Canada. (2001). Internet site. (http://www.indonesia-ottawa.org).

[4] Eliot, 1998; Soetjipto et. al., 1994.

[5] Estimate based on BPS Indonesia (2000) data for 1990 (8.26 million), 2000 (8.38 million).

[6] Ida Ayu Indira Dharmapatni et. al., 1995.

[7] Soetjipto et. al., 1994.

[8] Department of Foreign Affairs and International Trade (DFAIT), 1995.

City	Island	Size[1] (>0.7 million but <5 million)	Urban Growth[2]	Recognized Institute or University[3]	Economy of city[4]	Notes
Medan	Sumatra	2.0 million (1998)	Yes	University of North Sumatra	Government. Port. Important commercial centre. Handles many of North Sumatra's natural resource exports: tobacco, rubber, palm oil, tea, petroleum and industrial goods.[1]	Capital of Sumatra. Rioting in 1998 – safety a concern.[2]
Palembang	Sumatra	1.2 million (1998)	Yes	Sriwijaya University	Heavy industrial economy based on tin mining and oil.	
Ujung Pandang	Sulawesi	1.2 million (1998)	Yes	Hasanudin University	Government. Port with container terminal.[3]	Capital of Sulawesi.

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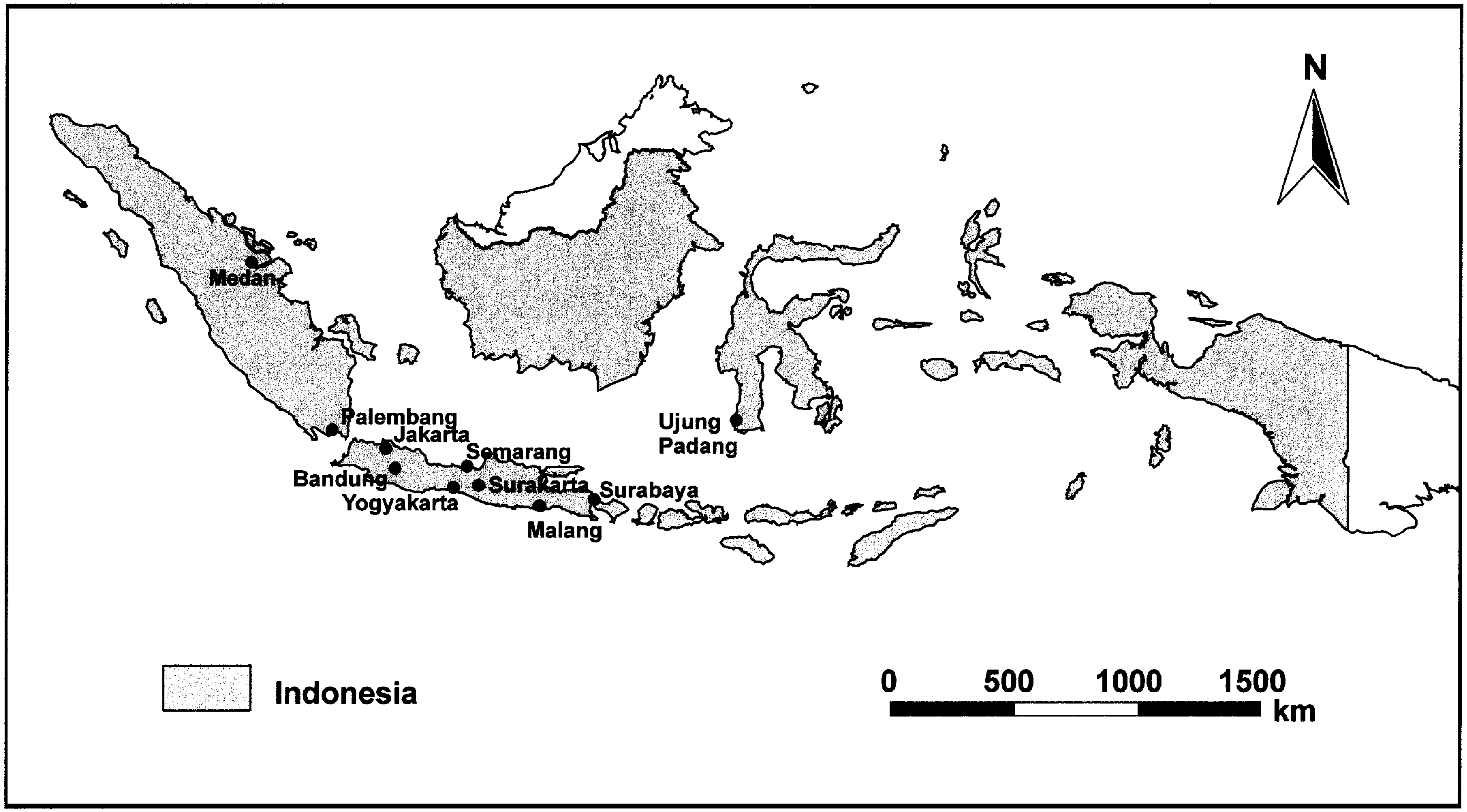
[1] Eliot, 1998.

[2] Thursday, May 7, 5:14pm EDT 1998. Indonesia urges calm but Asia markets shaken. - by Andrew Marshall. Jakarta, Indonesia (Reuters) - "Truckloads of Indonesian troops maintained an uneasy peace in Medan Thursday after three days of rioting, but fears of further violence sent tremors through markets across Asia….In Medan, convoys of soldiers backed by armored cars and with sirens blaring patrolled the city's riot-scarred areas and troops with automatic rifles and riot shields stood beside gutted shops and the charred shells of burned-out vehicles…A plainclothes security official held a gun to the head of a Reuters Television cameraman, before firing into the air and pushing him over a wall into a ditch."

[3] Eliot, 1998.

Figure 16: Major Cities In Indonesia



Malang, with a population of 0.7 million, is on the borderline of the population criterion of >0.7 million. Population aside, Malang was eliminated from consideration (prior to embarkation on the research trip), due to personal security concerns. At the time the research was being undertaken, there were outbursts of violence across the country due to the Asian economic crisis. For this reason, easy egress out of the country via Jakarta, Indonesia's main international air transport gateway, was sought. To exit the country from Malang, a three hour bus or train trip to Surabaya, then a plane trip to Jakarta would be required. By contrast, Yogyakarta, the city finally selected, has frequent, direct air service to Jakarta.

The remaining six candidate cities all fulfill the criteria of having positive growth rates and hosting universities. However, Yogyakarta stands out from the other cities with regard to the quality of one of its universities. Yogyakarta is home to Gadjah Mada University or "UGM". Founded in 1949 during the Indonesian Revolution, UGM "is Indonesia's oldest and one of its most prestigious universities." (Eliot, 1998, p. 206). The geography department at UGM is well-respected, and has expertise in human survey research and GIS and mapping systems.

Applying the fourth criterion, that the economy of the city is based on service activities, eliminates all the remaining candidates except for Yogyakarta. The cities of Semarang, Surabaya, Medan and Ujung Padang are all ports which ship out natural resource exports and, consequently, are industrial in nature. Palembang, while not a port, also possesses a highly industrial economy.

Thus, *Yogyakarta* was chosen as the Indonesian field site (see Figure 13 and Figure 15). It fits all four criteria. Yogyakarta has a growing population registering approximately 3.0 million in 1997 (BPS Indonesia, 2002a). The University Gadjah Mada, located in the city has expertise in the area of the author's research. Finally, Yogyakarta's economy is based on service activities, including tourism and government.

2.2.1 Overview of Field Site Cities

2.2.1.1 Government

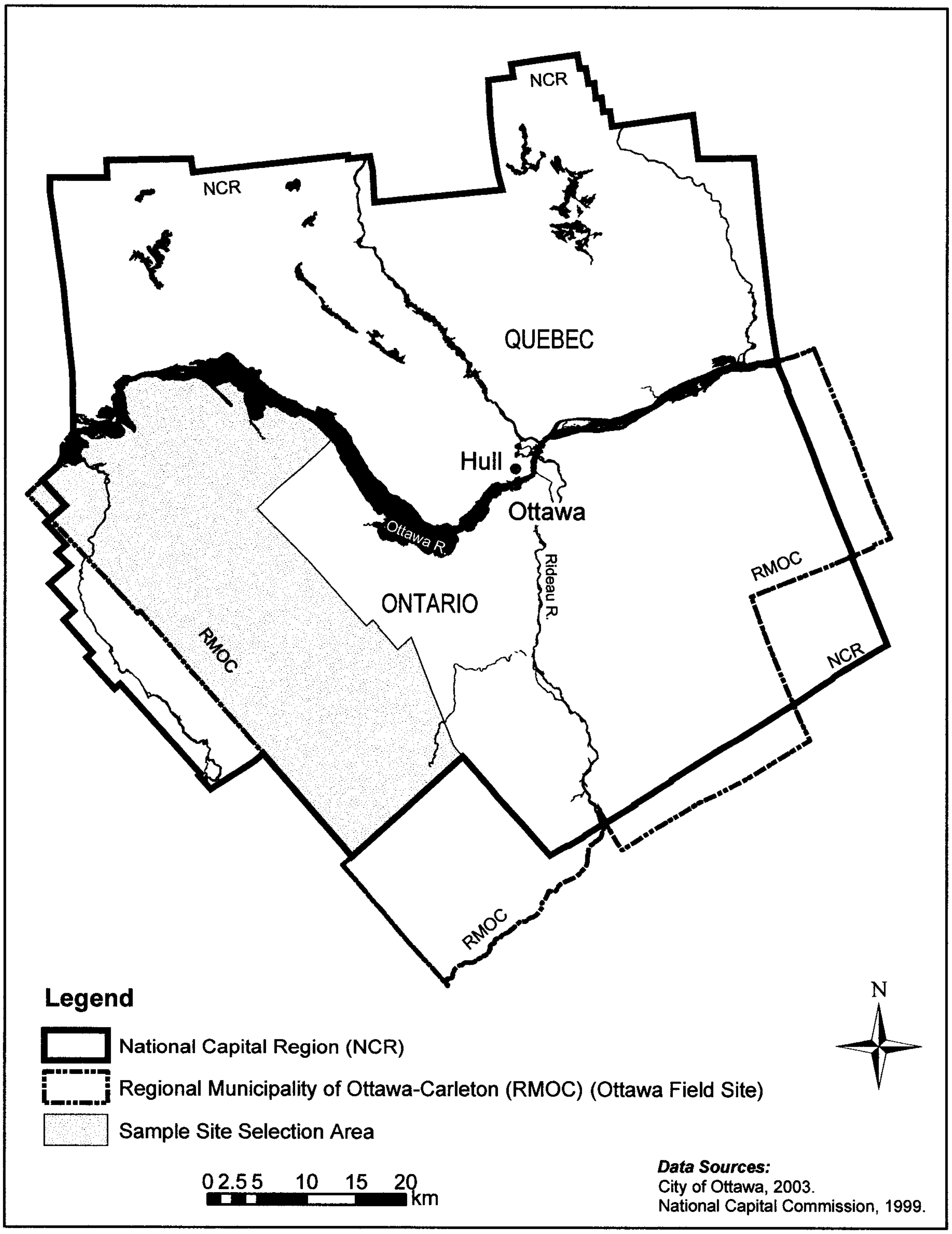
Ottawa

The Ottawa field site is defined by the boundaries of the Regional Municipality of Ottawa Carleton (RMOC) which represents the government on the south side of the Ottawa River (see Figure 17). At the time of the proposal and field work, a two-tier local government structure was in place on the south side of the Ottawa River. On January 1, 2001, the Regional Municipality of Ottawa-Carleton and the eleven lower-tier municipal governments were amalgamated to form the (new) City of Ottawa.

A large proportion of the RMOC land area is also part of the National Capital Region (NCR). The NCR is under the jurisdiction of the National Capital Commission (NCC), a body charged with guiding the development of the region in its role as the national capital. As an interprovincial area, the NCR includes lands on both the north (Province of Québec) and the south (Province of Ontario) sides of the Ottawa River.

The south side of the Ottawa River, defined by the RMOC, was selected as the thesis field site as a result of the knowledge of a north-south (Ottawa River) divide. A major contributor to this divide is of course the physical separation forced by the river. Another strong influence can be attributed to linguistic and cultural differences. The majority of the population on the north side of the river is of francophone mother tongue, while the majority of the population on the south side (in the RMOC) is of anglophone mother tongue.

Figure 17: Ottawa Field Site and Sample Site Selection Area in the Context of the National Capital Region



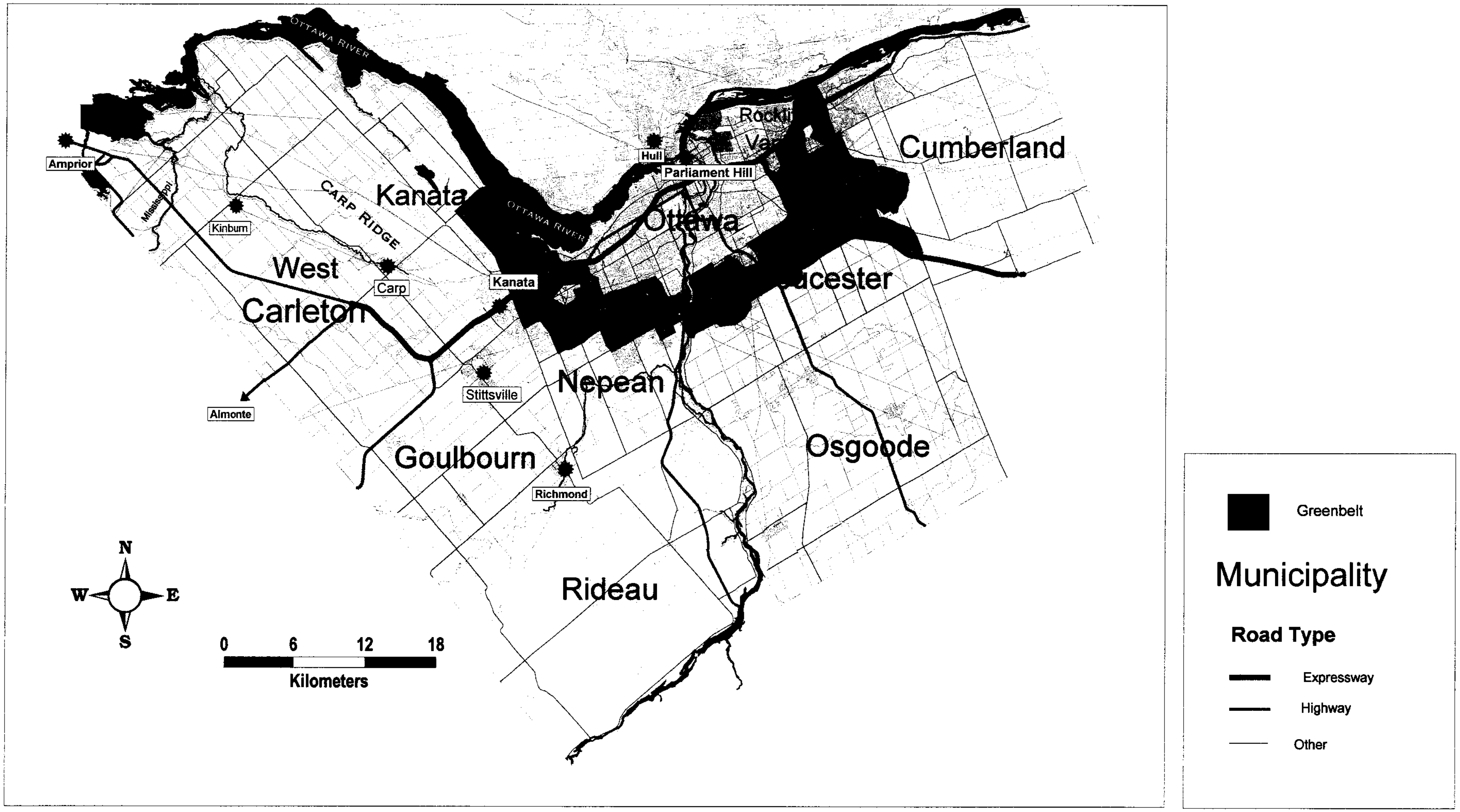
The Gallant Report noted this north-south division in 1974, "the two city centres of Ottawa and Hull remain distinct and separate entities" (National Capital Commission, 1974, p 13). In designing the current research, the north-south divide was hypothesized to correspondingly limit travel patterns. The north-south divide was indeed substantiated through the research. Relatively few trips were made by survey respondents to the north side of the Ottawa River. Maps of the Ottawa field site therefore focus on the RMOC part of the National Capital Region. To accommodate the few trips that were made to Québec, the maps are modified as necessary to include the area north of the Ottawa River.

In addition to the north-south divide across the Ottawa River, there is polarization within the RMOC in an east-west direction on either side of the Rideau River (see Figure 17). The east-west divide within the RMOC is due in large part to linguistic and cultural differences, with a higher proportion of francophones to the east of the Rideau River compared to the west (Lamarche and Perron, 1978; B. Wellar communications, 2000-2003).

This research samples the urban fringe in the western portion of the RMOC. Related research could sample residents in the urban fringe areas north of the Ottawa River and in the southern and eastern parts of the RMOC, to compare with the findings of this study.

The RMOC, which comprises the Ottawa field site, was created in 1969 and consisted of 11 municipalities (see Figure 18). The Region's functions were to provide integrated services such as: transportation, water treatment, waste management, protection of the environment, health and social services and regional planning across all municipalities (National Capital Commission, 2002). Subsequent to this field study, the "City of

Figure 18: General Map of the Ottawa Field Site



Ottawa" was created in January 2001 with 21 regional councillors and a mayor, and the regional and local governments were dissolved (City of Ottawa, 2002c).

Kuala Lumpur

The city core of Kuala Lumpur is a Federal Territory (called Dewan Bandaraya Kuala Lumpur or DBKL) administered by the Dato Bandar (Mayor) under the Malaysian Prime Minister's Office (Sime Darby, 1998). Since the urban population has spread outside the boundaries of the Federal Territory into outlying areas, Kuala Lumpur is defined in this study as the Klang Valley which includes four districts in the State of Selangor (Gombak, Klang, Petaling and Hulu Langat) and DBKL (see Figure 19).

Yogyakarta

Yogyakarta is defined as the Yogyakarta Special Region in this study. The Special Region consists of one Municipality and four regions: Yogyakarta Municipality and the Bantul, Sleman, Gunung Kidul, and Kulon Progo Regencies (see Figure 20). Sub-districts (*kecamatan*), villages (*kelurahan*) and *rukun warga* (RW) are the lower administrative levels of government (Guinness, 1994; Mantra, 1981).

2.2.1.2 *Economy*

Of the three field site cities, Ottawa's economy has the highest level of service-based employment (88%), compared to Kuala Lumpur (50%) and Yogyakarta (43%) (in 1996) (Statistics Canada, 2002a; Selangor Darul Ehsan, 2001; BPS Indonesia, 2001b) (see Table 17). All three field sites have government and tourism functions, with Ottawa and Kuala Lumpur as national capitals and Yogyakarta as a regional and cultural centre. In terms of other service activities, the advanced technology sector employs 10% of Ottawa's work

Figure 19: General Map of the Kuala Lumpur Field Site

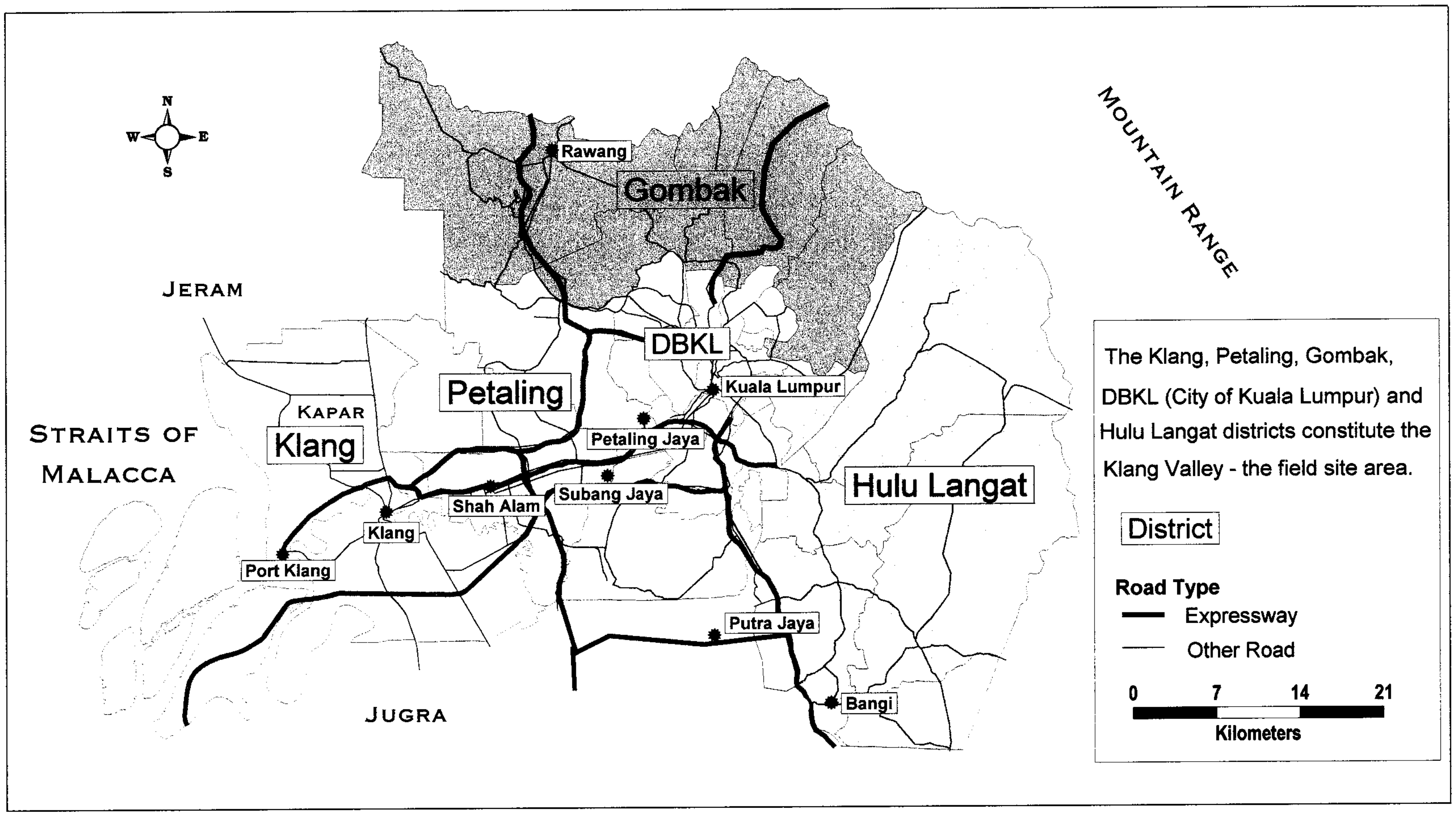
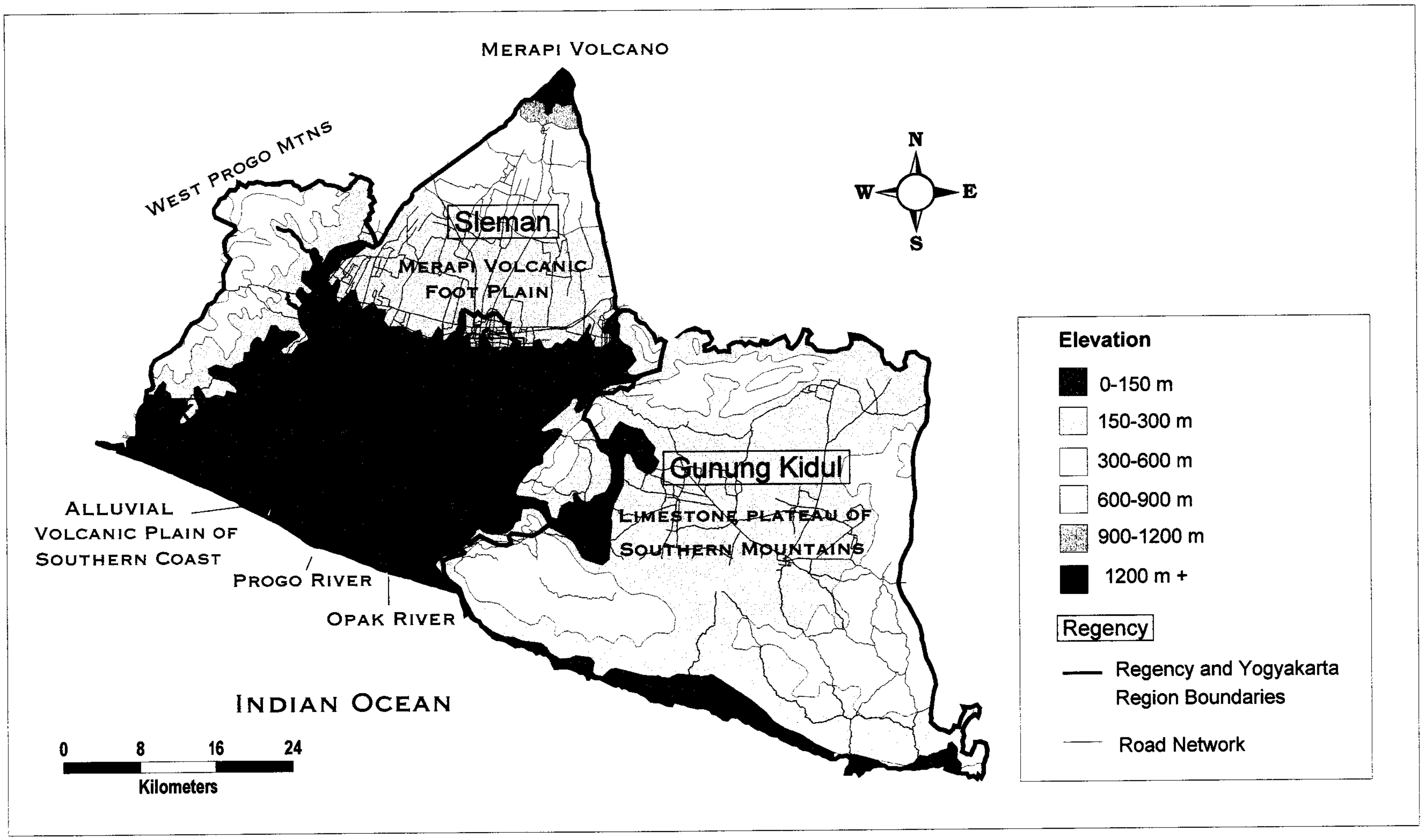


Figure 20: General Map of the Yogyakarta Field Site



force (data for 1996) (Ottawa Carleton Economic Development Corporation, 2000). As the decision-making centre of Malaysia, Kuala Lumpur hosts many company headquarters which generate service-based employment.

Kuala Lumpur's economy is the most heavily weighted towards manufacturing (43%), compared to Yogyakarta (21%) and Ottawa (11%) (in 1996) (Selangor Darul Ehsan, 2001; BPS Indonesia, 2001b; Statistics Canada, 2002a). Kuala Lumpur is a manufacturing centre for electrical products (including semi-conductors), and also food, building supplies, iron and steel, tin and rubber products (Major, 1991; Ness, 1999). Foreign investment from Japan, other Asian countries and abroad created a strong manufacturing base.

Agriculture (and other resource-based industries) forms a major part of Yogyakarta's economy, employing over a third (36%) of the region's population (in 1996) (BPS Indonesia, 2001b). In Kuala Lumpur and Ottawa, by comparison, only 7% and 1% of the population in each city respectively was engaged in resource-based activities (Selangor Darul Ehsan, 2001; Statistics Canada, 2002a). Agriculture is the second largest sector of Yogyakarta's economy with crops including in the dry season: soybeans, cassava, corn, peanuts, tobacco, and Spanish peppers. Wet rice is cultivated during wet season (Mantra, 1981).

Differences in the economies of the three cities mirror their level of development. Employment in Ottawa (developed) is largely service-based, while the manufacturing sector plays a strong role in Kuala Lumpur's (newly industrialized) economy. By contrast, in Yogyakarta (developing) agriculture is an important economic activity.

2.2.1.3 *Geology and Geography*

Ottawa

Ottawa is located in central Canada in the southeastern part of the province of Ontario. It lies between two other major Canadian cities. Toronto is 350 km to the west, and Montreal is 150 km to the east. New York City in the United States is 500 km south of Ottawa (see Figure 14). The city of Ottawa is situated on the south side of the Ottawa River. Hull is situated on the north side of the Ottawa River, directly across from Ottawa. The National Capital Region includes both Ottawa and Hull (see Figure 18).

Geologically, the National Capital Region is nestled in the Ottawa-St. Lawrence Lowland, surrounded by rocks of an ancient Precambrian formation. The Canadian Shield, as it is known, runs parallel to the Ottawa River on its north bank and also outcrops to the west of the Mississippi River. A finger of this same "Shield", commonly known as the "Carp Ridge", runs through Carp towards Hazeldean, west of the city core (Bond, 1968). The rich soils of the Ottawa Valley make it a successful farming area, yielding substantial revenues compared to other urban areas in Canada (City of Ottawa, 2002b).

Kuala Lumpur

Kuala Lumpur, Malaysia, is located halfway down the west coast of the Malay Peninsula, 35 km inland from the Straits of Malacca (Brooks, 1995) (see Figure 15 on page 91). The city is approximately 200 miles northwest of Singapore and about 800 miles northwest of Jakarta, Indonesia.

Kuala Lumpur lies in the Klang Valley and is bordered to the east by a mountain range that forms a north-south spine down the length of the Malay Peninsula. (see Figure 15 on page 91 and Figure 19 on page 101). Agricultural land is found to the west of the central core of the city along the coast of the Straits of Malacca (Lee Boon Thong, 1994).

Yogyakarta

Yogyakarta, often shortened to "Yogya" and pronounced "Jogja" is located in the southern part of central Java, 450 km east of Jakarta (see Figure 20 on page 102). Yogya, the city, is part of a larger administrative unit called the "Yogyakarta Special Region" (*Daerah Istimewa Yogyakarta*).

The Region takes the shape of a triangle, with the base being the Indian Ocean 28 km to the south of the city of Yogya, and the apex being the Merapi volcano, 30 km to the north of Yogya (see Figure 20). Mt. Merapi's peak towers over the city at 3,000 metres. It is one of the most active volcanoes in Indonesia, erupting just a few months before this thesis field study. The Yogyakarta region consists of the Merapi volcanic area, a limestone plateau of the southern mountains, the Merapi Volcano foot plains, the alluvial volcanic plain of the southern coast, and the West Progo Mountains. Two rivers, the Progo and Opak, run in a parallel fashion north-south through the region. The plains surrounding Mt. Merapi and the alluvial areas of the southern coast are the areas of wet rice production with fertile soil and irrigation systems (Mantra, 1981).

2.2.1.4 Population

While the three field sites are all roughly the same size (3,000 km^2), the size of their population differs. Ottawa (RMOC) is the least populated with approximately 0.75 million residents in 1997 (estimated population) (Statistics Canada, 2002a), although the whole urban region (Ottawa-Hull Census Metropolitan Area) including the Ontario and the Quebec urban and rural municipalities adjacent to Ottawa is over 1 million

(Statistics Canada, 2002b). The population of Kuala Lumpur (3.78 million) and Yogyakarta (2.98 million) (estimated 1997 data) are about three times greater than that of Ottawa's (Selangor Darul Ehsan, 2001; DBKL, 2001; BPS Indonesia, 2002a).

The population densities of the three field site areas from least to most populated are as follows: Ottawa (272 persons/km^2), Yogyakarta (937 persons/km^2) and Kuala Lumpur[1] (1,337 persons/km^2) (calculated from populations and land areas presented in Table 17, page 88). In each city, population density varies across the field site. Population density data for sub-units within each field site are presented and discussed in the next chapter.

With the exception of Jakarta (an urban area),Yogyakarta had the highest population density of all provinces in Java in 1930 (Mantra, 1981). This characteristic persists today. The overall population density of the Yogyakarta field site is 937 persons/km^2. Rural population densities exceed 1,000 persons/km^2, as a result of the well-managed cultivation of wet rice (Eliot, 1998).

In 1997, 54% of Yogyakarta's population was urban, while 46% was rural (BPS Indonesia, 2002a). By contrast, the urban component (~90%) of Ottawa's and Kuala Lumpur's populations are much greater (City of Ottawa, 2002a, Department of Statistics Malaysia, 2002b).

The majority of the residents in the RMOC are English-speaking (65%), followed by French-speaking (15%) (Statistics Canada, 2002a). Chinese form the majority (44.7%) of the population in Kuala Lumpur[2], followed by Malay (38.4%), Indian (11.8%) and other

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[1] Since the maximum level of 1,670 persons/km^2 includes the urban area of Petaling Jaya, which was not sampled, the actual range of the sample area is estimated to span 109 to 1,000 persons/km^2.

[2] Federal Territory of Kuala Lumpur (DBKL), 1994.

(5.1%) (DBKL, 2002). Yogyakarta's population is made up mainly of residents of Javanese heritage (Mantra, 1981).

2.2.1.5 *Development History*

Ottawa

Ottawa is located at the point where two rivers, the Rideau and the Gatineau, flow into the Ottawa River, and it is also the site of two river barriers: the Chaudière Falls on the Ottawa River, and the Rideau Falls at the mouth of the Rideau River.

During the War of 1812, between Canada and the United States, the British were concerned that their earlier policy of allowing Americans to settle in Upper Canada was ill advised due to the questionable loyalty of the settlers. A second concern was that up until 1814, most of Upper Canada's population was concentrated along the northern shores of Lake Ontario and Erie – close to the United States. To correct this situation, following the end of the war in 1814, the British encouraged emigrants from Britain to come to Canada. The new loyal British settlers, along with disbanded soldiers, were offered property *inland* in Upper Canada (Bond, 1968).

> "...a population in the back townships, producing supplies for those on active duty at the American frontier, in case of further difficulty with the perverse people..." (Haydon, 1925, p. 14).

In 1815, a proclamation in Edinburgh offered prospective settlers free passage and 100 acres of land in either Upper or Lower Canada, along with supplies for the first six months. Four ships of emigrants arrived in the autumn of 1815 (Bond, 1968). In 1826, Lieutenant Colonel John By came to Richmond Landing as the engineer in charge of constructing the Rideau Canal. The canal was built by the British Government as a defence measure, to provide secure inland transportation and a communication link between Montreal and Lake Ontario in case of an American invasion of Canada.

Fortunately, the canal was never needed for this purpose. Richmond Landing, soon became known as "Bytown" after Colonel By, and developed as a supply depot for the Rideau Canal construction (Welch, 1979). As well as building the canal, Colonel By laid out the settlement of Bytown which grew quickly (Bond, 1968).

Early agriculture in the Ottawa area was geared towards wheat production and for feeding the Ottawa Valley lumber camps. Provisioning lumber camps provided capital for farming and the shanties provided winter employment for farmers. Agriculture was not generally oriented towards feeding Bytown (Elliot, 1991).

Ottawa officially became the capital of Canada in 1858, and the lumbering village began to prepare for its new role. Railways came to Ottawa in the 1850's. In addition to the railways many bridges were built.

> "(Ottawa's) network of water courses...made necessary many expensive bridges and bridge approaches. When upon this water network there was superimposed an almost chaotic collection of railway lines, spurs, yards, termini and warehouses, the effect on the flow of traffic throughout the region, can be imagined. Railways crossed

streets at hundreds of points, and scores of dead end streets marked the points where no crossings were provided." (Eggleston, 1961, p. 152).

The coming of the automobile in 1915 began to create a "the sprawling uncontrolled extension of the urban area of the capital in an age of mass ownership of automobiles and trucks." (Eggleston, 1961, p. 252). The intention of the first Municipal Act of 1849 was that subdivisions springing up in the rural townships adjacent to cities would eventually obtain urban services through seeking annexation to the urban area (Elliot, 1991). However, this did not happen quickly or easily, as the residents in rural townships preferred to keep their taxes low. Both the provinces and the rural townships responded to pressure from taxpayers, rather than initiate changes on their own (Elliot, 1991).

In 1927, the Federal District Commission was founded and was given greater powers than that of its predecessor, the Ottawa Improvement Commission. However, the city had still not yet resolved the city's railway maze. In 1936, Prime Minister William Lyon MacKenzie King invited Jacques Gréber, a French architect, to help the federal government with plans for Ottawa's Confederation Square. Beyond a design for the square, Gréber was asked to help guide the development of the national capital as a whole. While the onset of World War II delayed Gréber's work for 10 years, the project continued in 1946. Gréber's master plan for the national capital was finally published in 1950.

A controversial recommendation of the plan was the Greenbelt, a no-development zone around the City of Ottawa separating the urban from the rural areas. The Greenbelt's functions were to protect areas of natural beauty, limit urban sprawl and provide sites for buildings, but not exclusively government buildings (Eggleston, 1961).

In 1950, part of the Township of Nepean and Township of Gloucester were annexed to the City of Ottawa. This purchase of 24,000 acres allowed the main elements of Gréber's master plan to be achieved. The city's maze of railway lines were relocated, allowing the construction of a new east-west highway through the city. Also, new industrial areas, the Greenbelt and new parkways were developed (Figure 18). The 1950's and 1960's were a period of great growth in Ottawa with an enlarged federal civil service.

Urban sprawl was observed in the 1960's by Walker (1968, p. 509):

> "Goulbourn's present population (1968) is 3,500...But much of the future of the township is contained in the new "Glen Cairn" development of 600 acres, adjacent to the Green Belt perimeter on Highway 15 at the western end of the Queensway. When completed in five stages it will be a modern self-contained community of nearly 10,000 people housed in 2,000 single unit homes. Its present population is 1,500. But what the end result will be when 600 acres of some of the finest farm land in the County is converted into another satellite suburbia of the capital is something beyond the thinking of anybody." (Walker, 1968, p. 509)

Since the 1960's, the city has continued to sprawl outside the Greenbelt (Wellar, 1996; Stonehouse, 2000). Growth in Ottawa's west-end high technology sector during the 1990's (see Section 3.2.2.1.1) and the year 2000 (Adam, 2000; Hughes, 2000) contributed to further sprawl. Also recently, high technology businesses have expanded into the Greenbelt itself as the National Capital Commission (successor of the Federal District Commission) divests itself of property.

Kuala Lumpur

The Klang area was a centre for trade as early as 100 AD. At that time, the area was controlled by Malay chiefs (Lee Boon Thong, 1994). "The Klang River was an ideal place for settlement as it joined the great commercial seaway of the Malacca Straits." (Sime Darby, 1998, p. 16). In the 1600's, Bugis traders (from Sulawesi in Indonesia) gained control of Selangor and founded the Selangor sultanate (Sime Darby, 1998).

Tin deposits were discovered in the area in the mid 1800's, giving a start to Kuala Lumpur which became an important trading post and supply centre for the tin industry. It was Chinese miners who gave Kuala Lumpur its name, meaning "muddy river mouth", deriving from its location at the junction of the Klang and Gombak Rivers. (Brooks, 1995).

Internal conflict between Chinese secret societies during the 1860's and early 1870's resulted in a depopulation of Kuala Lumpur. However, to protect trade, in August 1874 the British intervened to restore order. With the British in charge, new settlers were welcomed to help develop more tin mining areas, construct more tracks, and develop agriculture in the areas opened up by the tracks (Lee Boon Thong, 1994).

Kuala Lumpur's rapid growth was due to its strategic location vis-à-vis the surrounding tin mining areas which were all connected by bullock car tracks to the settlement (Lee Boon Thong, 1994).

Malays, Javanese, Sumatrans and Chinese immigrants moved to the coconut growing areas of Jeram in 1875 (see Figure 19 on page 101). At the same time, the lands around

Klang were cleared and planted with a number of crops including tobacco, coconut, nutmeg, gambier, sugar cane, tea and rice (Lee Boon Thong, 1994).

In 1880, the British moved their administrative centre from Klang to Kuala Lumpur. Frank Swettenham became the British "Resident of Selangor" in 1882, and it is he who is credited with rebuilding Kuala Lumpur. He levelled tin shanties, had brick buildings constructed and oversaw the construction of the Klang-Kuala Lumpur railway (Brooks, 1995). Up until 1886, goods had been transported by river and track, but the 32 km railway line between Kuala Lumpur and the Klang area put an end to river transport (see Figure 19).

Prices for pepper fell in 1893, so cultivation turned to coffee. In 1895, another 2,000 Javanese settled in Klang area as farmers. Klang had become an important agricultural area because of the coastal road running to the north in Kapar and to the south in Jugra (Lee Boon Thong, 1994).

Kuala Lumpur was chosen as the capital of the Federated Malay States in 1895, which reinforced development of road and rail networks within the Klang Valley. Again in 1898 another major switch in agriculture took place. Rubber was in demand worldwide, so planting changed from coffee to rubber. Eventually the Klang Valley became the centre of the rubber industry (Lee Boon Thong, 1994).

Kuala Lumpur continued as the capital following Malaysia's independence in 1957.

> "After independence the economy developed faster still, and the Klang Valley underwent a further transformation – its rubber plantations being converted into housing estates, often enough still bearing the same names...and the great tin mines giving way to

factories, mills and assembly plants, and the disused mining pools being converted into theme parks." (Sime Darby, 1998, p. 17).

Squatter areas which had developed since World War II prompted the development of a new town "Petaling Jaya" in the mid-1950's (Lee Boon Thong, 1995). In 1972, Kuala Lumpur became a city, and then in 1974 the federal territory of Kuala Lumpur was carved out of the state of Selangor. Selangor's capital moved from Kuala Lumpur to the new town of "Shah Alam" (see Figure 19). The location of Shah Alam in the centre of the Klang Valley, reinforced by a highway running parallel to the railway along the Klang River, created a corridor between K.L. and Port Klang (Lee Boon Thong, 1995). Another new town, "Subang Jaya", was built in the 1970's in the corridor between Petaling Jaya and Shah Alam. McGee (1995) notes that the establishment of Kuala Lumpur as a Federal district and the polynucleated structure of the new towns located along the major transportation routes have controlled development in the Kuala Lumpur region.

Subsequent to this field study (in 2000-2001), most of Malaysia's federal departments were relocated to a new city in order to relieve traffic congestion. "Putra Jaya", the new city built for 250,000 people, has been developed on a former rubber estate south of Kuala Lumpur (see Figure 19). A 15 km wide corridor with fibre-optic cable, called the Multimedia Super Corridor or "MSC", connects the Kuala Lumpur International Airport (KLIA) to the Kuala Lumpur City Centre (Ariff et al., 1998). Housing developments have been created for government employees as part of the new city (Brooks, 1995). One of the Kuala Lumpur sample sites is a village near the Multimedia Super Corridor.

Cyberjaya, a second new city also located in the corridor, is planned to be the base for some of the world's largest multimedia companies. To attract companies to set up operations there, tax holidays have been offered to prospective companies and special laws, termed "cyber laws", have been put in place to protect computer businesses. Also, MSC companies will be able to import foreign knowledge workers. The city has been designed for 240,000 people, and the plan involves a green environment and strict zoning.

Highway and transportation systems (including commuter rail and Light Rail Transit) have been planned to link the cybercities to Kuala Lumpur City Centre (Ariff et. al., 1998).

Yogyakarta

The name Yogyakarta comes from the Sanskrit "Ayodya' – the capital city of Rama in the 2,000 year old Indian Hindu drama, the Ramayana. While the current city of Yogyakarta was founded in 1755, it occupies the centre of the ancient region of Mataram – site of the first great Central Javanese empire. From the 8th to the early 10th century, the Mataram area was ruled by Hindu-Buddhist kings.

During their rule, the kings built massive stone monuments such as Borubudur and Prambanan which are tourist attractions today. One of the attractions of Central Java is its suitability for wet rice agriculture. The Mataram area "...already in ancient times...must have supported a vast population, who all participated in the erection of these state monuments." (Apa Productions, 1985, p. 23).

Expansion of Yogyakarta in the past was due to the city's role as a court city (Ocampo, 1982). Since 1900 the city has grown due to the development of a railroad connection to Western Java, construction of facilities and utilities in the city, and establishment of universities and other educational centres (Ocampo, 1982). During the 1950s and 1960s, Yogyakarta expanded again, and while many commercial functions remained in the central area, the rise of motorized transport allowed residential areas and shopping facilities to be established in the periphery of the city (Ocampo, 1982).

2.2.1.6 *Transportation*

This section provides an overview of the transportation systems in each field site city. A more detailed comparison of the cities' transportation systems is provided in Chapter 5.

Ottawa (in 1998) had a transportation system largely dominated by the car, and supplemented with a public bus system. Approximately 91% of annual[1] travel (per capita occupant km) is by private vehicle (mainly car) and 9% is by public transport (passenger km per capita) (Kenworthy and Laube et. al., 1999). Metered taxis are available, and limousines and self-drive cars can be rented. Also, a pilot light rail transit system has recently been launched. Due to the Ottawa River to the north, the general axis of movement is east-west across the city. More details about Ottawa's transport system are listed in Table 19.

Kuala Lumpur has a diverse transportation system made up (in 1998) of buses (four major bus lines service the city and suburban areas) and Light Rail Transit (LRT). Also, a commuter train operates from the central city with lines to the north, west and southeast. Metered taxis are available, and limousines and self-drive cars can be rented. Cars are the dominant mode. Approximately 80% of all annual urban travel in Kuala Lumpur is in private vehicles (Kenworthy and Laube et. al., 1999). The Central Business District of Kuala Lumpur is the centre point of a radial road system. The radial road system, created due to topographic constraints, has resulted in severe congestion in the

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[1] Annual total motorized passenger km of travel (total per capita occupant km) as collected by Newman and Kenworthy, 1998 and Kenworthy and Laube et. al., 1999 from local transportation agencies in each city.

Table 19: Characteristics of Transport Systems (1990) at Field Sites[1]

Characteristic	Ottawa, Canada	Kuala Lumpur, Malaysia[2]	Surabaya, Indonesia[3]
% Work trips by transit	27.0%	25.5 %	21.0%
% Work trips by walking and cycling	7.0%	16.9%	23.5%
Road supply (metres per person)	7.1	1.5	0.3
Average speed by car (km/h)	40.0	29.4	27.0
Average speed by bus	24.0	16.3	17.5
Annual travel in private vehicles (total per capita occupant km)	8,236 (90.6%)	6,299 (80.0%)	1,568 (73.9%)
Annual travel in public transport (passenger km per capita)	850 (9.4%)	1,577 (20.0%)	555 (26.1%)
Total annual travel (private and public) (passenger km per capita)	9,086	7,875	2,123
% Transit cost recovery	61%[4]	135%	127%
Metropolitan density population/jobs intensity	31.3 / 15.8	58.7 / 22.4	176.9 / 77.9
Central city (CBD) density population/jobs intensity	39.7 / 364.0	123.1 / 178.5	360.2 / 355.6
Inner-area density population/jobs intensity	49.2 / 97.7	68.8 / 35.7	265.1 / n.a.[5]
Outer area density population/jobs intensity	30.1 / 10.4	53.7 / 15.7	144.9 / n.a.[5]
Private transportation energy use per capita (MJ)	32,126	19,243	5,317
Total CO_2 per capita (kg)	2434.3[6]	1424.0	404.0
NO_x per capita (kg)	27.0[4]	11.2	3.1
SO_2 per capita (kg)	2.3[4]	1.0	0.9
CO per capita (kg)	160.6[4]	90.0	42
Volatile hydrocarbons (VHC) per capita (kg)	21.7[4]	22.8	11.7
Volatile particulates (VP) per capita (kg)	3.9[4]	1.0	4.3
Transport deaths per 100,000	6.5[4]	22.7	7.8

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[1] Source: Newman and Kenworthy, 1998; Kenworthy and Laube et. al., 1999.

[2] Kuala Lumpur is defined as the Klang Valley including four districts in the State of Selangor Darul Ehsan (Gombak, Klang, Petaling and Hulu Langat) and the Federal Territory of Kuala Lumpur.

[3] Data for Yogyakarta, Indonesia is not available, therefore Surabaya, Indonesia is used as a surrogate.

[4] Figures are for Toronto, Canada. Data for Ottawa are not available.

[5] Data not available.

inner core of the city (Mohamad, 1992). Table 19 provides further details on Kuala Lumpur's transport system.

Yogyakarta possesses a diverse transport system. There is a great variety of local transport including *becaks* (bicycle powered rickshaws, found only in central area of the city) and horse-drawn *andongs* (horse or pony carts with four wheels, found in some areas of the urban area). Yogyakarta has paved roads, but not modern freeways as such.

The road network divides the city into quarters, with three main routes for north-south traffic and another two for east-west movements (Ocampo, 1982). Metered taxis are available, and one can hire a chauffeured vehicle, bicycles and motorcycles. Since data for Yogyakarta are not available, data on Surabaya (a city on the east coast of Java) are used as a surrogate for Yogyakarta because no other comparable data are available. More details on the transport system in Surabaya, Indonesia are listed in Table 19.

2.3 SUMMARY

This section provides the rationale for selecting the three field site cities: Ottawa (Canada), Kuala Lumpur (Malaysia) and Yogyakarta (Indonesia). Canada was selected for operational reasons, being the home base for the author. Malaysia and Indonesia were chosen because of their land use patterns, population densities and transportation modes.

Kuala Lumpur was the Malaysian city selected, as it is the only city with a population greater than 0.7 million. Several Indonesian cities were considered. Yogyakarta fits all the criteria: population greater than 0.7 million, but less than 5 million; city experiencing growth in its population; presence of a recognized institute/university specializing in transportation or human geography research; and, with government, tourism or other service activities comprising a major part of the local economy. The three field site cities and the three countries in which they are located are compared and contrasted to provide a general context for the research.

As required by a field site city selection criterion, all three cities have a service industry making up a major component of their economies. In addition, all three cities have government functions (Ottawa and Kuala Lumpur are both national capitals, and Yogyakarta is a special district) and have a tourism component to their economies. Differences in the economies of the three cities mirror their level of development. Employment in Ottawa (developed) is largely service-based, while the manufacturing sector plays a strong role in Kuala Lumpur's (newly industrialized) economy. By contrast, in Yogyakarta (developing) agriculture is an important economic activity.

The differing levels of development in the three field site cities are correlated to a degree with the level of automobile ownership. In developing countries the automobile is not an economically feasible means of transport for the whole population, and as a result other modes of transport are used.

The three field sites are all roughly the same size (3,000 km^2). Kuala Lumpur has the highest population (3.78 million), followed by Yogyakarta (2.98 million) and Ottawa (0.75 million). Yogyakarta has a high agricultural population density (among the highest in the world) at 937 persons/km^2. Rural population densities exceed 1,000 persons/km^2, as a result of the well-managed cultivation of wet rice (Eliot, 1998).

Of the three field countries, Malaysia has the most ethnically segregated (Malay, Chinese and Indian ethnic groups) population. The segregation is evident in many areas of society, including politics and the economy, but also in practical matters such as residential location. Ethnic segregation in residential areas needed to be taken into account while sampling for the field survey.

Muslim religious observance in Malaysia and particularly Indonesia plays an important role in the lives of the majority of the population. As a result, interviews were avoided on Fridays in both these countries.

Although Ottawa does have a bus system, its transportation system is dominated by the car. The car is also the dominant mode in Kuala Lumpur, although buses, light rail transit and commuter train also operate there. By contrast, in Yogyakarta a diversity of transport modes operate including motorcycles, car and several types of buses. Further comparison of the transportation systems and modes at the field sites is included in Chapter 5.

3. Research Design and Implementation of Travel Survey

3.1 *Research Objectives*

This research project has six objectives:

1) design a household travel survey instrument that uses an activity analysis approach;
2) pre-test the survey instrument;
3) undertake survey field research in Ottawa, Kuala Lumpur and Yogyakarta;
4) design an approach for describing and classifying activity travel patterns;
5) present results derived from the empirical study conducted in the three field site cities; and,
6) suggest how the travel pattern classification approach could be applied in transportation and land-use policy-making.

In this chapter the first three objectives of the research project are outlined: design, and pre-test of the survey instrument, and description of the field research. The remaining objectives are addressed in subsequent chapters.

3.2 *DESIGN OF TRAVEL SURVEY*

3.2.1 SCOPE OF THE RESEARCH

In this section, the general boundaries of the research are outlined by:

a) defining the geographic area from which the samples were drawn;

b) setting spatial limits for regional travel; and,

c) listing the travel modes considered in the research.

Individual travel patterns of residents living in the urban fringe of a city region are examined in this study. Respondents were sampled on a household basis from different types of residential development spanning the urban fringe. The following section discusses and defines the term *urban fringe*.

3.2.1.1 Scale of Interest

Separate terms have been advanced to describe the *urban fringe* in Western and Southeast Asian cities. The differing terminology reflects distinct urbanization processes that have been observed in the West and in Southeast Asia.

Urbanization Processes

Urbanization at the Ottawa field site is distinguished from that at the two Southeast Asian field sites. Ottawa exhibits mainly *city-based* urbanization (see Section 5.7) which refers to the spread of population from city into surrounding areas as documented by Gottmann (1961) in the Northeastern United States. Gottmann (1961, p. 218) describes *city-based* urbanization as follows: "...an exodus from the cities to neighbouring zones that had been rural. At the same time other migrants from far away towns and farms come to crowd the central cities. Thus urban growth goes on and on..."

In Southeast Asia, McGee (1995) notes the emergence of *region-based* urbanization, which involves drawing in existing residents of the extended metropolitan area, as well as attracting migrants from other rural areas.

One key difference between the two types of urbanization is that in *region-based* urbanization a greater proportion of new residents to a city move directly to the extended metropolitan area (area outside city core and suburbs) without having lived in the central city. By contrast, in *city-based* urbanization, migrants first move to the central city and then later move outwards in direction from the city core.

In Kuala Lumpur there is some evidence of migrants (originating from rural areas of Malaysia) moving directly to the metropolitan and urban fringe area (outside the city core) (Lee Boon Thong, 1995; McGee, 1995). Urbanization processes in Yogyakarta, however, are not as well documented as for Kuala Lumpur. A comparison of population characteristics in Kuala Lumpur and Yogyakarta yields two differences that may influence urbanization patterns.

1) Population growth rates in areas outside the highly urbanized portion of the city[1] are higher in Kuala Lumpur (~20%) compared to Yogyakarta (<5%) (see Table 21 and Table 22). Urbanization is therefore proceeding at a higher rate in Kuala Lumpur than in Yogyakarta.

