ESTIMATING SOCIO-ECONOMIC VALUE OF CYCLING USING OPPORTUNITY COST METHODOLOGY

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March, 2011

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Enschede, The Netherlands, March, 2011

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ABSTRACT

Increase in development activities might pose a threat to the environment when it comes to transport. That is growth in development catalyses the shift from cycling to motorised modes of transport, which in turn increases CO_2 emissions. Cycling possesses both socio-economic and climate values of cycling hence the need for the development of a methodology to investigate the travel behaviour of cyclists to appreciate the current cycling mobility so as to make an argument for at least maintaining current bicycle shares by preventing the substitution of bicycle trip with an alternative mode of transport.

The opportunity cost methodology quantifies the effect of cycling based on the cost and benefit to cyclists when cycling is no more an option to them. In this research stated preferences of current cyclists with respect to their most likely alternative mode and its attributes are used to estimate the first and second order effects for both the study sample and the population. This reveals the socio-economic opportunity value of cycling. Zanzibar is the case study area.

The highest average socio-economic value ($ 0.61) per trip was recorded in the ward Kikwajuni Bondeni and the least socio-economic value of $ 0.03 per trip recorded in Matarunbeta. The ward Mpendae recorded the highest socio-economic value of $ 112.92 per day for the population and $0.79 per day for the ward Vikokotoni. Finally, the socio-economic value was seen to relate directly to the climate value (parallel research) hence two situations aroused; (i) Low socio-economic value and low climate value implies that cyclists are likely to shift to alternative mode of transport but low implications to climate. (ii) High socio-economic value and high climate value also implies that potential shift to alternative mode transport is low but high implications to climate. In terms of opportunities, 5 minutes network buffer was created by using different travel speed of the modes. It showed that motorcycle had the largest coverage with 504 opportunities, car covered 196 opportunities, bus covered 161 opportunities, walking covered 121 opportunities and bicycle covered 346 opportunities.

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TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

1. INTRODUCTION

1.1. Urban transport reality

The movement of people in a city from one activity point to the other determines to a greater extent the growth of that city (Murray, et al., 1998; Rodrigue, et al., 2009). A good transportation network of a city also forms the basis by which its economic and social development evolves. A well planned transportation system is therefore needed when developing a city. The quality of life of people is affected if there is no physical access to health, jobs, education and other amenities. Inappropriate transport design can therefore worsen the condition of the poor. This is because it is believed that investing in transport promotes growth (World Bank, 1996).

In the developing world, private car ownership and use are increasing at a faster rate than the road space (Hensher, 2007; World Bank, 1996). This tends to reduce the diversity and availability of non-motorised transport such as cycling services to the public and the poor especially. Without the use of the bicycle, most people will resort to other transport modes, but the poor who are captive cyclists will have no option than to walk. This will increase the inequity in the system since the poor on top of income inequality are restricted from having access to the urban or social amenities. Non-motorised mode of transport plays a significant role in transportation in developing countries especially in Sub-Sahara Africa (SSA) where rate of motorization is averagely low (Sieber, 1998). Moreover, in these countries the economic growth rate has been low, thereby leading to inability of the government to provide sufficient funds to maintain and/or develop new transport infrastructures and this in turn has failed to meet up with rate of urbanization during the past few decades (Khisty, 1993). The high urban rate places a high demand on public services and the limited infrastructure (Frank, 1968). The effect of the poor economy is also reflected in the transport sector invariably serving as a constraint to national development (Sieber, 1998). This situation has been well studied in some selected countries in East Africa. Generally, in East Africa, it is obvious that investment in the transport sector has a direct and/or indirect impact on the livelihood of the poor within the urban areas (Howe & Bryceson, 2001), while the urban areas are often characterised by unskilled and semi-skilled workers, casual labourers, female-headed households, the physically handicapped, HIV/AIDS orphans and street children (Howe & Bryceson, 2001). Tanzania has been classified as one of the poorest countries in the world. The present deterioration of the road networks in Tanzania is impacting negatively on the mobility and access to markets and services, this situation is more pronounced in the rural areas, a major contributing factor is the inadequate allocation of resources and poor legal and institutional structures. Tanzania has been classified as one of the poorest countries in the world, and provides the case study for this study.

As a result of the financial constraints faced by countries, especially the developing ones, an improved public transport system is seen as the most likely solution to controlling congestion on our roads as compared to investing in the construction of road infrastructures (Palmner, et al., 1996). This is good, but will be better if most private car trips were substituted by non-motorised modes like cycling, they would reduce the already serious congestion problems on central city roads, where most cycling is concentrated (Pucher, et al., 2010). Presently in rural areas Tanzania, use of NMTs is higher than in urban areas, this is probably due to difference in income level, while use of bicycle serves simultaneously as a means of transport as well as a source of income in rural areas and also for the urban poor (Cordula, 2004). The likelihood of this trend to change when there is growth in economic development and rise in income level is high and should be considered when dealing with development activities.

In the Subsaharan Africa (SSA), bicycles are used widely in Mozambique, Burkina Faso, Uganda, Tanzania, Zimbabwe, Ethiopia, Rwanda and Kenya (Heyen-Perschon, 2001).

1.2. Research problem and justification

The main problem of this research is the development of a methodology using the opportunity costing concept to quantify the socio-economic value of current cycling mobility. This is to appreciate current cycling mobility to give arguments for maintaining current levels and preventing the "shift" from cycling to motorized modes. Socio-economic value of cycling in this respect is considered as the net value of the positive and negative effects (benefits and costs) that the shift of transport mode from cycling to any other alternative mode of transport brings onto the society. Some of these effects are, loss of employment for the local bicycle industry, more cost of travelling, possible health deterioration, climate change effects etc (Buis, 2000). The methodology developed here builds on an existing methodology for estimating the climate value of cycling as reported in (Massink, et al., 2011).

The socio-economic value of cycling is very important when it comes to sustainable development. This is because sustainable development looks at the well being of the society in terms of its balance in environmental, economic and social qualities (Sahely, et al., 2005; Steg & Gifford, 2005). These indicate that sustainable development is also concerned with the equity among the three characteristics namely social, economic and environmental of both the present and the future generations.

This shows that there is a connection between climate change and socio-economic development in terms of sustainable development and that development goals can be hampered seriously by climate change. This is why the relationship between development and climate change should be investigated (Davidson, et al., 2003).

High climate value means large cycling modal shares in combination with high motorised (car) substitution rates which may be due to development and industrialisation or/and urban form. In this case people will not lose their mobility. Similarly, a high socio-economic value means less cycling modal shares or less motorise mobility. This means that climate change can undermine the achievement of development activities. Table 1-1 shows the relationship between the socioeconomic value and climate value and their implications.

Socioeconomic Value	Climate Value	Implication	Risk to climate
Low	high	High potential to shift from cycling to motorised (more CO_2 emitter) modes or loss of access to opportunities with cycling	high
Low	Low	High potential to shift from cycling to non-motorised modes or less CO_2 emitter modes or loss of access to opportunities with cycling.	medium
High	High	Low potential to shift away from bicycle to motorised modes or high access to opportunities with cycling.	medium
High	Low	Low potential of shift away from bicycle to non motorised modes or less CO_2 emitter modes or loss of access to opportunities.	Low

Table 1-1: Linkage between socioeconomic value and climate value

The opportunity cost methodology is developed to estimate the socioeconomic value of cycling and to connect to the climate value of cycling in order to achieve a sustainable development. This will also help to achieve the development goals and at the same time reduce the vulnerability to climate change (Davidson, et al., 2003). It is therefore important in transport development and in developing countries, to fully address both the social and environmental unacceptable or negative impacts that the rapid increase in motorise transport can bring or cause in our society (World Bank, 1996).

A number of researches have been carried out to develop methodologies to estimate the economic and the environmental values of cycling for this purpose. Some of these researches led to the estimation of the economic value of cycling traffic (Ploeger & Boot, 1987) as cited in Massink (2009) and the development of the climate value of cycling model (Massink, 2009), which substitute bicycle trips with their most likely alternative transportation mode leading to the climate value of cycling.
Most of the assessment methods like cost-benefit analysis provide a general economic evaluation of transportation, mainly for individual projects. Opportunity cost method tries to assess (appreciate) current sustainable behaviour in monetary, environmental or social units (Massink, 2009). Opportunity cost in general terms is defined as whatever must be given up to obtain some items and can be used to estimate the value of unvalued or undervalued assets. It is an implicit price of goods or assets that cannot be determined directly in the market place and so needs to be calculated.

There are uncertainties surrounding the climate value of cycling which has been developed by Massink (2009). It was realised that cycling possess a climate value and that low climate values imply low motorised or large walking substitution rates. In the same way cycling possess a socio-economic value. That is, large walking substitutions rates could indicate that cyclists are captive and that they will fall back in socio-economic opportunities when they are not using their bicycles.

This study is relevant for Zanzibar, because it has a high cycling population and undergoing economic development as a result of tourist activities which would have a positive impact on the livelihood of the people of Zanzibar. It is therefore important to know the impact of cycling on the people and development in general, so as to put in place measures that would prevent the shift from cycling to motorised modes, since development activities can also encourage shift from cycling to motorised modes of transport.

1.3. Research objectives and questions

1.3.1. Research objectives

The main objective of this research is to develop a methodology to estimate the socio-economic value of cycling. That is to estimate the value of current cycling mobility on the society reasoning back to the potential cost/benefits if these cycle trips were not made, e.g. instead by walking or any other motorised mode of transport. This estimated socio-economic value will be compared with the climate value which is being developed by parallel research as a sustainable development indicator of cycling mobility.

To aid in achieving this objective, several sub-objectives have been set:

1. To identify the relevance of cycling in terms of socio-economic development.
2. To identify suitable indicators to measure the effects of cycling.
3. To develop an opportunity cost methodology from the indicator to identify the socio-economic value of cycling.
4. To relate the socio-economic value of cycling to the climate value of cycling.

1.3.2. Research questions

The sub-objectives are formulated to help achieve the main objective of the research. It is also believed that in order to arrive at these sub-objectives, there is the need to answer certain questions. These questions are shown in the table 1-1 below.

No.	Objectives	Questions
1	To identify the relevance of cycling in terms of socio-economic development.	What are the costs and benefits of cycling in terms of selected economic opportunities, i.e. work/job, school and shopping?
2	To identify suitable indicator to measure the effects of cycling	Which indicators to measure socio-economic opportunity impacts of cycling are available in literature and can be applied in this context?
3	To develop a methodology from the indicators to identify the socio-economic value of cycling	What is the representation of each mode of transport in Zanzibar?
		At what spatial scale is the research going to be done?
		Which methods have been used to analyse indicators of socio-economic effects of cycling?
		How can these methods be adapted and be used in this context?
		What would be the level of access to opportunities if all bicycle trips are replaced by other modes of transport?
4	To relate the socio-economic value of cycling to the climate value	How do trends of the socio-economic values relate to the climate values?

Table 1-2: percentage shift from cycling to other modes of transport

1.4. Conceptual framework

Cycling is a non-motorised mode of transport which has a lot of potentials ranging from economical, social to environmental advantages. They are very much needed when it comes to sustainable development which deals with a development with a balance of social, economical and environmental factors. It therefore means that to achieve a development which is sustainable, these three factors must be achieved. It is unfortunate that most people do not know these potentials of cycling and therefore pay less attention to it.

The value of cycling potentials has been discussed substantially in literature, but most of them do it using general economic and environmental factors only. These methodologies mostly assess "shift" from other modes to cycling and associated costs and benefits, while this research aims at assessing or appreciating current cycling mobility to give arguments for maintaining current levels and preventing the "shift" from cycling to motorized modes. Figure 1-1 below shows the conceptual framework of the research:

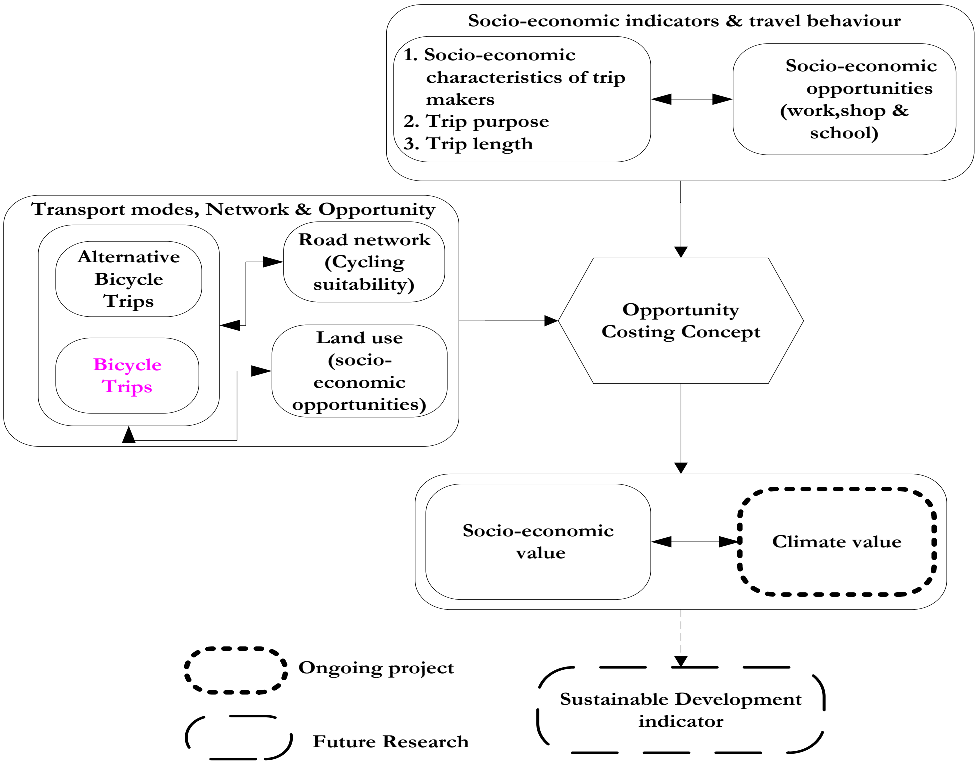


Figure 1-1: Conceptual framework

1.5. Research design

Through literature review, the concept of developing a methodology using opportunity cost methodology was established. This was as a result of trying to estimate the socio- economic value of cycling in order to relate it to the climate value of cycling which is another ongoing project for the development of a sustainable development indicator. Based on this research problem, the research objective and questions were formulated.

The variables to be used in the analysis were identified with the help of literature. The data included the socio-economic characteristics of the trip makers, demographics, trip length, trip duration and purpose, the modal split in the study area and land use data. The socio-economic opportunities or attractions were extracted from the land use data and field GPS survey. The spatial scale of this study was the ward level. Some of the data was acquired from literature and existing database. Others were acquired by survey; this was done by a road side cyclist survey. The combination of the socio-economic characteristics of cyclists and those of the cycling trips themselves gave the socio-economic impacts of cycling.

Certain assumptions were made during the analysis stage. These assumptions were based on literature and the data available. From the data collected in the field, the socio-economic value of cycling was estimated. This value is an indication of the costs and benefits in terms of opportunities or attractions, travel time and travel cost (transport fare and cost of mode) to the society when people are forced to shift away from cycling to other transport modes. It is determined from the net cost of using a bicycle and its alternative modes, the number of extra opportunities that is gained (reached) or lost (out of reach) in using alternative modes of transport instead of cycling. This applies to cyclists who changed their destinations as a result of the shift (Second Order Effects) and the net value of the time used by cyclists and its alternative modes in reaching their destinations.

Using the spatial analyst tool in ArcGIS and a spatial layer with opportunities as derived from land use data and a GPS survey, the number of opportunities within the reach of using these alternative modes is determined. See figure 1-2.

Based on the analysis, conclusions would be drawn and recommendations would be made from the findings and literature.

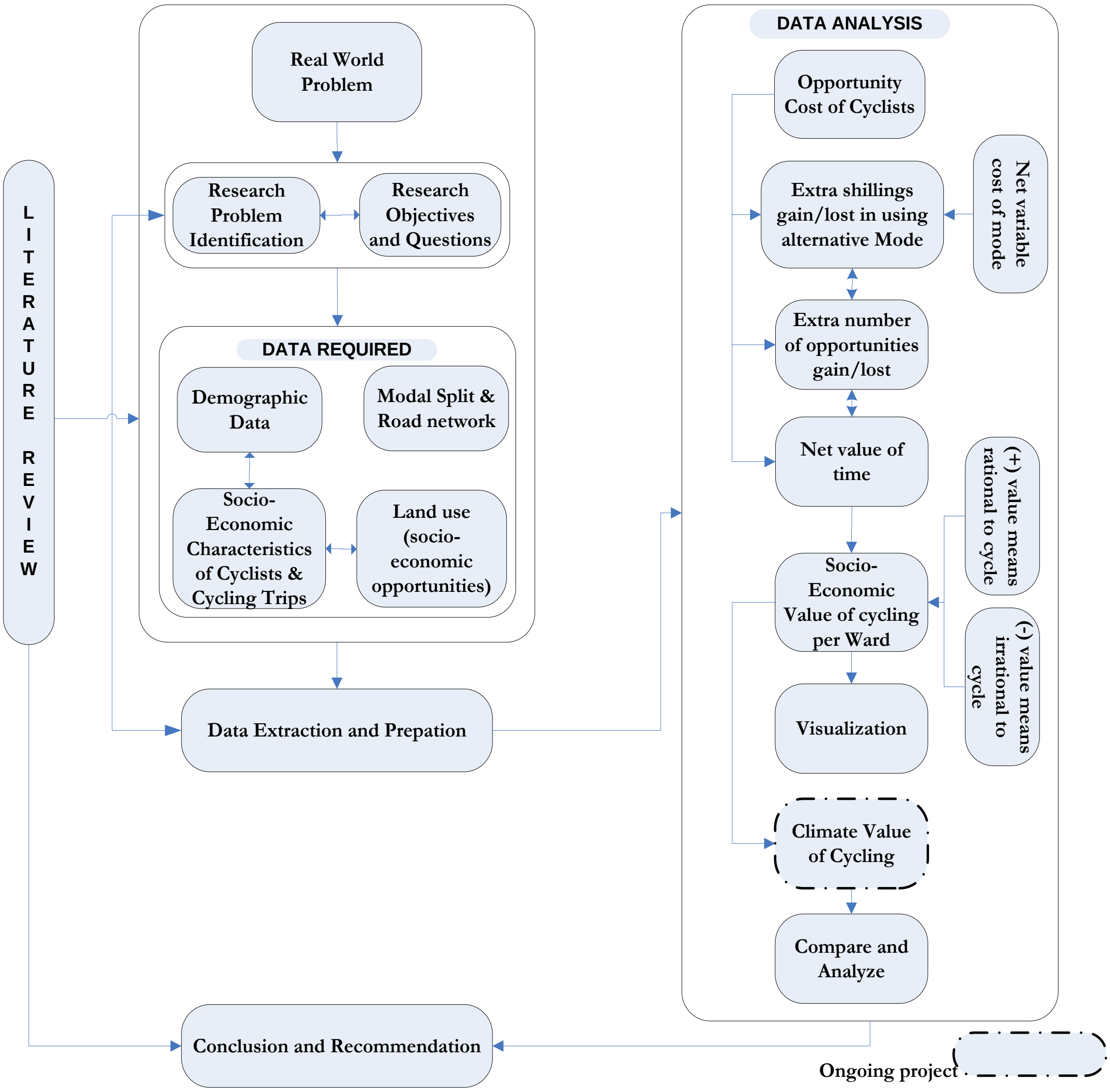


Figure 1-2: Research Design

1.6. Research matrix

The table below shows the research matrix. It gives the research objectives, research questions, data required, and data source, data acquisition tools, the time frame within which to achieve each objective and the method of analysis. The content of this matrix adds up to achieve the overall objective of the research work.

No.	Objectives	Questions	Data required	Data sources	Data acquisition tools	Time	Method of analysis
1	To identify the relevance of cycling in terms of socio-economic development.	What are the cost and benefits of cycling on work/job?	Relevant literature on socio-economic opportunities	Secondary data	Literature search	Pre-field work/field work	Literature review
2	To identify suitable indicators to measure the effects	Which socio-economic indicators are available in literature and can be applied in this context?	Relevant literature on socio-economic transport indicators	Secondary data	Literature search	Pre-field work/field work	Literature review
3	To develop a methodology from the indicators to identify the socio-economic value of cycling	What is the representation of each mode of transport in Zanzibar?	Modal split	Primary and secondary data	Existing database and field survey	Pre-field work/ Field work	GIS analysis/ Statistical analysis
		At what spatial scale is the research going to be done?	Relevant literature on transport	secondary data	Literature search	Pre-field work/ Field work	Literature review

		Which methods have been used to analyse socio-economic effects of cycling?	Relevant literature on socio-economic effects of cycling	Secondary data	Literature search	Pre-field work/ Field work	Literature review
		How can these methods be adapted and be used in this context?	Relevant literature on transport	Secondary data	Literature search	Pre-field work/ Field work	Literature review
		What would be the level of access to jobs/work if all bicycle trips are replaced by other modes of transport?	Socio-economic data, modal split and road network (bicycle suitability)	Primary and secondary data	Survey	Field work/ Post field work	GIS analysis and Statistical analysis
4	To relate the socio-economic value of cycling to the climate value	How do trends of the socio-economic values relate to the climate values as currently developed by a colleague?	Relevant literature on climate and development	Primary and secondary data	Literature search	Field work/ Post field work	Literature review

Figure 1-3: Research matrix

1.7. Research limitations

All though this research was carefully prepared, the researcher is aware of its limitations and shortcomings. First of all, the research was conducted in two parts which is the field work (data collection) and theory. One month is not enough for the researcher to observe the travel characteristics of the cyclists in all the wards. Therefore, to generalise the result to the population, the study should have involved more cyclists at the different ward levels. This would be achieved if the research is done for a longer period.

Second, the field budget is not enough to hire a lot of field assistants. The researcher would use the money to hire the services of other field assistants to help collect the data from all the wards within the limited period given.

Third, there is not enough data on cyclists in Zanzibar (population) which makes it difficult to scale up the sample to represent the population. There is therefore some degree of error regarding the final result.

Fourth, since the questionnaire is designed in Swahili it is difficult to communicate with the interviewees and therefore the researcher do not get the right answers if the interviewee does not directly understand the designed question.

Fifth, the scale of the research is the ward level which is large for some of the activities in the research. For instance, the centroid of the ward is used as the origin of the trip in the determination of the accessibility of opportunities by the different type of modes. This would give a better representation if there had been a smaller scale than the ward.

Finally, since the main objective of the research is set by the researcher, it is unavoidable that in this study, certain degree of subjectivity can be found.

1.8. Outcomes research

Below are the expected outcomes of the research;

1. An overview of the role of bicycle in the study area; understanding the travel behaviour, alternative modes and the purpose of travel of the cyclists of Zanzibar.
2. Insight and understanding of the catchment or accessibility in the study area by bicycle and its alternative modes (car, motorcycle, bus and walking) (i.e the second order effect)
3. Insight and understanding the Opportunity Costs of cycling related to socio-economic opportunities
4. Insight into the relationship between environmental and socio/economic opportunity costs of cycling so as to determine the risk involved (table 1-1) in shifting from bicycle to more environmentally unfriendly modes of transport.

2. URBAN TRANSPORT

The ability of vehicles to convey people and goods with good protection over a longer distance caused the rejection of bicycle even though it was one of the most popular modes of transport in the United States. At a point in time cycling was discouraged on roadways in order to provide a convenient environment for motorists which will intend protect the safety of the public. This trend still did not eliminate the use of bicycle since it was still serving an important purpose for some road users because it was simple, affordable, exercisable and enjoyable (Buis, 2000; Goodridge, 2001).

The rapid increase in the use of personal vehicle in urban cities has it own advantages and disadvantages. The increase use of automobiles can cause congestion on our road space, air and noise pollution, traffic accident and social inequity (Ahmed, et al., 2008; Banister, 2008). Despite these negative factors, we should not forget the numerous benefits that the use of automobiles can provide. It provides access to all the important amenities and services that is needed in human life such as education, employment, health services and even leisure (Ahmed, et al., 2008; Buis, 2000). These two components of urban transport make it very delicate as to which part to support.

Several researches have also been carried out on the effects of high level of automobile use in urban cities and their side effects. This chapter aims to explain the benefits of encouraging the use of non-motorised modes of transport like the bicycle and discusses the impacts of cycling and the development of cycling facilities in relation to socio-economic development and health. It finally, compares the effects of cycling to the effects of other modes of transport like walking, motorcycle, public transport and private car by considering their operating costs.

2.1.1. Non-motorised transport

Non-motorised transport (NMT) modes come in many forms. These include wheel barrow, tricycles, horses (animal carts), cycle rickshaws, bicycles and pedestrians. The use of NMT is increasing in SSA mainly because of their affordability, flexibility and cost-effectiveness in providing low cost transportation (Heyen-Perschon, 2001; Riverson & Carapetis, 1991). It provides basic mobility, access to motorised transport (MTs), physical fitness and it is enjoyable (Goodridge, 2001; Litman, 2004). Relatively, the presence of NMT's can influence the speed of MT's, thereby affecting the operating costs of motorised transport (Odoki & Kerali, 2000). Furthermore, the increasing focus on efficiency in energy use, and the environmental impacts arising from the ever-increasing use of motorised transport (MT), has highlighted the need for better provision of NMT facilities. The discussion in this section centres on the use of the bicycle as a non-motorised mode of transport.

2.1.1.1. Cycling and its effects

Cycling is an active and environmentally friendly mode of travel which covers distances considered long enough to constitute most urban trips (Moudon, et al., 2005). Cycling as a transport mode is underutilised especially in the developing countries according to its potentials, this is likely due to the fact that bicycle facilities are often not developed because more emphasis is being placed on development of motorised transport system (Heyen-Perschon, 2001). In the research carried out by Laustere (2002) the social, economic and environmental benefits of cycling were extensively discussed. The economic benefits were

considered in terms of direct, indirect and induced impact of cycling and development of cycling facilities in the society.
Good cycling policies according to Buis (2000) brings a wide range of cycling benefits as listed below:

- The costs of traffic and transport facilities: Money is saved in the construction and maintenance of car and public transport infrastructures as well as cost savings since bicycle facilities are cheaper than facilities for motorised transport.

- Reduced traffic congestion: Cycling plays an important role in minimizing use of automobiles for short distance trips, especially in congested urban areas. Litman (2004) also highlighted the conditions under which cycling can reduce congestion, these include when the road is congested and there is space for cycling and when the road is narrow and congested with low speed traffic. He also noted that uncongested roads and separate paths can facilitate shift from motorised to non motorised transport. Contrarily, additional cyclists will increase congestion in a narrow congested road with high speed traffic. In terms of parking space, bicycles occupy less space than motorised transport and therefore congestion is reduced. The space required to park a car can be used to park between 14-20 bikes (Litman, 1999; Queensland Transport and Main Roads, 1999). Bicycle parking is usually free, easily accessible and more convenient than car parking (Laustere, 2002).

- The urban economy and the quality of life: The bicycle can help to reduce the negative impact of motorised traffic on the urban quality of life. This, especially in city centres, can lead to a more attractive climate for retailers, cafes and even companies to locate a new business.

- Improving the environment: A clean and quiet means of transport like the bicycle can help as a calming measure for congestion effects in cities and to combat urban air pollution and noise nuisance (Beirão & Sarsfield Cabral, 2007; Martens, 2004). It can contribute to the mitigation of carbon emissions as cycling possesses an intrinsic zero-emission value. Mobility of cycling is perceived as a carbon-sink because each cycle trip represents potential carbon emission when made with an alternative, motorised transportation mode (Beirão & Sarsfield Cabral, 2007).

- Health; In most developed countries more than half of the population exercise too little. Cycling for half an hour a day would have a major effect on the prevention of a number of illnesses. Cycling can also serve as a form of exercise which also has it own health benefits. It is believed that cycling half an hour a day has an effect on the prevention of certain diseases like heart and vascular diseases, chronic disease and premature death (Buis, 2000; Goodridge, 2001; SQW Limited, 2007). On the other hand, health benefits can also increase tremendously if car trips are substituted with cycling trips due to reduction in carbon emission (SQW Limited, 2007). This will go a long way to reduce the cost of health care. For example, some people play sports or exercise regularly in a gym to keep fit, but these cost money and require special time and effort, so most people will not participate in such activities regularly over their full lifetime (Sevick, et al., 2000).

- Traffic safety: Cyclists do not cause severe accidents. An increase in bicycle use, nevertheless, can cause an increase in accident rates, because cyclists are vulnerable road users. On the other hand, when bicycle infrastructure is designed in a proper way, the total amount of accidents can fall as studies in the Netherlands have shown.

- The role of the bicycle for employment: the bicycle can play a role for employment in various ways. In the first place there is the bicycle industry including selling and repairing, which can lead to local economic activity. Furthermore the bicycle can be used at work leading to increased incomes, especially in developing countries.

- Travel costs and individual mobility: the bicycle is not only a cheap mode of transport for society, but also individual users can save money through such use. This is the case in both developed and developing countries. For poor people a bicycle means access to markets (to buy and sell) and jobs, thus improving their economic situation.

These and other benefits are summarised according to Heyen-Perschon (2001) as shown in the figure 2-1 below.

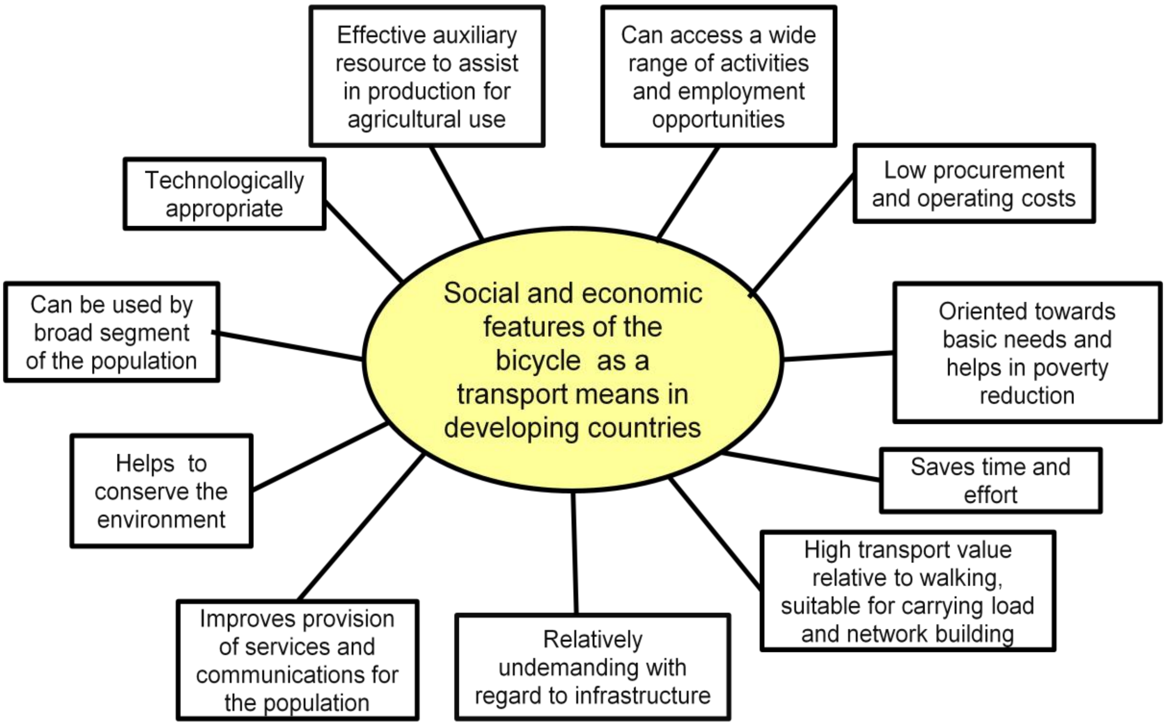


Figure 2-1: Social and economic features of the bicycle (Heyen-Perschon, 2001)

2.1.1.2. Factors of cycling

Certain factors such as closeness to social amenities, public prestige factors, urban size and density, climate, landuse pattern and presence of bicycle infrastructures all facilitates the use of bicycle or walking (Plaut, 2005).

In addition, the following factors that determine the potential of cycling in urban areas have been identified by Laustere (2002) and Buis (2000).

- The length of the trips made by urban residents and the urban structure, this has to do with the length of bicycle lane/trail/road and accessibility to community resources or services.
- The present transport and traffic system and mobility patterns (this includes road safety).
- The socio-economic features of the population, Young (10-20 years), elderly, and low-income people tend to rely more on walking for transport. Young and low-income people tend to rely on cycling for transport.
- Ownership of cars, motorised two-wheelers and bicycles,
- The attitude towards cycling and other modes of transport
- The geographical features of the concerned urban area, in terms of topography and climate: These factors can affect walking and bicycling, but not as much as might be expected.

Land use patterns (density and mix): Walking and bicycling for transportation tend to increase with density (i.e., number of residents and businesses in a given area) because higher density makes these modes more efficient (Laustere, 2002).

These factors, apart from the determination of cycling potentials also give insight to the reason why people don't cycle for their daily urban trips. For cyclists to accept cycling as a mode of transport for urban trips it has to be incorporated into policies.

