Development of Equitable Algorithms for Road Funds Allocation and Road Scheme Prioritisation in Developing Countries: A Case Study of Sub-Saharan Africa

Andrew Grace Naimanye

Submitted in accordance with the requirements for the degree of Doctor of Philosophy

The University of Leeds
Institute for Transport Studies

September, 2015

The candidate confirms that the work submitted is his own and that appropriate credit has been given where reference has been made to the work of others.

Acknowledgements

The author acknowledges the enormous assistance given by the two supervisors Dr Tony Whiteing and Ms Frances Hodgson without whose guidance and support this research would not have been completed. The guidance provided at Transfer Stage by Dr John Nellthorp and Jeff Turner is acknowledged. The critique of the 'Transfer Report' by Professor Donath Mrawira, Dr Jennaro Odoki, Dr Aggrey Ningiriye and Dr Charles Adams is appreciated.

Heartfelt thanks go to the forty four international panellists for having spared time to participate in the surveys. The guidance from several experts who undertook the detailed review of the case studies is acknowledged and they include: Dr Yohane Tembo, Zambia National Road Fund Agency; Jacob Ruwa, Kenya Roads Board; Joseph Haule, Tanzania Roads Fund Board, Robert Quaye, Ghana Road Fund; Timothy Mukunyu, Ronald Namugera and Andrew Kagoda, Uganda Road Fund; Erkenwald Khiba and Günter Seydack, Namibia Road Fund Administration; and Rianus Gonteb, Namibia Roads Authority.

Dr Sion Haworth (formerly Ministry of Works and Transport, Uganda) and Dr Charles Adams (Kwame Nkrumah University of Science and Technology, Ghana) are specifically thanked for having proof read and critiqued several versions of the thesis.

I am indebted to the Board of Directors of Uganda Road Fund, Executive Director (Dr Michael Odongo) and colleagues at the Secretariat for having created a challenging environment which enabled me to come up with this novel idea; and requisite perseverance for timely completion of the research.

I particularly thank Mr. Joseph Haule, Tanzania Roads Fund Board (RFB) for facilitating a workshop in Arusha, Tanzania; which gave me the opportunity to test the findings and recommendations of the thesis with the Board and management of RFB.

My dear wife Margaret is thanked for having taken care of the children whilst I concentrated on this study; may the good Lord reward you abundantly. I am eternally grateful to my Dad and Mum for having created a nurturing environment and for their love and support throughout my education.

I dedicate this thesis to my wife and three children: Andrew, Amanda and Edward.

Abstract

Equitable allocation of resources for roads and systematic prioritisation of road projects in developing countries is important in order to enhance equality of transport opportunities and to achieve sustainable developments. This has been recognised as a research problem as it has challenged stakeholders. Existing decision systems are complex, data intensive and equity is not considered appropriately whilst data is often obsolete or unreliable. Therefore, the crux of this research is to investigate and develop new approaches with specific emphasis on Sub-Saharan Africa (SSA).

This thesis offers a distinctive contribution to knowledge by proposing new equity-centred algorithms, Goal Programming (GP) models, formulae and frameworks/tools for SSA road sector which are based on expert opinion and literature evidence.

Following establishment of Road Funds and Road Authorities in SSA and subsequent increase in resource allocations, a clear understanding of equity in road funds allocation and road scheme prioritisation is important as road transport is by far the most predominant form of transport in Africa. The premise of this thesis supported by expert opinion is that there has been a historical bias towards funding of capital investment road projects at the expense of maintenance of existing roads; and road funds distribution and road scheme prioritisation is often non-systematic.

The research uses both quantitative and qualitative methods; and a two stage web-based survey. Salient road sector equity aspects analysed include funds allocation between: capital investment projects versus maintenance (macro); road network classes under maintenance (meso); and the various lower local government jurisdictions and prioritisation of competing road schemes (micro). The developed decision tools are then applied to critique road sector allocations and systems from the case study countries of Uganda, Ghana, Zambia, Kenya, Tanzania and Namibia.

The study finds that inequity and political interference are commonplace in the SSA road sector and allocation formulae are important instruments to achieve Rawlsian equity thus ensuring equality of transport opportunities and sustainability. Furthermore, the study concludes that road maintenance funding ought to be increased following country specific needs assessments. Road funds allocation and road scheme selection should be multi-criteria based prioritising economic efficiency for national roads and social equity/multi-dimensional poverty for rural roads.

Finally, it is recommended that the Rawlsian equity assessment tool, formulae, GP models and algorithms developed in this study which are based on expert identified factors and weightings (rankings); are used to mitigate the inequity in allocations and the haphazard road scheme prioritisation in SSA and other developing regions.

Table of Contents

List of Tables

List of Figures

Acronyms and Abbreviations

1G	-	First Generation
2G	-	Second Generation
AAPOR	-	American Association of Public Opinion Research
AFCAP	-	African Community Access Programme
AfDB	-	African Development Bank
AHP	-	Analytical Hierarchy Process
AICD	-	Africa Infrastructure Country Diagnostics
AIDS	-	Acquired Immune Deficiency Syndrome
APRP	-	Annual Public Roads Program
ARMFA	-	Association of Road Maintenance Funds of Africa
BAA	-	Basic Access Approach
BMJ	-	British Medical Journal
Bn	-	Billion
CBA	-	Cost Benefit Analysis
CEA	-	Cost Effective Analysis
CID	-	Coefficients of Income Distribution
CRN	-	Core Road Network
CRONEMI	-	Core Road Network Meso Level Equity Index
CSM	-	Consumer Surplus Method
DEFINITE	-	DEcisions on a FINITE set of alternatives
DETR	-	Department of Transport, Environment and the Regions (UK)
DfID	-	Department for International Development (UK)
DFR	-	Department of Feeder Roads
DfT	-	Department for Transport (UK)
dTIMS	-	Deighton Total Infrastructure Management System
DUCAR	-	District, Urban and Community Access Roads
DUR	-	Department of Urban Roads

DVLA	-	Driver and Vehicle Licensing Authority
ECIB	-	Effective Capital Investment Budget
ECLAC	-	Economic Commission for Latin America and the Caribbean
ERMB	-	Effective Road Maintenance Budget
ERTTP	-	Ethiopian Rural Travel and Transport Program
ESAL	-	Equivalent Standard Axle Loading
FY	-	Financial Year
GBP	-	Great Britain Pound
GDP	-	Gross Domestic Product
GHA	-	Ghana Highway Authority
GH₵	-	Ghana Cedis
GIS	-	Geographic Information System
GoG	-	Government of Ghana
GoT	-	Government of Tanzania
GoU	-	Government of Uganda
GP	-	Goal Programming
GRF	-	Ghana Road Fund
GRN	-	Government of the Republic of Namibia
GSS	-	Ghana Statistical Service
HDM-4	-	Highway Development and Management Model
IFRTD	-	International Forum for Rural Transport and Development
IRAP	-	Integrated Rural Accessibility Planning
IRR	-	Internal Rate of Return
KCCA	-	Kampala Capital City Authority
KDP	-	Kecamatan (sub district) Development Project
KeNHA	-	Kenya National Highways Authority
KeRRA	-	Kenya Rural Roads Authority
km	-	Kilometres
KRB	-	Kenya Roads Board

KShs	-	Kenya Shillings
KURA	-	Kenya Urban Roads Authority
KWS	-	Kenya Wildlife Services
LRA	-	Local Roads Authority
LREF	-	Local Road Equity Factor
LREI	-	Local Road Equity Index
MCA	-	Multi-Criteria Analysis
MEC	-	Macro Equity Coefficient
MEI	-	Macro Equity Index
MLEC	-	Meso Level Equity Coefficient
MLGH	-	Ministry of Local Government and Housing
MoCT	-	Ministry of Communications and Transport
MoWT	-	Ministry of Works and Transport
MPI	-	Multi-dimensional Poverty Index
MRT	-	Ministry of Roads and Transport
MTEF	-	Medium Term Expenditure Framework
NATA	-	New Approach to Appraisal
NCC	-	National Construction Council
nCRN	-	Non-core Road Network
n-CRONEMI	-	Non-core Road Network Meso Level Equity Index
NDP	-	National Development Plan
NPV	-	Net Present Value
NRB	-	National Roads Board
NRFA	-	National Road Fund Agency
NRSC	-	National Road Safety Commission
NTMP	-	National Transport Master Plan
OECD	-	Organisation of Economic Cooperation and Development
ORN	-	Overseas Road Note
OYRMP	-	One Year Road Maintenance Plan

p.a.	-	Per Annum
PAM	-	Performance Assessment Model
PCI	-	Per Capita Income
PCU	-	Passenger Car Unit
PIARC	-	World Road Association
PIR	-	Poverty Impact Ratio
PM	-	Periodic Maintenance
PMMR	-	Performance based Maintenance and Management of Roads
PMORALG	-	Prime Minister's Office for the Regional Administration and Local Government
PRA	-	Participatory Rural Appraisal
PSM	-	Producer Surplus Method
RAI	-	Rural Accessibility Index
RDA	-	Road Development Agency
RED	-	Roads Economics Decision model
RFA	-	Road Fund Administration
RFB	-	Roads Fund Board
RM	-	Routine Maintenance
RMB	-	Road Maintenance Budget
RMS	-	Road Management System
ROADSIP	-	Road Sector Investment Programme
RONET	-	Road Network Evaluation Tool
RSAWP	-	Road Sector Annual Work Plan
RSDP	-	Road Sector Development Programme (2), (3)
RTSA	-	Road Transport and Safety Agency
RUCs	-	Road User Charges
SLA	-	Sustainable Livelihood Approach
SNDP	-	Sixth National Development Plan
SSA	-	Sub-Saharan Africa

SSATPP	-	Sub Saharan Africa Transport Policy Programme
SUMINI		Sustainable Mobility Inequality Indicator
TANROADS	-	Tanzania National Roads Agency
TEE	-	Transport Economic Efficiency
TRL	-	Transport Research Laboratory
TRRL	-	Transport and Road Research Laboratory
TRSB	-	Total Road Sector Budget
TShs	-	Tanzania Shillings
UGX	-	Uganda Shillings
UK	-	United Kingdom
UN	-	United Nations
UNDP	-	United Nations Development Programme
UNRA	-	Uganda National Roads Authority
URA	-	Uganda Revenue Authority
URF	-	Uganda Road Fund
US$	-	United States Dollars
US$M	-	United States Dollars (Millions)
USA	-	United States of America
WCED	-	World Commission on Environment and Development
ZAWA	-	Zambia Wildlife Authority
ZMK	-	Zambian Kwacha
ZRA	-	Zambia Revenue Authority

Chapter One - Introduction

1.1 Aim of research

The aim of this study is to investigate and develop multi criteria equity-centred algorithms, equations, indices, formulae, decision guidance systems, Goal Programming (GP) models and frameworks; which are then recommended for the allocation of road funds and road scheme prioritisation in developing countries with specific emphasis on Sub-Saharan Africa (SSA). Similarly, the thesis attempts to develop new and fairer generic allocation and prioritisation principles cognisant of Rawlsian equity; and can be adapted to individual developing countries based on network metrics and local expert opinion.

The developed formulae and GP models which are buttressed with international expert opinion and literature review evidence; are tested by applying statistical techniques whilst interrogating road sector budgets and expenditure data from case study countries of: Uganda, Ghana, Zambia, Kenya, Tanzania and Namibia.

This thesis also critiques equity aspects of some of the existing decision support systems, frameworks, allocation formulae and road scheme selection processes used in the case study countries and proposes adjustments; consequently advocating for equality of transport opportunities and sustainable road projects in SSA. Furthermore, the transferability (relevance in SSA context) of some of the systems used in the developed world is analysed.

1.2 Rationale and motivation

Road transport is by far the most predominant form of transport for both passengers and freight in SSA and this situation is unlikely to change in the foreseeable future as alternative transport provisions are very limited.

Nearly five decades ago, Bonney and Millard (1966) highlighted four aspects of transportation research in developing countries requiring special attention namely: (i) improvements in methods of data collection, (ii) bespoke studies to precisely analyse the relationship between road construction and maintenance costs with vehicle operating costs, (iii) construction of more comprehensive transport analysis models, and (iv) systems analyses to understand the multiplier effects of transport investment in physical and financial terms. It can be deduced that the central theme running in the aforesaid research facets is to obtain more knowledge of traffic characteristics and effects of transport investments including appropriate allocation of road funds and road scheme selection to provide the transport systems necessary for development. Furthermore, it is considered that all the identified research areas are hitherto relevant to transport equity in SSA; and it can be argued that all the aforementioned research areas are interconnected with this study.

More recently, Petts (2013) observes that the issue of how much road maintenance funding should be allocated by developing countries is increasingly being recognised as a serious problem as it has challenged engineers, economists, accountants, development partners and politicians for decades as these key stakeholders rarely collectively consult on the issue and there has been limited research and comprehensive record keeping to provide concrete guidance. It can therefore be argued that there is an urgent need to develop an algorithmic approach to road funds allocation and road scheme prioritisation in order to consider equity issues adequately (particularly Rawlsian equity).

The road transport infrastructure in SSA during colonial times was essentially built primarily for exploitation of mineral and agricultural resources; the driving factor in the location of roads was to link mines, plantations and other sites for the exploitation and transportation of natural resources to ports, rather than to provide general connectivity within the region or at country level (Porter, 2002; Gwilliam, 2011). This created spatial polarisation and poor territorial cohesion; it can therefore be argued that road transport investment and road funds allocation in SSA has not been equitable from the onset. However, the developing countries should have attempted to address the inequity during the periods immediately after gaining independence. Moreover, the development partners (donor agencies) particularly the World Bank may have exacerbated the situation as they mainly fund new road projects and still prioritise port links. The colonial legacy also meant that the key decision makers in road sector departments immediately after independence were mostly expatriate staff and they may have inadvertently continued the inequitable road planning processes of their predecessors.

1.2.1 Convoluted corruption and maladministration in the road sector

According to Porter (2007), corruption in the road sector in the developing world is widespread throughout the supply chain. This view is also supported by Hawkins and Wells (2007, p.37) who posit that corruption stretches from “identification of the project through to monitoring and enforcement, operation and maintenance…[and] is a major inhibitor to improved contractual and social performance”. Similarly, the World Bank (2011a, p.vii), points out that “…dangers of fraud, corruption, and collusion plague the [road] sector worldwide…and [in] developing countries it is much more costly in terms of opportunity costs [especially for the poor] and lost economic growth". Furthermore, a recent report by OECD (2014) shows that the construction sector is one of the most corrupt; which affects equity. The 2014 Corruption Perception Index of the case study countries is analysed in Table 6-7. It is widely acknowledged that the convoluted corruption and collusion are major catalysts of the inequities in road funds allocation and road scheme prioritisation and this subsequently affects equality of transport opportunities and sustainability of road projects in SSA. The most commonly used definition of 'sustainability' is that given in the Brundtland Report (WCED, 1987) as "development that meets the needs of the present without compromising the ability of future generations to meet their own needs". Road sector sustainability is currently a major challenge in SSA.

In most SSA countries, expert opinion is that poor planning; inappropriate and uncoordinated resource allocation combined with inadequate corporate governance in road sector institutions has to some extent led to the escalation of the road maintenance backlog as governments have overly concentrated on capital investment road projects. Moreover, the relatively short political horizon of legislators often clouds logical strategic decision making, as self-interests and short term vote winning policies are sought. However, adhering to an agreed programme in accordance with a common vision encompassing equity should provide a framework for decisions and encouraging political ownership at an early stage.

Petts (op. cit., 2013) observes that highway maintenance is a much more serious burden in SSA than in most parts of the world. Moreover, during the period immediately after most SSA countries became independent in the 1960's, the road sector was poorly managed and roads deteriorated and this was further exacerbated by political turmoil and economic mismanagement in most SSA countries. However, in the last thirty years, the situation has relatively improved following road sector reforms under the World Bank's driven Road Maintenance Initiative operationalised through the Sub-Saharan Africa Transport Policy Programme (SSATPP). This has led to creation of institutions such as Road Funds, Road Authorities and changing the roles of the Ministries of Transport (Works).

Evidence in this study shows that road sector budgetary allocations have generally increased over the years especially for countries with a Road Fund; however there has been a bias towards capital investment (new roads and major rehabilitation) to the detriment of maintenance (routine and periodic works aimed at road preservation). Nonetheless, capital costs are usually higher than maintenance costs.

Road funds allocations and road scheme selection in SSA in most instances is subject to political manipulation and issues such as equality of transport opportunities and other non-monetary benefits including social equity and alleviation of multi-dimensional poverty are seldom considered appropriately. Moreover, even in circumstances where there is some semblance of equity considerations; there is limited follow up to monitor and evaluate the equity benefits in order to guide future year's road funds allocations. However, road sector governance challenges are not limited to SSA only; Castalia (2009), cited in Raballand et al., (2013), opines that throughout the world, the road sector has proven particularly prone to major governance issues and high investments in the road sector are not necessarily synonymous with efficient investments.

1.2.2 The burden of Rawlsian equity-centred road sector planning in SSA

Several studies have reported that road infrastructure evaluation and scheme prioritisation for World Bank funded schemes is undertaken solely based on economic criteria using decision support systems such as HDM-4 and RONET (Edmonds, 1983; Bradbury, 2006; Shi and Zhou, 2012). However, equity is not addressed at all in the aforesaid tools even though it has a wide definition range. Despite the use of models, it is important to bear in mind that reliability of results using prediction models is dependent on how well the data provided to the model represent the reality of the current condition and influencing factors; and how well the predictions of the model fit real behaviour (Odoki and Anyala, 2010). Although models require calibration and the results are not sacrosanct, decision makers often have a tendency of completely disregarding them and follow political guidance and this may partly be a testament to the continuing deteriorating road network in SSA; however, models are better than political guidance.

In the current economic climate characterised by budget constraints following a prolonged global recession, governments and funding agencies are requesting more stringent accountability of funds allocated to road infrastructure projects; and more detailed appraisals are being undertaken prior to investment or allocation of loans and grants. There is a need for new logical approaches in the allocation of road funds and road project selection to achieve Rawlsian equity (see Section 2.1.1.1). Prolonged inequity is likely to exacerbate poverty in society and can be a trigger for conflict. Transport can affect equality by creating fair societies or it may also cause disparities between different or within same regions (Beyazit, 2011). Transport plays a crucial role in assuring social justice in societies by distributing the "social and economic benefits that are created by both means of transport itself and also [indirectly] acts like a catalyser in supporting capabilities by linking them" (ibid., p.131).

Importantly, road infrastructure can reduce inequality and inequity if it enhances accessibility of the poor (Calderón and Servén, 2008). In SSA, it is believed that lack of good roads has played a big role in exacerbating poverty and it has been a hindrance to commerce and trade. For example, fewer than 40% of rural Africans live within two kilometres of all season roads; by far the lowest level of rural accessibility in the developing world (Gwilliam et al., 2009). Therefore, the majority of rural Africans have long distances to travel to access services which takes up time that could have been used for more productive activities. However, Edmonds (op. cit., 1983, p.120) observes that "the objective of providing a network which gives access to the majority of the [rural] population is a long way from being achieved…it seems unlikely that it ever will be". Furthermore, although a community may be in close proximity to a road, a lack of appropriate transportation services will limit the community's potential for economic growth (Raballand et al., 2009).

According to Gronau (1991), clearing the maintenance backlog in most SSA countries would require close to 5% of Gross Domestic Product (GDP) per annum if clearing is spread over 5 to 10 years; however this could potentially suffocate other critical sectors of the economy. The aforesaid notwithstanding, there is a need for a total paradigm shift in financing policy and reallocating resources from capital investment projects to maintenance in order to reduce the backlog (Serageldin, 1991). In many countries in SSA surveyed by the World Bank in 1988, there was room for such reallocation as construction (capital investment road projects) accounted for 58% of total expenditure (ibid).

In Africa, the road sector reforms have affected rural roads much less although agriculture is viewed as an engine for growth (AfDB, 2011). It is argued by Chambers (1983, 1997) and Minot et al., (2003), cited in Bryceson et al., (2008), that physical isolation sustains poverty and accentuates vulnerability. Therefore, "rural road investment is logically assumed to alleviate poverty associated with spatial isolation" (ibid., p.460). Furthermore, insufficient attention to the non-core road network is seen as a non-optimal use of resources by "user representative" Boards (Gwilliam and Shalizi, 1999). However, inadequate attention to unpaved roads may result either from a lack of adequate representation from local interest groups or the perceived non-economic nature of such roads albeit they perform social and economic functions (ibid). From the foregoing, it can be concluded that there are major Rawlsian equity challenges in the SSA road sector.

1.2.3 Road sector institutions in SSA

Road sector institutions in SSA mainly include: Ministries of Transport (Works) and of Local Government, Road Authorities, Road Funds, Road Safety Agencies, Vehicle Licensing Agencies and Transport Authorities. A Road Fund is an institution through which Road User Charges (RUCs) and other revenues (specific taxes and grants) are managed and allocated to road sector institutions and implementing agencies. Most Road Funds mainly manage financial resources for road maintenance. A first generation (1G) Road Fund is not fully independent and is usually allocated roads financial resources periodically by Government. Furthermore, most 1G Road Funds were set up by Statutory Instrument (Ministerial Order). Second Generation (2G) Road Funds are independent and able to collect and manage RUCs; and they are usually set up by Act of Parliament with majority private sector led Boards. A Road Authority is a body or implementing agency set up to manage the road network.

1.2.4 The incentive for new approaches and study genesis

The central theme of this thesis is to use Goal Programming (GP) as the method to establish allocation and road prioritisation algorithms using surveys of expert opinion to determine the weights (scores and rankings). According to Tamiz et al., (1998, p.579), “GP is a pragmatic and flexible methodology especially capable of addressing complex decision problems where several objectives as well as many variables and constraints are involved”.

About one hundred and seventy years ago, Cost Benefit Analysis (CBA) was used for project evaluation by Dupuit, a French Hydraulic Engineer, and this method has prevailed ever since. However, the conventional CBA approach does not adequately consider equity which falls into the category of indirect or wider effects of transport infrastructure projects (Thomopoulus et al., 2009). Similarly, CBA is unable to address some intangible social, environmental and strategic concerns including social exclusion policies as it requires all impacts to be monetised which can be difficult or infeasible due to limited resources (Van Wee and Geurs, 2011). It is important that alternative multi-criteria appraisal mechanisms specifically for SSA road sector are developed to supplement CBA.

Equity should be fundamental in SSA transportation and possibly much more important than the case in developed economies. According to Colantonio (2010, p.81), “basic needs and equity are consistently held as fundamental pillars of social sustainability…[and] are deemed necessary for the physiological and social survival of human beings individually and communities as a whole".

In SSA, there is now an urgent and increasing need by development partners and governments to justify road infrastructure investment to take account of socio-equity issues with the aim of alleviating poverty and rectifying some of the previous inconsiderate road funds allocation and road scheme prioritisation policies.

The complex issue which has challenged Road Fund managers hitherto is on how much to allocate to the different implementing agencies involved in road maintenance. This is particularly relevant for rural roads with very low traffic which most likely may have to be allocated a somewhat higher proportion of the fund than the contribution tariffs collected on such roads. The OECD (1994) agrees that rational allocation of road funds becomes complex with budget constraints and road maintenance remains a challenge.

This research study was conceived through the author's experience working as a Road Fund manager in Uganda which provided the opportunity to interact and share challenges with other key staff from road sector institutions and consultants in several SSA countries. The above encapsulates the fundamental rationale and motivation for this thesis envisioning and providing advocacy for equitable road transport opportunities and systematic road scheme prioritisation intended to enhance sustainability and equality; consequently alleviating multi-dimensional poverty.