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[1] The most highly urbanized districts of Kuala Lumpur are the Federal Territory of Kuala Lumpur and Petaling. In Yogyakarta, the city of Yogyakarta is the most highly urbanized sub-unit.

2) The in-situ population in the districts surrounding the highly urbanized portion of the city in Kuala Lumpur[1] is less dense than the districts that encircle the city of Yogyakarta[2]. The difference in densities between the two Southeast Asian field sites is mainly due to agricultural patterns (Webster, 1995). The lower densities in Kuala Lumpur are associated with plantation-based agriculture (e.g. rubber estates), whereas the much higher rural densities in Yogyakarta arise in conjunction with intensive wet-rice agriculture.

Thus, if a form of region-based urbanization is indeed operating at each Southeast Asian field site, Yogyakarta underlines the first part of the definition – urbanization of an existing (dense) agricultural population, whereas Kuala Lumpur emphasizes the second part of the definition – attracting migrants from other rural areas.

Urban Fringe and *Desakota*

At the Ottawa field site, the *urban fringe* area is the spatial focus of this thesis. Pryor (1968), in a literature review spanning 1930 to 1960 observes that the term *urban fringe* is not clearly defined and that there is a marked absence of case studies to illustrate key concepts. Recently, Johnston et. al. (2000) note that there are still widely differing views on the spatial extent of the urban fringe. A generally accepted definition (Bryant et. al., 1982) given by Pryor (1968, p. 206) is used to guide the urban fringe component of this study:

"...a zone of transition in land use, social and demographic characteristics, lying between:

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[1] See Klang, Gombak, Hulu Langat and Sepang districts in Table 21.

[2] See Bantul and Sleman regencies in Table 22.

a) the continuously built-up urban and suburban areas of the central city, and;

b) the rural hinterland, characterized by the almost complete absence of non-farm dwellings, occupations and land use..."

A conceptual framework for the structure of the urban fringe is provided by Bryant, et. al. (1982) deriving from observations of Western cities. They define the following zones within a *city region*:

a) *concentrated city*;

b) *inner fringe*: land in transition from rural to urban uses;

c) *outer fringe:* rural land uses are dominant, but urban features such as single-family dwellings are located along transportation routes (the inner fringe and outer fringe comprise the *urban fringe* or *rural-urban fringe*);

d) *urban shadow:* few urban elements are evident, although there are "some non-farm residences, country estates, the commuting patterns that develop from these and the outlying small communities and towns" (Bryant et. al., 1982, p. 13; Gertler and Hind-Smith, 1962); and,

e) *rural hinterland:* mainly rural, but with detectable urban influence, for example areas in which urban residents own cottages and travel for recreation.

The zones of a city region are dynamic and since they are intertwined with each other Bryant et. al. (1982, p. 14) note that "it is perhaps best to accept the various approaches to delimiting the rural-urban fringe – for as long as the criteria are made explicit in each study, we can at least evaluate them for what they are".

In the Ottawa component of the study, households are sampled from both the *inner fringe* and *outer fringe*, together comprising the *urban fringe* (Bryant et. al., 1982). The definition of the *rural hinterland* is employed in distinguishing between regional and intercity travel.

Pryor in his literature review (1968) notes that there are few references to the urban fringe outside North America. For this reason, an alternative definition for the urban fringe area in Southeast Asia is reviewed.

McGee (1995) outlines three structural components of the *region-based* urbanization in Southeast Asia:

- *city core* (older defined city limits);
- *metropolitan area* (an area broadly delineating the most heavily built-up population centres that have expanded from the city core); and,
- *extended metropolitan area* (areas of urban settlement located in corridors that radiate from the metropolitan area).

The term *desakota* refers to the extended metropolitan area, where non-agricultural activity is mixed with agriculture (McGee, 1991; McGee, 1995). Emphasizing a combination of farm and non-farm development, McGee's definition of *desakota* is similar to that of the *urban fringe* (see page 123). Although it is recognized that the Southeast Asian *desakota* may differ from the Western urban fringe[1], for the purposes of this comparative study, the term *urban fringe* refers to both the *urban fringe* in the West and the *desakota* in Southeast Asia.

While the urban fringe is the focus of the inquiry, the full urban area was examined because fringe dwellers commute to urban areas to work, to buy goods/services, and to participate in recreational activities. At each individual field site, a boundary delineating regional travel from intercity travel was drawn according to the concept of the *rural hinterland* (Bryant et. al., 1982). Since intercity business travel is not a focus of this study, respondents were asked to omit work days on which they made intercity trips. In some instances, one household member made intercity trips on a frequent basis (weekly or bi-weekly), thereby making substitution of days difficult. Such trips were coded as "intercity" but were not analyzed for the purposes of this study. If intercity trips were made on non-work days, then they could be included, as will be explained in a later section.

3.2.1.2 *Modes of Transport*

In this study a distinction is made between the term *vehicle* and the more general term of *mode*. In the first part of the questionnaire, household members were asked about the type of personal *vehicle(s)* they "own" ("leased" vehicles were not encountered in any of the three field sites). A personal vehicle can be a bicycle, motorcycle, car or truck. In the second part of the questionnaire, household members were asked about the *mode* of transportation they used to reach activities. The term *mode* includes all means of transportation, not just personal vehicles that are owned. For reasons of resource constraints (time and money) the study does not include airplane or ferry travel. Train travel was included in Kuala Lumpur because it is a form of urban travel in that city.

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[1] McGee (1995) notes that development in Southeast Asian extended metropolitan areas is occurring at a faster pace and involves a different mix of transportation modes (greater motorcycle ownership), compared to Western urban fringe development.

3.2.2 RESEARCH POPULATION AND SAMPLE

All households in the defined urban fringe area comprise the research population. In the three field study cities (Ottawa, Kuala Lumpur and Yogyakarta), a "slice of a donut" was the area from which the sample was drawn. The donut is a circle around the city with its inner diameter positioned roughly at the edge of the suburbs and its outer diameter approximating the limit of the outer fringe. By taking a "slice of the donut", land uses at different stages of the "urban-rural transition" were examined (Figure 21). Within this area, termed the "sample site selection area", different types of residential development or "sample sites" were selected.

The quadrant or segment of the city from which to take the "slice of the donut" was selected on the basis of having an increasing or constant population. That is, an area with a stable or growing population was selected in Kuala Lumpur and Yogyakarta to match the characteristics of the Ottawa sample (all area in Ottawa experienced growth in population between 1991 and 1996) (see Table 20). The boundaries of the "slice of a donut" (or the sample site selection area) were defined through field survey in combination with review of the population densities of administrative sub-units at each field site[1].

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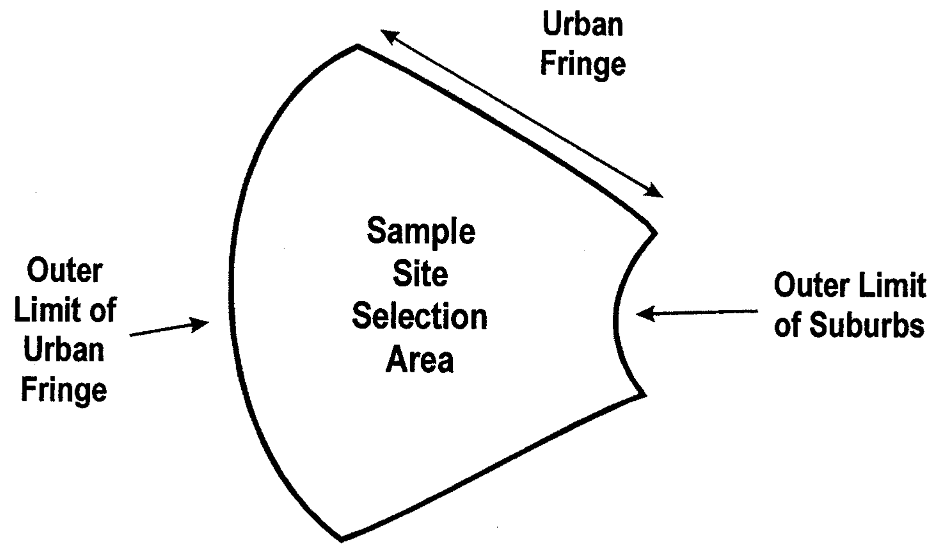
[1] The spatial limits of each field site (city) are defined in Section 2.2.1.1.

Figure 21: General Illustration of Sample Site Selection Area



3.2.2.1 *Sample Site Selection Area*

3.2.2.1.1 Ottawa

In Ottawa, the urban area has been expanding throughout the urban fringe zone that lies south of the Ottawa River (Table 20). Growth in the high technology industry, based in the western suburb of Kanata, has led to urban expansion (highest in region, 28% increase in population between 1991 and 1996) to the west of the city. For this reason, a sample site selection area to the northwest of the urban core was chosen.

Table 20: Population Characteristics for Municipalities in the Ottawa Field Site[1,2]

Municipality	Population 1996 (thousands)	Population change 91-96	Land Area (sq. km)	Density 1996 (persons/sq. km)
Vanier	17.3	+5.0	2.9	5,886
Ottawa	323.3	+3.0	110.2	2,935
Rockcliffe	2.0	+5.6	1.7	1,147
Nepean	115.1	+6.9	217.0	530
Kanata	47.9	+28.3	132.2	362
Gloucester	104.0	+2.3	293.9	354
Cumberland	47.4	+16.4	315.7	150
Goulbourn	19.3	+19.3	271.3	71
Osgoode	15.9	+13.8	379.9	42
Rideau	12.4	+5.7	408.8	30
West Carleton	16.5	+12.9	623.5	27

Population density differs between cities/townships in Ottawa (Table 20). The inner core of the city has the highest densities: Vanier (5,886 persons/km^2), Ottawa (2,935 persons/km^2) and Rockcliffe (1,147 persons/km^2). Densities of cities bounding the core are: Nepean (530 persons/km^2) and Gloucester (354 persons/km^2). Kanata, a centre for advanced technology, has a density of 362 persons/km^2. Outlying townships have the lowest population densities: Cumberland (150 persons/km^2), Goulbourn (71 persons/km^2), Osgoode (42 persons/km^2), Rideau (30 persons/km^2) and West Carleton (27 persons/km^2) (Statistics Canada, 2002a). The Ottawa sample site selection area includes Goulbourn and West Carleton which are lower density areas located to the west of Kanata.

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[1] Data has been rounded.

[2] Statistics Canada. (2002a). Internet site. (http://ceps.statcan.ca/english/profil) (profile for Ottawa Carleton Public Health Unit).

The Ottawa sample site selection area (Figure 22) is bounded as follows:

1) Northerly boundary: Ottawa River;

2) Easterly boundary: Boundary between West Carleton and Kanata, boundary between Goulbourn and Nepean;

3) Southerly boundary: Boundary between Goulbourn and Rideau; and,

4) Westerly boundary: Regional Municipality of Ottawa Carleton.

In Figure 23, the boundary separating Ottawa urban and regional travel from intercity travel is illustrated. Regional destinations include recreational cottage and skiing areas surrounding Ottawa. However, trips to places such as to Kingston, Brockville and Montreal are treated as intercity trips.

Figure 22: Ottawa Sample Site Selection Area and Sample Locations

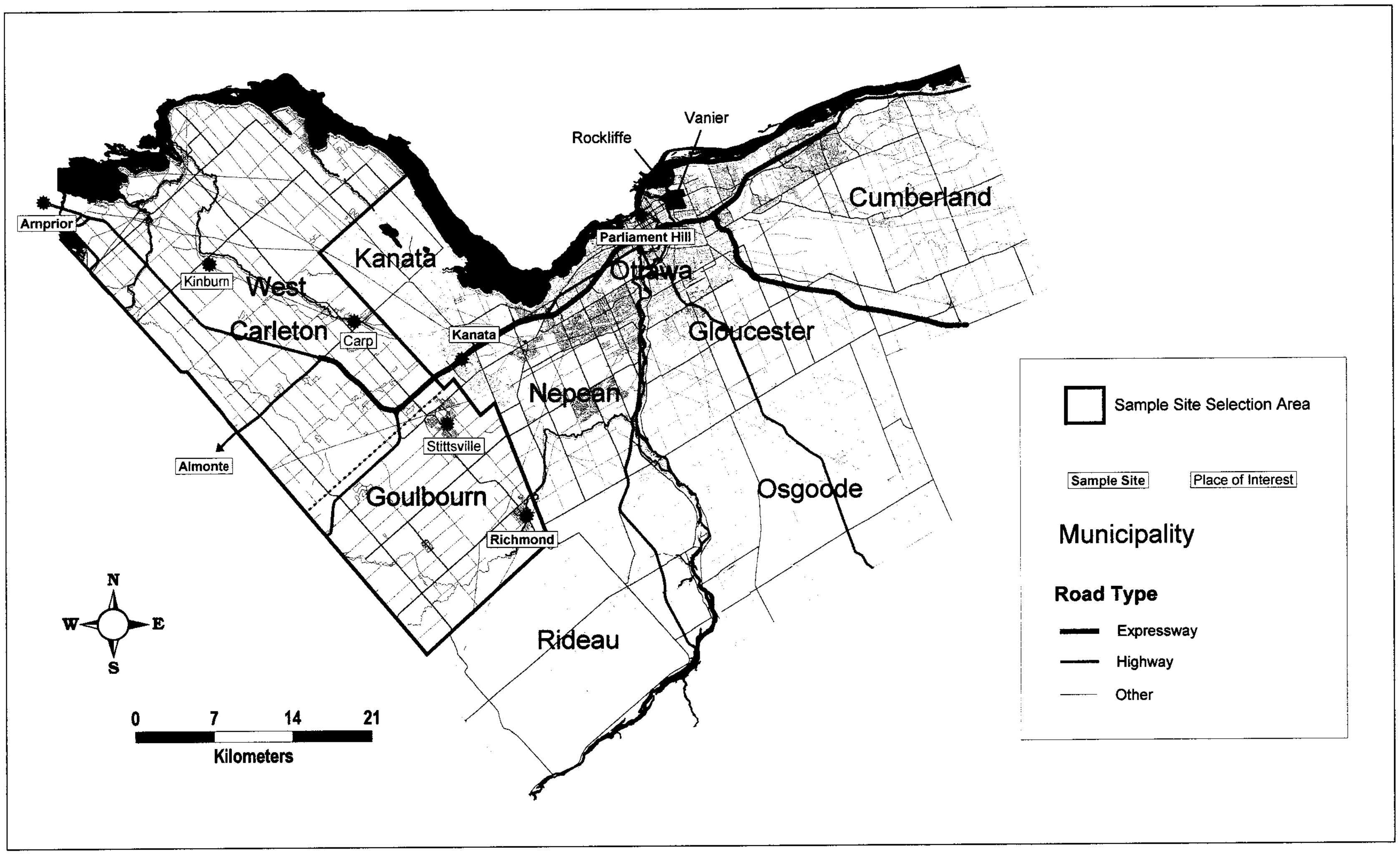
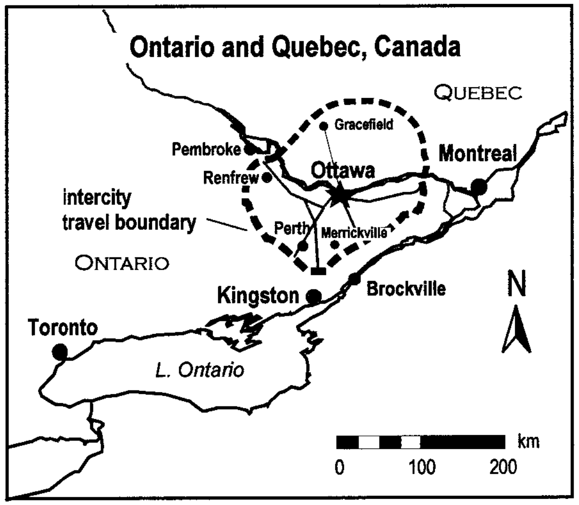
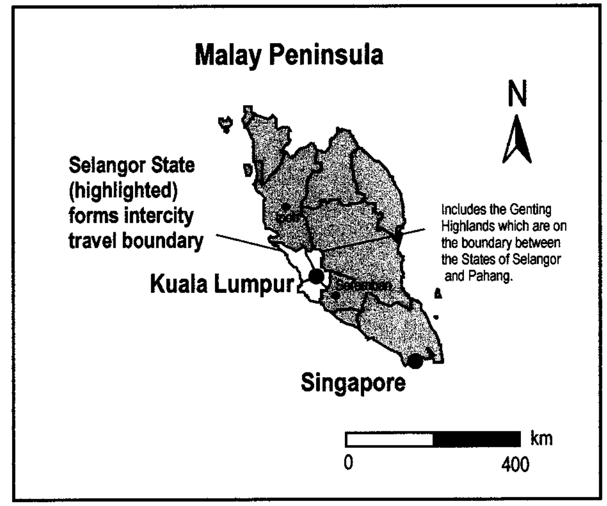
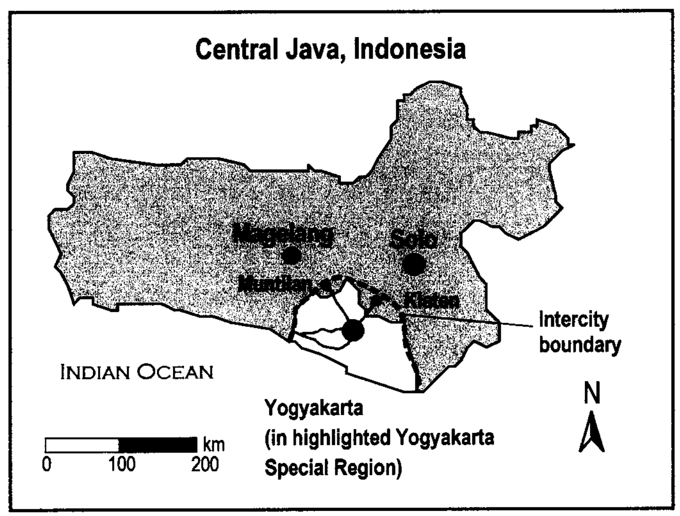


Figure 23: Intercity Travel Boundaries of Field Sites







3.2.2.1.2 Kuala Lumpur

In Kuala Lumpur, urban expansion has been occurring more recently to the west, north and southeast of the city. The main axis of expansion is west along the Klang Valley following the path of the Federal Highway which links Kuala Lumpur to Klang (Figure 24). To the north there has been urban expansion (Mohamad, in conversation, 1998), and the new North-South Highway has preferentially encouraged growth in that area. Growth has also occurred along the North-South Highway to the southeast of the city.

Positive growth rates in the order of 20% were experienced by all sub-units of the Klang region (see Table 21) between 1991 and 1996. The sample site selection area encompassed the westerly part of Gombak, Petaling and the mainland portion of Klang. A special site outside the Klang Valley proper, and outside the formal field site, was sampled in the rapidly developing area of Sepang (see Table 21).

Table 21: Population Characteristics for Districts in the Kuala Lumpur Field Site

District	Population 1991 (thousands)[2]	Population 1996 (thousands)[2]	Population change 91-96[2]	Land Area (sq. km)[2]	Density 1996 (persons/sq. km)[2]
Federal Territory of Kuala Lumpur[3]	1,145.3	1,374.7 (1997)[4]	+20.0% (91-97)	243.7	5,641 (1997)
Petaling[1]	671.0	808.2	+20.4%	484.3	1,670
Klang[1]	430.4	504.7	+17.3%	626.8	805
Gombak[1]	373.9	463.4	+23.9%	650.8	713
Hulu Langat[1]	438.5	551.5	+25.8%	826.2	668
Sepang[5]	57.8	109.2	+89.0%	599.7	109

[1] Data for Gombak, Klang, Petaling, Hulu Langat (Selangor). Selangor Darul Ehsan. (2001). Internet site. (http://www.selangor.gov.my).

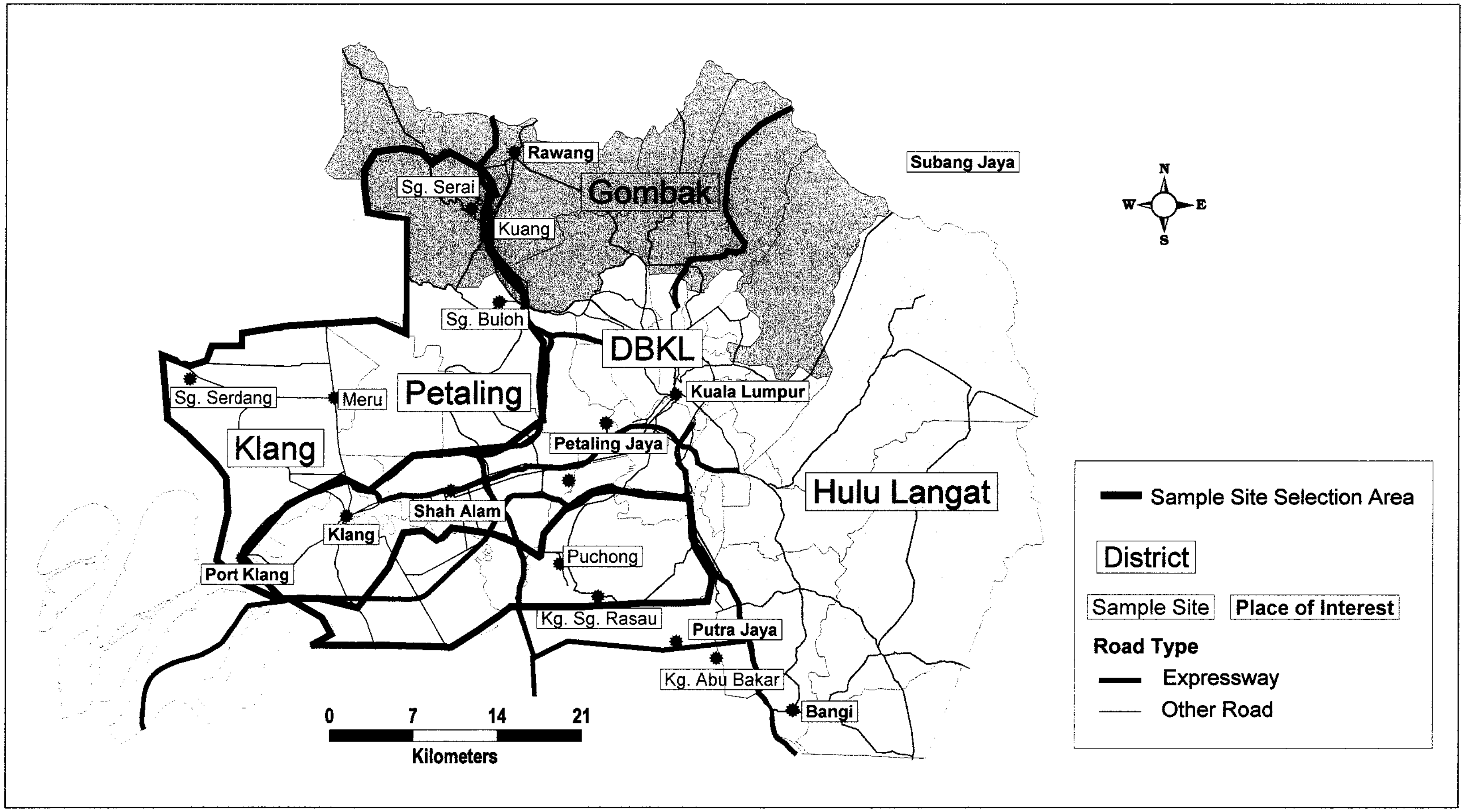
[2] Data in the table has been rounded.

[3] Data for Federal Territory of Kuala Lumpur. Department of Statistics Malaysia. (2002a). Internet site. (http://www.statistics.gov.my/English/precensus2k.htm) and DBKL. (2002). Internet site. (http://www.dbkl.gov.my/info/eng_frm_maklumatkl.htm).

[4] Data for 1997. Tiscali UK. (2002). Internet site. (http://www.tiscali.co.uk/reference/encyclopaedia/hutchinson/m0017304.html).

[5] Sepang is not part of the Klang Valley proper, nor part of the formal field site. Data on its population is presented as a special sample site was selected in this district.

Figure 24: Kuala Lumpur Sample Site Selection Area and Sample Locations



Within the Kuala Lumpur field site, the 1996-1997[1] population density (Tiscali, 2002; Selangor Darul Ehsan, 2001) differs as follows from highest to lowest density: Federal Territory of Kuala Lumpur (inner core of city – 5,641 persons/km^2); Petaling (largely urban area – 1,670 persons/km^2); Klang (805 persons/km^2); Gombak (713 persons/km^2) and Hulu Langat (668 persons/km^2). Sepang is the location of a special sample site. It is less densely populated than the Klang Valley districts with a density of 109 persons/km^2.

The urban fringe sample site selection area of Kuala Lumpur (Figure 24) is as follows:

1) Northerly boundary: a boundary line south of Rawang, Gombak district. Rawang is an outlying centre separated from Kuala Lumpur by a forest reserve;
2) Easterly boundary: North-South Highway;
3) Southerly boundary: Southerly boundaries of Klang and Petaling districts;
4) Westerly boundary: Straits of Malacca;
5) North-westerly boundary: northerly boundary of the Klang district; and,
6) Inner boundary: New Klang Valley Expressway (north) and Klang River and Shah Alam Expressway (south) excludes Kuala Lumpur-Klang corridor development.

The map in Figure 23 on page 132 delineates the intercity travel boundaries. The State of Selangor forms the regional boundary, as first – there may be travel north from the sample sites in Klang. Second – the boundary is extended to the south of the field site into the Sepang district, thereby encircling the new Kuala Lumpur International Airport. Regional travel also includes the Genting Highlands which are on the border between the States of Selangor and Pahang.

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[1] The densities for Petaling, Klang, Gombak and Hulu Langat are for 1996. The density for the Federal Territory of Kuala Lumpur is for 1997.

3.2.2.1.3 Yogyakarta

In Yogyakarta, urban expansion has been occurring more recently to the north and east of the city. Expansion to the north has occurred on the slopes of Mt. Merapi where there are no springs available for rice cultivation. Because the area is deemed unsuitable for agriculture, development has been allowed to take place, despite the threat of volcanic eruption[1]. There has been expansion to the east of the city along the Yogyakarta-Solo Road. In Yogyakarta, the area northwest of the city has been selected because it offers a spectrum of socio-economic levels, compared to segments to the south or east of the city (Susilo, Prihanto and Retnadi, in conversation, 1998).

Within Yogyakarta, population density (1995) differs greatly (see Table 22). Yogyakarta (inner city) has a density of 12,891 persons/km^2. The Sleman and Bantul regencies have

Table 22: Population Characteristics for Sub-Units in the Yogyakarta Field Site

Regency/ Sub-Unit[1]	Population 1990 (thousands)[2]	Population 1995 (thousands)[2]	Population change 90-95[2]	Land Area (sq. km)[2]	Density 1995 (persons/ sq. km)[2]
Yogyakarta	412.1	418.9	+1.7%	32.5	12,891
Sleman	780.3	809.7	+3.8%	574.8	1,409
Bantul	696.9	707.0	+1.4%	506.9	1,395
Kulon Progo	372.3	355.9	-4.4%	586.3	607
Gunung Kidul	651.0	625.3	-4.0%	1,485.4	421

[1] Data in the table has been rounded.

[2] BPS Indonesia. (2001). Internet site. (http://regional.bps.go.id//~yogya).

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[1] "Indonesian volcano may erupt." (CBC News, WebPosted Sun Jan 21 17:32:25 2001)

YOGYAKARTA, INDONESIA - The most active volcano in Indonesia is getting ready to rumble, and hundreds of thousands of people are getting ready to run. Mount Merapi, on the densely-populated island of Java, has been spitting and spewing red-hot rocks and huge clouds of ash for a week now. About one million people live in the nearby city of Yogyakarta, and they've been put on alert to prepare for a sudden evacuation. They don't want to take any chances. Back in 1994, Mount Merapi erupted unexpectedly, killing 60 people in a nearby village...

densities of 1,409 and 1,395 persons/km^2 respectively, while the Kulon Progo and Gunung Kidul regencies have a lower density at 607 and 421 persons/km^2 (BPS Indonesia, 2001a). The high densities of Bantul and Sleman are due to their young and volcanic soils, combined with a reliable water supply and intensive irrigation network. The boundaries of the Yogyakarta sample site selection area (see Figure 25) are defined as follows:

1) Northerly boundary: *Jalan Turi* (Turi Road).

   The Turi Road defines the base of the Merapi Volcano. The population density, agricultural land use, and road network density are all considerably lower, north of the Turi Road, compared to south of the Turi Road. Tourism is the main economic activity north of the Turi Road.

2) Easterly boundary: *Jalan Kaliurang* (Kaliurang Road).

   Kaliurang Road is a two-lane main road north of Yogyakarta, connecting Yogyakarta to Kaliurang. The easterly boundary includes the Minomartani sample site which is located in close proximity to Kaliurang Road.

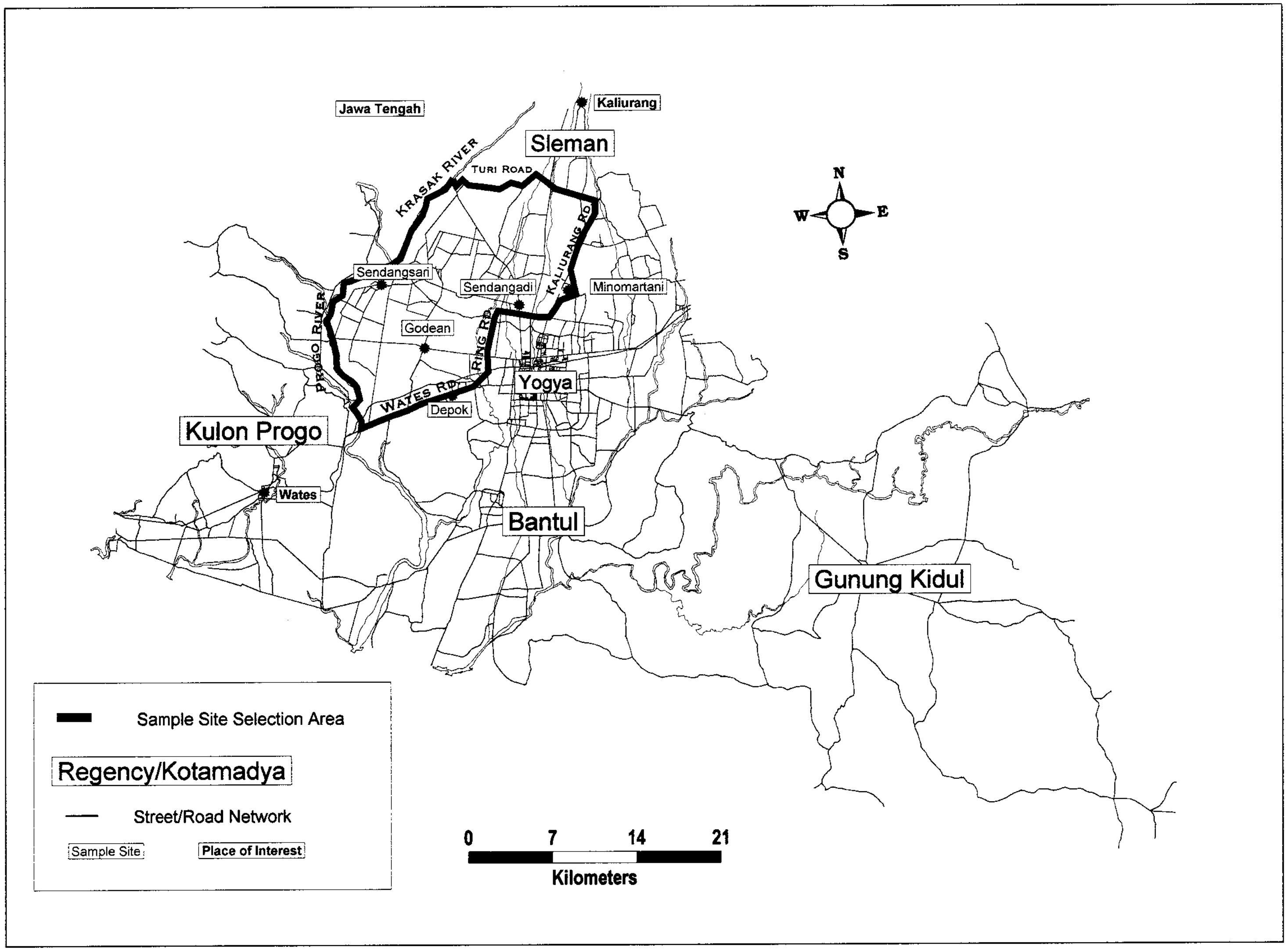
3) Southerly boundary: *Jalan Wates* (Wates Road).

4) Westerly boundary: *Sungai Progo* (Progo River).

   The Progo River is a barrier in that it is a substantial sized river, and can only be crossed at bridges. Also due to differing geology, topography and soil conditions on either side of the river, the residents to the east of the Progo River have different socio-economic characteristics compared to those on the west side of the river.

5) North-westerly boundary: Boundary of special province of Yogyakarta.

Figure 25: Yogyakarta Sample Site Selection Area and Sample Locations



This boundary is also delineated by the *Sungai Krasak* (Krasak River). By virtue of being a special territory, land use and transportation policies differ between the special province and *Jawa Tengah* (Central Java) (on the other side of boundary).

7) South-easterly boundary

   The northwest quadrant of the Yogyakarta Ring Road, a main thoroughfare with four car lanes, plus two motorcycle lanes.

Figure 23 on page 132 shows the boundary defining urban and regional travel from intercity travel. To the west and also to the east, the region is limited by the administrative boundary of the Yogyakarta region. To the northwest, travel as far as Muntilan is considered to be a regional trip. Travel to the north as far as Kaliurang, and to the east travel as far as Klaten, is still classified as regional. The Indian Ocean is the boundary delimiting regional travel to the south.

3.2.2.2 *Sample Site Selection*

A spatial sampling technique was employed by which respondent households were sampled from different types of residential development within the urban fringe. Bryant et. al. (1982) describe *nodal* (small cities, towns, villages and hamlets) and *dispersed* (farm holdings, single family dwellings on lots and countryside subdivisions) development in the Western urban fringe. Both types of development were sampled in Ottawa, whereas only nodal development was sampled in Kuala Lumpur and Yogyakarta because it is the predominant form of habitation at the two Southeast Asian field sites.

Since the urban fringe literature is only limited to the Western context, a typology of urban fringe residential development was created specifically for this study to accommodate a comparison between the three field sites. The typology was designed to take into account differences in settlement form and population density. Residential development was categorized according to a combination of characteristics including: size of development; proximity and accessibility of development to the city core and other population centres; location vis-à-vis agricultural and undeveloped land areas; and for single houses on rural lots, reliance of the household on farm income.

The types of residential development sampled in the Ottawa area were: fringe town; transition rural village; small, rural hamlet; tract housing subdivision; rural lot residence; and working farm. As noted on page 139, due to differences in development patterns between the three field site cities, fewer types of residential development exist in Kuala Lumpur and Yogyakarta, compared to Ottawa, and therefore fewer were sampled. Guided by the sample site criteria, field site investigation, and discussions with local research associates, actual locations in the urban fringe areas of Ottawa, Kuala Lumpur and Yogyakarta were selected. Table 23 summarizes the sample site selection criteria and locations chosen.

3.2.2.2.1 Fringe Town

The first type of development, termed the *fringe town,* is characterized as an urban development that is beginning to merge with the city, and on a main road leading to the city core. The actual locations sampled were: Stittsville (Ottawa), Sungai Buloh and Puchong (two sites) (Kuala Lumpur) and Minomartani (Yogyakarta). Both parts of Sungai Buloh (Malaysia) – the old Malay village and the new village – were sampled.

3.2.2.2.2 Transition Rural Village

The second type of development, the *transition rural village,* is characterized as semi-agriculturally based with some commuters, yet separated from the city morphologically

Table 23: Sample Site Selection Criteria and Locations Chosen

Type of Residential Development	Characteristics of Residential Development	Name of Sample Site Locations		
		Ottawa	Kuala Lumpur	Yogyakarta
Fringe town	▪ Not agriculturally based ▪ Beginning to merge with the city ▪ Urban in nature ▪ On main road leading to a major destination	Stittsville	• Sungai Buloh Note: Both parts of Sungai Buloh were sampled: the old Malay village and the New Village. • Puchong	Minomartani
Transition rural village	▪ Semi-agriculturally based ▪ Separated from city morphologically by agricultural and undeveloped land areas ▪ On secondary road, not leading to a major destination ▪ Some residents are commuters	Carp	Meru	Godean
Small, rural hamlet	▪ Agriculturally-based ▪ Rural ▪ On secondary road not leading directly to the city centre	Kinburn	• Kampung Sungai Rasau Hilir • Kampung Sungai Serdang • Kuang	Sendangsari
Tract housing subdivision	▪ Houses on lots 3 acres or less ▪ Housing lots originally created together in a cluster development ▪ Development is spatially isolated and not part of a hamlet, village or suburb ▪ Usually serviced with an internal road	Termed an *estate lot subdivision* in Canada. 2 acre lots sampled from 3 subdivisions between: ▪ Stittsville and Carp ▪ Carp and Constance Bay ▪ Carp and Galetta	Not common in Malaysia.	Exists in Yogyakarta, but the subdivision houses are purchased by absentee landowners for investment purposes and left vacant and hence they cannot be sampled.
Rural lot residence	▪ House on a single lot, not part of a subdivision ▪ Limited to hobby farming	Sampled from areas close to 3 estate lot sites	Rare in Malaysia	Termed *rumah toko* in Indonesia. Rare.
Working farm	▪ A portion of the family income depends on farm income	Sampled randomly from sample site selection area.	Rare in Malaysia. Farmers usually live in villages (*kampungs*). A FELDA settlement (Kampung Sungai Serai) was sampled.	Does not exist in Indonesia. Farmers live in *kampungs*.
Special Case		No "special case" sampled in Ottawa.	Kampung Datuk Abu Bakar Baginda A traditional	Depok An agriculturally-based community located on

Type of Residential Development	Characteristics of Residential Development	Name of Sample Site Locations		
		Ottawa	Kuala Lumpur	Yogyakarta
			kampung in the rubber plantations that are on the path of the multimedia corridor between Kuala Lumpur City Centre and the new Kuala Lumpur International Airport.	a main regional road. Sendangadi Permai A high density urban-oriented development located close to a main regional road.

by agricultural and undeveloped land areas, and on a secondary road not leading to a major destination. The actual locations sampled were: Carp (Ottawa), Meru (Kuala Lumpur) and Godean (Yogyakarta).

3.2.2.2.3 Small, Rural Hamlet

The third development type, the *small, rural hamlet*, is a rural, agriculturally-based development on a secondary road not leading directly to the city centre. Actual locations sampled include: Kinburn (Ottawa); Kampung Sungai Rasau Hilir, Kampung Sungai Serdang and Kuang (three sites in Kuala Lumpur), and Sendangsari (Yogyakarta). In addition to satisfying all criteria, Sendangsari was selected because the Indonesian research associates had contacts in this area. As noted on page 156, it is important to have personal contacts in order to gain trust needed to survey private households in Yogyakarta.

3.2.2.2.4 Tract Housing Subdivision

The fourth type of development, *tract housing subdivision*, is found in Ottawa and Yogyakarta, and not in Kuala Lumpur. The subdivision is comprised of lots (3 acres or less in size) in a clustered development. The houses are usually serviced with an internal road. In Ottawa, such developments are termed *estate lot subdivisions.* A total of three subdivisions in Ottawa were sampled.

In Yogyakarta, tract housing subdivisions exist, but the subdivision lots and houses are purchased by absentee landowners for investment purposes and left vacant. Hence, they cannot be sampled for survey purposes since they do not contain households. For example, *Pesona Merapi*, a Yogyakarta subdivision development, is an investment vehicle for individuals of high socio-economic status from the Indonesian cities of Jakarta and Bandung. Approximately 80% of the houses in this development are held for investment purposes. The owners do not usually rent or loan these investment houses. Instead, they are left empty and are guarded by a lower income person who looks after the house by arrangement (Susilo and Prihanto, in conversation, 1998).

3.2.2.2.5 Rural Lot Residence

The fifth type of development, the *rural lot residence,* is a house on a single lot and is not part of a subdivision. While the house owner might engage in limited hobby farming, it is not a full working farm upon which the owner's income depends. This type of residence is commonly found in Ottawa, but it is rare in the other study sites.

3.2.2.2.6 Working Farm

A sixth type of development, the *working farm*, was sampled in Ottawa and Kuala Lumpur. In Ottawa, the survey design included households residing on single lots and where a portion of the family income was derived from farm activities. In both Kuala Lumpur and Yogyakarta, farmers live together in villages (*kampungs*) and not on isolated single lots. A specific type of farm development, called Federal Land Development Authority or "FELDA", was sampled in Kuala Lumpur at Kampung Sungai Serai.

The FELDA was established in 1956 to promote rural economic development for the Malays (Sidhu and Jones, 1981). Areas of 4,000 acres or more, with soils suitable for rubber or oil palm cultivation and easy accessibility, were selected for development. The government cleared the land, planted crops and constructed houses for the settlers. After a period of 18 years working the land the settlers received title to their property. By 1978 FELDA had developed 800,000 acres of land and resettled 40,000 settlers (96% Malay) away from the coast into inland areas (Sidhu and Jones, 1981).

3.2.2.2.7 Special Cases

Three special case sites were sampled, one in Kuala Lumpur and two in Yogyakarta.

Kampung Datuk Abu Bakar Baginda, located south of Kuala Lumpur city, is a traditional *kampung* situated in a rubber plantation. However, just recently the village was designated to be within the path of the multimedia corridor between Kuala Lumpur City Centre and the new Kuala Lumpur International Airport.

Depok is situated to the east of Yogyakarta. It is an agriculturally-based community and is located on a main regional road that leads to the city centre.

Sendangadi Permai is a high density, urban-oriented development located north of Yogyakarta, close to a main regional road.

3.2.2.3 *Overview of Samples*

This section provides an overview of the number of households, sample site location, the number of respondents and their age for each field site. Recruitment and selection of households is outlined in Section 3.2.4.

3.2.2.3.1 Ottawa

In Ottawa a total of 57 households, amounting to 167 people, were sampled as detailed in Table 24. The sample sites are illustrated in Figure 22 on page 131.

Table 24: Ottawa Detailed Household Survey Sampling Plan

Residential Development Type	Municipality	Head of Household <55	Head of Household ≥55	Total
Fringe Town (Stittsville)	Goulbourn	8	9	**17**
Transition Village (Carp)	West Carleton	4	4	**8**
Small Rural Hamlet (Kinburn)	West Carleton	3	3	**6**
Working Farm	West Carleton	3	2	**5**
Estate Lots	West Carleton			**8**
• Carp & Stittsville		2	0	
• Carp & Constance Bay		1	1	
• Carp & Galetta		3	1	
Rural Lots	West Carleton			**13**
• Carp & Stittsville		2	2	
• Carp & Constance Bay		1	2	
• Carp & Galetta		4	2	
Total		**31**	**26**	**57**

3.2.2.3.2 Kuala Lumpur

A total of 96 households, amounting to 432 people, were sampled in Kuala Lumpur as detailed in Table 25. The sample sites are illustrated in Figure 24 on page 134.

Table 25: Kuala Lumpur Detailed Household Survey Sampling Plan

Residential Development Type	District	Head of Household <55	Head of Household ≥55	Sub-Total	Total
Fringe Town • Sungai Buloh • Puchong	• Petaling • Petaling	16 10	1 1	17 11	**28**
Transition Village (Meru)	Klang	10	8	18	**18**
Small Rural Hamlet • Kampung Sungai Rasau Hilir • Kampung Sungai Serdang • Kuang	• Petaling • Klang • Gombak	6 8 8	2 4 3	8 12 11	**31**
Working Farm (FELDA) (Kampung Sungai Serai)	Gombak	9	2	11	**11**
Special Case (Kampung Datuk Abu Bakar Baginda)	Sepang	6	2	8	**8**
Total		**73**	**23**	**96**	**96**

3.2.2.3.3 Yogyakarta

A total of 34 households[1] totalling 144 individuals, were sampled as detailed in Table 26.

The sample sites are illustrated in Figure 25 on page 138.

Table 26: Yogyakarta Detailed Household Survey Sampling Plan

Residential Development Type	Regency	Head of Household <55	Head of Household ≥55	Total
Fringe Town (Minomartani)	Sleman	6	1	**7**
Transition Village (Godean)	Sleman	4	5	**9**
Small Rural Hamlet (Sendangsari)	Sleman	3	3	**6**
Special Case (Depok)	Sleman	5	3	**8**
Special Case (Sendangadi Permai)	Sleman	4	0	**4**
Total		**22**	**12**	**34**

[1] The Indonesian field research was constrained due to the fact that it was conducted during the Asian financial crisis of 1997-1998 when the political climate in the country was unstable. A total of 33 households was the maximum number of households that could be surveyed at the time.

3.2.2.4 *Lifecycle, Household Role and Lifestyle*

Pas (1980) identifies lifecycle, household role and lifestyle as the major determinants of general travel-activity behaviour. Koppelman et. al. (1978) identified occupational, marital, parental and gender-related roles as important sociological determinants of travel behaviour, and investigated the importance of occupational and marital roles by market-segmentation analysis. The term *lifecycle* refers to stages of development and aging of households. Wen (1998) notes that variables such as age, marital status, household size and composition can be used to assess lifecycle stage.

Lifecycle and Household Role

To obtain a range in lifecycle (younger and older households) and hence travel patterns, respondent households were selected on the basis of the head of the household being younger or older than 55 years of age[1]. The cut-off point of 55 years of age was chosen because "55" is the retirement age for government civil servants and academics in Malaysia and Indonesia. Over the age of 55, there are less likely to be children at home and older adults may have different travel patterns since they may not be employed full time. Since the age of 55 was the cut-off in Kuala Lumpur and Yogyakarta, the same age was adopted as the cut-off in Ottawa.

All members of the household were surveyed on their travel patterns, which means all household roles were examined in this research.

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[1] Specifically, the sampling criteria was <55 and ≥ 55 years of age.

Lifestyle

Koppelman's work (1978), reflects a North American or Western European social environment. Due to cultural and developmental factors, there is a broader range of lifestyles available in North America and Western Europe than in Southeast Asia. Moreover, most of the population in both Malaysia and Indonesia lives within a "family" unit. In these two countries the "family" is comprised of a man (usually the man is still the head of the household), a woman and children. Some family units are extended (with grandparents or grandchildren) living in the household.

As a result, the presence and number of children in a family is not a good indicator of "lifestyle" in Malaysia and Indonesia, since most families have children. Similarly, marital status is not a distinguishing factor because the vast majority of the population is married and, unlike North America, there are few cases of "single mothers".

In order to sample a range of "lifestyles" in Asia, the sampling strategy is based on the simple criterion of income. That is, low, medium or high income of the head of household.

For consistency, the same strategy was initially applied in Canada. However, in the Canadian pre-test it was found that if respondents were asked about income they became wary of the survey, and were not cooperative in disclosing their travel patterns. For this reason, questioning on income was omitted from the protocol. Ultimately, the main sampling criterion for all field sites was age (see page 147).

3.2.2.5 *Temporal Aspects of Household Survey*

In the past, household surveys asked respondents about their travel activity over a 24-hour period. It is now well recognized that there is day-to-day variation in travel (Transportation Research Board, 1995b). It therefore stands to reason that a household travel survey should span more than a single day in order to obtain a more complete picture of a household's activity patterns. For this reason, travel patterns were collected from each household for three days during a week.

Regular *work days* in Canada are Monday-Friday. Regular *work days* in Malaysia are: Monday-Friday, the Friday being a Muslim holy day. Regular *work days* in Indonesia are: Monday-Thursday and Saturday. In Indonesia, Friday is a work day, but the Muslim holy day is widely observed. Respondents' travel patterns at all three field sites were collected for one *work day*. Where respondents were willing, travel patterns for more than one work day were also gathered.

In the Canadian phase of the research, it was found that the travel patterns of some individuals (e.g. farmers and retired persons) vary on a daily basis during the work week (Monday-Friday). For these individuals their activities can be of weekly, bi-monthly, monthly, quarterly, yearly or variable frequency, and may not be picked up by surveying over a one week interval. Since the survey initially only asked for travel patterns on one weekday, there was potential to miss important travel destinations. Halfway through the survey field research, farmers and retired persons were asked for their travel patterns for two days (instead of one) over the work week. Approximately half (13/26) of the households surveyed with a head of the household over 55 years of age, and a smaller fraction (1/5) of the farming households, provided an extra day's travel patterns.

In the cases of Malaysia and Indonesia, Friday is a Muslim holy day on which men go to the mosque to pray at noon hour. It was therefore thought at the outset of the study that different travel patterns would be generated on Friday (compared to Monday-Thursday). In Indonesia, Friday travel did exhibit differences from other work days and thus travel data were collected separately. However, while Friday travel data were also collected in Malaysia, it was found that travel patterns on Friday were not markedly different from those on Monday-Thursday. So, instead of Friday the remaining respondents were asked for their travel patterns on Saturday to represent Day 2 travel. The initial Malaysian Friday patterns (collected for a sub-set of the Malaysian respondents) were analyzed as a second weekday. Saturday travel patterns were requested in Ottawa and Kuala Lumpur since it is generally a *day off* in Ottawa and a limited work day in Kuala Lumpur.

Sunday is a day of rest for most people in all three field site countries, and therefore travel patterns were expected to vary from other days. For this reason Sunday travel patterns for the households were requested separately.

A summary of the days for which travel patterns were collected from households at each of the field sites is provided in Table 27.

Table 27: Temporal Sampling Strategy for Three Field Sites

	Ottawa	Kuala Lumpur	Yogyakarta
Differences in General Daily Activity Patterns between Field Sites	*Monday-Friday:* work days *Saturday + Sunday:* days off	*Monday-Thursday:* work days *Friday:* work day and Muslim Holy day. *Saturday:* limited work day *Sunday:* day off	*Monday-Thursday:* work days *Friday:* work day and Muslim Holy day *Saturday:* work day *Sunday:* day off
Day 1 (no intercity travel)	One day from Monday-Friday.	Initially*: One day from Monday-Thursday. Later*: One day from Monday-Friday.	One day from Monday-Thursday and Saturday
Day 2 (intercity travel acceptable in Ottawa and Kuala Lumpur)	Saturday	Initially*: Friday. Later*: Saturday.	Friday
Day 3 (intercity travel acceptable)	Sunday	Sunday	Sunday
Day 4 (intercity travel acceptable)	Optional. Any day.	Optional. Any day.	Optional. Any day.

*Initially: First 32 households. Later: Last 64 households.

The travel survey was not meant to address business-related intercity travel. Respondents were asked to omit work days (Monday-Friday in Ottawa and Kuala Lumpur[1], and Monday-Thursday and Saturday in Yogyakarta) on which they made intercity trips. In some instances one household member made intercity trips on a frequent basis (weekly or bi-weekly), thereby making substitution of days difficult. Such trips were coded as "intercity" but were not analyzed for the purposes of this study. If intercity trips were made on non-work days, then they could be included. Intercity travel was acceptable on Saturday in Kuala Lumpur and Ottawa, and in all field site locations on Sunday. Generally, in Kuala Lumpur and Ottawa, recreational intercity travel mostly takes place on Saturdays and Sundays (in Yogyakarta on Sunday only), and less frequently on *work days*.

3.2.3 SURVEY PROTOCOL AND PRE-TEST

The household travel survey design took into consideration that the survey field sites were in different countries, and that different cultural environments could be encountered. The protocol was first drafted with Ottawa in mind. It was then implemented in Yogyakarta, then adapted for use in Kuala Lumpur, and subsequently modified again for use in Ottawa. At each field site any needed modifications were made to the survey protocol immediately following the first few household interviews. As new insights were obtained throughout the interview process modifications were made to the protocol, and additional questions were added to obtain data on aspects of travel that could be missed by simply asking for a respondent's travel schedule. Using this continuous improvement approach, the final Ottawa protocol is the most highly refined

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[1] Saturday is a limited work day in Kuala Lumpur.

version of the survey. Copies of the final survey protocols developed and used at the three field sites are in Appendix A.

Data gathered in *all* field sites include both respondent and household characteristics, and travel details for all household members. (see Table 28).

Table 28: Data Collected from Respondents at Three Field Sites

Respondent and Household Characteristics
Age
Gender
Motor vehicle licence (car and motorcycle)
Ownership/lease of car or motorbike
Ownership of bicycle
Total number of cars, motorcyles and bicycles in household

Travel Details
Activity name
Activity location
How long did it take to get to each sequential activity
Start and end time for each activity
How long did it take to get home from each sequential activity
Mode of travel
Single or multi-purpose trip
Accompanying household member

3.2.4 IMPLEMENTATION OF TRAVEL SURVEY

Yogyakarta was the first field site visited, with interviews conducted there between September and October 1998. Next, the Kuala Lumpur field research took place between November and December 1998. Finally, the Ottawa interviews were conducted between March and September 1999 (see Table 29). Although the Ottawa interviews stretched over the spring-summer period, the bulk of the interviews were conducted in May, June and July. If a household with children was interviewed during the summer holiday period, the respondents were asked about differences in their travel patterns during the school year.

Table 29: Time Periods of Field Research

Field Site	Time Period
Ottawa	March-September 1999
Kuala Lumpur	November-December 1998
Yogyakarta	September-October 1998

Letters of reference on letterhead from the University of Ottawa, University of Malaya and BAPPENAS (National Planning Bureau for Indonesia) were carried by the interviewers and shown to respondents to assure them that the survey represented institutionally-approved research (see Appendix B).

All Ottawa household surveys were conducted by the author. For the most part the Malaysian and Indonesian research associates conducted the interviews alone without the principal researcher. This was done to preclude the presence of the foreign, non-Malaysian researcher having a negative influence on the data collection from respondent households. However, for quality control purposes the principal researcher did join both the Malaysian and Indonesian interviewers on several occasions to supervise and take part in the interview rounds. Frequent contact (meetings and telephone conversations) between the author and interviewers was maintained throughout the survey. The author was present at both foreign sites during all interviews.