To reduce the amount of trips made by motorised modes of transport and especially prevent the shift from cycling to motorised, there is the need to reduce the deterrents to cycling and increase its attractions. For example, the perceived danger of cycling is one of the main reasons people give for not cycling (Unwin, 1995). Increasing safety problems due to not considering cycling as a valid mode of transport and an increase in private motor ownership led to a decline in bicycle use. It is prudent to study the potential effects of the cycling environment (perceived and actual) on cycling behaviours to provide much needed support future policy and interventions promoting cycling (Moudon, et al., 2005).

The choice of bicycle as a transport mode largely depends on its convenience as compared with other modes, the higher the convenience, the higher the attractiveness to cycle. Other people such as vehicle owners normally compare the speed of bicycle to the automobiles and think that cycling would have been more useful should it compete with automobiles in terms of speed. But for non-vehicle users, bicycle is very useful as it is an improvement on walking. In suburban environments, bicycle takes about twice the time that car travel which is less for short trips. See figure 2-2. Bicycle is relatively faster than bus especially when waiting time and the walking time to the bus stop of the bus is included. It can be deduce that car is the fastest, but bicycle can be very attractive to non-car users who travel more than one kilometre. Bicycle finally allows easy stopping especially when you have a lot of activities between the origin and destination which will involve a lot of walking and time consuming (Goodridge, 2001).

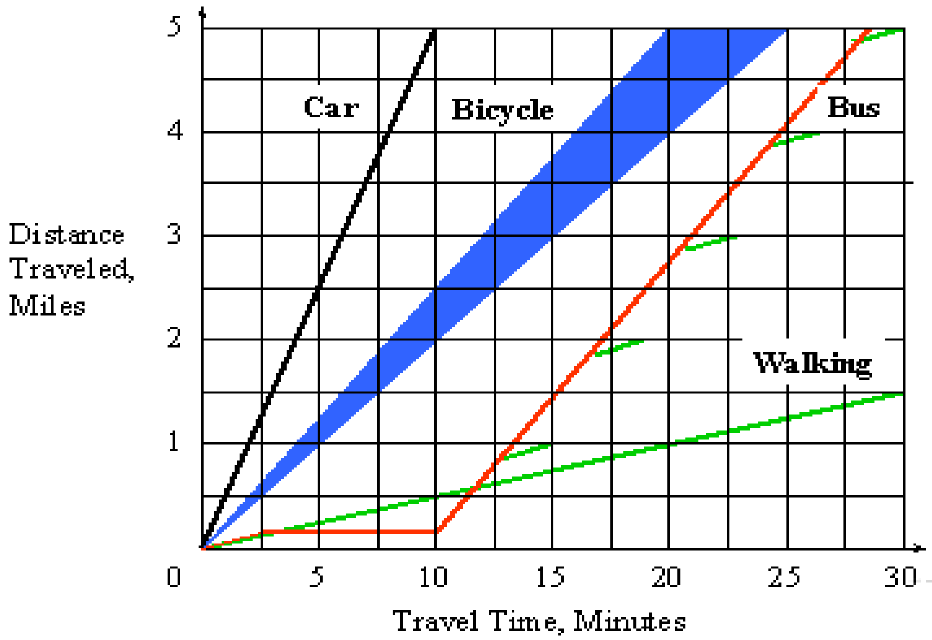


Figure 2-2: Comparison of various modes for short trips. Bus travels direct to it destination (Goodridge, 2001)

2.1.2. Socioeconomic impact of cycling

Investment in and development of a good transportation system of a city has been linked to economic, social and cultural development of the city (Heyen-Perschon, 2001). This relationship has been extensively studied, both on a local level and regional level (Heyen-Perschon, 2001; Preston, 2001; Schofer & Levin, 1967; Sieber, 1998) but more emphasis has been laid on transport development of urban areas with respect to accessibility of people to basic needs, such as education, health services, and market and employment opportunities. Accessibility in urban centres includes available transport means such as private cars, public transit and bicycle, which in turn depends on Education and/or income level of each individual/household (Preston, 2001) In view of this, there is therefore need to analyse the cost benefit of using the non-motorised mode of transport. (Krizec, 2007) highlighted the factors considered in use of bicycle and development of bicycle facilities, this include cost benefit analysis, economic impact assessment, cost effectiveness evaluation and financial risk analysis, of which the cost benefit analysis is widely used (Heyen-Perschon, 2001; Krizec, 2007; Laustere, 2002). For sometime, analysis of non-motorised mode of transport has been affected by insufficient data; however efforts are being made to estimate the cost benefits of cycling. It has been noted that the benefits exceeds the cost (Krizec, 2007).

2.1.3. Urban form and mobility

Importantly, In terms of access to workplace, the use of bicycle provides inexpensive means of transport both to short distant and long distant trips and especially short distant trip is more time efficient (Wisconsin Division of Transportation, et al., 1998). Economically, bicycle can be used to work and market by low income earners in developing countries (Buis, 2000). Existing literature shows that the relationship between urban density and travel behaviour is highly complex (Buchanan, et al., 2006) research has shown when sites of employment and residence are close together, the commute to work is shorter than when employment and residential locations are further apart while longer trips have to be made in larger cities.

The relationship between urban development and transportation was studied in-conjunction with change in transportation mode. It was realized that increase in average work-trips distance has led to change in mode of transportation (Buchanan, et al., 2006). According to Schwanen & Dijst (2002), this is influenced by duration of work an individual has to partake in and the utility value (Munshi & Brussel, 2005). In some cities, most workplaces/employment opportunities and facilities are concentrated in the city centres (Vega & Reynolds-Feighan, 2009), thereby encouraging use of non-motorised mode of transport, it has been noted that majority of these centres are dominated with densely populated neighbourhoods, which is usually characterised by households of middle-low income earners, with low rates of car ownership (Kitamura, et al., 1997). In light of varying level of income, higher income earners tend to reside further away from the city centre, using a faster mode of transport (Vega & Reynolds-Feighan, 2009). Education and skill level of commuters/individual also plays an important role in access to job opportunities and employment status. By modelling the relationship between workplace and residential location, incorporating job opportunities,(Simpson, 1980) noted that highly skilled workers have a larger job market and vice versa, and has a higher probability of finding job far from their residential location, this is determined by the satisfaction derived from an activity, in this case; workplace (Munshi & Brussel). Cross-sectional empirical evidence from over the world suggests that average home-to-work trips mostly range from 25 to 35 min (Kenworthy & Laube, 1999).In addition, the impact on livelihood and development of rural communities in East Africa(Uganda) was studied by (Heyen-Perschon, 2001), by introducing bicycle use to the communities, there was considerable increase in income level of households, local and regional integration of rural areas and also accessibility to markets and health facilities.

2.2. Motorised transport

Motorized transport constitutes a wide variety of public and private motorized modes. These are discussed here.

2.2.1. Public transport

Public transport is one of the sustainable transport systems and therefore need to be made easily accessible to the public (figure 2-3). It is very important that policy makers look at the effectiveness of their performance when assessing their policies (Murray, et al., 1998).

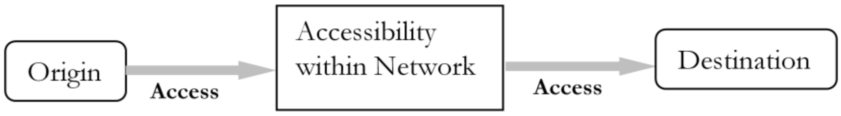


Figure 2-3: Public Transport Accessibility (Murray, et al., 1998)

Public bus transport is considered as the major sustainable transport in the Sub-Saharan Africa where other forms like the tram and the train are rarely used. Even in the developed countries it is still the major sustainable mode of transport because it has less investment cost as compared to the other sustainable transport systems like the train, tram etc. It uses the same existing roads and on few instances that extensions are made. Since it transports or conveys a lot of people at the same time it reduces the road space that would have been taken should the individuals travel in their individual vehicles and thereby reducing congestion levels on roads (Badami, 2005). It also reduces the amount of greenhouse gases released into the atmosphere hence the reduction in air pollution and climate change (Banister, 2008). This is because of it large occupancy rate as compared to other private saloon vehicles due to the same reason that the amount of greenhouse gases that will be released into the environment in case the individuals travelled in their individual vehicles.

2.2.2. Private car

Private car ownership has become rampant in developing countries most especially in Africa. This has a wide range of negative effects such as air pollution, congestion, noise, road accidents upon society and the environment (Banister, 2008; Bergström & Magnusson, 2003; Hensher, 2007). Despite this peculiar problem with African cities it is also believed that all over the world, the problem of the automobile and its impact on urban societies is a major issue and therefore a reduction in the use of motorised modes of transport in urban areas would be desirable and could be achieved by increasing cycling as a means of personal travel (Kenworthy & Laube, 1999).

There is the assumption that reducing car travel needs significant personal sacrifice, but this is not necessarily the case. The reduced car use is rather rewarding and enjoyable as it comes with lots of benefits. Yes, using a car also has it own benefits like good transportation and land use alternatives but the negative effects on the society is enormous (Victoria Transport Policy Institute). The addiction to cars by car owners makes them travel in their cars for both short and long trips. More than half of car trips made in the world are shorter than 5km which will not cause any problem to cycle (Bergström & Magnusson, 2003).

In most developing countries, people who cycle or use public transport due to low economic status tend to use private cars when their situation improves. Kenworthy & Laube (1999) also said, that, the wealth of an urban city determines greatly its relationship to the patterns of automobile dependence, that is, the international patterns of vehicle ownership, vehicle use, transit service and use, transit share of motorised travel, and some important journey-to-work factors such as mode split, trip times and trip distances.

2.3. Cost of transport modes

This section discusses the direct financial costs of the use of the various transport modes. These are divided into fixed costs, which are unaffected by mileage, and variable costs, which increase with mileage. These indicate the savings from transportation improvements that allow consumers to reduce or increase the use and ownership of these modes. Emphasis will be placed more on the operating cost of the various transport modes.

2.3.1. The cost of a car

The ownership and use of a car is largely dependent on it cost of buying and running (Kirwan, 1992). The cost of a vehicle can be put into two perspectives being the fixed and the variable costs, which together contributes to the total cost of the vehicle (O'Farrell & Markham, 1975). The fixed costs are the costs incurred in the vehicle purchase or lease, insurance and the registration and vehicle taxes. The variable costs come in the form of maintenance and repair, fuel and oil, paid parking and tolls (Akcelik & Besley, 2003). The variable costs depend on the mileage that the car runs. In view of this, costs like insurance and depreciation are partly variable. This is due to the fact that the frequency of replacement and repair increase whiles the driving increases. Increased driving also reduces the resale value and increases the risk of crash (Litman, 2002). Variable costs unlike fixed costs are applied to all conditions of driving like the off-peak, urban peak and rural travels as in the case of the united states (Victoria Transport Policy Institute). Table 2-1 shows the operating costs of motorised transport in the US during traffic congestion and low traffic periods, both in urban cities and rural settings. Similarly, operating cost of MTs has been calculated in Sub-Sahara Africa (SSA) using the Road User Effects (RUE) models. For instance, the average operating cost of an average car in US is a little lower (0.10 dollar per km) as compared with the operating cost of a car in SSA (0.12 dollar per km) see table 2-1. While the parameters used to calculate these values are road surface condition (paved, gravel, earth) vehicle type, road geometry (includes the road alignment data, speed limit, roadside friction factor, section length, width and the number of lanes) also incorporating congested traffic conditions or free flow traffic. As Odoki & Kerali (2000) stated, vehicle operating cost or variable cost of a car depends on the following aspects, i.e: types of vehicles using the road, traffic volume on the road section, road geometry (particularly, the curvature, gradient and road width), road surface condition (primarily roughness and texture depth) and driver behaviour.

2.3.2. The cost of motorcycle

The average per mile cost of a motorcycle is higher than that of a car even though the purchase and fuel cost of car is higher. This is as a result of the low average miles that motorcycle travels. An average motorcycle is driven only 2,500 miles annually and travels 50 miles per gallon of fuel. For over 2,600 annual miles, the average cost per mile is about $1.35 (Victoria Transport Policy Institute).

2.3.3. The cost of cycling and walking

In SSA, bicycles serve as a means of personal mobility, commercial use, and carrying of heavy loads for example in Uganda, Tanzania, and some part of western Kenya. In a study carried out by I.T. Transport (2003) on effect of road surface on bicycle use, high operating cost of bicycle was observed. This was attributed to the present situation of roads in Africa. In calculating this operating cost, the bicycle use is usually considered and also the road surface texture (earth, gravel and bitumen). The study shows that it was more costly to travel on the rougher bitumen roads and gravel roads and cheaper to travel on earth roads. On the other hand, HDM-4 indicates a relatively insignificant bicycle operating cost when compared with motorised mode due to modal share, see table 2-1.
Also, the physical size and performance of NMT is usually considered in calculating the speed, which is also incorporated in calculating the operating cost of each NMT according to its use (Odoki & Kerali, 2000).

Walking on the other hand might seem to cost nothing physically, but does cost something indirectly. We normally wear shoes whiles walking and shoes typically last for 500-5,000 miles of walk. Therefore walking cost the price of the shoe for that trip. We should not also forget that walking and cycling burn calories that may also increase the amount of food we eat. This is also another cost to both walking and cycling even though people consider burning of calories or loss of weight as a benefit (Victoria Transport Policy Institute).

	Average ($/ km)	
	SSA	US
Average Car	0.12	0.1
Motorcycle	0.09	0.0443
Bicycle		0.0164
Walk		0.0328
Bus/light truck	0.15	0.1435

Table 2-1: Estimated Vehicle Operating Costs in US and SSA
extracted from (Victoria Transport Policy Institute)and Estimated Vehicle operating cost as a function of road surface condition in Sub-Saharan Africa. Source: RED - HDM-4 VOC (Archondo-Callao, 1999)

2.4. Time valuation

The choice of a transport mode is highly influenced by the economic value of travel time (Beesley, 1965; Truong & Hensher, 1985) which is also derived from theories of time allocation but the mode choice utility expressions are hardly explained in terms of these theories (Truong & Hensher, 1985). The valuation of time by mode plays a great role in predicting methods for rationing the use of existing transport investments (Beesley, 1965; Victoria Transport Policy Institute). In developing countries, time is less valued with respect to the type of transport mode and therefore choices of modes are not dependent on travel time. Time value is expressed in monetary terms. This means that a reduction in travel time is an increase in speed which also implies positive value for time. But the average income of developing countries is low and the speed-distance relationship shows the difference between the value of time in developed and developing countries which in turn depends on cultural, social, and economic characteristics of the population (Khisty, 1993). Travel time comes in many forms. These are summarised in table 2-3 below;

Name	Description	Implication
Travel Time	Any time devoted to travel.	This is the least specific definition.
Clock Time	Travel time measured objectively	This is how time is usually quantified.
Perceived Time	Travel time as experienced by users, which can vary greatly from clock time	This reflects traveller comfort.
Paid (also called On-the-Clock or commercial)	When workers are paid for their travel time (for deliveries, travelling to worksites etc.).	This type of travel tends to have a relatively high value per hour.
Personal Travel Time	Time devoted to personal travel (commuting, errands, etc.).	This is the largest category of time value in most economic studies.
Generalized Costs	Combined travel time and financial costs.	This is how travel time is incorporated into traffic models.
Effective Speed	Total time devoted to travel; including time spent earning money to pay transport costs.	Higher costs for more expensive modes.

Table 2-2: Summary of the various perspectives for valuing travel time and travel time saving(Victoria Transport Policy Institute)

The time spent on a particular transport has a cost component which is the travel time value, or value of time (VOT). Travel time is not like travel cost which can be accumulated for future use but only be

transferred from one type of activity to another. The value of travel time helps us to estimate both the qualitative and quantitative changes in the transport system. The quantitative changes are determined by the opportunity cost. The modal shift from a bus to a car possesses a qualitative change which is the transfer of time between these modes (Truong & Hensher, 1985).
History tells us that the amount of time spent at work has never consistently been much greater than that spent at other activities. Working time has decline partly due to the delay of young people to enter the labour market. This is because the length of schooling has increased or students spend a lot of time schooling. This time could have been use profitably in the labour market and therefore the foregone earnings are one of the costs of education(Becker, 1965).

Beesley (1965) researched the journeys made to work in London. The aim was to set a value on the time spent by different income groups of people in travelling to work by public transport and by privately-owned cars. They first inferred as a general method, the average value for cost of time spent on public transport for groups choosing between public transport alternatives. This value was used as the alternative public transport value when similar groups choose between public transport and cars to infer an average value for car time. In order to have an acceptable outcome, the following assumptions were made;

- The choice of mode is made in order to minimise disutility of travel.
- The people of an income group have the same incomes.
- Marginal and average disutility of travel equal for each person.
- The disutility of public transport travel is the same for those in a group who report choices between modes.

Finally, the value set for each income group was substituted into the choices made by the same income group who report choice of different transport modes. Based on the assumption that people are indifferent to proportions of travel time associated with each transport mode choice and time spent on each mode a summation of each person's choice is represented as $(K+M<Y+X)$
where $(K+M)$ represent the preferred mode with K=minutes spent to go to work, and M=cost (fare, parking etc). The values $(X+Y)$ are similar quantities for the rejected mode.

In another situation, the value of time was determined for the time people in Ukunda, Kenya use in fetching water from the various sources to their homes. Xinming (1990) believe that the higher the number of water sources in the community the better, but also the higher the cost of investment. This also influenced by the value of time savings by households.

The reveal and stated preferences are approaches used in the valuation of time, but they are not used in most cases instead the approaches that involve the use of indirect indicators like the GDP, wage rates, and Regional Domestic Product are used (IT Transport, 2005). It is sometimes not possible to obtain locally the travel time value due to lack of data. This is poses a challenge to Banks and therefore exclude VOT in their project evaluations. Gwilliam (1997) in the evaluation of World Bank transport projects provided a guide which gives the value of time as a proportion of the household income per hour and the wage rate per hour. The method was proposed for the calculation of value of time for time savings for countries which lack of standard VOT values. He recommended that;

- Work trip = 133% of the wage rate per hour
- Non work trip (Adults) = 30% of household income per hour

The above 133% is assumed on the base that the value to an employer of the working time of employees must, at least, be equal to the wage rate, plus any extra costs directly associated with employment of labour. While high levels of unemployment might justify the use of shadow prices below the wage rate. It is recommended that working time saved should normally be valued at this "augmented" wage rate. On the hand, non work trips are valued based on the assumption that wage rate is a reward for giving up leisure, effort of the task and special skills. Then the value of non-work time (leisure) is less than wage rate by the sum of the effort and special skills for the task, which in principle may differ by journey purpose or timing. Different studies so far have not shown any significant change in non-work time values for different non-work journey purposes. A common value of 30% of household income per hour is therefore recommended for the valuation of non-work time (Gwilliam, 1997).

IT Transport (2005) after reviewing several literature including that of (Gwilliam, 1997) and making adjustments required to correct market distortions caused by unemployment, underemployment, taxes and subsidies and also based on three studies conducted in Bangledesh, Tanzania and Ghana recommended several approaches for valuing time in developing countries. These were categorised into two groups namely; work trip and non-work trip valuation approaches. See table 2-3 below.

WORKING TRIPS	
Ideal approach	**Second best approach**
Conventional work trips: Average observed formal employment wage rate (adjusted by shadow SWR and overheads factors)	Conventional work trips: 1.33 x adjusted average observed formal employment wage rate (adjusted by SWR factor)
NON-WORKING TRIPS	
Ideal approach	**Pragmatic approach 1**
Empirically derived travel time saving values for nonworking time using preference approaches (using SP method) disaggregated by social, gender and age groups, modes, journey conditions etc. Also values derived for walking and waiting time. These values need to be adjusted by SCF	Adult's IVT value(currency/hr): 0.55 x weighted average wage rate per hour (adjusted by SCF)

Table 2-3: Recommended methodologies to estimate the value of time for working and non-working trips (IT Transport, 2005)

Due to market distortions in developing countries caused by unemployment, underemployment, taxes and subsidies these parameters need adjustments with shadow wage rate (SWR) and Standard Conversion Factor (SCF) to working and non-working time savings respectively.

The IT Transport VOT used the Gwilliam formula as base and introduced another factor which corrects for the distortion in the African market caused by unemployment, underemployment, taxes and subsidies. It was seen that the western concept of dividing travel time savings into working and nonworking time savings is valid in the rural context of a developing country. However, only a small proportion of total rural trips can be defined as "working trips" according to the conventional western definition, so there was the need to redefine work trips to suit the African context, for instance trips made for purchasing and selling is also included as working trip. Conclusively, time is scarce and should be valued.

2.5. Consumer travel behaviour

The theory of utility serves as a platform for evaluating alternative choices made by organizations, firms and individuals. Utility refers to the satisfaction that each choice provides to the decision maker. The underlying factor of making a decision is the utility maximization principle, which states that the decision maker will go for a particular choice which provides the highest utility Xinming (1990). In transportation system, utility can simply be defined as satisfaction derived from a trip.

Transportation system can be assessed from the economics point of view, where transport services are referred to as goods demanded by a consumer, the demand for a good depends on it's price, characteristics and characteristics of the consumer (Zuidgeest & Maarseveen, 2007). One of the determinants of demand for transport services is the economic value of travel time; a traveller will consider this before deciding to travel. People travel to participate in a particular activity in a location (Thill & Kim, 2005). Based on this, a traveller's choice mode and destination is influenced by utility derived in participating in the activity or disutility of making a trip, ultimately ensuring that the net utility is maximised. The utility of a trip and travel demand, therefore is determined by the characteristics of the intended trip, the available modes and the socioeconomic character of individual making the trip (Zuidgeest & Maarseveen, 2007), while disutility represents the general cost of travel which in turn involves time, monetary cost, inconvenience, discomfort etc. Generally, there's a inherent disutility associated with travel, as a result, people will travel if the net utility of the activity at the destination end is more than the utility involving no travel (Bowman & Ben-Akiva, 2001).

In a research done to estimate the value of travel time, using an income cost approach on the basis that a traveller have different choices of modes, it was noted that a traveller will choose an alternative mode if the greater disutility associated with a mode outweighs its time and cost advantages. Similarly, he will not change mode if the monetary advantage exceeds its disutility in order to minimise travel cost (Moses & Williamson Jr, 1963).

Travel behaviour is a function of utility (Zuidgeest & Maarseveen, 2007), (Rietveld & van Woudenberg, 2003) also analysed the interrelationship between travel behaviour and utility function with the distance travelled, given a traveller has a set of potential destination a model was developed which takes into account the spatial distribution of the destinations and the distribution of their utility. They observed that longer distant destination might yield a higher utility

3. STUDY AREA DESCRIPTION

3.1. Background of study area

Zanzibar is a semi-autonomous part of Tanzania, in East Africa. Zanzibar was once a separate state; it united with Tanganyika to form Tanzania in 1964 and still enjoys a high degree of autonomy within the union. Tanzania (formerly known as Tanganyika) gained independence of British colonial rule in December 1961, it later then became a republic on December 9, 1962. After the rule of the Sultanate, Zanzibar islands became independent on January 12, 1964, but later joined with Tanganyika to form the republic of Tanzania. Zanzibar City is the capital of Zanzibar which is located on the island of Unguja. Its historic centre is known as Stone Town (Wikipedia, 2010).

3.2. Physical characteristics

3.2.1. Location

Zanzibar lies on the east coast of Africa and consists of two major islands, Unguja Island (also called Zanzibar) and Pemba Island, with several surrounding small islands forming a total of 54 islands which altogether are referred to as the Zanzibar Archipelago. Unguja island is located at approximately 35 km Northwest off the mainland of Tanzania, and falls within the latitude 6° 00" and 6° 30" south of the Equator, and 39° 20" and 39° 36" east of the Prime Meridian, Figure 3-1. Pemba Island is about 40km separated from the coast of East Africa and Unguja Island is situated about 40km south east of Pemba.

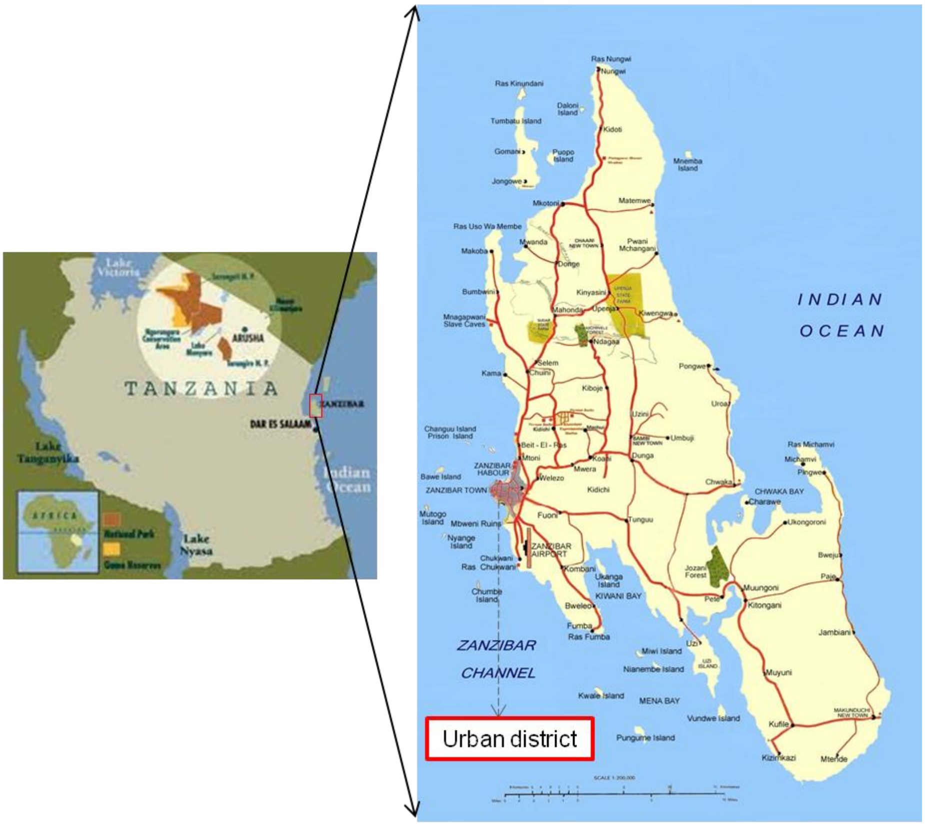


Figure 3-1: Study area location

3.2.2. History and physical geography

Zanzibar Town is a historical town which was already serving as a trade centre for Arabs, Indians and Europeans in the middle ages (Gössling, 2002). It also served as a gate way to East Africa. Since the mid 1980's Zanzibar has been a tourist attraction centre and is presently experiencing development in the social and economic sector, tourism is now a major income earner for the country and attracts investors from all over the world (Marks, 1996). Physically, The topography of Unguja Island is generally flat but with a central ridge running from north to south whose highest point is at Masingini about 130m above sea level. It is about 86 kilometers long and 39 kilometers broad, and has an area of 1464 square kilometres. Zanzibar experiences good climate conditions which is favourable for agricultural activities, agriculture serves as the mainstay of the economy and creates a large number of employment opportunities.

3.2.3. Landuse management

The mainland of Tanzania is divided into 21 regions and Zanzibar into 5 regions, North and South Pemba, North and South Unguja and Urban West. Each region is then further sub-divided into districts. The study area is situated within the Urban district in urban west region of Unguja Island. The total area of Unguja Island is 1464 Sq Km, of which the Zanzibar municipal area covers about 4424 hectares of land (Khatib & Mmochi, 2004). Table 3-1 shows the land use structure of Zanzibar municipality at present. About 43.5% of the built up area is used for residential purposes.

For several years, a number of measures have been taken to improve land administration of Zanzibar, aimed at making land available for different purposes, increasing productivity and improving quality of life, by also considering the growing population of the island. Zanzibar islands have undergone several changes in land use and land ownership throughout their history under different government policies, land administration institution and different schemes. In 1989 Zanzibar Land and Environmental Management was introduced, in addition to this, Zanzibar National Landuse plan was proposed in 1995 even though, it is not a comprehensive land use zoning plan for Zanzibar (Abdulla S. R, 2006). The plan was to aid in future development and to guide the government in strategic planning in the development projects such as roads, health, education facilities, agriculture, tourism etc, but this plan was terminated in 1996, due to unavailability of finances. The project re-emerged again in 2003 under the scheme Sustainable Management of Land and Environment (SMOLE) of which the Land Use Planning is a part (Ali M. H & Sulaiman M. S, 2002).

Based on the 2006 report of the SMOLE project, it stated that the first ongoing landuse plan in Zanzibar is outdated. Moreover, emphasis was laid more on agricultural problems; projections on population growth were not taken into account and employment opportunities in different fields of the economy. Also, there are no plans for the future need of land for different landuse purposes as residential, industrial, service, and tourism areas. Land use economy has totally been forgotten as well as estimates of the suitability of land for different purposes (Toropainen T, 2006). There is the attempt now to develop a new landuse map of Zanzibar. This has been digitised from the existing topographical map of Zanzibar. The spatial distribution of the ongoing landuse preparation is presented in figure 3-2.

Land use category	Area (ha)	Area (%)
Residential	846	43.5
Roads and squares	165	8.5
Special areas	165	8.5
Public open spaces	108	5.5
External communication	103	5.3
Colleges	95	4.9

Public utilities	59	3
Industry	55	2.8
Public buildings	53	2.7
Agricultural establishments	33	1.7
Commercial	18	0.9
Other areas	247	12.7

Table 3-1: Land use structure of Zanzibar Town (Khatib & Mmochi, 2004)

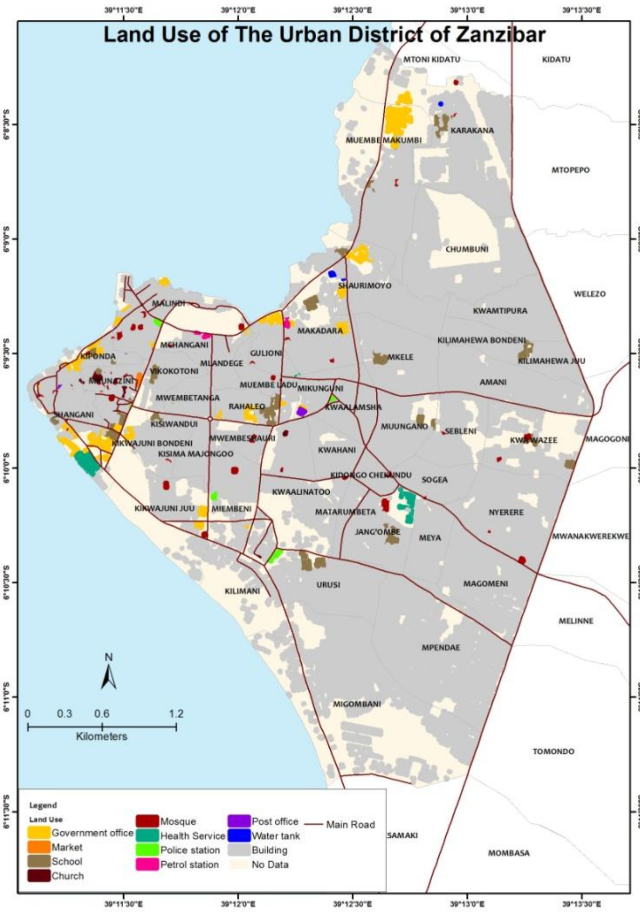


Figure 3-2: Landuse of Urban district, Zanzibar

3.2.4. Road network

In Tanzania Zanzibar, the dominant mode of transportation is by road with 70% freight and 90% passenger movement. Despite the importance of the road sector, an average of about 44% of the road network is in good condition especially in the rural areas. Generally, good road network enhances economic development and poverty reduction in sub-sahara Africa, unfortunately, majority of these roads have been poorly and inadequately managed. Due to bad road conditions, transport cost escalated through high vehicle operating cost (Addo-Abedi, et al.). However, in Ugunja, efforts are being made by the government to restore the roads into good condition. Unguja has a total road network of about 700km. Most of the paved and over 70% of the gravel roads are in bad conditions. According to the 2007 interim report of Zanzibar Transport Master Plan (ZTMP), there is a high level of traffic in the urban areas resulting in the need to upgrade the roads. Furthermore, a town plan which proposed construction of secondary roads was proposed in 1982, this has not been implemented (ZTMP). As stated in the report, the ZTMP's vision for 2020 is to upgrade the principal access roads, provide improved traffic circulation in urban areas, reduce accidents, improve on safety for pedestrians and non-motorised vehicles, and upgrade bus routes and parking areas. Figure 3-3 shows the general representation of the road network in the Urban district.