1.3 Scope and research objectives

In this study, the fundamental aspiration is to analyse and delve into three key equity aspects of allocation of road funds in developing countries with particular emphasis on SSA and this leads to the establishment of the first, second and third research aim and subsequent objectives:

The first aim is to examine and critique the allocation of funds between capital investment projects (new road construction and major rehabilitation) versus maintenance (periodic and routine); this *horizontal split (latitudinal allocation)* at a global level is referred to as *strategic* or *macro-level road network equity.* The key objectives under macro-equity analyses are:

1. To determine whether an allocation framework or formula is necessary and justifiable for allocating financial resources between capital investment road projects and maintenance schemes. This is based on the review of existing literature to identify merits and de-merits of historical funds allocation between

new and existing road infrastructure projects in developing countries using case studies from SSA.

2. To develop Goal Programming (GP) models and assessment parameters which are based on empirical analysis and expert opinion; and use them to analyse and critique existing macro-equity allocations of the case study countries.
3. To demonstrate to key stakeholders such as governments, funding agencies, politicians and policy makers that continued prioritisation of expenditure on capital investment road projects at the expense of maintenance of existing road infrastructure gradually leads to an overall increase in maintenance backlog, higher vehicle operating costs and is not equitable as most capital investment road projects are expensive, unsustainable and usually funded from government borrowings and do not benefit the majority of the population.

Summary hypothesis: it is widely acknowledged that policy makers in most SSA countries have a strong bias towards prioritisation of expenditure on capital investment road projects to the detriment of road maintenance schemes which leads to the loss of asset value and is not fair to the majority of the people who potentially would benefit from road maintenance projects. It seems that the ideal equitable allocation between capital investment and road maintenance is not well understood; moreover, politicians are strongly biased towards the often expensive capital investment projects for short term political gains and this affects equality of transport opportunities and is a hindrance to sustainable developments. Consequently, there is a need for a re-evaluation of macro-level allocation principles and advocate for a paradigm shift; considering that it is also widely acknowledged that the Internal Rate of Return of road maintenance projects is much higher than that of new road projects. The hypothesis under the first aim is tested through experts' surveys, statistical analyses of data from case study countries and literature review evidence.

The second aim is to perform an analysis and critique of the allocation of road maintenance funds between the various road network classes. This *vertical split (longitudinal distribution)* in the maintenance budget among road network categories is termed as *meso-level road network equity.* The key objectives under meso-level equity analyses are:

1. To investigate reasons for the causation of the disagreement between key stakeholders on the allocation principles for maintenance funds under the various road network classes and determine whether the existing models and formulae include appropriate equity goals.

2. Using evidence from literature and expert opinion; propose appropriate equitable allocation algorithms, GP models and assessment parameters for allocation of road maintenance funds among the various road network classes.
3. To critique existing methods and propose improvements to the underlying principles in existing allocation systems which are inequitably biased towards national/trunk roads. Subsequently, the thesis attempts to develop new multi-criteria equitable formulae and assessment parameters which adequately consider the non-core road network and use more accurate data that is readily available, defensible, representative and easy to collect in SSA.

Summary hypothesis: there is an over emphasis in allocation of resources by Road Funds and governments in SSA towards the core or strategic highway network (based on economic efficiency criteria) at the expense of feeder, rural and provincial/district roads. However, the latter are used by the majority of the populace, are important primary networks for movement of agricultural produce and also link communities to key amenities such as employment centres, schools and health facilities. The possibly wrongly termed 'non-core road network' provides a vital social network; therefore, there is a need to re-evaluate meso-level allocation principles. This hypothesis is tested through experts' surveys, statistical analyses of data from case study countries and literature review evidence.

The third and final aim is to investigate and critique the equity aspects of road scheme prioritisation and allocation of road funds taking account of the following categories: (i) capital investment schemes; (ii) road maintenance schemes, and (iii) the various lower local government jurisdictions such as: regions, districts, provinces, municipalities, town councils, villages and sub-counties. This *diagonal split* of road infrastructure resources among lower local government jurisdictions and road scheme prioritisation amongst the various network classes considering both capital investment and road maintenance projects is referred to as *micro-level road network equity*. The key objectives under micro-equity analyses are:

1. To review using literature and case studies some of the existing prioritisation models and allocation mechanisms and provide a critique with reference to transferability (relevance in SSA context), complexity, data intensity and equity; and subsequently propose modifications and new expert based equity indices which incorporate more reliable and readily available data.

2. To develop new equity-centred multi-criteria formulae, algorithms and GP models for road scheme prioritisation and road funds allocations to the various lower local government jurisdictions.
3. To logically and systematically develop new rational and participatory prioritisation frameworks that can be used by funding agencies and policy makers in the comparative assessment of road funds allocation and road scheme selection.

Summary hypothesis: decision makers in SSA appear not to be fully conversant with the governing principles of road scheme prioritisation and often do not follow analytical results of decision support systems (tools). Furthermore, road funds allocation amongst various jurisdictions is often non-systematic, unfair and aimed at political patronage. Road schemes are in most instances selected on a political basis without stakeholder participation and devoid of equitable allocation principles such as Rawlsian ‘maximin’. Consequently, this affects equality of transport opportunities and is unsustainable. This hypothesis is tested through experts’ surveys, statistical analyses of data from case study countries and literature review evidence.

1.3.1 Research gap and benefits of this study

The problem of equitable transportation resource allocations has been recognised and according to Thomopoulus et al., (2009; p.351), “during the last two decades scholars have turned their attention to developing alternative methods [of transport impact appraisal to include equity] either as substitutes or as supplements to CBA”. Therefore, this thesis attempts to narrow the research gap by proposing new equity-centred approaches for the SSA road sector and other developing regions.

It is widely acknowledged that road scheme prioritisation in SSA is not very systematic and is often subject to political manipulation due to lack of clear and all-encompassing guidance which takes account views of all key stakeholders and experts. Raballand et al., (2010, p.47), point out that “road-building funds are usually not allocated on the basis of any systematic prioritisation arrived at through a modeling process…[and] roads are used as political tools”; which results in lack of equality of transport opportunities. In 1995, the World Bank reported that one-third of the investment in roads in SSA had been depleted due to lack of timely maintenance (Heggie, 1995). Furthermore, a survey of nine countries covering Latin America, Africa, Eastern Europe, Middle East and Asia showed that maintenance allocations varied from as high as 89% of requirements to a low of 29%; and allocations amounted to 50% of requirements (ibid). This would seem to have been a short sighted policy since a reduction of $1 from the maintenance budget of roads in poor conditions increases vehicle operating costs by about $2 to $3 (ibid).

It is considered that this research is important due to four reasons. The first is to advocate for gradual increases in funds allocation towards road maintenance projects which have been ignored for a long time. This view is also supported by Rioja (2003) who notes that empirical evidence from developing countries shows that reallocating funds from new infrastructure to maintenance can have a positive effect on GDP. Secondly, to propose fairer allocations to the various road classes (particularly rural and community access roads) which have been neglected for a long time and are often wrongly termed as the 'non-core' road network. Thirdly, to show some of the weaknesses in existing processes and propose fair multi-criteria road scheme prioritisation frameworks, algorithms and GP models which take account of non-monetary benefits such that resources are shared fairly in a Rawlsian manner by all individuals and all regions of a country; and finally to advocate for appropriate equity consideration in road funds allocation and road scheme prioritisation in SSA.

Buehler and Holtgrave (2007) observe that the fairness of formula funding is based on the notion that formulae represent an objective and evidence based approach to resource allocation. The central question as regards research benefits is: what would be the alternative without formulae and would the alternative options be acceptable especially as regards Rawlsian equity? In the absence of formulae, politicians would have to determine and negotiate detailed allocations afresh each fiscal period; and the planning managers would have to deal with pressures from recipient jurisdictions and political influence whilst allocating resources each year (Louis et al., 2003).

Despite the challenges with data collection and analysis, formulae are believed to be important policy tools particularly in the context of SSA where equity has challenged stakeholders for a long time. Based on the author's experience, road funds allocations and road scheme prioritisation is often haphazard with limited (often ignored) scientific basis thus the need to develop new equity-centred approaches.

This Rawlsian equity-centred research considers theoretical principles, takes account of expert opinion and is approached from a practical implementation perspective. The aforementioned notwithstanding, changes should be gradual and the principle of *Pareto optimality* (hold-harmless) ought to be recognised such that adjustments are not drastic.

1.4 Uniqueness and novel contribution to knowledge

To the best of the author's knowledge and experience and mindful of the literature review, experts' surveys and consultation workshop undertaken as part of this study; this is the first attempt to gain a deeper understanding of SSA road sector equity as defined by this thesis. Similarly, it is the first attempt at developing over-arching equity driven road funds allocation formulae and road scheme prioritisation process which are buttressed with expert evidence from practitioners with significant African road sector practical experience. The developed processes are then applied to critique the road sector in the case studies of Uganda, Ghana, Zambia, Kenya, Tanzania and Namibia. Furthermore, the developed Rawlsian equity assessment tool and GP models are recommended for application in SSA countries and other developing regions depending on data availability and local expert opinion.

Forty four experts with experience from seventeen countries constituted the Stage One web-based panel and fifteen of these panellists had experience from other developing regions apart from SSA. Twenty nine experts continued with the detailed Stage Two survey (aimed at gaining deeper knowledge); and their experience encompassed fifteen countries. Furthermore, three experts were interviewed face to face and in more detail to further gain in-depth knowledge relating to the objectives of this thesis.

A review of key transport policy documents from the case study countries indicates that economic efficiency and road network modernisation are suggested as the main governing factors in resource allocation. With the current levels of expenditure, the road maintenance backlog is escalating in most developing countries particularly those allocating meagre resources to road maintenance. The allocation of funds between maintenance and capital investments is not equitable as it is highly skewed towards capital investment. Furthermore, the non-core road networks (district, rural and community access roads) are not adequately funded. Indeed, there are inequities and inequalities at macro, meso and micro level.

GP models, algorithms and indices for comparative analysis of equity-centred allocative efficiency are proposed and these include; macro equity coefficient, macro equity index, and core and non-core road network meso level indices. At the micro-level, new equitable multi-criteria frameworks are proposed which are participatory, iterative and take account of salient factors including: modified equitable Rural Accessibility Index, equalisation fund, population, surface area, network metrics, Multi-dimensional Poverty Index and Human Development Index. Appropriate equity parameter ranges are proposed having been derived from the analysis of capital investment versus road maintenance expenditure in nineteen SSA countries to obtain 50th percentile (median) rates; and cognisant of expert opinions obtained from a two stage web-based survey. Similarly, new meso level equity ranges are proposed based on Road Fund allocations for the various road network classes in fifteen SSA countries using 50th percentile (median) rates; and taking account of expert opinion.

An allocation framework in the form of a spreadsheet where a panel of experts can provide scores and rankings for various criteria which can then be statistically analysed to determine allocations to the various road network classes has been developed. Using statistical techniques, sensitivity of allocations can be analysed and equity effects monitored and evaluated. Furthermore, weighted and lexicographic GP models suitable for use by decision makers in SSA countries which are based on expert opinions have been developed to mitigate the inequity in allocations and the haphazard road scheme prioritisation. The new analytical process ensures that appropriate consideration is given to equality of transport opportunities which should most probably lead to sustainable developments.

The re-contextualised GP models for road scheme prioritisation are a confluence and extension of the work undertaken in this area by Leinbach and Cromley (1983) in Indonesia; and Taplin et al., (1995) in Western Australia. However, in order to ensure that the developed GP models are *Pareto efficient*, they incorporate an implementation efficiency factor (absorption constraint), funding availability factor (cash flow constraint) and adapting the goals to SSA countries based on the expert panel identified equitable criteria. This study's combination of web-based expert surveys and GP is also a re-contextualisation of a similar technique used by Khorramshahgol and Okoruwa (1994) in Atlanta for funds allocation (investment decisions) for shopping malls but customised to the road sector in SSA albeit the Poisson gravity model is excluded to limit complexity. As pointed out by Tamiz et al., (1998, p.579), "the work of Khorramshahgol incorporates GP into decision support system[s]…for the purposes of preferential weight estimation". In the same vein, the survey process is a redesign of a similar technique used for an e-commerce infrastructure provision project in SSA undertaken by Okoli and Pawlowski (2004) but improved with a pilot case study and applied to the road sector. Furthermore, the web-based experts' survey process is similar to work undertaken in Australia in nursing education research by Gill et al., (2013).

Through this discourse, this study critiques and contributes to the illumination of the critical but often not documented practical issues in road funds allocation and road scheme prioritisation thus advocating for equality of transport opportunities. The study attempts to reduce the problem space and the findings have implications for future research in this field which may have been limited by lack of data, challenges with time lags associated with cross country data comparisons and incongruent opinions on equity. A further challenge is that there are a limited number of scholars with detailed practical experience in day to day operations of Road Funds and Road Authorities in SSA; or their findings have not been widely documented or circulated.

1.5 Research exclusions and limitations

The research has been undertaken using data from SSA countries and expert opinion was sought mainly from practitioners working as consultants, employees of Road Authorities, academicians, Road Fund staff and development partners with experience mainly in Africa. Applicability of the findings to other developing regions in the World requires careful consideration; however, the underlying principles are most likely to replicate. Case study data was collected from Anglophone countries only and the study questionnaires were in English. However, the findings are also expected to replicate in Francophone SSA countries.

Some of the findings and recommendations of this study may have limited applicability to the Republic of South Africa whose road network standards and management systems are almost at par with countries in the developed world. The study does not address the issue of optimal budgetary allocations for the road sector in relation to a country's GDP. Furthermore, data was mainly obtained for the periods after 1990 and comparability of allocations for the various years for a given country needs to be analysed cautiously as some currencies were rebased as was the case with the Zambian Kwacha. However, this has been mitigated by standardisation through the use of percentages rather than absolute figures when undertaking comparisons. In some instances, the currencies have been converted to US$ where an official central bank exchange rate was readily available.

Mindful of the cross-country nature of data collection, different road sector institutional set-ups (and maturity) with varying periods in which they have been in operation and limited data availability covering long periods; customised analyses and processes (which are variants to the standard algorithms) are used for the different case study countries. The analyses in this thesis have considered both budgets and expenditures depending on data availability from a given country; however, SSA data on network metrics and actual road sector expenditures for various activities may not be reliable and is often obsolete. There are various funding streams for the road sector and not all are captured in government budget policy statements or annual reports of Road Authorities and Road Funds. Inter year analysis of expenditures has not taken account of indexation for inflation; moreover, at the end of the Financial Year (FY), unutilised funds of implementing agencies in some countries such as Uganda are returned to Treasury. Furthermore, although the level of political interference (intervention) and its effects are evident, the magnitude of ‘equity loss’ has not been analysed. Although most findings are generalisable and the proposed indices, algorithms and frameworks will always provide a robust preliminary estimate; they need to be adjusted to suit specific country conditions. The issue of whether value for money is achieved as a result of using the new allocation principles has not been investigated in detail as the main goal of this thesis is to enhance and advocate for adequate Rawlsian equity consideration in the SSA road sector. The aforesaid notwithstanding, increased funds allocations towards maintenance is not directly proportional to improved road conditions or everyone being better off as there are many interrelated factors to consider.

The definition of equity, inequity and algorithms varies to some extent depending on discipline, contextual setting, individual opinions, beliefs, subject matter and perspective. The description and interpretation of equity and algorithms is as per this study’s definitions (see Sections 2.5 and 3.1.2 respectively). Some characteristics may not be homogeneously in sync with common usage of the terms although the underlying principles and ultimate goals are consistent. A major criticism of use of GP models is concerned with *Pareto efficiency*; the standard GP formulation can produce inefficient solutions if the target values are set too pessimistically (Tamiz et al., 1998). However, this problem has to some extent been solved by use of efficiency boundaries in the developed weighted and lexicographic GP models.

1.6 Research methodology

In the development of equitable algorithms for road funds allocation for SSA, it was considered prudent to use a variety of methods which deal with numbers as funds allocation is expressed numerically and to ensure that social impacts are considered, opinions of road sector experts ought to be obtained and examined. An ideology envisaging a fairer SSA in terms of road funds provision and road scheme prioritisation is advocated for in the research methodology. A decision process may be equitable when analysed one way but not equitable when considered in an alternative manner. The research design uses case studies from SSA comprising of Uganda, Ghana, Zambia, Kenya, Tanzania and Namibia but involves a combination of both quantitative and qualitative methods. Data was collected from both ‘academic and grey literature' and a two stage web-based expert panel was set up to seek opinions on equity as defined in this thesis. Detailed discussions (face to face interviews) were also held with three of the Stage Two experts. Furthermore, a consultation workshop was held in Arusha, Tanzania, to discuss the findings of the thesis with the Board and management of Tanzania Road Fund; and their recommendations (opinions) have been used to enrich the study conclusions. All the selected case study countries have operational Road Funds and Road Authorities and geographically cover East, West and Southern Africa. Three of the case study countries are analysed in-depth whilst the rest are covered to a lesser depth but with key equity factors considered.

1.7 Thesis layout

Following this introduction, Chapter Two provides a literature review of equity. Furthermore, transport equity is defined and categorised in the context of this thesis including some of its various measurement (analysis) methods, theoretical foundation and some typical transport equity issues are also assessed.

Chapter Three contains a literature review of algorithms by providing a definition and categorisation of algorithms, assessment of their properties and a review of their use in road funds allocation to address equity is also carried out. Furthermore, a critique of formula based allocations is undertaken. In the same vein, strengths and weaknesses in some of the existing decision support systems and road scheme prioritisation methods are analysed; including relevance and transferability (applicability) to SSA road sector. The literature review in Chapters Two and Three culminates in the identification of the research gap which this thesis endeavours to narrow.

Chapter Four elucidates research methodology and provides an exploration of the principles, categorisation and ethos behind some of the various research types and how to prepare a research plan or design; and the major research methods are identified. It is noted that research should generally commence with epistemology followed by ontology and subsequently methodology. Chapter Four ends with justifying the proposed research method which is the use of case studies but combining both quantitative and qualitative procedures; buttressed with expert opinion surveys.

Chapter Five examines and critiques the results of the two stage web-based survey and also discusses the sampling process. Expert opinion on key aspects of equity and road scheme prioritisation is analysed and the results are incorporated in developing formulae in Chapter Six. Similarly, the profiles and global representation of experts is highlighted including measures that were undertaken to limit attrition.

In Chapter Six, GP models, equity assessment parameters and frameworks to be used in the analysis of the case study countries are developed. Similarly, the limitations and operational boundaries of the GP models are examined. The reasons for selection of the case study countries and analysis levels are also provided.

Chapter Seven includes an in-depth analysis of road funds allocation and road scheme prioritisation in Uganda which is the pilot case study and has a 1G Road Fund.

Chapters Eight and Nine include an in-depth analysis of allocations of road funds and road scheme prioritisation for Ghana and Zambia respectively. Both countries have 2G Road Funds. However, Zambia has tendencies of a ‘third generation’ Road Fund as it manages funds for both maintenance and major capital investment projects.

In Chapters Ten and Eleven, an analysis of allocations of road funds and road scheme prioritisation for Kenya and Tanzania respectively are undertaken albeit to a lesser depth; and the same process is undertaken in Chapter Twelve for Namibia. These three case study countries operate 2G Road Funds and the critical aspects as regards equity are interrogated.

Finally, Chapter Thirteen provides conclusions to the research by reviewing the research aims and how each aim has been addressed with particular emphasis to advocating for enhancement of Rawlsian equity in the SSA road sector. The limitations of the research are elucidated and some of the resultant potential areas for further work are identified/proposed.

Chapter Two - Literature Review of Equity

2.1 Introduction

In Chapter One, the aims and specific objectives of the research were analysed and they revolve around the various salient road sector expenditure equity aspects to be examined in this study. This Chapter explores and reviews the theoretical and practical principles of equity in transport and how they can be applied in the allocation of road funds and road scheme prioritisation in developing countries with particular emphasis on SSA. The various categories of equity are reviewed to determine their relevancy and transferability in road funds allocation and road scheme prioritisation in order to advocate for equality of transport opportunities and sustainable road projects in SSA. Some of the existing commonly used appraisal methodologies which incorporate equity in road funds allocation and road investment decisions are also reviewed. The analysis in this chapter also considers the intrinsic challenges in the measurement of equity and its subjectivity. Furthermore, a critique of existing processes and equity definitions and categories are also elucidated. The literature review confirms that equity has wide interpretations depending on contextual setting; however, the principles of Rawlsian equity are not highly prioritised in the SSA road sector. The review confirms that economic efficiency assessment through Cost Benefit Analysis (CBA) is the most commonly used method for road project appraisals in SSA albeit it does not adequately take account of non-monetary benefits such as equity. In order to satisfactorily consider equity, the review shows that road funds allocation and road scheme prioritisation is best handled using simple Multi-Criteria Analysis systems.

2.1.1 Theoretical foundation of equity

The equity theory is based on the principle that transport being a basic requirement, it should be provided at a minimum level to all citizens to avoid the exclusion of any sector (Banister, 1994). It is derived from an early traditionalist view on transport investment as a development initiator needed at the early stages in the development process for any economy to instigate a market widening effect (Button and Gillingwater, 1986).

Van Wee and Geurs (2011) observe that equity is synonymous with ‘moral judgment’ thus the ethical perspective. They further state that three theories on ethics are relevant for transport and accessibility evaluation namely: “utilitarianism, egalitarianism and sufficientarianism” (ibid., p.356). Similarly, Martens (2012) outlines some of the major theoretical underpinnings of equity (justice) which include

Rawls' theory of 'justice as fairness' and Walzer's 'Spheres of Justice' and relates these to transport.

According to Young (1994), cited in Thomopoulos et al., (2009), the three principal theories of equity include: egalitarian, utilitarian and Rawlsian; and these are further examined below:

a) **Egalitarian**: applicable where each individual has the same rights or benefits for a particular service or scheme. It ensures equality in resource allocation without necessarily involving stakeholders and is aimed at satisfying the minimum needs of sectors which are worse off.

b) **Utilitarian**: where the aim is to maximise the total welfare of the society as a whole. This is defined as the sum of individual utilities which can be used to measure the quality of resource allocation from the view point of social inclusion (Sandholm, 1999). It is based on non permanent and non quantifiable social indicators. The methods used in utilitarian equity include decentralisation, impact statements and stakeholder prioritisation. Individual preferences could also be mapped with numerical values for objective analysis. Thomopoulus et al., (2009, p.353) observe that "Utilitarianism – the underlying theory of CBA – often does not differentiate among different beneficiaries of a project or policy…[and] it does not account for the welfare loss of certain groups or regions, focussing only on the aggregate welfare".

c) **Rawlsian**: where the aim is to retain the existing status quo between those better and worse-off as much as possible, after everyone has secured their fundamental rights. Consequently, primary social and economic inequalities (liberty, opportunity and wealth) should be arranged/distributed to the greatest benefit of the less advantaged members of society (maximin).

The underlying theme throughout the equity theories above is the ultimate goal of achieving a reasonable degree of fairness. However, this thesis advocates for enhancement of Rawlsian equity in SSA road sector which is further discussed below:

2.1.1.1 Application of the fundamentals of Rawlsian equity in SSA road sector

Rawls' *Theory of Justice* posits that each person is to have an equal right to the most extensive basic liberty compatible with a similar liberty for others; and social and economic inequalities are to be arranged so that they are reasonably expected to be to everyone's advantage (Rawls, 1971, cited in Cropp, 1998, p.189). Rawls advocates for a society in which justice is paramount in the sense that all may take a fair share of the scarce resources available albeit 'fair' does not necessarily mean 'equal'. Furthermore, justice is seen as having a primary distributive goal and injustices occur when inequalities are not shared by all.

Rawls (1971), cited in De Silva and Tatam (1996, p.210), posits that equity is an issue of distributive justice, concerns what is fair and is important in the context of enhancing general welfare. In the same vein, Oyeshile (2008, p.66) observes that Rawls' 'maximin' or 'difference principle' requires that inequalities in wealth, income and authority must work to the greatest benefit of the worst off, subject to lexical priority of the 'principle of greatest equal liberty' and the 'principle of fair equality of opportunity'.