3.2.4.1 Ottawa

In Canada, a travel diary was tested using printed sheets, specially-designed booklets and even electronic e-mail forms, but a majority of respondents chose to be interviewed (see Table 30). They preferred being asked questions and wished to avoid filling out a survey form. In some cases, respondents would jot down a skeleton of their travel patterns and their full travel patterns would be reconstructed during the interview.

Table 30: Ottawa Percentage Response Rate by Interview Method

Interview Method	Percentage response
Personal interview	60%
Telephone	23%
Self reporting	17%

The Canadian interviews were generally conducted by appointment at a time of the respondents' preference. For example, in households where the adults worked, the full-time interviews would generally occur at night. With farmers, housewives and elderly people, an appointment was scheduled during the day. Most interviews lasted approximately an hour and took place at the respondent's home. For the convenience of respondents, a few interviews took place over the telephone or at a restaurant.

In comparison to Kuala Lumpur, recruitment of survey respondents in Ottawa was much more difficult. Door-to-door recruitment was tested in the Stittsville field site but it had a very poor success rate. A more productive strategy was to use referrals from community leaders, personal contacts, and second-person contacts.

3.2.4.2 *Kuala Lumpur*

In Malaysia, "speech" or "conversation" is the preferred means of communication over the written word, especially for those in the lower and middle classes. Therefore, the Malaysian research associates (see Appendix A2) used a copy of the English survey protocol as a reference and asked household members verbally about their travel patterns. The interviews generally took place in the respondents' homes.

One field observation made early in the course of the Kuala Lumpur field research was that "mother knows where everyone is". At the Meru field site, in particular, the majority of Malay women stay home to look after their children in the traditional Malay way. For this reason, interviews could be conducted during the days (on Saturdays and on weekdays). Less introduction and explanation of the survey was required in Kuala Lumpur compared to Ottawa or Yogyakarta, with the length of the Kuala Lumpur interviews ranging from 10 to 30 minutes compared to an hour in Ottawa and Yogyakarta. The shorter interviews can possibly be attributed to the lead Malaysian interviewer who had previous, professional experience in conducting household and travel interviews. Also, the respondents in Kuala Lumpur were generally very cooperative and did not require any "cajoling" to discuss their travel activities.

The Malay people in the urban fringe of Kuala Lumpur were very responsive (almost 100 percent response rate), and could be recruited easily just by knocking on doors. Respondents from the Chinese Malaysian community were more difficult to interview, which is the similar experience of other researchers (Mohamad, in conversation, 1998).

3.2.4.3 *Yogyakarta*

Similar to the Ottawa case, the travel survey interviews in Yogyakarta generally lasted about one hour, with the shortest interview being 15 minutes in duration. There was a positive reaction among the households asked to participate, with a response rate of approximately 90 percent. Similar to the survey in Ottawa, personal contacts and referrals from community members aided the recruitment process. Some difficulties were encountered when interviewing respondents from a low socio-economic level. More than an hour was required to explain the survey to these respondents and, unlike the experience in medium to high socio-economic level households, the survey had to be explained separately to each household member.

Minor difficulties were experienced at the other end of the socio-economic spectrum with highly educated people. In some cases, they did not wish to respond to the survey because they could not see any personal gain in doing so.

In Yogyakarta, a typical interview unfolded as follows.

1. A brief introduction explained the purpose of the travel survey, and noted that transportation is influenced by many factors, one being personal activity. The interviewers then showed the prospective household a letter of reference from BAPPENAS, and indicated that their responses would be confidential. The interviewers then asked the household if they would be willing to participate in the survey. If the household agreed to participate, the interview continued with the second step.

2. The interviewers began the interview by illustrating on a sheet of paper an example of the information needed. This part would generally take about 10 to 15 minutes. The Indonesian respondents (similar to their counterparts in Ottawa and Kuala

Lumpur) preferred to be questioned. Travel pattern data were collected from all members present at the time of the interview. The interviews took place in the evening to maximize the number of family members present. If a family member was missing, another participating member of the family was asked to recount the missing member's travel. The interviewers aimed to keep the questions, and the interview as a whole, brief and to the point.

In Yogyakarta, the language and mode of speech was adjusted according to the respondent household. Approximately 75 percent of the interviews were conducted in Javanese, with 25 percent conducted in Bahasa. Using Javanese was more successful in gaining the respondents' cooperation, as it is a "softer" and more polite language, and communicates one's personality more fully, compared to Bahasa Indonesia. Within the Javanese group of interviews, some were conducted in *moko* (or regular) Javanese. Older respondents were interviewed using the *kromo* form of Javanese, while communication with the oldest respondents was established in *kromoinggil* or high Javanese, showing respect for the elders' age and status in society.

3.3 *SUMMARY*

In all three field sites, the spatial focus of this study is the rural-urban transition zone, termed the *urban fringe*, where non-agricultural activity is mixed with agriculture. Respondent households were sampled from a cross-section of residential development spanning the urban fringe. Sample site selection areas (quadrants or segments of the urban area) were defined on the basis of having an increasing or constant population, and also based on a review of their population densities in relation to densities across the field sites.

The types of residential development sampled in the Ottawa area were: fringe town; transition rural village; small, rural hamlet; tract housing subdivision; rural lot residence and working farm. Due to differences between the three field site cities, fewer types of residential development existed and hence were sampled in Kuala Lumpur and Yogyakarta, compared to Ottawa. Three special case sites were sampled, one in Kuala Lumpur and two in Yogyakarta.

To obtain a range in lifecycle characteristics (younger and older households) and travel patterns, respondent households were selected on the basis of the head of the household being younger or older than 55 years. Travel patterns were collected for one work day (Monday-Friday) and Saturday and Sunday in Ottawa and Kuala Lumpur, and for one workday (Monday-Thursday or Saturday), and Friday and Sunday in Yogyakarta.

The protocol was first drafted with Ottawa in mind. It was then tested in Yogyakarta, adapted for use in Kuala Lumpur, and subsequently modified again for use in Ottawa.

In Ottawa, the survey data were collected from respondents through different means according to their preferences. Approximately 60% of respondents were personally interviewed, 23% were interviewed by telephone and 17% reported their own travel patterns on printed forms. Malaysia and Indonesia both have an "oral" culture and therefore all data were collected through personal interview.

A summary of the number of households and people surveyed is provided in Table 31.

Table 31: Number of Households and People Surveyed

Field Site	Number of Households Surveyed	Number of People Surveyed[1]
Ottawa	57	167
Kuala Lumpur	96	432
Yogyakarta	34	144
TOTAL	**187 households**	**743 people**

[1] This chart provides a summary number of respondents for which demographic data was obtained. The actual number of respondents surveyed differs between survey days.

4. GIS DATABASE DESIGN AND CONSTRUCTION

This chapter begins by establishing the need to employ GIS capabilities during the course of the study, then proceeds with describing the actual GIS database design and construction. The next chapter, Chapter 5, compares and contrasts the three field sites on the basis of transportation modes, land use, transportation network, travel patterns, and individual and household characteristics.

4.1 GIS CAPABILITIES

The capabilities of a GIS are employed in this research because the spatial aspect of the phenomena (household travel patterns) is being investigated. As Wellar (1993, p. 8) notes "The data in a GIS are by definition geographic – the G of GIS – meaning that they have a location identifier."

A GIS can represent spatial features as points, lines and polygons (Wellar, 1993).

> "The language of GIS translates the contents of the built and natural environments into points, lines and polygons. That occurs in part because geographic locations, distributions and patterns are effectively described by points, lines and polygons." (Wellar, 1993, p. 8)

The household travel patterns and supporting data (land use, transportation network) under study can be represented as points, lines and polygons as detailed in Table 32.

Table 32: Spatial Elements of Study Data

Points	• Household locations • Activity locations (stops)
Lines	• Travel patterns • Road network
Polygons	• Land use areas • Census areas • Administrative areas

Due to the sheer volume of survey data collected for the study, the GIS is required to manage (store, and manipulate) and query (spatial and non-spatial) the data set. Also, the GIS can be employed to perform analysis/synthesis procedures (Wellar et. al., 1996). At the time the GIS software was purchased for this study most packages did not include a full slate of statistical functions. As a result, *Systat®*, a statistical software package was used for some of the non-spatial analysis.

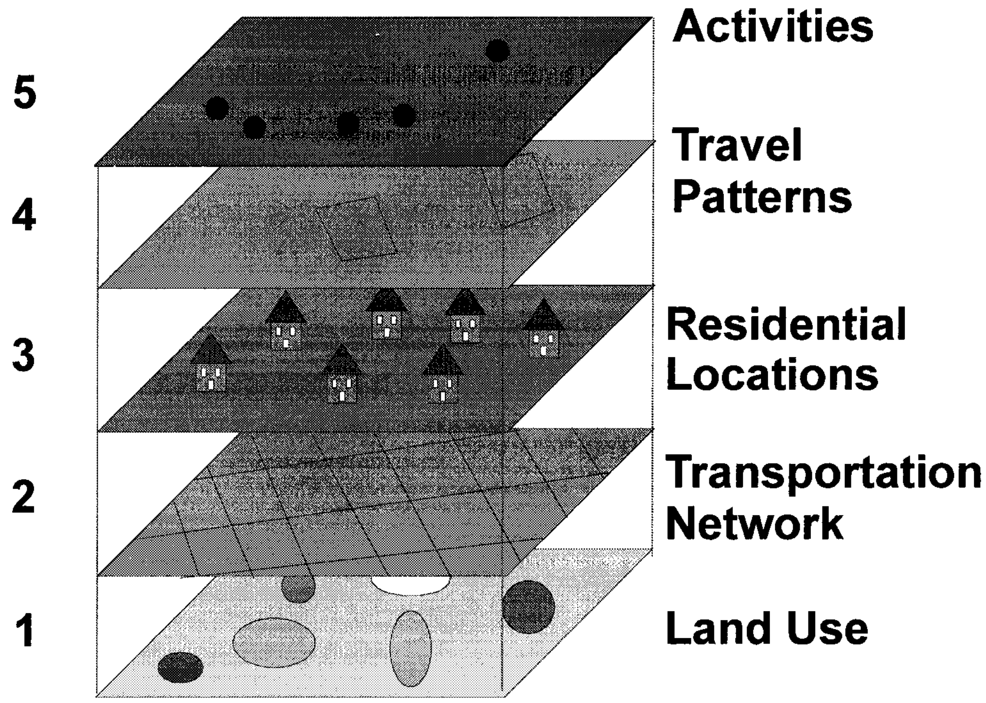
4.2 FUNCTIONALITY IN DESIGNING THE GIS DATABASE

An overriding principle applied throughout the design process is the creation of a structure that allows maximum flexibility in exploring and analyzing the data. Each individual's travel patterns and stops were therefore coded separately so that they could be grouped and viewed with data on the travel patterns of other respondents.

4.2.1 DESIGN OF GIS DATABASE

The layers in the GIS were organized in such a way as to allow maximum flexibility in exploring and analyzing the data on respondents' travel patterns, as shown in Figure 26. The bottom layer in the GIS comprises *land use* categories for the field site, and the next layer is the *transportation network.* The transportation networks at the three field sites were classified according to expressway, highway, regional road, and other to enable travel patterns to be analyzed by road type. The third overlaying layer is a demand layer comprised of the *residential locations* of the respondents. The fourth layer is comprised of the respondents' *travel patterns* (drawn as lines on top of the street network). The final overlay, Layer Five, contains the point locations of stops that respondents made on their tours.

Figure 26: Conceptual Design of GIS



Re-stated, the GIS database is made up of de-constructed individual travel patterns, which can be re-constructed by individual or by household for one survey day or for three survey days (Day 1, 2, 3). The travel pattern data could also be reassembled for certain spatial characteristics (e.g. activity locations) or non-spatial characteristics (e.g. gender, age range). A major benefit of using a GIS in this research is that it allows travel patterns of individuals or groups of individuals to be visualized (Wellar et. al., 1996).

4.3 GIS SOFTWARE

In evaluating which software to use for the research, the desired mapping, database management and analytical/synthetical capabilities of the software (Wellar et. al., 1996) were specified (see Table 33). Other criteria considered in the software decision process were cost of the software and ease of use.

Table 33: Desired Capabilities of the GIS Software

Capabilities
▪ map thematic datasets
▪ represent different network characteristics for different trip distances
▪ determine minimum path distance
▪ measure distance between stops
▪ calculate areas
▪ perform radius search (local/regional)
▪ produce overlays and intersections of the data

Five software programs (Table 34) were initially considered: *TransCAD®* (Caliper Corporation), *Grassland* (Global Geomatics Inc.), *ArcView®* (ESRI), *Idrisi®* (Clark Labs) and *MapInfo®* (MapInfo Corporation). Each program was assessed on the basis of desired capabilities, cost and ease of use. As a result of this evaluation, three programs (*TransCAD®*, *Grassland*, *ArcView®*) were shortlisted and two (*Idrisi®*, *MapInfo®*) were eliminated. *Idrisi®* was not considered further because of its raster (as opposed to vector) orientation. *MapInfo®* was also eliminated because of its business orientation.

Table 34: GIS Software Programs Considered

Shortlisted
▪ TransCAD®
▪ Grassland
▪ ArcView®
Eliminated
▪ Idrisi®
▪ MapInfo®

TransCAD® was ultimately chosen from the three shortlisted candidates because it has a variety of transportation and network related functions allowing maximum procedural flexibility. The software was purchased in 1998.

4.4 DIGITAL MAPS

Next, digital maps of each field site were obtained. The Yogyakarta digital map was obtained from Bappeda (Regional Development Planning Board) of Yogyakarta[1]. The map of Kuala Lumpur was made available through the University of Malaya, while the digital map of Ottawa was obtained from the Regional Municipality of Ottawa Carleton[2].

[1] Map obtained with the assistance of Max Pohan (Head of Bureau for Regional Development Planning I, BAPPENAS, Indonesia).

[2] Map obtained with the assistance of Grace Welch (Head of the Map Library, University of Ottawa).

4.5 TRAVEL SURVEY DATA

The travel surveys yielded both spatial and attribute data as shown in Table 35.

Table 35: Spatial and Attribute Data Gathered in Travel Surveys

Type of Data	Spatial		Attribute	
Survey Data Category	Locational characteristics of respondents	Travel patterns	Demographic and other personal characteristics of respondents	Non-locational survey responses
Example	Home, work locations	Work day and non-work day tours	Age, gender	Ownership of car

4.6 CONSTRUCTION OF GIS DATABASE

The GIS database was constructed according to the steps outlined below.

Step 1: Land Use Representation

a) A digital map of the *land use* in each field site (includes urban centre and urban fringe survey area) was obtained.

b) The digital land use map was imported into the *TransCAD*® software.

Step 2: Digital Street Network

a) Detailed digital maps of the *street network* in each field site (includes urban centre and urban fringe survey area) were obtained.

b) The street network file was imported into the *TransCAD*® software.

c) The road network in Ottawa was classified as expressway, highway, regional road or other road types.

Step 3: Demographic and Qualitative Survey Data

a) The demographic data were entered into a separate flat file database. Each household and individual was assigned a code.

b) Qualitative questions were processed separately.

Step 4: Coding and Entering Travel Patterns

a) The travel patterns were entered as a separate layer for each household. A coding system was assigned to each household, individual, tour, leg and road segment.

b) Travel patterns were digitized into the GIS with a separate layer for each household survey day (e.g. Day 1, 2, 3). Since individual members of a household often travel together, layers were created on a household basis thereby enabling common travel patterns to be coded concurrently. The data were coded in such a way that each individual travel pattern was labelled separately.

c) When digitizing the line segments[1] in *TransCAD®*, the "endpoint" option was selected so that the node points of lines could be captured and labelled as stops.

4.7 *PREPARATION FOR ANALYSIS*

The GIS data were prepared for analysis as detailed in the following steps.

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[1] Where route data was not recorded on surveys, the *TransCAD®* shortest path network function was used to measure distances between the origin and destinations of tours.

a) The digitized line segments and endpoints were exported from *TransCAD®* into spreadsheet software.

b) Line segments in all field sites were labelled by mode. In Ottawa, the line segments were also labelled by road type. Endpoints were labelled by the general location of stops (central city, suburb, urban fringe and outlying centre) (described in next chapter).

c) The distances of the labelled line segments and the coordinates[1] of the endpoints were then integrated into the *tour* database. The *tour* database lists all tours for all respondents for a particular survey day. In total, there are nine *tour* databases (one for each of the three survey days for all three field sites).

d) In the *tour* databases, tour purposes reported by the respondents were categorized and standardized across field sites.

e) Data in the *tour* databases were subtotaled to produce the daily *total* databases. The *total* databases list travel characteristics aggregated on a daily basis for all respondents, plus all other survey responses[2]. In sum, there are nine *total* databases (one for each of the three survey days for all three field sites).

f) Finally, all data were verified.

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[1] Integrating the coordinates of the tour stops into the main database facilitates their export back into *TransCAD®* (with additional data found in the "tour" database) for mapping and visual analysis.

[2] Some personal characteristics of the respondents (e.g. age), contained in the "total" database, were added into the "tour" database for analysis.

a) The *tour* and *total* databases were exported from the spreadsheet software into *Systat*®.

b) Eventually, the three *total* databases for each field site were merged allowing analysis across survey days.

4.8 SUMMARY

A GIS is employed in this research because the *spatial* aspect of household travel patterns is being investigated. The household travel patterns and supporting data can be represented spatially by points, lines and polygons. The GIS is required to manage and query the large volume of survey data, as well as to analyze the dataset.

The GIS database was designed in such a way as to allow maximum procedural flexibility in exploring and analyzing the data. Land use, transportation network, household respondent locations and individual travel patterns comprise the layers of the GIS database.

To accommodate flexibility during the course of the research, the GIS software package, *TransCAD*®, was chosen to process the data. *TransCAD*® contains a variety of transportation and network-related functions as well as a full slate of conventional GIS management, query and analysis features.

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A COMPARATIVE STUDY OF INDIVIDUAL TRAVEL PATTERNS OF URBAN FRINGE DWELLERS IN OTTAWA, CANADA; KUALA LUMPUR, MALAYSIA; AND, YOGYAKARTA, INDONESIA

BY
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A THESIS
PRESENTED TO THE UNIVERSITY OF OTTAWA
IN FULFILLMENT OF THE REQUIREMENTS
FOR THE DEGREE OF DOCTOR OF PHILOSOPHY
IN GEOGRAPHY
SUPERVISOR: DR. B. WELLAR

DEPARTMENT OF GEOGRAPHY
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5. COMPARISON OF TRAVEL BEHAVIOUR BETWEEN FIELD SITES

In this chapter, the results of the household travel surveys are compared and contrasted between the three field sites on the basis of:

a) whether travel is undertaken;

b) modes of travel;

c) distance, time and speed of travel;

d) destination;

e) reason for travel; and,

f) complexity of travel.

The chapter concludes by discussing the role that spatial familiarity of the regional area may play in influencing travel patterns in Ottawa, Kuala Lumpur and Yogyakarta. Integrated into the comparison between the three field sites are results of a more detailed analysis of the Ottawa field site, which represents the richest dataset. The Ottawa results demonstrate how this in-depth travel survey technique can be used to explore travel relationships in more detail. Also, the Ottawa findings provide a background for the following chapter in which respondents with similar travel patterns are clustered into groupings. Because of the complexity of the findings, the results of each individual sub-section are integrated in the "synthesis and summary" at the end of the chapter.

A reminder that throughout the following text, Day 1 is a work day in all sites, Day 2 is Friday, a workday in Yogyakarta, a Saturday, a limited work day in Kuala Lumpur, and a Saturday, generally a non-working day in Ottawa. In all three field sites, Day 3 is a Sunday, a non-working day.

5.1 WHETHER TRAVEL IS UNDERTAKEN

A traditional origin-destination travel survey intercepts travellers to ask about their travel schedule, but is not always able to gauge readily who is <u>not</u> travelling. In this technique, those respondents not making a *tour*[1] on a survey day can be identified.

Day 1

A comparison of those respondents (in all three field sites) who did not make tours on Day 1 (weekday) is presented in Table 36. The percentage of respondents not making tours is the same in Yogyakarta and Ottawa (3-4%). By contrast, Kuala Lumpur stands out with approximately 21% of respondents not travelling on Day 1.

Table 36: Day 1 "No Tour" Comparison by Field Site

Field Site	Tours	No Tours	Total	% No Tours
Ottawa	157	5	162	3%
Kuala Lumpur	328	87	415	21%
Yogyakarta	126	5	131	4%

A cross-tabulation between gender and "tours" reveals that the Kuala Lumpur respondents who did not make tours on Day 1 are predominantly female[1] (Table 37). A

[1] Travel from home to (a) destination(s) and return to home. Wen (1998, p. 5) describes a tour as a "single departure from home."

further disaggregation of the female Kuala Lumpur respondents indicates that the percentage with "no tours" are females over the age of 25 (please see Table 38). Of the female respondents who did not make tours on Day 1, at least 40%[2] are "full-time housewives".

Table 37: Day 1 Kuala Lumpur "No Tours" by Gender

Gender	Tours	No Tours	Total*	% No Tours
Female	124	65	189	34%
Male	194	15	209	7%
Total	**318**	**80**	**398**	

* Note the totals in Table 37 differ from Table 36 because gender was not recorded for 17 respondents.

Table 38: Day 1 Kuala Lumpur Female "No Tours" by Age

Age (years)	Tours	No Tours	Total	% No Tours
0-24	79	14	93	15%
25-54	43	38	81	47%
55+	2	13	15	87%

To investigate whether the female "no tours" are spatially segregated, the Kuala Lumpur data were cross-tabulated by sample site for female respondents. With the exception of Kuang and Meru, the sample sites are not markedly different in terms of percentage of "no tours" among females (please see Table 39). Kuang's high tour rate may be partly explained by its young respondents (59% of sample is less than 25 years of age), compared to other sample sites (Table 39).

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[1] Cross-tabulation data presented in Table 37. Test statistic: Pearson Chi-Square, Value: 45.0596, df:1, Prob: 0.0000.

[2] Of the 65 female respondents who did not make tours on Day 1, 26 respondents or 40% were recorded as being "full-time housewives". Since the survey protocol did not formally include a question asking if a

Table 39: Day 1 Kuala Lumpur Female "No Tours" by Sample Site

Sample Site	Tours	No Tours	Total	% No Tours	% Population 25+
B.B. Sg. Buloh	24	9	33	27%	46%
Kg. Dat Abu Bakar	6	4	10	40%	60%
Kg. Sg. Rasau	11	3	14	21%	64%
Kuang	20	2	22	9%	41%
Meru	16	16	32	50%	56%
Puchong	12	7	19	37%	53%
Sg. Serai	15	10	25	40%	52%
Sg. Serdang	20	14	34	41%	47%
Total	**124**	**65**	**189**		

In contrast to the Kuala Lumpur housewives, all the Ottawa homemakers surveyed made tours on Day 1. It is notable that the homemakers (as a group) made the highest number of tours (group mean of 2.7 tours), compared to all other work status categories (please see Table 40). The homemaker work status group also recorded the highest mean travel distance on Day 1 (Table 40).

respondent was a housewife, responses were not obtained for the whole sample. Thus, it is likely that *more* than 40% of the females who did not make tours are housewives.

Table 40: Day 1 Ottawa Mean Tours and Distance by Work Status

Work Status	n*	Mean Total Tours**	Mean Distance** (km)
Baby	6	1.5000	43.3
Day off work	7	2.0000	67.4
Home work	17	1.5294	58.0
Homemaker	9	2.6667	75.2
Retired	23	1.5652	52.6
School	36	1.5556	28.8
Work	59	1.4068	69.9
TOTAL	**157**		

*Excludes respondents who did not make tours on Day 1.

**Excludes recreational walk tours.

These results should be interpreted with caution as the sample size of homemakers in the Ottawa study is only *n*=9. Due to the small sample size, the homemaker group's mean total tours and mean distance are not significantly (statistically) different from other work categories.

Day 2

In Ottawa, Day 2 (Saturday) is not a regular work day for many survey participants (compared to Day 1, see Table 41[1]). The consequence is an increase in Day 2 of 10% over Day 1 in the number of Ottawa respondents reporting "no tours" (see Table 42). Similarly, in Kuala Lumpur, approximately 42% of respondents reported "no tour" on Day 2. The gender gap narrows in Kuala Lumpur, compared to Day 1, with approximately 45% of female and 38% of male respondents reporting "no tours". In Indonesia, Day 2 is a working day (see Table 42) and a similar percentage of respondents (5%) report "no tour" compared to Day 1 (4%).

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[1] Table 41 is based on stops rather than tours due to multi-purpose tours. Some respondents accomplish more than one purpose on a given tour.

Table 41: Percentage of Total Stops Made for Work Purposes by Field Site

Field Site	Day 1	Day 2	Day 3
Ottawa	19.0%	10.4%	8.9%
Kuala Lumpur	43.4%	43.0%	16.2%
Yogyakarta	25.4%	26.5%	15.1%

Analysis includes farming.

Table 42: Day 2 "No Tours" by Field Site

Field Site	Tours	No Tours	Total	% No Tours
Ottawa (Saturday)	139	23	162	14%
Kuala Lumpur (Saturday)	195	139	334	42%
Yogyakarta (Friday)	124	7	131	5%

Day 3

On Day 3 (Sunday), a non-work day for the majority of the population in all three cities (see Table 43), a greater percentage of "no tours" were recorded in all three field sites (compared to Days 1 and 2) (Table 43). It is noted that nearly two-thirds of Kuala Lumpur respondents did not make a tour on Day 3. Similar to Day 2, those reporting "no tours" are evenly split between genders with 58% of female respondents and 54% of male respondents reporting "no tours".

Table 43: Day 3 "No Tours" by Field Site

Field Site	Tours	No Tours	Total	% No Tours
Ottawa	120	43	163	26%
Kuala Lumpur	188	237	425	56%
Yogyakarta	121	15	136	11%

Relationship between "No Tours" and Work Travel Distance in Ottawa

In a detailed analysis of the Ottawa dataset, an hypothesis tested whether those respondents who are employed outside the home on Survey Day I (weekday) and who did not make any tours on Sunday (Day 3), have a greater distance to work on Day I.

Using a two sample t-test (95% confidence interval), it was found that amongst respondents who were greater than or equal to 45 years of age, those making "no tours" on Day 3 had a greater distance to work on Day I than those who made tours (see Table 44). The relationship does not hold for those less than 45 years of age.

Table 44: Results of Two-Sample t-tests on Day 1 Distance to Work Grouped by Day 3 "No Tours"

	Distance* (km)		
Group	*n*	Mean	Std. Deviation
Tours	18	50.90	34.71
No tours	9	88.58	44.30
p	p=0.0437		

*The above numbers have been rounded for presentation purposes.

5.2 Modes of Travel

The modes of travel used at each field site for all survey days are presented on a tour basis and on a distance basis in this section. The more commonly used modes at the three field sites are bicycle, bus, car, motorcycle, walk (and recreational walk[1], jog or ski).

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[1] In the remainder of the text the term "recreational walk" is used to refer to recreational walking, jogging and skiing. The number of jogging and skiing tours is very low compared to the number of walking tours.

5.2.1 COMMONLY USED MODES

Car

While the car is used for the majority of tours in Ottawa (74-82%) on all three survey days, its use is less prevalent in Kuala Lumpur and Yogyakarta. The lesser use of the car in Kuala Lumpur and Yogyakarta can be explained by a lower car-to-person ratio in these two cities, compared to Ottawa. Calculated from the survey data, the respondents in the Ottawa field site had a ratio of 0.97 cars or light trucks per person (for respondents greater than or equal to 20 years of age), compared to Kuala Lumpur and Yogyakarta with ratios of 0.32 and 0.15 respectively (please see Table 45).

On a distance basis in Ottawa, the car accounted for 93% of all travel on Day 1, far exceeding all other modes (see Table 46, Figure 27). Even though the car is used for only 74% of the tours (Table 47), the distances travelled are long. Similarly, in Kuala Lumpur while the car accounts for 24% of the tours on Day 1 (Table 47), the greater distances travelled by car compared to other modes, contribute to car travel making up 40% of the total distance (Table 46, Figure 27).

Table 45: Number of Vehicles Per Person

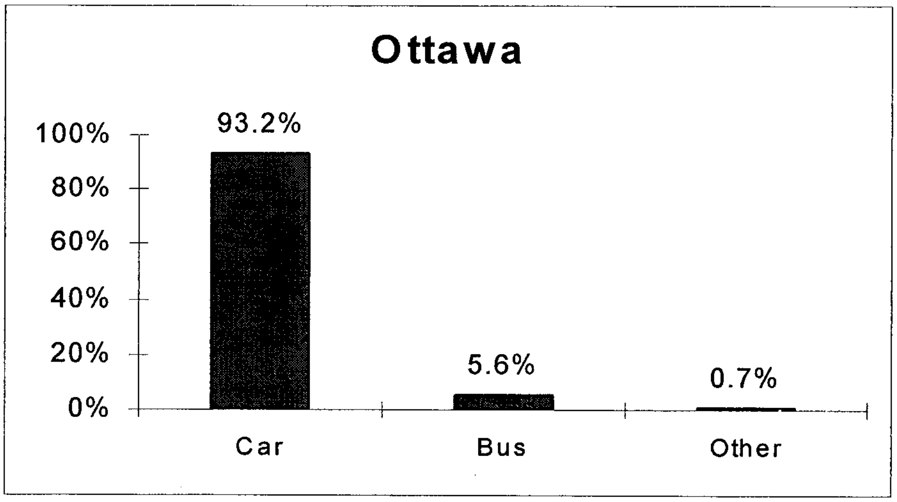
Vehicle Type	Ottawa	Kuala Lumpur	Yogyakarta
Car/Light Truck (ages>=20)	0.97	0.32	0.15
Motorcycle (ages>=15)	0.02	0.31	0.49
Total Car/Light Truck/Motorcycle (ages>=15)	0.89	0.57	0.61

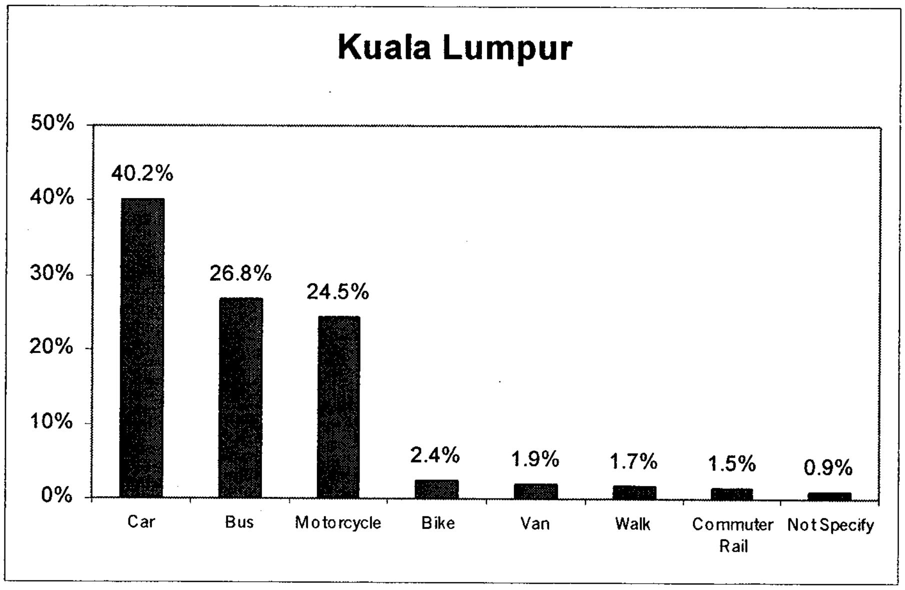
Table 46: Ottawa Modes of Travel as a Percentage of Total Distance

Mode	% of Total km					
	Day 1		Day 2		Day 3	
Car	93.2%		98.7%		99.4%	
Bus Total	5.6%		0.4%		0.0%	
School Bus		*4.0%*		*0.0%*		*0.0%*
Bus		*1.6%*		*0.4%*		*0.0%*
Other	1.1%		0.9%		0.5%	
*Walk**		*0.7%*		*0.6%*		*0.5%*
Bicycle		*0.4%*		*0.1%*		*<0.1%*
Unspecified		*0.0%*		*0.2%*		*0.0%*
TOTAL	**99.9%**		**100.0%**		**99.9%**	

*Includes recreational walks.

Figure 27: Modes on Day 1 by Total Distance





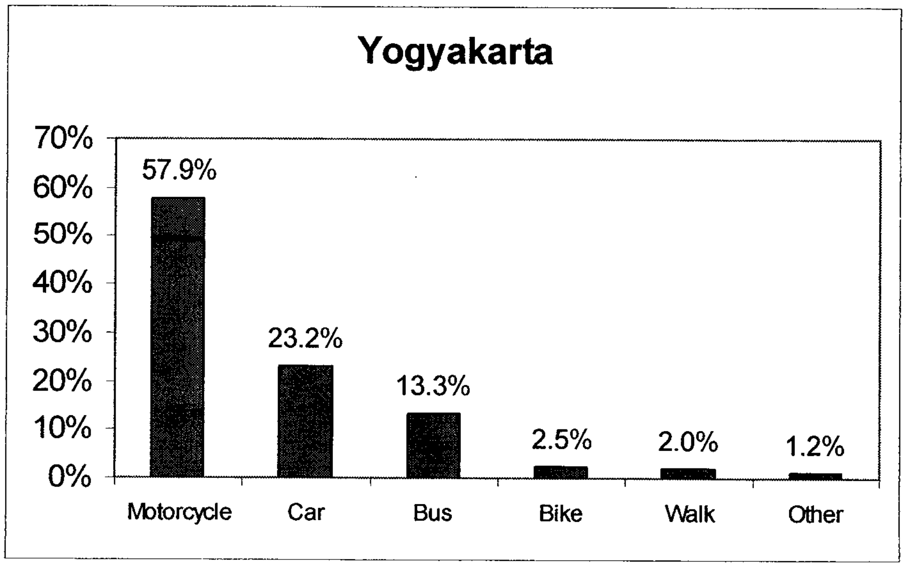


Table 47: Mode of Travel for Tours by Field Site

	Ottawa Day 1		Day 2	Day 3	Kuala Lumpur Day 1		Day 2		Day 3		Yogyakarta Day 1		Day 2		Day 3	
Commonly Used Modes																
Bicycle	1.1%		1.6%		12.1%		8.2%		5.4%		10.5%		9.1%		12.6%	
Bus (Total)	5.3%				20.0%		12.8%		6.9%		7.2%		6.7%		1.1%	
Bus (General)						*19.7%*		*12.3%*		*6.4%*		*1.0%*		*1.0%*		
Angkudes												*1.0%*		*1.0%*		
Bis Kota												*2.9%*		*4.3%*		*1.1%*
Company Bus						*0.3%*		*0.5%*								
Intercity Bus										*0.5%*		*0.5%*				
Mini Bis												*1.9%*		*0.5%*		
School Bus		*5.3%*														
Car	73.7%		82.0%	80.0%	23.7%		32.0%		43.6%		13.9%		10.5%		26.2%	
Motorcycle					20.0%		22.8%		18.8%		47.4%		40.2%		42.1%	
Walk	7.3%		4.5%	6.2%	19.2%		17.8%		23.8%		16.7%		26.3%		16.4%	
Walk, Jog or Ski (Recreational)	5.0%		6.5%	10.3%	0.5%										0.5%	
Less Commonly Used Modes																
Company Truck					0.3%		0.5%		0.5%							
Four-Wheeler				0.5%												
Mobil Jemputan											0.5%		0.5%			
Rental Colt															0.5%	
Taxi							0.5%									
Tractor	1.5%		1.6%													
Van (Total)					2.1%		1.8%		1.0%							
Van (General)						*1.8%*		*1.4%*		*1.0%*						
Company Van						*0.3%*		*0.5%*								
Unspecified			0.4%		0.3%											
Multi-Mode*	6.1%		3.3%	3.1%	1.8%		3.7%				3.8%		6.7%		0.5%	
	n=157		*n*=139	*n*=120	*n*=328		*n*=195		*n*=188		*n*=126		*n*=124		*n*=121	
	100.0%		100.0%	100.1%	100.0%		100.0%		100.0%		100.0%		100.0%		100.0%	

*Multi-mode: The breakdown of "multi-mode" for Ottawa Day 1 and Yogyakarta Day 2 is as follows:

Ottawa Day 1 (n=16): car (75%), bus (25%), bike (19%), walk (50%), school bus (25%).

Yogyakarta Day 2 (n=14): car (14%), bus (general) and *bis kota* (79%), bike (14%), walk (14%), motorcycle (64%), *angkudes* (7%), *ojek* (7%).

Note that the above percentages are not additive to 100% since the modes were used in combination with each other. A breakdown is not provided for Kuala Lumpur and other survey days since their n<10.

Table 48: Kuala Lumpur Modes of Travel as a Percentage of Total Distance

Mode	% of Total km		
	Day 1	Day 2	Day 3
Car	40.2%	61.8%	78.7%
Bus Total	26.8%	15.1%	4.1%
Motorcycle	24.5%	17.6%	10.5%
Bicycle	2.4%	0.7%	0.6%
Van	1.9%	1.7%	0.2%
Walk*	1.7%	0.9%	0.9%
Commuter Rail	1.5%	1.6%	0.0%
Unspecified	0.9%	0.0%	0.0%
Intercity Bus	0.0%	0.0%	4.9%
Taxi	0.0%	0.6%	0.0%
TOTAL	**99.9%**	**100.0%**	**99.9%**

*Includes recreational walking.

Table 49: Yogyakarta Modes of Travel as a Percentage of Total Distance

Mode	% of Total km					
	Day 1		Day 2		Day 3	
Motorcycle	57.9%		58.4%		37.5%	
Car	23.2%		19.9%		57.0%	
Bus Total	13.3%		15.5%		1.3%	
Bis Kota		*5.4%*		*11.4%*		*1.3%*
Mini Bis		*2.7%*		*0.5%*		*0.0%*
Intercity Bis		*1.8%*		*0.0%*		*0.0%*
Bus (General)		*1.7%*		*1.9%*		*0.0%*
Angkudes		*1.7%*		*1.7%*		*0.0%*
Bicycle	2.5%		2.3%		2.5%	
Walk*	2.0%		2.8%		1.4%	
Other	1.2%		1.0%		0.2%	
Mobil Jemputan		*0.7%*		*0.8%*		*0.0%*
Ojek		*0.0%*		*0.2%*		*0.0%*
Rental Colt		*0.0%*		*0.0%*		*0.2%*
Unspecified		*0.5%*		*0.0%*		*0.0%*
TOTAL	**100.1%**		**99.9%**		**99.9%**	

*Includes recreational walk, jog and ski.

It is noted that for all three field sites, the percentage of car use increases on days (see Table 47) when fewer respondents are working. In Ottawa, car tours as a percentage of total tours are between 80-82% on non-work days, compared to approximately 74% on a working day. Similarly, in Kuala Lumpur, the car is used for 44% of the tours on Day 3, compared to the working day range of 24-32%. In Yogyakarta, 26% of the tours are made by car on a non-work day, compared to 11-14% for working days.

The increase in car use on Day 2 and 3 in Ottawa and Kuala Lumpur, and Day 3 in Yogyakarta, appears to come at the expense of bus use in all field sites, and bicycle travel in Kuala Lumpur.

Bus

On a distance basis[1], on Day 2 in Ottawa, car use increases by 5.5% while bus use drops by 5.2% compared to Day 1 (mainly because school buses do not operate on Saturday and Sunday). On Day 3, no bus travel was recorded in Ottawa, and car use rises to 99.4% (Table 46).

In Kuala Lumpur on Day 2, total bus distance drops from 27% to 15%, while car use increases from 40% to 62% of total distance, compared to Day 1 (Table 48). Car travel rises to 78.7% of total distance on Day 3 in Kuala Lumpur, while bus use drops from 27% to 4% from Day 1.

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[1] The results for bus are presented on a distance travelled basis, since bus (not "school bus") trips are often multi-modal in Canada and hence are not easily comparable between field sites on a tour basis.

A similar decrease in bus[1] use on non-working days is revealed in Yogyakarta with a drop of 14% in the percentage of total bus travel between Day 2 and 3, while the car gains 37% by total distance (Table 49).

Bus travel is low on a distance basis in the Ottawa survey (0-5.6%), compared to Kuala Lumpur (4.1-26.8%) and Yogyakarta (1.3-13.3%). Note that there is not a "school bus" service in either Kuala Lumpur and Yogyakarta, as there is in Ottawa, so that some student travel is in the "bus" category in the Southeast Asian field sites. Regular bus tours (excluding "school bus" tours) in Ottawa do not show in the tour mode chart (Table 47), because they are all multi-modal. There is no opportunity for direct door-to-door bus service in much of Ottawa survey area. In the one Ottawa sample site where there is a direct bus connection offered (Stittsville), it was not used by any survey respondents. The respondents from Stittsville who did use the bus were picked up and dropped off in Kanata (the farthest point to the west in Ottawa where frequent service is offered).

Motorcycle

Motorcycle use as a percentage of total tours holds consistently over the three survey days in Kuala Lumpur (18-23%) and Yogyakarta (40-47%). The wider use of the motorcycle in Yogyakarta, compared to Kuala Lumpur, is reflected in the higher motorcycle ownership rate in Yogyakarta (see Table 45). On a distance basis (see Table 46-Table 49), motorcycle share decreases due to the greater distances travelled by car. The motorcycle was not used as a travel mode in Ottawa.

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[1] There are several distinct types of buses in Yogyakarta, *bis kota* (or city bus), mini bus, intercity bus (for regional and intercity trips) and *angkudes* (a rural bus service).

Bicycle

Bicycle use as a percentage of total tours is higher in Kuala Lumpur (5.4-12.1%) and Yogyakarta (9.1-12.6%), compared to Ottawa (0-1.6%). In Kuala Lumpur, the level of bicycle travel varies over the three survey days. On a tour basis, from a high of 12.1% on Day 1, Kuala Lumpur bicycle use drops off to 8.2% on Day 2 and 5.4% on Day 3 compared to Day 1. The decrease in bicycle travel on Day 2 and 3 is due to fewer school-related activities on Day 2 and 3, for which the bicycle is heavily used on Day 1 (see Table 50). Bicycle use in Yogyakarta as a percentage of total tours holds steady at 9.1-12.6%.

Table 50: Kuala Lumpur Bicycle Stops by Stop Purpose

Type of Tour	Day 1	Day 2	Day 3
School-related	34	9	1
Non-school	12	10	10
Total	**46**	**19**	**11**
%School-related	**73.9%**	**47.4%**	**9.1%**

Walk

Walk tours as a percentage of total tours do not vary greatly between the three field sites. Over the three survey days, Ottawa is a little lower (11.0-16.5%), while Kuala Lumpur registers (17.8-23.8%) and Yogyakarta (16.4-26.3%).

Ottawa's proportion of walking for recreation is higher than the other two field sites. Recreational walking increases to 10.3% of all tours on Day 3, a non-work day, up 4-5% from Days 1 and 2.

In Yogyakarta, the percentage of tours made by walking (including recreational walking) is equal between Days 1 and 3 (16.7% and 16.9%), while Day 2 is higher at 26.3%.

Further investigation indicates that the increase in walking tours on Friday is due to walking tours made to the mosque. A cross-tabulation on tours made for religious purposes on Friday indicates that approximately 68% of the trips for religious purposes on Friday were made by walking (Table 51).

Table 51: Yogyakarta Day 2 Stops for Religious Purposes by Mode

Mode	Number of Stops	% of Stops
Bicycle	1	2.4%
Car	2	4.9%
Motorcycle	10	24.4%
Walk	28	68.3%
TOTAL	**41**	**100%**

Of all stops reached by walking, approximately 49% were for religious purposes (Table 52).

Table 52: Yogyakarta Day 2 Walking Stops by Stop Purpose

Stop Purpose	Number of Stops	% of Stops
Farming	7	12%
Recreation	5	9%
Religion	28	49%
School	6	11%
Shopping	10	18%
Social	1	2%
TOTAL	**57**	**101%**

5.2.2 LESS COMMONLY USED MODES

The less commonly used modes encountered at the three field sites include commuter rail (Kuala Lumpur only), company truck (Kuala Lumpur only), four-wheel all terrain vehicle (used in the Ottawa survey for recreational purposes), mobil jemputan (a special pickup service in Yogyakarta), rental colt (rental truck in Yogyakarta), taxi, tractor (used for farming in Ottawa survey), van and ojek (motorcycle taxi in Yogyakarta).

Individual Modal Variability Comparison

An analysis was undertaken to investigate the degree to which respondents at the three field sites used different modes over the three survey days.

In preparation for the analysis, the modal categories were simplified[1] so that the three field sites could be compared on an similar basis. The categories used for the analysis are presented in Table 53. Only respondents who were surveyed and had tours on all three survey days were included. For each respondent, the number of modes taken on each survey day was counted and the results were totalled across the three survey days. Next, the results for individuals were averaged across each field site.

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[1] In the interests of comparativeness, the analysis does not include the less-commonly used modes of "recreational, walk or ski", "tractor", "four-wheel all terrain vehicle", and instances where the mode of transport was not specified."Company van" was classified in the "van" category and "company truck" was placed in the "car" category. The various bus types "*bis kota*", "intercity bus", "mini bus", "*angkudes*" and "company bus" were amalgamated into a broader "bus" category. Ottawa's "school bus" was assigned to the "bus" category.

Table 53: Modes Included in Variability Comparison

Mode
Bicycle
Bus Total
Car
Commuter rail
Mobil Jemputan
Motorcycle
Ojek
Rental Colt
Taxi
Van
Walk

The results of the analysis are presented in Table 54. A series of two-sample t-tests (95% confidence interval) were conducted sequentially between the modal variability indices for each field site. Yogyakarta's modal variability over the three survey days is significantly higher than that of Kuala Lumpur (p=0.0000) and Ottawa (p=0.0000). There is not a significant difference in modal variability between Ottawa and Kuala Lumpur. Over the three days, the respondents in Yogyakarta used a greater number of modes than those respondents in Ottawa and Kuala Lumpur.

Table 54: Modal Variability by Field Site

Field Site	*n*	Modal Variability Index
Ottawa	103	1.4563
Kuala Lumpur	90	1.5333
Yogyakarta	111	2.0180

A further exploration of the Yogyakarta modal variability over three days disaggregated the dataset by gender and age (less than and greater than 20 years of age). The breakdown by gender did not yield any differences. However, while the age analysis results show that there are no significant differences in modal variability for those respondents less than 20 years of age, there are differences between field sites for respondents aged 20 years and above. Yogyakarta's modal variability as determined through consecutive two-sample t-tests (95% confidence interval) is significantly higher for those respondents greater than or equal to 20 years of age, than Ottawa (p=0.0000) and Kuala Lumpur (p=0.0001) (Table 55).

Table 55: Modal Variability Index (MDVAR) by Age by Field Site

Field Site	*n*	MDVAR <20 years of age	*n*	MDVAR >=20 yrs of age
Ottawa	27	1.7778	76	1.3421
Kuala Lumpur	20	1.8000	70	1.4571
Yogyakarta	28	2.2143	83	1.9518

Amalgamating data from all three field sites, the <20 age group (n=75, group mean: 1.9467) has a significantly (p=0.0026) higher modal variability than the group of respondents >=20 years of age (n= 229, group mean: 1.5983), as yielded by a two sample t-test (95% confidence interval).

It is postulated that the higher modal variability in those <20 years of age in all field sites is due to lack of their own personal vehicle. While the respondents may be able to walk or bike to destinations close by, they are often dependent on other family members and transport services to reach more distant locations. For those >=20 years of age in Yogyakarta, their greater modal variability may be related to the lower car ownership ratio (compared to other field sites), combined with a wide variety of transport services and hence more flexibility in the use of different modes for different types of trips.

Gender of Car Passengers in Ottawa

An hypothesis was tested regarding the gender of car passengers in Ottawa. Males and females who made tours by car on each of the three survey days were included in the analysis. First, both genders were compared on the basis of their total distance travelled by car (either as a driver or a passenger). On Day 1 and 3 both males and females travelled equal distances by car (See Table 56). On Day 2, males travelled further (59.99 km) than females (50.20 km), but the difference is not statistically significant. Next, males and females were compared on the basis of distance travelled as a car passenger. A two-sample t-test (95% confidence interval) grouped by gender yielded a significant difference between the two genders. The female Ottawa respondents were more frequently the car passenger (rather than the car driver).

Table 56: Ottawa Car Passenger Distance by Gender

	Day 1			Day 2			Day 3		
	n	Mean	Std. Deviation	*n*	Mean	Std. Deviation	*n*	Mean	Std. Deviation
Mean Travel Distance of **Females** by Car (km)	73	57.68	43.84	68	59.99	49.17	58	59.05	38.99
Mean Travel Distance of **Males** by Car (km)	69	57.68	40.97	66	50.20	43.86	52	61.32	46.14
Mean Distance of **Female** Car Passengers (km)	58	18.31	34.60	53	31.21	42.93	43	34.52	41.25
Mean Distance of **Male** Car Passengers (km)	50	2.74	13.41	48	3.86	11.96	37	2.31	9.72
p of t-test between male and female car passengers	*p*=0.0023			*p*=0.0000			*p*=0.0000		

The mean and standard deviation figures in this table have been rounded for presentation purposes.

5.3 DISTANCE, TIME AND SPEED OF TRAVEL

5.3.1 DISTANCE

A comparison of mean total travel distance per survey day (for those respondents making tours) is provided in Table 57. Ottawa has the highest mean total travel distances (54.3-56.4 km), over the three days, followed by Kuala Lumpur (21.5-35.7 km) and Yogyakarta (17.8-28.1 km). In terms of variation between the three survey days, Ottawa holds consistently across the three survey days, while the mean total distance travelled in Kuala Lumpur is lower on Day 1, compared to Days 2 and 3, and in Yogyakarta lower on Days 1 and 2, compared to Day 3.

Table 57: Average Travel Distance by Sample Site

	TOTAL (km)			CAR (km)		
Field Site	Day 1	Day 2	Day 3	Day 1	Day 2	Day 3
Ottawa (1)	56.0	54.3	56.4	57.7	55.2	60.1
Kuala Lumpur (2)	21.5	35.7	32.3	30.7	65.2	56.2
Yogyakarta (3)	20.0	17.8	28.1	26.5	24.5	52.4

Both Kuala Lumpur and Yogyakarta have shorter *total* distances on regular working days, compared to non-work days. Ottawa, by contrast, has similar total distances across the work and non-work days.

Car distances follow a similar pattern to total distances, with work day distances lower [Kuala Lumpur (30.7 km) and Yogyakarta (24.5-26.5 km)] than those of non-work days [Kuala Lumpur (56.2-65.2 km) and Yogyakarta (52.4 km)]. Ottawa's distances are similar across the three survey days (55.2-60.1 km). Yogyakarta's two working days (1 and 2) yield equal distances, but Day 3, a non-work day, is higher.

The survey includes intercity trips on Days 2 and 3 in Kuala Lumpur and Yogyakarta only, since no intercity trips were recorded in Ottawa. Kuala Lumpur's average car distances on Days 2 and 3 are increased by the inclusion of intercity car trips. Because many residents in Kuala Lumpur have immigrated to the city from other parts of Malaysia, they often (once a month is a typical frequency indicated on surveys) make intercity trips to visit their "hometown" village (*kampung*). On Day 3 in Yogyakarta, some survey respondents made "refreshing" or day recreation trips to outlying areas by car, boosting the Day 3 car total.

A more detailed analysis of Ottawa travel distances by sample site is provided in Table 58. On Day 1, the estate lots exhibit the highest average travel (78.0 km), followed by rural lots (75.8 km). Distances for Carp (51.8 km), working farm (43.3 km) and Stittsville (40.2 km) are lower. On Day 2, all the distances are slightly lower than Day 1, but the rankings between sample sites remain the same, with estate lots having the highest average distance.

On Day 3, the working farm category has the highest average distance (104.6 km). This is due to the farming respondents making leisure trips to outlying centres. Rural lot (71.4 km) and estate lot (59.1 km) follow, and Stittsville (46.4 km) and Carp (39.7 km) are lower.

Table 58: Ottawa Average Travel Distance by Sample Site

Sample Site	Day 1 (km)	Day 2 (km)	Day 3 (km)
Carp	51.8	52.8	39.7
Estate Lot	78.0	67.2	59.1
Kinburn*	32.1	nsd	nsd
Rural Lot	75.8	65.4	71.4
Stittsville	40.2	41.2	46.4
Working Farm	43.3	37.8	104.6

*Insufficient data (nsd) (n<10) for Kinburn Days 2 and 3. Day 1 data for Kinburn should be interpreted with caution as n=11.

5.3.2 TRAVEL TIME

In Table 59, the total, car and motorcycle travel times are presented for all field sites. It is emphasized that the data were based on reported times by respondents, and the results should therefore be viewed as a guide for comparison between the field sites, rather than an exact measure.

Table 59: Total, Car and Motorcycle Average Travel Time by Field Site[1]

	TOTAL (min)			CAR (min)			MOTORCYCLE (min)		
Field Site	Day 1	Day 2	Day 3	Day 1	Day 2	Day 3	Day 1	Day 2	Day 3
Ottawa (1)	77.6	69.0	79.1	72.4	60.9	69.4	not applicable		
Kuala Lumpur (2)	50.4	64.8	50.1	65.4	100.4	75.2	50.5	50.3	34.0
Yogyakarta (3)	54.4	51.7	62.2	58.5	58.8	91.9	48.8	49.5	48.1

In terms of total daily travel time, Ottawa respondents have the highest average time (69.0-79.1 minutes), compared to Kuala Lumpur (50.1-64.8 minutes) and Yogyakarta (51.7-62.2 minutes). By car, travel times are more variable across days and field sites (especially Days 2 and 3 in Kuala Lumpur and Day 3 in Yogyakarta) mainly because of the

[1] Only those respondents who had tours on each sequential survey day and whose total travel time>0 for total calculations, and car and motorcycle travel times>0 for modal calculations were included.

inclusion of intercity travel. An examination of Table 60, which excludes intercity travel, shows more constant travel times across days and field sites.

Average motorcycle travel times are similar (~50 minutes) between Kuala Lumpur and Yogyakarta, except for Kuala Lumpur on Sunday (34.0 minutes). Looking back at Tables 43 and 46, motorcycle use in Kuala Lumpur as a percentage of tours decreases slightly to 18.8% on Day 3, compared to 22.8% on Day 2. In Table 48, motorcycle use as a percentage of total distance drops to 10.5% on Day 3 compared to 17.6% on Day 2. The increase in car use (in terms of tours) (see Table 43) may be indicative of the car being driven for longer trips on Day 3 and the motorcycle being used for shorter trips.