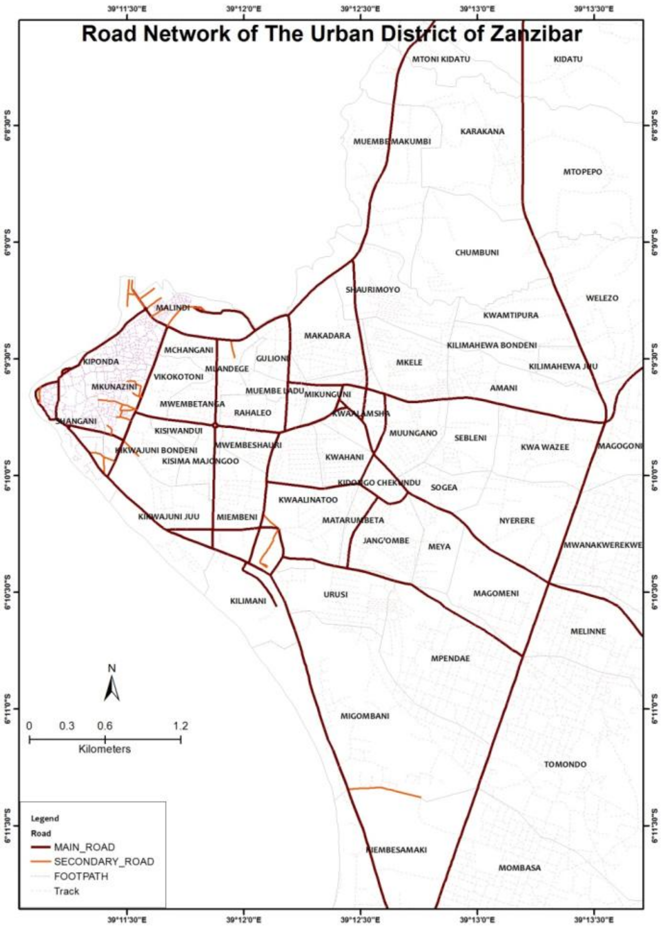


Figure 3-3: Road network of the Urban district of Zanzibar

3.2.5. Demographic characteristics

A total of 4 censuses have been carried out on Zanzibar in the last three decades, the last being the census conducted in 2002, which puts the total population of Zanzibar at 981,754 (The United Republic of Tanzania, 2004). The study area for this research is the Urban district in Zanzibar, from the 2002 census, the population stood at 205,870. Statistics on age distribution shows that people within age group 15 and 64 years constitute relatively higher percentage of 60 percent of the total population, when compared with 38 percent of people below 15 years and 3 percent of people above 65. As a result, people in age group below 15 years and above 64 years are less economically active and the dependency ratio was about 68 (The United Republic of Tanzania, 2004). Table 3-2 shows the age and sex distribution of Urban district, although this data is affected by age mis-reporting due to digital preference.

Age group	Male	Female	Both Sexes	Percent
0-4	13312	13326	26638	12.94%
5-9	12659	13511	26170	12.71%
10-14	11517	12629	24146	11.73%
15-19	10748	12313	23061	11.20%
20-24	12022	12865	24887	12.09%

25-29	10219	10335	20554	9.98%
30-34	6802	7520	14322	6.96%
35-39	5047	6136	11183	5.43%
40-44	4149	4840	8989	4.37%
45-49	3414	3481	6895	3.35%
50-54	3072	2844	5916	2.87%
55-59	1994	1693	3687	1.79%
60-64	1643	1680	3323	1.61%
65-69	957	995	1952	0.95%
70-74	826	1105	1931	0.94%
75-79	415	544	959	0.47%
80+	452	805	1257	0.61%
Total	**99248**	**106622**	**205870**	**100.00%**

Table 3-2: Total Population distribution by 5 year Age group: Urban district, Zanzibar.
Source: The united republic of Tanzania, 2002 Population and Housing census

3.2.6. Population growth rate

The first population census in 1967 shows the total population of Zanzibar to be 354,815 of which the Urban West constitutes about 27 percent. Based on a survey in Zanzibar in 2006, the total population was estimated to be 1.1 million, with 40.8 percent residing in the urban areas (The Revolutionary Government of Zanzibar, 2008). Using the Compound annual growth rate (CAGR), the annual growth rate in Zanzibar, between 1978- 1988 was calculated to be 2.9 percent, while it is 3.0 percent between 1988 and 2002, see table 3-3 below. The annual intercensal growth rate for Urban district of Zanzibar, from1988 to 2002 is 1.9. A population projection software have been used to predict the population of the urban and west districts by 2025, by incorporating indicators such as number of people by age and sex in the base year, current year data and future assumptions about Total Fertility Rate (TFR), age distribution of fertility, life expectancy at birth by sex, appropriate model life table, and the magnitude and pattern of international migration. The projections show that population growth rate will decrease from 2.8 percent in 2003 (with a population of 401,337) to 1.8 percent in 2025 (with a population of 659,109).

Where CAGR = $(V_f/V_i)^{1/T} - 1$, and V_f = Initial Value V_i = Final Value T = Number of years.

Census Year	Population	Intercensal Change	Growth Rate (%)
1967	354,815		
1978	476,111	121,296	2.7
1988	640,578	164,467	2.9
2002	981,754	341,176	3.0

Table 3-3: Zanzibar population trend (The United Republic of Tanzania, 2003)

3.2.7. Population density

Unguja's Central District is one of the most densely populated areas in Africa. Based on the 2002 population census, the population density was derived as shown in figure 3-4. From the population density data obtained from the national bureau of statistics, some wards like Kwa wazee, Kisiwandui, Meya and Migombani were splitted from other wards after 2002 census. These wards therefore had no population figures. To get the population density of these wards, we assumed that the population density of the area (Urban district) was uniform. The shape areas of these wards were multiplied by the uniform population density of the area to obtain their population figures which were also used to calculate their population densities. The incomplete data shown on the map is as a result of un-availability of population density data for the areas from the national bureau of statistics. A ward like kilimahewa was splitted into kilimahewa Bondeni and kilimahewa juu, the population figure was assigned to kilimahewa Bondeni, Hence the population density of kilimahewa juu was calculated based on this assumption.

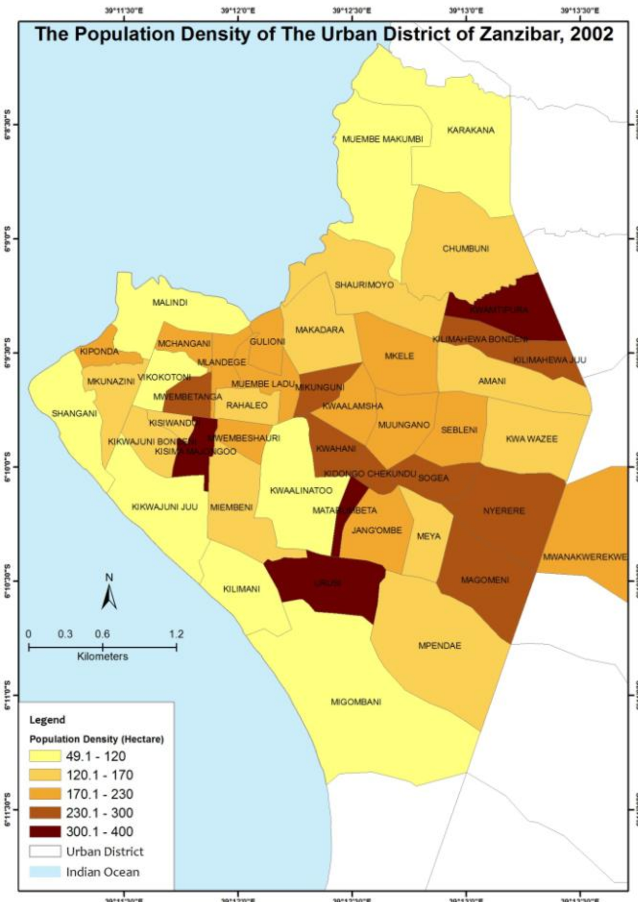


Figure 3-4: Population density of the Urban district of Zanzibar

3.3. Modal shift

There is no proper modal split data of Zanzibar, so the information below was derived from the traffic count which excludes pedestrians. This is conducted by the Ministry of road and Transport of Zanzibar. Table 3-4 shows that the most frequently used mode of transport in Zanzibar is the bicycle. It shows that about 17 percent trips are by motorcycle, 0.80 percent by animal drawncart, about 26 percent uses the private cars (Saloon cars and Pickups). Bus has a modal share of 13 percent; Trucks constitute about 1 percent to the modal share, with the utility truck taking 0.04 percent.

Mode of Transport	Percentage
Bicycle	40.5%
Animal drawn cart	0.8%
Motorcycle	17.2%
Saloon car	6.0%
Pickup	20.8%
Tractor (Utility truck)	0.0%
Bus (2-axel)	13.3%
Truck (3-axel)	1.3%
Pedestrian	—

Table 3-4: Modal share of transport modes in Zanzibar

3.4. Current situation of public transport in Zanzibar

Public transport in Zanzibar operates under private ownership, and the government do not own or control any public transport presently. This mode is generally known as Dala Dala. Apart from the social advantages, the public transport is also important to people living in the outskirts of city centres and they mainly commute using the public transport.

As observed during field study, public bus (Daladala) in Zanzibar is efficient. It is zoned and the fare is also regulated. The regulating body made sure that operators of the bus system do not charge exorbitant prices. The charges are also based on the zones and therefore people travelling within the zone pay the same fare as practised in the Netherlands. This makes it easy for almost everybody to afford the fare of the bus.

The main means of transportation between coastal villages is by roads. Every coastal village is connected to the town by the main road with passenger busses constantly ferrying people between places. Feeder roads for the coastal villages are all tarmac except for few ones like Muwanda and Makoba (UNEP/FAO/PAP/CDA, 2000). Zanzibar has a total road network of 1,600 kilometres of roads. 85% of these roads are tarmacked or semi-tarmacked. The remainder are earth roads, which are rehabilitated annually to make them passable throughout the year.

The main study area of this research is the urban district of Zanzibar. The use of bicycle is springing up in this area and due to that the city has proposed to separate traffic types to use the existing road space more effectively and to reduce traffic accidents. People might have different opinions about the inconveniency that a mixture of modes like bicycle and pedestrians cause. However, this inconvenience truly causes a little or negligible danger to all parties (The Revolutionary Government of Zanzibar, 2007).

Sea transportation presently serves two purposes in Zanzibar Islands. It is basically a means of external transportation and provides a vital link between Unguja and Pemba Islands, between the main islands and the surrounding islets. Better still, it is the only means of transportation between the Unguja Island and the Tumbatu Island.

The Zanzibar main port at Maindi acts as a gateway for locals, tourists, and freight into and outside Zanzibar. Mkokotoni small port is also in use but not very frequently. The port serves for incoming goods from Pemba, Tanga, and Mombasa in dhows and small boats (UNEP/FAO/PAP/CDA, 2000)

4. METHODOLOGY AND DATA ACQUISITION

This chapter describes the method and the data required to complete this research work. The first section of this chapter outlines the secondary data sets used in the research and their sources. This is followed by the procedures and processes used in the primary data collection. The next is the quality and the limitation of the data acquired and finally the research methodology.

4.1. Secondary data acquisition

Data collected from secondary sources were used to complement the primary data. These datasets include the road network, land use and the socio-economic data of Zanzibar. Some of the secondary datasets were given in digital format and the remainder in hardcopies. See table 4-1 for all the secondary datasets acquired;

Data	Description	Institution
Traffic count	General information about traffic count conducted in Zanzibar Island. It gives the overview of the modal split in the entire Zanzibar. This information is from November 2008 and is a hardcopy	Ministry of Communication and Transport
Attraction points (for cyclists)	We identified 7 attraction points which were: Malindi market (fish market) Darajani or vikokotoni market (bus station and principal market in Zanzibar), Michenzani or Rahaleo market, Mikunguni market, Magomeni market, Jang'ombe market and Mwanakerekwe market (this is out of our study area)	
Demographic information	The 2002 Population and Housing Census (hard copy, softcopy) Urban west region: Census Results in Brief (softcopy-year 2002) Urban west district: population distribution per sex, age, in each ward (excel sheet- year 2002)	Office of chief government statistician- Zanzibar
Socio economic information	Household budgetary survey final report, September 2006 (hard and soft copies) Socio - Economic Survey- 2009 (hard and soft copies) Urban district profile (hard and soft copy - year 2002)	
Administrative boundaries	Updated administrative boundaries of urban district-2010 (hard copy)	
Land use	Shape file	Department of Survey and urban planning

Table 4-1: Acquired data and sources

4.2. Primary data

4.2.1. Study area selection

The initial plan was to use Stone Town as the study area, but upon visiting the area we realised that Stone Town was a small place. Moreover, there were not many attractions for cyclists. This observation was also confirmed by the traffic count conducted by the Ministry of Communication and Transport. Stone Town then became unattractive for this research. The roads are very narrow and used by both cyclists and motorised vehicles. The cyclists are likely to be knocked down by vehicles. It has a good connectivity density but very sharp curves which is also dangerous to vehicular traffic and cyclists.
The study area was extended to cover the whole urban district, which includes also stone town in order to intersect more cyclists. See figure 4-1 below;

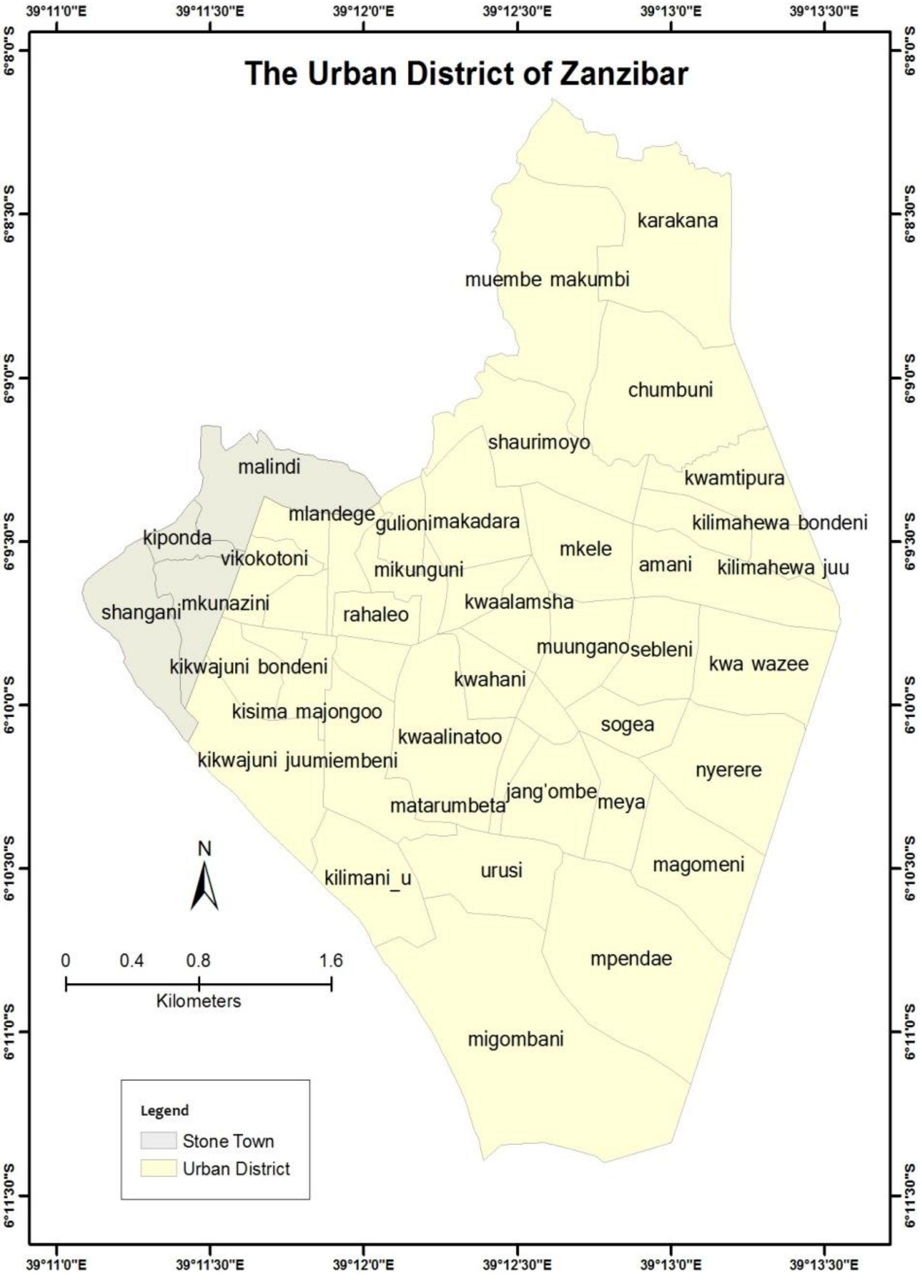


Figure 4-1: Wards in the study area

4.2.2. The design of questionnaire

The field questionnaire was designed to collect the socio-economic characteristics, the present and the alternative travel behaviour or pattern of cyclists. This is to aid in the calculation of the socio-economic values of cycling.

The variables in the questionnaire were selected during the preliminary fieldwork preparation phase. In order to get the correct sequence of the questions and give flow to the administering of the questionnaire, there was a discussion with some staff of the National Bureaux of Statistics of Zanzibar including the chief statistician which gave the current or existing order of the questionnaire. It was agreed that the questionnaire be translated to Swahili to help the field assistants to administer them with ease.

The first nine questions of the questionnaire refer to the socio-economic characteristic of the cyclist, which is about age, household composition, income and vehicle ownership, and attraction point where the cyclists were intersected and origin point where the cyclists were coming from.

The second part of the questionnaire collects information about the previous day trip with the aim of understanding the present travel pattern, (origin-destination) and travel purpose and knowing the travel mode and travel time.

The last part captures information about the alternatives of the trips, such as for the transportation mode, destination, travel purpose, travel cost. This gives insight of the socio-economic value of cycling. See appendix 15 for the copy of the questionnaire.

4.2.3. The sample design

The design of our sample was set up in such a manner that most cyclists in the study area could be intersected. To achieve this we visited the Ministry of Transport and Communication where;

- They gave us a traffic count document which was conducted in the city.
- They assisted us to identify the main roads along which most cyclists were counted in the study area.
- Along these major roads, we selected stations or locations were these cyclists converge for their daily activities so that we can interview them. We identified the market centres on the satellite image as shown in figure 4-2.

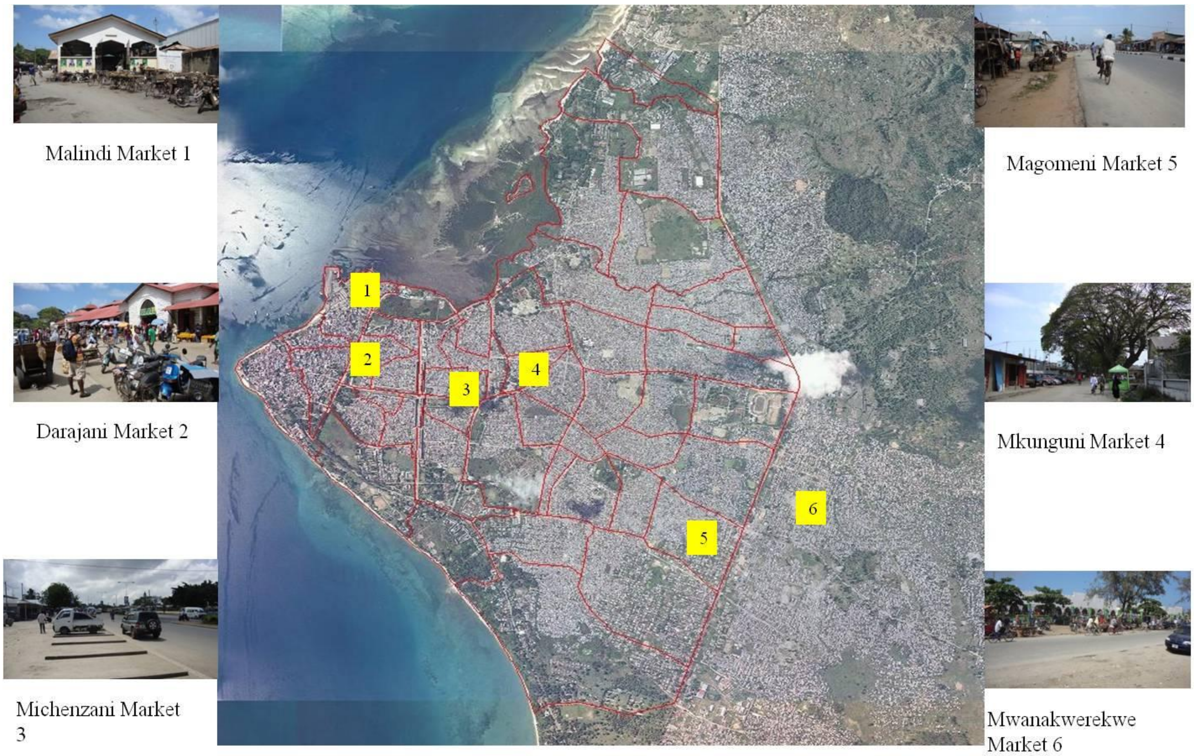


Figure 4-2: Sample frame (satellite image) showing the major attraction points (market centres)

The market centres were considered as the major attraction points in the study area according to the Ministry of Communication and Transport. These market centres were visited one after the other to interview cyclists. The cyclists were asked questions following the questionnaire as outlined above. The previous trip could be a trip made yesterday or a day before yesterday so far as the cyclist remembers all the trips he made that day.

The survey was conducted from Tuesday to Saturday and as early as 7:00am to 5:00pm. This was done to cover their start and close work times. Sundays and Mondays were not used for surveying as the days before each of these days are non-working days. Sundays and Mondays were used to prepare for the survey from Tuesday to Saturday.

After visiting all the seven attraction points or centres, we use the centrality index calculation to identify the origins of the majority of the cyclists. The origin of these cyclists then became our next batch of attraction points. We assume that the probability of finding cyclists in these areas was higher.

To identify the wards where most cyclists were originating, we used the Fuzzy Cognitive Mapping (FCM) which gives a possibility to visualize where most of the bicycle trips are coming from. It also helped to represent the relationship between origin and destination wards. For our particular case we visualize an OD table from our sample and then calculated hotspots or centrality.

Figure 4-3 shows the centrality index of all the wards in our study area. The centrality index (CI) is the thus the centrality expresses how large a role of a given variable is in the system. A high centrality shows a high importance and a low centrality reflects a lower importance.

• The yellow circle represents attraction points; the size represents centrality index, which shows the number of cyclists from different wards intersected in this particular attraction point and the number of cyclists with origin in this attraction point intersected in another attraction points.

• The red boxes represent the rest of wards: the size determines centrality index, shows how many cyclists with same origin were intersected in the different attraction points.

• The arrow represents the direction of the bicycle trips.

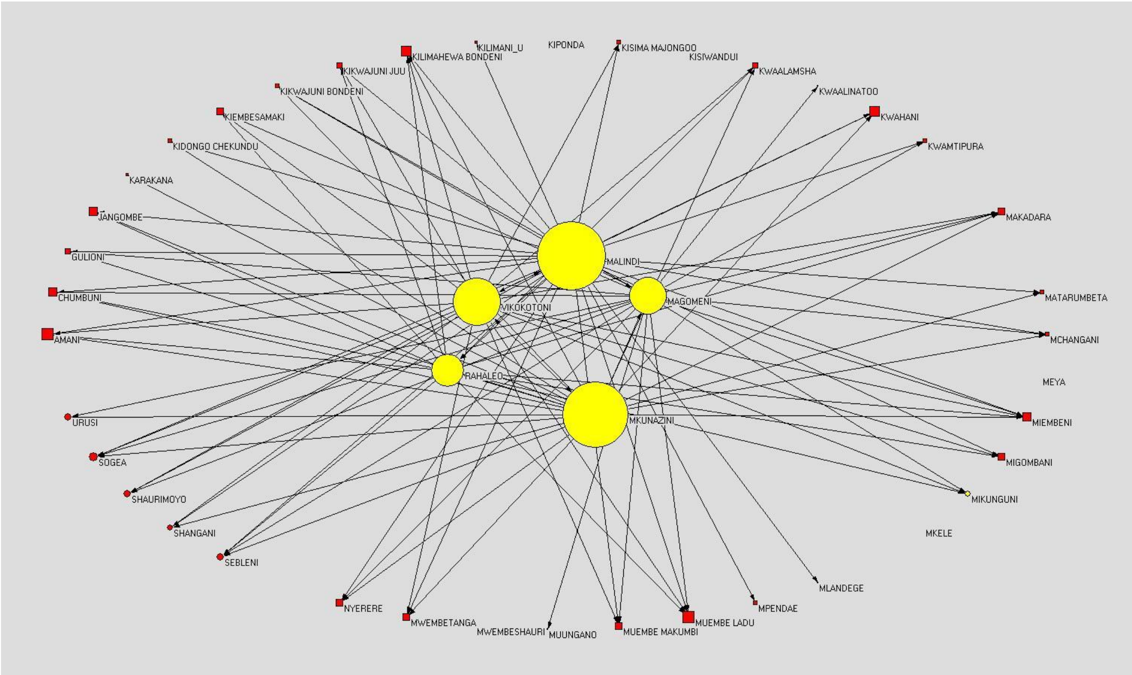


Figure 4-3: The centrality index of all the wards in our study area

Similarly, these origins were also visited one after the other and the available cyclists intersected were interviewed to answer the same questions mentioned in the questionnaire design above.
At the end we were able to collect a sample size of 1,022. These responded questionnaires yielded a valid 2,229 trips. See table 4-2.

Purpose	# of Cyclists	Trips
Worship	43	43
Work	576	739
Shopping	278	309
School	163	169
Other	231	244
Return Home	577	725
TOTAL DATA	1022	2229

Table 4-2: Distribution of trip purposes in the study area

Among the total sample collected, the research was conducted with trips concerning only work, school and shopping. The number of cyclists who made these trips and the attraction or survey point where they were interviewed is shown in table 4-3 below.
The survey was done using a questionnaire but since we cannot speak Swahili which is the official language of the cyclists we hired four people to assist us to administer. Two of the assistants were from the National Bureaux of Statistics of Zanzibar and the other two were also from University of Zanzibar.
Apart from the administering of the questionnaire we also surveyed the locations of the attraction points along side. This was done by using the GPS to pick the coordinates of the points. These were plotted and added to the land use layer as the number of opportunities like schools, government offices, shopping centres etc, in the study area.

Attraction Centre	# of cyclist (First Order)	# of cyclist (Second Order)
Amani	34	4
Chumbuni	10	2
Vikokotoni	60	10
Gulioni	23	0
Jangombe	26	5
Kikwajuni juu	58	10
Kilimahewa Bondeni	9	0
Kilimahewa	9	1
Kisongoni	2	0
Kwa Alinatoo	18	2
Malindi	102	16
Mikunguni	103	13
Magomeni	35	4
Miembeni	20	2
Michezani	21	2
Mpendae	38	6
Mlandege	1	1
Muembe ladu	35	6
Mwembeshauri	20	2
Mwanakwerekwe	42	8
Shaurimoyo	26	4
Sogea	42	0
soko muhogo	17	2

Table 4-3: Number of cyclists interviewed at the each attraction or survey point

4.3. Data quality

A lot of effort was made to control data quality in the field and during and after data entry. The data entry process had range of consistency and additional checks. Where problems were identified they were corrected either immediately by ourselves or by calling the field assistants to rectify. For instance a ward name was written as 'Forodhani' on a questionnaire, but there is no ward by that name. A phone call was made to one field assistant to get the ward which 'Forodhani' belongs. Where this was not possible, the questionnaire was rejected. On the whole 15 questionnaires were rejected.

4.4. Data limitations

There were some unconnected segments in the transport network which made some of the attractions inaccessible during the OD matrix analysis. Digitising of the segments was done in such a way that there were a number of very short segments, which made computations quite difficult and not realistic.

4.5. Research methodology

The research methodology employed in this thesis outlines the steps used to answer research questions as described in section 1.4.2.

The socio-economic value of cycling is determined by using the ArcGIS analysis tools which is available in the ArcToolbox. Spatial coverage analysis in ArcGIS will be done to determine the catchment of the bicycle trips and the alternative modes, especially for those cyclists that have a change of destination. This shows how much opportunities or attractions are accessible or inaccessible by using the various alternative modes and changing their destinations. To gain insight in the relation between environmental sustainability and socio-economic sustainability, the socio-economic values and the climate values are compared and analyzed (spatially and non-spatially).

4.5.1. The socio-economic opportunity cost of cycling

The opportunity cost methodology creates a model of imaginary substitution of bicycle trips with trips made with alternative transportation modes. This substitution affects the transportation system on both the demand and the supply side. According to Massink (2009), these effects are called the first and the second order effects. In the same manner, Lee, Klein, & Camus (1999)termed these effects as the induced traffic and induced demand effects.

- First order or induced traffic effects: It is assumed that the utility derived at the destination end of the trip with the bicycle and the alternative transportation modes are the same. In this situation people will continue to make the trip with an alternative transportation mode if the utility at the destination is bigger than the disutility and will not make the trip at all if the disutility exceeds the utility hence no substitution. These are normally on the short term.
- Second order or induced demand effects: As a result of different opportunities provided by the different alternative modes and based on the objectives of the utility maximization of the individual, the travel pattern of the people who substituted their bicycle trips with an alternative transportation mode could potentially change. For instance, somebody who visits a nearby market for vegetables might go to a far away market to maximize his or her utility because of the shift from bicycle to maybe a private car. A change in land use distribution could occur due to this shift hence longer travel distances (Martens, 2004).

In this research, the two effects mentioned above are dealt with. These effects will be determined via the indicator; trip measured for the purposes of work or job, school and shopping. Work is defined in the context of this research as any activity made with the aim of getting income either immediately or in the future. School is defined as all activities made to impart or receive knowledge. Shopping is also defined as all activities made to look for something with the intention of acquiring it. In view of this all the data used in this research are work or job, school and shopping trips.

The first order socio-economic effect looks into the opportunity cost in terms of;

1. Travel time difference: this is defined as the time used by an alternative mode of transport to traverse a particular distance minus the time taken by a bicycle to traverse the same distance. If this value is a positive then it is a benefit to cycling value and vice versa. The cost or benefit in terms of time is valued in monetary terms.
2. Net variable cost: this is the difference in the variable cost of a bicycle and the variable cost of any alternative mode if the user incurred the cost of that mode (owner). This is expressed as cost per kilometre.
3. Fare: this is the physical cost one incurs for using an alternative mode, for instance the fare for taking a public transport. This is always a benefit to cycling unless the bicycle was hired and costs more than public transport fare.

The summation of these three components mentioned above gives the socio-economic value of cycling under the first order effect.

The second order socio-economic effect also deals with the calculation of the three (3) components mentioned above in the same way for those who changed their destinations. In addition, the number of opportunities gained or lost when a bicycle trip was substituted by any alternative trip which resulted in change of the original destination was also calculated. In this situation the researcher counted the number of opportunities covered or accessed by the service area of the alternative mode and deducted it from the number of opportunities covered or accessed by the service area of the bicycle. Accessibility here means the ease of reaching valued destination. It is used as a tool to evaluate the land use and transportation system in the study area for this research (El-Geneidy, et al., 2006)

The total socio-economic value of cycling is equal to the summation of the all these components mentioned above under the first and second order effects. This value in theory always should be positive; otherwise the cyclists show irrational behaviour and should have used already the alternative mode of transport. Figure 4-4 provides the detailed process to arrive at the socio-economic value.

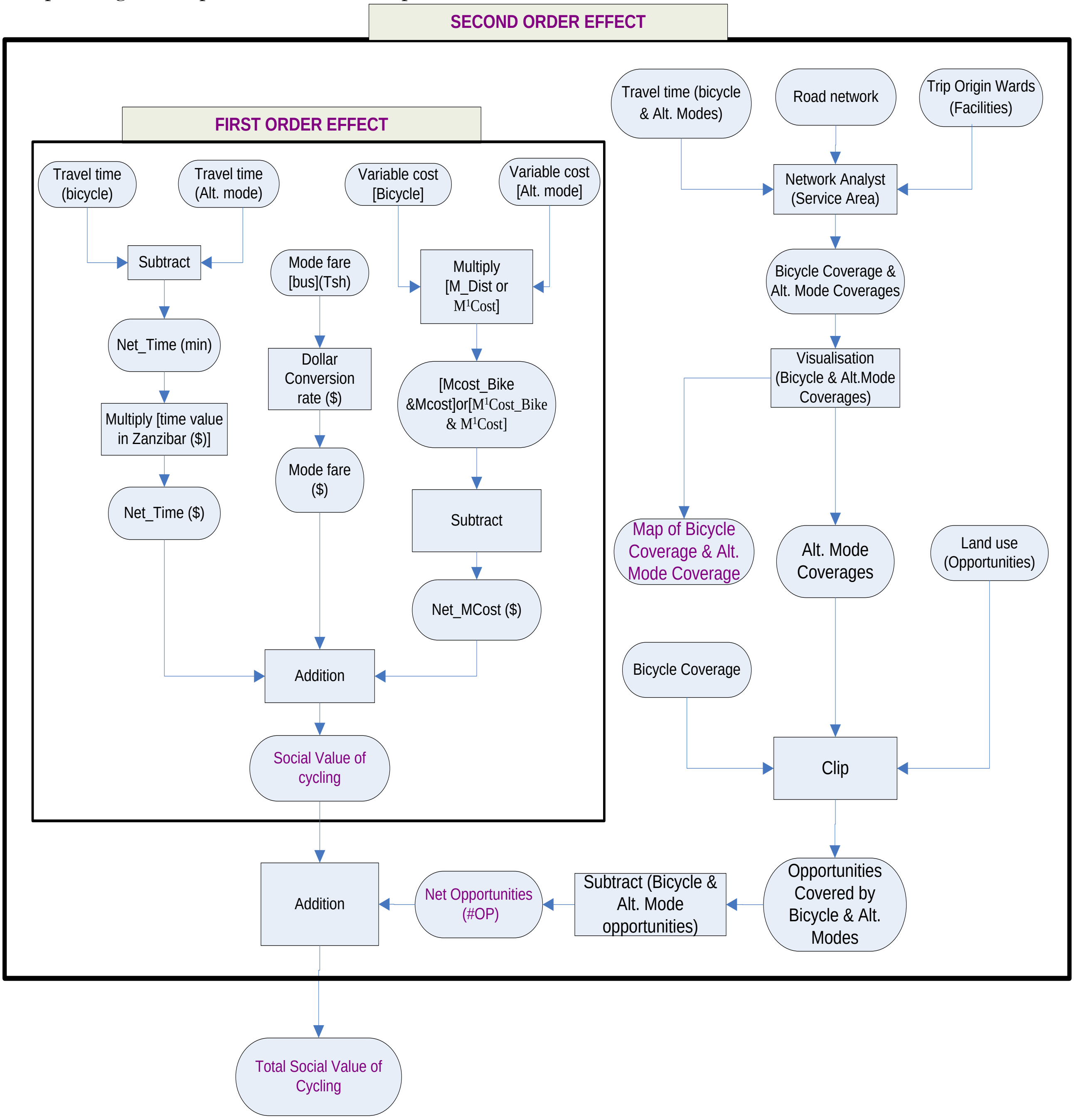


Figure 4-4: Detailed process of the first and second order effects

4.5.2. Assumptions

During the calculation of the various components of the Socio-economic value of cycling, a lot of assumptions were made. These include;

- Average walking speed = 4.8 km/hr (Moudon, A & Lee, 2003)

- Average cycling speed = 13.7 km/hr. This might be lower than values in the Netherlands but this is because Zanzibar does not have separate lanes and therefore compete with other modes (Chen, et al., 2009)
- Average speed for car and motorcycle were assumed to be 50 km/hr. This is due to that fact that the Government of Tanzania enforces intra-city road speed limit of 50 km/hr. (Chiduo & Minja, 2001).
- Average speed for Bus is assumed to be 35 km/hr. This is because the buses have several intermittent stops and therefore prevent them from achieving the maximum road limit. This was verified in the field by measuring the distance and time from our lodging place (Chukwani) to Darajani to compute the speed.
- The operating costs of walking and bicycle are assumed to be zero.
- The operating cost of bus is assumed to be zero. This is because the cyclist does not incur any operating cost of the bus.
- For the time of bus, the walk time from home to the bus station was not considered
- The average number of daily trips per person and time budget allocated to transport show stability (Hupkes, 1982). This applies to the second order effects
- Self and paid employees work for 8 hours.
- The alternative time stated by the cyclists is the time they take from their origin to the place of activity by using the alternative.