It is believed that using transport as a means of wealth redistribution in SSA is inefficient; however, this thesis argues that the underlying principles of Rawlsian equity (maximin) should be embedded in road funds allocation and road scheme prioritisation to enhance equality of transport opportunities and mitigate multi-dimensional poverty by treating people as substantive equals. Despite the challenges of the 'maximin' principle, it is a useful axiom for an egalitarian society (ibid., p.69).

2.1.2 Definition of equity in transport

In its broadest interpretation, equity can be considered to be tantamount to overall fairness. Indeed, the fundamental principle underpinning transport equity is the homogeneous treatment of all affected persons or societies by taking account of spatial, temporal and socio-demographic distributional impacts (DfT, 2011). Equity is also commonly termed as "justice", "fairness" or "cohesion" and refers to the distribution of impacts (benefits and costs) and whether that distribution is considered fair and appropriate (Bröcker et al., 2010; Litman, 2013; Monzón et al., 2013). Several scholars observe that equity, fairness and justice are usually used interchangeably depending on context, adding a further degree of construal scope (Thomopoulos et al., 2009; Bröcker et al., 2010; Van Wee and Geurs, 2011; Martens, 2012; Litman, 2013; Monzón et al., 2013). Therefore, it can be argued that equity is based on notions of fairness and social justice. However, some transportation disparities are naturally inevitable and are unavoidable (such as those caused by extreme remoteness, bad weather and very difficult terrain).

KonSULT (2012) defines equity as "equality especially between different groups in society, in opportunities to travel, costs of travel and environmental safety impacts of travel" and intergenerational equity is considered to be equivalent to sustainability. Similarly, equity is frequently interwoven with broader socio-economic or environmental objectives under the 'social sustainability' ethos (Willetts et al., 2010, Thomopoulos and Grant-Muller, 2013).

The social sustainability of road networks is strongly correlated with equity and equality in society by providing satisfactory and safe road transport linking communities with key facilities and this is more critical for inhabitants located in the remote and ‘hard to reach areas’ of SSA. Lack of good roads for long durations of the year particularly in the remote areas affects people’s ability to survive as these community roads provide critical links to health facilities, water sources and trading centres.

In practice, it can be argued that ultimate equity in road funds allocation and road scheme prioritisation is a challenging goal to achieve due to limited consideration in existing transportation planning appraisal processes and the intrinsic economic imbalances in society. According to Martens et al., (2012, p.684), “there is no clear definition in practice or theory, of what constitutes a fair distribution of benefits from transportation [particularly roads] investments; and no standards, goals or performance measures exist, against which agencies can measure progress or success in the distribution of transportation benefits”. However, it can be argued that a fair distribution and quantification of transportation benefits in practice is achievable to a reasonable extent provided that everyone is better off and the margins within the ‘better off category’ are not very wide (a reasonably level playing field).

Equity is considered from diverging views and is seldom highly prioritised in road funds allocation mechanisms and road scheme prioritisation in SSA. According to Jones and Lucas (2012, p.5), there has been a “historical oversight of the social impacts and distributional effects of transport decision making”. However, there are weaknesses with this view as regards developed economies which have to some extent embraced equity in the last fifty years unlike the situation in SSA where the marginalised communities (such as rural poor) and pedestrians are not highly prioritised in the transport planning process. Paradoxically, it may be considered that “inequalities are fair if they tend to benefit those in society who are worst off; if they produce no such benefits, they are unfair” (Walker, 1974, cited in Hillman, 1975, p.19). Despite the status quo, awareness and accentuating the equity issues in SSA transport planning and resource allocation should allow a gradual confluence of ideologies with the overarching target being to improve accessibility, mitigate spatial polarisation and improve equity assessment parameters. Furthermore, this should subsequently reduce inequality and poverty levels in the long term and would assist in offering equal transport opportunities and sustainable road developments.

In common usage, equity is often juxtaposed with equality whilst inequality is often mixed up with inequity albeit the terms differ in meaning depending on context.

Transport equity ought to be differentiated from transport equality and the aim of equity-centred transport interventions or policies should not necessarily be targeted to an absolutely ‘level playing field’ but to eliminate the unfair, excessive and avoidable disadvantages created by decision makers. Transport inequities could be classified as those possibly ‘intentional’ disadvantages created by transport interventions or policies and are avoidable, inhumane and clearly disregard the common notions of fairness. For example: provision for vehicular traffic whilst not effectively prioritising pedestrian facilities; provision of road infrastructure which separates communities, provision of toll roads without appropriate alternatives, environmental degradation and distracted access to homesteads and other amenities during road maintenance/construction.

The equity analysis in this thesis relates mainly to road funds allocation and road scheme prioritisation in developing countries with particular emphasis on SSA which encompasses 48 countries comprising of some of the poorest developing economies. Equity definition in this thesis is covered in detail in Section 2.5 and is based on three road network equity levels namely: macro, meso and micro.

It is widely acknowledged that equity is not highly considered in Cost Benefit Analysis (CBA) which is the traditional method of road scheme investment appraisal in SSA and other parts of the developing world. Whilst recognising the historically established advantages of the standard *modus operandi*, the conventional CBA approach however does not adequately take account of equity considerations which fall into the category of indirect or wider effects of transport infrastructure projects and are difficult to evaluate (Wepener et al., 2001; Thomopoulus et al., 2009; Van Wee and Geurs, 2011).

2.1.3 Categories of equity in transport

Litman (op. cit., 2013, p.4) points out that the major categories of transportation equity are: “Horizontal equity (also called fairness and egalitarianism; vertical equity with regard to income and social class – also called social justice, environmental justice and social inclusion) and vertical equity with regard to mobility need and ability (which means that transport facilities are accessible and inclusive for all users, including those with special needs)”. Furthermore, vertical equity entails the distribution of impacts between individuals and groups that differ in abilities and needs. Policies benefiting disadvantaged groups are called progressive, while those that excessively burden disadvantaged people are termed as regressive (ibid). Horizontal equity is concerned with the distribution of impacts between individuals and groups considered equal in ability and need and public policies should avoid favouring one individual or group over others (ibid). Similarly, Toutkoushian and Michael (2007) suggest that vertical equity implies the "unequal treatment of unequals" and horizontal equity is the 'equal treatment of equals'. The various categories of equity are analysed in Table 2-1 below:

Equity Description	**Features**
Horizontal equity	Comparable individuals, groups or regions should be treated in a similar way.
Vertical equity	Disadvantaged individuals, groups or regions deserve protection.
Territorial equity	Territories need to get equal funding and connectivity.
Compensation for negatively affected individuals	The principle has its starting point in the status-quo situation and implies that winners have to compensate losers.
Spatial equity	Refers to the geographical location affected by a project.
Social equity	Refers to impacts on personal, economic or social characteristics.

Table 2-1 Equity description and features (Source: adapted from Thomopoulus et al., 2009, p.356; Litman, 2013, pp.2-10)

The categories in Table 2-1 are commensurate with the equity aspects enshrined in this thesis; and the underlying principles of fairness and equality are consistent.

Horizontal and spatial equity could be considered in light of allocation of resources per given region, local authority, province or district. Vertical equity could be appraised taking account of regional and supranational network connectivity. Allocation of resources at strategic macro-level between road authorities and new road projects versus maintenance may also be classified as horizontal equity. Comparison of road schemes with reference to the social benefits of the rich and poor, rural or urban dwellers, motorised or non-motorised users and ethnic/tribal background can be categorised as vertical equity.

Table 2-2 overleaf analyses proxies of existing equity definitions to those considered in this study.

Equity types	**Research study equity proxy**	**Implications for equity and typical application**
Horizontal	Macro-level	A fair balance between maintenance and capital investment projects.
Vertical	Meso-level	Rural inhabitants should benefit from road projects. Remote and difficult terrain areas should receive adequate funding.
	Micro-level	Lower local governments should get equal minimum road funds allocations.
Territorial	Macro, meso and micro level	Roads prioritised based on connectivity both regionally and internationally.
Spatial	Macro, meso and micro level	All individuals and regions should benefit from fair road funds allocation.
Social	Macro, meso and micro level	Road scheme prioritisation should take account of social equity issues.

Table 2-2 Comparison of existing equity types to research definitions and transferability to the SSA road sector

With reference to the equity classifications in Table 2-2 above, the following section provides some typical examples of road sector equity imbalances in SSA and how they can be synchronised with the standard equity categories.

2.1.4 Equity equilibrium in SSA road sector

Lack of equity equilibrium in the SSA road sector resources allocation could take some or a combination of the following forms: (i) urban versus rural inhabitant, (ii) 'off-road' versus roadside settlement, (iii) income groups: rich (car owning household) versus poor (non-car household), (iv) mobility and accessibility levels (able bodied and mobility impaired), (v) tribe, ethnicity and religious background, (vi) procurement methods, (vii) project implementation method (contracting or force account/direct labour), (viii) maintenance versus major rehabilitation/new road projects (capital investment), and (ix) national roads versus district/provincial roads. The aforementioned categories are examined in detail below:

(i) Urban versus rural dwellers (territorial equity): SSA policy makers tend to reside in the capital cities or major urban centres and it is almost certain that they allocate significant road fund resources to benefit the urban dwellers at the expense of rural residents thus creating an equity imbalance. Furthermore, urban dwellers tend to have higher political influence when compared to rural residents. As pointed out by Dalvi (1987, p.156), in developing countries, "cars are either institutionally owned or their ownership is the prerogative of only the rich…[and] a high proportion of the national car population is concentrated in the metropolitan or capital cities". Furthermore, "rural transport facilities and resources in the [developing] world are more inequitably distributed and poorly coordinated than the facilities in the urban area" (Patankar, 1985, cited in Dalvi, 1987, p.161). However, even in urban centres in SSA cities where there is some semblance of planning; equitable access to social infrastructure is inadequate despite its importance in linking social welfare, economic development and ensuring sustainable urban communities (Brown and Barber, 2012). The aforementioned notwithstanding, there may be a justified case to consider urban dwellers at a marginally higher level than rural inhabitants purely based on economic productivity (GDP per capita contribution). As analysed by Kumar and Barrett (2008), around 33% of Africans lived in a city in 2000; and by 2030, around 50% will reside in cities. However in most cities in SSA, authorities have major challenges meeting the service demands of new urban migrants, particularly the poor. Moreover, many African cities have extended exponentially to the extent that governments are struggling to cope resulting in road network inefficiencies and congestion (peak hour spreading) is ubiquitous.

Several studies in road infrastructure investment indicate that politics and road improvements including funds allocations are interwoven (Porter, 2002; Castells and Sole-Olle, 2005). Moreover; considering cohesion, spatial and territorial equity, Dalvi (1987, p.162) points out that "the uneven spatial distribution of roads is to some extent a reflection of the poor quality of regional planning in the [developing countries]…the question of affordability, however, raises important equity issues which need to be [tackled]…".

(ii) 'Off road versus roadside settlement' (spatial equity): Porter (2002, p.285) defines 'off road' settlements as "areas away from a good gravelled road or paved road which, for at least part of each year, are inaccessible or accessible only with difficulty by motorised transport". The transport burdens for those living 'off road' are enormous and the lack of access greatly limits life chances and this creates a vicious cycle of poverty. The definition of 'off-road' as suggested by Porter could be expanded to include those remote areas that can only be accessed via rivers and lakes which are often treacherous.

(iii) Income groups - rich versus poor (egalitarian and social equity): in most SSA cities, road infrastructure resources allocation tends to favour the wealthy households that are able to have access to private cars for commuting whilst the poor people tend to walk to the commercial centres or use public transport which is often in poor condition and unreliable. It is widely acknowledged that infrastructure provision for public transport users and non-motorised users in most SSA cities and rural areas is very poor. As Sohail and Maunder (2007, p.185) point out “inadequate infrastructure provision is a major hindrance to the operation of public transport services”. For example, the mode share in Kampala the capital city of Uganda, is around 48% walk, 33% mini-buses, 10% motorcycles, 9% other, including private car (MoWT, 2013c). However, the infrastructure provision for pedestrians and minibuses is abysmal when compared with the provision for private cars. Until the provision of public transport becomes more people focused and environmentally friendly, equitable sustainable developments will remain an unachievable dream (Sohail and Maunder, 2007). There is an established link between wealth and employment status and education level. Wealth is positively correlated with mobility and poverty is negatively correlated with mobility. In most of SSA, road funds allocation and road scheme prioritisation tends to favour provision of facilities for the affluent who are usually more educated and also in employment but are generally fewer than the poor therefore creating a Rawlsian equity imbalance.

(iv) Mobility and accessibility levels (able-bodied and mobility impaired) – social equity: in SSA countries, road infrastructure resources allocation tend to favour infrastructure for the able-bodied and limited attention is paid to infrastructure for the mobility impaired whose accessibility is greatly constrained. Although legislation is in place (for example, the Disability Act in Uganda), the reality is that there is hardly any semblance of provision for the mobility impaired pedestrians or motorists thus creating an equity imbalance.

(v) Tribe, ethnicity and religious background (social equity): it is widely acknowledged that ethnicity, tribe and religion play some role in the politics of many SSA countries. Inevitably, this leads to road infrastructure resources allocations with regions of different tribes, ethnicity or religious affiliations not receiving an equitable share despite the fact that they may have the same demographics and other characteristics such as: type of terrain, network metrics, economic potential, agricultural productivity and traffic profile. As pointed out by Booth and Golooba-Mutebi (2009, p.19), the “decision to build or maintain a road here rather than there can have a tribal or ethnicity linkage”.

(vi) Procurement method (egalitarian and social equity): the procurement method adopted in the sourcing of the contractor or supervision consultant to undertake the implementation of a road infrastructure project has implications on how the social and equity objectives can be achieved. For example, in a case study undertaken in India, Indonesia, Nigeria and Kenya; Hawkins and Wells (2007, p.35) found out that “all four countries give a margin of preference in the tender process (commonly 10%) to domestic contractors…preference is also granted for the benefit of tenders using locally produced goods and services”. Although the process many not be fair, it ensures lower prices and capital flight is controlled; and the initial infrastructure monetary gains are shared by the indigenous people which enhances social equity.

(vii) Project implementation method (contracting or force account/direct labour) – social equity: the method adopted in the project execution especially for rural roads routine maintenance has an impact on equitable distribution of financial resources and social impact. Depending on the type of work, direct labour methods which offer local employment particularly for women are often promoted by development partners. Force Account works execution using methods such as ‘road gangs’, ‘lengthman system’ for routine manual maintenance has more trickledown effect in financial benefits for local residents. In SSA, road works done through contracting which in most cases are undertaken by overseas/international firms (particularly for high value road projects) mainly benefit the foreign contractor (through capital flight). However, this can be limited by adopting a procurement method which involves mandatory local sub-contracting. Force Account which is purely labour based has limitations on the types of works that can be carried out.

(viii) Maintenance versus capital investment (horizontal equity): in the SSA road sector, there is evidence of persistent capital investment bias in spending. On average, Gwilliam et al., (2009) observe that investment accounts for two-thirds of total spending on a few kilometres; leaving only one-third for maintenance (the largest part of the network in the order of 95%). Furthermore, it is suggested that based on practice elsewhere in the world, the balance between investment and maintenance should be closer to half and half (ibid). However, such expositions by Gwilliam et al., may have fundamental flaws as evidence of nearly ‘equal splits’ has not been found in the literature review undertaken as part of this research. Moreover, such an equal split does not necessarily imply that equity is achieved. Nevertheless, five experts proposed equal splits for SSA countries (see Table 5-4).

Robinson and Stiedl (2003, p.67) point out that “new investment projects are politically more desirable than maintenance works, as well as being more immediately popular with beneficiaries…[but the] imbalance between capital and recurrent priorities inevitably leads to longer term problems and wasted resources”. This view is also highlighted by Edmonds (1983, p.123) who writes that “from a psychological point of view, road construction is much more visible to the people and status bearing than road maintenance". There is need to determine an equitable balance between funding of maintenance and new road construction in order to have sustainable road projects and to ensure equality of transport opportunities.

Assuming a perfect and well performing economy without major budgetary constraints, road maintenance funds should be released as and when maintenance is required particularly for routine maintenance. However, in SSA, this is not often achieved due to constrained road sector budgets and lack of expertise to determine the network metrics and quantification of maintenance needs on a detailed and regular basis. The macro-equity issues are analysed in detail within the case studies (Chapters Seven to Twelve).

(ix) National roads versus district/provincial roads (non-core road network) – vertical and territorial equity: road infrastructure planning in SSA is dominated by political interests and focuses disproportionately on the national road network and does not take a multi-sectorial approach (i.e. decisions made by ministries of education or health are usually made without investment decisions of ministry of works) - (SSATPP, 1997). Similarly, Porter (2002) found out that politics plays a big role in the selection, alignment and prioritisation of roads across much of SSA and although roads cannot be constructed everywhere, politicians influence which roads are constructed or maintained.

In SSA countries, there is more emphasis on funds allocation towards national roads to the detriment of district and community access roads (rural roads/non-core road network) and these have "been neglected by most governments in developing countries" (Robinson and Stiedl, 2003 p.70). However, it can be argued that rural roads serve "the majority of the population" (Dalvi, 1987, p.160). Moreover, when compared to national roads, rural roads provide salient links in the social capital network (Bradbury, 2006). In contrast, expenditure on national roads due to the high volume of traffic (vehicle kilometres) is justified on CBA grounds, however this scenario may not be *Pareto-optimal* or equitable. Road sector reforms have focussed heavily on national roads with limited attention to the non-core road network. Moreover, in Uganda, district and community access roads have been often taken as the pro-poor investment (Booth and Golooba-Mutebi, 2009). The meso and micro equity issues are covered within the case studies (Chapters Seven to Twelve).

2.1.5 Section summary

In the above section, this study has analysed some of the existing equity issues in SSA road sector and attempted to synchronise them with literature review equity definitions. The theme throughout the equity definitions leans towards fairness and equal treatment of all and the main types of equity have also been examined. Horizontal and spatial road infrastructure equity could be considered in light of allocation of resources per given country region, local authority, province or district whilst vertical equity could be appraised taking account of regional and supranational network connectivity. Allocation of resources at strategic macro-level between road authorities, new road projects versus maintenance may also be considered as horizontal equity (equal treatment of equals), whilst comparison of road schemes with reference to the social benefits may be categorised as vertical equity (unequal treatment of unequals).

From the literature review, it appears that equity in relation to road funds allocation in SSA has had limited consideration. As advocated for by development partners, project investment experts and transaction advisors for development banks; economic efficiency is arguably the primary criterion for project appraisal for road schemes in SSA. There is a strong case for incorporating principles of Rawlsian equity in the SSA road sector to ensure equality of transport opportunities.

2.2 Measurement methods of equity in transport

Quantification of equity issues is challenging due to various interpretations and assessment mechanism whilst the benefits often manifest at different time horizons. According to Jones and Lucas (2012, p.6), “some have primarily short-run outcomes, where the impacts are directly associated with a transport system or policy intervention (e.g. travel time savings, collision reductions [job creation, improved access to health facilities]), while others occur over a longer term and are less direct”.

Several scholars observe that transport equity measurement and analysis is a complex phenomenon due to the various equity categories, numerous impacts and data sources and a wide range of parameters that may be considered albeit a scenario may be equitable whilst unequal and vice versa (Van Wee and Geurs, 2011; Shi and Zhou, 2012). Similarly, there is no rule of thumb or standard computation methodology of equity or “ideal” equity index (Monzón et al., 2013, p.22). In addition, varying definitions of equity can result in very different priorities (Litman, 2002); which may turn out to be unfair.

According to Van Wee and Geurs (2011, p.354), “a particular decision may seem equitable when evaluated one way but inequitable when evaluated another [way]”. Indeed, it appears that most practitioners in road funds allocation in SSA have different views of equity; albeit the ultimate goal is to achieve a reasonable degree of fairness. However, what may be equitable in one country may not be the same in a neighbouring country. Therefore, it is probable that there is no standard (overarching) rule or agreed method for transportation equity measurement in SSA. Nevertheless, an equity measurement parameter is important to ensure equality of transport opportunities and sustainable developments considering that what cannot be measured is challenging to accomplish, monitor and evaluate.

Several studies on road funds allocation in SSA have consistently shown that road funds are allocated to new road construction, network expansion and upgrade to bitumen standard with limited interest in road maintenance (Howe, 1999; Zietlow, 2011; Khan, 2012). It may be that road authorities in SSA are not advocating convincingly for increases in funds allocation for road maintenance despite its importance. In 2004, research undertaken by the South African National Roads Agency Limited (SANRAL), cited in Burningham and Stankevich, (2005, p.1), shows that "…repair costs rise to six times maintenance costs after three years of neglect and 18 times after five years of neglect" which is testament to the importance of equitable allocation of road funds between capital investment and maintenance.

Innes and Stoddard (1988, p.99) propose that "a formula can give an incorrect impression that…equity issues have been addressed simply because it contains factors which have a rough intuitive connection to such objectives". However, having an equity factor embedded in a formula is a plausible and commendable starting point albeit inclusion of an equity index or factor in a formula or algorithm does not necessarily mean that equity is addressed appropriately. The equity factors should be monitored to determine whether the intended equity goals are achieved and if they are not; consideration should be given to undertaking adjustments.

2.2.1 Examples and challenges of equity measurement

The following section analyses some of the existing equity measurement parameters (indices) and assesses their transferability (relevance) to the SSA road sector context.

A common parameter used in measurement of the degree of equality or inequality is the *Gini coefficient* and can range from 0 to 1, with 0 indicating complete income equality and 1 indicating complete income inequality (George and Shorey, 1978, Van Wee and Geurs, 2011). The *Gini coefficient* is a statistical function derived from the *Lorenz curve* and is equal to the area between the Lorenz curve and the diagonal, divided by the total area under the diagonal (George and Shorey, 1978; Delbosc and Currie, 2011; Van Wee and Geurs, 2011). The Lorenz curve is a graphical proposition of equality whilst the *Gini coefficient* is an arithmetical metric defining degree of inequality (ibid). Other factors used to consider income inequity include the '*Theil* *coefficient/index', 'Atkinson Index'* and the '*Coefficient of variation'* whilst the *Suit index* and *Gini coefficients* are also used to assess vertical equity (ibid).

The *Gini coefficient* provides an index to measure inequality and is used by the United Nations in the ranking of equality in the various countries. However, of recent scholars are of the view that it may not be an appropriate assessment parameter (as it does not very explicitly cover changes in the bottom 40%) and alternatives such as *Palma ratio* are being proposed. This thesis is more concerned with detailed assessment of the road sector expenditures in the study countries and although the *Gini coefficient* is widely used as an equity measure, it may not be a very relevant assessment parameter for equity categories as defined by the aims of this thesis. However, it can provide a general assessment of equity issues covering various sectors of the country. For example, Calderón and Servén (2008) explored the empirical relationship between infrastructure development and income inequality whilst using the *Gini coefficient* as the dependent variable. Their computation analysis based on data from 136 countries including 36 from SSA shows that the *Gini coefficient* of income inequality is strongly negatively correlated with the synthetic indices of infrastructure quantity and quality; and the indices proposed take account of power, telecommunication and roads. The quantity index variable for roads is a factored logarithm of overall road density whilst the quality index is a factor of paved road density (ibid). Furthermore, it is demonstrated that the "*Gini coefficient* is negatively correlated with quantity of infrastructure in roads (-0.53) and to quality in transportation (-0.62)" (ibid., p.22). One possible drawback of Calderón and Servén (2008) analysis is that reliability and accuracy of such large amounts of data used is a challenge given that official road density figures in most SSA often vary depending on the intended usage and source.

Using twelve case studies from China; Shi and Zhou (2012) developed complex algorithms to quantitatively measure transportation equity for different mode users, different social groups, different regions and different generations. The algorithms take account of various parameters such as: willingness to pay, number of traffic modes, social cost and compensation, extent of benefit equity, systemic entropy, price index, housing expense, personal income, life quality, environment and technology. They assess equity impacts of highway infrastructure investment and categorise them in three aspects: public involvement in and awareness of decision making, regional equity with regard to economic development differences and social economic distribution of benefits between income groups. Factors considered include: equity index, compensation coefficient and number of social groups. The equity principles as proposed by Shi and Zhou are reasonable measures; however, transferability and applicability in SSA would be challenging given the data intensiveness of the evaluation models proposed.