Table 60: Total, Car and Motorcycle Average Travel Time (excluding intercity travel) by Field Site

	TOTAL (min)		CAR (min)		MOTORCYCLE (min)	
Field Site	Day 2	Day 3	Day 2	Day 3	Day 2	Day 3
Ottawa (1)	69.0	79.1	60.9	69.4	not applicable	
Kuala Lumpur (2)	55.7	44.4	77.0	67.4	50.3	34.0
Yogyakarta (3)	51.7	57.0	58.8	78.8	49.5	48.1

5.3.3 SPEED

Total, car and motorcycle average speeds are compared between field sites in Table 61. Ottawa has the fastest average speeds (42.7-45.7 km/h), followed by Kuala Lumpur (25.1-35.0 km/h) and Yogyakarta (20.7-27.2 km/h). Ottawa's higher car speed may be due to its publicly available highway and road network, compared to Kuala Lumpur's partially toll highway system and the complete absence of highways in Yogyakarta.

Table 61: Total, Car and Motorcycle Average Speed by Field Site

	TOTAL (km/h)			CAR (km/h)			MOTORYCYCLE (km/h)		
Field Site	Day 1	Day 2	Day 3	Day 1	Day 2	Day 3	Day 1	Day 2	Day 3
Ottawa (1)	43.0	45.7	42.7	49.4	53.5	53.3	not applicable		
Kuala Lumpur (2)	25.1	32.7	35.0	29.4	39.5	39.8	29.3	31.1	29.6
Yogyakarta (3)	22.0	20.7	27.2	28.1	25.0	34.2	24.5	24.3	25.5

Car speeds for all three field sites are slightly higher than total speeds, but the ranking between the field sites remains the same. The total speeds and car speeds are higher on non-work days in Kuala Lumpur (39.5-39.8 km/h) and Yogyakarta (34.2 km/h), compared to work days, [Kuala Lumpur (29.4 km/h) and Yogyakarta (20.7-22.0 km/h)]. The higher speeds on non-work days in Kuala Lumpur and Yogyakarta are likely due to increased use of the car on non-work days, plus more tours outside the region on main roads. The Ottawa speeds do not differ greatly between working and non-work days.

A detailed analysis of Day 1 total average speeds within the Ottawa field site is provided in Table 62. The estate lots have the highest speed (58.3 km/h), followed by rural lots (53.9 km/h). Carp, working farm, and Kinburn have similar speeds (43.3, 42.1 and 38.3 km/h respectively), while Stittsville has a lower speed of 31.5 km/h.

Table 62: Ottawa Day 1 Total Average Speed by Sample Site

Sample Site	Time (h)	Distance (km)	Total Speed (km/h)
Carp	1.27	55.01	43.3
Estate Lot	1.22	71.05	58.3
Kinburn	1.17	44.79	38.3
Rural Lot	1.37	73.95	53.9
Stittsville	1.34	42.06	31.5
Working Farm	0.77	32.32	42.1

The higher speeds exhibited by the estate lots and rural lots on Day 1 are perhaps reflected by a greater percentage of travel by expressway.

Morning Congestion Avoidance in Ottawa

An hypothesis was tested that those respondents who did not go to an external work location on Day 1 would avoid making trips during the morning rush hour. In the *tour* database, each trip leg was coded if it started between 6:30-8:30 am. A "1" was assigned to each congestion leg in the tour database. The tour database was sub-totaled and the totals were added for each respondent. Ottawa respondents were divided into two groups based on whether or not they made a work tour to an external location (outside their home) on Day 1.

A two-sample t-test (95% confidence interval) was conducted on those respondents who made tours on Day 1 and who were greater than or equal to 20 years of age. It was found that those respondents who did not travel to an external work location (n=52, group mean=0.2115, std. deviation=0.4124) were less likely (p=0.0000) to begin their tours between 6:30 and 8:30am, compared to those who travelled to an external work location (n=57, group mean=0.6842, std. deviation=0.4690) on Day 1.

5.4 DESTINATIONS

To gauge the general direction of travel, each field site (see Figure 28, Figure 29 and Figure 30) was divided up into five zones:

a) central city;
b) suburbs/service centres;
c) urban fringe;
d) outlying centre/area; and,
e) intercity.

The intercity travel boundaries for each field site are shown separately in Figure 23 on page 132.

Figure 28: Ottawa General Travel Zones

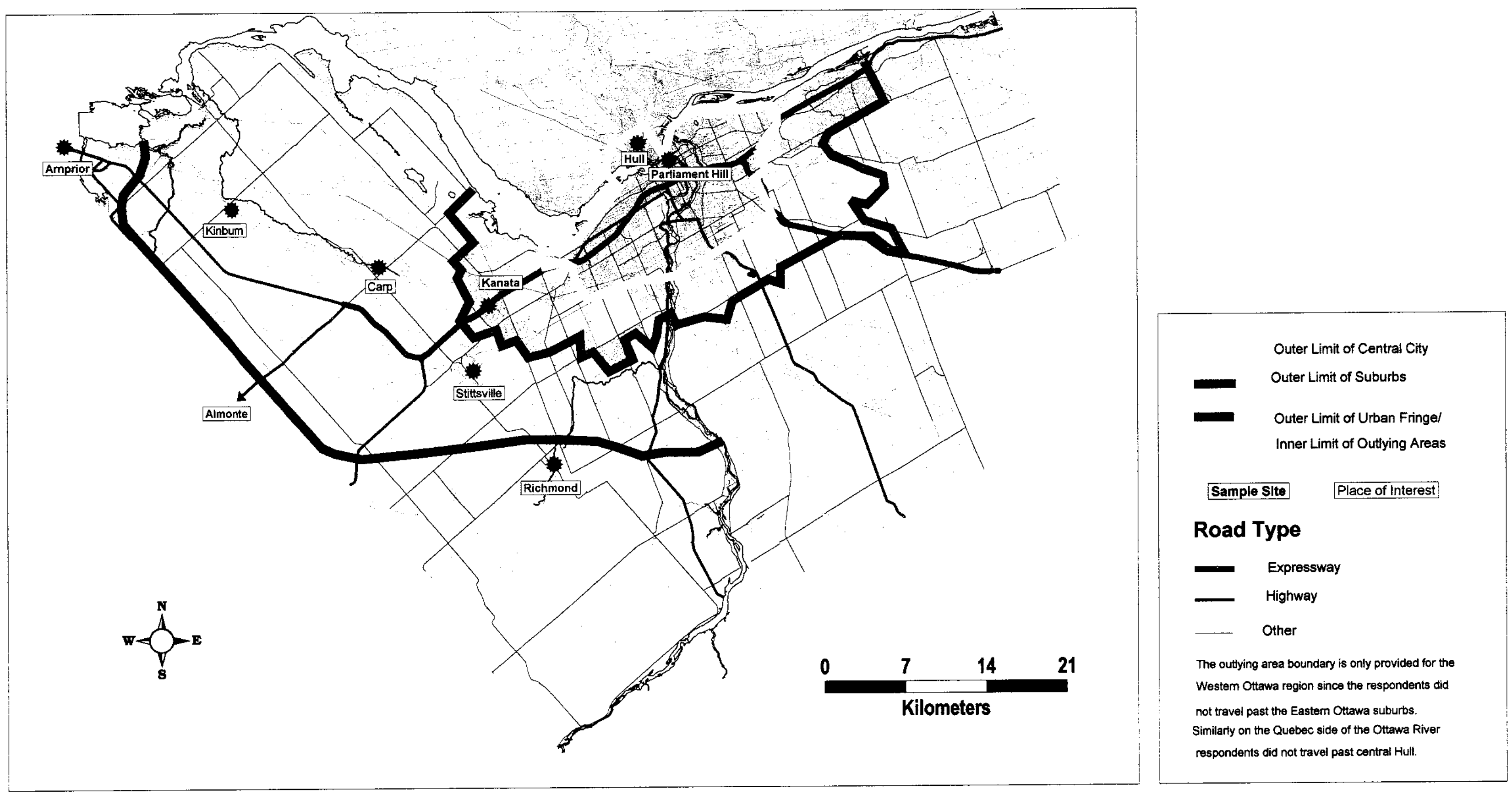


Figure 29: Kuala Lumpur General Travel Zones

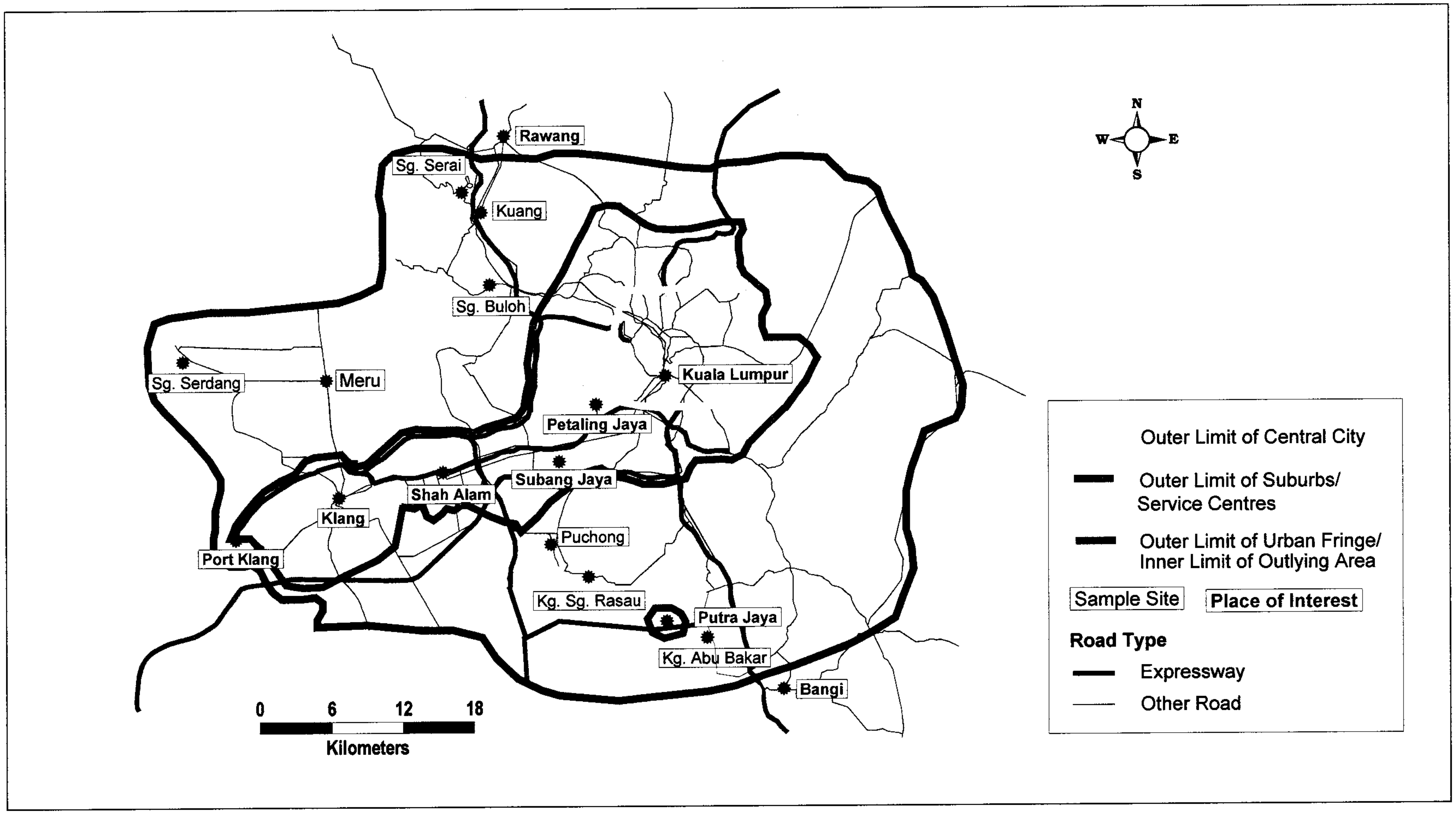
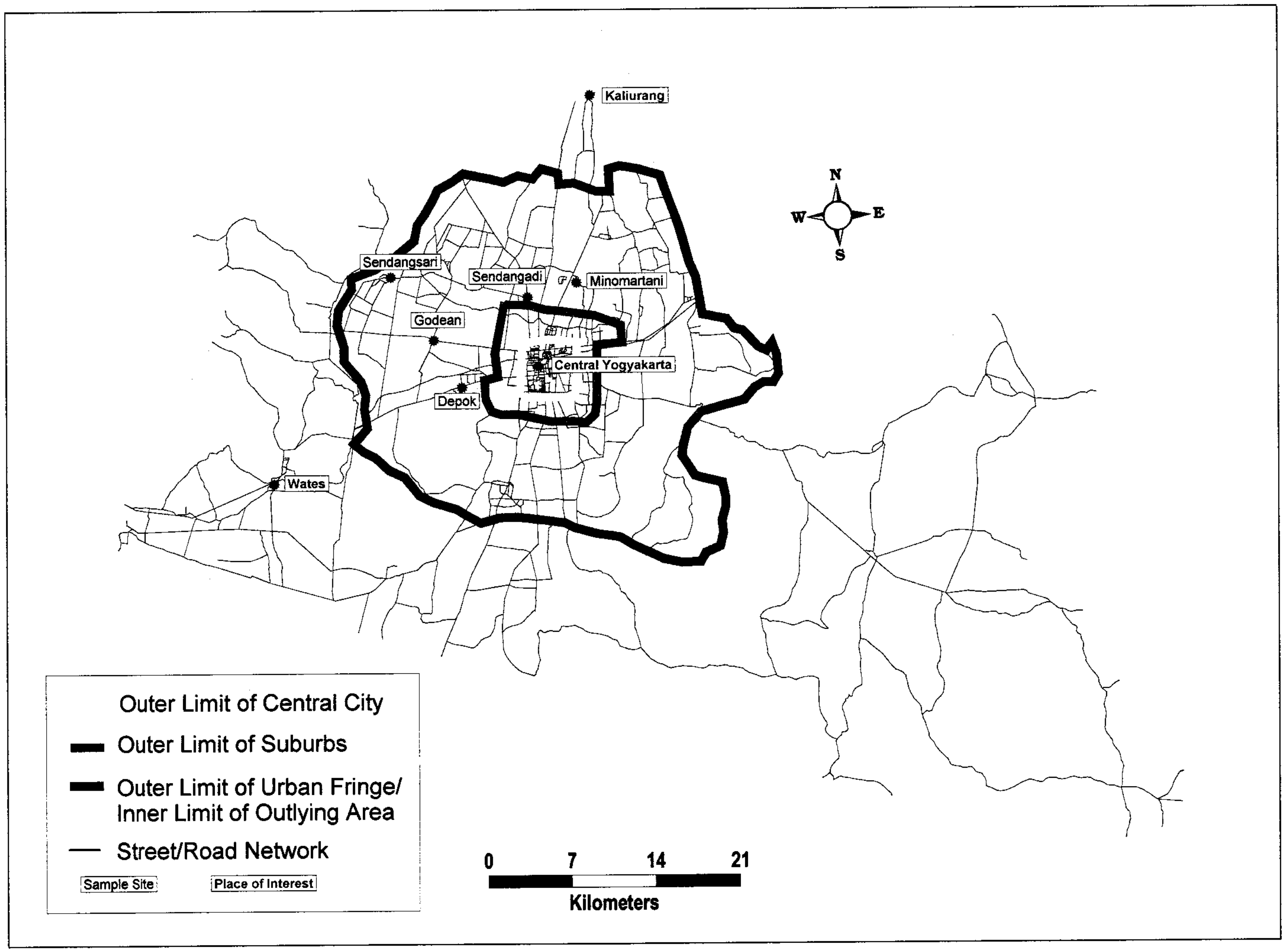


Figure 30: Yogyakarta General Travel Zones



This classification is not meant to be definitive, but rather it is simply a general guide to categorize travel destinations. It is recognized that the spatial layout of the three cities differs somewhat. Kuala Lumpur is of the "decentralized" type. The "new towns" along the axis of the Klang Valley are defined as "suburbs/service centres", with the city of Kuala Lumpur classified as the central city. Ottawa and Yogyakarta share the same spatial form, that of a "concentric" model. Ottawa, however, has a greater area of suburbs compared to Yogyakarta. Due to the presence of multi-stop tours, the results are presented on a stop rather than a tour basis. The stops that respondents made on all survey days are classified as central city, suburbs, urban fringe, outlying centre/area and intercity. The results are presented in Table 63, Figure 31 and Figure 32.

Table 63: General Location of Tour Stops by Field Site

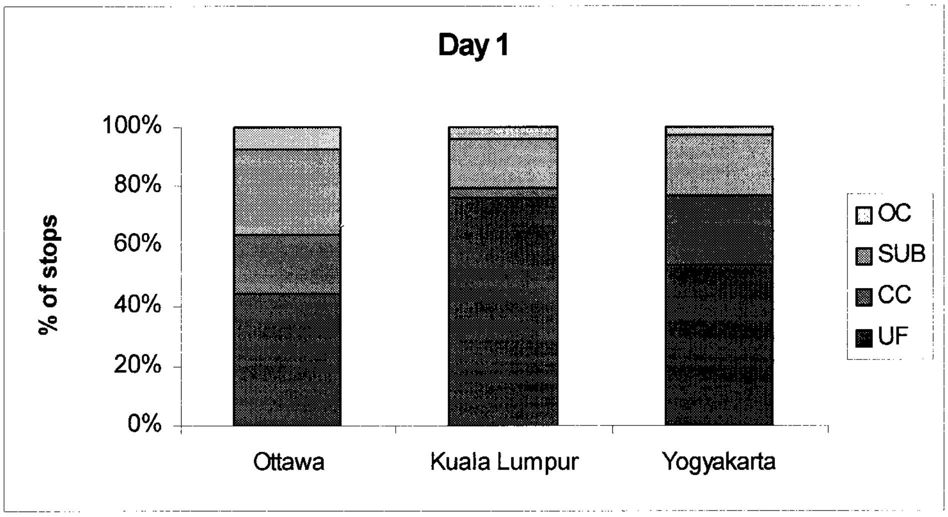
	Central City			Suburbs			Urban Fringe			Outlying Centre			Intercity	
Day	1	2	3	1	2	3	1	2	3	1	2	3	2	3
Ottawa	19%	19%	21%	29%	24%	23%	44%	51%	38%	7%	7%	18%	0%	0%
Kuala Lumpur	3%	9%	7%	17%	19%	18%	76%	65%	69%	4%	5%	3%	2%	3%
Yogyakarta	23%	21%	10%	20%	20%	16%	54%	57%	58%	3%	2%	12%	**	3%

*Number of Day 1, 2, 3 stops: Ottawa (*n*=487, 447, 302); Kuala Lumpur (*n*=422, 249, 204); Yogyakarta (*n*=248, 248, 202).

**Since Day 2 is a work day in Yogyakarta, intercity travel is not included.

Ottawa and Yogyakarta, sharing the same concentric spatial layout, have a similar percentage of stops made in the central city (~20%) (except for Yogyakarta on Day 3, which is discussed below). Kuala Lumpur, with the decentralized city form, has less than 10% stops on all survey days in the city centre.

Figure 31: General Location of Tour Stops Days 1 and 3



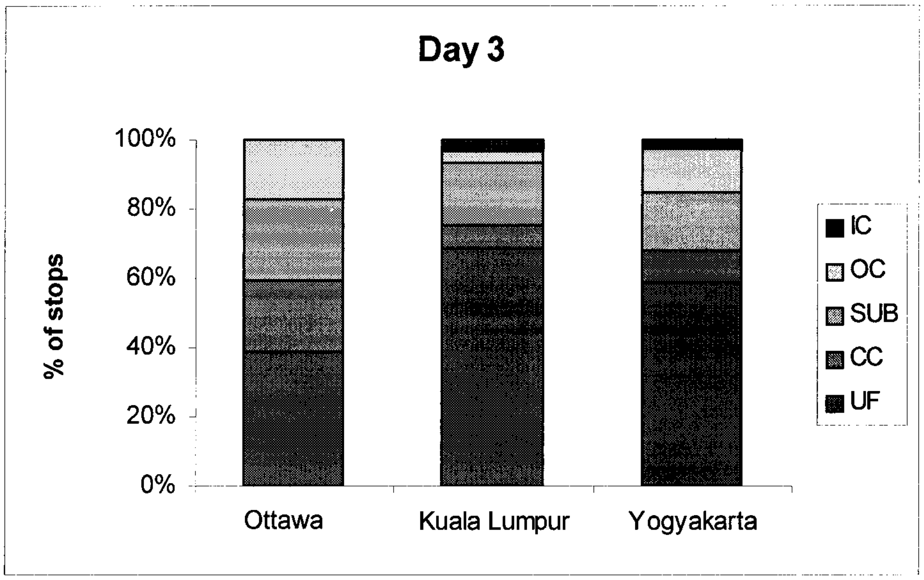
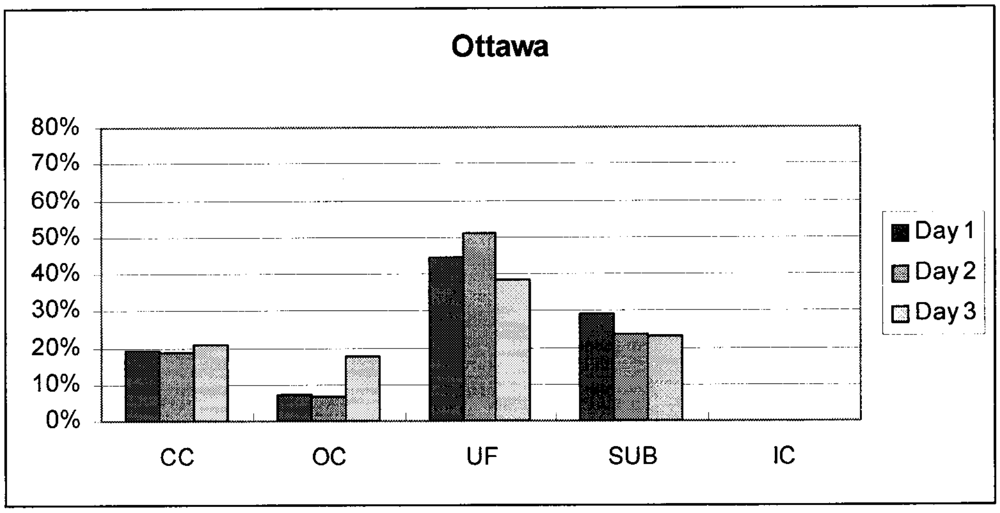
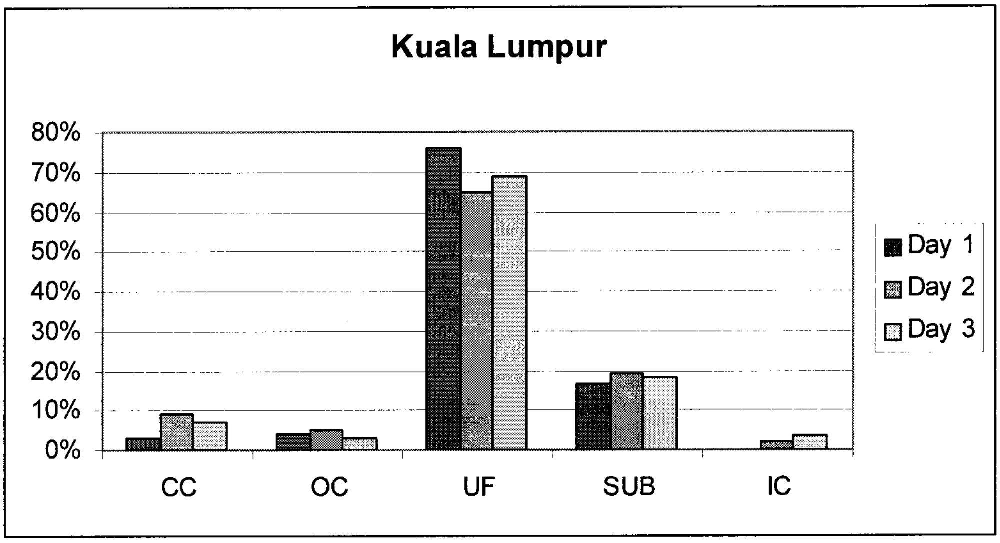
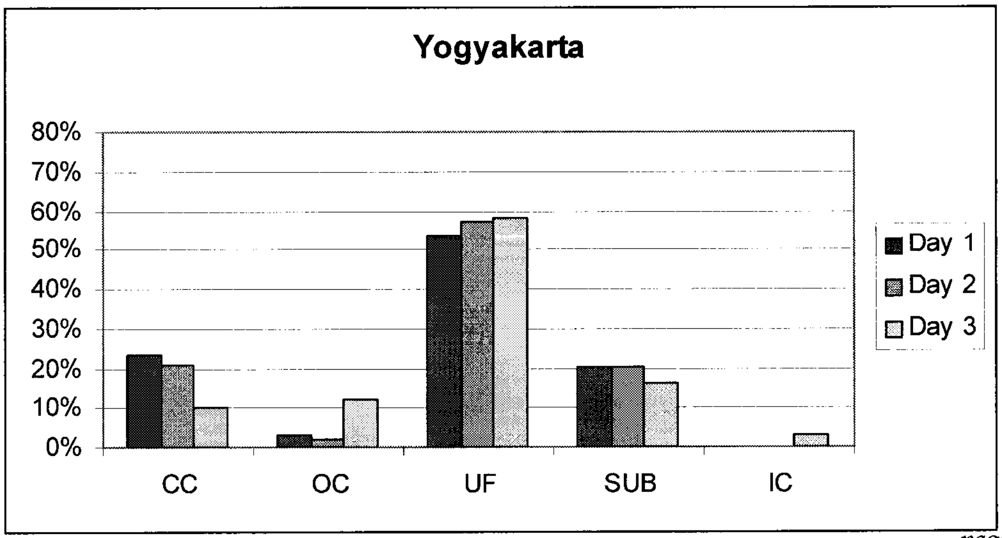


Figure 32: General Location of Tour Stops







Kuala Lumpur and Yogyakarta have a similar number of stops to the suburbs/service centres (~16-20%). As mentioned previously, Yogyakarta's suburbs concentrically surround the central city, while Kuala Lumpur's suburbs are "new towns" along the axis of the Klang Valley. Ottawa's suburbs, like Yogyakarta's, radially envelop the city centre. The number of stops in the suburbs is a little higher than the other two field sites at (23-29%).

A high percentage of the stops in the Kuala Lumpur survey were made in the urban fringe (65-76%). Yogyakarta respondents made a lesser percentage of their stops in the urban fringe compared to those respondents in Kuala Lumpur, yet the Yogyakarta total exceeded 50% for all three survey days. In Ottawa, a smaller percentage of stops (38-51%) were made in the urban fringe compared to the other field sites.

Comparing the three field sites on the basis of percentage of tours to outlying centres/areas, the three field sites do not differ greatly on Days 1 and 2 with values of 2-7%. However, on Day 3, while Kuala Lumpur holds even with Day 1 and 2, Ottawa and Yogyakarta both show an increase of approximately 10%. A further exploration (Table 64 and Table 65) shows the majority of Day 3 stops to outlying areas in Yogyakarta are "refreshing trips" (included in broader leisure/entertainment category), while in Ottawa, social and shopping purposes make up the bulk of stops to outlying centres on Day 3.

Table 64: Yogyakarta Day 3 Stops in Outlying Areas by Purpose

Stop Purpose	Number of Stops	% of Stops
"Refreshing" trip	13	52%
Recreation	3	12%
Social	3	12%
Other*	6	24%
TOTAL	**25**	**100%**

*Includes unspecified (12%), work (8%), school (4%).

Table 65: Ottawa Day 3 Stops in Outlying Areas by Purpose

Stop Purpose	Number of Stops	% of Stops
Social	12	24%
Shopping	11	22%
Rummage/Auction Sales	6	12%
Religion	5	10%
Restaurant	5	10%
Other*	11	22%
TOTAL	**50**	**100%**

*Includes berry picking, pick-up/drop-off, scenic drives, leisure trips, services and work.

While no intercity trips were recorded in Ottawa, Kuala Lumpur registers 2% intercity stops made on Day 2[1], and on Day 3 Kuala Lumpur and Yogyakarta both show 3% intercity trips.

Looking at the shifts in the general location of stops between days, Ottawa's percentage of tours to the central city held even across the three survey days. Those travelling to the central city on Day 3 did so for shopping (30.2%), social (15.9%) and religious (14.3%) purposes (as a percentage of all central city stops) (n=63).The level of stops in the suburbs is slightly higher on Day 1 (29%), compared to 23-24% on Days 2 and 3 (non-work days). There is an increase in the percentage of urban fringe stops on Day 2 (up to 51%, compared to 44% on Day 1). This is due to a rise (16%) in urban fringe shopping stops on Day 2, compared to Day 1. Adding together suburban (Day 1 n=50, Day 2 n=53) and urban fringe *shopping* stops (Day 1 n= 22, Day 2 n=61), urban fringe stops make up 30.6% of the total on Day 1, while they make up 53.5% of Day 2 total urban fringe and suburb shopping stops.

[1] Since Day 2 is a work day in Yogyakarta, intercity travel is not included.

Stops in Ottawa outlying centres/areas make up 7% of total stops on both Day 1 and 2, but increase to 18% on Day 3. This increase draws from the suburb and urban fringe categories as the percentage of trips to the city centre holds equal across all three survey days.

There is little variation in the location of stops by Kuala Lumpur respondents, except for a slight flux between stops made in central city (increase of 4-6% on Days 2 and 3, compared to Day 1), and those made in the urban fringe (decrease of 11% on Day 2 and 3, compared to Day 1) (Table 66).

Table 66: Flux Days 1-3 Between Regional Zones by Field Site

Field Site	Flux*, **	Stable**
Ottawa	SUB (-), UF (+Sat), OC (+Sun)	CC
Kuala Lumpur	CC (+), UF (-)	SUB, OC
Yogyakarta	CC (-), OC (+)	SUB, UF

*+ increase in % of stops on non-work day, - decrease in % of stops on non-work day

**SUB: suburb, UF: urban fringe, OC: outlying centre, CC: central city

In Yogyakarta, stops in the suburbs and urban fringe held relatively steady across the three survey days (slight 4% decrease in suburb stops on Day 3), while there is flux in Day 3 between central city and outlying centre stops, with a 10% decrease in central city stops and a 10% increase in outlying centre stops (see Table 63). Those travelling to the city centre did so mainly for shopping (45%) (*n*=20).

5.5 REASON FOR TRAVEL

In the next section the purposes of tour stops are first analyzed from a broad perspective across field sites, then working and shopping tours are examined in greater detail. Again, due to the presence of multi-purpose tours (which entail multiple stops), the results are presented on a stop rather than a tour basis.

The purposes of stops made by respondents on each survey day are categorized across field sites as presented in Table 68. Comparing the three field sites, Ottawa has the highest proportion of stops made for shopping (21-37%) with Day 2 (Saturday) the peak day. The number of stops made for shopping in Kuala Lumpur is variable ranging from 5% on Day 1 (a work day), to a high of 30% on Day 3 (a non-work day). Similar to Kuala Lumpur, Yogyakarta's Day 3 at is also the top shopping day (21% of all stops for shopping), compared to workdays (Days 1 and 2) which are nearly equal at 14-15%.

Kuala Lumpur has the highest number of work and school stops (as a percentage of total) of the three field sites. The increased share of stops for work and school may be explained by the demographic profile of the survey sample (please see Table 67). The respondents in Kuala Lumpur are younger than those in the other two field sites. Ottawa and Yogyakarta are similar in that on their respective workdays (Day 1 in

Table 67: Age Characteristics of Day 1 Survey Data by Field Site

Field Site	<20 years of age	>=55 years of age
Ottawa	28.4%	25.9%
Kuala Lumpur	41.0%	8.2%
Yogyakarta	28.2%	12.8%

Canada, and Day 1 and 2 in Yogyakarta), approximately 20% of total stops are for work purposes.

In all three field sites, the proportion of pick-up and drop-off stops are higher on work days compared to non-work days. Presumably, the heightened level on work days is related to pick-ups and drop-offs from school and work.

Stops for social purposes are higher (as a percentage of total) on Day 3 in all field sites, compared to Days 1 and 2. Yogyakarta has the greatest percentage of stops (22%) on Day 3, while Kuala Lumpur has 11%. Conspicuously, 24% of all Kuala Lumpur's Day 3

Table 68: Percentage Stops by Purpose[1] by Field Site

	Ottawa			Kuala Lumpur			Yogyakarta		
Day	1	2	3	1	2	3	1	2	3
Shop	20.6%	36.7%	28.6%	4.5%	19.7%	29.9%	14.9%	13.7%	20.5%
Work	18.2%	9.1%	8.9%	41.7%	42.2%	12.7%	19.4%	21.3%	8.3%
Pick-up/Drop-off	16.5%	12.2%	9.9%	7.6%	4.8%	1.0%	10.1%	10.8%	0.5%
Services	12.4%	2.9%	1.3%	0.9%	0.4%	0.5%	5.2%	1.2%	2.0%
School	7.3%	0.0%	0.0%	34.4%	10.0%	2.0%	21.8%	20.1%	2.0%
Social	7.3%	9.6%	13.8%	1.2%	3.6%	10.8%	10.9%	4.4%	22.0%
Restaurant	5.9%	8.2%	5.3%	1.4%	2.0%	2.0%	2.8%	0.8%	5.4%
Recreation	5.3%	6.7%	6.9%	1.2%	3.2%	9.3%	2.0%	2.4%	4.9%
Transit Connection	3.7%	1.3%	2.0%	1.2%	2.4%	0.0%	0.0%	1.2%	0.0%
Leisure/ Entertainment	1.2%	10.2%	8.6%	0.5%	4.4%	24.0%	1.6%	0.4%	7.8%
Farm	0.8%	1.3%	0.0%	1.7%	0.8%	3.4%	6.0%	5.2%	6.8%
Religion	0.4%	0.7%	13.5%	2.8%	2.0%	3.9%	4.4%	16.5%	14.1%
Unspecified	0.2%	1.1%	1.3%	0.9%	4.4%	0.5%	0.8%	2.0%	5.9%
n stops	490	450	304	422	249	249	304	204	205

[1] Stop purposes were categorized across field sites as follows.

Shop : bake shop, beer/wine shop, convenience shop, department shop, drugstore, farmer's market, garden supply shop, gas, general shop, grocery shop, hardware shop, house furnishing shop, mall shop, market, meat store, newspaper/books, office supply shop (personal), *pasar malam* (night market), photo shop, real estate shop, rice shop, speciality shop (clothes, computers, fabric store), vegetable store, window shop.

Work: business, job search, office, ration food, volunteer, work, work meeting, mobile work, work shopping, work pick up/drop off.

Pick up/Drop off: pick up/drop off at babysitter, pick up item, pick up/drop off person, school pick up/drop off.

Services: babysitter, bank, car shopping/servicing, dry cleaner, hair dresser, health clinic, mail, medical/dental.

School: school, religious school, course, tuition, university.

Social: *arisan*, attend invitation, Brownies, Community Centre, dates, family meeting, play cards, play group, Scouts, telephone, village office, visit family, visit friends, visit patient in hospital, workshop.

Restaurant: bar, coffee, food stall, fruit stall, restaurant.

Recreation: fish pond, football, playing, playing with friend, tennis, volleyball.

Transit Connection: car park, pick up or drop off vehicle, bus connection, park and ride, car pool meeting.

Leisure/Entertainment: casino, day trip, events, intercity trip, *jalan-jalan*, library, movie, overnight, parties, rummage/auction sales, weddings.

Farm: farm, gardening, rice field, rice mill.

Religion: bar, chapel, church, *kenduri*, mosque, *pengajian*, temple, *TPA*.

Unspecified

stops are for leisure/entertainment purposes. Many of these stops are for weddings that take place on Sunday.

A sub-category of leisure/entertainment termed *jalan-jalan* (following the Indonesian and Malaysian word) refers to stops made on *jalan-jalan* or "wandering tours". Such tours are not made for any particular purpose other than for the process of making the tour itself, although stops may be made on the journey. In Ottawa, a scenic drive (without a pre-determined destination) is considered to be a form of *jalan-jalan*. The wandering tours documented in this study were made via the car mode by respondents in Ottawa and Kuala Lumpur.

Across all field sites and survey days, farming makes up 0-7% of all stops. In both Kuala Lumpur and Yogyakarta, farming is at a peak on Day 3 (a non-work day), compared to Days 1 and 2. Amongst the field sites, Yogyakarta's stops for farming as a percentage of total are the highest (4.2-6.8%).

Reflecting the different religions at each field site, the percentage of stops for religious purposes varies across days and by field site. In Ottawa, while religious stops make up less than 1% of the total on Days 1 and 2, Sunday peaks at 13.5%.

Stops in Kuala Lumpur for religious activities make up 2.0-3.9% of the total across survey days. While a portion of the Kuala Lumpur respondents were surveyed on the Muslim holy day of Friday, the sample size is not large enough to allow presentation of the results. Had Friday been included, it is expected that the percentage of religious stops would be higher than the three survey days presented. In Yogyakarta, stops for religious purposes ranges from 4.4% on Day 1, to 16.5% on Friday (a Muslim holy day) to 14.1% on Day 3.

Table 68 illustrates that compared to work days, on non-work days, work and school stops decrease, while leisure/entertainment, recreation, shopping and social stops increase (as a percentage of total stops) across all field sites.

5.5.1 WORK TRAVEL

The general location of work stops on Day 1 is presented in Table 69 and Table 70. Farming is excluded from the first table but is included in the second to highlight the location (urban fringe) of farming stops in Yogyakarta. A high proportion of Ottawa's stops (43%) were in the central city compared to Yogyakarta (23%) and Kuala Lumpur (6%).

In examining Table 69, both Kuala Lumpur and Yogyakarta have 50% or higher of their work stops in the urban fringe. By contrast, only 30% of Ottawa's work stops are in the urban fringe. Including farming, the percentage increases by 12% in Yogyakarta

Table 69: General Location of Day 1 Work Stops (excludes farming) by Field Site

Field Site	CC	OC	SUB	UF	*n*
Ottawa	43%	2%	25%	30%	89
Kuala Lumpur	6%	8%	31%	55%	176
Yogyakarta	23%	10%	17%	50%	48

Table 70: General Location of Day 1 Work Stops (includes farming) by Field Site

Field Site	CC	OC	SUB	UF	*n*
Ottawa	41%	2%	24%	33%	93
Kuala Lumpur	6%	8%	30%	56%	183
Yogyakarta	17%	8%	13%	62%	63

(see Table 70). Across field sites, work stops in outlying centres make up 2-10% and in the suburbs 17-25%.

The average length of Day 1 work tours (excluding farm tours) by field site (Table 71) shows much longer mean distances for Ottawa (59.3 km) and shorter for Kuala Lumpur (27.7 km) and Yogyakarta (18.6 km). The inclusion of farm tours reduces the mean tour distance in all field sites (see Table 71).

Table 71: Average Length of Day 1 Work Tours by Field Site

	Excludes Farm Tours		Includes Farm Tours*	
Field Site	Mean Distance** (km)	*n*	Mean Distance** (km)	*n*
Ottawa	59.29	70	56.11	74
Kuala Lumpur	27.72	172	26.90	179
Yogyakarta	18.60	47	14.66	62

*Farm tours refer to tours made to points outside of one's personal property for farming purposes.
**Distance of whole tour, not direct distance from home.

5.5.2 SHOPPING TRAVEL

The general location of shopping stops is presented in Table 72.

Table 72: General Location of Shopping Stops and Percentage Market Stops by Field Site

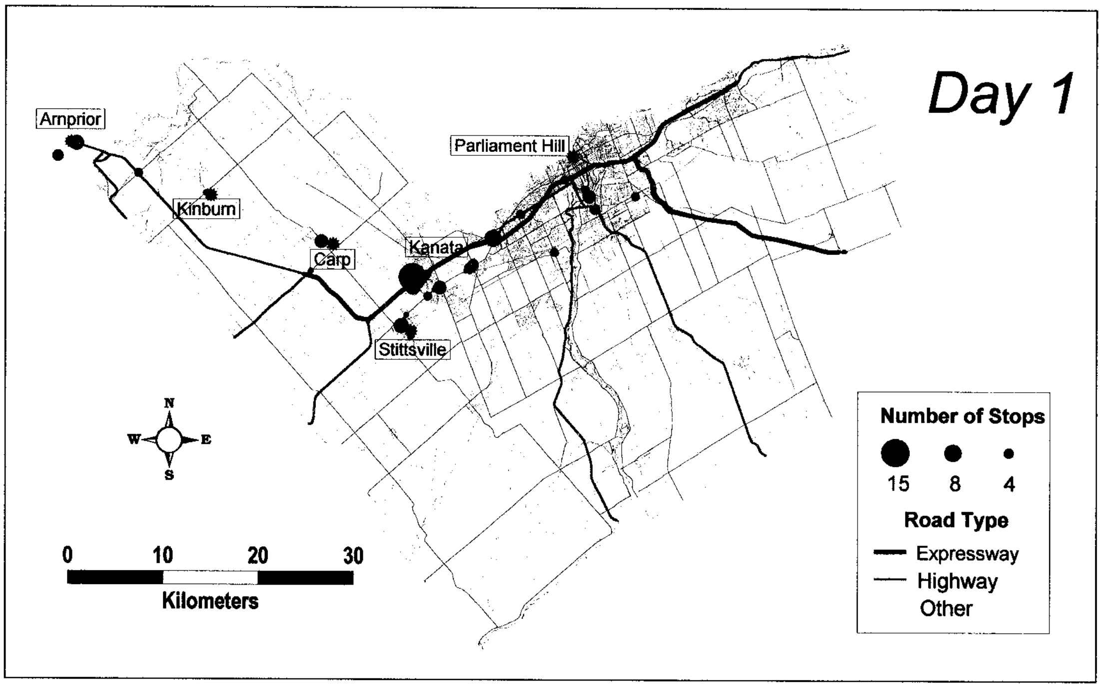
Day 1	*n*	CC	OC	SUB	UF	Total	% Market
Ottawa	101	22%	7%	50%	22%	100%	0%
Kuala Lumpur	19	0%	0%	11%	89%	100%	21%
Yogyakarta	37	27%	0%	8%	65%	100%	54%
Day 2	*n*	CC	OC	SUB	UF	Total	% Market
Ottawa	162	24%	6%	33%	38%	100%	10%
Kuala Lumpur	49	14%	2%	22%	61%	100%	18%
Yogyakarta	34	38%	0%	12%	50%	100%	41%
Day 3	*n*	CC	OC	SUB	UF	Total	% Market
Ottawa	87	22%	13%	47%	18%	100%	0%
Kuala Lumpur	61	7%	0%	21%	72%	100%	30%
Yogyakarta	42	21%	0%	29%	50%	100%	62%

Maps of the field site areas illustrating shopping locations are presented for Ottawa (Figure 33), Kuala Lumpur (Figure 34) and Yogyakarta (Figure 35). Ottawa and Yogyakarta are similar in the percentage of stops made in "city centre" (21-38%), while Kuala Lumpur is much lower at 0-7%. Ottawa is the only site that has a pull towards the outlying areas for shopping.

Across all survey days, Ottawa has a higher percentage of shopping stops in the suburbs (33-50%), compared to the other two field sites (8-29%). A greater percentage of Kuala Lumpur's and Yogyakarta's shopping stops are made in the urban fringe. This can be partially explained by the proportion of market stops in the Southeast Asian field sites, where many villages have their own local markets. Yogyakarta has the highest market patronage across the three survey days (41-62%), followed by Kuala Lumpur (18-30%).

There is a 16% increase in the percentage of shopping stops made in Ottawa's urban fringe on Day 2, compared to Days 1 and 3. In examining a breakdown of Ottawa's Day 2 urban fringe shopping tours (Table 73), it is noticeable that the Carp Farmer's Market, as a single destination, makes up the greatest proportion of stops. Unlike many local markets in Kuala Lumpur and Yogyakarta, the Carp Farmer's Market only operates once a week. Approximately 9.7% of the Ottawa survey shopping stops on Day 2 are at the Farmer's Market.

Figure 33: Ottawa Shopping Locations



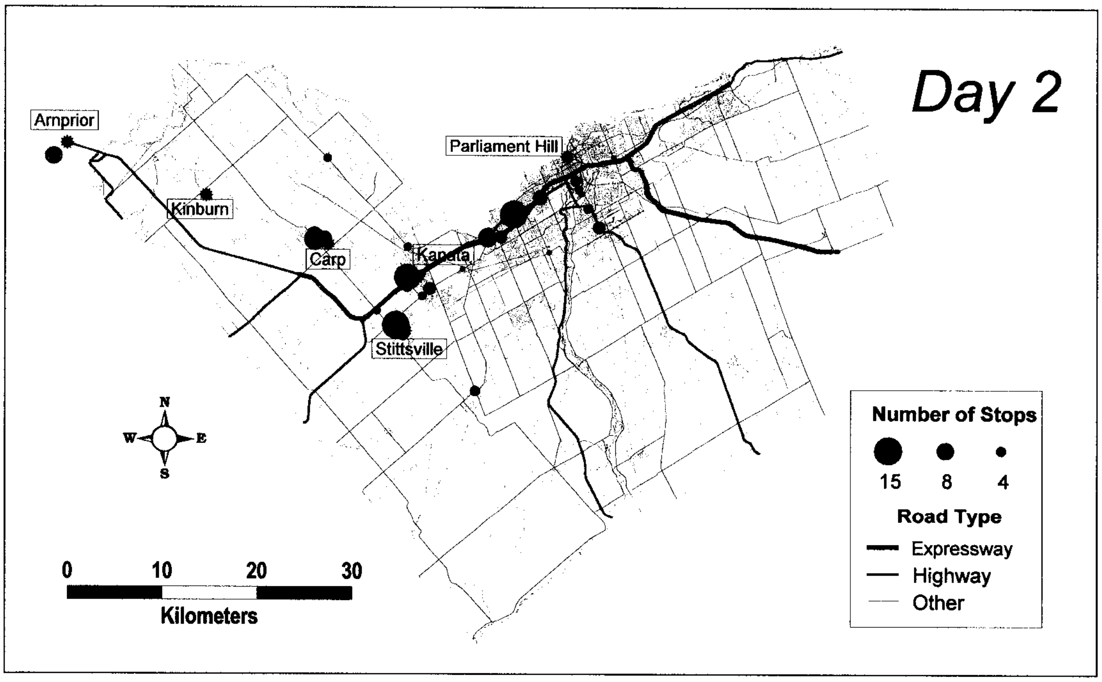


Figure 33: Ottawa Shopping Locations (continued)

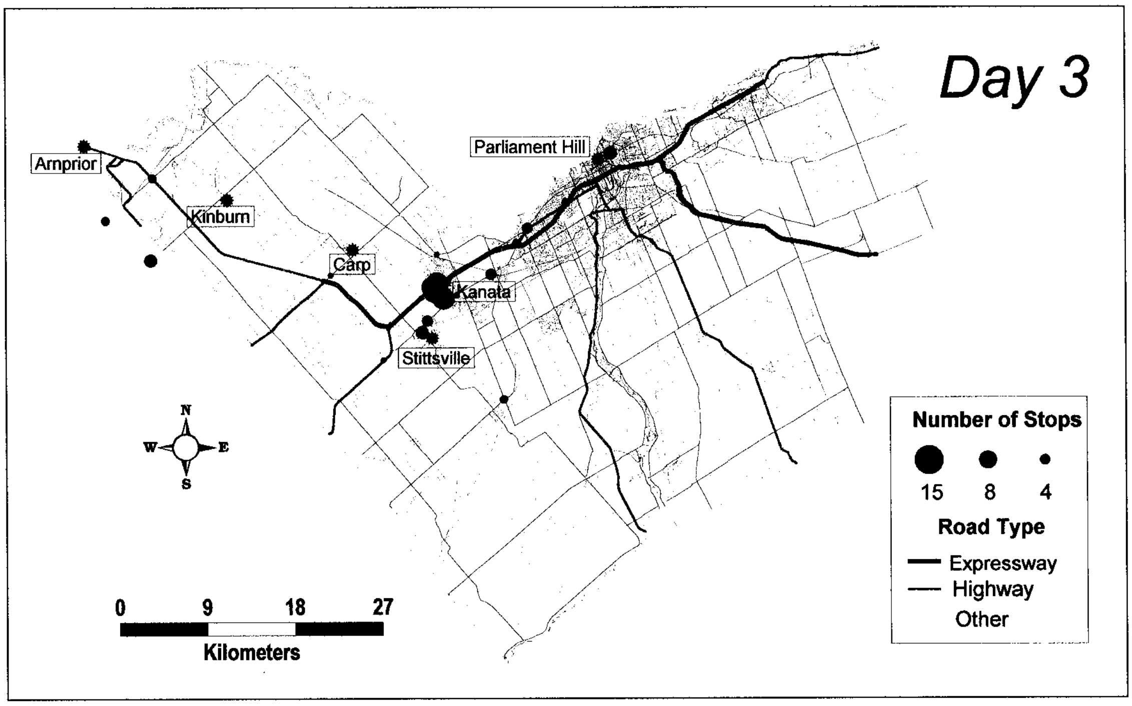
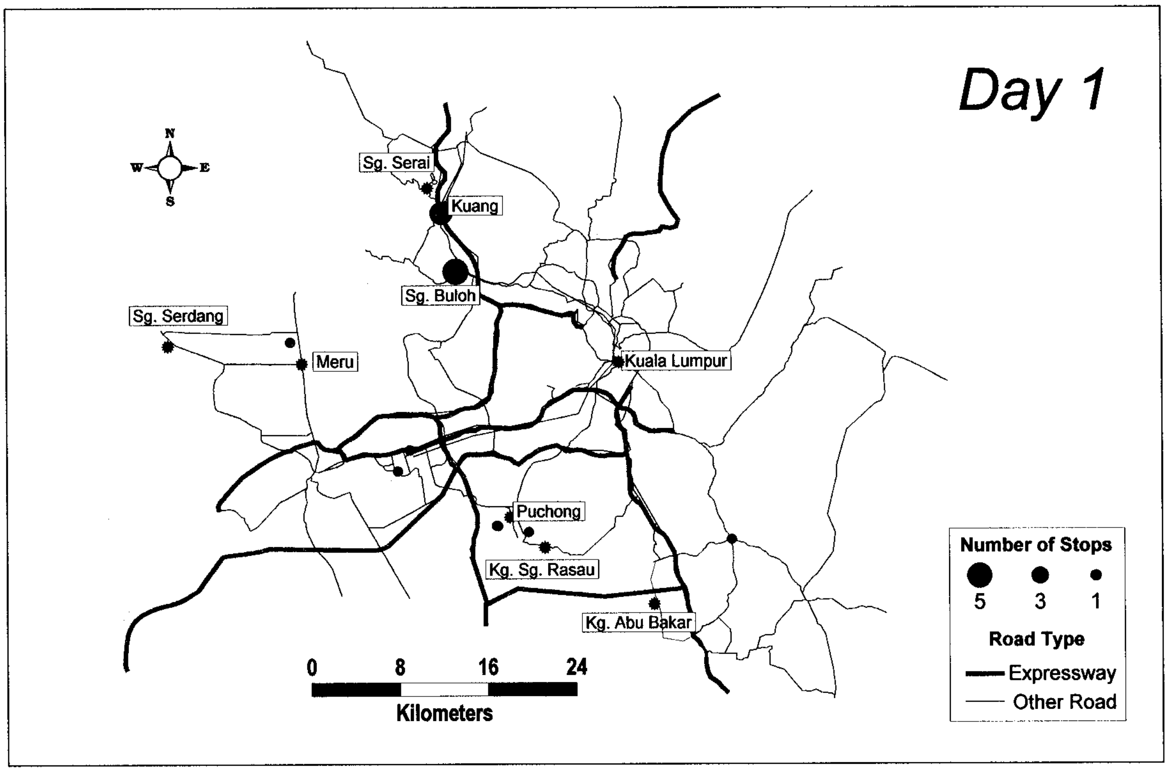


Figure 34: Kuala Lumpur Shopping Locations



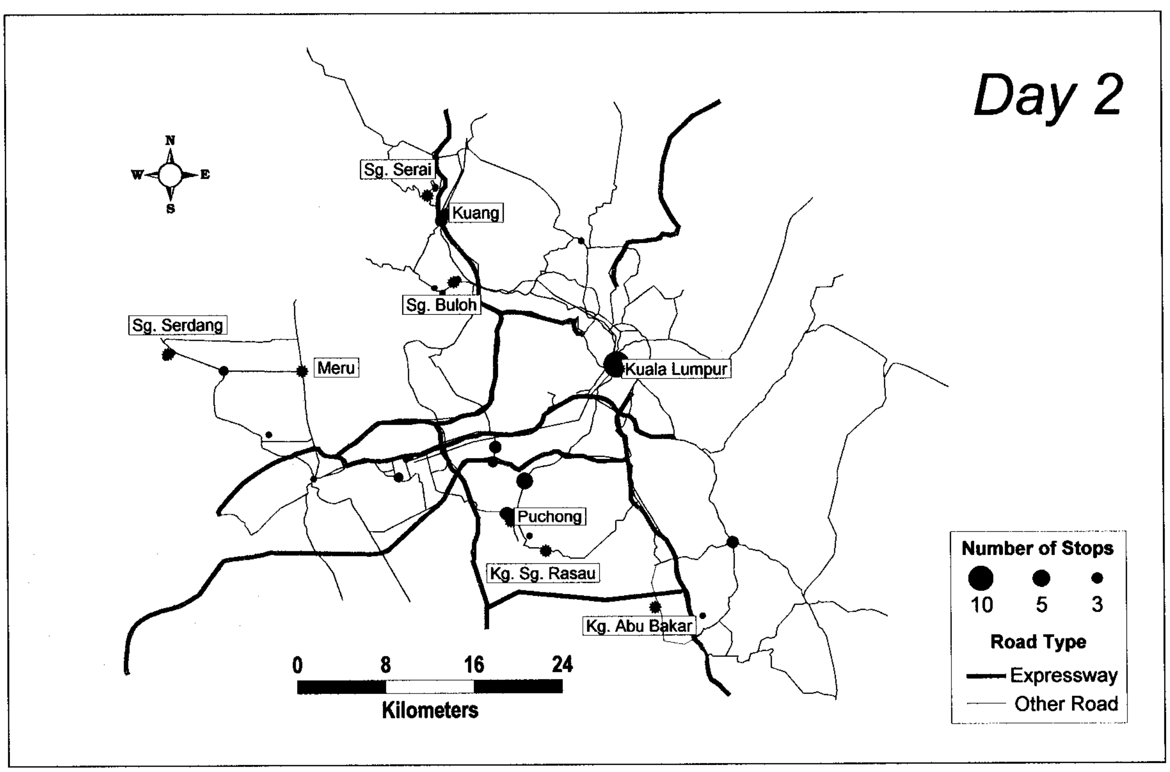


Figure 34: Kuala Lumpur Shopping Locations (continued)