4.5.3. Calculation of the First and Second Order Effects

This section portrays the actual methodology and demonstrates the step by step calculations of the socio-economic effects with empirical data.

Cyclists #	Purpose	Alt_Mode	Fare (Tsh)	# of HH	D_Dist	A_Dist	M_Dist	VCost	VCost_Bike	MCost	M1Cost	M1Cost_Bike	MCost_Bike	Dest_T	Alt_T	Net_T_time (min)	Net_T_time ($)	Fare ($)
1	Shopping	4	250	3	3.43	4.67	4.05	0.00	0.0	0.0	0.0	0.0	0.0	15	8	-7	-0.0140	0.1722
3	Shopping	5	0	7	3.43	1.84	2.63	0.00	0.0	0.0	0.0	0.0	0.0	15	30	15	0.0300	0.0000
3	Shopping	4	500	7	6.85	8.75	7.80	0.00	0.0	0.0	0.0	0.0	0.0	30	15	-15	-0.0300	0.3444
4	Work	5	0	11	3.43	1.60	2.51	0.00	0.0	0.0	0.0	0.0	0.0	15	30	15	0.1201	0.0000
5	Work	5	0	2	6.85	3.60	5.23	0.00	0.0	0.0	0.0	0.0	0.0	30	60	30	0.1942	0.0000
6	Work	4	250	6	6.85	10.50	8.68	0.00	0.0	0.0	0.0	0.0	0.0	30	18	-12	-0.0961	0.1722
52	School	4	150	7	1.14	1.17	1.15	0.00	0.0	0.0	0.0	0.0	0.0	5	2	-3	-0.0060	0.1033
56	Work	5	0	2	1.14	1.20	1.17	0.00	0.0	0.0	0.0	0.0	0.0	5	15	10	0.0801	0.0000
57	School	5	0	10	1.14	1.60	1.37	0.00	0.0	0.0	0.0	0.0	0.0	5	20	15	0.0300	0.0000
59	Work	2	0	8	1.14	5.83	3.49	0.12	0.0	0.4	0.0	0.0	0.0	5	7	2	0.0160	0.0000
59	Work	5	0	8	6.85	2.80	4.83	0.00	0.0	0.0	0.0	0.0	0.0	30	55	25	0.2002	0.0000
178	Shopping	1	0	3	3.88	6.67	5.27	0.0900	0.0000	0.5000	0.0000	0.0000	0.0000	17	8	-9	-0.0180	0.0000
								SECOND ORDER EFFECT										
1	Shopping	2	0	3	4.57	8.33	6.45	0.12	0.0	0.0	1.0	0.0	0.0	20	10	-10	-0.0200	0.0000
2	Shopping	4	1000	3	9.59	17.50	13.55	0.00	0.0	0.0	0.0	0.0	0.0	42	30	-12	-0.0240	0.6889
7	Shopping	5	0	4	0.69	0.80	0.74	0.00	0.0	0.0	0.0	0.0	0.0	3	10	7	0.0140	0.0000
9	Work	5	0	9	3.43	0.80	2.11	0.00	0.0	0.0	0.0	0.0	0.0	15	10	-5	-0.0324	0.0000
10	Work	5	0	10	6.85	3.60	5.23	0.00	0.0	0.0	0.0	0.0	0.0	30	45	15	0.1201	0.0000
10	Shopping	5	0	10	0.69	2.40	1.54	0.00	0.0	0.0	0.0	0.0	0.0	3	30	27	0.0540	0.0000
15	Work	5	0	3	3.43	1.76	2.59	0.00	0.0	0.0	0.0	0.0	0.0	15	22	7	0.0453	0.0000
17	Work	4	500	4	0.69	2.92	1.80	0.00	0.0	0.0	0.0	0.0	0.0	3	5	2	0.0129	0.3444

Table 4-4: Sample table containing the components of the Socio-economic value of cyclingNote:

Refer to the variable cost of the different modes in table 2-5 in section 2.3.3. Refer to the value of time (VOT) in Zanzibar in Section 5.3

Alt_Mode 1, 2, 4, 5 = Motorcycle, Car, Bus and Walk respectively.

D_ID = Identity of the destination ward.

Alt_ID = Identity of the alternative destination ward.

Dest_T (min) = Travel time by bicycle to initial destination (min).

Alt_T (min) = Travel time by alternative mode to alternative destination (min).

Fare = Fare of using a Bus.

SEV = Socio-Economic Value of cycling

D_Dist (km) = [Dest_T] (hours) multiply by the average speed of bicycle (km/hours)

A_Dist (km) = [Alt_T] (hours) multiply based on alternative mode type by the average speed limit of the road (km/hours)

M_Dist = ([D_Dist] + [A_Dist])/2. This applies to only first order effects since both the initial and the alternative destinations are the same.
VCost = the vehicle operating cost (VOC) of the alternative mode of transport ($/km)
VCost_Bike = the vehicle operating (VOC) cost of bicycle ($/km) MCost = [M_Dist] * [VCost]. This is for first order effects
MCost_Bike = [M_Dist] * [VCost_Bike]. This is for first order effects
M1Cost = [A_Dist] * [VCost]. This applies to the second order effects
M1Cost_Bike = [D_Dist] * [VCost]. This applies to the second order effects
Net_MCost = MCost - MCost_Bike
Net_T_time = Alt_T - Dest_T
#OP = the difference between the opportunities reached by bike and the car when the destination changed. This applies to only second order effects.

4.5.3.1. First Order Effect

From the above table 4-4, cyclist # 3 made a bicycle shopping trip and substituted the same trip with a walk. The opportunity cost of trip (SEV1) is as follows;

[Net_T_time (min)] multiply by the value of time in Zanzibar = Net_T_time **(1)**

Net_MCost = MCost − MCost_Bike **(2)**

But MCost_Bike = 0 since VCost_Bike = 0, hence Net_MCost = MCost
The MCost here is that of walking.

Therefore SEV1 = [Net_T_time ($)] + [MCost ($)]

i.e. SEV1 = 0.03 + 0 = $ 0.03

This value means that it will cost the cyclist extra 3 US cents to substitute the trip with a walk hence rationality to continue cycling.

From the above table 4-4, cyclist # 59 made a bicycle working trip and substituted the same trip with a car. The opportunity cost of trip (SEV2) is as follows;

[Net_T_time (min)] multiply by the value of time in Zanzibar = Net_T_time ($) **(4)**

Net_MCost = MCost − MCost_Bike **(5)**

But MCost_Bike = 0 since VCost_Bike = 0, hence Net_MCost = MCost
The MCost here is that of car.

Therefore SEV2 = [Net_T_time ($)] + [MCost ($)] **(6)**

i.e. SEV2 = 0.016 + 0.4 = $ 0.416

This value means that it will cost the cyclist extra 42 US cents to substitute the trip with a car hence rationality to continue cycling.

From the above table 4-4, cyclist # 178 made a bicycle working trip and substituted the same trip with a motorcycle. The opportunity cost of trip (SEV3) is as follows;

[Net_T_time (min)] multiply by the value of time in Zanzibar = Net_T_time ($) **(7)**

Net_MCost = MCost − MCost_Bike **(8)**

But MCost_Bike = 0 since VCost_Bike = 0, hence Net_MCost = MCost
The MCost here is that of motorcycle.

Therefore, SEV3 = [Net_T_time ($)] + [MCost ($)] **(9)**

i.e. SEV3 = -0.018 + 0.5 = $ 0.482

This value means that it will cost the cyclist extra 48 US cents to substitute the trip with a motorcycle hence rationality to continue cycling.

From the above table 4-4, cyclist # 52 made a bicycle school trip and substituted the same trip with a bus. The opportunity cost of trip (T4) is as follows;

[Net_T_time (min)] multiply by the value of time in Zanzibar = Net_T_time ($) **(10)**

$$\text{Net\_MCost} = \text{MCost} - \text{MCost\_Bike} \quad \textbf{(11)}$$

But MCost_Bike = 0 and MCost = 0 since VCost_Bike = 0 and VCost = 0, hence Net_MCost = 0 MCost and VCost are that of a bus.

$$\text{Fare (Tsh) divided by dollar rate} = \text{Fare (\$)} \quad \textbf{(12)}$$

Therefore, $\text{SEV4} = [\text{Net\_T\_time (\$)}] + [\text{Fare (\$)}]$ **(13)**

i.e. SEV4 = -0.006 + 0.1 = $ 0.094

This value means that it will cost the cyclist extra 9 US cents to substitute the trip with a bus hence rationality to continue cycling.

4.5.3.2. Second Order Effect

To calculate the effects of the second order, the same steps from section 4.5.3.1 are followed except that the number of opportunities covered by the different type of modes. Below is a demonstration using motorcycle as a mode:

From the above table 4-4, cyclist # 1 made a bicycle shopping trip and substituted the trip with a motorcycle which resulted in a new destination. The opportunity cost of trip (SEV5) is as follows;

$$[\text{Net\_T\_time (min)}] \text{ multiply by the value of time in Zanzibar} = \text{Net\_T\_time (\$)} \quad \textbf{(15)}$$

$$\text{Net\_MCost} = \text{M1Cost} - \text{M1Cost\_Bike} \quad \textbf{(16)}$$

But MCost_Bike = 0 since VCost_Bike = 0, hence Net_MCost = M1Cost

The M1Cost here is that of motorcycle.

Therefore, $\text{SEV5} = [\text{Net\_T\_time (\$)}] \pm [\text{M1Cost (\$)}] + [\#\text{OP}]$ **(17)**

i.e. SEV5 = -0.02 + 1.0 $\pm$ #OP= $ 0.98 $\pm$ #OP

This value means that it will cost the cyclist extra 98 US cents in addition to number of opportunities gain or lost to substitute the trip with a motorcycle. It will be rational to continue cycling if the value of the opportunities gain exceeds 98 US cents and the value of opportunities lost is less than 98 US cents.

This is repeated for all other modes as in equation 1, 6, 9 and 13.

The total Socio-Economic Value (SEV) of cycling by the second order effect is the summation of the effects by the various modes.

Note: The first order effect do not have the '#OP' component because there is no change in destination for the alternative trip hence the number of opportunities reached by the initial trip is the same as the substituted trip.

5. ANALYSIS, RESULT AND DISCUSSION

This chapter analyses the first and second order effect of cycling in terms of time gained or lost and the vehicle operating cost involved by substituting bicycle trip with an alternative mode. The unit of this analysis is trip since it is the basic unit of transport.

5.1. Description of the sample

Socio-economic characteristics are some of the important factors that influence the travel behaviour of cyclists. The number of socio-economic opportunities reached by cyclists depends on how far the cyclist can go which is also directly proportional to the travel time (Beirão & Sarsfield Cabral, 2007). This means that faster modes can reach more opportunities than slower modes (Martens, 2004).
This section portrays the statistics socio-economic characteristics of the data used in this study. The sample for this study involves three indicators representing work, school and shopping purposes. See the tables 5-1 to 5-8 below for the statistics of the data showing the socio-economic characteristics of the cyclists and their average travel distances in the study area.

Among the data collected for the work, school and shopping purposes, majority of them were males with very few women. There were 95.6%, 98.2% and 95.7% males for work, school and shopping respectively. The percentage of women cyclists is very low, that is 2.26% for work, 1.84% for school and 3.60% for shopping; so no further effort was made to compare the travel pattern of men and women See table 5-3. Not less than 60% of the cyclists for all the three purposes were secondary school leavers with about 80% categorised to be in the medium income class, a sizable percentage of about 16% in the low income class and very few in the high income class (The Revolutionary Government of Zanzibar, 2008). See table 5-2 and 5-5.
In order to get the average trip length by purpose, the stated travel time by the cyclists were used with the average speed of the bicycle to calculate the distance per trip. The individual trip distances were summed and divided by the total number of trips by purpose. The result show that, with the first order effects, works trips has longer lengths followed by the school trips and then shopping. But the second order effect showed slight variations between the trip lengths. This shows that people change mode and as a result of the change their trip lengths also changes. It is seen that the average trip length of work and school is reduced indicating that they are not willing to travel extra distance for the purpose of work and school, but will do that for shopping purpose. See tables 5-6 and 5-7.

	Work		School		Shopping	
Employment Status	**No of Cyclist**	**Percentage**	**No of Cyclist**	**Percentage**	**No of Cyclist**	**Percentage**
Employed	189	32.8%	56	34.4%	97	34.9%
Self-employed	248	43.1%	64	39.3%	114	41.1%
Pensioner	18	3.1%	6	3.7%	6	2.2%
Unemployed	33	5.7%	7	4.3%	17	6.1%
Student	83	14.4%	27	16.6%	38	13.7%
Other	1	0.2%	1	0.6%	1	0.4%
Total	576	100%	163	100%	278	100%

Table 5-1: Employment status of Cyclists

Education Level	Work		School		Shopping	
	No of Cyclist	Percentage	No of Cyclist	Percentage	No of Cyclist	Percentage
No Education	20	3.5%	5	3.1%	14	5.0%
Primary	162	28.1%	41	25.2%	64	23.0%
Junior School	3	0.5%	0	0.00%	1	0.4%
Secondary	368	63.9%	111	68.1%	179	64.4%
University	17	3.0%	5	3.1%	11	4.0%
Other	1	0.2%	0	0.00%	2	0.7%
Total	576	100%	163	100%	278	100%

Table 5-2: Education level of cyclists

Distribution by Sex	Work		School		Shopping	
	No of Cyclist	Percentage	No of Cyclist	Percentage	No of Cyclist	Percentage
Male	562	97.6%	160	98.2%	266	95.7%
Female	13	2.3%	3	1.8%	10	3.6%
Total	576	100%	163	100%	278	100%

Table 5-3: Gender of the cyclists

Age	Work		School		Shopping	
	No of Cyclist	Percentage	No of Cyclist	Percentage	No of Cyclist	Percentage
14-29	194	33.7%	58	35.6%	86	30.9%
30-45	273	47.4%	79	48.5%	137	49.3%
46-60	98	17.0%	23	14.1%	45	16.2%
> 60	10	1.7%	3	1.8%	7	2.5%
Total	576	100%	163	100%	278	100%

Table 5-4: Age of cyclists

Household Income (Tsh)	Work		School		Shopping		Class
	No of Cyclist	Percentage	No of Cyclist	Percentage	No of Cyclist	Percentage	
< 100000	93	16.2%	26	16.0%	43	15.5%	**Low**
100001-190000	461	80.0%	128	78.5%	220	79.1%	**Medium**
> 190001	17	3.0%	7	4.3%	9	3.2%	**High**
Total	576	100%	163	100%	278	100%	

Table 5-5: Household income per month of the cyclists

Purpose	No of Trip	Total Trip Length (km)	Average Trip Length (km)
Work	692	4807.2	7.0
Shopping	263	1263.1	4.8
School	158	940.4	6.0

Table 5-6: Total and average trip length of the purposes for first order effect and

Purpose	No of Trip	Total Trip Length (km)	Average Trip Length (km)
Work	47	249.3	5.3
Shopping	46	228.3	5.0
School	11	52.8	4.8

Table 5-7: Total and average trip length of the purposes for second order

Purpose	# of Cyclists	Trips/day	Average # of trip	Total # of People	Missing HH/Trip	Av. HH_size/Cyclist	Average HH_Size/Trip
Worship	43	43	1.0	240	1	5.7	5.7
Work	576	739	1.3	3334	3	5.8	5.8
Shopping	278	309	1.1	1577	4	5.8	5.8
School	163	169	1.0	964	1	6.0	5.9
Other	231	244	1.1	1345	0	5.8	5.8
Return Home	577	725	1.3	3288	9	5.8	5.7
TOTAL DATA	1022	2229	2.2	5874	18	5.8	5.8
	Overall average		1.12			5.80	5.80

Table 5-8: Summary statistics of household characteristics of the sample

5.1.1. Number of work, school and shopping trips at attraction or survey points

The attraction points were selected in order to study the previous behaviour of the cyclists and their trips. These were main destination points for the socio-economic activities of the cyclists. A total of 1,217 work, school and shopping trips were recorded at these points. Among these were 739 working trips which were made by 576 unique cyclists. There were also 169 school trips made by 163 unique cyclists. Finally, shopping trips also recorded 309 trips and made by 178 unique cyclists. These three set of data is used for this research. The total number of trips intersected at each attraction points in their respective wards is presented in figure 5-1.

Mikunguni which is a market area recorded the highest number of cyclists intercepted. This was followed by Malindi which is also a market area. This gives a signal that most of the socio-economic activities are either found at the market areas or the market centres are used as transit points. The distribution of the various cyclists interviewed at the different attraction points making work trips are shown in Appendix 1.

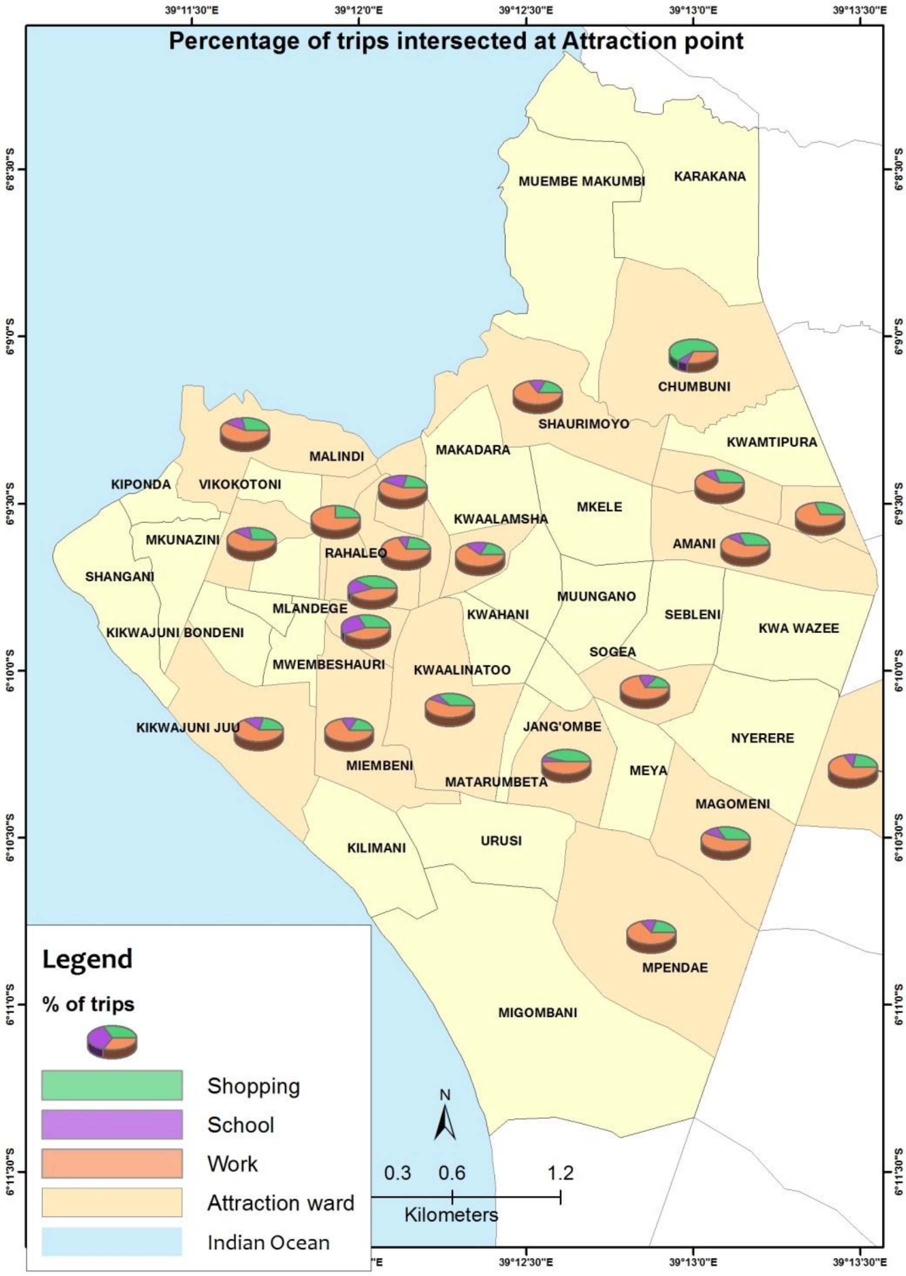


Figure 5-1: Percentage of work, school and shopping trips intersected at the attraction points

The numbers of school trips intersected are not as much as work trips. It shows that Mikunguni has the highest number of trips recorded with Malindi and Kikwajuni juu following in the same order as mentioned in the work trip case above.The number of shopping trips was higher than that of School trips, but lower than the number of Work trips. Malindi has the highest number of shopping trips, followed by Mikunguni and Magomeni. See appendices 2 and 3 for the detail values.

5.2. Work, school and shopping trips originating and departing from ward

At the attraction centres, cyclists were interviewed about their socio-economic and trip characteristics. Lots of working trips were recorded at the various wards which portray the number of working trips made in and out of each ward. Mwanakwerekwe recorded the highest number of trips entering and leaving with 74 and 57 respectively. Mwanakwerekwe is not directly in the study area, but shares boundary and contributes a lot to the activities in the study area. This was followed by Malindi with in and out trip flow of 69 and 46 respectively. Mkunazini, Mikunguni and Vikokotoni followed in the same order.

It was also realised here that among these 5 top score wards, 4 of them were market centres. That's Mwnakwerekwe, Malindi, Mikunguni and Vikokotoni. This also comes to confirm the initial statement that most of the market centres have most of their socio-economic activities or are transit points to these activities. See figures 5-2.

Among the 169 school trips, Mkunazini recorded the highest number of School arrival with 25. The next highest arrival was in Vikokotoni with 14 arrivals and followed by Kilimahewa juu with 12 arrivals.
In terms of departures trips, Mikunguni had the highest number of School trips departing with 14 trips. This was followed by Malindi with 10 trips, Mwanakwerekwe with 10 trips and Amani, 9 trips. See figure 5-2.

Among the total of 309 shopping trips recorded, Mwanakwerekwe registered 93 arrivals as the highest and Malindi recorded 50 arrivals. Mkunazini and Mikunguni followed in that order with 40 and thirty seven 37 arrivals. Except Mkunazini, the other 3 locations are market centres with lots of socio-economic activities taking place. Mkunazini is also a tourist attraction centre where foreigners patronise everyday. Mwanakerekwe and Malindi recorded the highest departures with 28 and 9 respectively. Jang'ombe recorded 14 and Amani and Vikokotoni having 11 departures each. See figure 5-2. It is observed especially among work and shopping trips that all the wards that recorded the most arrivals most times record high departures. This probably because these centres are centres for economic activities so they only go there for their activities and return.

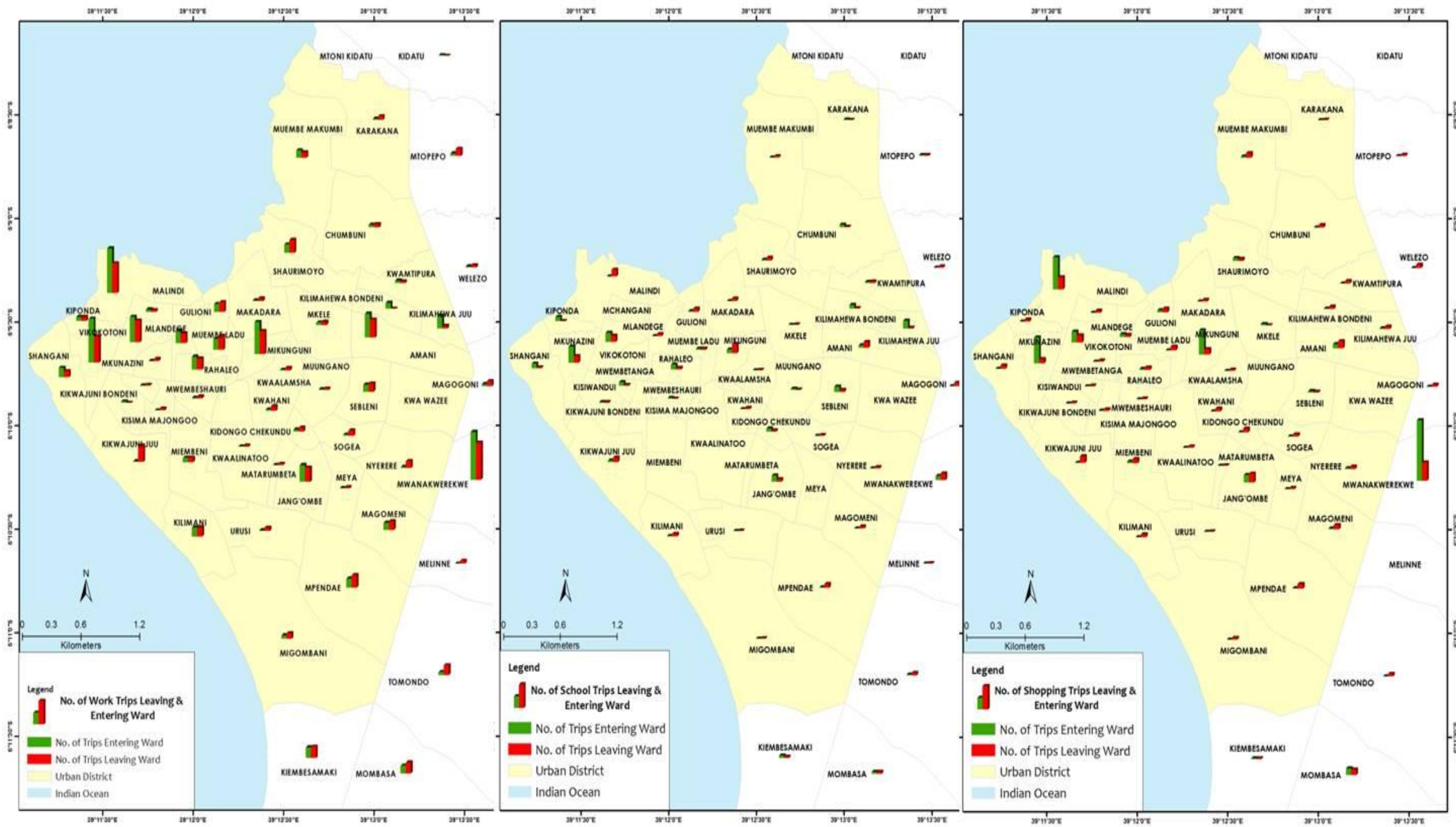


Figure 5-2: Spatial representation of work, school and shopping trips to and from ward (sample data)

5.3. Modal shift

5.3.1. Bicycle work trips shifted to other transport modes

A total number of 739 working trips were recorded. Assuming that all these trips were not made by cycling but by other modes of transport, what will be the effect? Figure 5-3 shows the number of shift from cycling to alternative modes of transport. People travel because the utility at the destination end is greater than at the origin. This shift shows that most people when change from cycling to bus which the majority preferred alternative, they will still derive a much bigger utility at the destination end. That is, utility will still be maximised by choosing bus as the alternative mode for their working activities. The 1% that shifted to car is the few people who (probably incur less cost than the utility additional utility at the end destination or are probably receiving higher income and therefore can still maximise their utilities at the destination by using car as an alternative mode of transport to bicycle). There are also an appreciable number of cyclists who choose walking as an alternative. This also might imply that the distances to their various working activities are short and prefer to walk or they are captive cyclists and therefore have no other options.

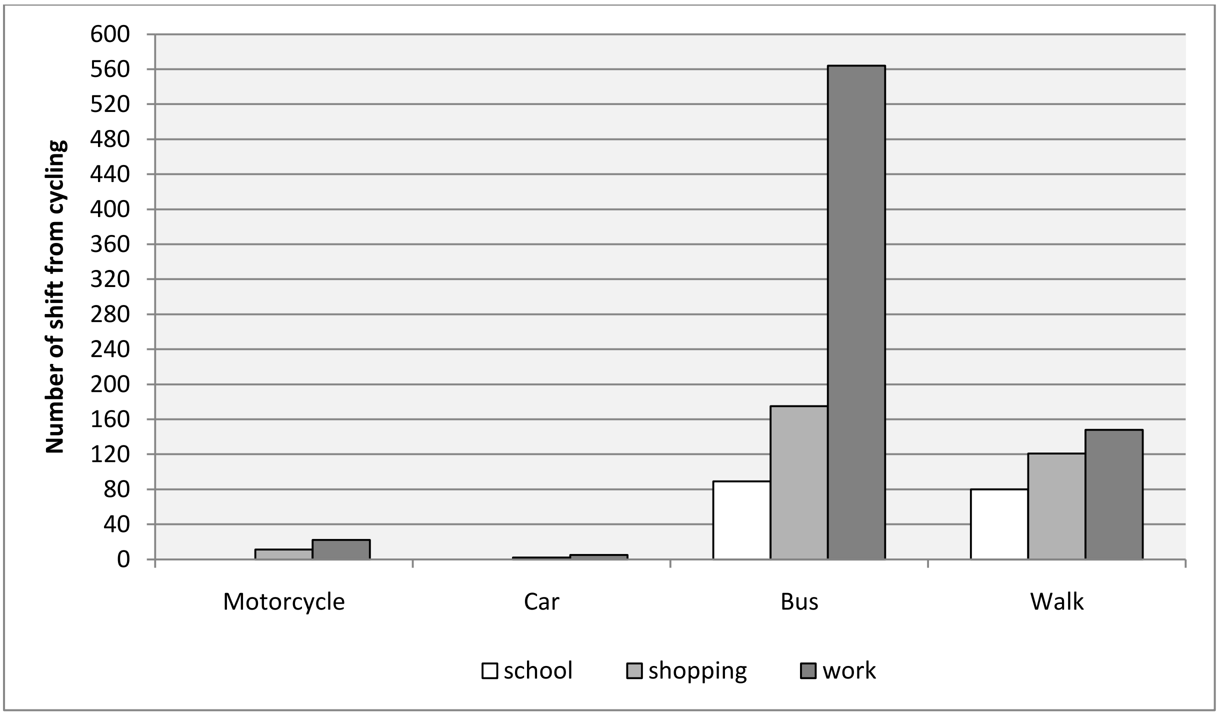


Figure 5-3: Number of cycling trip substituted with alternative modes of transport – sample data

5.3.2. Bicycle shopping trips shifted to other transport modes

The shift from bicycle to an alternative mode for shopping activities also showed a similar pattern as in the case of the working trips. It has the largest percentage of 57 changing for bus, 39 for walk and 1% and 3% going for car and motorcycle respectively just as in the case of the working trip. This might also be the same reason as mentioned in the working trip above. The trip makers will not want their disutility to be more than the utility at the end of the trip.

School trips had none shifting from bicycle to car and motorcycle. The percentage for bus and walk is 53 and 47 respectively. This means that the utility in attending school might not be maximised when they shift to car and motorcycle. The massive potential shift from cycling might be due to the field observation stated earlier in section 3.4. This makes it easy for almost everybody to patronise the bus. See figure 5-3

There are some people who choose to walk not because they can not afford the fare of the bus, but consider the trip length as short and prefer to exercise with it or think the bus might cause a delay because of the few stops or the perceived gained time is not sufficient to compensate for the additional costs.