In Indonesia, the Kecamatan (district) Development Project (KDP) addresses equity by determining the total number of people helped per project and dividing the total funding requested by a village to correct for the correlation of project size and taking account of the number of people a project affects (Chavis, 2010). Furthermore, poorer villagers might be expected to receive more funding if the goal is to target poverty, while from an efficiency point of view funds might be channeled to more productive villages (ibid). However, the process is data intensive and costly and does not address all the intrinsic poverty issues in the sub districts and would be challenging to replicate in SSA.

Using two infrastructure projects on the Trans-European Transport Networks (TEN-Ts) namely: the Oresund Link between Denmark and Sweden and the Egnatia motorway in Greece, Thomopoulos and Grant-Muller (2013) analysed equity as a policy objective in the Sustainable Mobility Inequality Indicator (SUMINI) approach for incorporation of wider impacts into the appraisal framework. Various equity objectives were considered: (i) horizontal equity – project allocates the same benefit to all regions with similar social economic characteristics; (ii) vertical equity – project benefits more the least advantaged regions instead of the most advantaged ones; (iii) environmental equity – the project benefits environmental protection, through direct or compensatory actions and policies; (iv) regional / spatial equity – the project distributes most benefits to the least advantaged and remote regions instead of those centrally located, and (v) accessibility objective – project improves accessibility for all regions impacted. Furthermore, the Analytical Hierarchy Process (AHP) is used to provide pair wise comparison of equity types and this identifies priorities for each stakeholder concerning the various equity principles (egalitarian, utilitarianism, Rawlsian). The major weakness of the SUMINI approach is that it is data intensive and transferability (replication) in SSA context would be a major challenge.

2.2.2 Importance of improving accessibility to enhance Rawlsian equity

Another option for measuring equity impacts of transport infrastructure investment is the resultant change in accessibility among regions or population groups (Bröcker et al., 2010). Improvements in accessibility are considered in the development of algorithms and frameworks covered in Chapter Six and it is proposed that a modified Rural Accessibility Index which takes account of availability of transport services is adopted (see Table 6-3).

Martens et al., (2012) postulate that access should be distributed evenly irrespective of the difference between peoples unless convincing arguments can be provided for alternative distribution mechanism. The aforesaid notwithstanding, it is challenging to provide equitable access to all. Moreover, it is almost certain that market forces and prevailing inherent values of individualism, selfishness and consumerism have been a catalyst for inequality in society amplified by economic policies geared towards individual wealth creation and proliferation. As alluded to by Martens (2012), equality is a scenario achieved when a service or good is shared uniformly irrespective of differences between people. However, this study shows that this is not the case in most parts of SSA as regards road funds allocation and road scheme prioritisation.

In SSA, rural transport is expensive and provision of transport services in the remote and sparsely populated areas is a major challenge; moreover, sparsely populated areas have lower road densities (see Figure 6-3). Furthermore, it is uneconomical to provide regular and reliable public transport services in the remote areas and rural inhabitants often have to prearrange and hire freight trucks which can only be used for a few days in a month.

Improvement or rehabilitation of an existing rural road has a negligible impact on agricultural prices but the upgrading of a footpath to a road providing vehicle access has a potential beneficial effect that is in the order of a hundred times that of improving an existing road; this is measured in terms of the change in farm gate prices as farmers and traders shift from head loading to motorised vehicles to buy and sell their crops (Hine et al., 1983). Therefore improvement of accessibility by upgrading of footpaths and community access roads is likely to alleviate poverty and enhance Rawlsian equity. Indeed, inappropriate rural transport is a major factor contributing to the poverty of the rural population of most developing countries (Hine, 2014). From the foregoing, it can be concluded that improvements in accessibility accompanied by appropriate transport services is likely to improve Rawlsian equity in SSA particularly for rural inhabitants in remote areas.

2.2.3 Equity and poverty correlation

There is some evidence to suggest that equity to some degree is negatively correlated with poverty (most economically equitable societies have lower levels of poverty). Therefore, lack of equity is likely to exacerbate poverty (as equity decreases poverty increases and vice versa). However, poverty just like equity has a wide definition range. The World Bank (2005b, p.9) posits measures of poverty which include Poverty Impact Ratio (PIR) and Coefficient of Income Distribution (CID). PIR is the ratio of benefits of the poor to total economic benefits, CID is the ratio of number of low income persons to total number of beneficiaries or CID is the ratio of value of net benefits of low income persons to economic NPV. Furthermore CID is the value of net benefits of low income persons to the difference between economic NPV and net government income. The aforesaid measures are unidimensional and cannot be easily applied to determine the effects of transport on poverty. A better approach is to use multi-dimensional poverty taking account of health, education and standard of living (Alkire and Santos, 2010; Alkire and Foster, 2011); whilst embedding availability of transport services and accessibility as key indicators.

2.2.4 Pareto optimality and equity

When undertaking economic efficiency evaluation of resource allocations, reference is usually made to the value judgement based on *Pareto optimality* which states that economic welfare is increased if one person is made better off and no one is made worse off (George and Shorey, 1978). Welfare declines if a change results in one person becoming worse off and no one is better off. Furthermore, *Pareto criterion* states that we should recommend any policy change that makes some people better off and harms no one. In addition, the *Pareto Optimality Criterion* specifies that in any social decision problem, a *Pareto optimal* alternative should be selected (ibid). Therefore it would be prudent to bear in mind, the 'hold-harmless' principle when allocating road funds and prioritising road schemes. However, economic efficiency principle should also consider the *Kaldor-Hicks compensation principle* where if a policy change results in some people being made better off and some worse off, and if the gains of the former are sufficiently large to compensate the losers and still leave something over, then the change is deemed as an improvement (ibid). This is indeed important as economic efficiency is one of the main criteria considered in road scheme prioritisation.

According to Kirkwood (1977, p.8), there is a conflict between *Pareto optimality* and equity issues considering that: "there does not exist a continuous social utility function...which results in decisions that obey both the *Pareto Optimality* and *Equity Criteria*". In other words, aggregation of individual preferences shows the difficulties of meeting various desirable criteria simultaneously. Similarly, Edelman and Fishburn (2001) observe that a scenario can have envy-free divisions none of which is *Pareto-optimal*. It may be that economic efficiency and equity are to some extent mutually exclusive. In contrast, Brams and Fishburn (2000), using algorithms suggest that divisions that are *envy-free*, *Pareto-optimal* and *equitable* can be achieved. This is only applicable for divisions for two people and when items being divided are many.

'Fair divisions' under a variety of circumstances are intellectually demanding and important criteria can conflict (Brams et al., 2000). It is believed that this is particularly the case with road funds allocation and road scheme prioritisation in SSA and this thesis attempts to reduce the problem space. To ensure some level of equity in the allocation of road resources and to mitigate impacts in changes in formulae, Oakley (2011) observes that the UK adopts a 'damping mechanism/floor' to guarantee minimum level of funding per local authority; such that they are not worse off.

2.2.5 Section summary

In the foregoing section, the study has identified and reviewed some of the existing measurement methods of equity in transport and their inherent challenges; including transferability (relevancy) in the SSA context. The research has revealed that measurement of equity in transport is a complex phenomenon which continues to challenge researchers mainly because there are many parameters that are eligible for consideration. A better approach in assessing the effect of transport on poverty is to use a Multi-dimensional Poverty Index with transport/accessibility as an indicator. Furthermore, some examples and challenges of equity measurement have been examined and critiqued. Finally, the importance of *Pareto optimality* as an equity characteristic has been identified and discussed.

2.3 Equity rationale and corporate governance complexities

Several authors observe that equity is a fundamental pillar of social sustainability and is interlinked with social equity; which entails access to key services, facilities, opportunities including employment and that the benefits produced by transport should be shared equitably by all sections of the community (Gwilliam and Shalizi, 1996; Brown and Barber, 2012). In addition, equity also includes social cohesion/inclusion and social capital measured by such indicators as happiness, wellbeing and quality of life as key determinants (ibid). However, social capital is a diverse term that infers emotional attachments to friends and family and it is extremely important in SSA and transport is a medium and facilitator of social capital networks (Parkin, 2000; Bradbury, 2006). According to Bradbury (2006, p.81), "social cohesion, defined as social capital, is critical in order for societies to prosper by increasing people's capacity to organise for development...[albeit] social capital cannot easily be measured". However, among developed countries such as UK, some aspects of social capital seem not to be a priority for planners and policy makers. Land uses that contribute to social capital are not included within the remit of sustainability in the planning policy framework (Greed, 2012). It is probable that with the changing demographics in the developed world particularly as a result of escalating immigration, there may be a strong case for consideration of social capital factors in the planning process in order to ensure comfortable immigrant communities.

Equity in road funds allocation and road scheme prioritisation is a major issue which hitherto continues to challenge decision makers in SSA as they traverse a tight rope balancing politics with scientific judgement (if any). A possible explanation is that political instability and tendencies of autocratic governance in most SSA countries post-independence exacerbated both horizontal and vertical inequity in transport investment due to the short political horizons concomitant with the lack of confidence in government longevity. Furthermore, it is common knowledge that in many SSA countries, politicians tend to favour road infrastructure investment in regions of their ethnic origin to achieve political advantage over possible competitors in future elections. Indeed, quite often the road sector policy decisions and election manifestos are aimed at creating opportunities for patronage and continuance of the incumbent government both at national and local level.

Evidence from this research shows that appointments to the Boards of road sector institutions in many SSA countries are to a great extent politically influenced (embedded within the law) and members may be suspended or dismissed if they are non-compliant to the appointing authority albeit the official reason given for dismissal tends to be different. For example, due to some of the aforementioned governance shortcomings, the Road Development Agency (RDA) in Zambia did not have a fully operational Board during long periods in 2012 and 2013 following Board suspension. The same was the case with Uganda National Roads Authority (UNRA) for the period 2012 to 2013 following Board suspension and the Minister undertook Board responsibilities during that period in accordance with the law. Furthermore, UNRA did not have a substantive Executive Director for nearly two years and in August 2014 most of the directors were interdicted. Subsequently, a judicial Commission of Inquiry into the operations of UNRA was set up in June 2015. In the same vein, the Uganda Road Fund Board Chairman resigned in January 2014 without a logical explanation and a replacement was made in September 2014. Similarly, the Kenya Roads Board did not have a substantive Executive Director as of September 2014 following resignation of the incumbent. In Zambia, the RDA is under the President's office; and in Ghana, the Road Fund Board is headed by the Minister of Roads and Highways whilst the Board for the Ethiopia Road Fund is made up of politicians. Furthermore, the Executive Director of the Roads Authority in Ethiopia was suspended in November 2014. In Djibouti, the Road Fund appears to be over-staffed and possibly used to create employment opportunities. Interviews with some of the existing and former directors of Road Authorities and Road Funds in SSA reveal that they have to pay allegiance to the appointing authority which inevitably clouds their decision making processes and subsequently affects equality of transport opportunities which may lead to unsustainable road projects. However, politicians being involved in governance is legal and ought to be welcomed (in a controlled manner) despite some ethical challenges. The parameters and processes proposed in this thesis can mitigate some of the challenges and contribute to appropriate equity consideration.

2.3.1 Typical multi-criteria approaches used to address equity issues in transport

The following section assesses some of the multi-criteria analysis systems used to address transport equity issues and considers their relevance (applicability) in the SSA road sector context.

The main challenges of incorporating equity and social impact in transport policy and project appraisal is that they take on many forms some of which are difficult to accurately analyse (Geurs et al., 2009). In 2004, the Department for International Development prepared a guide for pro-poor transport appraisal (Overseas Road Note 22) which identifies the nature of social benefits and how they can be measured using indicators (DfID, 2004). The salient aspect of the guidance is the participatory approach at all levels in the determination of social impacts by involving "local communities, transport users and decision makers" (ibid., p.9). Nevertheless, detailed and protracted consultations with local communities are likely to be expensive especially for sparsely populated and remote areas of SSA. Furthermore, social benefits tend to be multi-dimensional and not easily quantifiable and affect individuals at varying levels depending on their needs and circumstances thus requiring detailed consultations. An example of a list of social benefits is indicated in Table 2-3 overleaf.

The World Bank proposes performance indicators for measuring equity in SSA roads to include: "percentage of population within 10km of a classified road" or "within 2hrs walking time", and "processes in place for customer/road user feedback" (SSATPP, 1999). This is essentially a method for determination and measurement of accessibility levels and the principles are consistent with the fundamentals of Overseas Road Note 22.

A better and more practical approach for SSA ought to also consider availability of transport services (a modified equitable accessibility index) as a performance indicator. From the accessibility and mobility perspective; other factors considered by the World Bank include: "average road user cost" and road density ("km/sq.km of arable land") for classified roads and community roads or population by region (ibid). Furthermore, Sohail and Maunder (2007, p.187) draw our attention to the point that, "if access to and quality of public transport in developing countries are improved, this could lead to a significant positive impact on the quality of life of the poor". Therefore, another potential equity indicator in SSA could be availability of appropriate public transport road infrastructure and its accessibility not only for mini-buses but for rickshaws, motorcycles, bicycles and wheelbarrows.

Equity impact	**Description**
Social change	Increased national identity and security, Improves government-village relations.
Impact on women	Provision of roads is liberating and provides opportunities for employment; labour based road maintenance by women enhances income and social status.
Health and nutrition	Easy access to health centres, markets and safe water sources.
Education	Easier access to schools and teachers.
Migration	Local community solidarity enhanced.
Quality of life and accessibility	Increased mobility with visible/tangible benefits.

Table 2-3 Examples of equity impacts of improvements of rural roads (Source: adapted from USAID, 1982, cited in DfID, 2004)

The Asian Development Bank (1997), cited in World Bank, (2005b, p.4) provides a way of analysing the distribution of benefits by utilising a Transport Economic Efficiency (TEE) table. The aforesaid approach requires that the net project benefits for the economy (economic net present value) are allocated to different groups affected by the project. This can be expressed as $NPV_{econ} = NPV_{fin} + (NPV_{econ} - NPV_{fin})$ where the subscripts *econ* and *fin* refer to economic and financial flows respectively (ibid). Similarly, the TEE method is also used by the UK Department for Transport in the determination of Transport User Benefits (DfT, 2011). Furthermore, the World Bank (2005b) explains that the TEE distribution analysis approaches equity by disaggregation of the net benefits and could be based on the following categories: (i) for general case: disaggregation among project operating entity, workers of the project, consumer of the project outputs, input supplier, leaders of the project and government (representing the rest of the economy); (ii) for poverty: disaggregation by income levels of the beneficiaries; (iii) for gender or ethnic groups; disaggregation by gender or ethnicity of the beneficiaries; (iv) for spatial subdivisions; disaggregation by spatial subdivisions; and (v) for international or sub-regional project: disaggregation by participating countries. It may not be possible to apply all the equity disaggregation analysis categories on all projects thus the need for new approaches.

In the same vein, Thomopoulus et al., (2009, p.358) consider that a "Multi Criteria Analysis (MCA) framework approach is considered to be a useful option regarding the need to increasingly incorporate the indirect socio-economic impacts of transport projects, including equity considerations, in the evaluation procedure". Application of a framework approach to incorporate and assess equity considerations in transport infrastructure appraisal has been used by a range of countries with a tradition in transport project evaluation introducing a framework approach: New Approach to Appraisal (NATA) in the UK, Overview of Economic Effects of Infrastructure (OEEI) in the Netherlands, Federal Transport Infrastructure Plan (FTIP) in Germany and the Benefit Index Table in Japan (ibid).

The MCA approach is used in the UK in transport scheme appraisal to take account of equity issues in the form of "Social and Distributional Impacts" analysis (DfT, 2011). The factors assessed include: user benefits, noise, air quality, accidents, security, severance, accessibility and personal affordability. Such an approach may not be appropriate in SSA given the amount of data required – for example the data sets for socio-demographic analysis include: age, gender, disability, ethnicity, faith, household tenure, household income, economic activity, car ownership, deprivation, household structure, households with dependent children, educational qualifications, benefit claimants, urban/rural character or population density – data which would be challenging to collect and evaluate in SSA due to time and costs. Furthermore, in the UK, NATA is used for road scheme appraisal which requires assessment of objectives of environment, economy, safety, accessibility and integration – these are then tabulated in an Appraisal Summary Table (DETR, 1998). A modified and 'toned down' version of NATA could be replicated in SSA albeit the environment and safety issues which are not highly prioritised in SSA would need to be considered appropriately.

Most of the countries in SSA are landlocked with poor cross-border road networks creating territorial equity challenges and trade barriers. Road infrastructure investment and funding policies at a supranational level ought to recognise the spatial distribution of impacts. Appraisal mechanisms such as Spatial Computable General Equilibrium models can be used in the regional impact analysis of spatial welfare effects of transport infrastructure investment and policies (Bröcker et al., 2010). In principle, such tools would be useful in SSA transport infrastructure investment appraisal given that there is now more regional economic integration through bodies such as East African Community, Southern Africa Development Corporation, Economic Community of West African States, and Common Market for Eastern and Southern Africa. However; there would be limitations emanating from data scarcity and accuracy; and challenges with cross-border comparisons.

2.3.2 Limitations of existing transport equity analysis methods

One major criticism of the DfID's pro-poor transport appraisal (ORN, 22) includes its inclination towards rural roads and no consideration for equity issues for urban roads which also serve poor people albeit in a different way. Another weakness is the lack of quantification mechanisms of the impacts which makes it challenging for scheme benefits comparison at a strategic level.

The main limitations to the TEE approach with reference to this thesis include: (i) inability to segregate benefits at global level (between new roads and maintenance projects), (ii) non-motorised users not specifically considered, (iii) no segregation between urban and rural benefits and lack of access to all season roads within 2km, and (iv) no consideration of road maintenance backlog removal. The major drawback of the NATA approach is that it is data intensive, complex and weak on 'equity' issues and not very appropriate in the SSA context.

2.3.3 Section summary

In the foregoing section, this study has reviewed some of the available mechanisms for assessment of equity in transportation and the key conclusion is that the standard cost-benefit analysis appraisal of road schemes does not consider equity appropriately. Therefore, there are now a growing number of tools being used to incorporate equity. A multi-criteria analysis approach is most suited to addressing equity. However, equity is a very subjective issue and methods used in the developed world as analysed in this thesis are so data intensive and they would have limited applicability (transferability) to the SSA road sector. Economic efficiency is the main determinant in project evaluations; albeit equity needs to be embedded in project appraisals to ensure equality of transport opportunities and sustainable developments.

2.4 Importance of new equity approaches for road funds allocation and road scheme prioritisation in SSA

Road transport in Africa accounts for about 80% of all freight and passenger movements (Serageldin, 1991; Zeitlow, 2011). Moreover, it is the most predominant form of transport in rural areas albeit expensive and is likely to remain so for a long time (Bullman, 1982).

It is suggested by the World Bank (2005b) that the use of pure economic indicators as decision tools can lead to potentially a vicious circle being created where investments actually widen the income gap.

According to Heggie and Vickers (1998), five principles of road fund allocation include: needs basis, ensuring economic efficiency, equity, transparency, fairness and simplicity. Equity has been demonstrated to have a significant positive impact on economic growth and reducing poverty. It has a positive effect on creating a socially fair, peaceful; and democratic society. It is thought that some of the conflicts in SSA have occurred as a result of inequality and lack of social equity.

Good road transport infrastructure in SSA has long been viewed as *sine qua non* for economic development and reduction of income inequality thus furthering equity. From a strategic policy level, May (1997) explains that transport policy objectives ought to include amongst others: equity, accessibility and sustainability. This further highlights the importance of a fair distribution of road funds. Similarly, Downs (2008, p.50) writes that; “sustainable development requires a redistribution of the positive and negative impacts of development actions (and minimisation of the latter) for greater social justice and equity”. However, in most instances, road sector development policy in SSA is more geared towards identifying positive effects and ignoring to a large extent the negative effects of development.

It has been shown by Pendakur (2005) that the cost of urban transport in SSA is a significant part of household expenditure; and where it is more than 10%, the World Bank considers it as a poverty contributory factor. Therefore, it is imperative that the criteria used for road funds allocation and appraising road investments are improved to take account of equity issues even for the urban dwellers. Transportation affects ‘equality of opportunity’ and ‘equality of outcome’, lack of which can affect access to health facilities, water sources, farmland, trade, social networks, education, employment and can also aid in the escape from environmental hazards exposure (Feitelson, 2002). Basic levels of access to the aforementioned facilities should be ensured. As local authorities and funding agencies are permitted to raise revenue through levies and general taxation, an appropriate system should be established to incorporate efficiency and equity goals (Watson, 1998). Taking account of equity issues in a whole encompassing transparent manner can increase the “quality, effectiveness and efficiency of both the transport system and other important areas of economic and social policy delivery” (Jones and Lucas, 2012, p.4). Furthermore, Thomopoulus and Grant-Muller (2013, p.324) point out that “empirical research has shown that whilst equity features in several major policy documents, it is rarely explicitly addressed in formal appraisal methods”. In the case of SSA; literature review shows that most of the transport policy documents and National Development Plans to some extent consider the importance of equity. However, it is never implemented appropriately as posited in the documents.

In 2001, a survey undertaken in rural Kenya to determine the role that transport plays in providing access to and maintenance of social networks supported the assertion of sustenance of social capital networks through transport provision and rural road investment appraisal ought to take account of social capital benefits in areas where a conventional CBA analysis does not apply (Bradbury, 2006). Moreover, several studies have revealed that the availability or un-availability of transport affects poverty levels and shapes people’s life opportunities (Robinson and Steidl, 2003; Lucas, 2006; Martens, 2012). Adequate transport provision in SSA is critical in economic empowerment by providing access to education and employment in addition to health facilities.

Most of the current road infrastructure project evaluation mechanisms rely on CBA which has shortcomings as regards equity and benefits are identified purely in monetary terms. Mackie and Nellthorp (2001), cited in Thomopoulus and Grant-Muller, (2013), highlight the weaknesses of CBA in accurately assessing environmental and redistributive effects of transport infrastructure.

Nearly fifty years ago, prudent equitable allocation of road funds in the developing world was still high on the priority list. Bonney and Millard (1966, p.191) posit that “the provision of adequate [and equitable] transport facilities and the maintenance of these is essential for economic, social and, especially, political development…[of] the developing nations of Africa, Asia and South America”. Similarly, maintenance of infrastructure such as roads is important to ensure that they do not fail before the end of the design life (TRRL, 1988). The fundamentals of economic growth theory suggest that improvements in transport infrastructure, effective and timely maintenance are interwoven with economic development (TRRL, 1988; Li and DaCosta, 2013).

2.4.1 Section summary

In the above section, this study has shown that equity is an important consideration whilst undertaking road funds allocation and prioritisation of road schemes. Equity is critical in the reduction of income inequality and poverty levels. The standard economic appraisal criteria do not appropriately take account of equity given the quantification, analysis and measurement quandaries emanating from the intangible nature of social aspects. Economic efficiency is the paramount consideration when undertaking road projects investment appraisal in SSA; however; consideration ought to be given to incorporating equity to ensure equality of transport opportunities and sustainable developments.

2.5 Research definition of equity

The research definition and interpretation of equity or fairness in this study focuses mainly on three salient Rawlsian equity aspects of road funds allocation namely: *strategic* / *macro-* equity (balance in allocation of road funds between capital investment versus maintenance); *meso* equity (vertical split between the various road network classes under maintenance) and *micro* equity (prioritisation of road schemes and allocation between various lower local government jurisdictions such as regions, provinces, districts, municipalities, town councils and sub-counties).

The proposition in this study is that equitable allocation of road funds and road scheme prioritisation in developing countries particularly SSA should be commensurate with the principles of Rawlsian equity aimed at a fair and impartial distribution of resources without undue bias towards a particular road class type, without favouring a particular region or ethnicity and devoid of political manipulation albeit ensuring that fundamental rights are secured. A fair allocation should not be based on economic efficiency alone and equity should be a major criterion in road funds allocation and road scheme prioritisation.