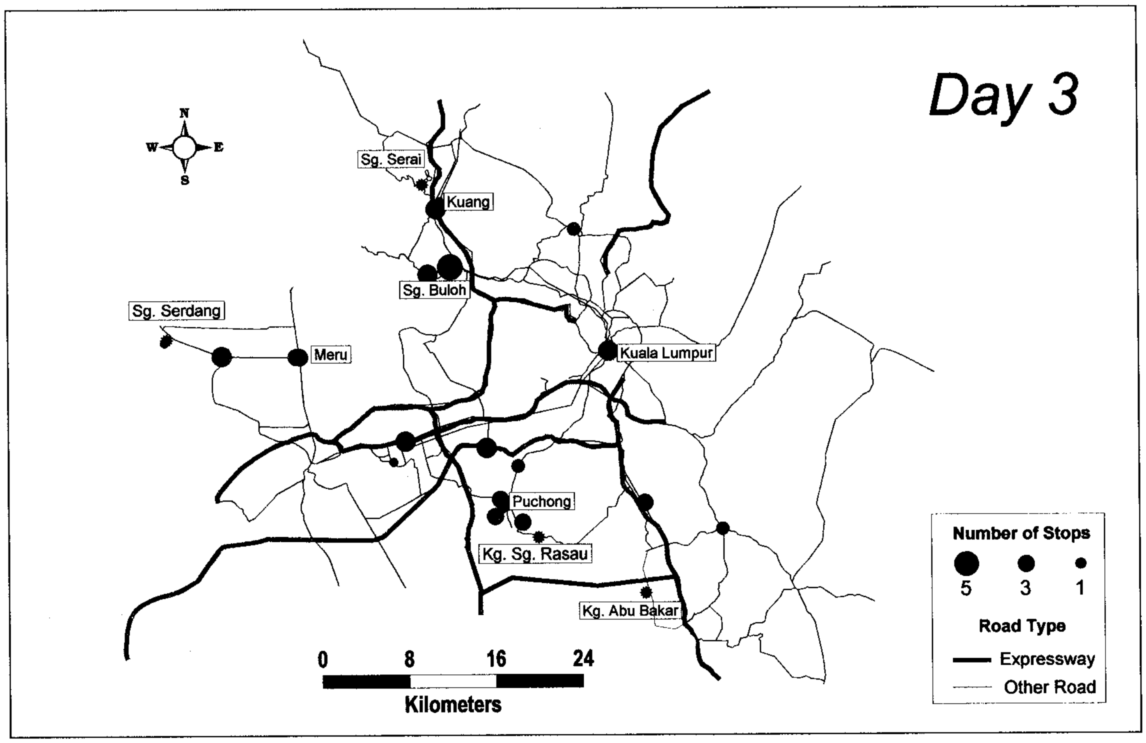


Figure 35: Yogyakarta Shopping Locations

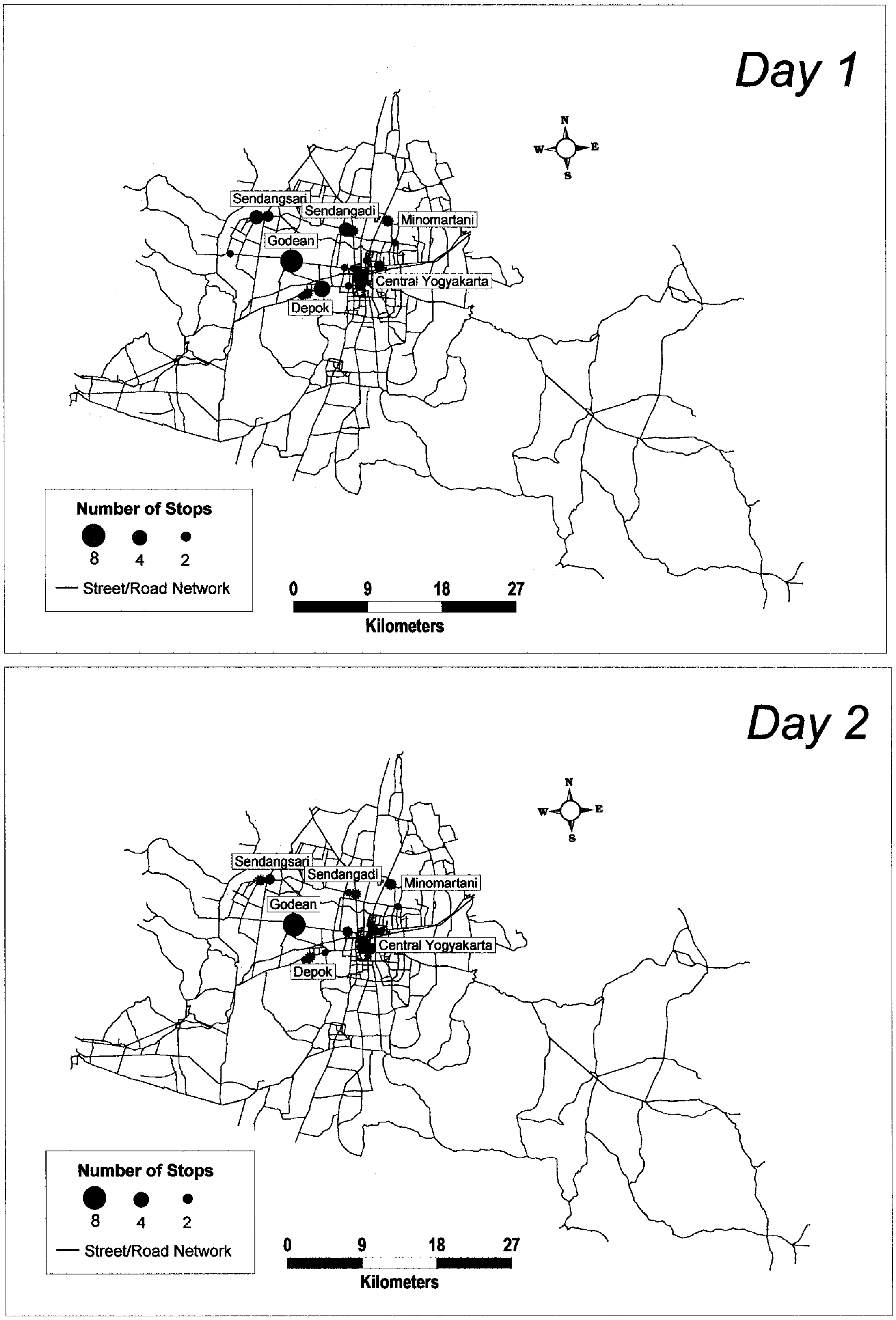


Figure 35: Yogyakarta Shopping Locations (continued)

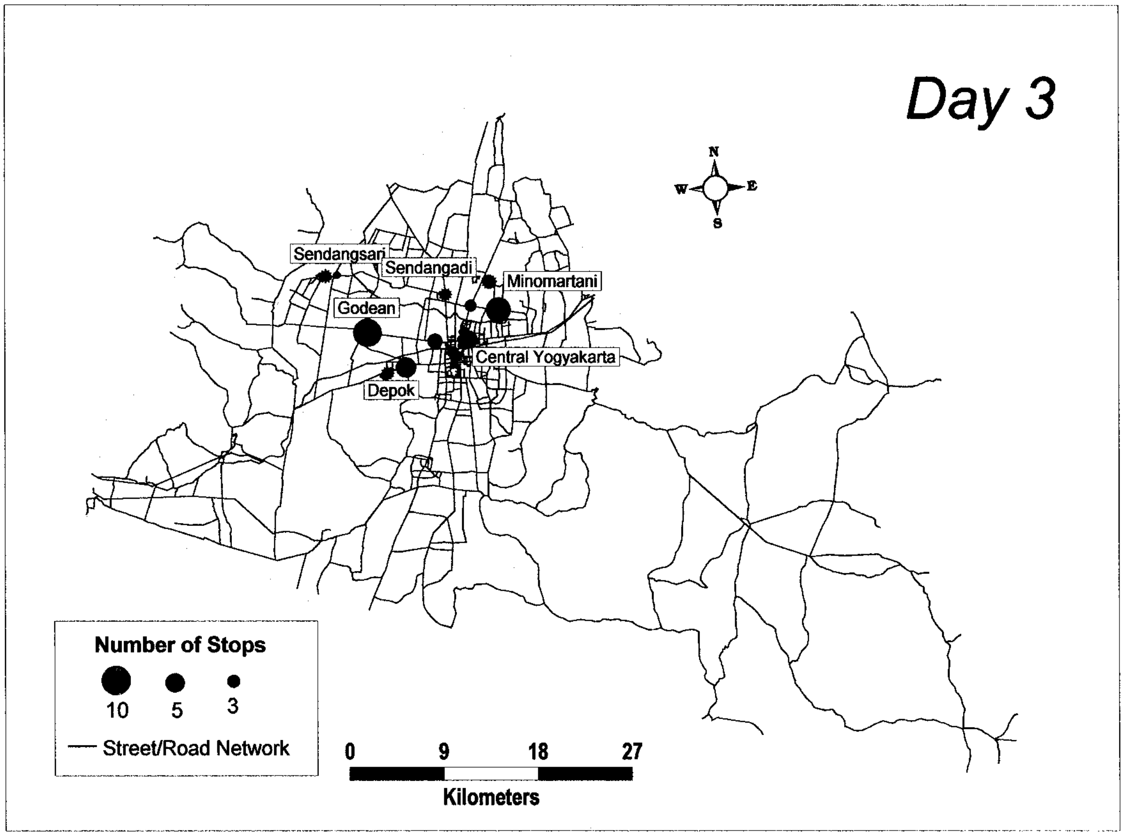


Table 73: Ottawa Day 2 Types of Urban Fringe Shopping Stops

Shop Type	*n*	%
Farmer's Market	16	26.2%
Grocery	14	23.0%
Convenience	4	6.6%
Newspaper	4	6.6%
Real Estate	4	6.6%
Other	19	31.0%
TOTAL	**61**	**100%**

Comparing the average length of shopping tours, Table 74 shows that the three field sites fall into the same ranking as for work tours (Table 71), with Ottawa having the highest mean shopping distances at 43.7-61.0 km. Kuala Lumpur is second with 16.8-30.8 km and Yogyakarta is the lowest at 8.1-14.9 km. As discussed previously, shopping at nearby local markets (which makes up a substantial proportion of total shopping, see Table 74), is a factor in the lower distances for shopping tours at the Southeast Asian field sites.

On Day 1, shopping tours in Ottawa are approximately the same length (61 km) as work tours (59 km), whereas in Kuala Lumpur and Yogyakarta shopping tours are shorter in length (17 and 8 km) than work tours (28 and 19 km). A difference between Ottawa and the two Southeast Asian field sites is that 32% of Ottawa shopping tours are multi-stop work tours, compared to fewer (6-8%) in Kuala Lumpur and Yogyakarta. This means that on Day 1 there is some overlap among the work and shopping tours in Ottawa, whereas work and shopping tours are separate journeys in the two Southeast Asian field sites.

Table 74: Characteristics of Shopping Tours by Field Site

Field Site	Single Stop (SS), Multi-Stop (MS), Non-Work Tour (NWT), Work Tour (WT)										
Day 1	Distance * (km)	*n* tours	SS	MS	%MS	SS NWT	MS WT	MS NWT	%SS NWT	%MS WT	%MS NWT
Ottawa	60.98	56	6	50	89%	6	18	32	11%	32%	57%
Kuala Lumpur	16.84	18	17	1	6%	17	1	0	94%	6%	0%
Yogyakarta	8.11	36	26	10	28%	26	3	7	72%	8%	19%
Day 2											
Ottawa	43.67	90	21	69	77%	21	9	60	23%	10%	67%
Kuala Lumpur	30.83	49	36	13	27%	36	5	8	73%	10%	16%
Yogyakarta	14.86	32	21	11	34%	21	5	6	66%	16%	19%
Day 3											
Ottawa	53.33	49	14	35	71%	14	4	31	29%	8%	63%
Kuala Lumpur	23.28	61	58	3	5%	58	1	2	95%	2%	3%
Yogyakarta	8.57	39	33	6	15%	33	0	6	85%	0%	15%

Analysis was conducted on those respondents who were surveyed and made tours on the particular survey day and who made at least one stop for shopping.

*Distance of whole tour, not direct distance from home.

5.5.2.1 *Frequency of Travel and Village Dwelling in Ottawa*

Frequency of travel is defined in this study as the rate of making tours (departing home and returning) over the course of a day. To investigate differences in the frequency of travel among village and non-village dwellers, a series of two sample t-tests (95% confidence interval) were conducted on the Ottawa survey data for Days 1, 2 and 3.

Two separate tests compared village to non-village (estate lot, rural lot or working farm) dwellers. The first test examined the number of tours per day, while the second investigated mean daily tour length.

Results of the first hypothesis test in Table 75 illustrate that on Days 1 and 3, respondents living in a village make a significantly higher number of tours (Day 1 mean: 1.9, Day 3 mean: 1.7) compared to those who live outside a village (Day 1 and Day 3 mean: 1.3).

Table 75: Ottawa Number of Daily Tours by Village and Non-Village Residential Location

Day	LIVE IN VILLAGE			LIVE OUTSIDE VILLAGE				
	n	Mean Tours*	Std. Deviation	*n*	Mean Tours*	Std. Deviation	*p*	Significant
1	56	1.8571	1.1974	55	1.3091	0.6346	0.0033	✓
2	58	1.6724	1.0660	46	1.5652	0.7196	0.5431	No
3	45	1.6667	0.9293	40	1.2500	0.6304	0.0169	✓

Analysis includes only those respondents who were surveyed and made tours on the particular survey day and who were greater than or equal to 20 years of age.

*Excluding recreational walk tours. If recreational walk tours are included. Day 1 p=0.0033, Day 2 p=0.3987, Day 3 p=0.0030.

The results for Day 2, however, show that there is not a statistically significant difference between the number of tours made by village dwellers compared to non-village dwellers (see Table 75).

It is postulated that there is a relationship between the number of tours made and mean daily tour length for non-village dwellers. Specifically, it is hypothesized that respondents living outside villages make fewer and longer tours on Days 1 and 3 (compared to village dwellers). Conversely, on Day 2 when the number of tours made by village and non-village dwellers is not statistically different, it is hypothesized that equally the tour length will not (significantly) differ between the two groups.

Examining Table 76, the hypothesized relationship is reflected in the results of a series of two sample t-tests showing that on Days 1 and 3 non-village dwellers make significantly longer tours, compared to village dwellers. It is noted that on Day 3, even when the "working farm" category (whose members made long tours on Day 3) is removed, the non-village group still makes significantly longer tours than the village dwellers. By contrast, on Day 2, there is not a significant difference in the length of tours between village and non-village dwellers.

Table 76: Ottawa Mean Tour Length by Village and Non-Village Residential Location

Day	LIVE IN VILLAGE			LIVE OUTSIDE VILLAGE				
	n *tours*	Mean Distance (km)*,**	Std. Deviation (km)	*n* *tours*	Mean Distance (km)*,**	Std. Deviation (km)	*p*	Significant
1	104	27.32	27.95	72	62.91	39.93	0.0000	✓
2	97	31.86	36.79	72	40.41	33.20	0.1162	No
3	75	25.31	27.14	50	57.23	41.31	0.0000	✓

Analysis includes only those respondents who were surveyed and made tours on the particular survey day and who were greater than or equal to 20 years of age.

*Distance of whole tour, not direct distance from home.

**Excluding recreational walk tours.

Next, the reasons for the difference in Day 2 travel patterns (compared to Days 1 and 3) as related to village and non-village dwellers are explored. Table 75 shows that for those who live in a village, the number of tours on Day 1 (mean: 1.9) is higher than that on Days 2 and 3 (mean both days: 1.7). For respondents living outside a village, the mean number of tours is the same on Days 1 and 3 (mean: 1.3) and higher on Day 2 (mean: 1.6).

Examining Table 76, the mean tour length of respondents living in a village is similar Days 1 and 3 (25-27 km), and only slightly higher on Day 2 (32 km). For respondents living outside a village, the tour length is not markedly different between Days 1 and 3 (63 km and 57 km), but is substantially lower on Day 2 (40 km).

From these observations, it is concluded that on Day 2, it is the behaviour of the *non-village dwellers* that has changed compared to that of the village dwellers. Specifically, the non-village dwellers make more tours and make shorter tours on Day 2 compared to Days 1 and 3. The reasons for the change in non-village dwellers' behaviour are investigated by examining destinations and reasons for travel on Day 2.

Referring to the destination analysis on page 202, it is noted that there is an increase in urban fringe stops on Day 2, compared to Day 1 (among those who travelled). This is attributed to a rise (16%) in urban fringe shopping stops on Day 2 compared to Day 1. Urban fringe and suburb shopping stops on Day 2 make up 54% of the Day 2 total compared to 31% on Day 1. In addition, review of the "reason for travel" section (Table 68) reveals that shopping is the most common stop purpose on Day 2 accounting for 37% of all stops.

Combining these two pieces of evidence points to the non-village dwellers making a higher percentage of their daily stops for shopping at locations closer to home compared to destinations on Days 1 and 3, resulting in a higher number of daily tours and shorter tours on Day 2 compared to other days. This is plausible since Day 2 is a non-work day for the majority of the Ottawa population and therefore respondents are home-based, rather than work-based, so their travel patterns are more likely to be centred around home. As documented earlier, Day 2 is the peak shopping day of all survey days, so non-village dwellers are likely travelling to shopping opportunities in closer proximity (in urban fringe and suburbs) compared to the other survey days.

In summary, it was found that on Days 1 and 3, village dwellers had a higher frequency of travel and made shorter tours than non-village dwellers. On Day 2, there was no significant difference found in the frequency of travel (based on the number of tours made) between the village and non-village dwellers. Equally, there was no difference between the two groups on the basis of tour length. The lack of difference between village and non-village dwellers in the number of tours and tour length on Day 2 (compared to Days 1 and 3) is attributed to a change in the behaviour of the non-village dwellers. The change is thought to be related to the non-village dwellers making a greater percentage of their daily stops for shopping at locations closer to home compared to the other two survey days.

At a more general level, for non-village dwellers there appears to be an inverse relationship in the Ottawa dataset between the frequency of travel (defined as the number of daily tours) and tour length.

5.6 *COMPLEXITY OF TRAVEL*

In this section the field sites are compared on the basis of travel complexity, then a more detailed look is taken at the characteristics of the grocery shopping tours of respondents in the Ottawa survey.

Complexity of travel is defined in this study as longer tour distances, tours with more than one stop (multi-stop tours), and travel to destinations past the next closest service centre.

Examination of Table 74 on page 217 reveals that Ottawa has the longest shopping tours (44-61 km) and the most multi-stop tours (89% on work day and 71-77% on non-work day). By contrast, Kuala Lumpur and Yogyakarta have shorter mean distances (Kuala Lumpur 17-31 km, Yogyakarta 8-15 km) and less multi-stop tours (Yogyakarta 28-34%, Kuala Lumpur 5-27% non-work day). Based on the tour complexity criteria, Ottawa is judged as having the most complex travel.

5.6.1 ANCHOR POINTS AND THE HOME-WORK CORRIDOR

Cullen and Godson (1972, p. 9) were among the early authors to allude to the propensity by which travellers structure their travel around fixed points, as described in the following quote:

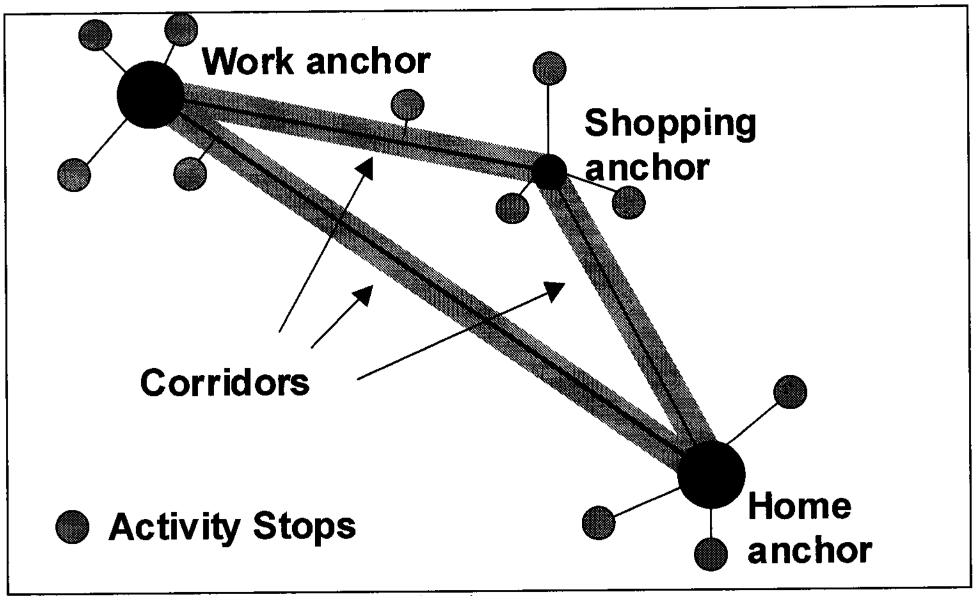
> "Activities to which the individual is strongly committed and which are both space and time fixed, or just time fixed, tend to act as pegs around which the ordering of other activities is arranged and shuffled according to their flexibility ratings."

In 1975, Golledge (1975) advanced the anchor point theory which holds that an individual's travel patterns are fixed around key locations, known as *anchor points*. Golledge and Stimson (1997, p. 167) note that "home, work and shopping tend to serve as the initial primary nodes and are among the major anchor points from which the rest of the hierarchy develops" as shown in Figure 36. Opportunities surrounding or connected with an individual's home, work and shopping anchor points are visited as a result of their proximity to or connection with the anchor point.

The term *corridor* refers to the channels through which travellers move to reach their anchor points. The corridor concept is explored in this research to explain the type of accessibility that many urban fringe dwellers (especially commuters) experience.

Many previous travel studies have considered only "home" as the point around which travel hinges, but as Golledge suggests the work-linked trip is also very important. This study explores the degree and extent to which other anchor points, beside work and home, are relevant for some individuals. For instance, an individual's anchor points may

Figure 36: Schematic Diagram of Anchors and Corridors



*Adapted from Golledge and Stimson (1997)

change over his/her lifespan. While employed people will likely have *work* as an anchor point (Golledge, 1997), other individuals such as the unemployed, students and retired persons will orient their travel activity towards *other anchor points* besides work (in addition to the home anchor point). In this sense, an anchor point isn't necessarily a "mandatory" point to visit, it can also be a discretionary one.

Commuters are hypothesized to develop new anchor points between home and the urban centre as a result of spatial knowledge obtained through their home-work commute, while home-based urban fringe dwellers are hypothesized to develop new anchor points locally (Golledge and Stimson, 1997). The larger urban centre exerts a greater gravitational pull (wider range of opportunities are available in the larger urban area), except in some cases where people have lived in a local area their entire lives and therefore have more habit-driven and loyalty-driven travel resulting in localized anchor points.

It is hypothesized that the longer travel distances and times in Ottawa are leading to multi-stop tours. Ottawa's Day 1 has the longest mean travel distance (61 km) for Ottawa shopping tours, compared to the other two days. Approximately 32% of the shopping tours on Day 1 are multi-stop work tours (see Table 74) in which commuters stop in the *home-work corridor* on their way to and from work. The concept of the "anchor point" (Cullen and Godson, 1972; Golledge, 1975) along with the concept of the *home-work corridor* is used to generally describe the behaviour of some urban fringe dwellers - path in which commuters travel to work, and also the area in which they may make non-work related stops.

Grocery shopping at the Ottawa site is examined as a case study to investigate the travel characteristics of those who make shopping stops on the way to/from work.

5.6.2 Grocery Shopping Tours

On the Ottawa questionnaire respondents were asked whether grocery shopping was the:

a) main objective of a single purpose trip from *home*;
b) main objective of a multi-purpose trip from *home* in conjunction with other errands;
c) secondary objective of a multi-purpose trip from *home* in conjunction with other errands;
d) secondary objective on a trip to and from *work;* and/or
e) other.

Survey respondents were grouped according to whether they conducted their grocery shopping "from home" (a, b, c) or on the "home-work" trip (d). Two-sample t-tests (95% confidence interval) were undertaken to test the following hypotheses designed to explore whether respondents who work and who do their grocery shopping in the home-work corridor:

1) live a greater distance from a full-line grocery store;
2) travel a greater distance on Day 1 (a work day) compared to those who do their shopping from home;
3) live a greater distance from downtown Ottawa; and,
4) go past the nearest major Ottawa suburban service centre (Kanata) less frequently than those who do their shopping from home.

Distance to Nearest Grocery Store

The first hypothesis, whether those who do their grocery shopping on a work trip live a greater distance from a full-line grocery store was tested by calculating the shortest path network distance to the nearest full grocery store (<u>not</u> convenience store), and then testing those distances grouped by whether the respondents report doing their grocery shopping from home or on a tour to/from work. As shown in Table 77, those respondents who do shopping on a trip to/from work live at a significantly (<=0.05 level) greater distance from a full grocery store than respondents who do their grocery shopping from home.

Table 77: Ottawa Grocery Shopping and Distance to Nearest Grocery Store

Group	*n*	Mean (km)	Std. Deviation (km)
From Home	20	9.08	7.55
Home-Work	15	14.85	7.31
$p = 0.0299$			

Analysis only includes respondents who are >=20 years of age and who travelled to an external (outside the home) work location during the survey period.

Total Day 1 Travel Distance

The second hypothesis tests whether those who do their grocery shopping in the home-work corridor travel a greater distance on Day 1 (work day), compared to those who do their shopping from home. Total Day 1 travel distance (excluding recreational walks) was grouped by whether the respondents report conducting their grocery shopping from home or on a tour to/from work (see Table 78).

Table 78: Ottawa Grocery Shopping and Total Day 1 Travel Distance

Group	*n*	Mean* (km)	Std. Deviation (km)
From Home	20	54.75	30.55
Home-Work	15	93.05	38.77
$p = 0.0040$			

Analysis only includes respondents who were surveyed and made tours on Day 1, and who are >=20 years of age and who travelled to an external (outside the home) work location during the survey period.

*Excludes recreational walk distance.

As shown in Table 78 those who do grocery shopping in home-work corridor, travel a greater distance on Day 1 (93 km) than those that shop from home (55 km).

Distance from Downtown Ottawa

In the next hypothesis test the (shortest path network) distance to downtown Ottawa (defined as Parliament Hill) was calculated for each respondent. The distances are grouped by whether the respondents reported conducting their grocery shopping from home or in the home-work corridor. The results are presented in Table 79.

Table 79: Ottawa Grocery Shopping and Distance from Downtown Ottawa

Group	*n*	Mean (km)	Std. Deviation (km)
From Home	20	33.35	7.94
Home-Work	15	42.79	9.05
$p = 0.0033$			

Analysis only includes respondents who are >=20 years of age and who travelled to an external (outside the home) work location during the survey period.

Those who do their grocery shopping in the home-work corridor live a significantly greater distance from the city centre compared to those who do their shopping from home. That is, as displayed in Table 79, those who do their grocery shopping from home live a mean group distance of 33 km from the city centre, compared to 43 km for those who do their grocery shopping in the home-work corridor.

Frequency of Non-Work Tours Past Kanata

For the Ottawa survey, respondents were asked how many times (per month) they travel past the nearest major Ottawa suburban service centre (Kanata), into central Ottawa, for purposes other than work.

The respondents' reported frequency of making non-work tours past Kanata was grouped by whether they conduct their grocery shopping from home or on a home-work tour. Results of a two-sample t-test are presented in Table 80.

Table 80: Ottawa Grocery Shopping and Frequency of Reported Non-Work Tours Past Kanata

Group	*n*	Mean (tours per month)	Std. Deviation (tours per month)
From Home	19	3.9647	2.4999
Home-Work	14	2.1786	2.4148
$p = 0.0477$			

Analysis only includes respondents who are >=20 years of age and who travelled to an external (outside the home) work location during the survey period.

As shown by Table 80, the finding is that among respondents who work those who do grocery shopping in the home-work corridor report travelling past Kanata (into central Ottawa) less frequently (group mean of 2.2 tours per month) for non-work purposes than those who do shopping from home (group mean of 4.0 tours per month).

The results of the above hypotheses tests suggest that, compared to those who grocery shop from home, respondents who report conducting grocery shopping in the home-work corridor travel a greater distance on Day 1, live a greater distance from downtown Ottawa, live a greater distance from a full-line grocery store, make less tours on Day 1, and report going past Kanata less frequently for non-work purposes. These results provide evidence that shopping in the home-work corridor is an economizing measure adapted by those travelling long, daily distances.

A detailed look at a sample site breakdown of Ottawa grocery shopping by access point (from home, or in the home-work corridor) is displayed in Table 81. It is noticeable that the estate lots and rural lots have a higher percentage (~47%) of respondents reporting grocery shopping in the home-work corridor, compared to those of other sample sites.

Table 81: Ottawa Grocery Shopping Access Point by Sample Site

Sample Site	From Home	Home-Work	Total	%Home-Work
Carp	7	1	8	13%
Kinburn	6	0	6	0%
Estate Lot	8	7	15	47%
Rural Lot	10	9	19	47%
Stittsville	16	1	17	6%
Working Farm	5	0	5	0%
TOTAL	**52**	**18**	**70**	

At a general level, then, there is a sub-group in the Ottawa sample that economizes by shopping in the home-work corridor, and has a reduced reported frequency of travelling past Kanata for purposes other than work. However, there are others within the Ottawa sample who are drawn to the city more frequently for non-work purposes. The pull towards the city is examined in the next section.

5.7 SPATIAL FAMILIARITY

Travel is defined by current as well as past anchor points (e.g. previous dwelling or workplace location), as noted by Kwan (1998). An individual may undertake travel to familiar parts of the city due to having previously lived or worked, or having another connection with that place. One way to incorporate a respondent's familiarity with an urban area is to ask respondents about which areas of the city they are familiar, and conduct the study by placing a grid over the city map (Kwan, 1998). The present research suggests that a more focussed and reliable way of obtaining this information in this study is to ask the survey respondents about past home and work locations in the urban area.

In the Ottawa survey, respondents were asked if they had lived in the local area when they were 5 years old. This question was asked to obtain a measure of how familiar they were with the immediate local area (not necessarily the larger urban area), and thus how historically fixed their home-based travel patterns might be. The data were also collected in order to compare the travel patterns of longtime residents, with those of newer immigrants to the local area.

The answer to this question in combination with an archival telephone book search, established if the respondents had lived in the urban area of Ottawa (suburbs or core) prior to moving to the urban fringe. Respondents were classified into two groups: "lived in city moved to fringe" or "did not live in city". These respondents could include both commuters and non-commuters.

A series of two sample t-tests (Table 82) were conducted on the general location of a respondent's stops (central city, suburb, urban fringe, outlying centre) over the three survey days. It was found that those respondents who had lived in the city previously had a higher number of mean (absolute) stops in the city centre on Days 1 and 3, and in the suburbs on Days 1 and 2 than those who had not lived in the city. That is, it appears that they make less stops in outlying areas on Day 1, presumably because they are pulled in the opposite direction towards the city centre. And, conversely, those who have never lived in the city make more stops in outlying centres on Day 1, compared to those who previously lived in the city.

Table 82: Ottawa General Location of Stops by Respondent Residential History

	Day	LIVE CITY MOVE FRINGE*			NOT LIVE CITY*				
		n	Mean Stops	Std. Deviation	*n*	Mean Stops	Std. Deviation	*p*	Significant
CC	1	60	1.05	1.17	41	0.54	0.95	0.0173	✓
	2	58	0.91	1.67	40	0.40	1.01	0.0609	No
	3	57	0.65	1.43	40	0.10	0.30	0.0067	✓
SUB	1	60	1.42	1.75	41	0.63	1.16	0.0080	✓
	2	58	1.02	1.53	40	0.35	0.66	0.0041	✓
	3	57	0.63	1.19	40	0.38	0.93	0.2357	No
UF	1	60	1.23	1.85	41	1.32	1.44	0.7992	No
	2	58	1.60	1.73	40	1.25	1.43	0.2721	No
	3	57	0.65	1.01	40	1.08	1.87	0.1953	No
OC	1	60	0.10	0.44	41	0.59	1.40	0.0365	✓
	2	58	0.14	0.35	40	0.43	0.93	0.0687	No
	3	57	0.30	0.98	40	0.65	1.44	0.1849	No

*Analysis only includes respondents who were surveyed and who made tours and whose age>=20 years.

To provide a confirmation of the increased pull of the city centre and suburbs on those respondents who had previously lived in the city, the respondent's reported frequency of trips per month past Kanata for work purposes are grouped by the two residential history types.

A two-sample t-test (Table 83) provides an added indication that those who lived in city previously travel into central Ottawa more frequently on a monthly basis (5.8 tours per month) for non-work purposes, than those who had not lived in the city (2.9 tours per month).

Table 83: Respondent Residential History and Frequency of Reported Non-Work Tours Past Kanata

Group	*n*	Mean (tours/month)	Std. Deviation (tours/month)
Live city move fringe	51	5.7776	4.7821
Not live city	30	2.9057	2.8474
$p = 0.0011$			

Analysis only includes only those respondents >=20 years of age.

Ottawa respondent residential history (lived in city moved to fringe, did not live in city) are shown in Table 84 disaggregated by sample site. Kinburn and the working farm categories have a lower percentage of respondents who had previously lived in the city.

Table 84: Ottawa Respondent Residential History by Sample Site

Sample Site	LIVE CITY MOVE FRINGE (LCITYMFR)	NOT LIVE CITY	TOTAL	%LCITYMFR
Carp	6	7	13	46%
Estate Lot	16	0	16	100%
Kinburn	1	6	7	14%
Rural Lot	14	10	24	58%
Stittsville	23	9	32	72%
Working Farm	0	9	9	0%
TOTAL	**60**	**41**	**101**	

General interpretation of the evidence suggests that respondents who have lived in the city previously are likely to have a greater connection to the central city on Days 1 (work day) and 3 (non-work day), and to the suburbs on Days 1 and 2 (non-work day) and less connection to outlying centres on Day 1, when compared to those who have not lived in the city. The reasoning here is that the opportunities available in the city, combined with a person's familiarity with the city through having lived or worked there (on Day 1) influences travel to the city on non-work days (Days 2 and 3).

5.8 *Synthesis and Summary*

Ottawa and Yogyakarta show a similar rate (3-4%) of respondents not travelling on a working day. By contrast, Kuala Lumpur has a higher rate, with 21% of the sample not travelling on Day 1. This 21% is composed mainly of females over the age of 25. Increased rates of "no tours" are evident in all three field sites on non-working days ranging from 11% in Yogyakarta to 56% in Kuala Lumpur.

The car is used for the majority of travel in Ottawa (74-82% of tours and 93-99% of distance). In Kuala Lumpur, the car has the largest single modal share, but it is less than in Ottawa (24-44% of tours and 40-79% of distance), followed by the bus and motorcycle. The motorcycle, as a mode, is used for the greatest percentage of tours and accounts for the largest share (38-58%) of kilometres travelled in Yogyakarta, followed by the car and bus.

The wider variety of modes in Yogyakarta and Kuala Lumpur leads to a more diverse modal share, compared to Ottawa's car-dominated environment. Yogyakarta's modal variability is higher than that of Ottawa and Kuala Lumpur, particularly for residents whose age is 20 or more years. This may be due to the lower vehicle ratio in Yogyakarta, combined with a wider variety of modes available. Amalgamating the findings from the three field sites, the less than 20 year-old age group has significantly higher modal variability than those greater than or equal to 20 years of age. This higher modal variability may be due to the lack of a personal vehicle among the young.

Car tours as a percentage of total increases while bus travel decreases in all field sites on non-work days. Ottawa has the highest mean total travel distances over the three survey days, followed by Kuala Lumpur and Yogyakarta. Mean distance is the same across the three survey days in Ottawa, but is higher on non-work days in Kuala

Lumpur and Yogyakarta when compared to work days. In Kuala Lumpur intercity trips back to the "*kampung*", and in Yogyakarta "refreshing" trips to outlying areas, lead to increased mean distances on Day 3. Farming respondents on Day 3 in Ottawa have the highest average distance compared to the other sample sites, mainly due to their leisure travel to outlying centres.

The total reported daily travel times are longer in Ottawa (69-79 minutes) than in Kuala Lumpur (50-65 minutes) and Yogyakarta (52-62 minutes). Ottawa has the fastest average speed (43-46 km/h), followed by Kuala Lumpur (25-35 km/h) and Yogyakarta (21-27 km/h). The greater modal share of the car in Ottawa is likely contributing to the higher total speed when compared to the other field sites.

A larger percentage of Kuala Lumpur's (65-76%) and Yogyakarta's (54-58%) total stops are made in the urban fringe, compared to Ottawa (38-51%). Disaggregating total stops in Kuala Lumpur, 56% of work stops (including farming) are in the urban fringe, compared to 62% in Yogyakarta, and 33% in Ottawa. Reflecting the location of work stops, the average work tour in Ottawa is much longer (59 km) than that in Kuala Lumpur (28 km) and Yogyakarta (19 km). In the Ottawa survey, approximately 65% of work stops are in the central city and suburbs.

A high proportion (50-89%) of shopping stops in Kuala Lumpur and Yogyakarta are made in the urban fringe and consequently the average shopping tour is shorter in Kuala Lumpur (17-31 km) and Yogyakarta (8-15 km) than in Ottawa (44-61 km). Higher densities in the urban fringe areas of Kuala Lumpur and Yogyakarta may be able to support greater services. Approximately 57-72% of shopping stops in the Ottawa survey are in the suburbs and central city.

Approximately 18-62% of all shopping stops in the Southeast Asian field sites are made to the "local market". All kinds of goods are typically sold at the market, so there may be less need to make multi-stop tours at different supply depots. A once a week market located in Ottawa's urban fringe increases urban fringe shopping stops among respondents by 16% (of total stops) compared to Day 1.

Ottawa has the longest shopping tours (44-61 km) and the most multi-stop tours (89% on work day, and 71-77% on non-work day). By contrast, Kuala Lumpur and Yogyakarta have shorter mean shopping tours (Kuala Lumpur 17-31 km, Yogyakarta 8-15 km) and less multi-stop tours (Yogyakarta 28-34%, Kuala Lumpur 5-27% non-work day).

On Day 1 in Ottawa shopping tours are nearly the same length (61 km) as work tours (59 km), compared to Kuala Lumpur and Yogyakarta where shopping tour distances are lower (17 and 8 km) than work tours (28 and 19 km). The equal shopping and work tour distances in Ottawa can be partially explained by a higher proportion of multi-stop work tours (32%), compared to Kuala Lumpur and Yogyakarta, meaning that a third of the shopping tours are also work tours. By contrast, in Kuala Lumpur and Yogyakarta, only 6-8% of shopping tours are multi-stop work tours. Therefore, in the two Southeast Asian field sites the majority of Day 1 work and shopping tours are separate events.

Tour length is further explored as it relates to frequency of travel. Frequency of travel is defined in this study as the rate of making tours. Comparing village and non-village dwellers on Days 1 and 3, it was found that village dwellers made a significantly higher number of tours and made shorter tours compared to non-village dwellers. However, on Day 2 there was no difference between the two groups based on the number of tours or tour length owing mainly to an increase in the number of daily tours and a decrease in tour length of non-village dwellers. The change in the non-village dwellers behaviour on Day 2 is attributed to the non-village dwellers making a higher percentage of their daily stops for shopping at locations closer to home compared to the other two survey days. In addition to this specific finding, the analysis shows an inverse relationship between the frequency of travel and tour length for non-village dwellers.

It is hypothesized that the longer travel distances and times in Ottawa, recognized as "complex" travel behaviour, are leading to multi-stop tours. Ottawa Day 1 has the longest mean travel distance (61 km) for Ottawa shopping tours, compared to the other two days. Approximately 32% of the shopping tours on Day 1 are multi-stop work tours in which commuters stop in the "home-work corridor" on their way to and from work. Shopping and other opportunities located near interchanges of the major highway leading in and out of the city facilitates non-work stops on the home-work journey. The term *home-work corridor* is used to generally describe the path in which commuters travel to work, and the area in which they may make non-work related stops.

Grocery shopping at the Ottawa site is examined as a case study to ascertain the travel characteristics of those who make shopping stops on the way to/from work. Hypothesis testing suggests that compared to those who grocery shop from home, respondents who conduct grocery shopping in the home-work corridor travel a greater distance on Day 1, live a greater distance from downtown Ottawa, and report going past Kanata less frequently for non-work purposes. These results provide evidence that shopping in the home-work corridor is an economizing measure adapted by those travelling long daily distances.

Within the Ottawa sample there is a sub-group that economizes by shopping in the home-work corridor and reports a reduced frequency of travelling past Kanata for purposes other than work. There is also another group within the Ottawa sample who is drawn to the city more frequently for non-work purposes.

A series of two sample t-tests were conducted on the general location of a respondent's stops (central city, suburb, urban fringe, outlying centre) over the three survey days. It was found that those respondents who had lived in the city previously had a higher number of mean (absolute) stops in the city centre on Days 1 and 3, and in the suburbs on Days 1 and 2 than those who had not lived in the city. They are less likely to make stops in outlying areas on Day 1, presumably because they are pulled in the opposite direction towards the city centre. The job opportunities and amenities offered by the city, combined with familiarity of the city through having lived or worked there (on Day 1) may influence travel to the city on non-work days (Days 2 and 3).

Migration and mobility patterns within the three cities may also be influencing travel patterns. In Kuala Lumpur, there is some indication that new urban fringe residents typically move directly to the metropolitan and urban fringe area (outside the city core) from other regions of Malaysia (Lee Boon Thong, 1995; McGee, 1995). As a result of not having lived in the city proper, they do not gain spatial knowledge of the city. This combined with a large proportion of job and shopping locations (current anchor points) in the urban fringe, "new towns" decentralized from the city core providing services, and the lesser use of the car (compared to Ottawa) result in the Kuala Lumpur travel patterns being more localized than those in Ottawa.

In Ottawa, by contrast, new urban fringe residents often move from the city out to the urban fringe (Bryant et. al., 1982). Having lived and worked in the city, they have spatial knowledge of the urban area. This background combined with the car as the dominant mode, downtown jobs, amenities and the concentric form of the city, results in greater travel to the central city than in Kuala Lumpur. The distance between Ottawa's urban fringe and the city, on the other hand, does exert friction against the positive attraction, resulting in economizing multi-stop tours of many respondents.

Yogyakarta is a cross between Ottawa and Kuala Lumpur. With a large proportion of respondents' work and shopping locations in the urban fringe, it is similar to Kuala Lumpur with localized travel patterns. The motorcycle, the dominant vehicle mode in Yogyakarta, also is a factor in reducing the range of travel (compared to the car). Differing from Kuala Lumpur in its concentric form (more like Ottawa), Yogyakarta with a greater percentage of respondents' work locations in the central city, the familiarity respondents have with the city centre (through working there), plus the attracting shopping opportunities, draws more non-work travel to the central city compared to Kuala Lumpur.

6. CLASSIFICATION OF TRAVEL PATTERNS

In this chapter cluster analysis is employed to explore travel patterns in Ottawa, Kuala Lumpur and Yogyakarta to search for natural groupings and to compare and contrast each dataset (Everitt, 1974). Also, the analysis investigates if dimensions of the data revealed in Chapter Five reappear in the cluster analysis.

6.1 SELECTION OF ANALYSIS TECHNIQUE

To explore the travel patterns, the analysis procedure (Jackson, 1983) was required to fulfill the following criteria:

- is a multivariate procedure (a series of variables represent the travel patterns);
- does not assign dependent and independent variables (exploration of the data was the objective, not development of a model);
- analyzes "groups" within a dataset;
- *searches* for groups within the data (rather than requiring group membership as an input); and,
- allows for the use of mixed scale variables.

Due to the frequency that "groups" or "segments" of individuals are the object of analysis in numerous kinds of studies, market research literature was consulted. Analytical techniques described by Wedel and Kamakura (1998) used for market segmentation are presented in Table 85. The table categorizes techniques in two ways. First, they are classified on the basis of whether they are:

Table 85: Classification of Methods Used for Segmentation

	A priori (segments identified in advance by researcher)	**Post hoc** (segments identified by results of analyses)
Descriptive (do not assign dependent and independent variables)	Contingency tables	Cluster analysis
	Log-linear models	Fuzzy techniques
		Mixture models
Predictive (assign dependent and independent variables)	Cross-tabulation	AID (*Automatic Interaction Detection)*
	Regression	CART (*Classification and regression trees)*
	Logit	Clusterwise regression
	Discriminant analysis	ANN (*Artificial Neural Networks)*
		Mixture models

Source: Adapted from Wedel and Kamakura, 1998, p. 18.

- *descriptive* (do not assign a dependent and independent variable); and,
- *predictive* (assign a dependent and independent variable).

Second, they are categorized as:

- *a priori* (groups are determined in advance by the researcher); and,
- *post hoc* (groups are determined through the analysis).

Since the analysis criteria dictate a *descriptive* and *post-hoc* procedure, the only techniques recommended are: cluster analysis, fuzzy techniques and mixture models. All three techniques are clustering method variants which fulfill the analysis criteria. Their relative merits are discussed in the next section.

6.2 *Cluster Analysis Specifications*

Cluster analysis is defined by Aldenderfer and Blashfield (1984, p. 7) as follows:

> "Cluster analysis is the generic name for a wide variety of procedures that can be used to create a classification.... More specifically, a clustering method is a multivariate statistical procedure that starts with a data set containing information about a sample of entities and attempts to reorganize those entities into relatively homogeneous groups."

Prior to conducting the cluster analysis, there are several parameters to be selected:

- clustering method;
- variables;
- similarity measure;
- standardization procedure; and,
- number of clusters.

6.2.1 Clustering Method

A *k-means optimization* clustering procedure (as implemented by *Systat*®) was selected to explore the data. The reasons for choosing an optimization procedure are illustrated by an examination of the alternative cluster analysis methods outlined in Table 86.

6.2.1.1 Clustering Methods Not Selected

An *optimization* procedure was chosen over a *hierarchical* one because it:

- is less sensitive to the presence of outliers and irrelevant attributes (Punj and Stewart, 1983);
- makes more than one pass through the data, allowing the initial partition to be adjusted (hierarchical only makes one pass) (Aldenderfer and Blashfield, 1984); and,
- is not based on hierarchical relations (travel pattern data in the current study were not hypothesized to exhibit a hierarchical structure).

Table 86: Methods of Cluster Analysis

Method	Description*
Hierarchical	Hierarchical relations among individuals are determined on the basis of a measure of similarity. There are two main types of hierarchical methods: *agglomerative* (sequentially fuses individuals together until a single group is reached) and *divisive* (a single group is sequentially partitioned down to single individuals). The mergers or divisions can be illustrated in a tree diagram. (Everitt, 1974)
Optimization	Clusters are initiated through a method defined in the chosen algorithm, then individuals are allocated to the initial clusters. Finally, individuals are re-assigned to clusters as specified criteria are optimized. (Everitt, 1974)
Finite Mixture Models	A finite mixture (sample) is defined as a collection of samples representing different populations of individuals. A mixture model assumes members of different populations have different probability distributions of variables. The finite mixture clustering model seeks to identify (cluster) groups in the sample and estimate the parameters of the density function for observations from the underlying populations. (Aldenderfer and Blashfield, 1984; Wedel and Kamakura, 1998)
Miscellaneous	
Density search	Clusters are formed by searching for areas containing a relatively dense concentration of individuals. (Gengerelli, 1963; Aldenderfer and Blashfield, 1984)
Overlapping	An individual may belong to more than one cluster. (Shepard and Arabie, 1979; Wedel and Kamakura, 1998)
Direct clustering of data matrices	Individuals and variables are clustered simultaneously in *reordering block* and *hierarchical* sub-types of this technique. (Hartigan, 1972; De Boeck and Rosenberg, 1988; Statsoft, 2002)
Clustering with constraints	Homogeneous regions are defined resulting in closed areal boundaries. (Gordon and Birks, 1972; Terraseer, 2002)
Fuzzy clustering	An individual has partial membership in more than one cluster. (Bezdek, 1974; Dunn, 1974; Wedel and Kamakura, 1998)

Framework from Everitt et. al., 2001.

*The term "individual" denotes a cluster member.

The *density search* method, classified by Everitt et. al., 2001 as a miscellaneous procedure, was not selected because computer software for its implementation is not as widely available as is the software for the hierarchical and optimization techniques.

An *overlapping clustering* technique is attractive from a theoretical perspective (recognizing the probabilistic nature of human behaviour) as it allows an individual to belong to more than one cluster. However, current overlapping algorithms are computationally intensive (Wedel and Kamakura, 1998), and the binary cluster membership is not as refined as the partial membership incorporated in the fuzzy and finite mixture clustering methods (Wedel and Kamakura, 1998).

The *direct clustering of data matrices* method was not selected as it was unnecessary in this research design to cluster both objects and individuals.

Clustering with constraints was not employed as the cluster analysis was undertaken as an exploratory exercise. Additional constraints could alter the natural groupings.

Similar to the overlapping method, *fuzzy set* and *finite mixture* clustering accommodate individual membership in more than one cluster (Wedel and Kamakura, 1998). Fuzzy set and finite mixture models differ in how individuals are assigned to clusters. In finite mixture modelling, individuals are assumed to belong to only one cluster, but due to uncertainty their probability of belonging to a cluster is estimated. Fuzzy set methods provide partial membership values. Wedel and Kamakura (1998) note that mixture models, in not incorporating membership values as actual parameters, have an advantage over fuzzy set methods from a computational and statistical point of view.

A finite mixture (clustering) model might be useful for confirmatory research with a larger sample. This method accommodates heterogeneity in a sample, allows use of variables on different scales, and uses a model-based approach connecting clustering to statistical theory. However, specialized computer programs are just now becoming available for implementing the mixture techniques (not available on standard commercial packages). Also the procedures used to estimate the mixture model have some limitations[1] (Wedel and Kamakura, 1998).

6.2.1.2 *Clustering Method Selected*

A *k-means optimization* procedure was selected as the clustering method. It divides a set of individuals into *k* groups by maximizing between-cluster variation and minimizing within-cluster variation. The procedure is included in several statistical software packages (unlike the density search, mixture model, overlapping and fuzzy set methods). Also, it is more robust than the hierarchical technique and better suited to the current application of clustering travel patterns than the hierarchical, direct clustering of data matrices and clustering with constraints approaches. Specifically, a *k-means* procedure as implemented by *Systat*®[2] was used for the analysis.

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[1] Wedel and Kamakura (1998) note a limitation of two methods that are commonly used to estimate mixture models: the Newton-Raphson method (McHugh, 1956, 1958) and the expectation-maximization (EM) method (Dempster, Laird and Rubin, 1977). Both iterative procedures may converge on a local optima (which may not be the global optima), because the algorithms are sensitive to starting values. One of the possible solutions is to use a clustering procedure such as k-means to obtain a starting partition. (Wedel and Kamakura, 1998)

[2] The *Systat*® procedure starts with a single cluster and calculates the centroid for that cluster by averaging the coordinates of all members. Next, it splits the single cluster into two selecting the case farthest from the centre as a seed for a second cluster and assigning each case to the nearest centre. Then the means of both clusters are re-calculated. The third seed is selected as the point having the greatest combined distance from the first two cluster means. The algorithm continues splitting the clusters until the specified number of clusters is formed. The procedure re-assigns cases until the within-cluster sum of squares can now longer be reduced. (Communication from Braginsky, 2002)

6.2.2 VARIABLES

Originally in conducting the analysis, a procedure (Kansky, 1967) was followed by which a slate of variables was subjected to factor analysis[1] followed by cluster analysis. However, a review of recent literature reveals that this combination of techniques is not recommended. Rohlf (1970) has reported that principal components analysis reduces distances between clusters that are not widely separated. Ultimately, all variables in this analysis were directly cluster analyzed (without factor analysis).

Aldenderfer and Blashfield (1984, p. 20) indicate that the "set of variables which best represent the concept of similarity under which the study operates" should be selected. For this reason, the variable set was designed to cover all the main dimensions of travel discussed in Chapter Five including:

- destination (urban fringe, suburb, central city, outlying area, intercity);
- reason for travel;
- mode of transport;
- travel distance and travel time;
- number of stops and tours;
- complexity of tours; and,
- work versus non-work travel.

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[1] Factor analysis is typically applied to interval scale data. While techniques have been developed for factor analysis of ordinal data, there are some difficulties in their implementation (Green, Tull and Albaum, 1988, p. 575). Due to the ordinal scale and mixed scale variables, it was inappropriate to factor analyze the current dataset. Further, correspondence analysis could not be used, as it is for categorical variables only.

Several combinations of variables were tested. Table 87 presents the final variable selection. Variables representing travel patterns on a workday (Day 1) and a non-workday (Day 3) are compared and contrasted between the three field sites[1]. Initially designed for and tested on the Ottawa dataset, the variables were adapted as consistently as possible to the Kuala Lumpur and Yogyakarta datasets.

All major mode choices, tour purposes (except for "not specified") and destinations were included, since it was observed that if only a selection was included, the cluster analysis was in fact being weighted. Similarly, including correlated variables also weights the analysis, so only those variables necessary were processed. Variables describing residential location, demographic and other respondent characteristics were purposely omitted from the cluster analysis and are used to exogenously profile the clusters.