5.3.3. Effects of modal shift

The shift from Cycling to other transportation modes leads to different effects at different levels of the transportation system (Massink, et al., 2011). The first effect is based on the utility at the end of the trip, where people continue or discontinue to make the trip with an alternative mode if the utility at the end of the trip exceeds or is less the disutility of making the trip. On the other hand when the disutility of substituting the bicycle trip is more than the utility at the end of the trip, the substitution may occur but in this situation a change in the original destination may also occur in other to maximise the utility of the trip.

Among the work trips, 22 are substituted with motorcycle trips with 20 maintaining destinations. There are five substituted car trips but all of them maintained their destinations. The highest number of bicycle trips would be made with Public bus in case the bicycle is not an option with 544 of them maintaining their previous bicycle trip destinations. There are also 123 bicycle trips that are substituted with walking. In a similar way, the bicycle school trips are substituted with 83 bus trips and 75 walk trips. Shopping trips are also substituted with 8 motorcycle trips, 1 car trip, 148 bus trips and 108 walk trips. See figure 5-4.

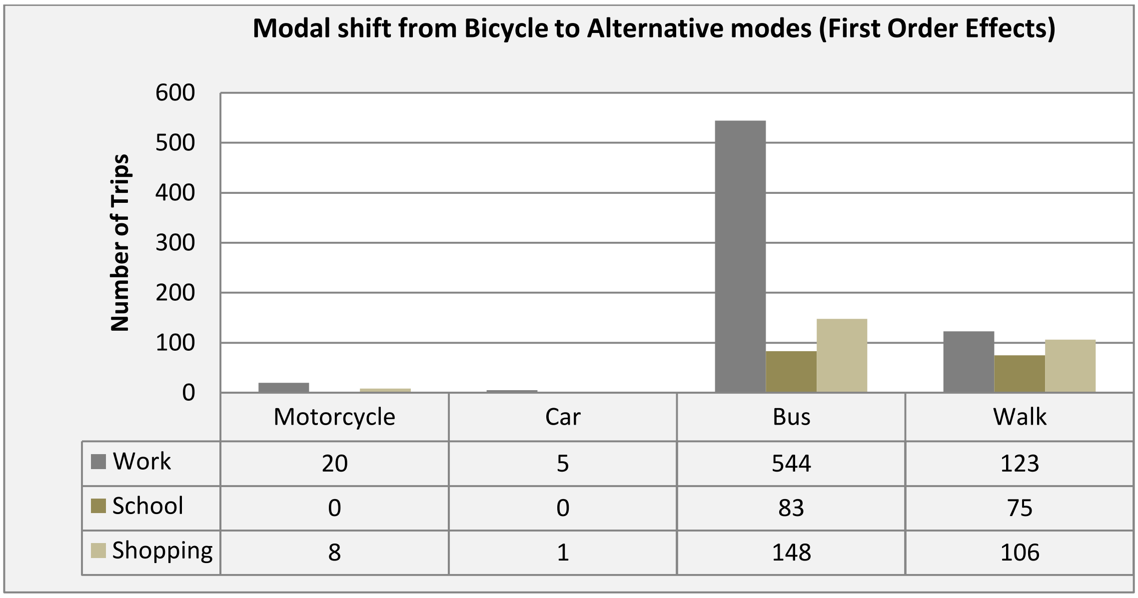
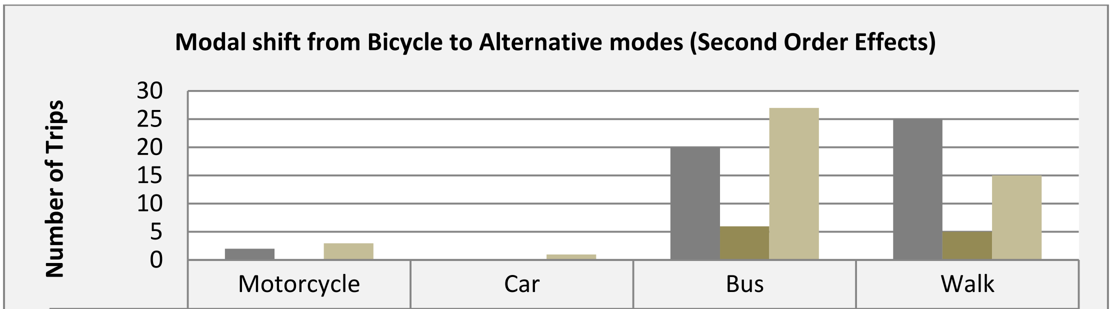


Figure 5-4: Modal Shifts from bicycle to alternative modes – sample data (Maintain destination)

For the second order effects, there are 2 work trips substituted with motorcycle trips, 20 are substituted with bus, 25 with walk and none with car. The school trips are substituted with 6 bus 5 walk trips and none for motorcycle and car. Similarly, the shopping bicycle trips are substituted with 3 motorcycle and a car trips. These are small numbers as compare to the substitution by bus and walk which are 27 and 15 respectively. See figure 5-5.



	Motorcycle	Car	Bus	Walk
Work	2	0	20	25
School	0	0	6	5
Shopping	3	1	27	15

Figure 5-5: Modal Shifts from bicycle to alternative modes - sample data (Changed destination)

5.3.3.1. Spatial representation of the modal shift

The scale of this research is the ward level, so all trips recorded in one ward are modelled to concentrate in the centroid of that ward. A graph is displayed as well as the spatial distribution of the number of trips made into and out of a ward which resulted in the same alternative destination when cycling trips were substituted. This helps to identify the part of the study area with the highest effect of shift due to the first order. Spatially, it is noticed that most of the work or job cycling trips are substituted by Public transport (bus) and next by walking. These effects were shown similarly in the shopping and the school trips with the majority substituting cycling trips with bus and walking. This shows that the use of bus as a substitute to cycling will still keep the generalised cost of most people below the utility of their trips. See figure 5-6 for the spatial representation and appendix 4 for the values used to generate the map. The table gives the number of cycling trips substituted with the alternative modes per ward. See appendices 5, 6, 7 and 8 for the spatial representations and tables of both the shopping and school trip substitutions.

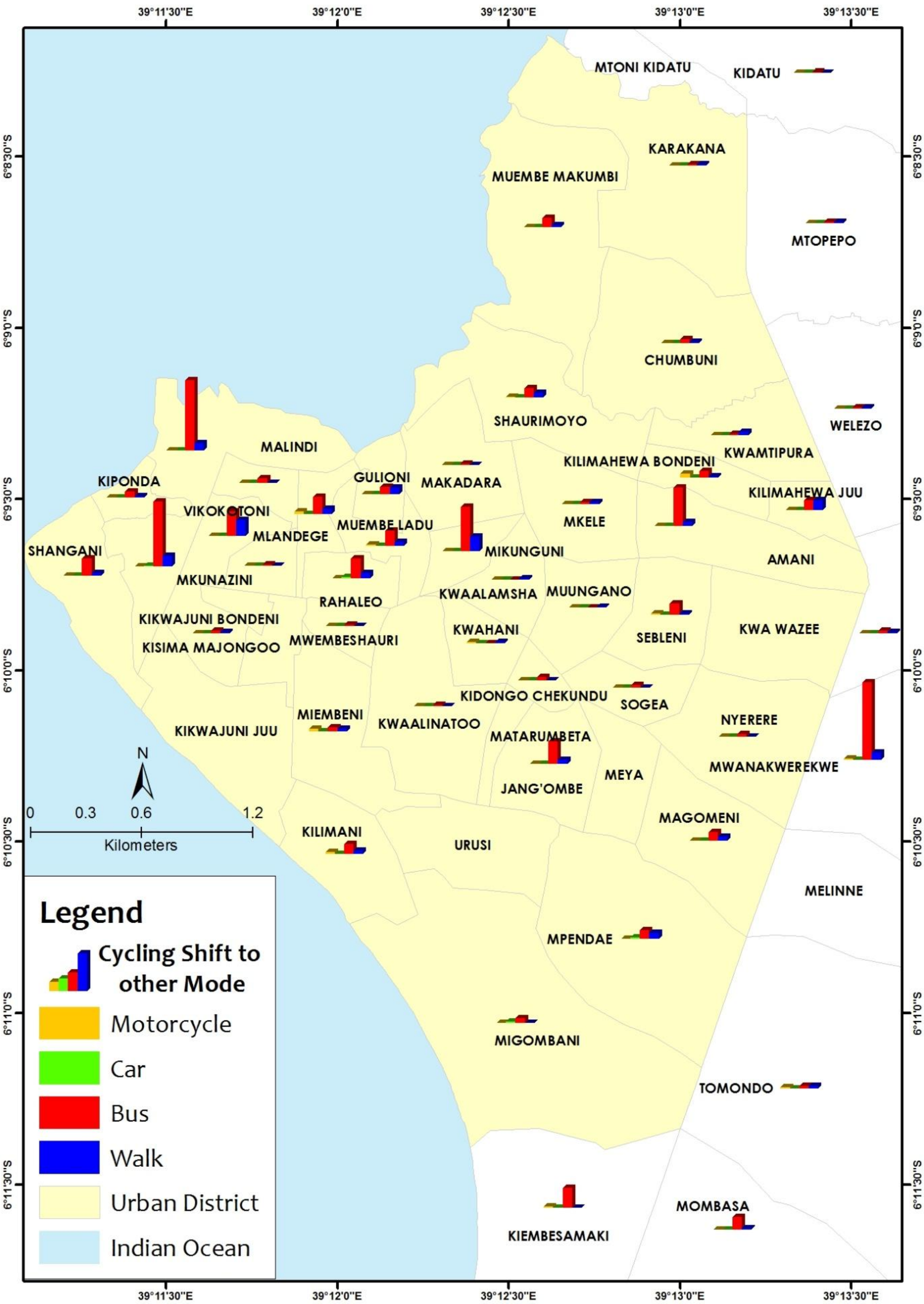


Figure 5-6: location of Modal Shift with the same destinations; from sample data (sample Work Trip)

It can be seen from figures 5-6 above that there were few trips which had a change of destination as a result of the bicycle trip substitution by other transport modes. Most of these shifts were also made to the use of public transport and walking. Work trips which resulted in a change of destination were substituted mostly with walking, shopping trips with bus and school trips were divided almost equally for both bus and walk.

In the first place, the limited substitution with a change in destination might mean that most cyclists will still have the utilities of their trips maximised when the trips are substituted with bus and walking and need not to change destination. These few trips with change of destination are the cyclists who will have to change their destinations to maximise the utilities of their trips since the benefits of the initial trip will be less than the generalised cost should the bicycle trip be substituted with an alternative mode of transport. See appendices 9, 10 and 11for the spatial representation of the shift with alternative destination.

5.4. VOT calculation

In order to determine the monetary value of cycling in Zanzibar, the travel time difference between the travel by bicycle for a trip and the travel time by any other alternative mode was calculated. This travel time difference is then multiplied by the monetised value of time. This travel time value is mostly categorised into two, namely; the value of time for work and non-work trips. These two are calculated based on the income generated.

Mean or median income is mostly used to analyse the distribution of income by different characteristics of employment. The table below gives the mean, median, standard deviation, coefficient of variation and the skewness for both paid and self employees.

According to the table 5-9, the mean income received by the paid employees is 67,809 Tsh which is lower than the mean income received by the self employment reaching 83,901 Tsh. The same pattern is observed for the median income that is 50,000 Tsh for the paid employees compared with 70,000 Tsh for the self employment. The result also shows that the income received by paid employees has lower variation than the income received by the self employment as indicated by the standard deviation and the coefficient of variation. The asymmetry compared with the normal distribution also reveals that the income received by the self employment is more skewed compared with income received by paid employees.

Type of Employment	Mean (Tsh)	Median	Standard Deviation	Coefficient of Variation	Skewness
Paid Employment	67,809	50,000	58,973	86,968	1.55035
Self Employment	83,901	70,000	110,476.8	131.67	8.604599

Table 5-9: Mean and Median Income for Paid and Self Employees (The Revolutionary Government of Zanzibar, 2008)

The household income is the income which is received by the people of a household. The 2006 Integrated Labour Force survey of Zanzibar reveals that the modal income is in the range of 50,000 to 99,999 and a median household income of **92,863** Tsh. More than one half of the households are in the low income group, that's 100,000 Tsh a month. See table 5-10.

Household Monthly Income Group	Percentage of Households (%)
0 – 49,999	14.7
50,000 – 99,999	41.2
100,000 – 199,999	35.2
200,000 – 499,999	8.2
500,000 – 999,999	0.5
1,000,000 and above	0.2
Number of Households	**215,717**

Table 5-10: Percentage distribution of Household's Monthly income by group (The Revolutionary Government of Zanzibar, 2008)

There are 20 working days in a month which the people of Zanzibar are supposed to work 8 hours each of day. This is not the case due to their Friday prayers. Most of them work for 4 hours on Fridays which reduces the actual monthly working hours. For self-paid workers, their working hours is a bit higher because they decide on when and how long to work. This might be the reason for their higher average income. The result reveals that among the workers, self-paid workers value time more than paid-workers but non-working group value time less. See table 5-11. See appendix 12 for the detail calculation of the VOT.

Trip	Value of Time ($/Hr)
Work (Paid Employees)	0.3883
Work (Self-paid Employees)	0.4805
Non work	0.1199

Table 5-11: Summary of the value of time for Zanzibar

5.5. The socioeconomic value (SEV) of cycling calculation

The estimation of the socioeconomic value of cycling has four components as described in section 4.5.3. These components are;

- The value of the time difference between the use of a bicycle and an alternative mode.
- The difference between the cost of using a bicycle and an alternative mode.
- The fare paid in using public transport (representation of VOC for bus)
- The extra opportunities gained or lost in using an alternative mode. This applies to only the second order.

  This is done by using the opportunity cost methodology as shown in section 4.5.3. Based on the data collected the following results were produced;

5.5.1. The average socio-economic value (SEV) of cycling per trip per mode per ward

All the calculations used bicycle as the reference and therefore positive values means benefit to cycling and negative values mean cost to cycling. Higher SEV then implies that low potential to shift from cycling and low SEV means high potential to shift from cycling.

Even though most cyclists would not have car as an option for their alternative trips, the few ones in Nyerere, Mkunazini, Muembeladu, and Mikunguni that would as stated by them show that car is not a good option for bicycle trip substitution since on the average it will cost more than using bicycle. This cost is also not uniform in all the wards since they have different trip characteristics. It is shown in figure 5-7 that an average car trip is more costly from Nyerere than Mikunguni which is also costly than a trip from Mkunazini and Muembeladu. Motorcycle is also costly as compared with the use of bicycle. The extra cost of bus is low as compared with that of motorcycle and car. This seems to be affordable with the observation from the field, but walking is the mode with the least cost compare to the cost of bicycle use.

On the average, a substituted bicycle trip with motorcycle will have extra cost from Mwanakwerekwe than from any other ward. Bus is the dominant mode and all the wards have cyclists who will go for bus should they stop using their bicycle. Among all the wards it will cost more to substitute a cycling trip with bus from Kikwajuni Bondeni. This might be due to the fact that they travel far for their socio-economic activities which attract higher fare. The two components that contribute to the SEV of bus are the travel time difference and bus fare, but there is virtually no traffic in Zanzibar. This means that the only contributing factor to the extra cost of bus hence the extra cost of bus in Kikwajuni Bondeni. Refer to figure 5-7.

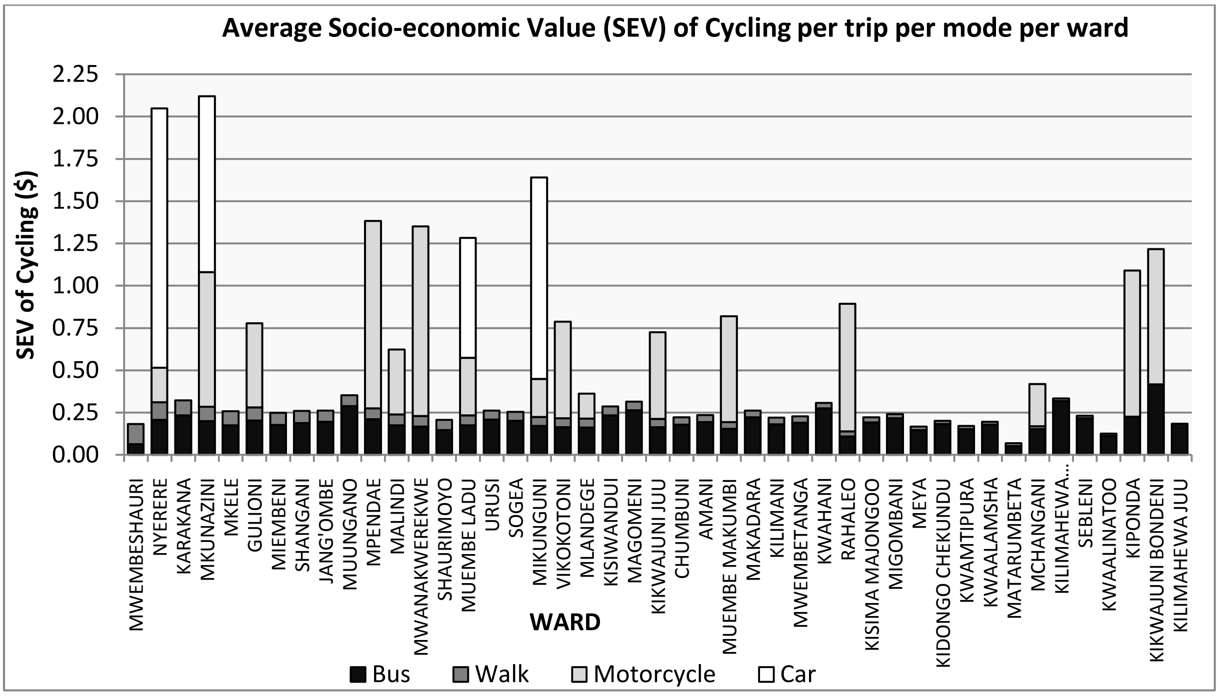


Figure 5-7: Average socioeconomic Value of cycling per trip per mode per ward, result of first order effect

5.5.2. The average socioeconomic value (SEV) of cycling per trip per purpose per ward

One major socioeconomic indicator was selected and this indicator is measured for 3 different trip purposes selected for this research in order to estimate the SEV of cycling. These were work, school and shop. The average SEV of cycling per trip based on these indicators in each ward was calculated and the outcome is shown as in figure 5-8.

Unlike the SEV based on the modes, all the wards had cyclists departing for at least two of the purposes. Mkele and Mungano had no cyclist departing for work. It shows from figure 5-8 that averagely, a school and a shopping trip from Mungano will cost more than these same trips in Mkele when using alternative modes to bicycle. From the same figure it is clear that making a shopping trip from Kiponda is more costly than from Kikwajuni Bondeni as compared to all the wards. Kikwajuni Bondeni has the highest cost for departing for school trip. It will actually cost a little extra to make a shopping trip from Urusi whiles Mwembeshauri and Kwalinaato has the least extra cost for departing for work and school trips respectively.

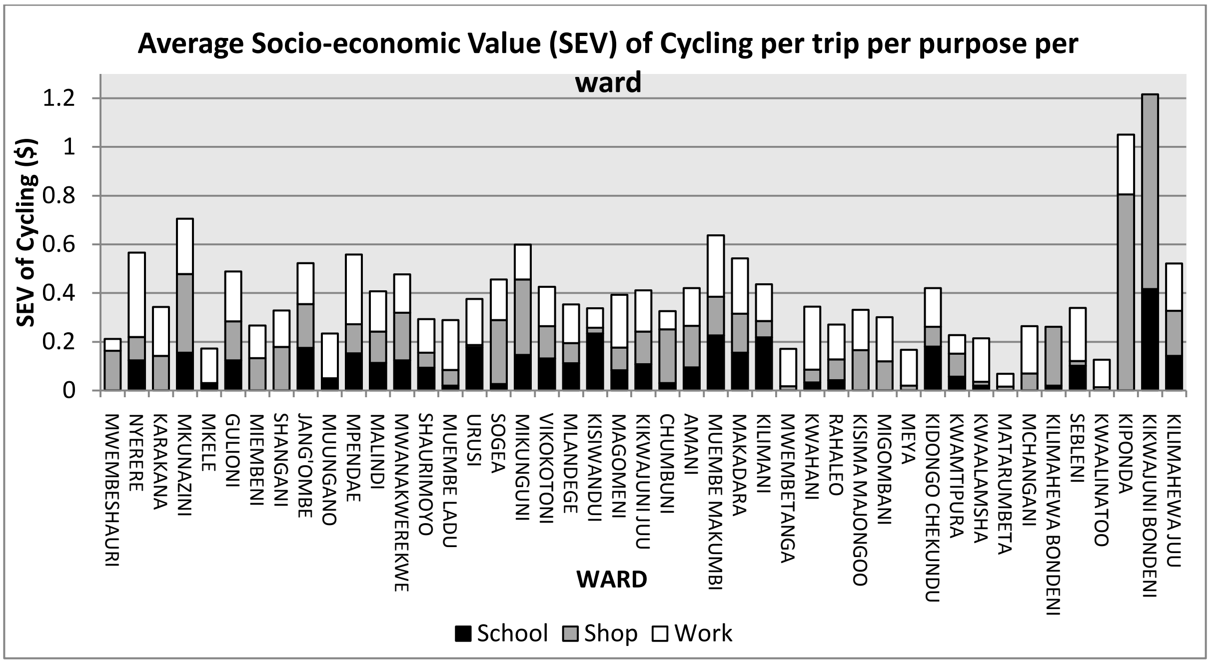


Figure 5-8: Socioeconomic Value of cycling per trip per purpose per ward, result of first order effect

5.5.3. Average socioeconomic value (SEV) of cycling per trip per ward

Combining all the indicators and the different types of transport modes shows that substituting an average bicycle trip with an alternative mode will cost extra as compared to the cost of using a bicycle. Appendix 13 shows that averagely, Kikwajuni Bondeni has an extra cost of about 60 US cents per each departure trip made. This is followed by trips from Kiponda and Nyerere with 39 and 28 US cents respectively. This means that it is rational to continue cycling than to substitute a bicycle in these wards. For example the cost of using alternative mode cost an extra 60 US cent from Kikwajuni Bondeni. This amount is about 882 Tanzanian shillings which can pay for two average trips in Zanzibar. This give a signal that the main contributing factor of this opportunity cost might be the use another mode apart from bus or they travel longer distances and therefore take more than one bus to get to their destination. It also seen that substituting an average bicycle trip with any alternative mode of transport, will cost a little above the cost of using the bicycle from Matarumbeta which also implies that using an alternative mode from Matarumbeta is rational than from any other ward based on the average aggregated value. See figure 5-9 for the spatial distribution of the total average SEV of cycling.

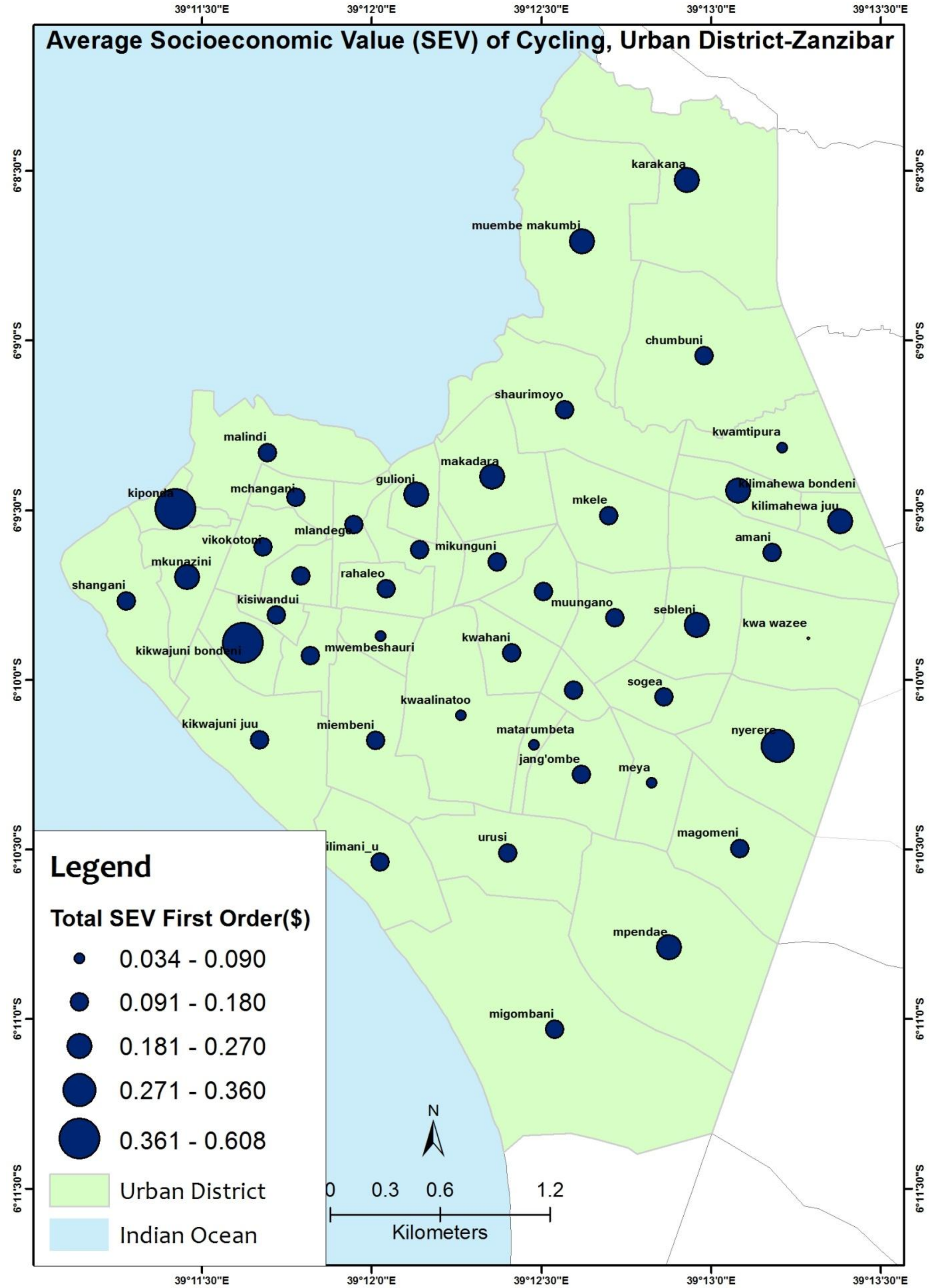


Figure 5-9: Spatial representation of the average socioeconomic value per trip per ward

5.5.4. Sensitivity analysis (Time value)

As it was mentioned earlier, the public transport system in Zanzibar is seen to be very effective and affordable. This is due to the fact that their public transport (Daladala) operating lines are zoned and so every transport operator has a specific line he or she operates. There is also a control or a regulatory body that ensures that the transport fares do not exceed the limits they have set for each zone.

During the period of the data collection it was realised that this mechanism put in place has attributed to the effectiveness and the affordability of the public transport system in Zanzibar. Figure 5-10 reveals that at the current hour rate (time value) in Zanzibar, bicycle is more advantageous than the rest of the modes in terms of socio-economic activities. It will cost less to substitute an average bicycle trip with walking than bus, motorcycle and car in that order.

Increasing the value of time to $1.20 per hour, it is seen that the SEV for bus is zero. This means that at this point the cost of using bus on the average is the same as using bicycle and might be rational for some people to shift from cycling to bus. The effectiveness and the affordability of the bus system, becomes clearer when the time value or hour rate is increased to $1.5 per hour. The SEV of bus then becomes negative showing that there is a high potential of shift from cycling to bus and might be rational to substitute the average bicycle trip with bus than any other mode. It also implies that it would be on the average better to use bus for the socio-economic activities in Zanzibar instead of even using bicycle if the hour rate of Zanzibar is raised to an average $ 1.5 per hour. It will cost less to use the bus than to use any other mode including the bicycle.

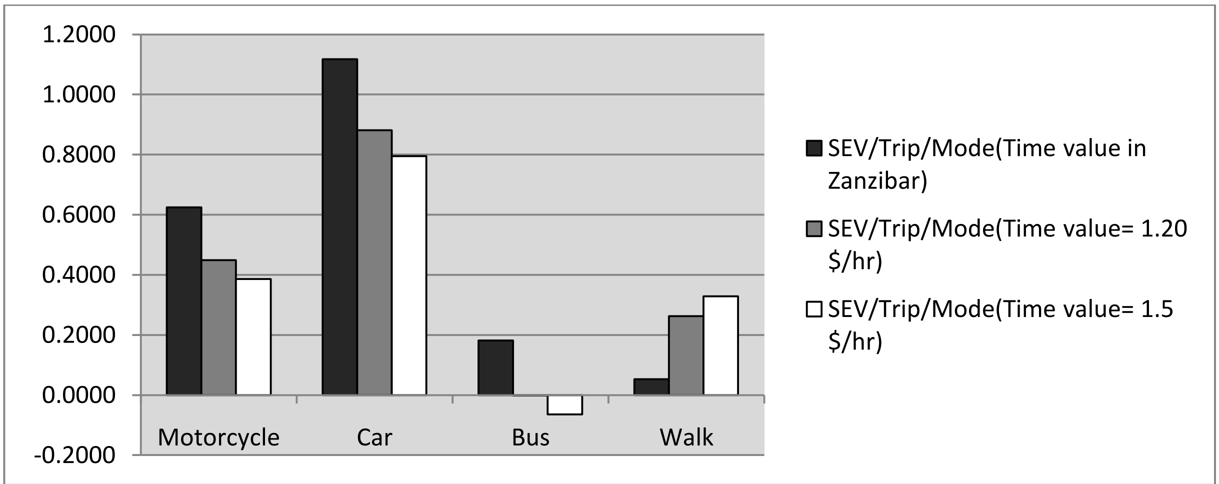


Figure 5-10: SEV per trip per mode with the hour rate of Zanzibar and hour rate increase to $1.2 and $1.5

5.5.5. The average socioeconomic value (SEV) of cycling per trip per purpose per ward and SEV per trip per mode per ward (Second Order Effects)

It was observed during the fieldwork that some cyclists when substitute their trips with other modes, will have their disutility exceeding the utility of their trip. These cyclists therefore intend to change their destinations in order to minimise their disutility or maximise their utility. As a result 104 trips were recorded with change in destination. This gave rise to the second order effect of shift. In this situation, the cyclist can move as far as they can, depending on the speed of the mode they choose and therefore opportunities might be gained or lost.

From the figure 5-10, it is clear that in order to maximise the utilities of their trip, walking is generally a good option which can be beneficial to them. Substituting an average bicycle trip from Kikwajuni juu, Mikunguni, Migombani, Magomeni and Amani with walking might be more beneficial than using a bicycle with Kikwajuni juu gaining about 42 US cents on per average trip. Combinations of figure 5-10 and 5-11 tell us that the 42 US cents is a gain in favour of work trips. It also shows that bicycle trips for shopping from Kidongo Chekundu will be more costly to substitute with car. Similarly, it is seen that trips made from Sebleni, Urusi, MuembeMakumbi and Mlandege is less costly, almost the same as the cost of using a bicycle. This means that substituting a bicycle trip with walking from these wards will not attract a cost too different from using a bicycle.

5.5.6. Average socioeconomic value (SEV) of cycling per trip per ward (second order effects)

The overall average due to the second order effects from figure 5-11 shows that averagely, bicycle trips can be substituted with alternative modes to certain parts of the ward for the same purposes to either reduce the disutility or increase the utility of their trips. By so doing some will end up incurring more cost and others less cost. For example cyclists who are captive might end up walking to shops close by but another who has access to car might also end up travelling from Enschede to Amsterdam for shopping. Substituted bicycle trips from Kidongo Chekundu will cost close to extra 1US dollar. On the other hand, average substituted bicycle trips from wards like Urusi, MuembeMakumbi, Mlandege etc might cost less, almost the same as using a bicycle. See figure 5-14 for the spatial representation of the average SEV per trip.