The split between funding of road maintenance and capital investment projects is often undertaken without a defensible scientific basis or needs assessment. Finance departments in government using the Medium Term Expenditure Framework projections tend to estimate or propose allocations to the different infrastructure interventions without taking account of the actual road network needs. The current road maintenance funds allocation practises in developing countries such as Zambia, Tanzania and Kenya albeit supposedly formulae based are purely fixed percentages (and to a some extent arbitrary and non-scientific); and they do not necessarily follow the financing strategic plans of the Road Authorities and Road Funds. Most crucially, they do not take full account of equity and sustainability issues. It is believed that there is a lot of political influence and allocations purely towards ‘vote winning’ road infrastructure; and in most instances schemes are selected by technocrats to appease their appointing authority. Similarly, it is widely acknowledged that some schemes which score poorly on economic efficiency criterion have been constructed. Moreover, allocations are skewed towards opening up of new roads rather than rehabilitation and reconstruction. As recommended by the World Bank, planning should not be targeted exclusively on capital investment road infrastructure (SSATPP, 1997). Maintaining existing road infrastructure is crucial and economically important, if not more, as adding to the capital stock, and should be part of the planning process and is a more efficient way of adding to the value of the asset. Moreover, once funds are allocated between the categories of maintenance and new projects, the distribution within each sub category is not very clear in many instances. Road Fund boards have been given the leeway to determine allocations for the various road classes within the maintenance sub-category and in the case of Uganda; there is evidence that allocations are sometimes unfairly adjusted mid-way through the FY as was the case in 2013/14 and a number of agencies were disadvantaged. Furthermore, access to the emergency (special interventions) road funds budget is political to a great extent and there is very limited scientific basis in allocations.

In developing countries such as Uganda, Zambia, Ghana, Kenya and Tanzania, when funds are allocated to new road infrastructure projects, the allocation of the qualifying road schemes is not fully transparent and normally has political inclinations. Furthermore, implementing agencies do not necessarily follow their road investment programmes and strategic plans.

This thesis ultimately advocates and targets improvements in Rawlsian equity (maximin) in road funds allocation and road scheme prioritisation in SSA considering that there have been road sector inequities for a long time; which are partly a legacy of colonialism and political interference. Examples of the inequalities and the proxies to existing equity categories addressed in this thesis are analysed in Table 2-2.

2.5.1 Identified research gap and equity limitations

The literature review on equity has revealed that there are many important factors to consider in order to achieve fair allocations. Furthermore, there are challenges in the transferability (applicability) to the SSA road sector of some of the equity analysis methods used in the developed world. This research is therefore intended to provide a new multi-criteria approach/framework for road scheme prioritisation and distribution of road funds using GP models and weights derived from expert opinion.

The gap area identified based on the literature review on equity and to be narrowed in this research is the lack of appropriate mechanisms for consideration of Rawlsian equity in SSA road sector at macro, meso and micro levels; and there is need for new equity analysis tools. With reference to the identified 'research problem space', one needs to be aware of the main aim of the research which is to develop easily understood empirically based equitable principles, algorithms and frameworks for allocation of road funds in developing countries based on expert opinion. The literature review has identified that there are several equity categories; however, there are challenges relating to uniform interpretation and applicability; and definition varies with contextual setting. Transport equity measurement is a complex phenomenon due to the various equity categories, different interpretation mechanisms, numerous impacts and data sources and a wide range of parameters to consider. Worldwide, there is no clear existing definition in practise or theory, of what constitutes a fair distribution of benefits from road schemes and no standards, goals or performance measures exist, against which agencies can measure progress or success in the distribution of transportation benefits. In the context of SSA, there is very limited literature relating to equity categories as defined by this thesis.

2.6 Chapter summary

Chapter Two has provided a review of the literature to determine a definition of equity which essentially is the distribution of impacts (benefits and costs) and whether that distribution is considered to be fair and appropriate. Equity is sometimes referred to as 'fairness', 'justice' or 'cohesion'. There is no ideal standard measure of equity and the main theories of equity include: egalitarian, utilitarian and Rawlsian. Equity plays a major role in reducing income inequality and poverty levels. However, it is a challenging 'parameter' to measure. The measurement of economic efficiency is the standard appraisal tool for road projects investment in SSA. It is now clear that policy makers ought to embed equity (particularly the Rawlsian maximin principle) in roads resources allocation tools for SSA to ensure equality of transport opportunities.

The review has shown that road infrastructure plays a crucial role in economic development and poverty eradication but it is equally clear that equity has not been highly prioritised in SSA. However, equity consideration will almost always lead to poverty reduction and lack of good roads increases income inequality. The thesis has analysed some of the available mechanisms for assessment of equity and a Multi-Criteria Analysis approach is most suited to addressing equity in SSA road funds allocation and road scheme prioritisation. Nevertheless, equity is a very subjective issue and methods used in the developed world are so data intensive and would have limited applicability (transferability) to the SSA road sector context. The analysis has shown that there is limited literature relating to extensive consideration of the equity categories as defined in the objectives of this thesis. It is further observed that politicians interfere in allocations and prioritisation decisions. The following chapter analyses algorithms, decision tools and allocation formulae and how Rawlsian equity can be appropriately embedded to ensure equality of transport opportunities and sustainable developments.

Chapter Three - Literature Review of Algorithms, Decision Support Systems and Allocation Formulae

3.1 Introduction

In Chapter Two, a critique and review of equity literature was undertaken with particular emphasis on road funds allocation and road scheme prioritisation. This Chapter explores and reviews the fundamentals and ethos of 'algorithms' and how they can be applied in the allocation of road funds and road scheme prioritisation in SSA. Furthermore, it examines ways in which algorithms can be used as tools in enabling equality of transport opportunities and sustainable developments. Some of the various categories and classification of algorithms are reviewed and a critique of algorithm (formula) based allocation processes is undertaken. Algorithms are essentially systematic problem solving processes and through the review, it is demonstrated that multi criteria formulaic allocation if appropriately used; has the potential for ensuring equity. Nevertheless, some of the existing decision support systems used in SSA are too complex, require calibration to individual country conditions and are data intensive. Furthermore, such systems do not adequately or appropriately embed principles of Rawlsian equity. The literature review shows that road funds allocation formulae should be simple and use a few factors.

3.1.1 Standard definition of algorithms

In its simplest interpretation and function, an *algorithm* is a systematic set of instructions or rules used in calculations or problem solving operations (Merriam-Webster, 2014). Similarly, Black (2007) defines an algorithm as a computable set of steps to achieve a desired result. This view is also supported by Erickson (2010) who describes algorithms as explicit, precise, unambiguous and mechanically-executable sequence of elementary instructions.

According to Burgin and Ades (2009), an algorithm provides rules to solve a problem or to perform a task. It is also noted that an algorithm is generally a procedure or formula for solving a usually complicated problem or set of problems by carrying out a precisely determined sequence of simpler, unambiguous steps (ibid). The aforesaid definitions are consistent with the fundamentals of this study's interpretation of algorithms particularly with regard to problem solving using mathematical procedures, formulae, instructions, frameworks and processes.

The crux of an algorithm is the step-by-step problem-solving process especially an established, recursive or iterative computational procedure for solving a task in a well-defined finite number of logical arithmetical or computational steps that if correctly and systematically applied will provide a solution to a mathematically determinate problem (Cohen, 1979; TRL, 1998). It can therefore be argued that if the same sets of instructions or processes are followed systematically by someone else with the requisite skills using the same assumptions and underlying fundamental principles and data sets, the same results should replicate *ceteris paribus*. Therefore, an algorithm, if applied logically and systematically within the confines of its boundaries, should be able to solve the general form of a clearly defined problem such as road funds allocation or road scheme prioritisation.

Bruno and Steiglitz (1972) suggest that the term ‘algorithm’ can be applied in various ways depending on context. It can be a process in the abstract and is often identified as a particular sequence of instructions, commands or procedures. An algorithmic problem is often outlined by describing the set of instances and ‘environment’ it must usually be applied in, and what desired properties the end result should have (ibid).

3.1.2 Research definition of algorithms

Conceptually, in the context of road funds allocation and road scheme prioritisation, algorithm definition and classification ethos as per this study covers a wide range of descriptions (parameters) which include: Goal Programming models, formulae, equations, instructions, rules, principles, decision frameworks, flow charts, figures, graphs, tables, tools, guidelines and procedures which are used when prioritising road schemes and allocating road fund resources at macro, meso and micro levels. However, the ultimate goal is always to try to ensure equality of transport opportunities and sustainable road projects in SSA.

3.1.3 Categories of algorithms

Burgin (2005) explains that algorithms are generally divided into three major classes; *sub-recursive, recursive* and *super-recursive* and they may be implemented according to different basic principles.

Table 3-1 overleaf distinguishes algorithms by implementation method and also posits potential applicability to road funds allocation in SSA.

Category	Salient features/ implementation method	Implications for equity in road funds allocation in SSA
Recursive or iterative	It calls itself repeatedly until certain conditions are met.	Minimum funds allocation per region could be a goal. Iterations are undertaken until the goal is achieved.
Logical or procedural	An algorithm may be viewed as a controlled logical deduction or process.	Logic could be: in order to receive ‘x’ amount of funds, the network length must be at least ‘y’ kilometres with a minimum population of ‘z’ inhabitants (‘x’ is a function of ‘y’ and ‘z’).
Parallel (concurrent) or Serial (sequential)	Computers sometimes execute one instruction at a time (serial algorithm); as opposed to several instructions at once (parallel algorithms). They divide the problem into smaller problems and pass them to several processors.	Parallel algorithms could take the form such as: to achieve horizontal or territorial equity; funding may not be allocated for routine maintenance on a road scheme undergoing major rehabilitation. For a serial algorithm; the step by step process could be: roads need to be gazetted as public roads prior to funding eligibility.
Deterministic or non-deterministic	Deterministic algorithms solve the problem with a predefined process. Non-deterministic algorithms must perform guesses of the best solution at each step by use of heuristics.	A deterministic algorithm would be more suitable for funds allocation as the process needs to be predefined and clear with limited guesses. The allocations should be transparent with clear processes devoid of subjectivity.
Exact or Approximate	Some algorithms reach exact solutions; others seek an approximation to the true solution.	Exact algorithms are most suited for determination of road funds allocations to ensure transparency and to limit corruption.

Table 3-1 Categorisation of algorithms by implementation method (Source: adapted from Cohen, 1979; TRL, 1998; Burgin, 2005)

The following section looks into the detailed typical application of algorithms by implementation methods described in Table 3-1 in the development of equitable allocation processes.

Recursive or iterative algorithms: participatory methods involving consultations with key stakeholders through the decision process may be considered to be typical iterative processes. The condition being sought is satisfaction of all key stakeholders as regards equity. This process is probably most suitable for rural and community access roads when analysing micro-equity (road funds allocation to the various rural settlements/villages/districts and road schemes).

Logical or procedural algorithms: all scientific allocation processes are supposed to be procedural, defensible and logical. However, in SSA there is some evidence that shows that logic is often not highly prioritised particularly when politicians are involved in road scheme selection and prioritisation. In contrast, it can be argued that politicians are being logical if they achieve their intended personal aims albeit disregarding equity. Nevertheless, logical algorithms are necessary if they can be used to achieve equity.

Concurrent or sequential algorithms: with road funds allocation formulae, it may be deemed unnecessary for the calculations to take place concurrently although decisions can take place simultaneously. As per the aims and objectives of this thesis, it is deemed prudent that algorithms follow systematically and address key issues of equity in a logical format commencing with macro-equity followed by meso-equity and finalised with micro-equity (a top - down approach).

Deterministic and non-deterministic algorithm: it is most probable that all existing formulaic allocation processes are deterministic as the procedures need to be pre-defined with clear rules to ensure transparency. Moreover, if the process is followed by another person with the appropriate competence using the same data and assumptions, the results should replicate.

Exact and approximate algorithm: in road funds allocation to achieve equity, exact and approximate algorithms can both be considered; however in order to ensure a level playing field and for replicability, algorithms should be exact.

Table 3-2 overleaf provides a differentiation of algorithms by design paradigm which is a domain in research or class of problems that requires a dedicated kind of algorithm. In addition, potential implications for equity are examined.

Categories	Design paradigm	Remarks and implications for equity
Divide and conquer	Reduces a problem to one or more smaller instances of the same problem.	Equity formulae may be broken down into simpler processes.
Dynamic programming	Optimal solution can be built from optimal solutions to sub problems.	Tackle the smallest equity problem first until the whole set is solved.
The greedy method	A 'greedy' choice can be made of what looks the best solution for the moment.	A 'greedy' choice can be made by use of 'rules of thumb'.
Linear programming	Problem is expressed as linear inequalities (attempt is made to maximise or minimise the inputs).	Goal Programming models which are an extension to linear programming are proposed (Chapter Six).
Reduction: transform and conquer	Solve a problem by transforming it into another problem (simplest transformation possible).	An equity problem may be dismantled into simpler versions for easier execution.
Using graphs	Many problems can be modeled as problems on graphs.	Graphs can be used to show the effect of equity and trends in allocations.

Table 3-2 Categorisation of algorithms by design paradigm (Source: adapted from Cohen, 1979; Burgin, 2005; Zehendner et al., 2011)

3.1.4 Properties of algorithms

According to Knuth (1998), five properties are usually considered as requirements of an algorithm: (i) finiteness (an algorithm normally completes after a finite number of steps or procedures); (ii) definiteness (each step of an algorithm must be exactly specified and the processes to be carried out must be rigorously and unambiguously defined for each case); (iii) input (quantities entered initially before the algorithm begins and these inputs are taken from specified set of objects); (iv) output (quantities resulting from inputs); and (v) effectiveness (all of the operations to be performed in the algorithm must be sufficiently basic that they can in principle be replicated in a finite length of time).

The properties outlined above are consistent with the algorithmic propositions in this study; however, a better and more comprehensive list of properties should also include: (i) simplicity (an algorithm should be easily understood), (ii) data validity (an algorithm should use readily available data that can be validated and from a reliable source), (iii) range of results (the final answer does not have to be sacrosanct, an algorithm should be able to provide a range of possible options or answers to a conundrum, (iv) stakeholder participation (algorithms should be developed with stakeholder involvement as far as it is reasonably practicable), and (v) iterative (algorithms should have condition loops).

3.1.5 History and motivation of formula (algorithm) based funds allocation

In the USA, the use of formulae to allocate federal and state funds to subordinate jurisdictions can be traced back to 'the Morrill Act' of 1862 which allocated to each state 30,000 acres of public land for each of its senators and representatives in Congress; and the land was to be sold and proceeds used to establish institutions of higher learning (Louis et al., 2003). The underlying principle of the Act was to allocate resources in a fair manner on the presumption that state representation in Congress was equitable.

In the UK, Darton et al., (2010, p.531) observe that "central government has provided a recognisable system of grants [allocation] to local authorities to support expenditure relating to national purposes [such as road infrastructure] since 1835". However, it was not until 1929 that the Local Government Act introduced a formula or algorithm to distribute its grant according to local needs and resources (ibid). Furthermore, the main aim of the formula based approach is to account for multiple local factors that drive need for services (ibid). During the recent Scottish independence referendum, one of the major issues was the continuity of the Barnett formula which has been used by the UK Treasury since 1978 in determining public expenditure for the various countries in the UK. In the 70's and 80's, the UK government used formulae to identify inner-city zones of deprivation. The variables included amongst others: car ownership, overcrowding and possession of an inside toilet. All the data were available from the national Census. Once identified, these areas were given additional resources.

Documented evidence in use of formulae and its controversies when allocating resources dates back to over 150 years and equity has been embedded to some extent albeit recent formulae and algorithms have become more complex requiring various factors and criteria to be addressed.

3.1.6 Characteristics of algorithms in funds allocation

Car-Hill and Sheldon (1992) observe that allocation of government resources in countries such as the UK has been increasingly dependent on formulae, many of which are a result of regression techniques and construction of indices. Furthermore, formula or algorithm design should aim for simplicity, using a single variable such as population as this has the advantage that policy makers can understand the formula quickly and make rapid comparisons of its impact on various regions (Innes and Stoddard, 1988). However, this approach may not be commensurate to 'single' programme objectives such as funds allocation to achieve equity or poverty alleviation. In addition, "simplicity and clarity are desirable qualities in [funds allocation] formulae, but few programmes have objectives which can be well translated into a single variable like population size" (ibid., p.96). Conversely, at the extreme end are formulae which include many variables which increases the problem of combining and weighting thus creating problems with understanding the formulae (ibid).

Considering the above, complex formulae may not be appropriate for road funds allocation in SSA as in most cases data is often unreliable, obsolete and incongruent. Furthermore, the effect of allocations particularly with regards to equity are hardly monitored or evaluated satisfactorily. The author's experience when analysing road condition data used to prepare the Uganda Road Fund Maintenance Financing Strategic Plan for FY 2014/15 to FY 2018/19 indicates that there are tendencies of data exaggeration when funds recipients (local authorities) are aware of the direct proportionality between funding and factors such as population and road network lengths. However, Innes and Stoddard (1988) suggest that policy makers need to be aware of the principle of formula design being both a political and a technical task with the politics intended to determine what the formula should achieve while the technical task is to make it succeed. One major issue that requires careful thought is that the aforesaid argument is probably not in the spirit of ensuring equality of transport opportunities and sustainability as politically based allocations are usually unsustainable. In most cases they are geared towards short-term gains. Allocations should be mainly a technical process based on scientific evidence and taking account all necessary criteria which should also include Rawlsian equity as a political goal.

3.1.7 Categories and principles of algorithms in transport

Algorithms in transport investment project appraisal and road funds allocation have been extant for a long while and the pre-eminent factor considered in most cases is economic efficiency. Several scholars suggest that there is a strong link between transport infrastructure investment and a country's economic growth (Rostow, 1960; Aschauer, 1989; Snaith and Khan, 2008). In contrast, although transport investment is likely to improve a country's economic growth, it does not necessarily improve equity if projects are incorrectly prioritised which subsequently affects economic growth. Similarly, economic growth is not directly proportional to equity enhancement.

Welfare economics models and algorithms for infrastructure appraisal widely used include: Cost Benefit Analysis, Consumer Surplus Method, Producer Surplus Method, Cost Effective Analysis and Decision Support Tools which are further examined and critiqued below:

Cost Benefit Analysis (CBA): CBA method analyses the incremental benefits with total investment costs over the lifetime using discounted rates to determine the economic worth of an investment and whether or not an investment is worthwhile (Soderbaum, 1982; Robinson, 2008). Furthermore, Hine (2003) explains that for a typical road investment appraisal, the benefits are calculated from traffic forecasts and transport cost savings, mostly composed of savings in vehicle operating costs and a valuation of passenger time values. The benefits are then compared with investment costs of the road and changes in maintenance costs whilst future benefits are discounted using a planning discount rate. Cost-benefit analysis is a tool used by decision makers to help inform the policy process (Hahn and Tetlock, 2005). Cost-benefit analysis examines how different policies affect the overall level of net benefits to society, or benefits minus costs and it may be used to explore equity issues by examining how the distribution of net benefits varies across key groups such as minorities (ibid).

The validity of a road project is satisfied when the benefit is greater than the cost and the benefits are determined by valuing the direct impacts in monetary terms through a willingness to pay mechanism. The "decision criterion" could be based on Benefit Cost Ratio (BCR), Internal Rate of Return (IRR) and Net Present Value (NPV), (Hine, 2003; Thomopoulos et al., 2009). The method is data intensive and agreement on the discount rate to be used may be contentious (ibid). This view is also supported by Pearce et al., (2006) who note that "few issues in CBA excite more controversy than the use of a discount rate". Factors that can create disagreement and diverse categories of rates include financial and social economic rates (Bickel et al., 2005). Moreover, distributive impacts are not appropriately considered in CBA and there is greater dependence on traffic volumes thus making it unsuitable for low volume roads. CBA can be very effective when the main goal is to maximise economic efficiency; however, CBA does not appropriately address equity as it is challenging to measure and monetise. Its other serious weaknesses are assumptions on perfect market situations and errors in valuing benefits and costs.

Consumer Surplus Method (CSM): CSM considers benefits to road users from existing and generated traffic resulting from transport infrastructure investment. The total yearly paybacks from the addition of the two Vehicle Operating Cost savings are compared to the total yearly road investment and maintenance costs to obtain the yearly net benefit (Van der Tak and Ray, 1971; Hine et al., 2000). A particular problem with the CSM is that if a road becomes very difficult for a motor vehicle to use or even impassable at certain times of the year then there may be little or no traffic to measure in order to calculate transport cost savings (ibid). A consumer surplus results if cost savings are obtained by consumers through reduced fares and freight charges; otherwise they accrue to vehicle operators as producers' surplus (Lebo and Gannon, 1999).

Producer Surplus Method (PSM): PSM analyses the economic rate of return of road infrastructure investment in terms of value addition to agricultural production increment less the increases in economic costs of production and transportation to local markets; plus reduced transport costs of non-agricultural traffic (Camemark et al., 1976; Beenhakker and Lago, 1983; Hine et al., 2000). A particular problem with PSM is that it can be extremely difficult to identify the extent which net agricultural output will respond to changes in accessibility (ibid).

Cost Effective Analysis (CEA): CEA compares the cost of interventions with their intended impacts and may be used in situations where benefits cannot be measured in monetary terms or where measurement is difficult (World Bank, 2005a, p.3). Road projects most suitable for CEA are those where social benefits form a significant part of the anticipated benefits, such as low volume roads (ibid).

Decision support tools for road infrastructure management include among others: HDM-4, RONET, and RED models. Analysis of the models is provided in Section 3.4, however the main challenge with these tools is the data intensity and inability to satisfactorily allocate maintenance resources for low traffic roads and when funding is limited. Since they are based on economic efficiency, they prioritise high traffic roads. Furthermore, they also do not address equity issues in any way at all.

3.1.8 Criticism of formulae based allocations

According to Buehler and Holtgrave (2007); formulae are not as transparent as they appear. Transparency means that someone else can determine how an allocation for a particular area was determined using a formula assuming the formula is carefully documented and publicly available (ibid). For example, in the relative needs formula used to allocate health and social works costs for the elderly in the UK, the complexity of estimating an equitable basis of allocation of funds and the need for transparency has plagued the process since its commencement (Darton et al., 2010). Furthermore, even when funds are allocated using formulae, there is no guarantee that objectives would be met as properties of data sources and statistical procedures used to produce formula inputs can interact in complex ways with formula features to produce consequences that may not have been anticipated or intended (Louis et al., 2003). At the very least, sensitivity analyses ought to be carried out to mitigate the effect of the complex interactions and data errors. Furthermore, in order to counter some of the allocation formula criticisms, monitoring and evaluation of formula effects should be promoted such that the consequences can be mitigated for future years by undertaking systematic formula adjustments.

3.1.9 Section summary

In the foregoing sections, this study has provided a background to the definition of algorithms and the various classification methods, properties, characteristics and motivation for formula based allocations. It has also been demonstrated that algorithms can be applied in the allocation of road funds and road scheme prioritisation. However, there is no standard definition of algorithms and its usage depends on context. There are practical problems with formulaic allocations but these can be mitigated.

3.2 Attributes of good allocation formulae and decision frameworks

Innes and Stoddard (1988) observe that the most common approach when attempting to make rational decisions in resources allocations is to develop an algorithm or formula using statistical tools and techniques as this makes the process scientific and on a sound technical foundation. Conversely, formulae can be misleading unless appropriate data is used and is clearly comprehensible. However, formulae should be based on available objective data which are not open to dispute and a long formula with variables that do not have a conceptual relation to the problem the legislation addresses is inappropriate (ibid). Furthermore, policy makers ought to be aware of formula factors chosen for convenience rather than underlying theory as the formula and algorithms may have dire consequences if the underlying conditions change.