6.2.3 Similarity Measure

The variables required to fully represent the travel patterns were on different scales. All the variables represent "count" (ordinal) data except for total distance and travel time which are ratio-scale. Wedel and Kamakura (1998, p. 46) note that "for ordinal variables, many authors recommend treating the ranks as metric data and applying some distance metric." The count variables (except for total tours and total stops) were converted into a ratio scale by calculating their percentage of survey day totals. Percentage data was used to give a composite picture of the whole travel day. Where responses were zero, variables were removed from the analysis.

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[1] Travel patterns on Day 2 have not been compared since work patterns on this day differ between the three field sites. Day 2 is a workday in Yogyakarta, a limited workday in Kuala Lumpur and a non-work day in Ottawa.

Table 87: Variables Used in Cluster Analysis

Variable	Description	Day 1			Day 3		
		Ottawa	Kuala Lumpur	Yogyakarta	Ottawa	Kuala Lumpur	Yogyakarta
LCC	% of Stops in Central City	✓	✓	✓	✓	✓	✓
LIC	% of Intercity Stops					✓	✓
LOC	% of Stops in Outlying Centre/Area	✓	✓	✓	✓	✓	✓
LSUB	% of Stops in Suburbs	✓	✓	✓	✓	✓	✓
LUF	% of Stops in Urban Fringe	✓	✓	✓	✓	✓	✓
MBICYCLE	% Tours by Bicycle	✓	✓	✓		✓	✓
MCAR	% Tours by Car	✓	✓	✓	✓	✓	✓
MCCTRUCK	% Tours by Company Truck		✓			✓	
MOTBIKE	% Tours by Motorcycle		✓	✓		✓	✓
MULTIM	% Tours by Multi-mode	✓	✓	✓			✓
MJEMP	% Tours by Mobil Jemputan			✓			
MRENTCOLT	% Tours by Rental Colt						✓
MSCBUS	% Tours by School Bus	✓					
MTOTBUS	% Tours by Bus (Total)[1]		✓	✓		✓	✓
MVAN	% Tours by Van		✓			✓	
MWALK	% Tours by Walk	✓	✓	✓	✓	✓	✓
QBABYS	% "Babysitter" Stops	✓	✓				
QBANK	% "Banking" Stops	✓		✓			
QFARM	% "Farm" Stops	✓	✓	✓		✓	✓
QJOBSRCH	% "Job Search" Stops		✓	✓			
QMAIL	% "Post Office" Stops	✓		✓			
QLEISET	% "Leisure/ Entertainment" Stops	✓	✓	✓	✓	✓	✓
QPUITEM	% "Pick-up/Drop off Item" Stops	✓			✓		
QPUPER	% "Pick-up/Drop off Person" Stops	✓	✓	✓	✓	✓	✓
QRECRE	% "Recreation" Stops	✓	✓	✓	✓	✓	✓
QRELIG	% "Religion" Stops	✓	✓	✓	✓	✓	✓
QRESTC	% "Restaurant/Coffee" Stops	✓	✓	✓	✓	✓	✓
QSCHOOL	% "School" Stops	✓	✓	✓		✓	✓
QSERVCT	% "Service Total" Stops	✓	✓	✓	✓	✓	✓
QSOCIAL	% "Social" Stops	✓	✓	✓	✓	✓	✓
QTRCONT	% "Transit Connection" Stops	✓	✓		✓		
QTOTSHOP	% "Total Shopping" Stops	✓	✓	✓	✓	✓	✓
QVOLU	% "Volunteer" Stops	✓			✓		✓
QWTOT	% "Work" Stops	✓	✓	✓	✓	✓	✓
RMS	% of Multi-stop Tours				✓	✓	✓
RMSWT	% of Multi-stop Work Tours	✓	✓	✓			
RSS	% Single-Stop Tours				✓	✓	✓
RSSFT	% Single-Stop Farm Tours		✓	✓			
RSSWT	% Single-Stop Work Tours	✓	✓	✓			
TOTTRVTM	Total Travel Time[2]	✓	✓	✓	✓	✓	✓
TPDIST	Total Travel Distance[3]	✓	✓	✓	✓	✓	✓
TSTOP	Number of Total Stops	✓	✓	✓	✓	✓	✓
TTOURRW	Number of Total Tours[4]	✓	✓	✓	✓	✓	✓

[1]Bus Total includes all types of buses (except school buses in Ottawa) such as *bis kota*, intercity bus, mini bus, *angkudes* and company bus.

[2]Includes recreational walks.

[3]Excludes recreational walks at the Ottawa field site. Includes recreational walks at the Kuala Lumpur and Yogyakarta field sites but n is very low. Kuala Lumpur Day 1 (n=2), Day 3 (n=0). Yogyakarta Day 1 (n=0), Day 3 (n=1).

[4]Excludes recreational walks.

L: Variables starting with "L" were calculated as a percentage of their total. See Chapter 5 for details on "destination".

M: Variables starting with "M" were calculated as a percentage of their total.

Q: Variables starting with "Q" were calculated as a percentage of their total (plus "not specified" which was not included in the analysis). See Chapter 5 for details on "reason for travel".

R: Variables starting with "R" were calculated as a percentage of total tours (excluding recreational walks at all field sites).

While initially included, the binary variable "no tours" was eliminated so as not to complicate the analysis with yet another scale of variable. Therefore, the cluster analysis was only conducted on those respondents who travelled on the survey day.

A *Euclidean* distance measure as implemented by *Systat®* (1997), using normalized Euclidean distance (root means squared distances) was selected. Missing values are excluded for all computations.

6.2.4 STANDARDIZATION

Since Euclidean similarity measures are scale sensitive (Everitt, 1974) and total distance and travel time data are ratio scale and are of a higher magnitude than the percentage count data, and because the variables total stops and tours represent count data, standardization of all variables was deemed appropriate[1]. In their research, Milligan and Cooper (1988) investigated various forms of standardization, and recommended standardization by *range* since it performed most consistently. Therefore, all variables were standardized by range (rather than by standard deviation) in *Systat®*.

6.2.5 CLUSTER NUMBER AND VALIDATION

As Gordon (1981, p. 4) notes "...in classification (in the sense in which the word will be used throughout this book), the number and composition of any groups are not known at the start of the investigation." Consequently, use of the *k-means* procedure requires the investigator to enter the number of clusters. The approach followed in deriving the cluster number is summarized as follows.

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[1]By converting the count data to percentages, they were in effect standardized already.

In their work in this domain, Aldenderfer and Blashfield (1984) comment that there are few techniques available for determining the number of clusters because of the lack of a null hypothesis related to the definition of a cluster (e.g. no structure), and also because of the mixture of multivariate distributions in real-world samples. Of the tests available few have been rigorously critiqued, and Aldenderfer and Blashfield warn that findings should be used cautiously. *Systat®* provides an f-ratio test for individual variables, but does not test the clusters as a whole.

The only indicator provided in the *Systat®* software package for whole clusters is the "between-cluster sum of squares" and "within-cluster sum of squares[1]" (over all variables). As a greater number of clusters is specified, the within-cluster sum of squares is minimized. If all cases were in separate clusters, the within-cluster sum of squares would equal zero.

For k-means clustering, Wilkinson (2002) recommends examining the "reduction in within sum of squares at each step and (to) stop adding clusters when this reduction is negligible." Following from those advisements and the *Systat®* limitation, the approach adopted for this study was to run each field site dataset through a series of k-means cluster analyses specifying a sequential number of clusters. The reduction in within-cluster sum of squares was calculated at each cluster step.

In conjunction with examining the reduction in within-cluster sum of squares, the resultant clusters and their statistics (variable means) were studied in order to identify an appropriate number of clusters. The selection process also took into account the

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[1] "Within-cluster sum of squares" refers to the sum of squared deviations of each case from its cluster on every variable.

sample size, being cautious not to over-extend the sample by clustering the entities into too many small (n<5) groups.

Aldenderfer and Blashfield (1984, p. 58) further observe that "...rules on how to determine the number of clusters present should be used in conjunction with an appropriate validation procedure." They outline five techniques for validating the results from a cluster analysis:

1. cophenetic correlation;
2. significance tests on variables used to create clusters;
3. replication;
4. significance tests on external variables; and,
5. Monte Carlo procedures.

In the next several paragraphs the validation techniques are briefly examined in terms of their applicability to the present study.

Cophenetic correlation cannot be used here as it is a procedure designed for validating hierarchical agglomerative cluster analysis results (Aldenderfer and Blashfield, 1984). *Replication* involves dividing the sample into two and conducting cluster analysis (using the same method) on each half to investigate if the results are similar (Aldenderfer and Blashfield, 1984). Since the sample size in the current study is small, this technique has not been undertaken.

Significance tests on variables used to create clusters is considered to be statistically inappropriate by Aldenderfer and Blashfield (1984), since cluster analysis will separate individuals into clusters that have little overlap among the input variables. Differences between clusters may be significant even if there are no clusters present in the data. In addition to Aldenderfer and Blashfield's (1984) dismissal of significance tests on internal variables, Everitt (1974) does not include this technique as a validation method. Thus, significance tests on variables used to create clusters were not employed in this study.

Monte Carlo procedures generate a dataset possessing the same general characteristics as the original dataset, but with no real cluster structure. The cluster analysis results using real data are compared to those using the synthetic data (Aldenderfer and Blashfield, 1984). The current dataset, being used for exploratory purposes, is too complex and its variables are too interrelated to create a synthetic dataset.

Significance tests on external variables are recommended by Aldenderfer and Blashfield (1984). They note that this validation method is not frequently employed in cluster analysis research, with one likely reason being that when cluster analysis is employed in exploratory studies, the necessary theory providing a foundation for the classification has not been sufficiently developed to determine which external criteria are relevant to the classification.

As illustrated, the validation rules proposed by Aldenderfer and Blashfield are not directly applicable here for several reasons. First and most important, this study is exploratory in nature and the theory surrounding the travel pattern classification is not fully developed. Second, the external variables deemed relevant to the classification are being hypothesized and tested in this study. Third, profiles including exogenous variables are prepared, but formal significance tests are deemed premature at this stage. When further confirmatory research is conducted with a larger sample, and with data on relevant external variables are available, formal significance tests would be appropriate.

6.3 CLUSTER ANALYSIS RESULTS AND PROFILES

Results of the cluster analysis of Day 1 and 3 data at each field site are reviewed and the clusters are profiled in this section. For each field site and for both survey Days 1 and 3, the following two tables are presented:

1) reduction in within-cluster sum of squares; and,

2) cluster profiles.

The first table shows the reduction in within-cluster sum of squares. An asterisk* and a shaded cell indicates the selected cluster solution.

The second table provides a profile with characteristics calculated on a cluster basis[1]. A dividing line in the profile separates the variables into two groups. The variables at the top of the profiles were included in the cluster analysis. Those variables at the bottom are exogenous and were not included in the cluster analysis. Only those variables that distinguish the clusters are reported in the profiles. The profiles are ordered according to the variable description list. Cluster means for all input variables as calculated by the *Systat*® software package are provided in Appendix C.

6.3.1 DAY 1

6.3.1.1 Ottawa

As described earlier in this chapter, the reduction in within-cluster sum of squares and the cluster statistics (variable means) at different cluster steps were studied in order to identify an appropriate number of clusters. For the Ottawa Day 1 cluster analysis, the

[1] For example, % shopping stops=(total cluster shopping stops)/(total cluster stops).

variable cluster means demonstrated that at the seven-cluster level, an "outlying centre" group became defined. Reference to Table 88 shows a greater decrease in the within-cluster sum of squares between Clusters Seven and Eight, compared to the decrease between Clusters Six and Seven. For these reasons an eight-cluster solution was selected.

Table 88: Ottawa Day 1 Reduction in Within Sum of Squares

Number of Clusters	Within Sum of Squares	Reduction in Within Sum of Squares
2	228.9	
3	211.3	17.6
4	200.0	11.3
5	182.7	17.3
6	164.0	18.7
7	155.0	9.0
8	135.8	19.2*
9	129.3	6.5
10	121.6	7.7
11	115.4	6.2
12	112.4	3.0
13	103.7	8.7

Next, descriptions for each of the Day 1 Ottawa clusters are provided. All data references are documented in the cluster profile (see Table 89). The following clusters of travellers are reviewed: urban fringe non-car; simple work tour; city non-work; urban fringe car, multi-mode; frequent urban fringe non-work; outlying centre; and multi-stop work. Finally, while not included in the cluster analysis, a group of respondents who did not make any tours on Day 1 is also profiled to provide a complete view of the sample (see Group 9 in Table 89).

Table 89: Ottawa Day 1 Cluster Profile

	Cluster Number and Title								
	1 Urban Fringe Non-Car	2 Simple Work	3 City Non-Work	4 Urban Fringe Car	5 Multi-Mode	6 Frequent Urban Fringe Non-Work	7 Outlying Centre	8 Multi-Stop Work	Group 9 No Tours
Cluster Analysis Variables									
% Central city stops	0%	46%	41%	8%	16%	4%	0%	40%	0%
% Outlying area stops	4%	0%	2%	0%	0%	1%	68%	2%	0%
% Suburb stops	9%	54%	49%	3%	77%	17%	0%	42%	0%
% Urban fringe stops	84%	0%	8%	89%	6%	77%	32%	16%	0%
% Tours car[1]	24%	100%	100%	100%	11%	75%	95%	100%	0%
% Tours multi-mode[1]	8%	0%	0%	0%	78%	7%	5%	0%	0%
% Tours school bus[1]	38%	0%	0%	0%	0%	0%	0%	0%	0%
% Tours walk[1]	19%	0%	0%	0%	0%	16%	0%	0%	0%
% Pick-up/drop-off person stops	2%	0%	12%	3%	6%	31%	5%	20%	0%
% School stops	51%	0%	2%	8%	6%	4%	0%	0%	0%
% Shopping stops	0%	0%	52%	3%	15%	17%	20%	19%	0%
% Transit connection stops	0%	0%	0%	3%	33%	2%	0%	3%	0%
% Multi-stop work tours[1]	0%	0%	3%	13%	67%	4%	5%	88%	0%
% Single-stop work tours[1]	0%	92%	0%	40%	0%	3%	5%	0%	0%
Mean total distance[1] (km)	20.0	53.6	79.5	27.4	59.6	47.6	58.5	95.5	0.0
Mean total stops	1.8	1.1	3.3	1.8	4.1	5.1	3.7	3.6	0.0
Mean total tours[1]	1.5	1.1	1.2	1.4	1.1	2.8	2.0	1.2	0.0
Exogenous Variables									
Mean distance to downtown Ottawa[2] (km)	32.1	31.2	37.5	36.1	35.1	32.2	45.0	38.0	37.3
Mean total bus[3] distance (km)	0.0	0.0	0.0	0.0	17.6	0.0	0.0	0.0	0.0
Mean total single occupancy car distance (km)	0.0	40.0	16.8	18.2	0.9	17.3	28.7	62.1	0.0
% Age <20 years	92%	8%	12%	29%	38%	30%	18%	0%	0%
% Age >=65 years	8%	0%	27%	10%	0%	11%	55%	0%	40%
% Female	40%	25%	65%	57%	50%	56%	55%	41%	60%
% Homemaker/day off	0%	0%	23%	0%	0%	33%	9%	0%	0%
% Lived in city, moved to fringe[4]	nsd	80%	68%	29%	nsd	63%	25%	72%	60%
% Live in village	68%	67%	23%	48%	50%	74%	55%	37%	60%
% Non-work (multi-stop) tours[1]	19%	0%	57%	7%	11%	39%	36%	3%	0%
% Non-work (single-stop) tours[1]	76%	8%	40%	40%	22%	51%	55%	9%	0%
% Retired	8%	0%	38%	10%	0%	7%	55%	4%	80%
% School pick-up and drop-off stops[5]	0%	0%	2%	0%	0%	11%	0%	3%	0%
% Travel in morning congestion[6]	79%	58%	15%	48%	75%	48%	55%	70%	0%
n (Total=162)	25	12	26	21	8	27	11	27	5

[1]Excludes recreational walks in value or calculation of percentage of total.

[2]Downtown Ottawa is defined as Parliament Hill.

[3]Does not include "school bus".

[4]Calculated as a percentage of those >=20 years of age in each cluster. The *n* for this variable differs from that listed at the bottom of the table. Cluster 2 (*n*=10), Cluster 3 (*n*=22), Cluster 4 (*n*=14), Cluster 6 (*n*=16), Cluster 7 (*n*=8), Cluster 8 (*n*=25), Cluster 9 (*n*=5).

[5]A subset of "pick-up/drop-off person".

[6]Morning congestion is defined as a tour starting between 6:30-8:30 am. In Cluster 1, *n*=19.

nsd: insufficient data (*n*<5)

Urban Fringe Non-Car Travellers – Cluster 1

Cluster One consists of individuals who make a high percentage of their Day 1 stops in the urban fringe (84%) and who use modes other than the car (only 24% tours by car). Approximately 38% of cluster tours are made by school bus and 19% are made by walking. Members of this cluster are young (92% are less than 20 years of age), but a few (8%) are greater than or equal to 65 years of age. Half (51%) of all cluster stops were made at elementary and high schools.

Simple Work Tour Travellers – Cluster 2

Individuals in Cluster Two are characterized by making single-stop work tours (92% of all tours) to the suburbs (54% of stops) or central city (46% of stops). Cluster Two members tend to be male (75%) and the majority (92%) are between the ages of 20 and 65 years. Approximately 80% of the members (greater than or equal to 20 years of age) in this cluster lived in the city before moving to the urban fringe.

City Non-Work Travellers – Cluster 3

Members of Cluster Three undertake non-work travel (97% of all tours) to the suburbs (49% of stops) and central city (41% of stops) by car (100% of tours) on Day 1. Approximately 52% of cluster stops are for shopping. The majority (60%) of tours are multi-stop. Cluster Three members tend to be female (65%), and nearly a quarter (23%) of the members are homemakers or have the day off work, while 38% are retired. Compared to all other clusters, Cluster Three has the lowest rate of tours starting between 6:30 and 8:30 am, leading to the label of members as "morning congestion avoiders".

Urban Fringe Car Travellers – Cluster 4

Cluster Four members make a high percentage (89%) of their Day 1 stops in the urban fringe. This cluster differs from "urban fringe non-car travellers" in that all their tours are by car. Half (53%) of all tours made by this cluster are for work purposes, whereas 47% are for non-work purposes. There is a span of ages in Cluster Four with approximately 29% less than 20 years of age, and 10% greater than or equal to 65 years of age. Travellers in this cluster do not travel far (mean distance: 27 km), compared to those in other clusters. Cluster Four has a low rate of "lived in city, moved to fringe" at 29%.

Multi-Mode Travellers – Cluster 5

Individuals in Cluster Seven are multi-mode travellers as evidenced by the high percentage of tours by multiple modes (78%). This cluster contains all the bus (not school bus) riders in the study with 18 km being the cluster mean total bus distance. There is a high cluster mean for percentage suburban stops (77%), pointing to transit connection stops (33% of stops) in the suburbs.

Frequent Urban Fringe Non-Work Tour-Makers – Cluster 6

Cluster Six possesses a high percentage of tours (90%) for non-work purposes made in the urban fringe (77% of stops). While the majority (75%) of tours are made by car, 16% are made by walking. Compared to the other clusters, Cluster Six has the highest mean number of stops and tours and the highest percentage of respondents living in a village (74%). A third of the members (33%) of Cluster Six are homemakers or have the day off work. Stop purposes include picking up and dropping off persons (31%) and shopping (17%). This cluster has the highest percentage of all clusters for "school pick-up and drop off" stops (a subset of "picking-up and dropping-off") (11%), indicating that some members of this group are parents who accompany their children to and from school.

Outlying Centre Travellers – Cluster 7

Cluster Seven is composed of individuals who make stops in outlying areas (68% of stops) by car (95% of tours). Of all the clusters, Cluster Seven members live the furthest from downtown Ottawa (mean distance 45 km). Approximately 30% of cluster members are less than 20 years of age, and 30% are greater or equal to 65 years of age. Compared to other clusters, few (29%) of the members (greater than or equal to 20 years of age) previously lived in the city.

Multi-Stop Work Travellers – Cluster 8

Multi-stop work travellers make up Cluster Eight, as exemplified in the high mean for multi-stop work tours (88%). The mean distance single occupancy car drive of 62 km, and the mean total distance travelled of 96 km, point to single car passenger travel over long distances. Individuals belonging to this cluster are between 20 and 65 years of age. Approximately 59% are male and 37% live in a village, and, conversely, 63% live outside a village on a rural lot, estate lot or working farm. The majority of stops made by members are in the suburbs (42%) or central city (40%). Cluster Eight has a high percentage (72%) of members (greater than or equal to 20 years of age) who lived in the city prior to moving to the urban fringe.

"No Tours" – Group 9

Since there are only five members in this cluster, the characteristics of those respondents not making tours on Day 1 are not discussed.

6.3.1.2 Kuala Lumpur

Results from the cluster analysis show a group of respondents who take a bus to school emerging at the six-cluster level. This observation, supplemented by the declining reduction in within sum of squares (see Table 90) from 44.3 at the five-cluster level to 20.3 for the six-cluster solution, and 13.1 at the eight-cluster level, led to the selection of a six-cluster solution.

Table 90: Kuala Lumpur Day 1 Reduction in Within Sum of Squares

Number of Clusters	Within Sum of Squares	Reduction in Within Sum of Squares
2	439.5	
3	387.9	51.6
4	365.0	22.9
5	320.7	44.3
6	300.4	20.3*
7	287.3	13.1
8	274.3	13.0
9	268.4	5.9
10	262.1	6.3
11	257.5	4.6
12	252.2	5.3
13	235.4	16.8
14	214.9	20.5
15	211.0	3.9
16	208.1	2.9

The six clusters defined in the Day 1 Kuala Lumpur dataset are: urban fringe school travellers; urban fringe work travellers; car travellers; urban fringe non-work travellers; suburban work travellers; and, bus riders to school. Cluster profiles are provided in Table 91. To provide a global view of the Kuala Lumpur sample, a group of respondents who did not make any tours is also profiled even though it was not formally included in the cluster analysis (see Group 7 in Table 91). A description is provided for each of these clusters in the next section.

Table 91: Kuala Lumpur Day 1 Cluster Profile

	Cluster Number and Title						
	1 Urban Fringe School	2 Urban Fringe Work	3 Car	4 Urban Fringe Non-Work	5 Suburban Work	6 Bus to School	Group 7 No Tour
Cluster Analysis Variables							
% Central city stops	0%	0%	6%	1%	13%	0%	0%
% Outlying area stops	0%	0%	2%	4%	18%	16%	0%
% Suburb stops	0%	3%	11%	7%	66%	79%	0%
% Urban fringe stops	100%	97%	82%	87%	3%	5%	0%
% Tours bicycle	27%	4%	0%	12%	0%	6%	0%
% Tours car	3%	22%	100%	5%	48%	0%	0%
% Tours motorcycle	2%	40%	0%	41%	27%	12%	0%
% Tours total bus	34%	5%	0%	5%	19%	76%	0%
% Tours walk	29%	25%	0%	28%	2%	0%	0%
% School stops	90%	0%	17%	4%	0%	74%	0%
% Shopping stops	0%	0%	8%	19%	0%	5%	0%
% Work stops	0%	100%	26%	26%	98%	11%	0%
% Multi-stop work tours	0%	0%	33%	7%	0%	12%	0%
% Single-stop farm tours	0%	0%	0%	9%	0%	0%	0%
% Single-stop work tours	0%	100%	8%	22%	98%	0%	0%
Mean total distance (km)	8.6	14.5	25.2	19.7	45.3	38.1	0.0
Mean total stops	1.2	1.1	2.0	1.7	1.0	1.2	0.0
Mean total tours	1.2	1.1	1.1	1.4	1.1	1.1	0.0
Exogenous Variables							
% Age <20 years	98%	7%	34%	24%	5%	75%	29%
% Age >=55 years	0%	8%	0%	22%	2%	0%	21%
% Age >=65 years	0%	1%	0%	7%	2%	0%	7%
% Campus[1] Stops	2%	0%	3%	1%	0%	21%	0%
% Female	44%	36%	34%	37%	38%	43%	81%
% Non-work (multi-stop) tours	2%	0%	17%	5%	0%	0%	0%
% Non-work (single-stop) tours	98%	0%	42%	57%	2%	88%	0%
% School pick-up/drop-off stops[2]	0%	0%	15%	6%	0%	0%	0%
n (Total=415)	106	72	32	41	61	16	87

[1]The category "campus" is a subset of the broader "school" category. "Campus" refers to a college or university.
[2]Subset of "pick-up/drop-off person".

Urban Fringe School Travellers - Cluster 1

Members of Cluster One are characterized by making a high proportion of their Day 1 stops in the urban fringe (100%) and a high percentage of their stops at school (90%). Tours are made by a variety of modes: 34% by bus, 29% by walking and 27% by bicycle, and. The mean total distance travelled on Day 1 for this cluster (9 km) is the lowest of all clusters. With 98% of the members of this cluster less than 20 years of age, the travel patterns of Cluster One members represent local school tours.

Urban Fringe Work Travellers – Cluster 2

Individuals in this cluster make single-stop work tours (100%) in the urban fringe. The motorcycle is the dominant mode being used for 40% of all tours, while tours are also made by walking (25%) and car (22%). Members of this cluster tend to be male (64%) and between the ages of 20 and 65 years (92%). The total mean travel distance for cluster members is low (15 km), compared to all other clusters (except Cluster One).

Car Travellers – Cluster 3

Cluster Three possesses the highest mean of all clusters for percentage of tours made by car (100%). This cluster also has the highest number of mean total stops (2.0) compared to other clusters. Members make multi-stop work tours (33%), multi-stop non-work tours (17%) and single-stop non-work tours (42%). Two-thirds of cluster members are male. Destinations of travel are mainly in the urban fringe (82% of stops). A third of members are less than 20 years of age. Also, 15% of total cluster stops are for school pick-up and drop-off purposes and 17% of cluster stops are for school indicating that some members of this cluster are children who travel to and from school by car (with an adult).

Urban Fringe Non-Work Travellers – Cluster 4

This cluster has a high proportion of stops made in the urban fringe (87%), with the majority of stops (62%) being made for non-work purposes. Shopping is the most common stop purpose at (19%). Cluster Four contains all the farming tours (9% of stops in Cluster Four, compared to 0% in all other clusters) in the survey. Approximately 88% are single-stop tours. The dominant mode is the motorcycle (41% of all tours), followed by walking (28% of all tours) and biking (12% of all tours). Males represent 63% of the members of this cluster. Of all the clusters, Cluster Four has the highest frequency of travel with a mean of 1.4 tours per day.

Suburban Work Travellers – Cluster 5

Cluster Five is made up of individuals who work (98% of tours are for work) outside the urban fringe, mainly in the suburbs (66% of stops), but also in the central city (13% of stops) or outlying areas (18% of stops). Nearly half (48%) of the tours are by car, 27% are by motorcycle and 19% are by bus. The mean total distance for this group is 45.3 km, the longest of all clusters. Approximately 62% of cluster members are male.

Bus Riders to School – Cluster 6

Members of Cluster Six use the bus at a higher rate (76% of tours), compared to other clusters. A high percentage (79%) of cluster stops are made in the suburbs, while 16% being made in outlying areas and 5% in the urban fringe, and none are made in the central city. Approximately 74% of stops are for school purposes. This cluster has a young demographic profile with 75% less than 20 years of age. Examination of the variable "% campus stops" indicates that 21% of cluster stops are at a college or university.

"No Tours" – Group 7

As discussed in Section 5.1, those making "no tours" on Day 1 in the Kuala Lumpur survey are mainly female (81%), and the majority (71%) are greater than or equal to 20 years of age.

6.3.1.3 *Yogyakarta*

In reviewing cluster analysis results for Yogyakarta, it was observed that a six-cluster solution yielded a travel group consisting of farmers. Added information obtained from examining the reduction in within sum of squares (see Table 92) showing a greater reduction between Clusters Six and Seven, compared to the reduction between Clusters Five and Six, led to the decision to use a seven-cluster solution.

Table 92: Yogyakarta Day 1 Reduction in Within Sum of Squares

Number of Clusters	Within Sum of Squares	Reduction in Within Sum of Squares
2	204.5	
3	178.8	25.7
4	160.9	17.9
5	152.1	8.8
6	143.5	8.6
7	132.6	10.9*
8	124.7	7.9
9	114.7	10.0
10	111.3	3.4
11	108.9	2.4
12	98.7	10.2
13	95.9	2.8

The seven Yogyakarta Day 1 clusters described in the next section are as follows: urban fringe non-work travellers; school attendees; urban fringe motorcyclists; central city non-work car travellers; car work travellers; farmers; and, city motorcyclists. Also, while not being directly included in the cluster analysis, a group of individuals who did not make any tours on Day 1 is also profiled (see Group 8 in Table 93).

Table 93: Yogyakarta Day 1 Cluster Profile

	Cluster Number and Title							
	1	2	3	4	5	6	7	Group 8
	Urban Fringe Non-Work	School	Urban Fringe Motorcycle	Central City Non-Work Car	Car Work	Farm	City Motorcycle	No Tour
Cluster Analysis Variables								
% Central city stops	0%	20%	22%	71%	17%	0%	40%	0%
% Outlying area stops	0%	2%	4%	0%	33%	0%	2%	0%
% Suburb stops	6%	39%	15%	14%	33%	3%	28%	0%
% Urban fringe stops	94%	39%	59%	14%	17%	97%	30%	0%
% Tours bicycle	19%	9%	0%	0%	0%	30%	3%	0%
% Tours car	4%	2%	0%	71%	58%	15%	0%	0%
% Tours motorcycle	28%	49%	100%	10%	8%	22%	93%	0%
% Tours total bus	2%	2%	0%	0%	0%	0%	0%	0%
% Tours walk	43%	7%	0%	10%	0%	33%	3%	0%
% Bank stops	2%	0%	0%	7%	0%	3%	0%	0%
% Farm stops	0%	0%	0%	0%	0%	50%	0%	0%
% Leisure/entertainment stops	0%	0%	4%	7%	8%	0%	0%	0%
% Pick-up/drop-off person stops	0%	6%	7%	25%	0%	7%	22%	0%
% School stops	12%	84%	0%	4%	0%	0%	8%	0%
% Shopping stops	24%	0%	11%	32%	0%	10%	20%	0%
% Social stops	24%	4%	0%	0%	17%	0%	22%	0%
% Work stops	6%	0%	70%	11%	75%	17%	16%	0%
% Multi-stop work tours	2%	0%	0%	5%	0%	4%	27%	0%
% Single-stop farm tours	0%	0%	0%	0%	0%	56%	0%	0%
% Single-stop work tours	4%	0%	70%	10%	75%	15%	0%	0%
Mean total distance (km)	6.4	20.9	20.1	27.2	39.0	9.3	33.9	0.0
Mean total stops	1.9	1.6	1.4	2.3	1.5	2.5	3.1	0.0
Mean total tours	1.7	1.4	1.4	1.8	1.5	2.3	1.9	0.0
Exogenous Variables								
% Age <20 years	22%	72%	0%	8%	13%	0%	19%	60%
% Age >=55 years	16%	0%	12%	8%	13%	50%	13%	0%
% Age >=65 years	4%	0%	0%	0%	0%	8%	7%	0%
% Campus stops[1]	2%	33%	0%	0%	0%	0%	2%	0%
% Female	67%	55%	26%	50%	50%	50%	44%	80%
% Non-work (multi-stop) tours	4%	11%	0%	29%	0%	4%	30%	0%
% Non-work (single-stop) tours	89%	89%	30%	57%	25%	22%	43%	0%
n (Total=131)	27	32	19	12	8	12	16	5

[1]The category "campus" is a subset of the broader "school" category. "Campus" refers to a college or university.

Urban Fringe Non-Work Travellers - Cluster 1

Cluster One is composed of individuals who make a high percentage of their stops in the urban fringe for non-work purposes (93%). Two-thirds (67%) of Cluster One members are female. This cluster has the lowest mean travel distance (6.4 km) compared to all the other clusters, which is consistent with the dominant mode being walking (43%), followed by motorcycle (28%) and bicycle (19%). Shopping (24%) and social (24%) are the main frequently reported stop purposes.

School Attendees - Cluster 2

Members of this cluster make a high percentage (84%) of their Day 1 stops at school. The category "school" includes college and university. In this cluster, 33% of all stops are made specifically to a college or university. Approximately 72% are less than 20 years of age. Destinations are diverse with 39% of stops in the urban fringe, 39% in the suburbs and 20% in the central city. The motorcycle is the dominant mode (49%) in Cluster Two.

Urban Fringe Motorcyclists - Cluster 3

Cluster Three is characterized by single-stop motorcycle travel (100% of tours by motorcycle). Approximately 70% of tours are for work purposes. The majority (60%) of Day 1 cluster stops are made in the urban fringe, while 15% are made in the suburbs and 22% in the central city. Cluster members tend to be male (73% male).

Central City Non-Work Car Travellers – Cluster 4

Members of Cluster Four are car travellers (71% of all tours are by car) for non-work purposes (86% of all tours are non-work). Approximately 71% of all stops are made in the central city. The main stop purposes are shopping (32%) and picking-up and dropping-off persons (25%). The majority of Cluster Four members are between the ages of 20 and 65 years (92%), and they are equally male and female (50%).

Car Work Travellers - Cluster 5

Members of Cluster Five are mainly (75%) work travellers. A third of cluster stops are made in the suburbs, while another third are made in outlying areas. Just over half (58%) of the tours are made by car.

Farmers - Cluster 6

Cluster Six shows high cluster means for percentage of farming stops (50%), percentage of Day 1 stops in the urban fringe (97%) and percentage of single-stop farm tours (56%). This cluster uses mainly non-motorized transportation with 33% of tours made by walking and 30% made by bicycle (22% are made by motorcycle and 15% are made by car). This group has the highest number of mean tours per day of all the clusters at 2.3 tours/day. Cluster Six has an older demographic profile compared to the other clusters with 50% of members greater than or equal to 55 years of age.

City Motorcyclists - Cluster 7

Members of this cluster made 93% of their tours by motorcycle to the city centre (40% of all stops) or suburbs (28% of all stops). Cluster Seven has the highest number of mean stops (3.1 stops/day) of all the clusters. Approximately 27% of all tours are multi-stop work tours and 30% are multi-stop non-work tours. Stop purposes, other than work, include picking up and dropping off persons (22%), social activities (22%) and shopping (20%).

"No Tours" - Group 8

Since there are only five individuals in the Yogyakarta survey who did not make tours on Day 1, their personal characteristics are not explored.

6.3.2 DAY 3

6.3.2.1 Ottawa

Selection of a nine-cluster solution for the Ottawa Day 3 cluster analysis was made on the basis of examining the variable cluster means, and the reduction in within-cluster sum of squares at different cluster steps. At the seven-cluster level, a recreational walk group develops, and at the eight-cluster level a group making long distance tours to outlying areas emerges. Examining the reduction in within-cluster sum of squares (see Table 94), declining reductions at the ten to thirteen-cluster led to the selection of a nine-cluster solution.

Table 94: Ottawa Day 3 Reduction in Within Sum of Squares

Number of Clusters	Within Sum of Squares	Reduction in Within Sum of Squares
2	175.5	
3	152.6	22.9
4	138.4	14.2
5	128.1	10.3
6	123.3	4.8
7	117.3	6.0
8	106.7	10.6
9	95.4	11.3*
10	90.5	4.9
11	85.8	4.7
12	81.6	4.2
13	79.2	2.4

The nine cluster groups identified through the Ottawa Day 3 analysis that are profiled (see Table 95) in the next section are: outlying area long distance travellers; suburban shoppers; urban fringe single-stop travellers; recreational walkers; frequent urban fringe travellers; outlying centre travellers; and, miscellaneous travellers. While not included in the cluster analysis, a group of respondents who did not make any tours on Day 3 is also profiled (See Group 10 in Table 95).

Outlying Area Long Distance Travellers - Cluster 1

Individuals in Cluster One make long tours (mean total distance of 103 km) to outlying areas (100% of stops) by car (100% of tours). None of the members (greater than or equal to 20 years of age) in this cluster have lived in the city previously.

Suburban Shoppers - Cluster 2

Cluster Two members make a high percentage of cluster stops in the suburbs (87%) and a high percentage of stops for shopping (77%). All tours are made by car and the majority of tours are multi-stop (67%).

Urban Fringe Single-Stop Travellers - Cluster 3

This cluster is distinguished by a high proportion of single-stop tours (91%) and Day 1 stops made in the urban fringe (88%). Members of this cluster do not travel far compared to other clusters as evidenced by their mean total distance of 28 km. Approximately 78% of tours are by car and 22% are by walking. There is a span of ages

Table 95: Ottawa Day 3 Cluster Profile

	Cluster Number and Title									
	1	2	3	4	5	6	7	8	9	Group 10
	Outlying Area Long Distance	Suburban Shop	Urban Fringe Single-Stop	Recre-ational Walk	Frequent Urban Fringe	Outlying Centre	Miscell-aneous	City Single-Stop	Central City Multi-Stop	No Tour
Cluster Analysis Variables										
% Central city stops	0%	9%	0%	0%	11%	0%	8%	50%	80%	0%
% Outlying area stops	100%	0%	13%	0%	7%	72%	4%	3%	0%	0%
% Suburb stops	0%	87%	0%	0%	6%	0%	24%	42%	10%	0%
% Urban fringe stops	0%	4%	88%	0%	76%	28%	64%	5%	10%	0%
% Tours car	100%	100%	78%	0%	100%	100%	27%	100%	91%	0%
% Tours multi-mode	0%	0%	0%	0%	0%	0%	45%	0%	9%	0%
% Tours recreational walk[1]	0%	5%	6%	100%	6%	8%	8%	5%	15%	0%
% Tours walk[2]	0%	0%	22%	0%	0%	0%	18%	0%	0%	0%
% Pick-up/drop-off person stops	0%	4%	2%	0%	22%	5%	16%	8%	0%	0%
% Recreation stops	0%	0%	21%	0%	2%	0%	8%	21%	0%	0%
% Religion stops	23%	2%	21%	0%	22%	10%	8%	24%	0%	0%
% Services stops	0%	0%	0%	0%	0%	3%	8%	0%	3%	0%
% Shopping stops	0%	77%	21%	0%	9%	26%	20%	8%	45%	0%
% Social stops	23%	13%	13%	0%	20%	15%	0%	5%	20%	0%
% Work stops	8%	0%	6%	0%	13%	0%	20%	13%	3%	0%
% Multi-stop tours[2]	0%	71%	7%	0%	62%	92%	91%	6%	100%	0%
% Single-stop tours[2]	100%	29%	93%	0%	38%	8%	9%	94%	0%	0%
Mean total distance[2] (km)	102.8	50.0	27.7	0.0	44.7	77.8	27.1	80.4	88.4	0.0
Mean total stops	1.1	2.9	1.8	0.0	3.6	6.5	3.1	1.9	4.0	0.0
Mean total tours[2]	1.1	1.1	1.7	0.0	1.9	2.0	1.4	1.8	1.1	0.0
Exogenous Variables										
Mean distance to downtown Ottawa[3] (km)	39.9	35.1	34.5	42.2	31.9	44.7	40.4	32.3	34.9	34.9
Mean distance to work (Day 1)[4] (km)	nsd	57.2	nsd	nsd	48.3	nsd	nsd	52.7	64.4	66.9
Mean total single occupancy car distance (km)	6.3	9.5	5.4	0.0	5.8	7.1	8.4	15.4	12.1	0.0
% Age <20 years	17%	13%	37%	17%	27%	0%	50%	45%	30%	30%
% Age >=65 years	17%	6%	22%	33%	7%	50%	25%	5%	0%	12%
% Female	33%	56%	44%	33%	53%	67%	63%	55%	60%	49%
% Lived in city, moved to fringe[5]	0%	45%	59%	40%	45%	50%	nsd	88%	100%	71%
% Live in village	17%	56%	67%	50%	73%	50%	63%	35%	40%	60%
% Working farm residence	67%	0%	0%	17%	7%	0%	0%	10%	0%	7%
n (Total=163)	12	16	27	6	15	6	8	20	10	43

[1]Calculated as a percentage of total tours, including recreational walk tours.

[2]Excludes recreational walks in value or calculation of percentage of total. Recreational walks are not coded with stops.

[3]Downtown Ottawa is defined as Parliament Hill.

[4]The *n* for this variable differs from that listed at the bottom of the page: Cluster 2 (*n*=10), Cluster 5 (*n*=6), Cluster 8 (*n*=9), Cluster 9 (*n*=6), Cluster 10 (*n*=18).

[5]Calculated as a percentage of those >=20 years of age in cluster. The *n* for this variable differs from that listed at the bottom of the page. Cluster 2 (*n*=11), Cluster 3 (*n*=17), Cluster 4 (*n*=5), Cluster 5 (*n*=11), Cluster 6 (*n*=6), Cluster 8 (*n*=8), Cluster 9 (*n*=7), Cluster 10 (*n*=28).

nsd: insufficient data (*n*<5)

in Cluster Three with 37% less than 20 years of age, and 22% greater than or equal to 65 years of age. Stop purposes include the following (with percentages of total stops): religion (21%), recreation (21%) and shopping (21%).

Cluster Three differs from Cluster Five (another urban fringe-oriented group) in that members of Cluster Three make single-stop tours, as opposed to the multi-stop tours made by Cluster Five.

Recreational Walkers - Cluster 4

Members of Cluster Four did not make any tours on Sunday, except for recreational walks (100% of all tours) as illustrated in Table 95. Since there are only six members in Cluster Four, their personal characteristics will not be elaborated upon.

Frequent Urban Fringe Travellers - Cluster 5

Cluster Five is characterized by a high number of mean stops (3.6) and mean tours (1.9) in the urban fringe (76% of all stops). The majority (62%) of tours are multi-stop (unlike Cluster Three with single-stop tours) and all are by car. Approximately 73% of the members of this cluster live in a village. Stop purposes include: religion (22%), social (20%) and picking-up and dropping-off persons (22%).

Outlying Centre Travellers - Cluster 6

Members of Cluster Six make a higher proportion of their tours to outlying areas compared to other clusters (except Cluster 1). Approximately 92% of all tours are multi-stop and all are made by car. Because there are only six members in this cluster, their personal profile will not be further discussed.

Miscellaneous Travellers - Cluster 7

Cluster Seven consists of respondents who make tours using multiple mode tours (mainly a combination of car and walk modes). Almost half (45%) of cluster tours are multiple mode, whereas there are no multi-mode tours in any of the other clusters except in Cluster Nine (9%). Destinations include the urban fringe (64% of stops), but also the suburbs (24% of stops). This cluster has the lowest mean travel distance on Day 3 (27 km), compared to all other clusters. Tour stops are made for a variety of purposes including: work (20%), shopping (20%) and picking up and dropping off persons (16%).

City Single-Stop Travellers - Cluster 8

Cluster Eight is characterized by single-stops (94%) to the suburbs (42%) or central city (50%) by car (100%). Stop purposes include religion (24%), recreation (21%) and work (13%).

Central City Multi-Stop Travellers - Cluster 9

Cluster Nine members make a high proportion of multi-stop tours (100%), tours by car (91%) and tours to the central city (80%). Members of this cluster travel the highest mean distance on Day 3 (88.4 km) compared to other clusters (except Cluster One). Almost half (45%) of all cluster stops are for shopping. All cluster members (greater than or equal to 20 years of age) lived in the city prior to moving to the urban fringe.

"No Tours" – Group 10

Those who did not make any tours on Day 3 lack any strong, distinguishing characteristics. Members are equally male and female, 30% are less than 20 years of age (greater than or equal to 20 years of age) not making tours lived in the city, prior to moving to the urban fringe.

6.3.2.2 Kuala Lumpur

A six-cluster solution was selected on the basis of a "long distance car leisure/entertainment" group emerging at the six-cluster level. Supplementing this observation, the reduction in within-cluster sum of squares (see Table 96) declines at the seven- and eight-cluster steps.

Table 96: Kuala Lumpur Day 3 Reduction in Within Sum of Squares

Number of Clusters	Within Sum of Squares	Reduction in Within Sum of Squares
2	306.2	
3	256.6	49.6
4	231.5	25.1
5	216.9	14.6
6	200.4	16.5*
7	193.1	7.3
8	186.1	7.0
9	173.1	13.0
10	152.3	20.8
11	143.0	9.3
12	140.1	3.1
13	135.9	4.2
14	131.4	4.5
15	115.2	16.2

The six clusters yielded through the cluster analysis of Day 3 Kuala Lumpur data are: walkers; car travellers; urban fringe motorcyclists; suburban travellers; urban fringe bicycle and bus riders; and, long distance leisure car travellers. A seventh group not included in the cluster analysis, consisting of respondents who did not make tours on Day 3, is also profiled (see Group 7 in Table 97).

Walkers - Cluster 1

Members of Cluster One make single-stop tours by walking (98% of total tours) in the urban fringe (100% of stops). Many of the stops are to attend weddings (57%). Another 17% of cluster stops are for work and farming. The total mean distance travelled by Cluster 1 members is the lowest of all clusters at 1.2 km. Cluster One has the oldest demographic profile of all the clusters with 23% of members aged 55 years or older.

Car Travellers - Cluster 2

Cluster Two is characterized by single-stop car (95% of tours) travel mainly to destinations in the urban fringe (55% of stops), but also to the suburbs (22% of stops) and central city (18% of stops). The most frequent stop purpose is shopping (39% of stops), followed by recreation (22% of stops) and social activities (14% of stops).

Urban Fringe Motorcyclists - Cluster 3

Individuals in Cluster Three make all their stops in the urban fringe (100% of stops), by motorcycle (96% of tours). The purpose of the majority of their stops is for shopping (49%), work (13%), religion (10%) and social activities (10%). Most members (81%) are male.

Table 97: Kuala Lumpur Day 3 Cluster Profile

	Cluster Number and Title						
	1	2	3	4	5	6	Group 7
	Walk	Car	Urban Fringe Motorcycle	Suburban	Urban Fringe Bicycle and Bus	Long Distance Leisure Car	No Tour
Cluster Analysis Variables							
% Central city stops	0%	18%	0%	0%	0%	0%	0%
% Intercity stops	0%	0%	0%	0%	0%	50%	0%
% Outlying area stops	0%	5%	0%	0%	0%	14%	0%
% Suburb stops	0%	22%	0%	100%	0%	29%	0%
% Urban fringe stops	100%	55%	100%	0%	100%	7%	0%
% Tours bicycle	2%	1%	0%	0%	43%	0%	0%
% Tours car	0%	95%	0%	7%	5%	88%	0%
% Tours motorcycle	0%	0%	96%	73%	0%	0%	0%
% Tours total bus	0%	1%	0%	20%	38%	6%	0%
% Tours walk	98%	3%	4%	0%	0%	0%	0%
% Farm stops	4%	1%	7%	0%	10%	0%	0%
% Leisure/entertainment stops	57%	10%	7%	0%	10%	79%	0%
% Recreation stops	4%	22%	0%	0%	0%	0%	0%
% Religion stops	0%	1%	10%	0%	14%	7%	0%
% Shopping stops	9%	39%	47%	19%	48%	0%	0%
% Social stops	7%	14%	10%	19%	5%	7%	0%
% Work stops	13%	6%	13%	56%	10%	0%	0%
% Multi-stop tours	0%	1%	7%	7%	0%	0%	0%
% Single-stop tours	100%	99%	93%	93%	100%	100%	0%
Mean total distance (km)	1.2	35.6	9.0	34.5	11.9	182.1	0.0
Mean total stops	1.0	1.1	1.1	1.1	1.2	1.0	0.0
Mean total tours	1.0	1.1	1.0	1.0	1.2	1.1	0.0
Exogenous Variables							
% Age <20 years	34%	33%	7%	27%	39%	43%	52%
% Age >=55 years	23%	4%	11%	0%	6%	0%	7%
% Age >=65 years	9%	1%	0%	0%	0%	0%	3%
% Female	52%	45%	19%	50%	76%	36%	50%
% Wedding stops[1]	57%	6%	3%	0%	10%	7%	0%
n (Total=425)	44	70	27	15	18	14	237

[1]The wedding category is a subset of the "leisure/entertainment" category.

Suburban Travellers - Cluster 4

Cluster Four consists of travellers to the suburbs (100% of stops). Approximately 73% of tours are by motorcycle, and another 20% are by bus. Work (56%) is the dominant stop purpose, followed by shopping (19%) and social (19%).

Urban Fringe Bicycle and Bus Riders - Cluster 5

This cluster has a high mean for percent stops in urban fringe (100%). Tours are made by bicycle (43%) and bus (38%). Purposes of stops include: shopping (48%), religion (14%), leisure/entertainment (10%) and farming (10%). Members of Cluster Five tend to be female (76%). This cluster exhibits the highest mean number of total tours (1.2/day) of all the clusters.

Long Distance Leisure Car Travellers - Cluster 6

Members of Cluster Six make long car tours (88% of all tours) to suburban (29% of stops), intercity locations (50% of stops) and outlying areas (14%), mainly for leisure and entertainment purposes (79% of stops). The demographic profile for this cluster is young, with 43% of members less than 20 years of age.

"No Tours" - Group 7

As described in Section 5.1, a substantial number of respondents (237) did not make tours on Sunday in the Kuala Lumpur survey. Those not making tours are equally male and female, and half (52%) are less than 20 years of age.

6.3.2.3 *Yogyakarta*

The cluster variable means for sequential cluster stops were examined, showing that at the seven-cluster level an urban fringe bike cluster formed. Obtaining further information by referring to Table 98, a reduction in within-cluster sum of squares at the eight- and nine-cluster level led to the selection of a seven-cluster solution.

The seven clusters profiled in the following section are: urban fringe motorcyclists, long distance car travellers, suburban travellers, city multi-stop travellers, car travellers, long distance motorcyclists; and, urban fringe bicyclists. An eighth group (not included in the cluster analysis) of those respondents who did not make tours is also profiled (see Group 8 in Table 99).

Table 98: Yogyakarta Day 3 Reduction in Within Sum of Squares

Number of Clusters	Within Sum of Squares	Reduction in Within Sum of Squares
2	198.1	
3	169.9	28.2
4	159.4	10.5
5	145.0	14.4
6	135.8	9.2
7	125.0	10.8*
8	119.6	5.4
9	114.8	4.8
10	107.5	7.3
11	104.1	3.4
12	100.8	3.3
13	85.3	15.5

Urban Fringe Motorcyclists - Cluster 1

Cluster One is made up of individuals who make single-stop tours in the urban fringe by motorcycle (63% of tours) or walking (35% of tours). Stop purposes include social activities (31%), shopping (27%) and farming (14%), religion (11%) and work (8%). This cluster has the lowest mean distance (10 km) of all the Day 3 Yogyakarta clusters.

Long Distance Car Travellers - Cluster 2

Members of Cluster Three make all Day 3 travel by car (100% of all tours). They travel long distances as evidenced by possessing the highest mean total distance (92 km) of all the clusters. Destinations of their tours are to outlying areas (68% of stops) and intercity locations (32%). The most frequent stop purpose is leisure and entertainment (63%).

Table 99: Yogyakarta Day 3 Cluster Profile

	Cluster Number and Title							
	1	2	3	4	5	6	7	Group 8
	Urban Fringe Motorcycle	Long Distance Car	Suburban	City Multi-Stop	Car	Long Distance Motorcycle	Urban Fringe Bicycle	No Tours
Cluster Analysis Variables								
% Central city stops	0%	0%	0%	50%	19%	26%	3%	0%
% Intercity stops	0%	32%	0%	0%	0%	0%	0%	0%
% Outlying area stops	0%	68%	0%	0%	10%	47%	0%	0%
% Suburb stops	2%	0%	92%	50%	35%	0%	5%	0%
% Urban fringe stops	98%	0%	8%	0%	35%	26%	93%	0%
% Tours bicycle	0%	0%	0%	0%	0%	0%	66%	0%
% Tours car	0%	100%	0%	29%	88%	11%	3%	0%
% Tours motorcycle	63%	0%	83%	57%	6%	89%	14%	0%
% Tours total bus	0%	0%	17%	0%	0%	0%	0%	0%
% Tours walk	35%	0%	0%	0%	6%	0%	17%	0%
% Farm stops	14%	0%	8%	0%	0%	0%	10%	0%
% Leisure/entertainment stops	2%	63%	0%	6%	0%	11%	0%	0%
% Recreation stops	2%	0%	8%	0%	0%	21%	10%	0%
% Religion stops	11%	0%	0%	0%	23%	5%	33%	0%
% Restaurant stops	5%	0%	0%	19%	6%	5%	5%	0%
% Shopping stops	27%	0%	50%	31%	23%	16%	8%	0%
% Social stops	31%	0%	17%	25%	37%	0%	15%	0%
% Work stops	8%	5%	8%	0%	3%	11%	15%	0%
% Multi-stop tours	3%	46%	0%	100%	3%	0%	11%	0%
% Single-stop tours	97%	54%	100%	0%	97%	100%	89%	0%
Mean total distance (km)	10.3	92.0	18.4	25.0	28.2	47.9	12.4	0.0
Mean total stops	1.5	1.5	1.1	2.3	1.8	1.4	2.7	0.0
Mean total tours	1.5	1.0	1.1	1.0	1.8	1.4	2.3	0.0
Exogenous Variables								
% Age <20 years	17%	46%	55%	14%	26%	7%	53%	47%
% Age >=55 years	22%	8%	0%	14%	5%	0%	27%	7%
% Age >=65 years	3%	0%	0%	0%	0%	0%	7%	7%
% Female	57%	38%	45%	100%	47%	29%	40%	64%
n (Total=136)	42	13	11	7	19	14	15	15

Suburban Travellers - Cluster 3

Individuals in Cluster Three are distinguished by a high proportion of Day 3 stops made in the suburbs (92%). Tours are mainly made by motorcycle (83%), but also by bus (17%). The main stop purpose is for shopping (50% of all stops), but also for social purposes (17% of stops). Cluster Three members tend to be young with 55% less than 20 years of age, and all are less than 55 years of age.

City Multi-Stop Travellers - Cluster 4

Cluster Four consists of multi-stop travellers who made stops in the central city (50%) and suburbs (50%). The main stop purpose is shopping (31%), but purposes also include social (25%) and restaurants (19%). Tours are mainly by motorcycle (57%), but also by car (29%). All members of Cluster Four are female.