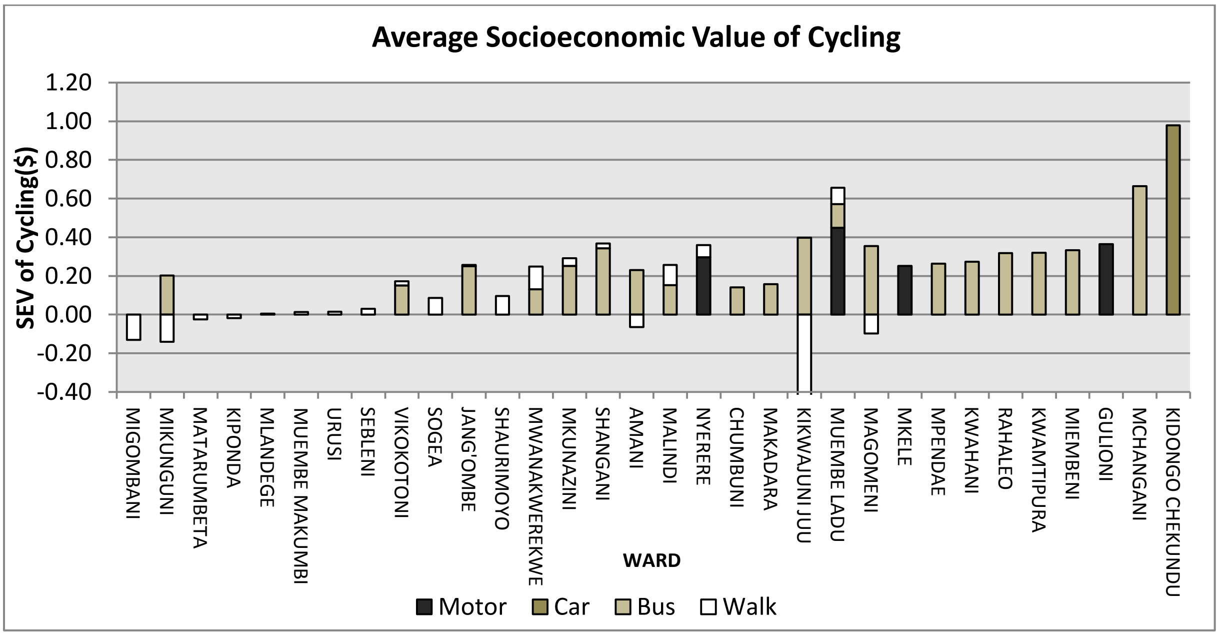


Figure 5-11: Average SEV per trip per mode per ward resulting from second order effect

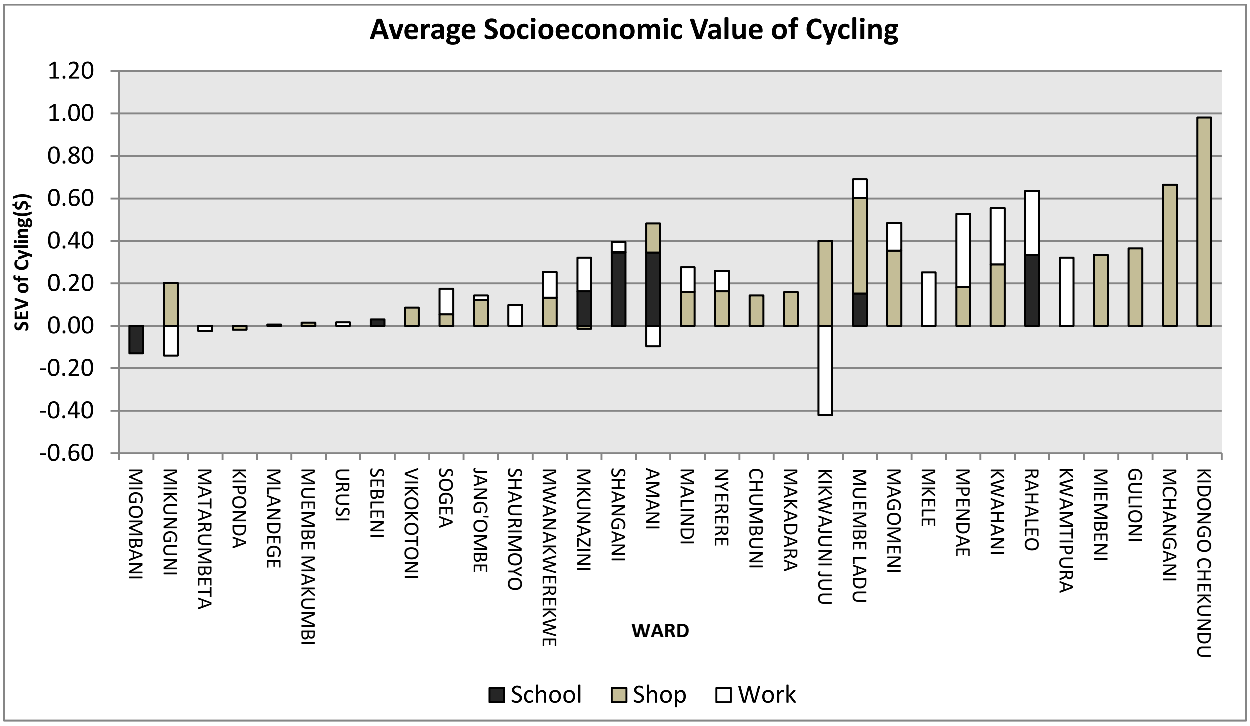


Figure 5-12: Average SEV per trip purpose per ward resulting from second order effect

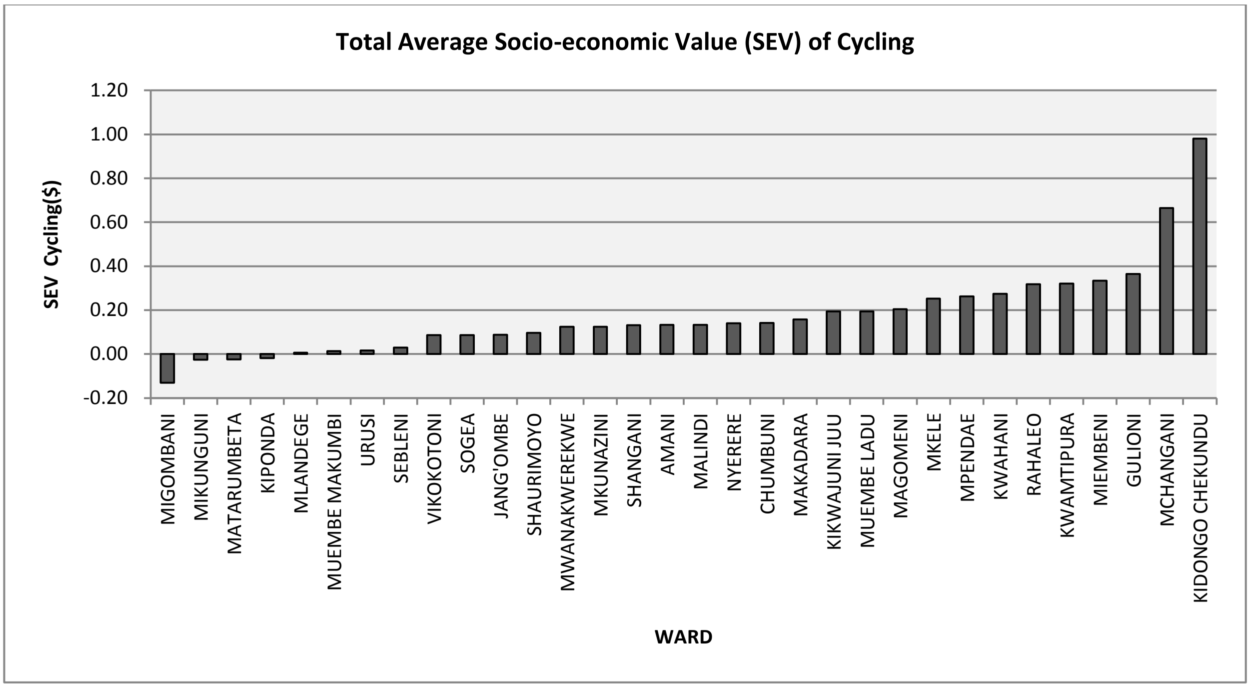


Figure 5-13: Average Socioeconomic Value of cycling per ward, second order effects

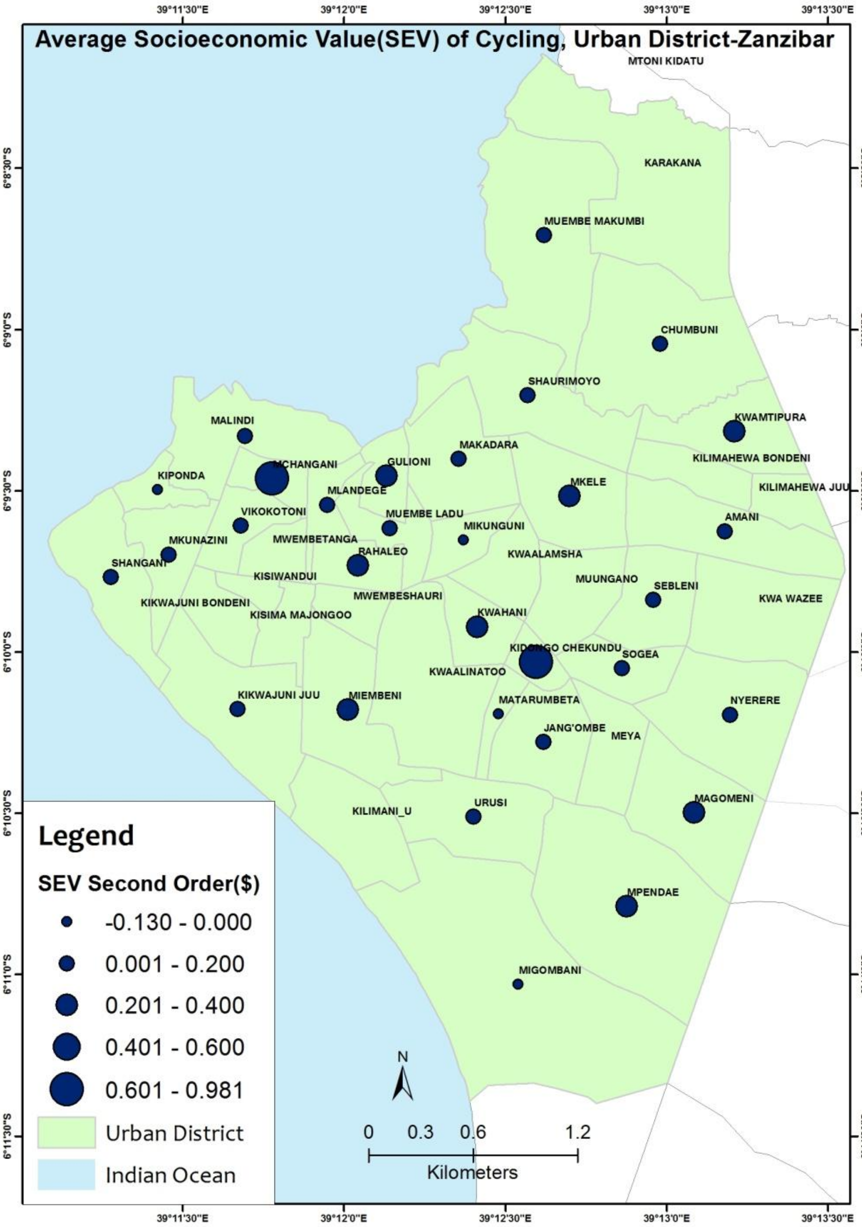


Figure 5-14: Spatial representation of the average socioeconomic value per trip per ward, Second order effects

5.5.7. Accessibility of opportunities (Second order effects)

Cyclists change their initial destinations in order to maximise the utility of their trips or minimise the disutility of their trips. This happens when they change their mode of transport. Depending on these modes, they either travel longer distances or shorter distances for the same purposes (Martens, 2004). This means that the higher the speed of the mode the further they travel and then have more access to opportunities.

According to the data collected in the Urban district of Zanzibar it was realised that the whole area is made up of very few main roads being used by buses and cars. The majority are footpath and tracks which is being used by bicycles, walking and motorcycles.

During the network analysis it was realised that car and bus trips beyond 15 minutes goes beyond the network. This might be due to the fact that the actual speed in the study area is less than the average speed assumed which might also be as a result of several stops and activities in between trips for bus and car trips since traffic rarely occur in Zanzibar. In this situation the actual time collected in the field can not be used for this purpose, but using the average speeds of the various modes, a common impedance of 5 minutes and the centroids of all the wards as the origin are used in the ArcGIS spatial analyst to create an accessibility level (5 minutes network buffer) common to all the modes. This accessibility buffer is used to demonstrate this process.

The land use layer of Zanzibar contains the opportunities as listed in table 5-12. The opportunities reached by the 5 minutes coverage of the bicycle is compared with the alternative modes to see whether there is a gain or lost of opportunities.

Comparing all the modes based on the 5 minutes network buffer or accessibility level it is seen that motorcycle has a higher speed and can be used on all the road types in Zanzibar therefore is able to cover large areas. This is followed by the bicycle which also has the next larger coverage. This is because the bicycle can also be used on all the roads and therefore has a larger coverage but not as much as that of the motorcycle which has a higher speed. The bus and the car are used on the main roads which limits their coverage to all parts of the study area that are accessible by footpath and tracks. The coverage of the car is bigger than that of the bus because it has a higher speed than bus. The mode with the least coverage is walking due to it lower speed. See figure 5-15.

Frequency	Type of Opportunity
11	Church
2	Dispensary
223	Government office
32	Hospital
6	Market
103	Mosque
4	Nursery school
18	Petrol station
12	Police station
4	Post office
157	School
5	Temple
3	Water tank

Table 5-12: Type of opportunities in Zanzibar

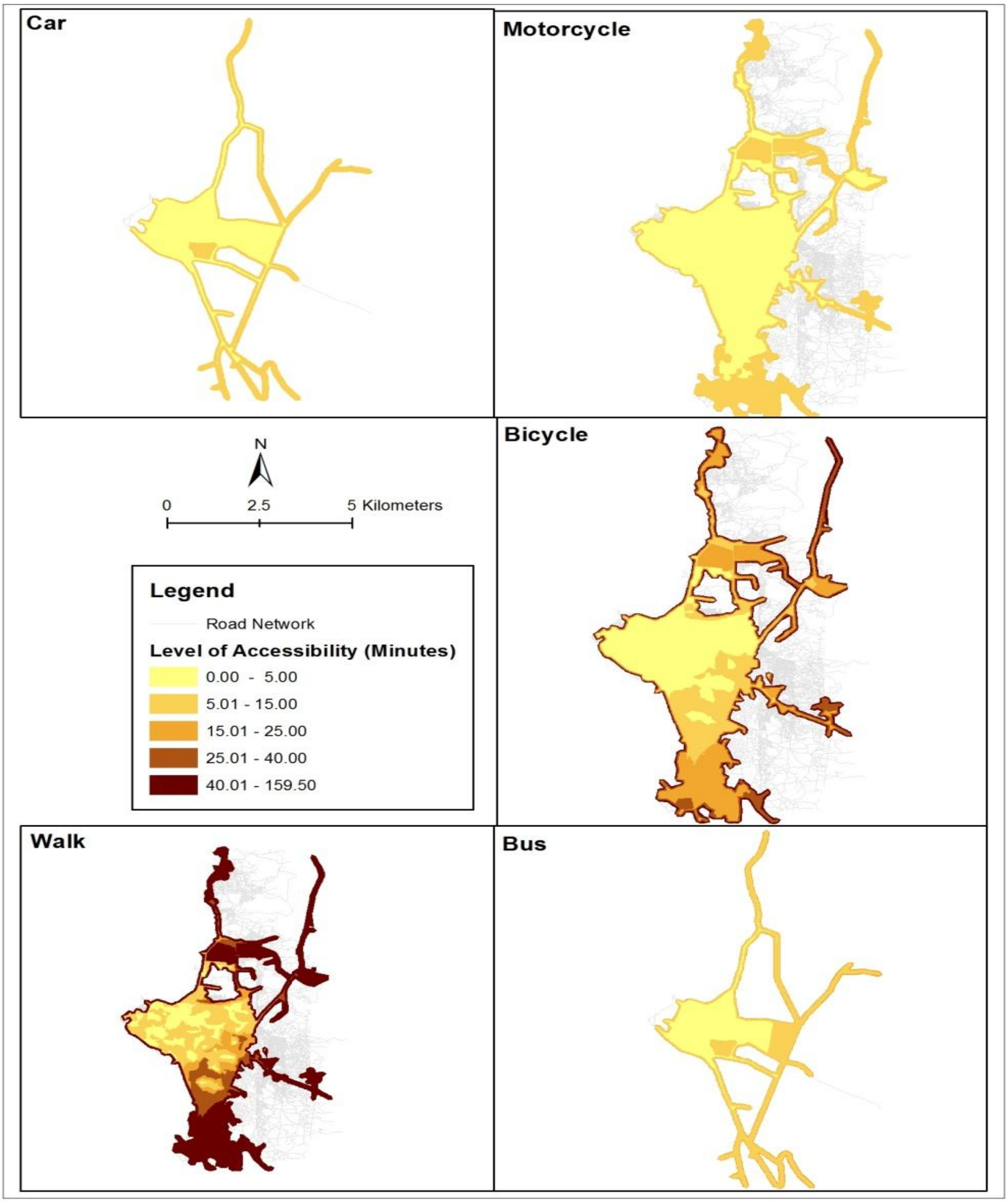


Figure 5-15: The spatial coverage of the different types of modes

The 5 minutes network buffer for each of the modes is used to clip (extract) the opportunities in the land use data of Zanzibar (figure 5-16). The number of opportunities extracted or reached by the 5 minutes network buffer of the bicycle is deducted from that of the alternative modes to know the number of opportunities gained or lost as a result of the modal shift.

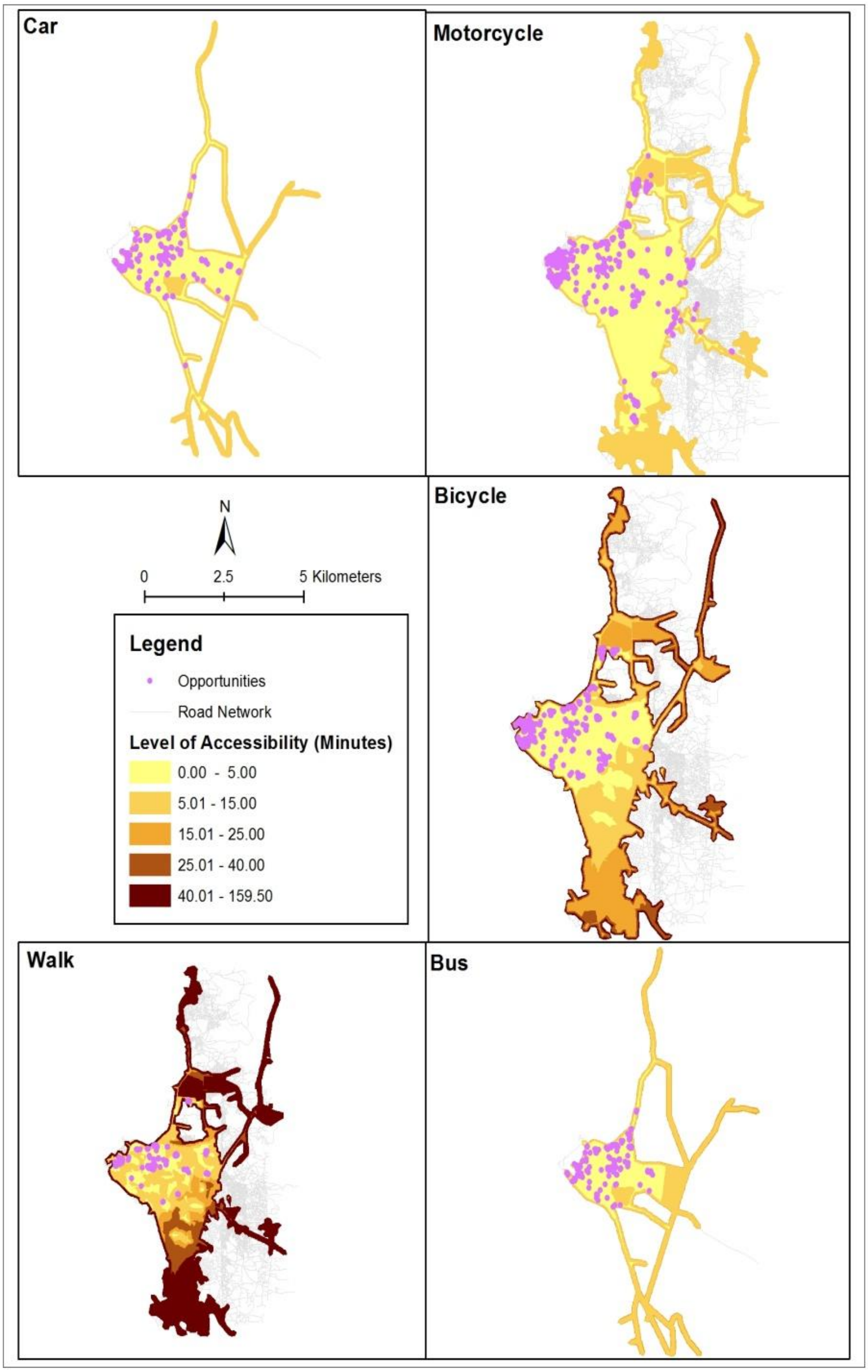


Figure 5-16: Spatial coverage of modes with clipped opportunities

As a result of the clipping or extraction by the different type of modes using the 5 minutes network buffer, it came out that the bicycle covered or extracted 346 opportunities. The opportunities covered by motorcycle, bus, car and walk are 504, 161, 196 and 121 respectively. The net opportunities are calculated by subtracting the opportunities captured by the bicycle 5 minutes network buffer from that of the each alternative ([Alternative modes] - [Bicycle]). This shows that opportunities gain or lost by motorcycle, bus, car and walk with reference to bicycle are 158, -185, -150 and -225 respectively. See table 5-13. This implies that substituting bicycle trip with motorcycle will gain you extra opportunities hence probability of shift from cycling but substituting with car, bus and walk you will lose opportunities hence rationality to continue cycling.

Mode	# of Opportunities(#OP)	#OP [Alt mode - Bicycle]
Bicycle	346	0
Motorcycle	504	158
Bus	161	-185
Car	196	-150
Walk	121	-225

Table 5-13: Opportunities captured by modes and the net opportunities with respect to bicycle substituted trip.

5.5.8. Average net travel time distributed over distance

In order to see the average time gain or lost and the percentage trips by the various modes compared to bicycle over the distances travelled in the study area, the net travel time (Alternative mode time – Bicycle time) of the various modes and the number of trip makers are aggregated over three distance classes (0-3, 3-6, >6) km. The average net travel time and the percentage of trips over the three distance classes are assessed.
From figure 3-4, it is seen that over a distance of (0-3) km motorcycle is faster than bicycle and therefore gains an average of about 5 minutes travel time over bicycle. This is followed by bus. Over the same distance car and walk is seen to loose time against bicycle. The situation of the car in this situation might be due to the fact that there is only one trip recorded for car and it is over a short distance. It could also be that the vehicle had no direct access to the activity place so walking is used to complete the trip.

Considering the distance from (3-6) km, motorcycle gains more time followed by car, bus and walk in that order. This order is different over the distances above 6 km where car gains more time than motorcycle which also gains more time than bus followed by walk which loses more time against bicycle. This shows that the longer the distance the more time the motorised modes gain against the bicycle. See figure 3-4. It is also seen in the same figure that about 14% , 53% and 32% of cyclists will substitute their trips with motorcycle over distances of 0-3km, 3-6km and >6 km respectively. Car trips are also seen to be made mostly over long distances (> 6 km) and very few will use car over distances less than 6 km. The situation is different for bus which is used mostly for distances above 3 km whiles walking is done mainly on distances less than 3km and in some cases between 3 and 6 km.

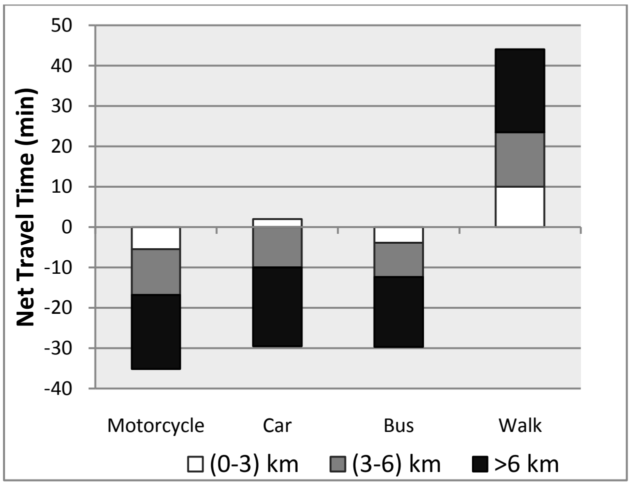


Figure 5-17: Net Travel time and distance relationship

	(0-3) km	(3-6) km	>6 km
Motorcycle Trips	4	15	9
Car Trips	1	1	4
Bus Trips	84	305	386
Walk Trips	143	129	32
Total Trips	**232**	**450**	**431**

Table 5-14: Trips made over distance classes

6. SAMPLE TO POPULATION CALCULATION

The sample is selected in order to represent the population. This means that before any research plans must be made regarding how the data will be collected. If the sample is well collected then any result from it will represent the behaviour of the population. This chapter outlines the steps taken in the up scaling of the result to represent the behaviour of cyclists in Zanzibar.

The socio-economic value of cycling is calculated based on the average trip in the sample. To let this value represent the population, there is the need to scale up the sample value. The following are the steps to scale up the sample:

- First, the number of bicycles per ward is calculated by using ratio and proportion. The total number of bicycles and population in the urban district is 39,511 and 274,802 respectively (The Revolutionary Government of Zanzibar, 2011). That is 39,511 bicycles is equivalent to the total population figure of 274,802. Given the population of the ward to be say W, the number of bicycles in the ward (BW) is expressed as (39511*W)/274802.
- During the data collection, samples were collected from some of the wards in the study area. Let 'Sw' represent the sample collected (cyclists interviewed) in a ward and 'Lw' represent the number of cyclists who live and started their trip in the same ward. Assuming that 'Lw' represent the behaviour of the population then the number of cyclists who use their bicycles is expressed as (Lw/Sw)*(39511*W)/274802.
- There are wards which did not have any cyclists living and starting their trip in the same ward. For these wards, the average percentage of the sample of cyclists who live and started their trip in the same ward is used.
- The final scale up is done by multiplying the number of bicycles used in the ward by the average number of trips made to school, work and shopping. This value is finally multiplied by the average SEV of cycling per trip per ward.

6.1.1. Limitations of the scale up

There were certain factors which affected the scale up of this result. These factors are stated below;

- Lack of data – there is no proper modal split of the study area which introduced generalisation in step 1.
- There is biasness in the data – considering step 2, it means that cyclist who did not use their bicycle the day of the interview were not counted and therefore reduces the number who use their bicycle.
- Step 3 introduces another generalisation, that is the percentage of the average number of cyclists living and started their trip in the ward is used to represent those who no dot have representation.

6.1.2. The socio-economic value (SEV) cycling for Zanzibar (First order)

The SEV of cycling according to this research as shown in section 4.5.3 is directly proportional to the valued time difference between the alternative mode bicycle [Net time ($)] and modal cost of the alternative mode [MCost ($)] or the bus fare ($) in the case of using a bus since the modal cost of bicycle is assumed to be zero. But the Net time ($) also depends directly on Net time (min) and the value people attached to the time difference (VOT). It is also shown in section 5.5.8; figure 5-17 that except for walking the Net time (min) decreases (more negative) gradually as the distance increases. That is, the alternative modes (bus, car and motorcycle) gain time whiles walking lose time as distance increases.

This implies that for faster modes (car, motorcycle and bus), as distance increases the Net time (min) decreases (more negative) and the MCost ($) or the bus fare ($) increases. In this case SEV can be positive or negative depending on the rate of time gain by the alternative mode. but the rate at which time is gain by the alternative modes for this research is less than the rate of increase in distance. Moreover, the value that people of Zanzibar attach to time is very low therefore the SEV is mainly dependent on type of mode (VOC) and the distance travel (MCost) and increases as MCost increases. See the sample calculations in section 4.5.3. For slower modes (walk), Net time (min) increases as distance increases hence positive SEV.

Figure 6-1 shows that the SEV for wards like Nyerere, Magomeni, Mpendae and Migombani are higher. This means that the opportunity cost of substituting bicycle trips with alternative modes is high and therefore the probability of cyclists from these ward shifting is very less.. It is also shown in the sample collected for these areas that most of them have their destinations at the central business district (CBD) which is far and also few of the bicycle trips were also substituted by car and motorcycle which have high operating cost therefore generating high MCost ($). Table 5-14 also shows that majority of the trips are substituted by bus. The long distance travellers sometimes join two buses to get to the activity centre which also increases their fare. These account for the high SEV. Kikwajuni bondeni is a residential area with high socio economic class and therefore there are very few cycling population. These cyclists substituted their cycling trips with motorised modes (bus and motorcycle) and instead of visiting the CBD within the urban district for their activities rather visit another market in the west district for those activities. The longer distance they travel and the type of mode they use for their socio-economic activities resulted into the high SEV. We should also bear in mind that the total SEV for the population depends on the cycling population in a particular ward, so comparing figure 5-9 and 6-1 shows that the cycling population in Migombani, Jangombe and Magomeni is high and Vikokotoni, Mikunguni and Kiponda have smaller cycling population.

Wards like Vikokotoni and Mikunguni are the two major market centres in the urban district where most of the socio-economic activities take place. The cyclists travel just within the same ward (short distant trip) for their socio-economic opportunities by mostly walk as shown in table 5-14 which has zero MCost ($) and very small Net time ($), hence smaller SEV. These apply to all wards in the CBD, but Mkunazini, Shangani and Kiponda have a little bit higher SEV even though they are in the CBD because most of the activities within these wards are not activities for local cyclists rather tourists, so these cyclists travel out of the ward for their socio-economic activities. See values in appendix 14 for the detailed values.

It is now clear that in order to maintain cycling mobility there is the need to increase SEV of cycling or the opportunity cost of substituting bicycle trips in Zanzibar. This can be done by using more of motorised mode over longer distance travel, but this activity will also increase climate change effects. Also cycling facilities should also be provided in all developing cities for the efficiency of cycling use and o avoid the competition of right of way with rapidly moving motor vehicles (Pucher, et al., 2005).

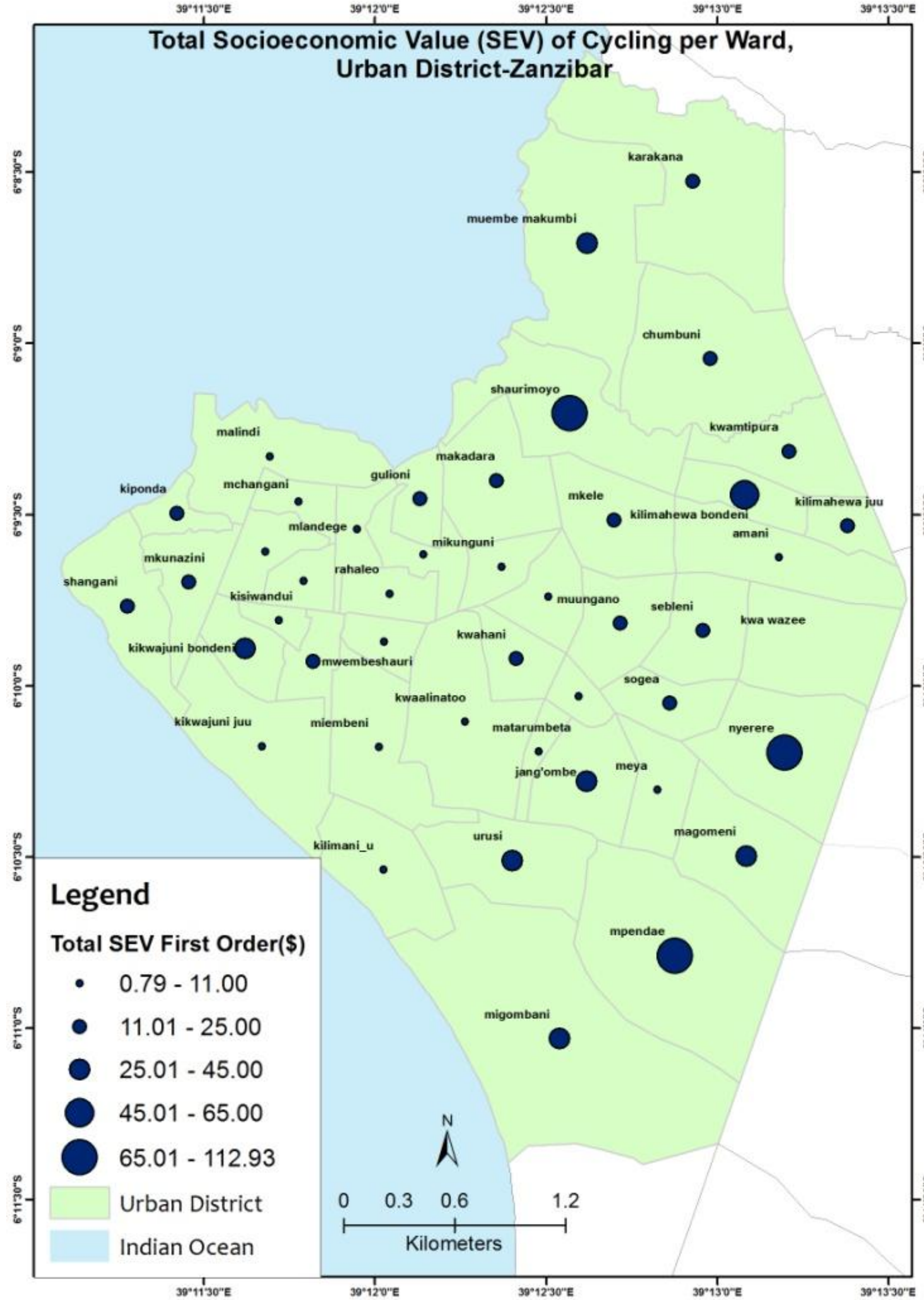


Figure 6-1: Spatial distribution of the total SEV of cycling per ward (First order)

6.1.3. The Socio-economic value (SEV) cycling for Zanzibar (Second order)

When people change mode, depending on the substitution mode they end up travelling longer or shorter distances for the same opportunities (Martens, 2004). This depends mostly on the type of mode, their socio-economic background and the accessibility of the area (Munshi & Brussel, 2005). Most of the times people who shift to faster modes travel longer distances unlike those who use slower modes. See figure 5-16.