In the opinion of Car-Hill and Sheldon (1992), formula allocation of resources should be welcomed as planning restraint on the exercise of arbitrary power and for democratic debate. However, they point out three caveats: (i) there is no point in employing complex statistical analysis to adjust allocations for one service area whose activities interact with another service area, the funding of which are both drawn from the same budget; (ii) any formulae must be publically justified and when they are inappropriate or conditions change, they should be open to review; and (iii) when they are based on statistical analysis, there is a special responsibility to present clearly the assumptions made and inferences drawn so that ill-conceived allocation policies are not masked by apparent statistical sophistication.

Wrongly designed formulae can lead to political consequences that distort policy making. Furthermore, when the meaning of the formula is unclear, policy debate cannot effectively deal with the intentions of policy (Innes and Stoddard, 1988). In addition characteristics which should be sought in formulae are: (i) they should be replicable and comparable (formulae should be based on data collected in a standardised way); (ii) sensitive to variations in the conditions it is intended to reflect; (iii) stability or predictability (without wide and unexpected fluctuations); and (iv) parameters used in formulae should be as current as possible (ibid).

According to Hine (2003), critical components useful in decision making frameworks are as follows: (i) the system should determine costs and benefits to minimise double counting and also simultaneously maximise coverage of requirements; (ii) projection and forecasting procedures should be embedded to show the consequences of a proposed intervention with and without intervention and the changes in future periods; (iii) a consistent valuation procedure of benefits and dis-benefits should be included; and (iv) results should be easily understood and summarised.

Similarly, Louis et al., (2003) observe that the essential feature of a formula allocation program is that funds distribution is derived by the application of a formula that uses statistical information to calculate or estimate values of inputs and the process essentially entails a basic calculation using a mathematical formula or algorithm. Moreover, formulae are developed normally to achieve multiple objectives in the context of a complex political process (ibid). There are input and output parts to the equation and legislators normally have intentions or policies which formula designers are required to interpret in a mathematical expression such as an equation or algorithm.

Jabine et al., (2001) explain that the USA National Research Council identified key elements and characteristics for considerations in the various formulae used in allocation of federal grants for various programmes as examined and critiqued in Table 3-3 below with reference to road funds allocation in SSA.

Characteristic	**Measure /parameter**	**Implications and potential applicability to allocations in SSA**
Assessment of direct or indirect measure of *need.*	Number or unit.	Proxy parameters may include population and accessibility.
A measure of the *capacity* or *capability.*	Per Capita Income (PCI), tax base.	Counterpart funding through local revenues.
A measure of *effort* (amount of available local resources targeted to meeting the need).	Local authority average expenditure.	Implementing agencies to show effort through counterpart funding to address equity.
An index of *costs* incurred towards program needs.	Index of wages paid to workers and other input costs.	Labour costs may be included in formulae.
A *threshold* which calls for a minimum level of need before funding eligibility.	Target resources to areas with greatest need (lowest PCI).	A threshold could be included in a formula as a minimum allocation.
A *minimum amount* to be received by each area.	A constant or uniform allocation.	An equity factor (constant) for each jurisdiction.
A hold-harmless provision which limits decreases.	Previous years funding levels.	Pareto optimality is an important equity criterion.

Table 3-3 Key elements in formulae and applicability to SSA road sector allocations (Source: adapted from Jabine et al., 2001, pp.4-5)

Furthermore, the USA National Research Council identified key data considerations in the various formulae used in allocation of federal grants for various programmes as examined and critiqued in Table 3-4 overleaf with reference to road funds allocation in SSA.

Characteristics	**Salient features**	**Remarks and implications for road funds allocation in SSA**
Conceptual fit between currently available data and formula elements as defined in enabling law.	If project objectives are not specific, evaluation of fit may be subjective.	The policy can be complex to replicate in formulae especially when a multitude of factors need to be taken into account.
Level of geographic detail for which data are provided.	Census data can provide estimates at all levels.	Global level data collected by central government is often more accurate.
Timeliness of data (elapsed time between the reference period for the estimates and the period for which the allocations are made).	Census data is at disadvantage compared with continuing or periodic sample surveys.	Data in SSA for the road sector is usually obsolete and statistical techniques are necessary to forecast and 'upgrade' the data. Timeliness is a challenge.
Accuracy, reliability and quality of the data.	Determined from sampling variability	Statistical techniques are necessary to 'sieve' out data.
Expenses and cost of collecting or compiling new data to provide inputs to the formula.	Improvements in data quality have to be weighed against cost.	Costs are a challenge due to constrained road budgets and the poor appreciation of the importance of up to date data.
Susceptibility of data to alteration and manipulation.	Recipients may manipulate data to their benefit.	Data like network lengths and road condition is subject to 'exaggeration'.

Table 3-4 Key data considerations (Source: adapted from Louis et al., 2003, p.56)

The US Office of Statistical Policy and Standards, 1978, cited in Jabine et al., (2001, p.62), identified key recommendations on allocation formula and they have been considered in the formula development as part of this study.

3.3 Importance of algorithms and formulae in road funds allocation and road scheme prioritisation

Khan (2012) observes that most SSA countries are land-locked and roads have a higher priority over other modes of transport. Therefore road transport plays a pivotal role in ensuring equality of transport opportunities. As a guide, Burningham and Stankevich (2005) note that 80% of traffic flows on 20% of the entire network which constitutes the strategic road network and this should receive first priority for routine and periodic maintenance. However, it can be argued conversely that 20% of the network (which mainly constitutes district, community and rural roads) though not heavily trafficked benefits 80% of the population. Nevertheless, from a Rawlsian equity perspective; the network that benefits the majority of the populace (least well off) ought to be given first priority or similar priority rating with the trunk road network.

PIARC (2013) recently reported that in a study of 32 countries in SSA; on average, 60% of their road funds are spent on trunk roads, 18% on rural roads and 15% on urban roads; while all countries allocate funds to urban roads, 6 of the 32 did not allocate funds to rural roads. However, there is a need to allocate road funds equitably for the various road classes.

The objective of sustainable road funds allocation for maintenance has brought to the fore front the need to maximise the returns on the limited resources. According to Heggie and Vickers (1998), roads are administered under different structures which compete for funding resources for road maintenance. These could be regions, provinces, districts or agencies responsible for road maintenance management. The competition stems from differences in road functions, levels of road service, resource capabilities, need and development objectives. Decisions have to be made on how funds are allocated to the competing sectors (Adler, 1987). This is critical because according to the OECD (1994), only addressing the first cause of the road maintenance funding problem by securing more funds will not necessarily solve the road maintenance conundrum. Careful road funds allocation is necessary both in constrained budget scenarios and circumstances where there is adequate funding. This is because allocating a lot of funds for roads does not necessarily mean fulfilling requirements and misallocation could result in wastage and possibly absorption problems or corruption. Limited resources also have to be maximised for optimal returns.

It is imperative that mechanisms are put in place for allocating funds between the different classes of roads and road scheme selection. They need to be simple, transparent and encourage consistency of standards between the various road categories and managing authorities (Robinson, 2008). Furthermore, Innes and Stoddard (1988, p.95) conclude that formulae are “easy to administer, and they remove allocation decisions from political pressures common to discretionary, case by case allocation…[and they] offer a seemingly equitable and objective way to allocate resources”. This view is also supported by Kreisel (1953) who opines that formulae, algorithms or numerical arithmetic are ‘transparent’ and ‘certain’ and any numerical arithmetic may be decided systematically. However, ‘transparency’ and ‘certainty’ are best manifested when the arithmetic analysis is simple to understand.

In an investigation undertaken in Botswana, Khan (2012) found out that capital investment schemes are selected through engineering judgment, political bias, public pressure and staff experience; whilst maintenance projects are based on visual condition assessment and socio-political factors. Both these processes are not very systematic and are a recipe for creating unsustainable developments to the detriment of equality of transport opportunities. Therefore, there is a clear need for a logical approach in project selection preferably aided by formulae.

Louis et al., (2003) provide the recommendations of the US National Academy of Sciences panel on formula allocations which have been incorporated in this study. The literature review confirms that road funds allocations and road scheme prioritisation are best handled using formulae as they are seen to be more transparent and they protect planning managers from political interference and intervention.

3.3.1 Review of some road funds allocation mechanisms used in the developed world and transferability to SSA

Heggie and Vickers (1998) identify three basic methods commonly used in allocating road funds and they include: (i) simple allocation formula, (ii) indirect assessment of needs; and (iii) direct assessment of needs. Simple formulae can be used to distribute funds on the basis of predefined percentages to the different parts of the network. Indirect assessment of needs is used where there are no reliable data for measuring need directly whilst direct assessment of needs is used when there is comprehensive data on the exiting road conditions (ibid). Furthermore, algebraic formulae can reflect policy intent if the variables considered measure the conditions that merit funding and if their combination and weighting appropriately reflects their relative policy importance (Innes and Stoddard, 1988).

The USA system for funds allocation for the road sector is based on undisputable measures of system extent and usage, notably mileage, vehicular travel, population and also due to varied geographical and economic characteristics, efficiency is the main criteria in fund allocation but equity is also a much more significant consideration (ibid). Vehicular travel would be challenging to measure in SSA particularly for the non-core road network although this may be the same situation with Alaska and other low traffic volume states.

The New Zealand Road Fund adopts the needs assessment approach to resource allocation complemented with economic prioritisation and the road network condition is assessed to determine the structural integrity and defective sections through condition surveys for diagnosing appropriate interventions for costing (URF, 2012).

In the UK, over a three year period from 2008/09 to 2010/11, the total block allocation for highways maintenance schemes in England (excluding London) was GBP 2.268bn with the vast majority GBP 2.109bn apportioned by a formulaic approach (Sutch, 2011). It is further pointed out that "…capital maintenance budget is split into three elements [using formulae and] covering roads (65%), bridges (30%) and street lighting (5%)," (ibid., p.49). For roads, the allocation is further split between principal (33%), classified non-principal (33%) and unclassified roads (34%); the allocation for the first two categories is based on road length and condition of the roads (ibid). It can be argued that the allocation for the various road classes is equitable as it does not vary majorly albeit there appears not to be much scientific basis as it is almost one-third throughout.

The funds allocation mechanisms used in the developed economies such as New Zealand, UK and USA may not be appropriate for SSA considering their complexity and they do not address the particular equity issues ubiquitous in SSA.

3.3.2 Analysis of some examples of consultative allocation and prioritisation frameworks

Overseas Road Note (ORN) 22 developed by TRL (DfID, 2004) is a typical multi-criteria analysis method which uses the Analytical Hierarchy Process (AHP) and addresses equity issues to some extent and has a pro-poor goal. The AHP initially developed by Saaty (1980) essentially compares options based on their relative performance taking account of stakeholder interests through quantification of their preferences. AHP is aimed at decomposing a complex decision making process into a hierarchical format (Tudela et al., 2006). It provides a means of using qualitative data for the selection of preferred options in a systematic manner. It applies a pairwise comparison of decision elements according to uniform parameters. As explained by Saaty (1980), AHP is based on the following principles: (i) decomposition which refers to splitting a complex problem into a hierarchy of small clusters, (ii) comparative judgment which is applied to construct pairwise comparisons of all combinations of elements in a cluster, and (iii) synthesis which is used to multiply local priorities of elements in a cluster by the global priority of the parent element, producing global priorities throughout the hierarchy and then adding the global priorities for the lowest level elements.

Hine et al., (2000) explain that the Ghana Feeder Road prioritisation framework aims to maximise economic and social benefits through extensive community participation together with a prioritisation index where social and economic benefits are estimated from predicted changes in accessibility and road roughness. The project was set up in 1999 by the Department of Feeder Roads of the Ministry of Roads and Transport (MRT) in cooperation with the UK Department for International Development and covered nine districts in the north east of the country. The procedure essentially covers the following steps: (i) first round of improvements: approximately 50% of the funds are allocated equally between the nine districts to ensure equitable spread of funds, (ii) consultation: a list of candidate roads are drawn up from each district and ranked by local communities prior to technical analysis, (iii) technical analysis of candidate roads: the ethos is to assess candidate roads on economic and social grounds and detailed surveys are undertaken to determine population served, location of important facilities, modal traffic distribution, traffic volumes, road condition in terms of roughness and road improvement costs for both access and full rehabilitation, and (iv) the total benefits are divided by the road improvement costs to determine a Prioritisation Index.

The Ghana Feeder Roads prioritisation partly covers social equity; however, its major drawback is that it is data intensive, costly, lengthy and potentially bureaucratic making it challenging to replicate in other SSA countries.

In Indonesia, Chavis (2010) observes that the Kecamatan (sub district) Development Project (KDP) requires local villages to compete against one another for funding which encourages villages to use their local information to weed out less efficient projects as they distribute funds among themselves. Furthermore, the KDP attempts to reduce inefficiencies by making project selection and allocation of funding as transparent as possible by holding a series of public meetings in each village to determine what projects will be undertaken. Similarly, Hine (2003) explains that the Ethiopian Rural Travel and Transport Program (ERTTP) involves rural district councils in deciding their own priorities for local road investment and other forms of rural infrastructure. The KDP and ERTTP partly address equity through the participatory approach; however, serious weaknesses with the processes is that they are lengthy and potentially very bureaucratic. Other prioritisation frameworks are covered in the following section.

3.4 Decision support tools and frameworks in road management

The World Bank (2008) observes that many road authorities and funding agencies in SSA are in possession of decision support tools; however, they are inadequately and insufficiently applied and have less than their potential impact on improved road networks. This study's definition of decision support tools is essentially Road Management Systems (RMS), project appraisal packages and systems for road infrastructure management or financing analysis and Rawlsian equity assessment tool (see Table 6-6). Decision support tools use algorithms, formulae and frameworks when proposing solutions to road infrastructure problems.

Overseas Road Note 15 defines a RMS as a "computer-based system used to assist with road management" and Road Management is "the process of maintaining and improving the existing road network to enable its continued use by traffic efficiently and safely, normally in a manner that is effective and environmentally sensitive" (TRL, 1998, p.66). RMS is certainly the major tool for road infrastructure management with other packages discussed in this study being supplementary to RMS.

3.4.1 Critique of equity in existing decision support systems

The section below critiques some of the most commonly used decision support systems and whether they adequately address the equity categories concomitant with the aims of this thesis.

Basic Access Approach (BAA): in order to maximise the impact of road infrastructure on poverty eradication, the right balance between interventions in the national and rural road network is paramount; and so the BAA adopts a holistic view in understanding mobility and accessibility needs of rural communities (World Bank, 2008). BAA ensures that rural transport infrastructure is generally provided in a fair way that ensures that basic access needs for rural communities are catered for instead of the traditional focus on national roads to the detriment of rural roads.

Balance Scorecard: is a generic tool for improving the overall performance of organisations. It is a management system that helps align key performance measures with vision and strategy and translates them into action (ibid). Equity in allocation of resources could be incorporated as a key performance indicator within the tool when measuring and evaluating an organizations' performance.

DEcision on a FINITE Set of Alternatives (**DEFINITE**): software package provides a single measure of project feasibility in a multi-criteria decision making environment. The process involves identifying and scoring investment options in a manner that is scientifically defendable and transparent. DEFINITE enables road authorities to rank investment proposals in terms of their overall feasibility and to select investment portfolios that maximise “value for money” (Vrije Universiteit van Amsterdam, 1994). Equity is not addressed at all.

Highway Development and Management model (HDM-4): this model is predicated on the premise that road infrastructure interventions ought to be economically viable to ensure appropriate allocation of resources, even if they are not equitable. However, Road Authorities and Road Funds as part of their strategic planning normally prepare one year and multi-year investment plans and workplans under severely constrained budgets. HDM-4 assists the aforementioned institutions in identifying optimal combinations of maintenance and improvement options in order to maximise return on investment. HDM-4 can be used for analysis at strategy, program and project analysis levels. At a strategy level, Kerali (2000, pp.13-14) points out that HDM-4 can be used for: (i) medium to long term forecasts of funding requirements for specified target road maintenance standards, (ii) forecasts for long term road network performance under varying levels of funding, (iii) optimal allocation of funds according to defined budget heads – routine maintenance, periodic maintenance and development (capital) budgets, (iv) optimal allocation of funds to sub-networks; for example by functional road class (main, feeder and urban roads) or by administrative region; and (v) policy studies such as impact of changes of the axle-load limit, pavement maintenance standards, energy balance analysis, provision of non-motorised transport facilities, sustainable road network size and evaluation of pavement standards. HDM-4 is generally driven by economic efficiency and equity is not prioritised at all. Road schemes are prioritised based on vehicle operating cost savings which is not equitable in a Rawlsian manner.

Integrated Rural Accessibility Planning (IRAP): Dingen (2000, p.xiii) defines IRAP as “a multi-sectorial integrated planning tool that addresses the major aspects of access needs of rural households for subsistence, social and economic purposes. The tool integrates the access and mobility needs of the rural population, the locations of basic social-economic services and the transport infrastructure in all sectors…it involves communities in all stages of the planning [process] and provides a platform for local level planners and beneficiaries to pro-actively plan for development”. IRAP addresses equity albeit it can also be potentially bureaucratic.

Logical Framework Analysis: implementation of intervention measures on the road network requires systematic processes to be in place; a logical hierarchy analysing ways of achieving obstacles and identifying challenges ought to be established (Australian Agency for International Development - AusAID, 2003). Logical

Framework Analysis provides a standard tool for analysis of infrastructure schemes at strategy, program and project level; and involves stakeholders.

New Approach to Transport Appraisal (NATA): is used in the UK to assess transport infrastructure projects. It was a result of the government's white paper, a new deal for transport (DETR, 1998). The project benefits are analysed by use of Appraisal Summary Tables and the objectives considered encompass; environment, safety, the economy, accessibility and integration (ibid). As explained in Section 2.3.2, NATA is weak on equity issues and extremely data intensive making its applicability in the SSA context challenging.

Performance Assessment Model (PAM): The World Bank (2008, p.79) describes PAM as "a simple, network-level macro evaluation tool that demonstrates the importance of the road sector in the economy, assesses the performance of road maintenance systems, and provides indicative figures of the consequences of budget constraints for road infrastructure". However, equity issues are not considered.

Participatory Rural Appraisal (PRA): all members of the community and other stakeholders should be involved in the planning process to improve transport infrastructure and accessibility. The PRA approach can be useful in the determination of the main local problems and the concerns of the villagers and other local people as it emphasises local knowledge to assist the inhabitants to make their own appraisal, analysis and plans (Hine, 2003). The PRA approach (sometimes referred to as Participatory Rapid Appraisal) addresses equity issues appropriately particularly for rural/community access roads and some the PRA features are included in the developed frameworks in this thesis.

Roads Economic Decision (RED) model: in road transport infrastructure, benefits and costs need to be compared to justify investment. In the case of low volume unpaved roads, benefits are different from national roads where savings are typically in the form of savings in journey time and vehicle operating costs. In the case of low volume roads of between 50 and 200 vehicles per day which is very common in SSA, benefits could be those associated with non-motorised traffic, social delivery and the environment (Archondo-Callao, 1999). As described by the World Bank (2008, p.95), "RED is a consumer surplus model designed to help evaluate investments in low volume roads…[the] model also computes safety benefits, and model users can add other benefits (or costs) to the analysis". The model tends to give the same answers as HDM4; it is only when users add other benefits that equity is considered.

Road Network Evaluation Tool (RONET): the model can be used by policy makers to analyse the state of the road network, its significance to the economy (e.g. asset value as a percentage of GDP) and to analyse a set of monitoring indicators (Mrawira, 2014). RONET can be used to analyse the funding shortfall which is defined as the difference between current expenditure on maintenance and required maintenance expenditure necessary to maintain the network at a given level of service and the effect of under spending on increased vehicle operating costs (ibid). However, there are no equity considerations.

Road User Charges (RUCs) model: economics fundamentals require that consumers take the full cost of the relevant product or service they consume. For road infrastructure, this procedure is known as “Road User Charging” (World Bank, 2008, p.113). The RUCs model estimates charges required to ensure that, for a particular country, the costs of operating and maintaining all roads are covered, and that each vehicle class covers its costs (ibid). Under some definitions, this would be considered equitable. Nevertheless, it does over-penalise trucks since they damage roads more although trucks could be the agents for economic growth in rural areas.

Sustainable Livelihood Approach (SLA): this approach is relevant in improving livelihood when considering rural transport infrastructure and putting people at the centre of development. The SLA is an improved way of thinking about the objectives, scope and priorities of development, that will better meet the needs of the poor including those in remote areas, both at project and policy level (DfID, 2000). SLA may be good for over-arching policy setting.

Deighton Total Infrastructure Management System (dTIMS): is an asset management tool consisting of a set of tools for developing a custom database as well as custom analysis modules according to the unique needs and requirements of the road authority. Equity is not addressed and dTIMS is apparently used by the Uganda National Roads Authority in road scheme prioritisation (see Section 7.3.7).

Road Transport Investment Model: was developed by TRL and is used in the economic appraisal of road investment options in developing countries. The model analyses road expenditures on road improvements and road maintenance with the operating costs over the road design life. The major weakness of the model is that reference data is based on only a few countries.

An analysis of the widely used HDM4 and RONET is provided in Table 3-5 overleaf.

Function	HDM 4 Version 2.09	RONET Version 2.0
Description / Overview	Package for investigating choices in road transport infrastructure appraisal. The system can analyse the total transport costs of alternative improvement and maintenance strategies through life-cycle economics. Recommended for evaluating highway investment options.	RONET was developed under the SSATPP for African countries. It is designed to assess the current characteristics of road networks and their future performance depending on different levels of interventions.
Adaptation or calibration of road deterioration models	It has comprehensive full sets of generic road deterioration and maintenance effects models that can be calibrated with local data at the country or regional level. It offers great flexibility on how to define maintenance, rehabilitation or improvement standards and can be used to evaluate maintenance, new road projects and upgrade to paved surface.	The model was developed from the same principles as HDM-4 however with simplified road deterioration and maintenance effects models (the models cannot be calibrated to local conditions). It is restricted on how to define intervention standards. It is also not possible to evaluate road upgrade options.
Road User Costs models	It consists of the full range of Road User Costs models with the flexibility to calibrate the Vehicle Operating Cost functions to local conditions.	Relies on the same principles as HDM-4 but with simplified Road User Costs models. It is based on representative road classes (Africa averages).
Budget Optimisation	It is capable of trade-off and optimisation analysis under unconstrained budget scenarios.	RONET does not support optimisation analysis under constrained budgets.
Other functionalities	HDM-4 can perform analyses at: strategic evaluation, program evaluation of entire road network and project evaluation. In the network-level analysis each road link condition and traffic can be evaluated to get optimal plans.	RONET performs simplified analyses based on representative road classes only (matrix of surface types, condition categories and traffic levels). It is not possible to do full network analysis.

Table 3-5 Analysis and comparison of key features of HDM-4 and RONET (Source: adapted from Mrawira, 2014)

3.4.2 Decision making frameworks and analysis methods

To determine logical and defensible road funds allocation mechanisms for SSA incorporating Rawlsian equity, policy makers ought to be cognisant and conversant with decision making frameworks, concepts and underlying principles. Decision analysis just like 'divide and conquer algorithms' described in Table 3-2; involve the decomposition of a decision problem into a set of smaller problems (Goodwin and Wright, 2009, p.3). Decision analysis may not produce optimal solutions to transport planning problems, however "its purpose is to produce insight and promote creativity to help decision makers make better decisions" (Keeney, 1982, cited in Ballantyne, 2013). Systematic decision analysis is focused on five main aspects of decision problems: (i) the perceived need to accomplish objectives, (ii) the selection of one alternative from a set of several, (iii) associated consequences differ from each alternative, (iv) there is usually an element of uncertainty about the consequences of each alternative, and (v) possible consequences are not of equal value (ibid).