Car Travellers - Cluster 5

Respondents in Cluster Five make a high proportion (88%) of their tours by car. A third of stops are made in the urban fringe, a third in the suburbs and nearly a fifth in the central city. Stop purposes include social (37%), religion (23%), and shopping (23%). Cluster Five differs from Cluster Two (also car-oriented), in that tours are short (28 km), compared to 92 km for Cluster Two. Also Cluster Five tours are in the urban area (central city, suburbs or urban fringe), whereas tours made by members of Cluster Two are destined for outlying areas and intercity locations.

Long Distance Motorcyclists - Cluster 6

This cluster is distinguished by a high proportion of tours made by motorcycle (89% of tours) to outlying areas (47%). Cluster Six has the second highest cluster mean distance at 47.9 km. Stops are also made in the urban fringe (26%) and central city (26%) for the purposes of recreation (21%), shopping (16%) and leisure/entertainment (11%). Members of this cluster tend to be male (71%). Only 7% are less than 20 years of age and all are less than 55 years of age.

Urban Fringe Bicyclists - Cluster 7

Cluster Seven members make a high proportion of their Day 3 stops in the urban fringe. This cluster differs from Cluster One (also consisting of urban fringe travellers) in that the dominant mode in Cluster Seven is the bicycle (66% of tours), followed by walking (17% of tours), whereas the motorcycle is the most frequently used mode in Cluster One. Similar to Cluster One, Cluster Seven has a low mean total distance on Day 3 of 12 km.

Members in this cluster are also proportionately younger than those in Cluster One, with 53% less than 20 years of age, compared to 17% in Cluster One. At the same time, there are also older people included in this cluster with 27% greater than or equal to 55 years of age. Of all the clusters, Cluster Seven has the highest number of mean tours (2.3 per day) and stops (2.7 per day), indicating a high frequency of travel. Tour purposes include religion (33%), social (15%), work (15%), recreation (10%) and farming (10%).

"No Tours" - Group 8

Only 15 out of the 136 Yogyakarta respondents surveyed did not make tours on Day 3. This group tends to be female (64%) and have a younger demographic profile (47% are less than 20 years of age).

6.4 Review and Comparison of Cluster Analysis Results

This section reviews and interprets the results of the cluster analysis by:

1) summarizing the results of the cluster analysis;

2) discussing the results for each individual field site; and,

3) comparing the results between field sites.

6.4.1 Summary

A summary of the cluster analysis results for all field sites is provided in Table 100. The results are organized according to destination of travel (urban fringe; suburbs and central city; and outlying area and intercity locations). Additional categories encompass car-specific travel in Kuala Lumpur and Yogyakarta, and site-specific travel in all three field sites. While not included in the cluster analysis, the final category consists of those respondents who did not travel on the survey day. To give an overall view of the sample partitioning within field sites, the number of individuals in each category is presented as a percentage of total. As noted in Chapter Five, Ottawa represents the richest dataset and the cluster analysis results for that field site are explored in detail.

Table 100: Summary of Cluster Analysis Results

	Site	Urban Fringe			Suburbs and Central City			Outlying Area and Intercity		Car-Specific	Site-Specific	No Tours
Day 1	Ottawa	Urban Fringe Non-Car$^{(1)}$ 15%	Urban Fringe Car$^{(4)}$ 13%	Frequent Urban Fringe Non-Work$^{(6),A}$ 17%	Multi-Stop Work$^{(8),B}$ 17%	Simple Work$^{(2)}$ 7%	City Non-Work$^{(3)}$ 16%	Outlying Centre$^{(7)}$ 7%			Multi-Mode$^{(5)}$ 5%	No Tours$^{(9)}$ 3%
	Kuala Lumpur	Urban Fringe School$^{(1)}$ 26%	Urban Fringe Work$^{(2)}$ 17%	Urban Fringe Non-Work$^{(4),A}$ 10%	Suburban Work$^{(5),B}$ 15%					Car$^{(3)}$ 8%	Bus to School$^{(6)}$ 4%	No Tours$^{(7)}$ 21%
	Yogyakarta	Urban Fringe Non-Work$^{(1)}$ 21%	Urban Fringe Motorcycle$^{(3)}$ 15%	Farm$^{(6),A}$ 9%	City Motorcycle$^{(7)}$ 12%	Central City Non-Work Car$^{(4)}$ 9%				Car Work$^{(5),B}$ 6%	School$^{(2)}$ 24%	No Tours$^{(8)}$ 4%
Day 3	Ottawa	Urban Fringe Single-Stop$^{(3)}$ 17%	Recreational Walk$^{(4)}$ 4%	Frequent Urban Fringe$^{(5),A}$ 9%	Suburban Shop$^{(2)}$ 10%	City Single-Stop$^{(8)}$ 12%	Central City Multi-Stop$^{(9)}$ 6%	Outlying Centre$^{(6)}$ 4%	Outlying Area Long Distance$^{(1),B}$ 7%		Miscellaneous $^{(7)}$ 5%	No Tours$^{(10)}$ 26%
	Kuala Lumpur	Urban Fringe Motorcycle$^{(3)}$ 6%	Walk$^{(1)}$ 10%	Urban Fringe Bicycle and Bus$^{(5),A}$ 4%	Suburban$^{(4)}$ 4%			Long Distance Leisure Car$^{(6),B}$ 3%		Car$^{(2)}$ 16%		No Tours$^{(7)}$ 56%
	Yogyakarta	Urban Fringe Motorcycle$^{(1)}$ 31%		Urban Fringe Bicycle$^{(7),A}$ 11%	Suburban$^{(3)}$ 8%	City Multi-Stop$^{(4)}$ 5%		Long Distance Motorcycle$^{(6)}$ 10%	Long Distance Car$^{(2),B}$ 10%	Car$^{(5)}$ 14%		No Tours$^{(8)}$ 11%

$^{()}$Cluster numbers are in superscripted brackets.
^{A}Site cluster with highest mean number of tours per day.
^{B}Site cluster with highest mean travel distance.
The percentages in each cell represent the percentage of total survey respondents in that cluster.

6.4.2 DISCUSSION

The review of clusters follows the order of appearance of field sites and destinations in Table 100, and the references to clusters proceed from left to right.

6.4.2.1 *Ottawa*

Review of Clusters

Most of the Ottawa clusters are differentiated by characteristics of travel (location, complexity), rather than specific transport modes (as yielded in Kuala Lumpur and Yogyakarta) (see Table 94). Alternative modes of transport to the car are the basis for two separate clusters on Day 1 ("urban fringe non-car" which includes school bus travel and "multi-mode" which includes bus travel), and two clusters on Day 3 ("recreational walkers" and "miscellaneous" which includes multi-mode travel).

On both Days 1 and 3, there is a group of "frequent urban fringe travellers" who exhibit a high number of mean stops and mean tours in the urban fringe by car. Approximately 47% of the members of the "frequent urban fringe travellers" on Day 3 are members of the Day 1 group (see Table 101). This cluster has the highest proportion of members (of all Day 1 and 3 clusters) living in a village with 73% of members of the Day 1 cluster, and 74% of the members of the Day 3 cluster residing in a village. The presence of the "frequent urban fringe traveller" group (with a high proportion of its members living in a village) appears to be consistent with findings in Chapter Five showing an increased number of tours amongst those who live in villages (at the Ottawa field site).

Table 101: Ottawa Percentages of Day 1 Clusters in Day 3 Clusters

Day 3 Cluster/Group	Day 1 Cluster/Group: Urban Fringe Non-Car[1]	Simple Work[2]	City Non-Work[3]	Urban Fringe Car[4]	Multi-mode[5]	Frequent Urban Fringe Non-Work[6]	Outlying Centre[7]	Multi-Stop Work[8]	No Tours[9]	Total	n=159
Outlying Area Long Distance[1]	17%	0%	17%	25%	0%	17%	8%	8%	8%	100%	12
Suburban Shop[2]	0%	6%	25%	19%	13%	13%	0%	25%	0%	100%	16
Urban Fringe Single-Stop[3]	28%	0%	20%	16%	0%	12%	4%	16%	4%	100%	25
Recreational Walk[4]	17%	17%	17%	0%	0%	33%	0%	17%	0%	100%	6
Frequent Urban Fringe[5]	0%	0%	20%	13%	0%	47%	0%	13%	7%	100%	15
Outlying Centre[6]	0%	0%	33%	17%	0%	0%	50%	0%	0%	100%	6
Miscellaneous[7]	14%	0%	0%	14%	0%	0%	43%	29%	0%	100%	7
City Single-Stop[8]	20%	15%	15%	10%	5%	20%	5%	10%	0%	100%	20
Central City Multi-Stop[9]	30%	20%	10%	10%	0%	0%	0%	30%	0%	100%	10
No Tour[10]	17%	12%	10%	10%	10%	17%	5%	17%	5%	100%	42

Cluster numbers are in superscripts.

A group of "multi-stop work travellers" exhibiting similar behaviour (making non-work stops on the way to and from work) to the home-work corridor grocery shoppers explored in Chapter Five, is revealed in the Day 1 cluster analysis. The grocery analysis only examined work travellers on the basis of whether they report conducting their grocery shopping on a trip from home, or on a trip to or from work. It was found that compared to those who grocery shop from home, respondents who report conducting their grocery shopping in the home-work corridor travel a greater distance on Day 1, live a greater distance from downtown Ottawa, live a greater distance from a full-line grocery store and report travelling into the central city less frequently for non-work purposes.

While the grocery shopping results are not directly comparable[1], it is noted that the multi-stop work group resides at the second highest mean distance from city centre (38 km) of all the clusters (the "outlying centres" group has the highest mean distance). Also, the multi-stop work group travels the greatest distance on Day 1 (96 km) compared to all other clusters.

The Ottawa Day 1 cluster analysis also includes a cluster entitled "city non-work travellers" who travel to the suburbs and central city for non-work purposes. The cluster profile (see Table 89 on page 254) shows that the city non-work travellers have the highest rate of "morning congestion avoiders" with few members beginning tours between 6:30 and 8:30 in the morning. This cluster trait exemplifies the same pattern documented earlier in the thesis of non-work travellers avoiding travel during morning rush hour.

Cluster analyses for both Days 1 and 3 contain a group of respondents who travel to outlying centres. Half (50%) of the Day 3 group are members of the Day 1 group (see Table 101). Examination of the profiles (see Table 89 on page 254 and Table 95 on page 268) reveals that the "outlying centre" clusters on Days 1 and 3 reside the greatest mean distance from downtown Ottawa, compared to other clusters.

Focussing on Day 3 results, the development of the Sunday recreational walk cluster is consistent with earlier findings showing increased recreational walking in Ottawa as a percentage of total travel on Day 3, compared to Days 1 and 2.

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[1] A variety of non-work stops (other than grocery shopping) were used in the cluster analysis defining the multi-stop work group. The grocery shopping analysis also differs in that it was based on reported behaviour, compared to observed behaviour for the multi-stop work group.

Also on Day 3 an "outlying area long distance traveller" group is present. This is the same group of "working farm" respondents identified in Chapter Five who make leisure trips to outlying centres. Table 95 on page 268 shows that 67% of cluster members reside on a working farm.

Spatial Familiarity

In Chapter Five the concept of spatial familiarity was investigated by examining the general location of a respondent's stops over the three survey days. It was found that respondents who previously lived in the city had a higher number of mean stops to the city centre on Days 1 and 3, and to the suburbs on Days 1 and 2 than those who had not lived in the city previously. A similar trend is reflected in the cluster profiles where "lived in city, moved to fringe" is an exogenous variable (not included in the cluster analysis).

Examining the "lived in city, moved to fringe" data for Day 1 (see Table 89 on page 254), the clusters with the highest percentage of previously living in the city (Cluster 2: 80%; Cluster 3: 68%; and Cluster 8: 72%) also make a high percentage of their Day 1 stops in the central city and suburbs (Cluster 2: 48% central city, 54% suburbs; Cluster 3: 41% central city, 49% suburbs; and, Cluster 8: 40% central city and 42% suburbs).

Conversely, those clusters with low rates of "lived in city, moved to fringe" (Cluster 4: 29%, Cluster 7: 25%), have equally low percentages of stops in the central city and suburbs (Cluster 4: 8% central city and 3% suburbs; Cluster 7: 0% central city, 0% suburbs). The frequent urban fringe travel group does not fit the general trend as it has a relatively high "lived in city, moved to fringe" rate of 63%, but only 4% of Day 1 stops are made in the central city and 17% are made in the suburbs.

Turning to Day 3, the two clusters with the highest rate of "lived in city, moved to fringe" (Cluster 8: 88% and Cluster 9: 100%) also have the highest percentage of their Day 3 stops in the central city compared to all other clusters with Cluster Eight at 50% and Cluster Nine at 80%.

Findings from the cluster analysis for Days 1 and 3 generally show that clusters with higher rates of former city dwellers making a greater percentage of their daily stops in the central city, compared to those clusters with lower rates of former city dwellers.

Whether Travel is Undertaken

As discussed in Section 5.1, there is a small group of respondents (n=5) who did not make tours on Day 1. The number of respondents not making tours on Day 3 increases proportionately from Day 1, representing 26% of the sample on Day 3, compared to 3% on Day 1. The profiles do not yield any strong distinguishing characteristics for those not making tours on either Day 1 and 3. The only observation of note is that the level of "lived in city, moved to fringe" of 71% on Day 3 is slightly elevated compared to the other clusters. The elevated level may be related to respondents who are greater than or equal to 45 years of age and who commute a long distance on Day 1 and who do not make tours on Day 3 (as explored in Chapter Five).

Investigation reveals that working members of Day 3 Cluster Ten have the highest mean distance (67 km) to work on Day 1 of all the clusters (see Table 95 on page 268). However, Cluster Nine is not markedly lower (64 km) than Cluster Ten. Further exploration indicates that in Cluster Nine, 83% of Day 1 workers are less than 45 years of age, compared to 52% in Cluster Ten. This finding is consistent with the Chapter Five result showing that amongst respondents who were greater than or equal to 45 years of age, those making "no tours" on Day 3 travelled a greater distance to work on Day 1 than those who made tours.

6.4.2.2 *Kuala Lumpur*

The Kuala Lumpur cluster analysis yields three urban fringe clusters on both Days 1 and 3. On Day 1, the urban fringe clusters are defined by work (school, work and non-work), whereas on Day 3 they are defined by mode (motorcycle, walk, bicycle and bus) (see Table 100 on page 280).

A site-specific group for those who take a bus to school is present on Day 1. Approximately 21% of their cluster stops are at a "campus", so a portion of the "bus to school" group are college/university students.

With a greater variety of modes available in Kuala Lumpur besides the automobile, separate "car" clusters are present in both the Day 1 ("car") and Day 3 ("car" and "long distance leisure car") analyses. The "car" cluster on Day 3 (16%) being proportionately larger than the equivalent cluster on Day 1 (8%), and the development of a separate "long distance leisure car" cluster on Day 3 is consistent with findings earlier in the thesis showing the rate of car travel increases on non-work days, compared to work days (see Table 100).

There is commonality in the "car" cluster between Days 1 and 3, with 47% of the members of the Day 1 cluster being members of the Day 3 cluster (see Table 102). Correspondence is weaker between the Day 1 "car" and Day 3 "long distance leisure car" categories with only 6% of the members of the Day 1 "car" category belonging to the Day 3 "long distance leisure car" group.

Table 102: Kuala Lumpur Percentages of Day 3 Clusters in Day 1 Clusters

Day 3 Cluster/Group	Day 1 Cluster/Group: Urban Fringe School[1]	Urban Fringe Work[2]	Car[3]	Urban Fringe Non-Work[4]	Suburban Work[5]	Bus to School[6]	No Tour[7]
Walk[1]	9%	17%	0%	15%	7%	0%	14%
Car[2]	13%	13%	47%	8%	21%	19%	14%
Urban Fringe Motorcycle[3]	1%	17%	0%	18%	8%	0%	2%
Suburban[4]	0%	3%	0%	5%	15%	6%	1%
Urban Fringe Bicycle and Bus[5]	5%	4%	0%	5%	5%	0%	6%
Long Distance Leisure Car[6]	6%	3%	6%	3%	2%	0%	2%
No Tour[7]	66%	43%	47%	48%	43%	75%	60%
Total	100%	100%	100%	100%	100%	100%	100%
n=411	106	70	32	40	61	16	86

Cluster numbers are in superscripts.

In addition to the "car" clusters, there is also correspondence between the Day 3 "urban fringe motorcycle" group and the Day 1 "urban fringe work" group, with 44% of the Day 3 group being members of the Day 1 "urban fringe work" group (see Table 103). The overlap between these two clusters is likely related to motorcycle ownership and usage as the motorcycle is the dominant mode in the "urban fringe work" group.

Table 103: Kuala Lumpur Percentages of Day 1 Clusters in Day 3 Clusters

Day 3 Cluster/Group	Day 1 Cluster/Group: Urban Fringe School[1]	Urban Fringe Work[2]	Car[3]	Urban Fringe Non-Work[4]	Suburban Work[5]	Bus to School[6]	No Tour[7]	Total	*n*=411
Walk[1]	23%	27%	0%	14%	9%	0%	27%	100%	44
Car[2]	20%	13%	22%	4%	19%	4%	17%	100%	69
Urban Fringe Motorcycle[3]	4%	44%	0%	26%	19%	0%	7%	100%	27
Suburban[4]	0%	13%	0%	13%	60%	7%	7%	100%	15
Urban Fringe Bicycle and Bus[5]	28%	17%	0%	11%	17%	0%	28%	100%	18
Long Distance Leisure Car[6]	43%	14%	14%	7%	7%	0%	14%	100%	14
No Tour[7]	31%	13%	7%	8%	12%	5%	23%	100%	224

Cluster numbers are in superscripts.

Both Days 1 and 3 have a "suburban" group which is work-oriented. On Day 1, the "suburban work" group makes 98% of total stops for work, while the Day 3 cluster registers 56% of all stops for work. There is commonality between the members of both groups with approximately 60% of the Day 3 group being members of the Day 1 cluster (see Table 103).

A "long distance leisure travel by car" group develops on Day 3. Some members of this group are respondents who make intercity trips back to the "kampung" documented in Chapter Five. A substantial proportion of school-goers make up the "long distance leisure car" group with 43% being members of the "urban fringe school" group on Day 1 (see Table 103).

On Day 3 in Kuala Lumpur only 44% of respondents travelled, compared to 79% on Day 1. Those not making tours on Day 1 are predominantly female (81%) and 71% are greater than or equal to 20 years of age. While the percentage of respondents not making tours on Day 3 increases to 56% of the sample, the gender balance evens out to 50% male and female. The "bus to school" (75%) and "urban fringe school" (66%) clusters have a higher rate of not making tours on Day 3 compared to other clusters (43-60%).

6.4.2.3 *Yogyakarta*

Similar to Kuala Lumpur, the urban fringe Yogyakarta clusters are defined by work versus non-work purposes (non-work, motorcycle (70% work tours), and farming) on Day 1, and by mode (motorcycle versus bicycle) on Day 3 (see Table 100 on page 280). The Day 3 urban fringe clusters represent an older and younger group with 17% of the motorcycle group less than 20 years of age, compared to 53% for the bicycle group.

This age difference is also reflected in a third (33%) of the bicycle group coming from the Day I "school group".

Examination of Table 104 shows commonality between Days I and 3 in the patterns of those who travel mainly in the urban fringe on Day I. In all three urban fringe Day I clusters, over 70% of members of the Day I "urban fringe non work" and "farm", and 53% of the Day I "urban fringe motorcycle" belong to the Day 3 "urban fringe motorcycle" cluster.

In Yogyakarta, a separate cluster developed for "school" without any spatial qualifiers (urban fringe, suburbs, central city). The "school" category includes not only primary and secondary education, but also post-secondary, which accounts for some of the diversity in location, as many of the colleges and universities in Yogyakarta are located in the suburbs and central city.

Table 104: Yogyakarta Percentages of Day 3 Clusters in Day 1 Clusters

Day 3 Cluster/Group	Day 1 Cluster/Group							
	Urban Fringe Non-Work[1]	School[2]	Urban Fringe Motorcycle[3]	Central City Non-Work Car[4]	Car Work[5]	Farm[6]	City Motorcycle[7]	No Tour[8]
Urban Fringe Motorcycle[1]	52%	13%	53%	0%	14%	50%	38%	20%
Long Distance Car[2]	4%	13%	0%	42%	29%	0%	0%	20%
Suburban[3]	4%	13%	11%	0%	0%	0%	13%	40%
City Multi-Stop[4]	4%	6%	5%	0%	0%	17%	6%	0%
Car[5]	7%	9%	16%	33%	29%	8%	0%	0%
Long Distance Motorcycle[6]	7%	6%	16%	8%	29%	0%	19%	0%
Urban Fringe Bicycle[7]	19%	16%	0%	0%	0%	25%	13%	0%
No Tours8	4%	25%	0%	17%	0%	0%	13%	20%
Total	100%	100%	100%	100%	100%	100%	100%	100%
***n*=130**	27	32	19	12	7	12	16	5

Cluster numbers are in superscripts.

Similar to Kuala Lumpur, there are two "car" clusters in Yogyakarta on both Day 1 ("central city non-work car" and "car work") and Day 3 ("long distance car" and "car"). The formation of specific car clusters reflects the lesser use of the car in Yogyakarta compared to Ottawa. Exhibiting the same trend observed in Kuala Lumpur of increased car use on a non-workday, the Yogyakarta cluster is proportionately larger on Day 3 (14%), compared to Day 1 (6%) (see Table 100).

There is correspondence between the car clusters on Day 1 and Day 3, particularly for the Day 1 "central city non-work car" and Day 3 "long-distance car" clusters. Combining the percentages of members of both Day 3 car categories ("long distance car" and "car"), represents 75% of the members of the Day 1 "central city non-work car" group (see Table 104).

In a parallel development to Ottawa, a separate "suburban" cluster forms in Yogyakarta on Day 3. Approximately 36% of the members of the "suburban" Day 3 group come from the Day 1 "school" group (see Table 105).

There is a "long-distance car" group on Day 3. Members of this group make "refreshing" stops to outlying areas as documented in Chapter Five. The "long-distance car" cluster is made up of the following percentages of Day 1 groups: 31% of "school", 38% of "central city non-work car" and 15% of the "car-work" cluster (see Table 105).

Table 105: Yogyakarta Percentages of Day 1 Clusters in Day 3 Clusters

Day 3 Cluster/Group	Day 1 Cluster/Group: Urban Fringe Non-Work[1]	School[2]	Urban Fringe Motorcycle[3]	Central City Non-Work Car[4]	Car Work[5]	Farm[6]	City Motorcycle[7]	No Tour[8]	Total	n=130
Urban Fringe Motorcycle[1]	33%	10%	24%	0%	2%	14%	14%	2%	100%	42
Long Distance Car[2]	8%	31%	0%	38%	15%	0%	0%	8%	100%	13
Suburban[3]	9%	36%	18%	0%	0%	0%	18%	18%	100%	11
City Multi-Stop[4]	14%	29%	14%	0%	0%	29%	14%	0%	100%	7
Car[5]	13%	20%	20%	27%	13%	7%	0%	0%	100%	15
Long Distance Motorcycle[6]	15%	15%	23%	8%	15%	0%	23%	0%	100%	13
Urban Fringe Bicycle[7]	33%	33%	0%	0%	0%	20%	13%	0%	100%	15
No Tours[8]	7%	57%	0%	14%	0%	0%	14%	7%	100%	14

Cluster numbers are in superscripts.

Similar to Ottawa, Yogyakarta has only a small group of respondents (*n*=5, representing 4% of the sample) who did not make tours on Day 1. The rate of not making tours increases to 11% on Day 3. The only two characteristics of note in the Day 3 profile is one, that 64% of the respondents not making tours are female. Being cautious since the number of respondents not making tours is only *n*=14, the second is that all Day 1 members of the urban fringe motorcycle, car work and farm categories do make tours on Day 3.

6.4.3 Comparison of Results Between Field Sites

The concluding section to this chapter compares and contrasts the three field sites on the basis of:

a) modes of travel;

b) travel distance, tour complexity and destination;

c) reason for travel; and,

d) frequency of travel.

Modes of Travel

Ottawa's travel is mainly by ***car***, so groups are defined by alternative modes of transport (except "urban fringe non-car" which includes school bus riders and "multi-mode" which includes bus riders on Day 1). Kuala Lumpur and Yogyakarta differ from Ottawa in that the car is less common, so separate clusters form for car travel.

The percentage of car use in all field sites increases on days when fewer respondents are working (see Chapter 5). This trend is reflected in the car-specific clusters in Kuala Lumpur and Yogyakarta increasing proportionately on Day 3, compared to Day 1 (see pages 286 and 288). Commonality in the membership of the car clusters between Days 1 and 3 in Kuala Lumpur and Yogyakarta, (discussed earlier in this chapter), may be indicative of car owners using modes of transport other than the car less frequently.

The wider use of the ***motorcycle*** in Yogyakarta, compared to Kuala Lumpur is reflected in the motorcycle-specific clusters in Yogyakarta ("urban fringe motorcycle", "city motorcycle") on Day 1, and two ("urban fringe motorcycle" and "long distance motorcycle") on Day 3. By contrast, there are no separately defined motorcycle clusters in Kuala Lumpur on Day 1. A motorcycle cluster ("urban fringe motorcycle") does develop in Kuala Lumpur on Day 3.

Bicycle use is more prevalent in Kuala Lumpur and Yogyakarta, compared to Ottawa. This trend is reflected in the Day 3 development in Kuala Lumpur of the "urban fringe bicycle and bus" cluster and the "urban fringe bicycle" cluster in Yogyakarta.

A greater proportion of travel by the ***bus*** mode in Kuala Lumpur, compared to Ottawa and Yogyakarta, is exhibited in the specific bus clusters of "bus to school" on Day 1 and "urban fringe bicycle and bus" on Day 3.

Travel Distance, Tour Complexity and Destination

Clusters with the highest mean travel distances for each field site and survey day are identified in Table 94 on page 266. Specifically, these Day 1 and 3 clusters are:

Day 1

- Ottawa "multi-stop work",
- Kuala Lumpur "suburban work", and,
- Yogyakarta "car work".

Day 3

- Ottawa "outlying area long distance",
- Kuala Lumpur "long-distance leisure car", and,
- Yogyakarta "long-distance car".

For Day 1 (a work day) travel within each city region (Day 1 did not include intercity travel), the clusters with the highest mean travel distances are work clusters (as opposed to non-work clusters). For Day 3 (a non-work day) travel both inside and outside each city region (Day 3 included intercity travel), the clusters with the highest mean travel distances are for non-work purposes.

Clusters defined by tours with multiple stops and the percentage of stops made in the central city and suburbs are: Day 1 Ottawa "multi-stop work" (40% central city and 42% suburbs), Day 3 Ottawa "central city multi-stop" (80% central city and 10% suburbs) and Day 3 Yogyakarta "city multi-stop" (50% central city and 50% suburbs). A common element among all three clusters is that they have a high proportion of stops in the central city. The cluster analysis of Kuala Lumpur data did not yield any clusters defined by multi-stop tours, and there are also fewer tours to the central city in the Kuala Lumpur survey.

The urban fringe being the destination of the greatest proportion of tour stops in all three field sites (see Chapter Five) is reflected in the cluster analysis by a greater number of clusters (three for each field site and survey day except Yogyakarta on Day 3), compared to other destinations.

A distinct "suburban" cluster of a similar percentage (8-10%) of the sample develops in both the Ottawa and Yogyakarta analyses on Day 3 (not present on Day 1 in either field site). Kuala Lumpur, by contrast, has a suburban cluster on both days. In the Ottawa suburban cluster, 77% of the stops are for shopping and in Yogyakarta 50% of the stops are for shopping. The Day 3 "suburban" cluster for Kuala Lumpur is mainly for work (56% of stops) with a smaller percentage (19%) for shopping.

As mentioned above, in comparing the results of the cluster analyses across all three field sites it is noticeable that Kuala Lumpur lacks "central city" clusters. In Chapter Five it was postulated that this may be partially due to the decentralized layout of Kuala Lumpur contributing to fewer respondents travelling to the central city of Kuala Lumpur, thereby explaining why there are no Kuala Lumpur "central city oriented" clusters.

Ottawa has an "outlying centre" group both days, whereas Kuala Lumpur and Yogyakarta do not. The formation of the clusters in Ottawa may be explained by the slightly higher level of stops in outlying centres of 7% on Day 1, compared to 3-4% for the other field sites, and 18% on Day 3 compared to 3-12% for the other two field sites. All field sites have a long distance travel group on Day 3 (Yogyakarta has two).

Reason for Travel

In Chapter Five it was documented that respondents in Ottawa made the highest proportion of their stops for shopping. This trend may be partially reflected in Ottawa having the only strongly defined shopping cluster "suburban shop" on Day 3. The "suburban shop" cluster emerged at the five-cluster level in the Ottawa analysis, so its presence can not be discounted by the fact that Ottawa has more clusters than the other two field sites.

Earlier in Section 5.5 it was noted that on Day 1 Kuala Lumpur had the highest number of school stops (as a percentage of total) (35%), compared to Yogyakarta (22%) and Ottawa (7%). Differences in school travel between the three field sites are reflected in the Day 1 cluster analysis. Kuala Lumpur has two school-oriented clusters ("urban fringe school" and "bus to school"), accounting for 30% of the sample[1], while Yogyakarta has one cluster "school" specifically defined on the basis of school stops accounting for 24% of the sample. Ottawa has one cluster "urban fringe non-car" (consisting of 15% of the

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[1] When referring to cluster sizes in terms of percentage of the sample, it is noted that the percentages are calculated on the basis of total respondents and include those not making tours, so they are not directly comparable to data presented from Chapter Five which is a percentage of total stops and tours. The cluster sizes cannot be inferred to apply to the field sites in general. The sampling strategy in this study was designed to give an overview of the different types of behaviour in the urban fringe, but was not matched specifically to the population to a degree that would allow statistical inference.

sample), containing school tours by school bus, but the cluster is not exclusively defined by school travel.

It was observed in Chapter Five that on Day 1 in Kuala Lumpur there was a higher number of work stops (as a percentage of total) compared to the lower (and equal) numbers in Yogyakarta and Ottawa. As mentioned previously, the greater work travel may be explained by the younger demographic profile of the Kuala Lumpur respondents. A reflection of this difference is the development of two strongly defined work clusters ("urban fringe work" and "suburban work") in Kuala Lumpur accounting for 32% of the sample.

Yogyakarta's stops for farming as a percentage of total are the highest compared to the other field sites, and are reflected in Yogyakarta having the only "farming" cluster in the study. By contrast, Ottawa's work-oriented clusters ("multi-stop work" and "simple work") make up 24% of the sample, and in Yogyakarta the "farm" and "car work" make up 15 % of the sample.

Frequency of Travel

The cluster exhibiting the highest mean number of tours (per day) in each field site and on each survey day is identified in Table 100. Specifically these six clusters on Days 1 and 3 respectively are:

- Ottawa: "frequent urban fringe non-work" and "frequent urban fringe";
- Kuala Lumpur: "urban fringe non-work" and "urban fringe bicycle and bus"; and,
- Yogyakarta: "farm" and "urban fringe bicycle".

In comparing the clusters across field sites and days, it is evident that they are similar in that the travel of cluster members is concentrated in the *urban fringe*. Table 106 compares the six clusters on the basis of travel mode and stop purpose. In Ottawa travel is by car, in Kuala Lumpur by a variety of modes, and in Yogyakarta by walking and bicycling. In Ottawa "pick-up/drop-off" stop purposes are among the main stop purposes on both days. "Shopping" is consistently the main stop purpose on both days in the Kuala Lumpur clusters. In Yogyakarta stop purposes differ between days, with farming and work being the main purposes on Day 1. On Day 3, similar to Ottawa, religion and social purposes make up the largest proportion of daily stops in Yogyakarta.

Thus, clusters with high mean daily tour rates use non-motorized transport in Yogyakarta, a combination of motorized and non-motorized transport in Kuala Lumpur, and largely motorized transport in Ottawa. Clusters with high mean tour rates in Yogyakarta make stops on Day 1 mainly for farming and work purposes, whereas at the other field sites the main stop purposes are for non-work purposes.

Table 106: Comparison of Clusters from Each Field Site with the Highest Number of Mean Tours

Field Site	Ottawa		Kuala Lumpur		Yogyakarta	
Day	Day 1	Day 3	Day 1	Day 3	Day 1	Day 3
Mode (% of total tours)	Car (75%) Walk (16%)	Car (100%)	Motorcycle (41%) Walk (28%)	Bicycle (43%) Bus (38%)	Walk (33%) Bicycle (30%)	Walk (17%) Bicycle (66%)
Purpose (% of total stops)	Pick-up/Drop-off (31%) Shopping (17%)	Religion (22%) Social (20%) Pick-up/Drop-off: (22%)	Shopping (19%)	Shopping (48%)	Farm (50%) Work (17%)	Religion (33%) Social (15%) Work (15%)

6.5 *Summary*

Chapter Six demonstrates a method for classifying travel patterns by using cluster analysis. The classification enables various dimensions of the travel patterns to be explored and facilitates a comparison of travel patterns across field sites between a work day and a non-work day.

The analytical technique of cluster analysis was selected for several reasons. Since this study is exploratory, a technique that *does not assign dependent and independent variables* was sought. The objective of the analysis is to develop a classification of travel patterns, to test an approach that *groups* individual cases together. Owing to the exploratory nature of the research, the classification groups were not pre-determined, thereby dictating a technique that *searches* for groups within the data. To fully represent the travel patterns, a series of variables was required which led to the selection of a *multivariate* procedure. It was learned through the research that the variables that most fully describe the dimensions of travel behaviour studied in this thesis are measured on different scales. Thus a technique that accepts *mixed scale variables* is necessary. Taking these criteria into account, the only appropriate methods from which to choose are variants of cluster analysis including clustering methods, fuzzy techniques and mixture models (Wedel and Kamakura, 1998).

Mixture models have an advantage over fuzzy techniques in that they model the probability of group membership, rather than providing an absolute estimate of membership as do the fuzzy techniques. The mixture models have some limitations and due to their recent introduction, software for their implementation is just now being developed. Thus, the only choice available fulfilling all criteria are clustering methods (other than fuzzy techniques and mixture models). A *k-means optimization* procedure was selected as it is more robust than *hierarchical* clustering and better suited to the current application than the *direct clustering of data matrices* and *clustering with constraints* approaches. The *k-means* algorithm was chosen over the *density search* and *overlapping* methods due to its wider availability in commercial software packages.

The variables used in the cluster analysis were designed to cover all the main dimensions of travel including: mode choices, tour purposes, destinations, distance and time travelled and number of tours and stops per day. A Euclidean distance measure was employed and since the variables are on different scales, they were standardized prior to clustering.

A series of k-means clustering tests using sequential numbers of clusters were conducted on each field site dataset for Days 1 and 3. The number of clusters was determined on the basis of the within-cluster sum of squares and variable means at each step. The results of the analysis are presented in cluster profiles for Days 1 and 3 for each field site. The profiles include both variables directly incorporated in the cluster analysis and exogenous variables (not included in the cluster analysis).

A comparison in Chapter Six between the findings of the cluster analysis and the summary statistics and hypothesis tests in Chapter Five demonstrate that the results are largely consistent. The variable set covering all major mode choices, tour purposes, destinations, distance and time travelled and number of tours and stops, used in the cluster analysis was found to be effective in capturing trends identified in Chapter Five through other means.

The definition of different travel groups each possessing distinguishing characteristics provides knowledge of the different types of travel behaviour at the three survey sites on a workday and on a non-workday. In addition, the study has revealed more general observations regarding urban fringe travel in the three surveys such as an increase in the size of "car" clusters in Kuala Lumpur and Yogyakarta on non-workdays compared to workdays, and clusters possessing the highest mean tour rate having destinations concentrated in the urban fringe in all three field sites.

7. Conclusion and Research Implications

This final section of the thesis is presented in two parts: conclusion and research implications. The conclusion outlines the travel pattern technique developed in this research, and identifies its contribution to the ways and means of adding to knowledge. Empirical research findings from all three field sites are also summarized, and their addition to knowledge is indicated.

In the second section, research implications, the following matters emerging from the thesis are discussed: data collection and analysis techniques; study methodology; and, further research.

7.1 Conclusion

Despite the identification of the 'urban problem' over 30 years ago and numerous reports in the interim on the need for and nature of corrective actions (Owen, 1966; Wellar, 1982; Wellar, 1994; Government of Canada, 2002), its symptoms persist in developing and developed urban areas alike. In the maturing transportation environment of North America, the traditional pattern of morning and afternoon peaks of commuters travelling to and from the city core is changing to one in which volumes are heavy throughout the day, and the suburbs are the origin and destination of proportionately more trips. Further, general travel volumes have increased since the 1950's, and there has also been growth in the amount of non-work travel (Torrie, 1996). In Southeast Asian urban areas, where the transportation networks are rapidly diversifying and expanding, congestion, road accidents, health concerns and environmental pollution are just some aspects of the transportation part of the urban problem (Rimmer, 1995).

Now, layered on top of these difficulties, is the global concern of climate change (IPCC, 1996). In Canada, automobiles and light trucks are a major source of greenhouse gas emissions, making up a large proportion of the transportation sector's total emissions which ranked second among all Canadian sectors in 1997 (Nietzert et. al., 1999). In contrast, less developed nations produced only 15% of the additional carbon dioxide released in 1988. However, their contribution has been increasing by 5% per year, compared to 0.7% for developed countries (Whyte, 1995). The increased demand for motorized vehicles, combined with the sizeable populations in the developing world, raise serious concerns about future levels of carbon dioxide emissions.

New technology to minimize emissions may not be able to solve the environmental repercussions of current transportation system activities. While vehicle emission controls have been able to reduce greenhouse gas emissions such as methane and nitrous oxide, carbon dioxide releases have followed fuel use patterns, and thus are not technology-dependent (Neitzert et. al., 1999). Further, advances like the fuel cell, while providing more efficient combustion, shift the carbon dioxide emissions to an indirect source since their fuel (hydrogen or methane) is produced using a secondary fuel, for example natural gas (Wiens, 1999). Alleviation of the carbon dioxide problem may be possible through using renewable fuels, however large quantities of energy would be required for use in automobiles (Wiens, 1999). It appears clear that in order to achieve urban sustainability it will be necessary to look beyond technology to reduce the impact of transportation on the environment (Wellar, 2003). That is, in question form,

> How can we organize our urban land use and transportation systems in order to accommodate the movement of people and goods without incurring the congestion, greenhouse gas emissions, pollution and other direct and indirect costs of current transportation networks?

In answer to such a question, this thesis outlines a methodology for gathering, analyzing and segmenting urban travel patterns. The approach is tested through a case study of three cities, and the results are compared and contrasted among the field sites.

7.1.1 Travel Pattern Analysis

Current transportation modelling paradigms were originally developed to forecast corridor demand in North America in the 1960's (Wen, 1998). As a result, they are not always appropriate for policy analysis and planning involving suburb-to-suburb travel, travel in outer fringes of large urban areas, or transportation networks outside North America.

The approach taken in this thesis may be used as a supplement to the four-step traffic forecasting model. While the "four step" is valuable for long-range strategic planning and forecasting volumes of major flows on a regional scale, the approach of looking at individual and household travel patterns can provide information on processes operating at a finer scale, which in turn influence major flows. Targetted surveys in specific urban fringe zones could provide trip generation and distribution estimates, as well as mode and route choice estimates, for input into region-wide four-step models. Individual scale modelling could also be used to estimate travel flows at specific locations as a result of socio-economic shifts and changes in transport modes, services or infrastructure.

Specifically, this technique gathers, analyzes and segments travel patterns. As travel patterns spread out in time and space in North America (Torrie, 1996), and as cities worldwide exhibit travel patterns that differ from the North American 1950's model, this technique provides a basis for achieving greater understanding of heterogeneity in system-wide travel behaviour.

A household survey approach is employed in this research since it yields detailed data on respondents' travel patterns and lifestyles, and thereby provides a means for examining individuals' travel behaviour in context. Activity analysis is then used to examine individual travel patterns. Specifically, the "decompositional direct travel/activity pattern" approach (Kansky, 1967; Hanson and Marble, 1971; Hanson and Huff, 1986) is used to break down travel patterns into component parts creating measures for each of the travel dimensions: destination; reason for travel (stop purpose); mode of transport; travel distance and travel time; number of stops and tours; complexity of tours; and, work versus non-work travel.

The travel patterns are then grouped using cluster analysis. Specifically, a k-means clustering procedure with a Euclidean distance measure is implemented using standardized variables. Socio-demographic and other variables not directly related to the description of travel patterns are explicitly excluded from the cluster analysis so that groupings are formed based only on the basis of commonality in travel characteristics. Following the cluster analysis, the clusters are profiled with external variables such as mean distance from city centre, age, gender, work status, residential and work history, and, residential setting.

Once travellers are segmented, heterogeneity in system-wide travel behaviour is represented and can be more easily understood by smaller, more homogeneous groups (Wedel and Kamakura, 1998).

The technique developed in this research is an accessory to the aggregate four-step model that estimates regional and inter-city demand for highways. By examining individuals and households living in a specific part of an urban area (here, the urban fringe), the technique looks at why, where, how and when travel is undertaken. Such an approach produces information that can be incorporated into aggregate regional models.

This study does not represent the first application of cluster analysis to define travel groups, as that line of inquiry was established a number of years ago (Kansky, 1967). Differentiating this technique from others, as a contribution to inquiry, are the following elements ***implemented in combination:***

- an urban fringe, spatial, residential sampling technique;
- a detailed household survey obtaining data on a variety of variables;
- data on travel patterns over a full day, for three separate days, covering work and non-work periods;
- a Geographic Information System to manage the large database; and,
- cluster analysis of survey data using the variable set identified in the research.

The travel pattern analysis technique has been implemented in a case study of three cities. The following section presents a summary of case study findings.

7.1.2 COMPARATIVE STUDY

A case study approach was selected for the empirical component as the research sought to conduct an in-depth survey of individual travel patterns. Travel behaviour in three cities are compared and contrasted: Ottawa, Canada; Kuala Lumpur, Malaysia; and Yogyakarta, Indonesia.

Findings of the travel pattern research at the three field sites are identified and discussed. The results derive from the summary data analysis and hypothesis testing conducted in Chapter 5, and also from the cluster analysis in Chapter 6. Results from a detailed analysis of the Ottawa travel pattern data are integrated into the main discussion. Specifically, the following topics are discussed:

a) whether travel is undertaken;

b) modes of travel;

c) distance, time and speed of travel;

d) destination;

e) reason for travel;

f) frequency of travel;

g) complexity of travel; and,

h) spatial familiarity.

The next part of this section looks at the role urban migration and mobility, combined with employment location, may play in influencing travel patterns.

Whether Travel is Undertaken

There is a wider span of the populations in both Ottawa and Yogyakarta travelling on Day 1, compared to Kuala Lumpur where 20% of the sample did not make tours. Of the respondents who did not travel 80% are female, meaning that a higher percentage of males were travelling (to work) in Kuala Lumpur compared to other field sites. The gender imbalance in Kuala Lumpur harkens back to the 1950's in North America, when many of the commuters were male. Commuters in Kuala Lumpur differ from those in 1950's North America in that the urban fringe and suburbs, rather than the city core, are the destination of the majority of work tours. On Day 3, while the gender balance evens out over half of the Kuala Lumpur respondents do not make tours, compared to a quarter of respondents in Ottawa and a tenth of respondents in Yogyakarta.

Detailed examination of the Ottawa dataset showed that amongst respondents greater than or equal to 45 years of age, respondents who did not make any tours on Day 3 had a higher distance to work on Day 1, compared to those who did make tours. The same trend was borne out in the Day 3 cluster analysis, where the "no tours" group and one of the clusters have a similar (high) mean distance to work on Day 1. The difference between the "no tours" group and the cluster is that 83% of Day 1 workers in the cluster are less than 45 year of age, compared to 52% in the "no tours" group.

The results show that while gender is an important variable in describing work day non-travel in the Kuala Lumpur survey, it does not appear to be a factor associated with non-travel in the Kuala Lumpur sample site on Days 2 and 3, or in the Ottawa or Yogyakarta field sites on any of the survey days.

Modes of Travel

In the low-density conditions of Ottawa, the car is used for the majority of travel. The car is also found to have the largest single modal share in the Kuala Lumpur survey (though less than in Ottawa), followed by the bus and motorcycle. As a nearly-developed nation, Malaysia now has its own car industry, and in the last few years the rate of car ownership has increased (The Financial Express, 1998). In Yogyakarta, the motorcycle is used for the greatest percentage of tours, and accounts for the largest share of kilometres travelled, followed by the car and bus.

The differing rate of car usage among the field sites is reflected in the cluster analysis, with most clusters in Ottawa being distinguished by characteristics other than the car. In the Kuala Lumpur and Yogyakarta analyses, the car is less common so separate 'car' clusters develop. In all field sites it was found that car use increased on non-work days, compared to work days. This trend is reflected in the car-specific clusters increasing in size proportionately on Day 3, compared to Day 1.

A hypothesis regarding the gender of car passengers was tested using the Ottawa dataset. It was found that on all three survey days, female respondents were more frequently the car passenger (rather than the car driver).

The second most commonly used mode of transport in Kuala Lumpur is the bus. Greater bus use in Kuala Lumpur, compared to Ottawa and Yogyakarta, is reflected in a bus cluster forming on both Days 1 and 3, in contrast to the absence of "bus" clusters in Ottawa or Yogyakarta on the same days.

The more frequent use of the motorcycle in Yogyakarta, compared to Kuala Lumpur, is mirrored in the formation of a motorcycle cluster in Yogyakarta on both Days 1 and 3. By comparison, there are no such separately defined clusters in Kuala Lumpur on Day 1, although a motorcycle cluster does develop on Day 3. Motorcycles were not used as a mode of transport in the Ottawa survey because few households owned motorcycles.

Bicycle use as a percentage of total tours is higher in Kuala Lumpur and Yogyakarta, compared to Ottawa. A bicycle-oriented cluster forms in both Southeast Asian field sites on Day 3, while none are present in the Ottawa dataset on any of the survey days.

Walk tours, as a percentage of total tours, are slightly higher in Kuala Lumpur and Yogyakarta, which is reflected in the formation of a "walk" cluster in Kuala Lumpur on Day 3. The level of recreational walking is higher in Ottawa (see Chapter 5), and is mirrored by the development in the cluster analysis of a separate recreational walk cluster in Ottawa on Day 3.

The wider variety of modes in Yogyakarta and Kuala Lumpur leads to a more diverse modal share, compared to Ottawa's car-dominated environment. Commonality in the membership of the car clusters between Days 1 and 3 in Kuala Lumpur and Yogyakarta may point to car owners using modes of transport other than the car less frequently.

Over the three survey days, Yogyakarta's modal variability is higher than that of Ottawa and Kuala Lumpur, particularly for study participants those greater than or equal to 20 years of age. This may be attributed to the lower vehicle ratio in Yogyakarta. Across all field sites, respondents less than 20 years of age have a significantly higher modal variability than those greater than or equal to 20 years of age. Lack of a personal vehicle among the younger respondents may be the reason for their higher modal variability. An example of modal variability is an instance documented in the Southeast Asian research, of a car owner taking his motorcycle (instead of a car) to allow him to weave past crowded areas on his journey.

The modes of transportation were found to vary greatly between the field site cities. A wider diversity of modes operates in the Southeast Asian field site cities, compared to Ottawa. In Yogyakarta there are a variety of bus types, including smaller scale models (e.g. mini bus and *angkudes*). Another example of the greater transportation options available in the Southeast Asian field sites is Kuala Lumpur's light rail transit and commuter rail. The rail system extends into the urban fringe, offering an alternative to the car.

Distance, Time and Speed of Travel

Travel distance, time and speed reflect the modal share of the car in all three countries, with Ottawa having the highest mean travel distances, travel times and speeds, followed by Kuala Lumpur, then Yogyakarta.

The ranking of the travel distances, times and speeds parallels the order of the population densities in the survey areas with Ottawa having the lowest, Kuala Lumpur the medium and Yogyakarta the highest population density.

Examination of tour length for mandatory (work) and discretionary (non-work) purposes reveals that the average work tour in Ottawa is much longer (59 km) than in Kuala Lumpur (28 km) and Yogyakarta (19 km). Similar to work tour length, the average length of shopping tours is much longer in Ottawa (44-61 km) compared to Kuala Lumpur (17-31 km), and Yogyakarta (8-15 km).

On Day 1, shopping tours in Kuala Lumpur and Yogyakarta are shorter in length (17 and 8 km) than work tours (28 and 19 km), whereas in Ottawa they are the same length (shopping tours: 61 km, work tours: 59 km). Of Ottawa's Day 1 shopping tours, a third are multi-stop work tours, compared to fewer (6-8%) in the Southeast Asian field sites. The equal work and shopping distances in Ottawa may be partially explained by the overlap between work and shopping tours (a third of shopping tours are work tours). By contrast, in Kuala Lumpur and Yogyakarta the majority of work and shopping tours on Day 1 are mutually exclusive.

These observations regarding tour length for work and shopping are reflected in the Day 1 cluster analysis, in that across field sites the clusters exhibiting the greatest travel distance are mainly related to work as opposed to non-work purposes. The Ottawa cluster with the highest mean travel distance is a multi-stop work cluster which combines work and non-work (including shopping) purposes. The members of this cluster may be contributing to the equal mean distances for work and shopping tours on Day 1.

Detailed analysis of the Ottawa dataset revealed that travel distances varied between sample sites. Mean daily travel distance for respondents living in a village ranged between 32-53 km, while residents of estate and rural lots exhibited higher daily travel distances of between 59-78 km. The working farm participants had a range of 38-43 km on Days 1 and 2 increased substantially to 105 km on Day 3 (due to tours to outlying areas). Results indicate that different residential settings (village, outside of a village or working farm) in the Ottawa survey area exhibited distinct mean total travel distances over the three survey days.

Another hypothesis regarding the timing of travel was investigated for Ottawa. It was found that respondents who did not travel to an external work location on Day 1 were less likely to begin their tours between 6:30-8:30 am (morning rush hour) compared to respondents who travelled to an external work location. The cluster analysis reflects this result in the formation of a cluster termed "city non-work travellers" on Day 1. Members of this cluster travel to the suburbs and central city for non-work purposes by car, and have the lowest rate of beginning tours in the morning rush hour. Nearly a quarter are homemakers or have the day off work, and over a third are retired.

The results indicate that the variable "work status" (work at an external location, homemaker or retired) is associated with the distance and timing of travel in the Ottawa survey.

Destination

The urban fringe was the destination of over half of all stops in both the Kuala Lumpur and Yogyakarta surveys, compared to less than half in Ottawa over all three survey days. The high percentage of stops in the urban fringe across all field sites is mirrored in the cluster analysis with a greater number of "urban fringe clusters" compared to clusters representing other destinations.

Respondents in Kuala Lumpur and Yogyakarta made a fifth of all stops in the suburbs, while respondents in Ottawa made a quarter of all stops in the suburbs. In the cluster analysis, Kuala Lumpur exhibits a suburban cluster on both Days 1 and 3. In contrast to the Kuala Lumpur clusters which are work-oriented, suburban clusters which appear only on Day 3 in Ottawa and Yogyakarta are mainly non-work (shopping) related.

Respondents in Ottawa and Yogyakarta make a fifth of their stops in the central city (except for Yogyakarta Day 3 which is lower), compared to less than a tenth of stops in Kuala Lumpur. The cluster analysis of Kuala Lumpur data parallels the earlier finding of few stops made in the central city, by not yielding any "central city" clusters. This may be attributed to the decentralized layout of Kuala Lumpur which reduces the need to travel to the central city.

On Days 1 and 2, the field sites don't differ markedly in the percentage of tours to outlying areas/centres (2-7%). Ottawa does have a slightly higher level reflected in the development of an "outlying area" cluster on both Days 1 and 3, in contrast to the absence of such a cluster in the Southeast Asian field sites on either day. However, on Day 3 the level of stops to outlying centres in Ottawa and Yogyakarta increases to 18% and 12% respectively.

The survey did not include intercity travel on Day 1, as business travel was not a focus of the study. Neither was intercity travel included on the Day 2 survey in Yogyakarta since it was a work day. Kuala Lumpur registered 2% intercity stops on Day 2, and Kuala Lumpur and Yogyakarta each recorded 3% intercity stops on Day 3. There were no intercity stops recorded in Ottawa on either Day 2 or 3.

Examining the destination of stops for mandatory (work) and discretionary (non-work) purposes, it was found that in Kuala Lumpur 56% of work stops (including farming) are in the urban fringe, compared to 62% in Yogyakarta and 33% in Ottawa.

Similar to the finding on work locations, a high percentage (50-89%) of shopping stops in Kuala Lumpur and Yogyakarta were made in the urban fringe, compared to in Ottawa (18-38%). The high proportion of urban fringe shopping stops in the Southeast Asian field sites can be attributed to patronage of local markets. In Ottawa, a parallel is observed with a one-day-a-week market increasing urban fringe shopping stops by 16% on Day 2.

Reason for Travel

Among the field sites, Ottawa has the highest proportion of stops for shopping reflected in the development of a specific shopping cluster on Day 3, while none develops at the other field sites.

Kuala Lumpur has the highest number of school and work stops due to a younger demographic profile. In the cluster analysis, results from Kuala Lumpur show two school-oriented clusters, while Yogyakarta has only one. Ottawa does have a cluster containing school bus tours, but it is not exclusively defined by school travel. All three field sites have two work clusters, with Kuala Lumpur's clusters covering 32% of the sample, whereas Ottawa and Yogyakarta's clusters make up less of the sample at 24% and 15%, respectively.

Among the field sites, farming makes up less than a tenth of all stops, but Yogyakarta's stops as a percentage of total are the highest, and are reflected in Yogyakarta exhibiting the only "farming" cluster in the analysis.

From an overall perspective across all field sites, on non-work days (compared to workdays) leisure/entertainment, recreation, shopping and social stops increase (as a percentage of total stops) while work and school stops decrease.

Frequency of Travel

Frequency of travel is defined in this study as the rate of making tours over a day. In the Ottawa dataset, the relationship between tour length and frequency of travel was investigated by comparing village and non-village dwellers. It was found that on Days 1 and 3, village dwellers made a significantly higher number of tours and shorter tours, compared to non-village dwellers. A related finding arose from comparing cluster profiles across days and field sites. It was found that the clusters with the highest mean number of tours (per day) are also similar in that the travel of cluster members is highly concentrated in the urban fringe. Considering the results of the Ottawa hypothesis testing and the cluster analysis, there appears to be an inverse relationship between frequency of tours and tour length.