Figure 6-2 shows that the effect of the second order has no direction. Depending on the type of mode wards in the CBD can travel far from if they substitute their bicycle trips with faster modes and travel far for the opportunities. Some wards far from the CBD could also reduce their longer travel distances which also result in using cheaper modes like walk to maximise their utilities. SEV can then be high or low; but depends entirely in addition to the alternative mode, the net increase cost which is due to additional vehicle costs minus the value of the time savings.

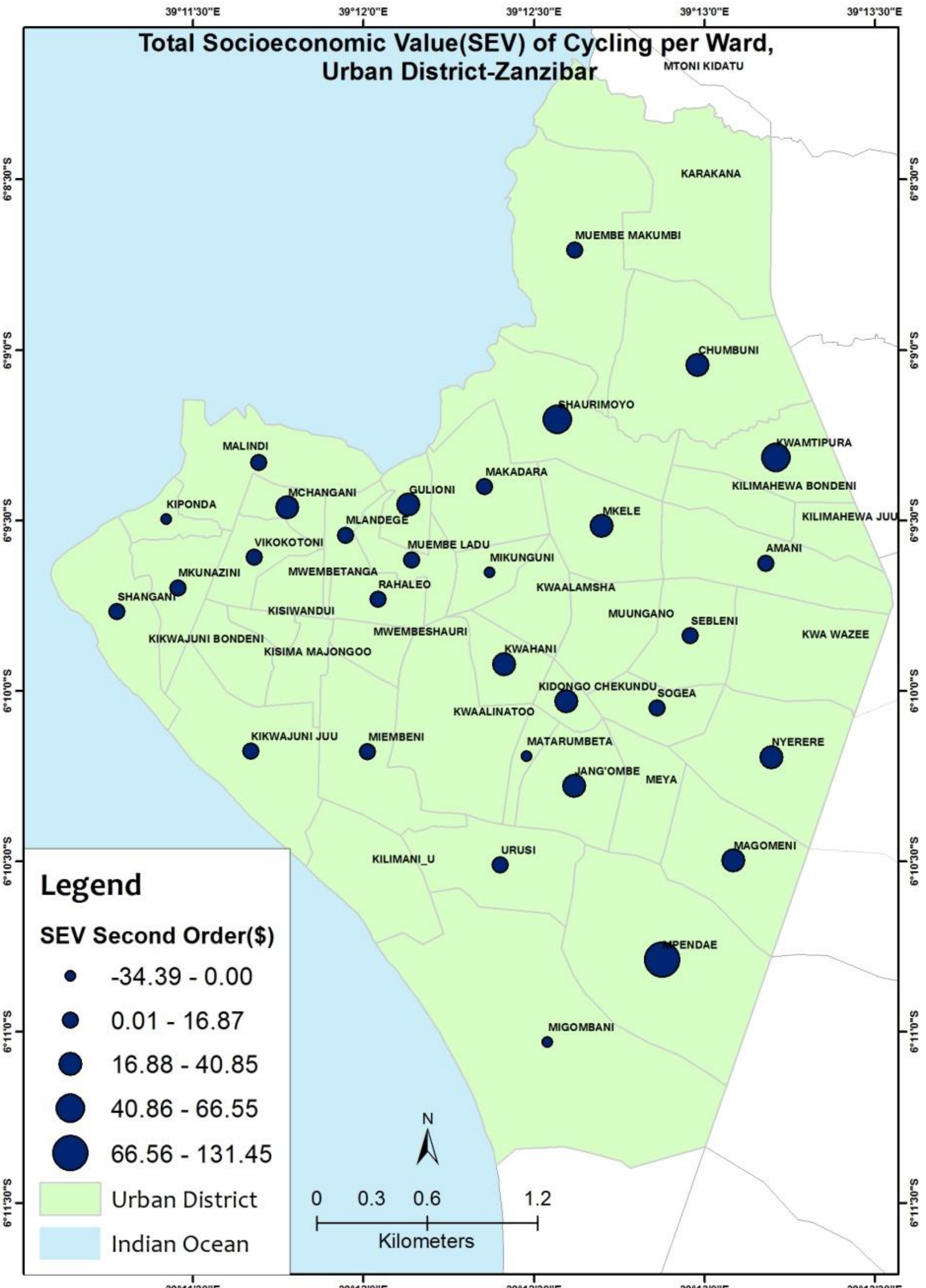


Figure 6-2: Spatial distribution of the total SEV of cycling per ward (Second order)

6.2. Socio-economic value (SEV) vrs climate value

The opportunity costing methodology of cycling substitutes bicycle trips with their most likely alternative modes of transport and calculates the loss or gain of the substitution in terms of socio-economic value (SEV) which is the difference in time and modal cost. Similarly, the shadow cycling model also substitutes bicycle trips with their most likely alternative transportation modes and calculate the gain or loss in terms of climate value which is the amount of CO2 produce or sunk (Massink, 2009). There is an uncertainty surrounding these two values which triggered this research. It is believe that socio-economic value of cycling and climate value of cycling relates and that socio-economic development could be hampered by climate change (Davidson, et al., 2003).

It is seen from this research that the SEV of cycling relates directly to the Net time ($) [alternative mode time minus bicycle time) and the modal cost (operating cost of alternative mode multiply by the distance travel), since the operating cost of bicycle is assumed to be zero.
i.e SEV = Net time (min) * VOT ($/min) + VOC ($/km) * d (km) .

Based on the formula above and the discussion in section 6.1.2, it is clear that the determination of the SEV is dependent on the type of alternative mode; the Net time and the vehicle operating cost. The Net time and VOC are also directly dependent on time. Similarly, the emissions of CO_2 are also determined by the type of alternative mode and by the distance. The longer the distance travel the higher the CO_2 emission and vice versa.

In the case of Zanzibar, it is seen that the motorised modes gain lot of time and walking loses lots of time against the bicycle. Depending on the difference between the VOC and VOT SEV could be positive or negative. They both act in opposite directions, so if VOC/km > VOT/km then larger distance implies larger the SEV and if VOC/km < VOT/km then larger distance implies smaller SEV. But theVOT ($/min) of Zanzibar is very low (average of about 33 US cents per hour) which when multiply by the Net time (min) gives a very minimal effect. This leaves the VOC and the distance as the determining factors. Wards far away from activities travel longer distances with motorised modes (figure 5-17 and table 5-14) resulting into higher SEV. The wards in the CBD also travel shorter distances to activity centres and the data confirms that most of these short trips are made by walk (table 5-14) which has no VOC and very small Net time ($) hence lower SEV. This pattern is seen also for the climate value in Zanzibar because it directly depends on the travel distance and the type of mode, so the wards outskirt the city centre travel longer distances to the CBD and mostly use the polluter modes (motorised modes) as the data shows. Those wards in the CBD travel shorter distances and also use non polluter modes (non motorised modes) like walking which results in lower climate value and higher climate value for the long distance travellers. This shows that in the case of Zanzibar the socio-economic value increases as the climate value increases and vice versa. See Figure 6-3. This is not clear graphically because different population data set is used to scale up the values.

The result of the study shows that SEV relates directly to climate value. Considering the wards far from the CBD it seen that SEV and climate values are both high which implies that the probability of shifting from cycling to any alternative motorised mode from these wards is very less but have high implications for climate. It is therefore rational to maintain their cycling mobility. On the other hand wards with low SEV and CV have high potential shift from cycling and low implications for climate, but as development starts and salaries increase then the environment becomes threatened by development. There will be a huge potential shift from cycling to motorised modes which will cause more production of CO_2 thereby increasing climate change effect.. In this case development activities might cause higher potential shift from cycling. The research shows that based on the sample there is a possibility of shifting from cycling when the VOT generally increases to 1.20 US dollars per hour. See figure 5-10

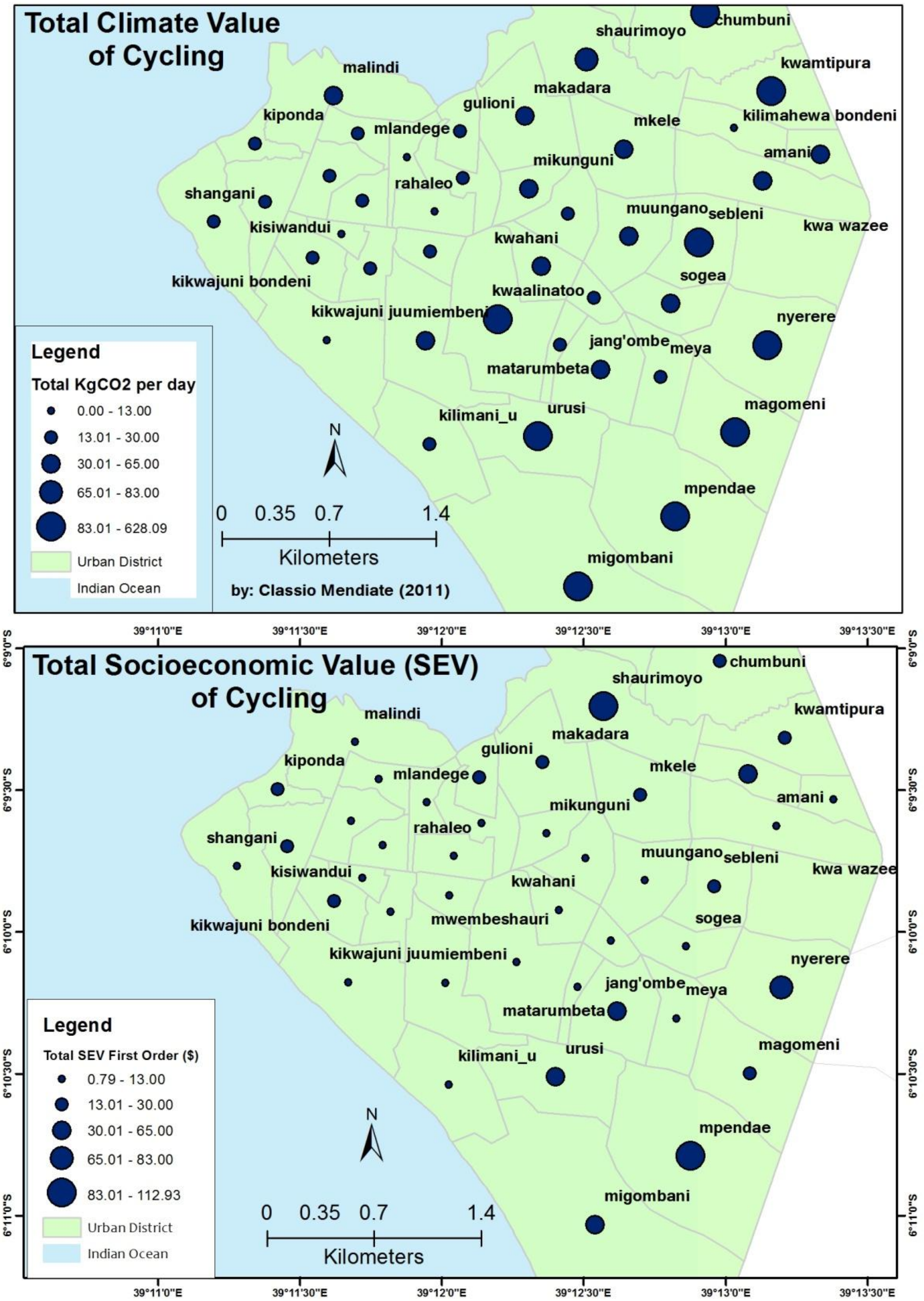


Figure 6-3: Spatial representation of the Socio-economic and Climate values of cycling

7. CONCLUSION AND RECOMMENDATION

7.1. General conclusions

Presently, people use bicycles for their daily activities, but as development increases they shift from cycling to motorised modes of transport. This is a threat to the environment since it has the ability to increase the production of CO2. It is therefore relevant to develop a methodology to investigate what cyclists would do if they do not cycle anymore and the additional cost they incur, so that the relationship between the socioeconomic and environmental values of cycling is justified.

7.2. Results and research objectives

The research objectives and questions in section 1.3 were evaluated based on the observations and the findings in this research to draw the final conclusions.

7.2.1. Relevance of cycling for Zanzibar

In order to identify the importance of cycling to the people of Zanzibar, the fieldwork carried out in the urban district of Zanzibar reveals that;

- It is relatively cheaper to use bicycle for the social activities which in turn saves money for other activities.
- Some parts of the city are not accessible by the motorised modes except motorcycle, so bicycle helps them to get access. For instance the access to parts of Stone town can be made by only motorcycle, bicycle and walking.
- It helps to reduce congestion in the city regarding parking especially at the market centres. Malindi fish market has a small parking space which cannot accommodate even 20 cars but since most of the fishermen use bicycle, not less than 100 fishermen park there everyday.
- It enhances the social and the economic development of Zanzibar by creating employment (trade business) such as selling of ice cream, fetching of firewood, fetching of water in gallons, carrying farm produce and distribution of fish to customers.
- Cycling has also created local bicycle industry where repairs and bicycles are hired for money.
- According to the modal split majority of trips in Zanzibar are made with bicycle which helps to reduce the level of CO_2 production and indirectly the long term climate effects.

7.2.2. Indicators to measure the effects of cycling

The effects of cycling were measured based on the first order and the second order. Under the first order, SEV is what a cyclist gain or lose if he or she is not using the bicycle any more. High SEV then means high cost to shift from cycling to an alternative mode which also implies that less potential shift from cycling hence the need for cyclists to maintain their cycling mobility. Low SEV means less cost to substitute a bicycle trip with an alternative mode which also implies higher potential shift from cycling.

In addition, the second order effect looks at the number of opportunities gain or lost through the road network based on the type of alternative mode. Faster modes gain time and usually gain opportunities if the network is accessible to them but slower modes usually lose time and opportunities.

A sample of cyclists collected showed that majority of the cyclists (56.6%) use their bicycles for work purposes, 16.0% use it for school activities and 27.3% cycle for shopping purposes. They also cycle longer distances to work (average of 6.95km) than to school (5.95km) and to shop (4.80km). With regards to trips made to work, Nyerere ward recorded the highest SEV of an average 35 US cents per trip which means that on the average a substituted bicycle trip costs extra 35 US cents. Similarly, Kiponda has the highest SEV of 81 US cents for shopping trips and 42 US cents for school trips in Kikwajuni Bondeni. Regarding the second order effects, the result showed that if a bicycle trip is substituted with a motorcycle the cyclist will gain a number of opportunities (158), but will lose 185, 150 and 225 opportunities if the substitution is done with bus, car and walk respectively. This shows that there is a potential shift from cycling to motorcycle but less potential shift from cycling to bus, car and walk.

7.2.3. Methodology for the estimation of the socio-economic value of cycling

A methodology has been developed to estimate the socioeconomic value (SEV) of cycling mobility using the opportunity costing concept. That is, estimating the effect of cycling based on what the cyclists gain or lose when they do not cycle anymore. It quantifies the first and the second order effects using the economic and spatial concepts respectively. The method assumes that the vehicle operating cost of bicycle and walking is zero. It simple and can easily be operationalized in a spreadsheet.

The method shows the relevance of cycling as compared to the other modes of transport. In calculating the SEV the components considered are net time (monetised in $ using the VOT) and modal cost ($). As distance increase the modal cost increase hence increase in SEV, but net time decreases as distance increases hence decrease in SEV. The data showed that Net time (min) of the motorised modes reduces as distance increases and increases for walking as distance increases but the rate of increase or decrease is less than the rate of increase in distance. Moreover VOT is very small (about 33 US cents per hour) which reduces the effect of Net time ($) therefore the main contributor of the SEV becomes the modal cost or bus fare which depends on distance. This resulted in positive values for all the wards for which first order effects were calculated. This means that using alternative mode for an average bicycle trip costs extra and makes it rational for the cyclists to maintain their current cycling mobility.

Using this formula, the highest SEV of $112.92 was seen in the ward Mpendae. This is most likely because this ward is far from the centre of activities so cyclists travel longer distance to the CBD. Moreover the cycling population of the ward is huge and most of the trips were indicated to be alternatively made by motorised modes like bus. At the same time Vikokotoni has the least SEV of $ 0.79. This also as a result of the fact that Vikokotoni is the biggest market where most of the socioeconomic activities take place therefore they travel shorter distances for their activities with mostly walking. Also there are few cyclists living in this ward.

Considering the cyclists who stated a change of initial destination with a change of mode, the level of access to opportunities was calculated using the ArcGIS spatial analyst. The results showed that compared to bicycle the motorcycle has the best coverage. This is followed by the car, bus and walking in that order. This means that the people travelling with motorcycle will have access to more opportunities than using car. Car also has more access to opportunities than bus followed by walking.

7.2.4. Significance of socio-economic value of cycling in relation to the climate value of cycling

The socioeconomic (SEV) and climate values (CV) were compared based on the values from each ward. It was seen that the smaller and larger values of SEV corresponds with smaller and larger values of CV respectively. As stated earlier in section 6.2.3, the SEV depends mainly on the VOC (type of mode) and the distance of travel. This means that the SEV increases with increased distance and VOC and decreases with decreased distance and VOC (so VOT is of less importance).

The CV also relates directly to the travel distance and the type of mode. That is the longer the travel distance the higher the CV. Also if the type of mode used pollutes more then the CV also goes up. The CV is the avoided cost of the amount of CO2 produced with the alternative mode, so modes which produce more CO2 over a long distance generate more CO2 hence higher CV.

The result from the SEV and the CV showed that generally, the two relates directly since they both depend mainly on the type of mode and the distance travel. This implies that high SEV corresponds with high CV and vice versa. Wards which have both SEV and CV high mean that less potential shift from cycling and high implications for climate. On the other hand wards with low SEV and CV have high potential shift from cycling and low implications for climate. In both situations the risk level is medium.
As development starts and salaries increase which in turn increases VOT from the current average value 33 US cents the net time become significant which may cause SEV and CV to relate indirectly. This might bring a situation of high SEV and low CV which imply high potential shift from cycling and high implications to climate resulting into high risk. On the other hand it could result in high SEV and low CV which also imply low potential shift from cycling and low implications for climate. The research shows that based on the sample there is a possibility of shifting from cycling when the VOT generally increases to 1.20 US dollars per hour.

7.3. Study area recommendations

Based on the observations and findings from the research, recommendations have been made to assist policy makers in taking decisions. These are summarised below:

- There should be decentralisation of development. This will reduce distance to activities and encourage people to cycle for short distance activities. This will increase the number of cyclists and the collective SEV value of the area.
- They should also practice smart growth (concentrated development) to reduce the movement of MT's and encourage the use of NMT's like bicycle.
- Separate bicycle lanes and bicycle phases in traffic light along the routes could be provided to make cycling attractive.
- The cost of CO2 emitted should be incorporated into the tax system to discourage them from using the MT's.

7.4. Further research recommendations

- In further research it would be interesting to consider other social aspects of cycling such as safety, comfort and health since they are potentially valuable. This will first give refined value of SEV and knowing the health and safety implications of cycling will encourage more people to cycle which will in turn reduce the emission of CO2 hence the reduction in climate change effects.
- The operating costs of bicycle and walking should be measured to know the actual effect of cycling on the society.
- With the lack of data on positions of the cyclists, a generalized origin-destination (ward centroid) was used in generating the accessibility coverage of the cyclists. This may be misleading as it might decrease or increase the number of opportunities reached by cyclists. This could be improved by using PDA with satellite image to mark their origin and destinations.
- The proper origin-destination information will also help to validate the stated preferences in the of the cyclists.
- Instead of the road side survey, a household survey and a traffic count should be conducted to get the right representation of cyclist.

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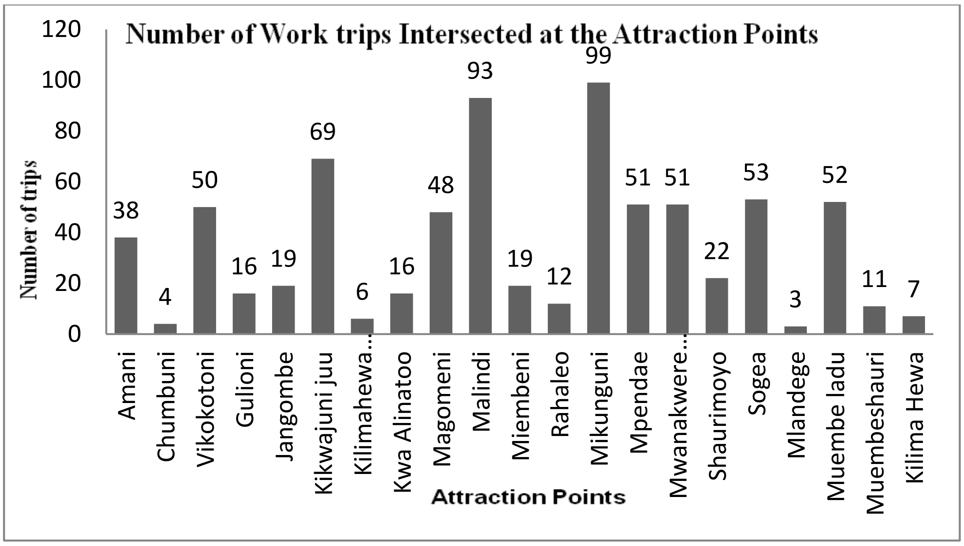
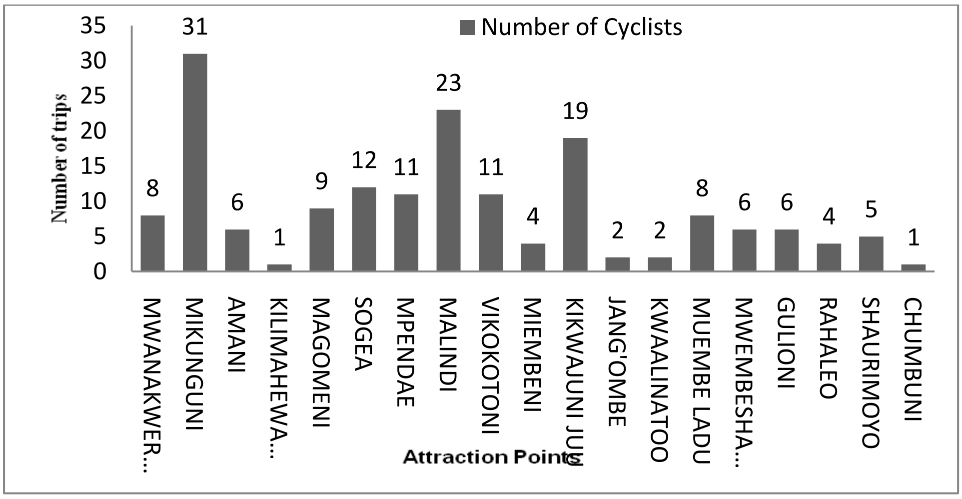
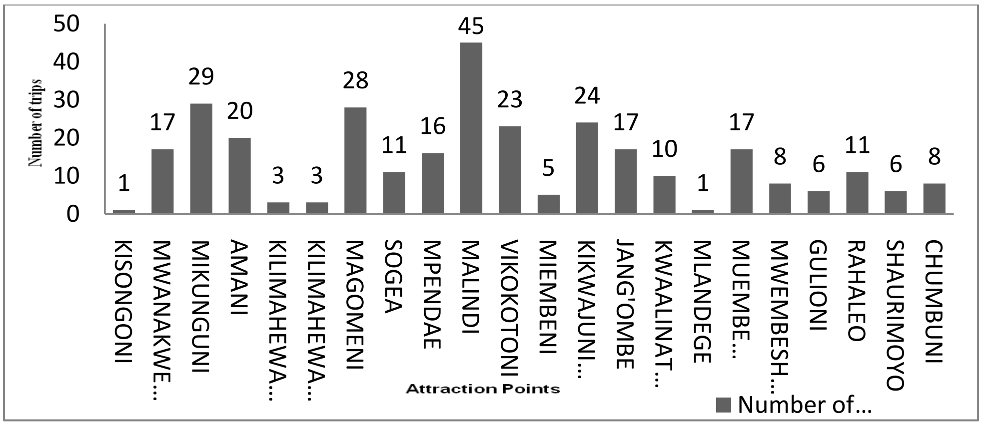
8. APPENDIX



Appendix 1: Number of work trips intersected at the attraction points



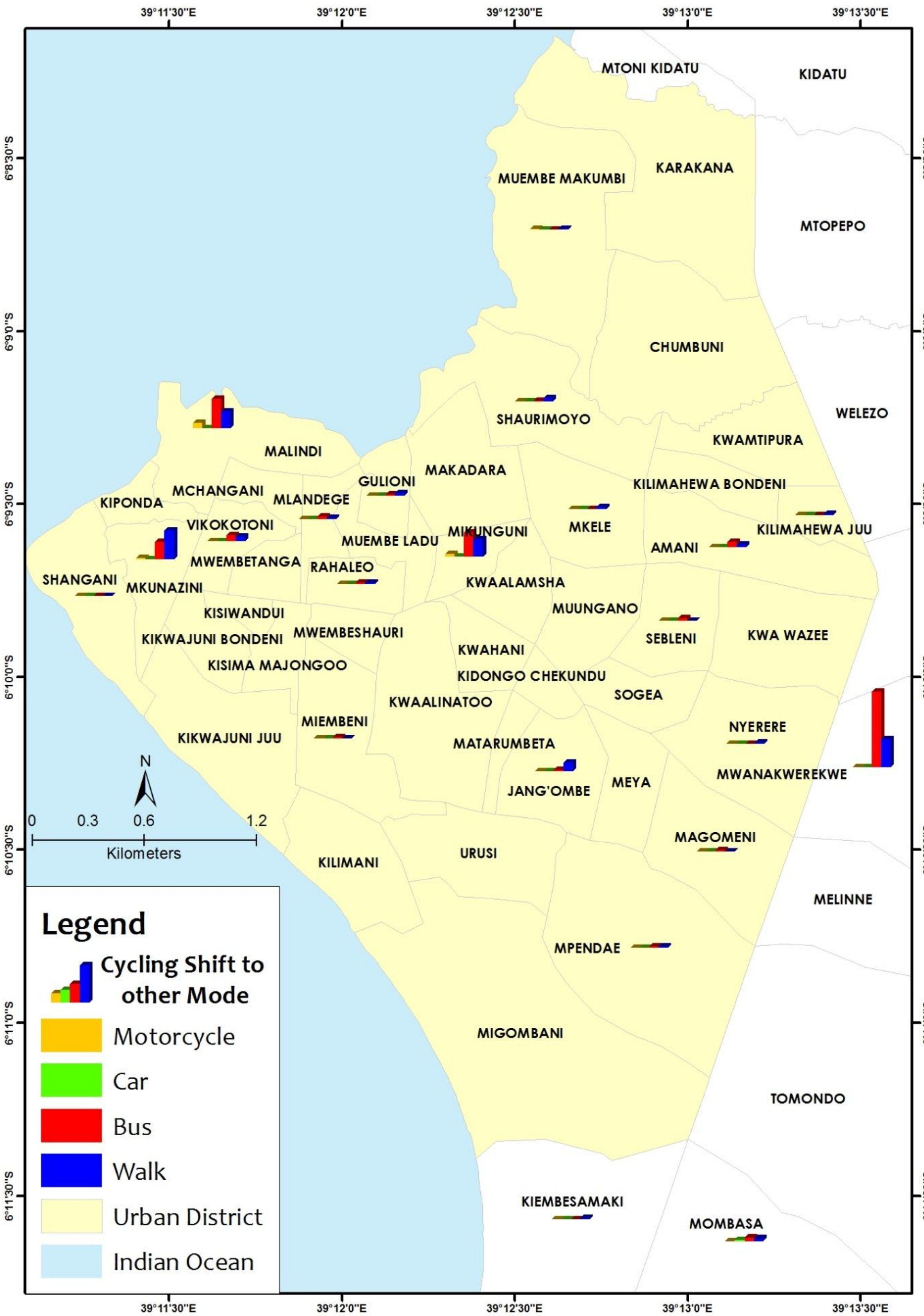
Appendix 2: School Trips intersected at the Attraction Points



Appendix 3: Shopping Trips intersected at the Attraction Points

WARD	Motorcycle	Car	Bus	Walk	WARD	Motorcycle	Car	Bus	Walk
Mwanakwerekwe	1	0	63	6	Sharifu msa	0	0	1	0
Malindi	0	0	57	6	Mwembeshauri	0	0	1	0
Mkunazini	0	0	50	9	Mahonda	0	0	1	0
Mikunguni	0	0	36	12	Chukwani	1	0	1	0
Amani	0	0	31	3	Kwamtipura	0	0	1	3
Vikokotoni	0	0	20	13	Mangapwani	0	0	1	0
Jang'ombe	0	0	18	3	Kihinani	0	0	1	0
Shangani	0	1	17	2	Mtopepo	0	0	1	1
Mtoni	1	0	17	0	Kidatu	0	0	1	0
Rahaleo	0	1	16	4	Kwaalinatoo	0	0	1	0
Kiembesamaki	1	0	16	0	Karakana	0	0	1	1
Mlandege	2	0	14	4	Welezo	0	0	1	1
Bububu	1	0	13	0	Kizimbani	0	0	1	0
Muembe ladu	1	0	12	3	Pete	0	0	1	0
Mombasa	0	0	10	1	Misufini	0	0	1	0
Sebleni	1	0	9	1	Gamba	0	0	1	0
Fuoni kijitoupele	0	0	8	1	Kitope	0	0	1	0
Kilimahewa juu	0	0	8	8	Kiwengwa	0	0	1	0
Kilimani	2	0	8	3	Mwembetanga	0	0	1	0
Muembe makumbi	0	0	8	2	Kisauni	1	0	1	0
Shaurimoyo	1	0	8	4	Makadara	0	0	1	0
Mpendae	0	1	7	5	Nungwi	0	0	1	0
Magomeni	0	0	7	3	Mkokotoni	0	0	0	1
Gulioni	0	0	6	5	Kwahani	1	0	0	1
Kiponda	0	0	5	1	Kwaalamsha	0	0	0	1
Mwera	0	0	5	1	Muungano	0	0	0	1
Kilimahewa bondeni	3	0	5	1	Fujoni	0	0	0	1
Migombani	0	1	4	0	Mwanyanya	0	0	2	0
Mchangani	0	0	4	0	Chuini	0	0	2	0
Mfenesini	0	0	4	0	Tunguu	0	0	2	0
Kinyasini	0	0	4	1	Mkele	0	0	2	2
Kibweni	0	0	3	0	Sogea	0	0	2	0
Chumbuni	0	0	3	1	Kikwajuni bondeni	0	0	2	1
Miembeni	2	0	3	2	Tomondo	1	0	2	2
Kidongochekundu	0	0	3	0	Nyerere	0	0	2	0
Kianga	0	0	2	1	Magogoni	0	0	2	1

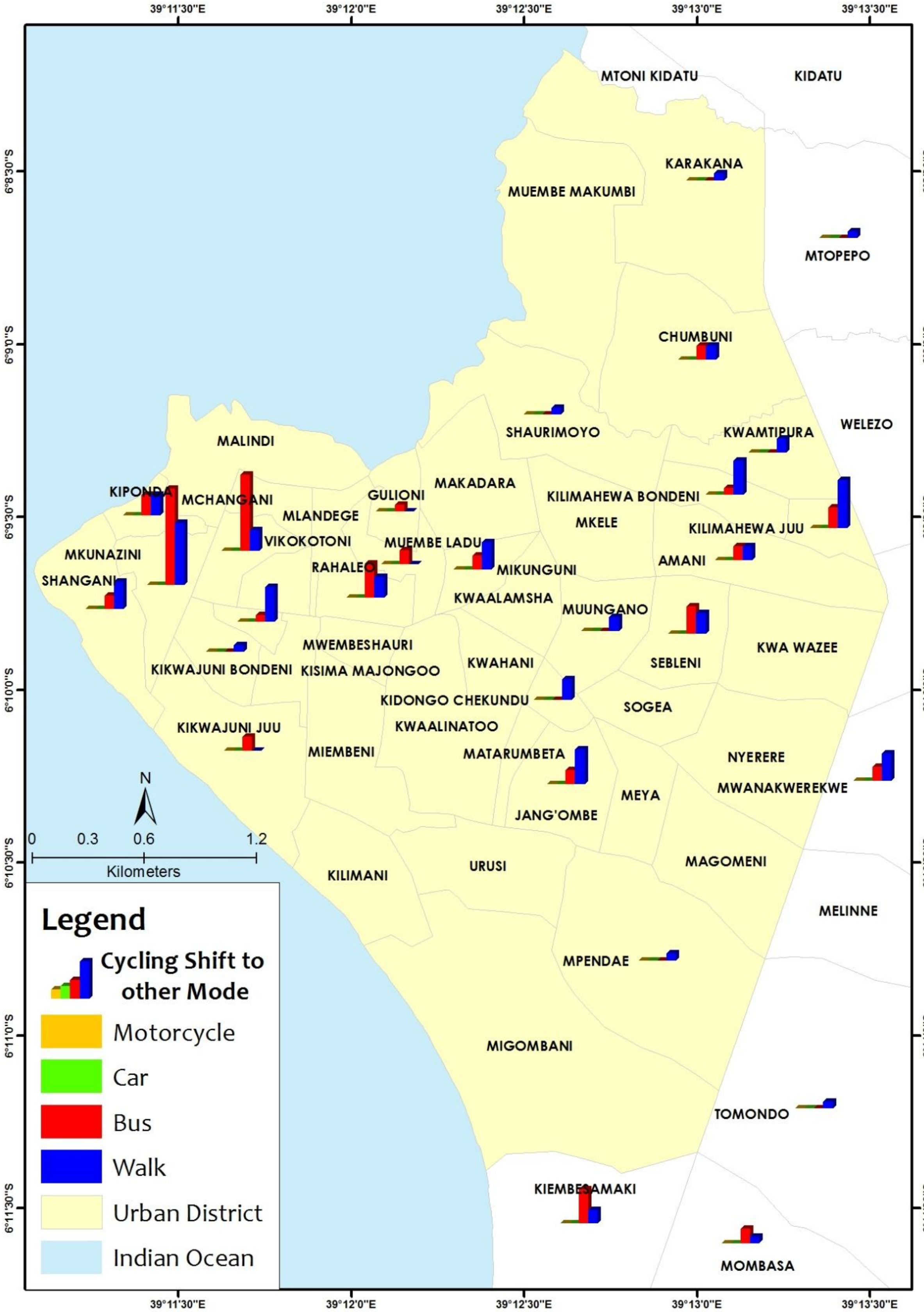
Appendix 4: Modal Shift per ward with the same destination (Work Trip)