According to Meyer and Miller (2001), there are five conceptual decision making models and principles for use in transport policy and planning namely: rational actor, satisficing, incremental, organisational process and political bargaining. The 'Rational Actor Approach' assumes a set of rational and informed decision makers; the 'Satisficing Approach' requires decision makers to choose options that achieve a determined minimum level of agreement; 'Incremental Approach' is one where decision making is made with reference to marginal or incremental differences in their consequences; 'Organisational Approach' is influenced by the formal and informal structures of an organisation, and 'Political Bargaining Approach' considers that when large number of stakeholders are involved in a decision they will often have diverse goals, and interests which create differences hence the need for political bargaining (ibid). Various tools can be used in undertaking decisions and these include among others: CBA, trade off analysis; decision conferencing; positional analysis and deliberative methods (Ballantyne, 2013). CBA was discussed in detail in Section 3.1.7 and the remaining tools are discussed below:

Trade off analysis: Merriam-Webster (2014) explains that trade-off is giving up one thing in return for another. Therefore a trade-off analysis can be defined as a comparison of the effect of increasing one or several factors whilst simultaneously reducing other factors or parameters. An example could be the comparison of the effect of increasing funding for road maintenance whilst reducing funding for capital investment and then determining the effect on the economy.

Decision conferences: are working meetings that can be used to solve a variety of problems including conflict resolution amongst experts, negotiation of multi-party agreements and in the development of government policy (Schuman and Rohrbaugh, 1991, cited in Ballantyne, 2013). In the context of funds allocation, these could be classified as stakeholder workshops and consultative meetings.

Positional analysis: is a possible option for public decision making and central to it is its ability to take account of interdisciplinary factors and views; environmental, economical; and social aspects (Soderbaum, 1982). "It aims at illumination of the many sides of a decision…[which] should be useful to politicians or other decision makers who differ with respect to values and ideologies" (ibid., p.391).

Deliberative methods: are discursive and citizens' juries like research methods that typically rely on focus groups in which lay people develop preferences about complex policy issues through informed discussion (Soderholm, 2001). In operation, "deliberative research methods normally involve the use of focus groups, which bring together about five to fifteen people to discuss a given topic" (ibid., p.490); however they should be considered a complement rather than a substitute.

3.4.3 Goal Programming models

In order to address the multiple and diverse objectives which all demand recognition, Khorramshahgol and Okoruwa (1994) use Goal Programming (GP) which is an approach to resource allocation cognisant of multiple objectives which are sometimes conflicting and incommensurable. GP addresses the issue of distribution of scarce resources among alternatives in the most ideal way by arithmetically stating the problem so as to minimise a given function subject to a set of constraints (ibid). The weighted and lexicographic GP models developed as part of this thesis are covered in detail in Chapter Six.

According to Tamiz et al., (1998), GP is a multi-objective programming technique whose ethos lies in the concept of satisfying objectives; and it is the most widely used multi-criteria decision making technique. When using GP approaches, the aim is to try to determine the alternatives that in some sense are the closest to achieve a determined goal or aspiration level (Belton and Stewart, 2002, cited in Loken, 2007).

Tamiz et al., (1998, p.570) classify GP models into two major subsets: (i) Weighted GP where the unwanted deviations (from satisfying the target values) are assigned weights according to their relative importance to the decision maker and minimised as an Archimedean sum; and (ii) Lexicographic programming where the deviations are categorised into a series of priority levels and minimised in a lexicographic sense

- a lexicographic minimisation being defined as a sequential minimisation of each priority whilst maintaining the minimal values reached by all higher priority level minimisations. It is reported in literature that about 64% of GP applications use Lexicographic GP and 21% use Weighted GP (ibid).

It is further posited by Loken (2007) that the idea in the GP methods is to solve the inequalities:

$$Z_i + \delta i \ \geq g_i$$

Where Z_i is the attribute value, δ_i is the non-negative deviation from the target value and g_i is the goal (a desirable level of performance) for each criterion *i*. The aim is to find a feasible solution that minimises the vector of deviations from the target value. If it is possible to find a solution where $\delta_i = 0$ for all *i* values, this will be the recommended solution. This is not the case always and another solution must be found; the simplest method for this purpose is to minimise the weighted sum of deviations.

GP has been previously used in allocation of road funds based on multi-criteria such as economic development, environment, accessibility and cost benefit analysis (Taplin et al., 1995). Whatever the goals, GP always maximises the payoff to limited resources and when heavy weight is given to the conventional economic benefits as goals then the result is similar to ranking by Cost Benefit Ratio (ibid).

As will be seen in Sections 6.3 to 6.5, Goal Programming based on factors and weightings (scores) derived from expert surveys is the proposed methodology for embedding Rawlsian equity principles in road funds allocation and road scheme prioritisation for SSA and other developing regions.

3.4.4 Value measurement algorithm

Loken (2007) suggests that when using value measurement methods, a numerical score (or value) ***V*** is assigned to each alternative; the scores produce a preference order for the alternatives such that ***a*** is preferred to ***b [a > b]*** if and only if ***V*** *(a)* > ***V*** *(b)*. When using this approach, the various criteria are given weights *(w)* that represent their partial contribution to the overall score, based on how important this criterion is for the decision maker. Ideally, the weights should indicate how much the decision maker is willing to accept in the trade-off between the two criteria.

The most commonly used approach is an additive value function (multi attribute value theory - MAVT):

$$V(a) = \sum_{i=1}^{m} w_i v_i(a)$$

where $v_i(a)$is a partial value function reflecting alternative $(a's)$ performance on criterion *i*. w_i is the weight applied to criterion *i*, and *m* is the number of alternatives. Loken (2007) observes that the partial value function must be normalised to some convenient scale (e.g. 0-100). Using the equation above, a total value score *V(a)* is found for each alternative *a*. The alternative with the highest value score is preferred.

3.4.5 Identified research gap

The literature review on algorithms, decision support systems and allocation frameworks has revealed that they do not adequately address the macro, meso and micro level equity problems as defined by this thesis. Similarly, there is no existing standard/overarching equity-centred algorithm, system or GP model for road funds allocation and road scheme prioritisation in SSA and other developing countries. With reference to the identified 'research problem space', the literature review shows that some of the existing algorithms and decision support tools are so data intensive and do not appropriately address transport equity thus the need for new approaches.

3.5 Chapter summary

Analysis in this chapter shows that an 'algorithm' is a step by step procedure of solving a task; and formulae are important in road funds allocation and road scheme prioritisation. Some of the decision support tools which incorporate algorithms have been reviewed and economic efficiency is the standard criterion for road projects investment appraisal in SSA; however, one ought to be aware of Rawlsian equity issues and these need to be embedded to ensure equality of transport opportunities and to achieve sustainable developments. In the context of road funds allocation in SSA, algorithm definition and classification ethos as per this thesis covers: GP models, formulae, instructions, rules, principles, frameworks, flow charts, figures, tables, tools, guidelines and procedures to be used when allocating road funds at macro, meso and micro levels in order to achieve equity.

The review of algorithms and decision support systems shows that there is no clear 'rule of thumb' or standard allocation framework for resources which takes account of equity appropriately as defined by this thesis. Attributes for good allocation formulae have been analysed and formulae for road funds allocation and road scheme prioritisation ought to be simple and use a few factors as possible. The following Chapter analyses research methodology to identify the preferred method.

Chapter Four - Research Methodology

4.1 Introduction

In Chapter three, a review of algorithms and their relevancy in road funds allocation was undertaken. This Chapter provides a review of some of the various research methods and instruments available and an assessment of their relevancy as regards the development of equitable algorithms for allocation of road funds and prioritisation of road schemes in SSA is undertaken. The critique and review of research methodology culminates in the illumination of the preferred and proposed mixed methods research (both quantitative and qualitative) incorporating expert opinion surveys; and use of multiple case studies.

4.1.1 Research exploration, theoretical and scientific foundation

Research methods are generally classified into two main categories consisting of quantitative and qualitative methods. Quantitative methods typically use numbers, are deductive and usually require a hypothesis whilst qualitative methods typically use words, are inductive and may not require a hypothesis (Yin, 2009; Harrison, 2013). Therefore, qualitative research is commensurate with qualities such as characteristics, nature, texture and attributes that make something what it is. On the other hand quantitative methods use statistics, and analysis is usually made concerning causal and interdependent relationship between variables (ibid). According to De Beuckelaer and Wagner (2007), the decision on whether to use quantitative or qualitative research is not clear cut and largely depends on the goal of the research and nature of the research problem. The nature of this research necessitates the use of both quantitative and qualitative methods as it requires arithmetical manipulations and seeking expert opinions.

Bennett and Elman (2006) suggest that when undertaking research; scholars ought to commence with ontology before proceeding to epistemology and then methodology. Epistemology (theory of knowledge) is the scientific study which deals with the nature and validity of knowledge (BMJ, 1995); and ontology is a formal specification of conceptualisation whilst methodology is a structured and systematic approach to solving a problem (United Nations, 2000). The aforesaid processes are followed in this research although not in the suggested order.

Mugenda and Mugenda (2003) explain that the purpose of research is to describe, predict, control and explain issues based on the assumption of a single tangible reality that can be observed, measured, monitored and evaluated. Moreover, the scientific method assumes that phenomena are orderly and that their causes are not only discoverable but can also be manipulated (ibid). In order to address epistemology and rigour, the following sections delve into the theoretical underpinnings of research plans, methods, validity and scope relevant to this study.

4.1.2 Research ideology of equitable road funds allocation and road scheme prioritisation

An ideology concomitant with the pursuit of a fairer SSA in terms of road infrastructure provision and funds allocation to that effect is advocated for in the research procedures proposed for this study. Sachs (2005) holds the view that extreme poverty defined by the World Bank as incomes of less than one dollar per day can be eliminated by the year 2025 through carefully planned development aid. The aforementioned assertion was before the onset of the current global recession and the subsequent intrinsic market adjustments. It is hitherto a major challenge to completely eradicate extreme poverty within the next ten years as posited by Sachs bearing in mind that road infrastructure provision should play a pivotal role in poverty alleviation especially in rural Africa.

Methods for analysis of equity in road funds allocations and road scheme prioritisation in SSA ought to use both quantitative and qualitative methods. However, Li and DaCosta (2013) posit that there is limited research to investigate the relationship between road infrastructure and income distribution and disparity directly or indirectly. Furthermore, research in this field with emphasis on income distribution and disparity has focused mainly on developed economies and only a few address issues in developing countries (ibid). It is acknowledged that some countries in SSA such as the Republic of South Africa have experienced improved and sustainable economic growth partly due to good road infrastructure. Moreover, in developing economies such as China, Zou et al., (2008), cited in Li and DaCosta, (2013, p.58), observe that “the higher growth level in East and Central China…[is directly linked to] better transport infrastructure”. It can therefore be deduced that equitable road infrastructure provision in SSA can be a catalyst for development and ensuring equality of transport opportunities thus alleviating multi-dimensional poverty.

4.1.3 Research systems and methods

A clear understanding of the various research methods is important as part of this study as they all have some advantages and disadvantages. Research methods can be classified as exploratory, descriptive or explanatory (Yin, 2009). Exploratory methods are implemented when researchers want to test or generalise qualitative results to a larger population or when new nascent research questions based on qualitative results cannot be addressed with qualitative data (Harrison, 2013). Furthermore, “explanatory design [methods] are employed when researchers want to investigate trends and relationships with quantitative data and explain reasons behind the quantitative results, or the researcher develops new questions based on quantitative results, that cannot be answered with quantitative data” (ibid., p.2161).

Yin (2009) explains that the three main conditions used in identifying a research methodology include: (i) type of research question, (ii) the extent of control an investigator has over events, and (iii) the degree of focus on contemporary as opposed to historical events. The aforesaid conditions have been considered in determining the research method for this study. The five major research methods are: experiments, surveys, archival analysis, histories and case studies (ibid., p.8).

Table 4-1 below provides an analysis of their relevancy to this study and it can be deduced that there is an overlap in the methods and a combination of methods is important in the development of algorithms which address equity. Woodside (2010) graphically provides a comparison of objectives attainment using the various research methods and it can be concluded that case study research has a high level of accuracy but low generalisation. However, the use of multiple cases can mitigate the weaknesses of generalisation.

Method	**Implications and applicability of the methodology to research study**
Experiment	May not be appropriate as it would require implementing the developed algorithms over several years and determining the effects through monitoring.
Survey	Web based questionnaire is developed with follow up interviews to seek expert opinions on equity.
Archival analysis	Analysis of existing records is necessary to determine how equity has been addressed.
History	Understanding of historical trends is necessary to analyse historical perspective of equity in allocations.
Case Study	Algorithms development is undertaken in a ‘real world environment’ thus the need for case studies.

Table 4-1 Typical research methods and applicability to this study

4.1.4 Research plan and design

A research plan or design is described by Yin (2009) as the logical sequence that connects the empirical data to a study’s initial research question and ultimately to its findings and conclusions. It is essentially the structure or systematic process (methodology) for undertaking the research and provides the adhesive that holds the research study together (ibid). As pointed out by Nachmias and Nachmias (1992), cited in Yin, (2009, p.26), a research design “guides the investigator in the process of collecting, analysing, and interpreting observations”. Of note is that “the main purpose of the design is to [predict and possibly] avoid the situation in which the evidence does not address the research questions” (ibid., p.27). Similarly, several scholars observe that the choice of research plan must be appropriate to the issue under investigation (Paton, 1987; De Beuckelaer and Wagner, 2007). A systematic research plan is relevant to the development of equitable algorithms.

Based on the analysis of various researches involving mixed methods designs, Harrison (2013) observes that for *explanatory designs*, researchers collect, analyse quantitative data and then build on those findings in a qualitative follow up for better understanding of the quantitative results. The building can involve either using quantitative data to select the cases or to identify questions that need further explorations qualitatively (ibid). However, for *exploratory designs*, researchers first collect and analyse qualitative data and then build on the qualitative data for the quantitative follow up (ibid). The approach followed in this study is to analyse qualitative data and then apply it to quantitative data (case studies).

According to Creswell and Clark (2011), cited in Harrison, (2013, p.2156), “the building process can involve identifying the types of questions that might be asked, determining the items/variables/scales for instrument design, and generating theories, typologies or classifications”. For *embedded designs*, researches amalgamate both qualitative and quantitative data consecutively or simultaneously with one form or both forms of data playing a supporting role in a large design; whilst for *convergent designs*, researchers collect both qualitative and quantitative data concurrently; analyse both data strands separately and then mix the databases by merging the data (ibid). Furthermore, a *hybrid design* method combines any two or more of the aforesaid design methods (ibid).

It is suggested by Yin (2009) that when undertaking case studies, the critical research design components are: (i) the question(s), (ii) propositions, (iii) units, metrics and factors of analysis, (iv) logic linking data to propositions, and (v) the criteria for interpreting the findings and conclusions. Furthermore, an adequate research plan should indicate which data is to be collected either by questionnaires, interviews or records; the subsequent propositions and units of analysis (ibid).

Kidder and Judd (1986) explain that the important criteria in ensuring satisfactory quality of research design include: construct validity, internal validity, external validity and reliability. Construct validity involves identifying the correct operational measures, internal validity seeks to establish a causal relationship rather than a spurious linkage, external validity outlines the range where the study's findings can be generalised, and reliability which can be authenticated by undertaking the operations of the study such as data collection to simulate the same findings and possibly conclusions *ceteris paribus*. Table 4-2 below illustrates how the aforementioned principles are applied in this study.

Principle	**Implications and applicability to this study**
Construct validity	Data is collected using various sources to ensure triangulation and to corroborate evidence. The most up to date data is collected and the peer review process is adopted early.
Internal validity	Similar standard statistical techniques are used for each case study to ensure evidence converges and for comparative assessments. Furthermore, opinions of peers and experts are sought through the entire study.
External validity	Multiple case studies are used and they are all developing countries from SSA. As far as possible, uniform analyses are undertaken for each case study depending on data availability.
Reliability	A pilot case study is undertaken in order to test and establish the research protocol. Furthermore, the questionnaires were aligned with the research objectives and also independently reviewed. The analysis is augmented with expert opinion.

Table 4-2 Study application of recommended research design principles

4.1.5 Quantitative research approach

De Beuckelaer and Wagner (2007, p.213) point out that "quantitative research typically assumes a high degree of generalisability of the research outcomes [and] has a high level of abstractness and relies heavily on principles of statistical testing". Furthermore, quantitative methods are suitable for determining mean or average strengths of relationships and since these are almost always anticipated with some probability, they can be easily elucidated and disseminated (Place et al., 2007). In contrast, Roe (2000, p.100) argues that "quantitative research may be problematic because it tends to be more concerned about calculating effects than seeking an understanding of social objects". Researchers in transport equity issues especially for SSA ought to recognise the inaccuracies and obsoleteness of data as conclusions may be drawn from analyses of wrong or non-corroborative data which subsequently may misguide decision makers. As reported by the Transport Research Laboratory in 1998, it is challenging in developing countries to obtain good data (traffic flows and road condition) as it is not monitored on a regular basis.

Roe (2000, p.101) points out that “quantitative analysis…cannot answer questions that demand an understanding of social processes nor provide a causal explanation”. This view is also supported by Jones et al., (2013, p.22) who note that “sustainable transport planning [in developing countries] cannot be limited to quantitative analyses, which are the core of conventional processes, still widely used throughout the developed world”. Assessment of the indirect impacts of transport requires knowledge of specific local conditions which are not easily quantifiable and require an understanding of the local context (ibid). The aforementioned weaknesses can be partly mitigated through qualitative analysis.

Some of the intrinsic challenges of quantitative research can be overcome through interpretative, qualitative studies, which reveal everyday experiences and seek explanations which can be augmented with quantitative analysis (Roe, 2000). Quantitative research is more attuned to responding to questions about relationships between specific variables, and questions of who, where, how many and how much (Harrison, 2013). The main outcome of quantitative methods is statistical evidence emanating from statistical data (Antameng, 2001). From the foregoing, it can therefore be deduced that a combination of both quantitative and qualitative methods is relevant to the development of equitable algorithms.

4.1.6 Qualitative research approach

In 1995, the British Medical Journal reported that the main qualitative research methods include: observation, questionnaire surveys, in depth interviews, focus groups, consensus methods and case studies. Furthermore, qualitative description is a prerequisite of good quantitative research particularly in areas that have received limited previous investigation; such as equitable road funds allocation and road scheme prioritisation in SSA. The goal of qualitative research is the development of concepts which enable understanding of social phenomena in a natural way rather than experiments therefore giving emphasis on the views of experts (BMJ, 1995).

According to Harrison (2013, p.2160), “qualitative research is more apt for answering why and how questions”. However, unlike quantitative researchers, qualitative researchers such as those undertaking case study researches are not exactly de-linked from research findings (De Beuckelaer and Wagner, 2007). The aforesaid notwithstanding, qualitative analyses can easily demonstrate or explain the diversity in outcomes especially those of the statistical outliers (Place et al., 2007). Similarly, Dugundji et al., (2011, p.240) explain that “qualitative methods have proved essential to enable the collection of personal [social] network data, and have also provided a way to more directly inquire about social interactions and context in transportation research"; which may be necessary for understanding statistical outliers. However, one ought to recognise the challenges associated with collecting data that is representative of individual choices and social ties as respondents may be uncomfortable with questions that may interfere with their privacy (ibid). This may be more pronounced when collecting or testing participatory data for social equity parameters of SSA rural dwellers taking account of the roles of the different genders in travel decisions which can also be linked to road funds allocation. Culturally, most developing country societies particularly in SSA are gerontocracies which has implications on the decision making process (TRL, 1988).

4.1.7 Use of quantitative and qualitative data

Qualitative data describes the attributes or properties that an object possesses whilst quantitative data expresses a certain quantity, amount or range of values related to an object (United Nations, 2000). Qualitative and quantitative data ought to be characterised as complementary rather than exclusive and ways this can be achieved include: (i) qualitative work such as observations, in-depth interviews and focus groups can be conducted as an essential preliminary to quantitative research; and (ii) qualitative methods can be used to supplement quantitative work as part of the validation process such as triangulation (BMJ, 1995). Triangulation is the underlying principle for the use of three or more different research methods in combination; principally to check validity (Woodside, 2010). Furthermore, according to Dugundji et al., (2011), research can go beyond being purely qualitative by using a mix of both qualitative and quantitative evidence and there is a benefit of applying both methods in combination to supplement each other.

Almost half a century ago, Bonney and Millard (1966, p.198) observed that "within the road system of a [developing] country there are broad problems of the distribution of capital and maintenance funds between different regions and between different classes of roads". Researching a scenario which has been extant for such a long time necessitates a concerted effort utilising both qualitative and quantitative methods. Moreover, the lack of some of the basic quantitative data such as traffic flows in rural SSA makes it more challenging for case planners and research workers to comprehend the scope of problem that requires tackling (ibid). Qualitative methods are indeed a valuable addition to quantitative methods based on statistical data thus the need for the use of both methods in this study.

4.1.8 Sampling techniques

Sampling may be described as the systematic procedure of identification and selection of a number of individuals or cases (sample) for a study in such a way that the individuals or cases selected represent the large group from which they were chosen (United Nations, 2000). The most often used sampling techniques are "*simple random sample* taken throughout all units of the sampled population and the *stratified random sample* where the sampled population is first divided into unique subpopulations (strata) then sampled at random within each stratum" (Bryson et al., 2012, p.737). The ethos of sampling is to secure a representative group to achieve generalisation. Careful characterisation of the sampling frame and the sampled population ensures the respondents represent the target population (ibid). Development of equitable algorithms requires identification of a number of countries in SSA with varying characteristics whose analysis, derived principles and results can be replicated in the other developing economies of SSA and beyond. In this study, purposive sampling when identifying case study countries is adopted and expert opinion is sought to authenticate the hypotheses of this thesis. The sampling process for the survey panel is discussed in Section 5.1.5.

4.1.9 Ethos of data collection and design process

In the field of transportation planning and research, it is widely acknowledged that data collection and analysis is the most widely used research tool. Data collection is an activity of the research life cycle which embodies gathering data from respondents and recording it for further processing (United Nations, 2000). As explained by Schofer and Levin (1967), cited in Jones et al., (2013, p.21), the process essentially entails "…data handling due to the large amounts of data and information that must be stored and manipulated". Furthermore, Bonney and Millard (1966) observe that in most developing countries, there is only scanty information of road travel and little is known of the use to which the road system was put and the value gained from it albeit most developing countries were able to provide basic statistics on the numbers of vehicles registered and on mileages of roads of different types. However, the situation has since improved.

Transportation data are most commonly modelled using statistics and/or computational intelligence (Karlaftis and Vlahogianni, 2011). Furthermore, Glymour et al., (1997), cited in Karlaftis and Vlahogianni, (2011, p.387), point out that "statistics is the mathematics of collecting, organising and interpreting numerical data…" In order to achieve construct validity and reliability in the realm of case studies, Yin (2009) posits three important principles of data collection namely: use of multiple sources of evidence, create a case study database and maintain a chain of evidence. These approaches are useful and have been incorporated in the research plan. Data collection methods blend themselves to the primary and secondary categories intertwined in both quantitative and qualitative methods (Mugenda and Mugenda, 2003). Primary data is that collected afresh and for the first time thus highly original whilst secondary data is that which has already been collected by someone else and possibly statistically analysed (ibid).

Yin (2009) suggests that enough data should be collected which provides confirmatory evidence (evidence from two or more different sources) and that the evidence includes attempts to investigate major rival hypotheses or explanations; and a clear chain of evidence is maintained. Case study evidence can come from various sources such as documents, archival records, interviews, direct observations, participant-observation and physical artifacts (ibid).

4.1.10 Surveys and applicability in research

A survey is defined by the United Nations as an "investigation about the characteristics of a given population by means of collecting data from a sample of that population and estimating their characteristics through the systematic use of statistical methodology" (United Nations, 2000, p.36). In addition, Bryson et al., (2012, p.738) posit that a well-developed survey report should clearly describe "(i) the research question; (ii) details of the target population and study sample; (iii) methods used to (a) develop the survey and measure its validity and reliability, (b) calculate the sample size, (c) administer and follow up on the survey, and (d) analyse the data; (iv) the results of the survey and interpretation and (v) conclusions that may be drawn directly from the results". The aforesaid principles of survey research have been incorporated in this study.