Complexity of Travel

In this research, *complexity of travel* refers to longer tour distances, tours with more than one stop (multi-stop tours), and travel to destinations past the next closest service centre. One occurrence of such defined complex travel behaviour was documented among a group of commuters in the Ottawa survey.

The term *home-work corridor* is used to describe the path in which commuters travel to work, and also refers to the area in which they may make non-work stops. In the Ottawa survey, approximately a third of all the shopping tours on Day 1 are multi-stop work tours in which respondents who make work stops also make shopping stops in the "home-work corridor" on their way to and from work. Fewer multi-stop tours were documented in Kuala Lumpur and Yogyakarta. In Ottawa, the location of shopping and other facilities adjacent to the major highway that provides an entry and exit point to the city, affords commuters the opportunity to make discretionary stops on the way to and from work.

In the cluster analysis, three "multi-stop" clusters formed: one on Days 1 and 3 in Ottawa, and one on Day 3 in Yogyakarta. All three clusters are similar in that respondents make a high proportion of stops in the central city. The Day 1 Ottawa cluster completely satisfies the definition of complex travel behaviour. In addition to multi-stop tours and central city orientation, the cluster exhibits the highest mean travel distance of all the clusters.

Grocery shopping at the Ottawa site is examined as a case study to investigate the travel characteristics of those who make shopping stops on the way to/from work. Hypothesis testing suggests that compared to those who grocery shop from home, respondents who conduct grocery shopping in the home-work corridor travel a greater distance on Day 1, live a greater distance from downtown Ottawa, and report going past the next closest service centre (Kanata) less frequently for non-work purposes.

These results may indicate that shopping in the home-work corridor is an economizing measure adapted by those travelling long daily distances.

In summary, there is a sub-group in the Ottawa sample that economizes by shopping in the home-work corridor, and has a reduced reported frequency of travelling past Kanata for purposes other than work, while there are others within the Ottawa sample who are drawn to the city more frequently for non-work purposes.

Spatial Familiarity

Since recent research suggests that an individual's travel is defined by current as well as past destinations (Kwan, 1998), the concept of "spatial familiarity" was integrated into the study. It was found that those respondents who had lived in the city previously had a higher number of (absolute) stops in the city centre on a weekday and Sunday, and in the suburbs on a weekday and Saturday, than those who had not lived in the city. The job and amenities offered by the city, combined with familiarity of the city through having lived or worked there, may influence travel to the city on non-work days (Saturday and Sunday).

The cluster analysis showed a similar trend with clusters having higher rates of former city dwellers making a greater percentage of their stops in the central city, compared to those clusters having lower numbers of former city dwellers. One cluster, however, does not follow this general trend. The Day 1 "frequent urban fringe traveller" group has a relatively high "lived in city, moved to fringe" rate, but a low percentage of stops made in the central city and suburbs.

A previous study (Kwan, 1998) gathered data on spatial familiarity by asking respondents about which areas of the city they are familiar with. The present research suggests that in the current study of urban fringe dwellers, a more focussed approach to obtaining familiarity data is to ask the survey respondents about past home and work locations in the urban area.

Urban Migration and Mobility and Employment Location

Kuala Lumpur exemplifies *region-based* urbanization, with many new residents typically moving directly to the urban fringe from other regions of Malaysia, and finding employment within the urban fringe area. In not having lived in the city proper, they do not have spatial knowledge of the city, nor is it gained through the trip to work. That characteristics of residents, combined with a large proportion of their job and shopping locations being in the urban fringe the fact of the "new towns" being decentralized from the city core providing services, and the lesser use of the car (compared to Ottawa) results in the Kuala Lumpur travel patterns being more localized than those in Ottawa.

Migration patterns in Ottawa, by contrast, fit that of *city-based* urbanization with new urban fringe residents first residing in the city, then later moving to the urban fringe (Gottmann, 1961). Having lived and worked in the city, they have spatial knowledge of the urban area. That feature of Ottawa residents, combined with the car as the dominant mode, jobs and in the downtown, and the concentric form of the city, results in greater travel to the central city than in Kuala Lumpur.

With a large proportion of respondents' work and shopping locations in the urban fringe, Yogyakarta is similar to Kuala Lumpur with localized travel patterns. Differing from Kuala Lumpur in its concentric form (more like Ottawa), Yogyakarta has a greater percentage of respondents' work locations in the central city. The familiarity respondents have with the city centre through working there, plus the attracting shopping opportunities, results in greater non-work travel to the central city, compared to Kuala Lumpur.

7.1.3 Concluding Comments

The research question underlying the dissertation is:

> How can we organize our urban land use and transportation systems in order to accommodate the movement of people and goods without incurring the congestion, greenhouse gas emissions, pollution and other direct and indirect costs of current transportation networks?

Elements of the answer to the question posed at the beginning of this chapter may be found in the two Southeast Asian field site cities studied. The location of employment closer to where people live, and the availability of more local shopping opportunities reduce the total daily distances travelled. The integration of agriculture with population serves to localize some travel patterns, and also provide other benefits to the community. Further, the lower car ownership levels in Yogyakarta may play a role in the greater diversity of transportation modes in that city and, hence, greater modal variability across days.

7.2 Research Implications

This next section discusses research implications of the study and is organized as follows:

a) data collection and analysis techniques;

b) study methodology; and,

c) further research.

7.2.1 DATA COLLECTION AND ANALYSIS TECHNIQUES

The household survey employed in this study was effective in gathering the required data, especially in the Southeast Asian field sites where the culture is oral. However, entering and preparing the travel pattern data for analysis was time-consuming. Future studies might investigate a tracking Global Positioning System (GPS) to automatically collect travel data from respondents.

A comparison in Chapter 6 between the findings of the cluster analysis and summary data and hypothesis tests in Chapter 5 demonstrate that the results are largely consistent. The variable set selected for the cluster analysis is effective in capturing trends identified in Chapter 5. The exogenous variables identified appear to be able to distinguish between many of the clusters, although further research (with a larger dataset and external variables collected directly from all respondents) is required to re-test the variables used in this study and to identify additional discriminators.

The exogenous variables in this study were used to profile the clusters in a descriptive manner. In future research and as software is developed, a concomitant mixture clustering model (a sub-type of the finite mixture model described on page 242) could be tested.

A benefit of using this type of model is that in addition to the concomitant (or exogenous) variables providing an input into the main model, a separate model based solely on the exogenous variables is developed (Wedel and Kamakura, 1998). With further research and development, the exogenous variable model could be used to predict travel pattern groupings without having to obtain a large volume of survey data.

7.2.2 STUDY METHODOLOGY

The cluster analysis in this study was designed to weight travel attributes equally over a day in order to obtain a wide view of the different types of travel behaviour. Such an analysis would be appropriate at a municipal level to outline the range of travel groups within a jurisdiction.

The residential location sampling procedure is a core element of the technique since it provides a "handle" for developing area-wide travel estimates (based on land use/residential and other exogenous data). Once the clusters are formed, they could be profiled on the basis of the land use sampling categories (for example, in Ottawa, estate lots, rural lots, village, working farm), and residential location vis-à-vis the suburbs and outlying centres. Travel patterns generated by particular land use categories could then be used (taking other variables such as socio-demographic into account) to predict travel patterns for other residential areas (proximal to the original sample site).

The cluster analysis variable mix could be adjusted according to the objective of the study, as illustrated in the following examples. To provide results from a transportation demand perspective, more weight could be placed on total distance travelled and destination could be analyzed on a finer-grained basis. Similarly, for a greenhouse gas emission study, more emphasis could be placed on distance travelled, and the clusters could be mapped back to the land-use categories to provide estimates of emissions generated by different land use and residential types.

To assess the impact of new development, a predictive concomitant mixture model could be applied. The type of development (village expansion, estate or rural lot), the location of the development, and the characteristics of potential homebuyers could serve as inputs, and the mixture model could predict the travel groupings to which potential residents would likely belong and their associated travel habits.

The siting of particular types of public and private facilities could also be examined using this technique. Once the potential client or customer characteristics for the service to be provided at the facility are defined, the clusters containing such respondents could be identified and their travel patterns taken into account for siting of the new facility.

7.2.3 FURTHER RESEARCH

This study focussed on urban fringe dwellers and took the following as case studies: a concentric, car-dominated, "developed" urban area in North America (Ottawa); a decentralized, semi car-dependent , nearly developed Asian city (Kuala Lumpur); and, finally a concentric, less car-dependent, Third World Asian city (Yogyakarta). By way of contrast, it may be instructive to compare the behaviour of city and suburban residents with that of urban fringe dwellers using the same technique. The following dynamics revealed in this study could be re-examined in further research:

a) *Frequency of travel.* The relationship between frequency of travel and tour length could be researched in the central core or suburb area of a city to investigate if frequent tour-making is restricted to the local area (central core or suburb respectively).

b) *Complexity of travel.* Complex travel behaviour was revealed in Ottawa, a concentric-form city with a substantial number of downtown jobs and high car usage, by a group of commuters who make both work and non-work stops in the *home-work corridor.* Complexity in their travel was characterized by long travel distances, multiple stops on single tours, and travel past the nearest service centre (into the central city).

To provide a contrast with a concentric city, a more decentralized urban area with high car usage and high suburb-to-suburb travel would be a suitable study site to investigate if *home-work corridors* develop between suburban areas.

c) *Spatial familiarity.* The relationship between residential and work location history (a measure of spatial familiarity) and travel behaviour could be investigated in a city core or suburb to examine if the patterns revealed by urban fringe dwellers in this study re-appear (respondents re-visiting past home and work locations). A city like Los Angeles with high suburb-to-suburb travel could be the subject of a case study to investigate if residential and job shifts are contributing to complexity in travel behaviour.

d) *Modal variability.* Further confirmatory work is recommended to examine modal variability as related to vehicle ownership. A case study location representing an extreme example – such as a central city survey area with residents having low vehicle ownership rates and with a diversity in transportation options – could be selected to investigate if low vehicle ownership rates are a factor in greater modal variability.

By conducting such research the sample size could be increased and the technique could be re-tested and refined. Also from an empirical perspective, exogenous variables that have been shown in this study to be able to differentiate between clusters could be collected directly from all respondents, and then be re-examined for their ability in distinguishing between clusters in a new setting.

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9. APPENDICES

APPENDIX A: SURVEY PROTOCOLS

Appendix A1: Ottawa

Household Travel Survey (Ottawa, Canada)

Residential Location: ☐ Stittsville ☐ Carp ☐ Kinburn ☐ Working Farm ☐ Subdivision Estate Lot (house on 2 acres, removed from a village) ☐ Rural Lot (house (NOT a farm) on a lot, greater than 2 acres, removed from a village)

Type of House: ☐ Single family house ☐ Semi-attached House ☐ Apartment ☐ Movable Dwelling

Head of Household First Name: __________ Occupation: __________________

Work Location: ☐ Same place everyday. Where? __________ ☐ At home ☐ Varies from day to day

Partner of Head of Household First Name: __________ Occupation: __________________

Work Location: ☐ Same place everyday. Where? __________ ☐ At home ☐ Varies from day to day

List of All Household Members

Household Member (First name)	Age	Male/Female		Valid Driver's Licence?	Valid Motorcycle Licence?	Own Car/Light Truck?	Own Motor-cycle?	Own Bicycle?	Do you bike near the house?	Do you walk near the house?
Household Member 1 (fill in blue survey) ____________	<20 ___ (give age) ☐20-24 ☐25-29 ☐30-44 ☐45-54 ☐55-64 ☐65-74 ☐75-79 ☐ ≥80	☐ M	☐ F	☐ Yes ☐ No Drive regularly? ☐Y ☐N	☐ Yes ☐ No	☐ Yes ☐ No	☐ Yes ☐ No	☐ Yes ☐ No	☐N ☐Y If Y: Purpose&How Often: ☐Errand ☐Work ☐Exercise ☐Fun ☐See friend ☐Go to recreation______	☐N ☐Y If Y: Purpose&How Often: ☐Errand ☐Work ☐Exercise ☐Fun ☐See friend ☐Go to recreation______
Household Member 2 (fill in yellow survey) ____________	<20 ___ (give age) ☐20-24 ☐25-29 ☐30-44 ☐45-54 ☐55-64 ☐65-74 ☐75-79 ☐ ≥80	☐ M	☐ F	☐ Yes ☐ No Drive regularly? ☐Y ☐N	☐ Yes ☐ No	☐ Yes ☐ No	☐ Yes ☐ No	☐ Yes ☐ No	☐N ☐Y If Y: Purpose&How Often: ☐Errand ☐Work ☐Exercise ☐Fun ☐See friend ☐Go to recreation______	☐N ☐Y If Y: Purpose&How Often: ☐Errand ☐Work ☐Exercise ☐Fun ☐See friend ☐Go to recreation______

Household Member (First name)	Age	Male/Female		Valid Driver's Licence?	Valid Motorcycle Licence?	Own Car/Light Truck?	Own Motor-cycle?	Own Bicycle?	Do you bike near the house?	Do you walk near the house?
Household Member 3 (fill in white survey) ____________	<20 ___ (give age) ☐20-24 ☐25-29 ☐30-44 ☐45-54 ☐55-64 ☐65-74 ☐75-79 ☐ ≥80	☐ M	☐ F	☐ Yes ☐ No Drive regularly? ☐Y ☐N	☐ Yes ☐ No	☐ Yes ☐ No	☐ Yes ☐ No	☐ Yes ☐ No	☐N ☐Y If Y: Purpose&How Often: ☐Errand ☐Work ☐Exercise ☐Fun ☐See friend ☐Go to recreation_____	☐N ☐Y If Y: Purpose&How Often: ☐Errand ☐Work ☐Exercise ☐Fun ☐See friend ☐Go to recreation_____
Household Member 4 (fill in green survey) ____________	<20 ___ (give age) ☐20-24 ☐25-29 ☐30-44 ☐45-54 ☐55-64 ☐65-74 ☐75-79 ☐ ≥80	☐ M	☐ F	☐ Yes ☐ No Drive regularly? ☐Y ☐N	☐ Yes ☐ No	☐ Yes ☐ No	☐ Yes ☐ No	☐ Yes ☐ No	☐N ☐Y If Y: Purpose&How Often: ☐Errand ☐Work ☐Exercise ☐Fun ☐See friend ☐Go to recreation _____	☐N ☐Y If Y: Purpose&How Often: ☐Errand ☐Work ☐Exercise ☐Fun ☐See friend ☐Go to recreation _____
Household Member 5 (fill in orange survey) ____________	<20 ___ (give age) ☐20-24 ☐25-29 ☐30-44 ☐45-54 ☐55-64 ☐65-74 ☐75-79 ☐ ≥80	☐ M	☐ F	☐ Yes ☐ No Drive regularly? ☐Y ☐N	☐ Yes ☐ No	☐ Yes ☐ No	☐ Yes ☐ No	☐ Yes ☐ No	☐N ☐Y If Y: Purpose&How Often: ☐Errand ☐Work ☐Exercise ☐Fun ☐See friend ☐Go to recreation _____	☐N ☐Y If Y: Purpose&How Often: ☐Errand ☐Work ☐Exercise ☐Fun ☐See friend ☐Go to recreation _____
Household Member 6 (fill in pink survey) ____________	<20 ___ (give age) ☐20-24 ☐25-29 ☐30-44 ☐45-54 ☐55-64 ☐65-74 ☐75-79 ☐ ≥80	☐ M	☐ F	☐ Yes ☐ No Drive regularly? ☐Y ☐N	☐ Yes ☐ No	☐ Yes ☐ No	☐ Yes ☐ No	☐ Yes ☐ No	☐N ☐Y If Y: Purpose&How Often: ☐Errand ☐Work ☐Exercise ☐Fun ☐See friend ☐Go to recreation _____	☐N ☐Y If Y: Purpose&How Often: ☐Errand ☐Work ☐Exercise ☐Fun ☐See friend ☐Go to recreation _____

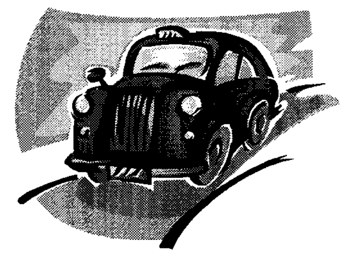
NOTE: If there are more than 6 persons in the household, please enter the first 6 on this questionnaire and continue on the second questionnaire.

List of All Vehicles in Household

How many cars/light trucks are in the household, in total? ______

How many motorcycles are in the household, in total? ______

How many bicycles are in the household, in total? ______



List Schools Household Members Attend

Household Member (First name)	School & Location	Do they take a bus?	How long does it take to get to school&back?
______		☐ Yes ☐ No If no, How?	There: ____ Back:
______		☐ Yes ☐ No If no, How?	There: ____ Back:
______		☐ Yes ☐ No If no, How?	There: ____ Back:
______		☐ Yes ☐ No If no, How?	There: ____ Back:

List Recreational/Extracurricular Activities Household Members Participate In

Household Member (First name)	Activity & Location	How often?	How do you travel there?
		1xmonth☐ 2xmonth☐ 1xweek☐ 2xweek☐	
______		1xmonth☐ 2xmonth☐ 1xweek☐ 2xweek☐	
		1xmonth☐ 2xmonth☐ 1xweek☐ 2xweek☐	
		1xmonth☐ 2xmonth☐ 1xweek☐ 2xweek☐	
______		1xmonth☐ 2xmonth☐ 1xweek☐ 2xweek☐	
		1xmonth☐ 2xmonth☐ 1xweek☐ 2xweek☐	
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		1xmonth☐ 2xmonth☐ 1xweek☐ 2xweek☐	
		1xmonth☐ 2xmonth☐ 1xweek☐ 2xweek☐	

Your Dwelling

How long has your household lived in your present dwelling (in years) ___?

Did either the head of household/partner live in the local area at the age of 5? ☐ *Yes* ☐ *No*

Do you: ☐ *Own* or ☐ *Rent* your dwelling?

When was your dwelling built? ☐ *1920 or before* ☐ *1921-1945* ☐ *1946-1960* ☐ *1961-1970* ☐ *1971-1980* ☐ *1981-1985* ☐ *1986-1990* ☐ *1991-1995* ☐ *1996-1999?*

How many bedrooms are in your house? ☐ *1* ☐ *2* ☐ *3* ☐ *4* ☐ *5* ☐ *6 or more*

How did you decide on your present residential location within Ottawa? *(check all that apply)*

☐ *family land/house* ☐ *close to family* ☐ *house price* ☐ *land price* ☐ *pleasant environment* ☐ *close to work, or within reasonable distance of work* ☐ *close to school or services* ☐ *other reason: Please name:* ______________

Questions on Driving/Bicycling/Walking

Are there any roads that you avoid travelling on? ☐ *Yes* ☐ *No* *If yes, which ones, why?* ______________

Do you avoid travelling at certain times during the day or week because of traffic or road conditions?

☐ *Yes* ☐ *No* *If yes, when, why?* ___________

Who drives when you travel together?____________________________

How often do you go into Ottawa (past Kanata) for purposes other than work? ☐ Social ☐ Recreational ☐ Shopping ☐ Dining/Entertainment ☐ Other______________

Do you take Sunday or exploratory drives? Generally where do you go? How often?_________________________

Do you use convenience stores? Where? How often? ____

How far are the children (if any) allowed to go (on bike or foot) from the house? _____________________________

____

Questions on Grocery Shopping

Where do you do your grocery shopping? ☐ Kanata ☐ Stittsville ☐ Bells Corners ☐ Carp ☐ Elsewhere

Where?____________

Who does the grocery shopping?____

How often do you go grocery shopping?__________

Is grocery shopping normally:

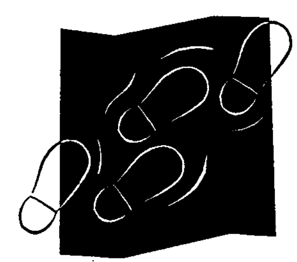
1) the main objective of a single purpose trip from home? ☐ *Yes* ☐ *No*

2) the main objective of a multi-purpose trip from home in conjunction with other errands? ☐ *Yes* ☐ *No*

3) a secondary objective of a multi-purpose trip from home in conjunction with other errands? ☐ *Yes* ☐ *No*

3) a secondary objective on a trip to and from work? ☐ *Yes* ☐ *No*

4) other____



Thank you!

Household Travel Patterns

Household Member #1 (First Name): ____________

Day#1: Weekday

Day #1: ☐ *Monday* ☐ *Tuesday* ☐ *Wednesday* ☐ *Thursday* ☐ *Friday*

Is this a "normal" weekday? ☐ *Yes* ☐ *No*

Trip No. and Start Place of Trip (Always Home)	What time did you leave home?	Why did you make trip? (Trip Purpose or Activity) (Go Home always last purpose)	If more than 1 trip purpose (to left), rate each trip purpose as: Main (M), Secondary (S) or of Equal (E) importance	Where did you go exactly? (Location or Landmark)	*Pick Option 1 or 2 for Recording Times*		Modes (list all) (car/light truck, carpool, school bus, OC Transpo, shuttle bus, commuter bus, walk, cycle, motorcycle, or taxi)	Route Taken (as specific as possible, so can be traced on map)	Were you joined by another household member? Who? (first name) Were they a passenger?
					Opt. 1: Time Segments	Opt. 2: Time Stamps			
					How long did it take to get to activity or to home? AND How long did you stay at activity?	What time did you get to activity or home? AND What time did you leave the activity?			
Trip #1 Home	am/pm	(1)	☐M ☐S ☐E		min & min	am/pm & am/pm			☐Pa
		(2)	☐M ☐S ☐E		min & min	am/pm & am/pm			☐Pa
		(3)	☐M ☐S ☐E		min & min	am/pm & am/pm			☐Pa
		(4)	☐M ☐S ☐E		min & min	am/pm & am/pm			☐Pa
		(5)	☐M ☐S ☐E		min & min	am/pm & am/pm			☐Pa
Trip #2 Home	am/pm	(1)	☐M ☐S ☐E		min & min	am/pm & am/pm			☐Pa
		(2)	☐M ☐S ☐E		min & min	am/pm & am/pm			☐Pa
		(3)	☐M ☐S ☐E		min & min	am/pm & am/pm			☐Pa
		(4)	☐M ☐S ☐E		min & min	am/pm & am/pm			☐Pa
		(5)	☐M ☐S ☐E		min & min	am/pm & am/pm			☐Pa

Trip No. and Start Place of Trip (Always Home)	What time did you leave home?	Why did you make trip? (Trip Purpose or Activity) (Go Home always last purpose)	If more than 1 trip purpose (to left), rate each trip purpose as: Main (M), Secondary (S) or of Equal (E) importance	Where did you go exactly? (Location or Landmark)	Pick Option 1 or 2 for Recording Times		Modes (list all) (car/light truck, carpool, school bus, OC Transpo, shuttle bus, commuter bus, walk, cycle, motorcycle, or taxi)	Route Taken (as specific as possible, so can be traced on map)	Were you joined by another household member? Who? (first name) Were they a passenger?
					Opt. 1: Time Segments	Opt. 2: Time Stamps			
					How long did it take to get to activity or to home? AND How long did you stay at activity?	What time did you get to activity or home? AND What time did you leave the activity?			
Trip #3 Home	am/pm	(1)	☐M ☐S ☐E		min & min	am/pm & am/pm			☐*Pa*
		(2)	☐M ☐S ☐E		min & min	am/pm & am/pm			☐*Pa*
		(3)	☐M ☐S ☐E		min & min	am/pm & am/pm			☐*Pa*
		(4)	☐M ☐S ☐E		min & min	am/pm & am/pm			☐*Pa*
		(5)	☐M ☐S ☐E		min & min	am/pm & am/pm			☐*Pa*
Trip #4 Home	am/pm	(1)	☐M ☐S ☐E		min & min	am/pm & am/pm			☐*Pa*
		(2)	☐M ☐S ☐E		min & min	am/pm & am/pm			☐*Pa*
		(3)	☐M ☐S ☐E		min & min	am/pm & am/pm			☐*Pa*
		(4)	☐M ☐S ☐E		min & min	am/pm & am/pm			☐*Pa*
		(5)	☐M ☐S ☐E		min & min	am/pm & am/pm			☐*Pa*

Appendix A2: Kuala Lumpur

Household Travel Survey (Kuala Lumpur, Malaysia)

A) Data to be collected when household is recruited to participate in the survey.
[Data to be omitted from final summary results.]

Name of Head of Household: ____________ ***Occupation[3]:*** ____________

Address: ____________ ***Field Site:*** ____________

Phone Number[1]: ____________ ***Description of House[4]:*** ____________

Income[2]: ☐ Low (<500-800RM/month) ***Description of Surrounding Land Uses[5]:*** ____________

☐ Medium (800-2000 or 3000RM/month)

☐ High (>3000RM/month)

Data on Household Members

Adults (19 years of age or over)	Age	Male/Female		Valid Driver's Licence?	Valid Motorcycle Licence?	Own Car/Light Truck?	Own Motorbike?	Own Bicycle?
		☐ *M*	☐ *F*	☐ *Yes*	☐ *Yes*	☐ *Yes*	☐ *Yes*	☐ *Yes*
		☐ *M*	☐ *F*	☐ *Yes*	☐ *Yes*	☐ *Yes*	☐ *Yes*	☐ *Yes*
		☐ *M*	☐ *F*	☐ *Yes*	☐ *Yes*	☐ *Yes*	☐ *Yes*	☐ *Yes*
		☐ *M*	☐ *F*	☐ *Yes*	☐ *Yes*	☐ *Yes*	☐ *Yes*	☐ *Yes*

Children (0-19 years of age)	Age	Male/Female		Valid Driver's Licence?	Valid Motorcycle Licence	Own Car/Light Truck?	Own Motorbike?	Own Bicycle?
		☐ *M*	☐ *F*	☐ *Yes*	☐ *Yes*	☐ *Yes*	☐ *Yes*	☐ *Yes*
		☐ *M*	☐ *F*	☐ *Yes*	☐ *Yes*	☐ *Yes*	☐ *Yes*	☐ *Yes*
		☐ *M*	☐ *F*	☐ *Yes*	☐ *Yes*	☐ *Yes*	☐ *Yes*	☐ *Yes*
		☐ *M*	☐ *F*	☐ *Yes*	☐ *Yes*	☐ *Yes*	☐ *Yes*	☐ *Yes*

Data on Vehicles in Household (double check)

How many cars/light trucks are in the household, in total?____________________

How many motorbikes are in the household, in total?____________________

How many bicycles are in the household, in total?____________________

Thank respondent

Footnotes on Household Survey

1. Only collect if the respondent household has phone service.
2. Income of the Head of Household. If the respondent appears uncomfortable in revealing income, just make an assumption and note that an assumption was made.
3. Important if income cannot be established. Otherwise optional.
4. Single family house (detached), attached townhouse, apartment, squatter housing, other.
5. Residential, industrial, retail, other.

B) Survey Directions & Explanation

All household members should collect data for the same three days (or an optional four days). The emphasis in this study is on urban and regional Kuala Lumpur travel. If on "Day 1" (Monday, Tuesday, Wednesday, Thursday or Friday), travel occurs outside the State of Selangor, another day should be selected. If intercity travel occurs on Saturday or Sunday, then it can be included in the survey. Every member of the household should collect travel data for 3 (or an optional 4 days) in the following manner:

Day 1: One day from either:

- **Monday**
- **Tuesday**
- **Wednesday**
- **Thursday**
- **Friday**

Day 2: Saturday

Day 3: Sunday

Day 4: Any day (optional)

Data to be collected from household:

- List of all activities outside of residence.
- Start and end time of activities.
- Mode of Travel (walk, taxi, bus (ask which type), car, truck, hire car, commuter rail and LRT).
- Length of time to travel to each activity and to travel back home.
- Routes (road, streets) travelled between home and each activity.
- Sequence of stops.
- Single purpose or multi-purpose trip?
- For multi-purpose trip: identify primary and secondary stops.
- Did the respondent travel with another household member?

B) Data to be Collected in Final Interview for Day#1, #2, #3 & Day#4 (optional) for all household members:

Name of Head of Household:______________________ **Name of Household Member:**____________________

Activity Name (destination)	Start time for activity	End time of activity?	Mode (walk, cycle, motorcycle, taxi, bus (Ask which type), car, truck, hire car, commuter rail, and LRT)	How long did it take to get to there? (each activity)	How long did it take to get home (or to next activity)?	Where (if not a landmark)	Routes Taken (Use map if necessary)	Single or Multi-Purpose	Trip purpose: If multi-purpose: Mark primary (P) or secondary (S) activity?	Were you accompanied by another household member? Who?

APPENDIX A3: YOGYAKARTA

Household Travel Survey (Yogyakarta, Indonesia)

English Version

A) Data to be collected when household is recruited to participate in the survey.

[Data to be omitted from final summary results.]

Household Name: ______________________

Address: ____________________________

Phone Number: ______________________

Income: _____________________________

Data on Household Members

Adults (19 years of age or over)	**Age**	**Male/Female**		**Valid Driver's Licence?**	**Valid Motorcycle Licence?**	**Own Car?**	**Own Motorbike?**	**Own Bicycle?**	**Own Horse?**
		☐ *M*	☐ *F*	☐ *Yes*	☐ *Yes*	☐ *Yes*	☐ *Yes*	☐ *Yes*	☐ *Yes*
		☐ *M*	☐ *F*	☐ *Yes*	☐ *Yes*	☐ *Yes*	☐ *Yes*	☐ *Yes*	☐ *Yes*
		☐ *M*	☐ *F*	☐ *Yes*	☐ *Yes*	☐ *Yes*	☐ *Yes*	☐ *Yes*	☐ *Yes*
		☐ *M*	☐ *F*	☐ *Yes*	☐ *Yes*	☐ *Yes*	☐ *Yes*	☐ *Yes*	☐ *Yes*

Children (0-19 years of age)	Age	Male/Female		Valid Driver's Licence?	Valid Motorcycle Licence	Own Car?	Own Motorbike?	Own Bicycle?	Own Horse?
		☐ M	☐ F	☐ Yes	☐ Yes	☐ Yes	☐ Yes	☐ Yes	☐ Yes
		☐ M	☐ F	☐ Yes	☐ Yes	☐ Yes	☐ Yes	☐ Yes	☐ Yes
		☐ M	☐ F	☐ Yes	☐ Yes	☐ Yes	☐ Yes	☐ Yes	☐ Yes
		☐ M	☐ F	☐ Yes	☐ Yes	☐ Yes	☐ Yes	☐ Yes	☐ Yes

Data on Vehicles in Household (double check)

How many cars are in the household, in total? ______________________

How many motorbikes are in the household, in total? ______________________

How many bicycles are in the household, in total? ______________________

How many horses are in the household, in total? ______________________

Thank respondent.

B) Survey Directions & Explanation of Travel

All household members should collect data for the <u>same three days</u>. The emphasis in this study is on <u>urban and Yogyakarta regional</u> travel. If on "Day 1" (Monday, Tuesday, Wednesday, Thursday, or Saturday), travel occurs outside the region of Yogyakarta (e.g. to Solo, Magelang or Jakarta), another day should be selected. The boundary defining urban and regional travel from intercity travel is the Yogyakarta Special Territory boundary, except for extension of study boundaries as far as Muntilan to northwest, and Klaten to the northeast. If intercity travel occurs on Sunday, then intercity travel can be included in survey results. <u>Every</u> member of the household should collect travel data for three days in the as follows:

<u>Day 1: One day from either:</u>

- Monday
- Tuesday
- Wednesday
- Thursday
- Saturday

<u>Day 2: Friday</u>

<u>Day 3: Sunday</u>

Data to be collected from household:

- List of all activities outside of residence.
- Start and end time of activities.
- Mode of Travel (walk, cycle, *becak*, motorcycle, *ojek*, taxi, *bis kota*, *angkudes*, *andong*, car and truck).
- Length of time to travel to each activity and to travel back home.
- Routes (road, streets) travelled between home and each activity.
- Sequence of stops.

- Single purpose or multi-purpose trip?
- For multi-purpose: identify primary and secondary stops.
- Did the respondent travel with another household member?

Data to be Collected in Final Interview for Day#1, #2, #3 for all Household Members:

Activity Name (destination)	Start time for activity	End time of activity?	Mode (jalan kaki, sepeda, becak, sepeda motor, ojek, taksi, bis kota, angkudes, andong, mobil, and, colt)	How long did it take to get to there? (each activity)	How long did it take to get home (or to next activity)?	Where (if not a landmark)	Single or Multi-Purpose	Trip purpose: If multi-purpose: Mark primary (P) or secondary (S) activity?	Were you accompanied by another household member? Who?

Keterangan Daftar Isian

<u>*Contoh di bawah ini, responden tinggal di Perumahan Bulaksumur*</u>

Kolom 1 Baris 3 (a*) :
dapat dipilih salah satu hari dari hari-hari berikut ini :
SENIN, SELASA, RABU, KAMIS, atau SABTU

Kolom 2 :
Kelompok aktivitas adalah serangkaian tujuan dalam satu kegiatan keluar rumah mulai dari berangkat hingga pulang kembali ke rumah, sebagai contoh: rumah - Kantor Pos - Galleria - Tempat Relasi - rumah. Contoh lainnya : rumah - Kantor - rumah. Seluruh tujuan tersebut ditulis urut ke bawah dalam satu kelompok, seperti contoh di bawah ini :

1	2	3
Hari	Kelompok Aktivitas (Tujuan)	Jika Tujuan Lebih ...
Senin	**- Kantor Pos** **- Galleria** **- Tempat Relasi**	
	- Kantor	

Kolom 3 :
Jika dalam kelompok aktivitas terdapat lebih dari satu tujuan, sebutkan salah satu tujuan yang menjadi tujuan utama. Sebagai contoh :

1	2	3	4
Hari	Kelompok Aktivitas (Tujuan)	Jika Tujuan Lebih Dari Satu, ...	
Senin	- Kantor Pos - Galleria - Tempat Relasi	**Galleria**	
	- Kantor		

Kolom 4 :
Jam berangkat adalah jam dimana awal mula aktivitas yang ditandai dengan keberangkatan dari rumah menuju tujuan pertama, sebagai contoh pukul 09.00 pagi.

Kolom 5 :
Jam pulang adalah waktu yang menunjukkan akhir dari setiap kelompok aktifitas yang ditandai dengan kepulangan ke rumah, sebagai contoh pukul 12.00 siang.

1	2	3	4	5
Hari	Kelompok Aktivitas (Tujuan)	Jika Tujuan Lebih Dari Satu, ...	Jam berangkat	Jam Pulang
Senin	- Kantor Pos - Galleria - Tempat Relasi	**Galleria**	09.00 pagi	12.00 siang
	- Kantor		07.00 pagi	13.00 siang

Kolom 6 :
Jenis/alat transportasi yang dipergunakan adalah sarana yang dipergunakan untuk mencapai setiap tujuan (dari tujuan satu ke tujuan lain) dalam kelompok aktivitas. Jenis/alat transportasi yang dapat dipilih diantaranya : Jalan kaki, kuda, sepeda, sepeda motor, ojek, mobil, taxi, becak, bis kota, angkutan, angkutan desa.

Kolom 7 dan 8:
Waktu mencapai setiap tujuan adalah waktu yang dibutuhkan untuk berpindah dari lokasi (tujuan) satu ke lokasi (tujuan) lain.

3	4	5	6	7	8
Jika Tujuan Lebih Dari Satu, ...	Jam berangkat	Jam Pulang	Jenis/alat Transportasi	Waktu Mencapai..	Waktu Untuk Sampai .....
Galleria	09.00 pagi	12.00 siang	Bis kota Bis kota Becak - jalan kaki	30 menit 20 menit 15 menit	8 menit
------------------------	07.00 pagi	13.00 siang	mobil	25 menit	40 menit

Kolom 9 :
Lokasi Yang dituju, apabila tidak ingat nama jalan dapat menggunakan obyek yang mudah dikenal contohnya: Sekitar Stasiun Tugu, Sekitar Pasar Beringharjo dan sebagainya.

5	6	7	8	9
Jam Pulang	Jenis/alat Transportasi	Waktu Mencapai..	Waktu Untuk Sampai	Lokasi Tujuan
12.00 siang	Bis kota Bis kota Becak - jalan kaki	30 menit 20 menit 15 menit	8 menit	Knt. Pos Besar Jl. Solo Bulaksumur
13.00 siang	mobil	25 menit	40 menit	Kepatihan

Kolom 10 : (Jika kolom tidak cukup, dapat dituliskan dibalik lembar isian)
Jalur yang dilalui, contoh : dari Bulaksumur ke Kantor Pos Besar melalui Jl. Kaliurang, Jl. Cik Ditiro, Jl. Malioboro atau Jl. Kaliurang, Jl. C. Simanjutak Jl. Mataram dan Gondomanan. Atau bila tidak ingat nama jalan bisa menggunakan nama daerah yang dilalui, contoh : Bulaksumur, Terban, Kotabaru dan Gondomanan

6	7	8	9	10
Jenis/alat Transportasi	Waktu Mencapai..	Waktu Untuk Sampai	Lokasi Tujuan	Jalur Yang di Lalui
Bis kota Bis kota Becak - jalan kaki	30 menit 20 menit 15 menit	8 menit	Knt. Pos Besar Jl. Solo Bulaksumur	Terban - Kt. Baru - Gondomanan Kusumanegara - Jembatan Layang - Jl. Solo Rahayu - Bulaksumur
mobil	25 menit	40 menit	Kepatihan	Terban - Jl. Mangkubumi - Jl. Malioboro

Kolom 11 : Anggota keluarga yang pergi bersama atau menemani dalam beraktivitas, contoh : ke kantor bersama bapak (cukup ditulis bapak), ke sekolah bersama kakak (cukup ditulis kakak) dan lain sebagainya.

****

Atas kesediaannya membantu penelitian ini, kami ucapkan terima kasih yang sebesar - besarnya.

Identitas responden kami jamin ***kerahasiaannya.***

****

Nama Anggota Keluarga:____________________ **Nama Kepala Keluarga:**____________________

Hari	Kelompok Aktivitas (Tujuan)	Jika Tujuan Lebih Dari Satu Sebutkan Tujuan Utama	Jam Berangkat	Jam Pulang	Jenis/Alat Transportasi Yang Digunakan	Waktu Mencapai Setiap Tujuan	Waktu Untuk Sampai ke Rumah Dari Aktivitas/Tujuan Terakhir	Lokasi (letak) Tujuan	Jalur Yang Di Lalui (Secara Garis Besar)	Sendiri atau Dengan Anggota Keluaraga Yang Lain (Siapa)

Appendix B: Institutional Reference Letters

Université d'Ottawa · University of Ottawa

Faculté des arts Géographie | Faculty of Arts Geography

January 18, 1999

To Whom It May Concern:

Nairne Cameron is a doctoral student in the Department of Geography at the University of Ottawa. As her supervisor, I wish to confirm that she is undertaking a field research study of individual travel patterns in the Goulbourn, Kanata and West Carleton areas of Ottawa-Carleton.

In the event of questions in this regard I can be reached as follows:

tel: 613-562-5800 X 1065

fax: 613-562-5145

e-m: wellarb@uottawa.ca

post: Dr. B. Wellar, Department of Geography,
University of Ottawa, Ottawa, ON, Canada
K1N 6N5

Sincerely,

Barry Wellar

Barry Wellar, Professor, and
Supervisor for N. Cameron
Doctoral Candidate

165, rue Waller C.P. 450, Succ. A
Ottawa (Ontario) K1N 6N5 Canada

165 Waller St., P.O. Box 450, Stn. A
Ottawa, Ontario K1N 6N5 Canada

(613) 562-5725 • Téléc./Fax (613) 562-5145

JABATAN GEOGRAFI
Universiti Malaya
59100 KUALA LUMPUR
Tel: 03-~~7555266~~ 7595403 Fax: 603-7563454

UNIVERSITI MALAYA
Department of Geography
University of Malaya
59100 KUALA LUMPUR
MALAYSIA

13 NOVEMBER 1998

KEPADA SESIAPA YANG BERKENAAN

Tuan / Puan,

Kebenaran menjalankan kajian mengenai perjalanan ahli isirumah untuk tujuan penyelidikan

Nama penemuduga : ______________________

No. kad pengenalan : ______________________

Saya, Profesor Madya Dr. Jamilah bte Mohamad, sedang membantu satu kajian yang sedang dijalankan berkenaan corak perjalanan penduduk di kawasan perkampungan sekitar Kuala Lumpur. Untuk tujuan itu, penyelidik memerlukan beberapa temuduga isirumah dijalankan. Beberapa penemuduga telah dilantik untuk tujuan tersebut. Saya ingin mengesahkan bahawa penemuduga yang bernama seperti di atas telah ditugaskan untuk menjalankan temuduga isirumah untuk mendapatkan maklumat berkenaan corak perjalanan yang dilakukan oleh isirumah tersebut di sekitar kawasan Lembah Kelang.

Isirumah tuan/puan telah dipilih untuk ditemuduga sesuai dengan kehendak penyelidikan tersebut. Saya ingin memohon jasa baik tuan/puan untuk meluangkan masa selama lebih kurang 1 jam untuk menjawab beberapa persoalan seperti yang dikemukakan dalam borang soal selidik yang disertakan. Ingin saya maklumkan bahawa segala maklumat yang diberikan akan dianggap sulit dan akan dirahsiakan. Maklumat tersebut hanya bertujuan untuk digunakan sebagai bahan penyelidikan.

Segala kerjasama tuan/puan amat saya hargai.

Sekian, terima kasih.

Yang benar,

Profesor Madya Dr. Jamilah bte Mohamad
Jabatan Geografi
Universiti Malaya.

REPUBLIK INDONESIA
BADAN PERENCANAAN PEMBANGUNAN NASIONAL
JALAN TAMAN SUROPATI 2, JAKARTA 10310
TELEPON : 336207 — 3905650

TO WHOM IT MAY CONCERN

I, the undersign, Max Pohan, the Head of Bureau for Regional Development I of the National Development Planning Agency (BAPPENAS) of the Republic of Indonesia, hereby gladly support the intention of Ms. Nairne Cameron, a doctoral candidate at the Department of Geography, University of Ottawa in Canada, to conduct a research study for a doctoral thesis on Planning Equitable and Sustainable Transportation in Expanding Southeast Asian Urban Areas: A GIS-based Approach, where the city of Yogyakarta is one of the urban cases taken.

I know Ms. Cameron since 1996, when she was visiting my office in Jakarta for the initiation of her research and have several contacts with her since then particularly on the subject matter.

For the purpose of her research project in Yogyakarta, I would be very happy to support so Ms. Cameron can have access to and full support from Gadjah Mada University, Yogyakarta, as well as access to data and information needed from government offices in Jakarta as well as in Yogyakarta.

With that, I expect that Ms. Cameron research study in Yogyakarta will be a successful one.

Jakarta, 8 May 1998

Max H.Pohan
Head, Bureau for Regional Development I
Bappenas, Indonesia.

APPENDIX C: CLUSTER ANALYSIS MEANS

Table C1: Ottawa Day 1 Cluster Means

Variable	Cluster 1	2	3	4	5	6	7	8
LCC		0.46	0.50	0.06	0.13	0.05		0.43
LOC	0.08		0.02			0.01	0.77	0.02
LSUB	0.08	0.54	0.43	0.02	0.82	0.14		0.41
LUF	0.83		0.06	0.91	0.05	0.81	0.23	0.14
MBICYCLE	0.08				0.13			
MCAR	0.18	1.00	1.00	1.00	0.06	0.78	0.97	1.00
MSCBUS	0.44							
MULTIM	0.06				0.88	0.08	0.03	
MWALK	0.24					0.12		
QBABYS	0.07			0.10	0.06	0.01		
QBANK			0.17	0.10		0.04	0.04	0.10
QFARM	0.04					0.02		
QLEISET	0.01	0.04	0.08			0.01		0.01
QMAIL	0.08		0.03	0.02		0.02		0.01
QPUITEM							0.09	
QPUPER	0.02		0.16	0.02	0.04	0.28	0.03	0.20
QRECRE	0.05		0.04	0.06	0.03	0.09	0.09	0.03
QRELIG				0.05			0.01	
QRESTC	0.03		0.16		0.05	0.12	0.24	0.09
QSCHOOL	0.62		0.08	0.06	0.16	0.06		
QSERVCT			0.05	0.05		0.04	0.18	0.01
QSOCIAL	0.10		0.01	0.05	0.07	0.10	0.34	0.02
QTOTSHOP			0.40	0.02	0.11	0.20	0.12	0.19
QTRCONT				0.02	0.46	0.03		0.06
QVOLU						0.07		
QWTOT		0.96	0.01	0.54	0.20	0.04	0.06	0.40
RMSWT			0.01	0.17	0.69	0.04	0.09	0.93
RSSWT		0.96		0.41		0.02	0.05	
TOTTRVTM	0.17	0.23	0.31	0.13	0.29	0.38	0.21	0.37
TPDIST	0.09	0.24	0.36	0.12	0.27	0.21	0.26	0.43
TSTOP	0.16	0.10	0.30	0.16	0.38	0.46	0.34	0.33
TTOURRW	0.30	0.22	0.23	0.29	0.23	0.56	0.40	0.24
n (Total=157)	25	12	26	21	8	27	11	27

*Zero values not shown.

Table C2: Kuala Lumpur Day 1 Cluster Means

Variable	Cluster					
	1	2	3	4	5	6
LCC			0.05	0.01	0.13	
LOC			0.02	0.04	0.18	0.19
LSUB		0.01	0.06	0.03	0.33	0.42
LUF	1.00	0.99	0.82	0.89	0.02	0.03
MBICYCLE	0.28	0.04		0.08		0.03
MCAR	0.02	0.24	1.00	0.03	0.48	
MCCTRUCK		0.01				
MOTBIKE	0.02	0.40		0.39	0.27	0.13
MTOTBUS	0.33	0.06		0.04	0.21	0.78
MULTIM	0.01	0.03		0.07		0.06
MVAN	0.04			0.01	0.02	
MWALK	0.29	0.22		0.26	0.02	
QBABYS			0.06	0.01		
QFARM				0.09		
QJOBSRCH						0.06
QLEISET	0.01		0.03			
QPUPER			0.30	0.05	0.01	
QRECRE	0.01			0.02		
QRELIG	0.03			0.07		
QRESTC			0.03	0.04		
QSCHOOL	0.94		0.26	0.03		0.81
QSERVCT				0.02		
QSOCIAL	0.01			0.04		
QTOTSHOP			0.13	0.26		0.03
QTRCONT				0.05		0.05
QWTOT		1.00	0.21	0.20	0.99	0.06
RMSWT			0.38	0.10		0.13
RSSFT				0.07		
RSSWT		1.00	0.05	0.15	0.99	
TOTTRVTM	0.13	0.17	0.23	0.22	0.41	0.39
TPDIST	0.06	0.10	0.18	0.14	0.33	0.27
TSTOP	0.15	0.13	0.25	0.21	0.13	0.15
TTOURRW	0.24	0.21	0.22	0.28	0.20	0.21
n (Total=328)	106	72	32	41	61	16

*Zero values not shown.

Table C3: Yogyakarta Day 1 Cluster Means

Variable	Cluster						
	1	2	3	4	5	6	7
LCC		0.18	0.24	0.70	0.19		0.39
LOC		0.02	0.05		0.31		0.02
LSUB	0.02	0.22	0.08	0.08	0.16	0.01	0.14
LUF	0.96	0.36	0.55	0.15	0.19	0.98	0.31
MBICYCLE	0.18	0.09				0.26	0.02
MBUSTOT	0.04	0.22		0.08	0.31		
MCAR	0.04	0.03		0.68	0.56	0.19	
MJEMP		0.03					
MOTBIKE	0.26	0.45	1.00	0.07	0.06	0.17	0.96
MULTIM	0.01	0.14		0.08	0.06		
MWALK	0.47	0.05		0.08		0.38	0.02
QBANK	0.04			0.17		0.08	
QFARM						0.63	
QJOBSRCH							0.02
QLEISET			0.05	0.17	0.13		
QMAIL	0.04						
QPUPER		0.04	0.05	0.18		0.03	0.14
QRECRE	0.07			0.08			
QRELIG	0.08	0.03	0.03			0.06	0.06
QRESTC	0.02	0.01		0.08		0.04	
QSCHOOL	0.10	0.89		0.04			0.06
QSERVCT	0.06		0.03				0.07
QSOCIAL	0.25	0.03			0.13		0.20
QTOTSHOP	0.30		0.08	0.38		0.09	0.21
QWTOT	0.05		0.79	0.07	0.81	0.11	0.21
RMSWT	0.04			0.08		0.08	0.50
RSSFT						0.65	
RSSWT	0.03		0.79	0.07	0.81	0.10	
TOTTRVTM	0.12	0.27	0.22	0.32	0.32	0.18	0.38
TPDIST	0.05	0.15	0.14	0.20	0.28	0.07	0.24
TSTOP	0.23	0.20	0.18	0.29	0.19	0.31	0.39
TTOURRW	0.35	0.28	0.28	0.35	0.30	0.45	0.37
n (Total=126)	27	32	19	12	8	12	16

*Zero values not shown.

Table C4: Ottawa Day 3 Cluster Means

Variable	Cluster								
	1	2	3	4	5	6	7	8	9
LCC		0.07			0.10		0.06	0.53	0.88
LOC	1.00		0.09		0.10	0.81	0.05	0.01	
LSUB		0.90			0.04		0.21	0.42	0.04
LUF		0.03	0.91		0.76	0.19	0.68	0.04	0.07
MCAR	1.00	1.00	0.80		1.00	1.00	0.19	1.00	0.90
MWALK			0.20				0.19		
QLEISET	0.33		0.07		0.12	0.22	0.13	0.03	0.02
QPUITEM						0.29		0.10	
QPUPER		0.03	0.04		0.16	0.05	0.13	0.03	
QRECRE			0.13		0.02		0.09	0.29	
QRELIG	0.21	0.02	0.26		0.23	0.07	0.13	0.25	
QRESTC	0.13	0.03	0.02		0.03	0.13		0.08	0.11
QSERVCT						0.07	0.25		0.08
QSOCIAL	0.25	0.13	0.08		0.20	0.10		0.02	0.30
QTOTSHOP		0.78	0.18		0.11	0.26	0.13	0.05	0.41
QTRCONT									0.13
QVOLU			0.07				0.08		
QWTOT	0.08		0.09		0.12		0.23	0.15	0.05
RMS		0.69	0.04		0.71	0.94	0.94	0.03	1.00
RSS	1.00	0.25	0.94		0.29	0.06	0.06	0.97	
TOTTRVTM	0.13	0.07	0.05	0.06	0.08	0.11	0.07	0.09	0.18
TPDIST	0.64	0.31	0.17		0.28	0.48	0.17	0.50	0.55
TSTOP	0.11	0.29	0.18		0.36	0.65	0.31	0.19	0.40
TTOURRW	0.27	0.28	0.43		0.48	0.50	0.34	0.44	0.28
n (Total=120)	12	16	27	6	15	6	8	20	10

*Zero values not shown.

Table C5: Kuala Lumpur Day 3 Cluster Means

Variable	Cluster					
	1	2	3	4	5	6
LCC		0.18				
LIC						0.54
LOC		0.05				0.08
LSUB		0.22		1.00		0.33
LUF	1.00	0.55	1.00		1.00	0.04
MBICYCLE	0.01	0.01			0.39	
MCAR		0.97		0.07	0.03	0.89
MCCTRUCK					0.06	
MOTBIKE			0.98	0.73		
MTOTBUS		0.01		0.20	0.44	0.11
MVAN					0.11	
MWALK	0.99	0.01	0.02			
QFARM	0.05	0.01	0.07		0.04	
QLEISET	0.58	0.09	0.07		0.11	0.71
QPUPER		0.02				
QRECRE	0.03	0.24				
QRELIG		0.01	0.11		0.13	0.04
QRESTC	0.07		0.04			
QSCHOOL		0.01		0.07	0.06	0.04
QSERVCT			0.04			
QSOCIAL	0.06	0.14	0.09	0.17	0.06	0.07
QTOTSHOP	0.08	0.39	0.46	0.20	0.53	
QWTOT	0.14	0.06	0.11	0.57	0.08	
RMS		0.01	0.07	0.07		
RSS	1.00	0.99	0.93	0.93	1.00	0.86
TOTTRVTM	0.04	0.23	0.09	0.20	0.12	0.43
TPDIST		0.11	0.03	0.11	0.04	0.58
TSTOP	0.15	0.16	0.16	0.15	0.17	0.14
TTOURRW	0.15	0.16	0.15	0.14	0.17	0.16
n (Total=188)	44	70	27	15	18	14

*Zero values not shown.

Table C6: Yogyakarta Day 3 Cluster Means

Variable	Cluster						
	1	2	3	4	5	6	7
LCC				0.52	0.20	0.32	0.01
LIC		0.23					
LOC		0.77			0.11	0.50	
LSUB	0.01		0.95	0.48	0.21		0.03
LUF	0.99		0.05		0.48	0.18	0.96
MBICYCLE							0.73
MCAR		1.00		0.29	0.90	0.07	0.02
MOTBIKE	0.62		0.82	0.57	0.04	0.93	0.14
MRENTCOLT	0.02						
MTOTBUS			0.18				
MULTIM				0.14			
MWALK	0.37				0.05		0.10
QFARM	0.13		0.05				0.09
QLEISET	0.01	0.69		0.07		0.11	
QPUPER						0.04	
QRECRE	0.01		0.09			0.21	0.18
QRELIG	0.09				0.32	0.07	0.28
QRESTC	0.05			0.17	0.04	0.04	0.03
QSCHOOL			0.09	0.07	0.02	0.07	
QSERVCT				0.10		0.04	0.01
QSOCIAL	0.33		0.18	0.24	0.27		0.19
QTOTSHOP	0.26		0.50	0.36	0.25	0.14	0.06
QVOLU	0.02						
QWTOT	0.09	0.08	0.09		0.05	0.07	0.13
RMS	0.02	0.46		1.00	0.03		0.11
RSS	0.98	0.54	1.00		0.97	1.00	0.89
TOTTRVTM	0.10	0.44	0.16	0.19	0.23	0.35	0.16
TPDIST	0.03	0.29	0.06	0.08	0.09	0.15	0.04
TSTOP	0.22	0.21	0.16	0.33	0.26	0.19	0.38
TTOURRW	0.21	0.14	0.16	0.14	0.26	0.19	0.33
n (Total=121)	42	13	11	7	19	14	15

*Zero values not shown.