Appendix 5: Geographic location of Modal Shift with the same destinations (Shopping Trip)

WARD	Motor	Car	Bus	Walk	WARD	Motor	Car	Bus	Walk
MWANAKWEREKWE	0	0	60	22	JANG'OMBE	0	0	1	7
MALINDI	4	0	23	13	SHAURIMOYO	0	0	1	3
MIKUNGUNI	2	0	19	14	MPENDAE	0	0	1	1
MKUNAZINI	1	0	14	23	FUONI KIJITOUPELE	1	0	1	0
BUBUBU	0	0	6	3	SHANGANI	0	0	0	0
VIKOKOTONI	0	0	5	4	MIEMBENI	0	0	1	0
AMANI	0	0	4	2	KIEMBESAMAKI	0	0	0	1
MOMBASA	0	1	3	2	NYERERE	0	0	0	1
MTONI	0	0	2	1	MKELE	0	0	0	2
MLANDEGE	0	0	2	1	KILIMAHEWA JUU	0	0	0	1
SEBLENI	0	0	2	0	NUNGWI	0	0	0	1
RAHALEO	0	0	1	1	MUEMBE MAKUMBI	1	0	0	1
MAGOMENI	0	0	1	0	GULIONI	0	0	1	2

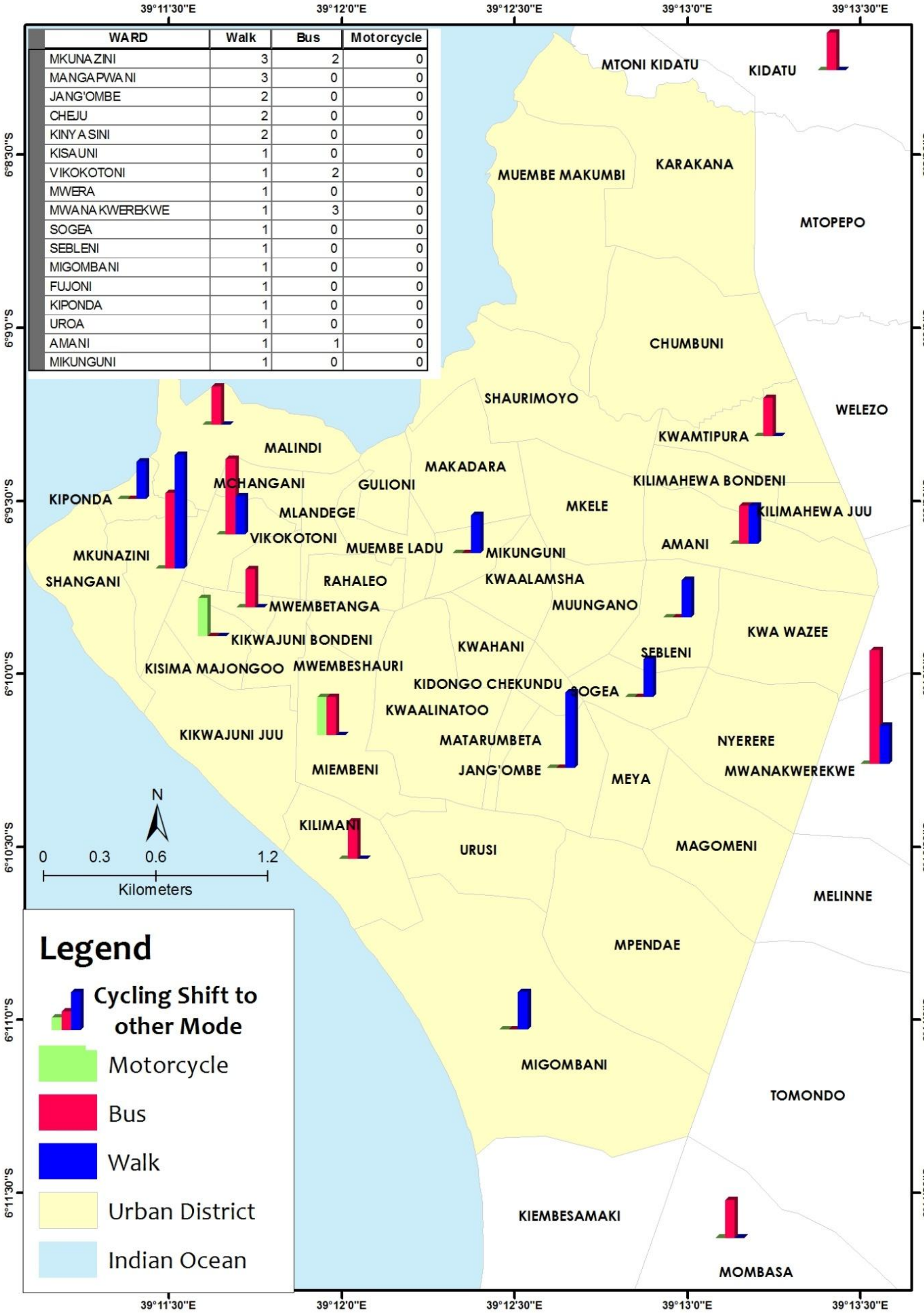
Appendix 6: Modal Shift per ward with same destination (Shopping Trip)



Appendix 7: Geographic location of Modal Shift with same alternation destinations (School Trip)

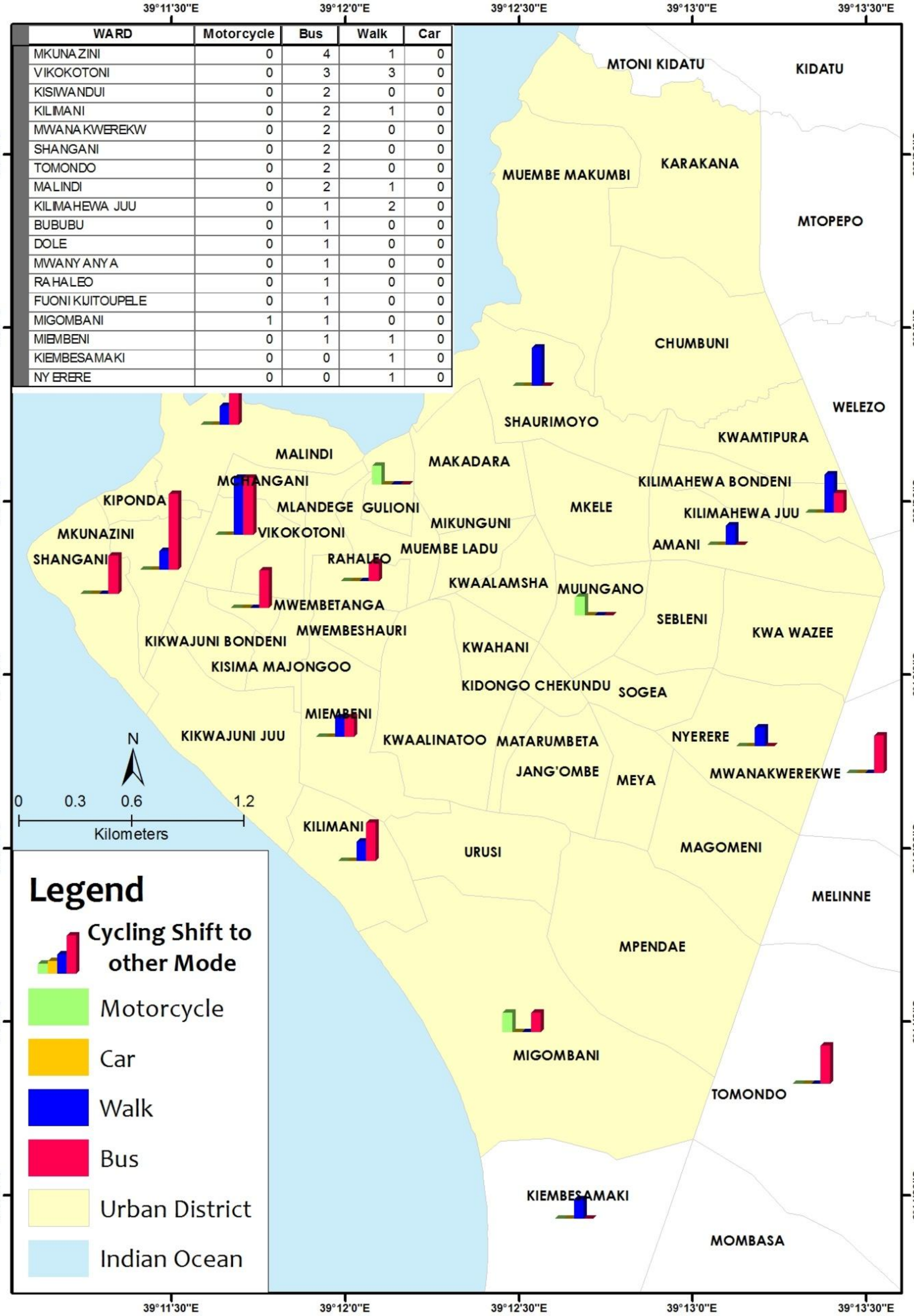
WARD	Motorcycle	Car	Bus	Walk	WARD	Motorcycle	Car	Bus	Walk
MKUNAZINI	0	0	14	8	AMANI	0	0	2	2
KILIMAHEWA JUU	0	0	3	7	MOMBASA	0	0	2	1
KISIWANDUI	0	0	1	5	KIKWAJUNI BONDENI	0	0	0	1
JANG'OMBE	0	0	2	5	KARAKANA	0	0	0	1
SHANGANI	0	0	2	5	SHAURIMOYO	0	0	0	1
KILIMAHEWA BONDENI	0	0	1	5	MPENDAE	0	0	0	1
MWANAKWEREKWE	0	0	2	4	MTOPEPO	0	0	0	1
MIKUNGUNI	0	0	2	4	TOMONDO	0	0	0	1
KIDONGO CHEKUNDU	0	0	0	3	TUNGUU	0	0	2	0
SEBLENI	0	0	4	3	FUONI KIJITOUPELE	0	0	1	0
RAHALEO	0	0	5	3	GULIONI	0	0	1	0
VIKOKOTONI	0	0	11	3	DOLE	0	0	1	0
KIPONDA	0	0	3	3	CHUKWANI	0	0	6	0
MUUNGANO	0	0	0	2	BUBUBU	0	0	4	0
KIEMBESAMAKI	0	0	5	2	DUNGA BWENI	0	0	1	0
KWAMTIPURA	0	0	0	2	MCHENZASHAURI	0	0	2	0
CHUMBUNI	0	0	2	2	MUEMBE LADU	0	0	2	0
KIKWAJUNI JUU	0	0	2	0					

Appendix 8: Modal Shift per ward with same destination (School Trip)



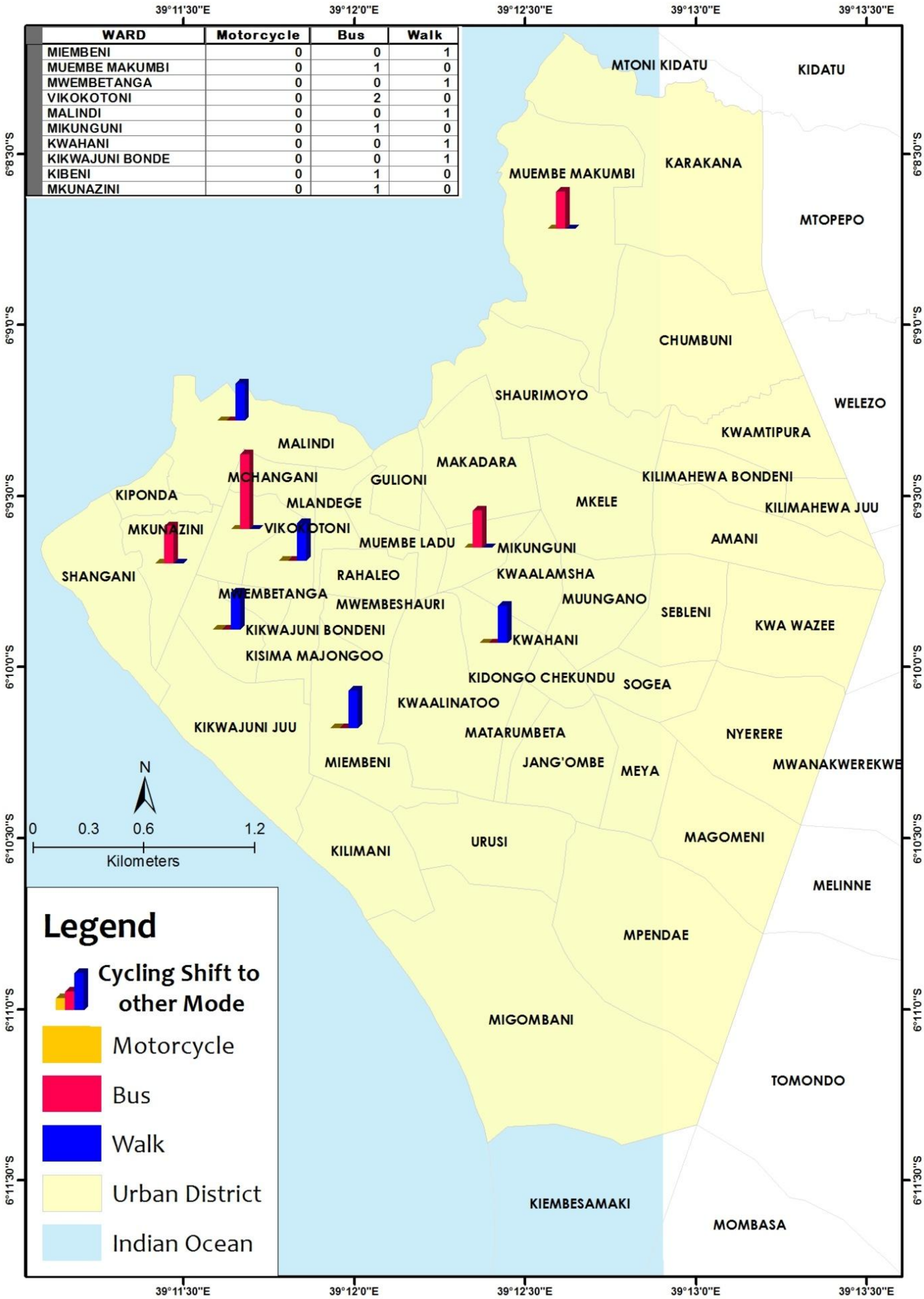
WARD	Walk	Bus	Motorcycle
MKUNAZINI	3	2	0
MANGAPWANI	3	0	0
JANG'OMBE	2	0	0
CHEJU	2	0	0
KINYASINI	2	0	0
KISAUNI	1	0	0
VIKOKOTONI	1	2	0
MWERA	1	0	0
MWANAKWEREKWE	1	3	0
SOGEA	1	0	0
SEBLENI	1	0	0
MIGOMBANI	1	0	0
FUJONI	1	0	0
KIPONDA	1	0	0
UROA	1	0	0
AMANI	1	1	0
MIKUNGUNI	1	0	0

Appendix 9: Geographic location of Modal Shift with alternative destinations (sample Work Trip)



WARD	Motorcycle	Bus	Walk	Car
MKUNAZINI	0	4	1	0
VIKOKOTONI	0	3	3	0
KISIWANDUI	0	2	0	0
KILIMANI	0	2	1	0
MWANAKWEREKW	0	2	0	0
SHANGANI	0	2	0	0
TOMONDO	0	2	0	0
MALINDI	0	2	1	0
KILIMAHEWA JUU	0	1	2	0
BUBUBU	0	1	0	0
DOLE	0	1	0	0
MWANYANYA	0	1	0	0
RAHALEO	0	1	0	0
FUONI KIJITOUPELE	0	1	0	0
MIGOMBANI	1	1	0	0
MIEMBENI	0	1	1	0
KIEMBESAMAKI	0	0	1	0
NYERERE	0	0	1	0

Appendix 10: Geographic location of Modal Shift with change destinations (sample Shopping Trip)



Appendix 11: Geographic location of Modal Shift with change destinations (Sample Shopping Trip)

For the purpose of this research we assume that both paid and self-paid employees work for 20 days in a month and for 8 hours each working day.
The average income paid employees per month = 67,809 Tsh.
The average income self employees per month = 83,901 Tsh.
The number of work hours in a month = 8*20 = 160 hours
The average wage rate in Zanzibar for paid employees = 67,809/160 = 423.81 Tsh/Hr
The average wage rate in Zanzibar for paid employees = 83,901/160 = 524.38 Tsh/Hr
One hundred United States dollars (100) = 145159.56 Tsh (Bank of Tanzania)
Therefore One United State dollar = 1451.60 Tsh
According to Gwilliam (1997)
Work trip time value = 133% of the wage rate per hour

Therefore the value of travel time for work trips in Zanzibar for paid employees
= (133/100)*423.81
= 563.67 Tsh/Hr
= 0.3883 Dollar/Hour
Therefore the value of travel time for work trips in Zanzibar for self employees
= (133/100)*524.38
= 697.43 Tsh/Hr
= 0.4805 Dollar/Hour

The median of the Household income per month = 92,863 Tsh
The number of work hours in a month = 8*20 = 160 hours
The median Household income per hour = 92,863/160 = 580.39 Tsh

According to Gwilliam (1997)
Non work trip (Adults) = 30% of household income per hour

Therefore the value of travel time for non work trip in Zanzibar
= (30/100)*580.39
= 174.12 Tsh/Hr
= 0.1199 Dollar/hour

Appendix 12: Detailed calculation of VOT

WARD	Bus ($)	Walk ($)	Motorcycle ($)	Car ($)	School ($)	Shop ($)	Work ($)	Average tot($)
MWEMBESHAURI	0.063	0.120	0.000	0.000	0.000	0.162	0.049	0.077
NYERERE	0.207	0.103	0.205	1.532	0.123	0.096	0.347	0.279
KARAKANA	0.234	0.089	0.000	0.000	0.000	0.142	0.201	0.193
MKUNAZINI	0.200	0.084	0.796	1.041	0.154	0.323	0.228	0.224
MKELE	0.175	0.082	0.000	0.000	0.030	0.000	0.142	0.120
GULIONI	0.204	0.077	0.497	0.000	0.123	0.160	0.206	0.180
MIEMBENI	0.176	0.072	0.000	0.000	0.000	0.132	0.133	0.133
SHANGANI	0.188	0.072	0.000	0.000	0.000	0.179	0.149	0.159
JANG'OMBE	0.195	0.067	0.000	0.000	0.174	0.180	0.168	0.172
MUUNGANO	0.288	0.065	0.000	0.000	0.050	0.000	0.184	0.139
MPENDAE	0.210	0.064	1.109	0.000	0.151	0.120	0.286	0.226
MALINDI	0.174	0.064	0.384	0.000	0.112	0.130	0.165	0.149
MWANAKWEREKWE	0.167	0.063	1.121	0.000	0.123	0.196	0.157	0.165
SHAURIMOYO	0.146	0.061	0.000	0.000	0.092	0.062	0.139	0.123
MUEMBE LADU	0.174	0.059	0.340	0.709	0.020	0.064	0.204	0.170
URUSI	0.208	0.054	0.000	0.000	0.177	0.010	0.188	0.157
SOGEA	0.202	0.053	0.000	0.000	0.026	0.263	0.167	0.172
MIKUNGUNI	0.171	0.053	0.225	1.190	0.145	0.311	0.142	0.165
VIKOKOTONI	0.164	0.053	0.572	0.000	0.131	0.132	0.162	0.151
MLANDEGE	0.162	0.052	0.148	0.000	0.111	0.083	0.159	0.145
KISIWANDUI	0.234	0.052	0.000	0.000	0.234	0.024	0.080	0.113
MAGOMENI	0.264	0.052	0.000	0.000	0.082	0.093	0.217	0.163
KIKWAJUNI JUU	0.164	0.050	0.512	0.000	0.108	0.133	0.170	0.152
CHUMBUNI	0.178	0.045	0.000	0.000	0.030	0.221	0.075	0.119
AMANI	0.193	0.042	0.000	0.000	0.095	0.170	0.155	0.146
MUEMBE MAKUMBI	0.153	0.040	0.627	0.000	0.226	0.159	0.252	0.214
MAKADARA	0.221	0.040	0.000	0.000	0.154	0.160	0.228	0.185
KILIMANI	0.181	0.039	0.000	0.000	0.217	0.068	0.150	0.144
MWEMBETANGA	0.190	0.038	0.000	0.000	0.000	0.017	0.154	0.099
KWAHANI	0.275	0.032	0.000	0.000	0.032	0.053	0.259	0.140
RAHALEO	0.108	0.031	0.755	0.000	0.042	0.086	0.143	0.123
KISIMA MAJONGOO	0.193	0.030	0.000	0.000	0.000	0.166	0.166	0.166
MIGOMBANI	0.217	0.023	0.000	0.000	0.000	0.119	0.181	0.164
MEYA	0.147	0.020	0.000	0.000	0.000	0.020	0.147	0.083
KIDONGO CHEKUNDU	0.183	0.018	0.000	0.000	0.180	0.081	0.159	0.132
KWAMTIPURA	0.153	0.018	0.000	0.000	0.057	0.095	0.075	0.078
KWAALAMSHA	0.179	0.017	0.000	0.000	0.020	0.015	0.179	0.109
MATARUMBETA	0.052	0.016	0.000	0.000	0.000	0.016	0.052	0.034
MCHANGANI	0.153	0.016	0.250	0.000	0.000	0.069	0.195	0.145

KILIMAHEWA BONDENI	0.319	0.015	0.000	0.000	0.020	0.242	0.000	0.197
SEBLENI	0.217	0.015	0.000	0.000	0.101	0.020	0.219	0.191
KWAALINATOO	0.113	0.013	0.000	0.000	0.000	0.013	0.113	0.063
KIPONDA	0.227	0.000	0.864	0.000	0.000	0.805	0.246	0.386
KIKWAJUNI BONDENI	0.416	0.000	0.799	0.000	0.416	0.799	0.000	0.608
KILIMAHEWA JUU	0.184	0.000	0.000	0.000	0.142	0.185	0.195	0.184

Appendix 13: socioeconomic value of cycling by mode and purpose

Note: All zero values are wards which did not have any departure of cyclists who intend to substitute their bicycle trips with alternative modes.

WARD	**Av_Sample SEV**	**Pop 2010**	**Total Bicycle**	**%_Using bike**	**Nr_using bike**	**Total Trips**	**Total Pop_SEV**
AMANI	0.15	6440	925.9	2.8	25.7	30.9	4.5
CHUMBUNI	0.12	12105	1740.5	8.3	145.0	174.0	20.7
GULIONI	0.18	2810	404.0	17.4	70.3	84.3	15.2
JANG'OMBE	0.17	6851	985.0	21.4	211.1	253.3	43.7
KARAKANA	0.19	7182	1032.6	9.4	96.7	116.0	22.3
KIDONGO CHEKUNDU	0.13	2581	371.1	9.4	34.7	41.7	5.5
KIKWAJUNI BONDENI	0.61	2835	407.6	9.4	38.2	45.8	27.8
KIKWAJUNI JUU	0.15	2884	414.7	13.3	55.3	66.3	10.1
KILIMAHEWA BONDENI	0.20	5408	777.6	25.0	194.4	233.3	46.0
KILIMAHEWA JUU	0.18	3941	566.6	9.4	53.0	63.7	11.7
KILIMANI	0.14	3412	490.6	9.4	45.9	55.1	7.9
KIPONDA	0.39	2238	321.8	9.4	30.1	36.1	13.9
KISIMA MAJONGOO	0.17	4845	696.6	9.4	65.2	78.3	13.0
KISIWANDUI	0.11	1048	150.7	9.4	14.1	16.9	1.9
KWAALAMSHA	0.11	4041	581.0	9.4	54.4	65.3	7.1
KWAALINATOO	0.06	5992	861.5	9.4	80.6	96.8	6.1
KWAHANI	0.14	4998	718.6	9.4	67.3	80.7	11.3
KWAMTIPURA	0.08	10709	1539.7	9.4	144.1	173.0	13.4
MAGOMENI	0.16	12772	1836.4	7.4	136.0	163.2	26.7
MAKADARA	0.19	6284	903.5	9.4	84.6	101.5	18.8
MALINDI	0.15	4064	584.3	6.5	37.9	45.4	6.8

MATARUMBETA	0.03	3102	446.0	9.4	41.8	50.1	1.7
MCHANGANI	0.14	2667	383.5	9.4	35.9	43.1	6.2
MEYA	0.08	4025	578.7	9.4	54.2	65.0	5.4
MIEMBENI	0.13	6139	882.7	4.8	42.0	50.4	6.7
MIGOMBANI	0.16	16393	2357.0	9.4	220.6	264.8	43.4
MIKUNGUNI	0.16	3597	517.2	3.7	19.0	22.8	3.8
MKELE	0.12	7125	1024.4	9.4	95.9	115.1	13.8
MKUNAZINI	0.22	4106	590.4	9.4	55.3	66.3	14.9
MLANDEGE	0.14	2561	368.2	9.4	34.5	41.4	6.0
MPENDAE	0.23	14104	2027.9	20.5	416.0	499.2	112.9
MUEMBE LADU	0.17	3858	554.7	2.9	15.8	19.0	3.2
MUEMBE MAKUMBI	0.21	9531	1370.4	9.4	128.3	153.9	32.9
MUUNGANO	0.14	5744	825.9	9.4	77.3	92.8	12.9
MWANAKWEREKWE	0.16	24953	3587.7	9.4	335.9	403.0	66.4
MWEMBESHAURI	0.08	2434	350.0	9.4	32.8	39.3	3.0
MWEMBETANGA	0.10	3220	463.0	9.4	43.3	52.0	5.1
NYERERE	0.28	15203	2185.9	9.4	204.6	245.5	68.6
RAHALEO	0.12	2309	332.0	9.4	31.1	37.3	4.6
SEBLENI	0.19	5475	787.2	9.4	73.7	88.4	16.9
SHANGANI	0.16	4644	667.7	9.4	62.5	75.0	11.9
SHAURIMOYO	0.12	9602	1380.6	41.4	571.3	685.5	84.1
SOGEA	0.17	5313	763.9	7.1	54.6	65.5	11.3
URUSI	0.16	14454	2078.2	9.4	194.5	233.4	36.6
VIKOKOTONI	0.15	2087	300.1	1.4	4.3	5.2	0.8

Appendix 14: Values for the calculation of the SEV for the population (Second order)

1

Nambari

Siku ilipofanyika utafiti huu

Siku	Mwezi	Mwaka

Muda	Saa	Dakika
Am		
Pm		

Muulizaji	
Msimamizi	
Kodi ya eneo	

2

Anuani ya nyumba

		Kodi
Mkoa		
Wilaya		
Shehia		
Mtaa		

3

Mueonekano wa anaehojiwa

M'mme ☐ M'ke ☐ Miaka ☐☐

Mkuu wa familia

Ndio ☐ Hapana ☐

4

Elimu

Hana elimu	☐	sekondari	☐
Chekechea	☐	Chuo kikuu	☐
Primari	☐	Nyenginezo	☐

5

Idadi ya watu wanaoishi nyumbani kwako

	Jumla		Chini ya miaka 6		Miaka 6 na zaidi: M'kazi		M'funzi		Nyengine
M'me		=		+		+		+	
M'mke		=		+		+		+	

Ajira ya mwendesha baiskeli — 6

Amejiajiri ☐ Ameajiriwa ☐
Mfanyakazi wa ndani ☐ Mstaafu ☐
Hajaajiriwa ☐ Mwanafunzi ☐
Other ☐
____

Kama umeajiriwa(aina ya ajira) — 7

Serekalini ☐ Binafsi ☐

Kipato cha nyumba kwa ujumla — 8

Chini ya 70000 ☐ 130001 - 160000 ☐
70001 - 100000 ☐ 160001 - 190000 ☐
100001 - 130000 ☐ Zaidi ya 190000

Umilikaji na upatikanaji wa vyombo — 9

Pikipiki ☐ Dala Dala ☐
Gari binafsi ☐ Baiskeli ☐
Taxi ☐ Ingine ☐
____

Mwanzo wa safari

10

Eneo		Anuani	
1. Nyumbani	☐	Mkoa	
2. Kazini	☐	Wilaya	
3. Skuli	☐	Shehia	
4. Msikitini/Kanisani	☐	Mtaa	
5. Ingine	☐		

Muda wa kuondoka ☐☐ ☐☐

Sehemu ya kwanza uliyoenda jana na baiskeli

11

D1

Eneo			Anuani ya eneo	
1. Nyumbani		☐	Mkoa	
2. Kazini		☐	Wilaya	
3. Sokoni :	kuuza ☐	Kununua ☐	Shehia	
			Mtaa	
4. Skuli		☐		
5. Ingie		☐		
Muda wa kuwasili		☐☐	☐☐	

Taarifa kuhusu safari

Muda wa kuondoka ☐☐ ☐☐

Aina ya usafiri ☐ Muda wa safari (dk) ☐

12

D2

Eneo			Anuani ya eneo	
1. Nyumbani		☐	Mkoa	
2. Kazini		☐	Wilaya	
3. Sokoni :	kuuza ☐	Kununua ☐	Shehia	
			Mtaa	
4. Skuli		☐		
5. Ingie		☐		
Muda wa kuwasili		☐☐	☐☐	

Taarifa kuhusu safari

Muda wa kuondoka ☐☐ ☐☐

Aina ya usafiri ☐ Muda wa safari (dk) ☐

13

D3

Eneo			Anuani ya eneo	
1. Nyumbani		☐	Mkoa	
2. Kazini		☐	Wilaya	
3. Sokoni :	kuuza ☐	Kununua ☐	Shehia	
			Mtaa	
4. Skuli		☐		
5. Ingie		☐		
Muda wa kuwasili		☐☐	☐☐	

Taarifa kuhusu safari

Muda wa kuondoka ☐☐ ☐☐

Aina ya usafiri ☐ Muda wa safari (dk) ☐

Mbadala wa usafiri

14

Kama usingekuwa na baiskeli ungetumia njia gani ya usafiri kwa safari yako ya jana?

Pikipiki	☐	Miguu	☐
Gari binafsi	☐	Nyengine	☐
Taxi	☐	________________	
Dala Dala	☐		

Mbadala wa sehemu ambazo ungekwenda

15

Kama jana usingetumia baiskeli jee ungebadilisha sehemu za kwenda?

Ndio ☐ Hapana ☐

D1

Eneo			Anuani ya eneo	
1. Nyumbani		☐	Mkoa	
2. Kazini		☐	Wilaya	
3. Sokoni :	kuuza ☐	Kununua ☐	Shehia	
			Mtaa	
4. Skuli		☐		
5. Ingie		☐		

Taarifa kuhusu safari

Aina ya usafiri ☐ Muda wa safari (dk) ☐

Gharama ya safari(Tsh)

16

Kama jana usingetumia baiskeli jee ungebadilisha sehemu za kwenda?

Ndio ☐ Hapana ☐

D2

Eneo			Anuani ya eneo	
1. Nyumbani		☐	Mkoa	
2. Kazini		☐	Wilaya	
3. Sokoni :	kuuza ☐	Kununua ☐	Shehia	
			Mtaa	
4. Skuli		☐		
5. Ingie		☐		

Taarifa kuhusu safari

Aina ya usafiri ☐ Muda wa safari (dk) ☐

Gharama ya safari(Tsh)

17

Kama jana usingetumia baiskeli jee ungebadilisha sehemu za kwenda?

Ndio ☐ Hapana ☐

D3

Eneo			Anuani ya eneo	
1. Nyumbani		☐	Mkoa	
2. Kazini		☐	Wilaya	
3. Sokoni :	kuuza ☐	Kununua ☐	Shehia	
			Mtaa	
4. Skuli		☐		
5. Ingie		☐		

Taarifa kuhusu safari

Aina ya usafiri ☐ Muda wa safari (dk) ☐

Gharama ya safari(Tsh)

Appendix 15: Stated preference road side cyclist survey questionnaire.