4.1.11 Theoretical aspects and data concepts

Theory is defined as a system of explaining phenomena by stating constructs and the laws that inter-relate these constructs to each other (Mugenda and Mugenda, 2003). A construct is a concept, abstraction or idea drawn from the specific (ibid). Furthermore, a theory provides the basis for establishing the hypothesis to be tested. The proposition in this research is that allocation of road funds in SSA is inequitable at macro, meso and micro levels and adjustments are necessary to achieve equity and equality of transport opportunities to ensure sustainable developments. The United Nations (2000, p.6) explains that data is "the physical representation of information in a manner suitable for communication, interpretation, or processing by human beings or by automatic means".

4.1.12 Review of some examples of qualitative data collection methods

Questionnaires: a questionnaire is a survey instrument which contains questions for gathering data from respondents. Questionnaires are developed to obtain salient information about the population and in such a way as to address specific research questions, objectives and hypothesis. Two broad groups of questionnaires are suggested: structured or closed-ended and unstructured or open ended (Mugenda and Mugenda, 2003). The expert survey questionnaire used in this research incorporates both categories. Furthermore, Gillham (2000), cited in Ballantyne, (2013, p.101), posits that questionnaires are "of most value when used in tandem with other methods".

Questionnaire design and procedures: Questions ought to be arranged in a systematic sequence to ensure respondents can find their way around with ease (see 5.1.4). In the question design process, consideration should be given to: commencing with interesting or intellectually probing items, not putting important questions at end of questionnaire, logical sequence when categorising questions into thematic areas and provision of brief introductions to question sub-sets (Mugenda and Mugenda, 2003). An additional good attribute could be to ensure that there is substantial completion of questionnaires and obtaining a representative sample of respondents. Furthermore, the researcher ought to be cognisant of avoiding bias in the questions. A biased questionnaire sent to a non-representative sample is unlikely to yield useful data (Bryson et al., 2012).

According to AAPOR (2011, p.13), when analysing results of questionnaires; a completion percentage of the questionnaire of at least "80% equals complete". The aforesaid proposition has serious weaknesses and can be misleading particularly if the 20% which is incomplete relates to salient features of the questionnaire. In this research, only fully completed questionnaires could be submitted electronically.

Interviews: Berg (2007) describes interviews as purposeful discussions or conversations used to collect data from participants. Similarly, Mugenda and Mugenda (2003) suggest that an interview is an oral administration of a questionnaire thus they are face to face encounters. This overlooks the fact that interviews can also be carried out via the phone or video link without face to face contact. Conversely, Yin (2009, p.106) points out that "interviews...[are] guided conversations rather than structured queries". There are weaknesses with this view as structured queries are the building blocks of interviews. In addition, Rubin and Rubin (1995), cited in Yin, (2009), explain that during interviews, although the researcher will be pursuing a consistent line of inquiry, the actual stream of questions in case study interview is likely to be fluid rather than rigid. To the contrary, in order to compare results accurately, case study interview questions ought to be more rigid rather than fluid in order to get meaningful answers.

4.1.13 Typical data types for road sector analysis in SSA

The section below identifies some of the data categories that are usually used in road funds allocation formulae and road scheme prioritisation processes in SSA.

Network metrics: these are the characteristics of the road network and consider factors such as international roughness index, road length, road condition, road features and traffic volumes.

Demographic data: this refers to quantifiable statistics of a given population. The type of demographic data used in allocation formulae include: population, population density and income (difference in economic performance of regions).

Geographical data: used in formulae includes surface area, terrain characteristics, topography and local government set up such as number of districts/regions.

Economic data: which encompasses incomes and expenditures; data used in analysis include: maintenance costs, Net Present Value, Benefit Cost Ratio, Internal Rate of Return, Producer Surplus Method, Consumer Surplus method, Cost Effective Analysis and productivity.

Social equity data: which considers parameters such as: population served, catchment area/regions served, employment created, travel time to amenities (particularly health and education), multi-dimensional poverty (health, education and standards of living); human development index and benefiting population.

Accessibility data: this takes account of aspects such as rural accessibility index and availability of transport services.

Climatological data: includes rainfall and temperature variations which affect the longevity and sustainability of road pavements.

4.1.14 Section summary

In the foregoing section, this study has critiqued and reviewed the principles and ethos behind some of the various research types and how to prepare a research plan or design. The five major research methods include: experiments, surveys, archival analysis, histories and case studies. The research process should generally commence with epistemology followed by ontology and subsequently methodology; however it has been argued in this thesis that the process should not necessarily follow the aforementioned order. Furthermore, typical data types for the SSA road sector have been identified.

A research design is essentially a systematic process outlining the procedures and steps to be carried out from the beginning to the end of the research study. To ensure good quality research, the plan should embody the principles of construct validity, internal validity, external validity and reliability. Research methods generally fall into two categories which are quantitative and qualitative.

4.2 Proposed research method

4.2.1 Rationale for combining quantitative and qualitative methods

The proposed research method is the use of a combination of both quantitative and qualitative methods incorporating a two stage web-based survey and multiple case studies. The ultimate goal is to use Goal Programming (GP) for systematic establishment of equitable algorithms and indices based on expert opinion surveys.

Combined or mixed methods of research refer to a categorisation of research methods where the researcher mixes, combines or integrates quantitative and qualitative research techniques, methods, approaches or concepts into a single study (Johnson and Onwuegbuzie, 2004; Woodside, 2010). Combined methods of research can contribute to solving more complicated research questions and enable investigators to collect a richer and stronger array of evidence than can be achieved using any single method alone (Yin, 2009). Harrison (2013, p.2153) explains that combined (mixed) methods have varying nomenclature which includes: "multiple methods, blended research, multi-method, triangulated studies and mixed research". However, Bennett and Elman (2006, p.472) observe that "methodological choices involve trade-offs. No method is optimised for every research objective and every domain, and none is able to surmount fully the well-known challenges of valid causal inference in non-experimental settings".

Woodside (2010, p.71) points out that use of "mixed or multiple methods in case study research usually contributes to increasing accuracy and complexity/coverage in a study more so than generality"; which is important for road funds allocation in SSA. Furthermore, Dubois and Araujo (2007), cited in De Beuckelaer and Wagner, (2007, p.214), indicate that "the comparative multiple case study logic relies on identifying causal relationships within particular cases, and an examination of the extent to which these relationships are generalisable to other cases". Similarly, Yin (2009, p.11) points out that "…case study is preferred in examining contemporary events, but when the relevant behaviors cannot be manipulated". In the same vein, Harrison (2013, p.2156) sums up that “research questions best suited for mixed methods inquiry include those in which one data source may be insufficient, results need to be explained [and] exploratory findings need to be generalised”. All the aforementioned scholars support the notion of using mixed methods and their arguments support the ethos of this research and its methodology.

4.2.2 Case studies and criticisms

According to George and Bennett (2005), cited in Bennett and Elman, (2006, p.459), “case studies are often mistakenly criticised for having a ‘degrees of freedom’ problem, when in fact within-case methods may provide evidence that bears on multiple testable implications of a theory within a single case”. Another concern about case studies highlighted by Yin (2009) is their perceived inability to provide scientific generalisation of results and its applicability to other scenarios especially when a single case study is used. To mitigate the aforesaid, Bennett and Elman (2006) argue that case study methods have the advantage of generalising beyond the cases studied; especially if multiple cases are considered. This further supports the notion of using multiple cases when analysing the developed road funds allocation and road scheme selection formulae. However, De Beuckelaer and Wagner (2007) caution that different case study researchers may interpret the same (secondary) data from the same cases but with contrasting opinions. Nevertheless, the same could be true with primary data. The aforesaid notwithstanding, case study sample selection process may be biased and increase the danger of overlooking alternative interpretations, explanations and conclusions (ibid).

A frequent complaint of case studies is that they take too long and result in massive and difficult to read documents; however traditional lengthy narratives can be avoided and case studies do not have to take long (Yin, 2009). Furthermore, Woodside (2010) observes that case study research is criticised for: (i) not having explicit steps to create and test theory, (ii) ‘thick descriptions’ of processes to support accuracy of findings reflect chaotic complexity to researchers using classical empirical positivistic methods, (iii) intrinsic weaknesses due to variability in multiple person interpretation of verbal data including objectivity in interpretations, opinions and beliefs; and (iv) inadequate replications to support generalisation or practical relevance to aid decision making in other contexts. Some of the above criticisms have been addressed in this study by using multiple case studies, setting hypotheses, and analysing expert opinion critically and objectively. Furthermore, to assist with evidence corroboration and triangulation of results, a consultative workshop was held with management of the Roads Fund Board of Tanzania.

4.2.3 Justification of the used research methods

Khorramshahgol and Okoruwa (1994) point out justifications of the use of expert opinion surveys as: (i) experts are familiar with the subject matters, (ii) different experts from different fields may provide opinions, (iii) anonymous expert surveys propagate risk and create a secure atmosphere for free and independent exchange of ideas, and (iv) participation of multiple experts from various fields is likely to mitigate bias. However, it is considered prudent that experts in this study are from similar disciplines as it is a specialist area. A web-based research is environmentally friendly and cost effective to carry out, enables participants to easily respond from diverse international locations, is time efficient, allows direct data import and input in analysis software, and enables quick turnaround time (Gill et al., 2013). In the opinion of Bennett and Elman (2006, p.473), "case study methods have advantages in developing internally valid and context-sensitive measures of concepts, heuristically identifying new variables through within-case analysis of deviant or other cases thus providing a potential check on spuriousness and endogeneity". Furthermore, Woodside (2010, p.71) observes that "a mixed-method approach is likely to provide confirmation and disconfirmation of some beliefs and feelings of participants collected during interviews". The aforesaid is relevant to reliability of this research.

4.3 Chapter summary

An exploration of the principles and ethos behind some of the various research types and how to prepare a research plan/design has been undertaken. The major research methods identified include: experiments, surveys, archival analysis, histories and case studies. A research design is essentially a systematic process outlining the procedures and steps to be carried out from the beginning to the end of the research study. To ensure good quality research, the plan should embody the principles of construct validity, internal validity, external validity and reliability. Research methods generally fall into two major categories namely quantitative and qualitative. In the development of equitable algorithms as per the aims of this study, it is prudent to use a variety of methods which deal with numbers as funds allocation is expressed numerically and to ensure that social impacts are considered, opinions of experts ought to be sought and investigated. The proposed research method is the use of both quantitative and qualitative methods incorporating a two stage web-based survey and multiple case studies. A panel was set up to seek expert opinion on equity in road funds allocation and road scheme prioritisation in SSA and the survey process and results are analysed in the following Chapter Five.

Chapter Five - Expert Opinion on Equity in SSA Road Funds Allocation and Road Scheme Prioritisation

5.1 Introduction

In the research methodology analysed in Chapter Four, the importance of using a combination of both quantitative and qualitative data collection methods was elucidated. This chapter provides a critical review and an analysis of the qualitative data collection process and the results obtained from a panel of experts (two stage web-based survey); in order to gain deeper knowledge and understanding of equity in SSA road sector as defined in the aims of this thesis. The chapter also analyses the key findings of the face to face interviews held with three Stage Two experts. The knowledge gained is incorporated in the development of new equitable algorithms, formulae, Rawlsian equity assessment tool and Goal Programming models with equity factor weightings (rankings) based on expert opinion. Furthermore, expert opinion confirms that equity is a complex issue and a needs assessment ought to be undertaken to guide road funds allocation; however, economic efficiency and equity should be highly prioritised.

5.1.1 Expert panel uniqueness and research novelty

Experts agree with the author that the panel set up as part of this research is the first attempt of analysing SSA road sector equity issues as defined by this thesis using panellists with significant practical experience gained from various countries in Africa. The experts are mainly from (or previously worked for) Road Funds and Road Authorities at managerial level and above. Most of the experts are employees or previously worked for the aforesaid institutions in countries such as Uganda, Ghana, Zambia, Kenya, Tanzania, Namibia, South Africa and Ethiopia.

Despite the varied opinions, most panellists conclude that allocations should be based on a needs assessment and road scheme prioritisation should take account of a combination of economic efficiency and social equity (multi-dimensional poverty) factors. Furthermore, most experts concur with the author that road sector resources allocations and road scheme prioritisation processes in most SSA countries are often non-systematic and very prone to political interference.

5.1.2 Aim and rationale of expert opinion surveys

The crux of the two rounds of surveys was to gain a deeper and practical understanding from experts on how equitable the existing road fund allocations at macro, meso and micro-level are; and what they ought to be. In the same vein, deeper knowledge and practical issues pertaining to road scheme prioritisation was also sought. Furthermore, the fundamental ethos of the expert opinion surveys was to identify the important factors that should be considered in SSA road sector allocation and to obtain weightings (scores and rankings) which are then used in developing the bespoke Rawlsian equity assessment tool and GP models for SSA and other developing regions as analysed in Chapter Six.

Considering that road fund allocations and road scheme prioritisation can sometimes be a subjective matter and procedures vary from country to country; it is crucial to use both quantitative and qualitative survey methods. This approach is also supported by Taylor and Bogdan (1998) who posit that surveys (such as questionnaires) are particularly effective in research that attempts to understand perceptions of respondents. The exploratory surveys and face to face interviews were aimed at triangulation, verifying and providing additional critique to three important issues namely: case study data analyses, literature review findings and equity classification as posited in this thesis.

The approach adopted to solicit for opinions was the use of a web-based questionnaire (see Section 4.1.12). According to Robson (2002), questionnaires are appropriate for standardised issues which will be interpreted in a uniform way by all respondents. The 'Bristol online survey' package (www.survey.bris.ac.uk) was used to develop the questionnaire and two rounds of surveys were undertaken. The results of the Stage 1 survey which included peculiar equity aspects that had not been considered before; were analysed critically and then used to develop a more detailed Stage 2 questionnaire which also included revised answer options based on the findings of the Stage1 survey. The Stage 1 completed questionnaires for all the forty four panellists are available at http://dx.doi.org/10.6084/m9.figshare.1305163 and the Stage 2 completed questionnaires for all the twenty nine experts are available at http://dx.doi.org/10.6084/m9.figshare.1304569 (see Sections 5.2 and 5.4 for analysis/summary results). For ethical reasons (see Table 5-2), the names of panellists and their contact details are excluded. The 'Bristol online survey' is a very user friendly way of setting up web based surveys. It allows the user to set up questions in various ways including giving the option to pilot the survey before launching. The package also offers basic statistical analyses of the data. Similarly, the requirement that all questions are completed prior to the survey form being accepted for submission mitigates against the possibility of sending incomplete responses.

The design of the questionnaire enabled the author to critique responses of experts; in addition, at the end of the questionnaire, a ‘blank’ space (open question) was provided for experts to specify their opinions as regards the thesis subject matter and SSA road sector equity in general terms. The survey process is an analytical study and the intention is to illuminate a specific problem through focused data analysis typically looking at the effect of one set of variables upon another and data is collected from the same panel sample (or part of) on each occasion (Kelley et al., 2003).

As pointed out by Kelley et al., (2003); survey research has various merits and demerits. The merits include: data is based on real world observations (empirical data), (ii) breadth of coverage means that it is more likely than other approaches to obtain data from a representative sample, and (iii) a large amount of data can be collected in a short time at a fairly low cost. The demerits include: (i) significance of data can become neglected if the researcher focusses too much on the range of coverage to the exclusion of an adequate account of the implications of data, (ii) data may lack details or depth on topic being investigated, and (iii) securing a high response rate to a survey can be hard to control.

The weaknesses as outlined above by Kelley et al., (2003) are mitigated by ensuring that the questions are succinct and also limiting attrition through regular reminders.

5.1.3 Scope and objectives of expert opinion surveys

The analyses in this thesis (Chapters Seven to Twelve) indicate that in all case study countries apart from Namibia, there is a strong bias towards capital investment road projects to the detriment of maintenance projects which leads to the loss of asset value and is not fair to the majority of the people who mainly benefit from road maintenance projects. Furthermore, road scheme prioritisation is believed to be largely non-systematic. The survey process was aimed at seeking views on the ideal equitable allocation between capital investment and road maintenance (macro equity); allocation of road funds between the various road network classes within the maintenance category (meso equity) and to obtain expert opinion on road scheme prioritisation and allocations to various lower local government jurisdictions (micro equity).

The questions and objectives of the two stage survey process are directly linked to the research aims discussed in Section 1.3. The questions also attempt to fill the gaps and areas that are not covered extensively in the case study countries where data was insufficient or incomplete.

5.1.4 Research instrument design

When developing the questionnaire, a matrix was prepared systematically showing the research objectives and linking them to the questions such that they specifically address the research aims and objectives. Before launching, the questionnaire was pilot tested with three panel members to seek their views on the clarity of questions and to determine if they specifically address the research aims and objectives. Their comments were incorporated to improve the questionnaire design. Furthermore, an independent reviewer who is completely unfamiliar with the road sector was also requested to provide comments on question clarity and relevancy.

The questionnaire was designed to be succinct but at the same time address all the key research aims and objectives. Furthermore, the layout of the responses to some of the questions was developed in such a manner that weightings (scores) of the factors for the GP models can be derived. The Stage One questionnaire required about 20 to 30 minutes to complete (uninterrupted) and is divided into five main sections covering: (i) general questions about road funds allocation, (ii) macro-equity allocations, (iii) meso-equity allocations, (iv) micro-equity allocations, and (v) the final section includes questions about expert's general experience in road funds allocation and road scheme prioritisation and whether experts had worked in other developing regions other than SSA. The questionnaire was designed to have slightly 'easy' starter questions before delving into more difficult but important aspects mid-way through the questionnaire. The purpose of this was to keep the experts interested in the questions so as to progress quickly to the next stage. A question progress tracker was also provided so that respondents could be able to determine the number of pages left to complete the survey. Furthermore, the option to save and complete the questionnaire at a later time was provided. Questions requesting for personal details were put at the end of the questionnaire including requesting participants to provide general comments on their understanding of equity and to provide their personal contact details such that they can be followed up for the Stage Two survey. Some members stressed that their responses were made in their personal capacity rather than that of their employers.

Contrary to suggestions that chain referral sampling is self-propelled, the researcher must actively and deliberately control the samples initiation, progress and termination (Biernacki and Waldorf, 1981). Therefore, in order to maintain momentum and limit attrition, a weekly reminder was sent via email and phone (where provided) to experts who had not completed the questionnaire. The Stage One survey which included both quantitativ and qualitative questions remained open for one and half months.

5.1.5 Recruitment of experts and sampling process

A combination of purposive and snowball sampling strategies were used to identify and recruit a number of suitable experts to invite for the survey. The sampling problem required identifying respondents who would start the referral chain and then identifying their eligibility as potential respondents with relevant expertise. An email was sent out to all the 32 Road Funds in Africa which subscribe to the Association of Road Maintenance Funding Agencies (ARMFA) to request for their willingness to participate in the survey; therefore the recruitment was non-random sampling. Contact details were obtained from the ARMFA website (www.armfa.org). In some instances contact details provided on the website were for ex-directors; furthermore, in some cases, the main Road Fund contact email was un-operational and this is another challenge when undertaking online surveys in SSA. Follow up phone calls were made to obtain up to date contact details as far as reasonably practicable. The same expert invitation email was also sent to the Africa Community Access Programme (AFCAP) online community of experts (www.afcap.org).

Key experts who did not belong to the aforementioned institutions but from other relevant fields such as academia, consultancy, government ministries and development partners were also invited; and other experts were identified through literature review and author's personal contacts which include various personnel working in the road sector institutions in SSA. Furthermore, the AFCAP secretariat which is now based in Oxfordshire assisted in sending the web-link of the online questionnaire to all members in their database. Experts who had expressed interest in joining the panel were also requested to identify other colleagues with relevant expertise to participate in the survey thus creating a snowball or chain referral. According to Biernacki and Waldorf (op. cit., 1981), the method yields a study sample through referrals made among people who share or know others who possess some characteristics that are of research interest. Snowball sampling emerged as a non-probability approach to sampling design and inference in hard to reach and geographically dispersed populations (Heckathorn, 2011). The aforesaid is similar to the current study as experts on the panel are geographically dispersed. Kelley et al., (op. cit., 2003) identify three main techniques for non-random sampling which include: (i) purposive sampling which deliberately targets individuals within a population and only its members are included in the survey, (ii) convenience sampling where the sample is made up of individuals easiest to recruit, and (iii) snowball where the sample is identified as the survey progresses. All the aforementioned approaches were used in the recruitment. Similarly, to encourage participation, the invitation email was sent using the author's employer email address and signed off using the University of Leeds logo to show both academic and practical relevancy.

In circumstances where the email was not received (bounced); potential experts were contacted by phone and when establishment of contact failed, potential panellists were excluded from the survey. Other potential 'experts' declined to participate in the survey on the basis that they were not knowledgeable enough in the field of road funds allocation and road scheme prioritisation in SSA albeit they were members of the AFCAP online community. The survey questionnaire was sent out in the English language; however, some of the participants identified in the ARMFA and AFCAP database were from Francophone countries. One expert requested that the survey questionnaire is translated to French; however, this option was not pursued given that all case study countries were Anglophone although in Tanzania, Swahili is the official language and in Namibia; Afrikaans and German are widely spoken. Fifty experts agreed to take part in the Stage 1 survey; however only forty four actually completed the web-based questionnaire creating an initial response rate of 88% of the target sample. Approximately 30% of the Stage 1 participants were based in Uganda albeit some had experience in other SSA countries; whilst other experts were located or had experience in various countries including: Uganda, Ghana, Zambia, Kenya, Tanzania, Namibia, Zimbabwe, Malawi, South Africa, Canada, USA, UK, Mozambique, France, Netherlands, New Zealand and Ethiopia. All the case study countries had representation from at least three Stage 1 experts in the survey. Table 5-1 overleaf analyses key profiles of experts for the Stage One survey.

It should be noted that in Tables 5-1 and 5-5, some experts had experience from more than one country and several experts' employer classifications and professional experience overlaps (the number of experts should not be summed up as the total(s) will not equate to the actual number of experts). All experts who participated in the surveys were thanked for having taken time to complete the questionnaire. To limit bias, one third of experts with Uganda experience were excluded in the statistical analyses during Stage Two; however comments of the participants are still recorded in the first stage. The panellists with Uganda experience whose results were excluded in the second round of surveys included those who were not directly involved with road funds allocations and those who filled some parts of the Stage Two questionnaire incorrectly. According to Saunders et al., (2000), when comprehension of reasons for attitudes and opinions is necessary, it may be prudent to undertake an in-depth interview. Therefore, after the Stage 2 data analysis and in order to gain deeper understanding, face to face interviews were undertaken with three key experts as analysed in Section 5.4.5.

Country experience	**Experts (No.)**	**Professional affiliation**	**Experts (No.)**	**Employer classification**	**Experts (No.)**
Uganda	13	Civil Engineer	19	Consulting	12
Ghana	3	Consultant	12	Development	7
Zambia	3	Donor	7	Road Fund	11
Kenya	3	Transport Planner	5	Road Authority	9
Tanzania	4	Academia	4	Ministry of Works	3
Namibia	3	Economist	2	Government	1
Zimbabwe	1	Road Fund Director	5	Contractor	1
Malawi	1	Ph.D. holders	8	Researcher	1
South Africa	3	Accountant	1		
Canada	1				
Americas	1				
UK	2				
Mozambique	1				
France	1				
Netherlands	1				
New Zealand	1				
Ethiopia	1				
Other developing countries	15				

Table 5-1 Stage One expert profiles and country experience in road funds allocation and road scheme prioritisation

5.1.6 Ethical considerations and risk assessment

An ethical review application was submitted to the Faculty Research Ethics Committee and the issues outlined in Table 5-2 overleaf had to be considered as the research progressed.

Identified ethical issue/risk	Thesis mitigation measure
Risk of disclosing corruption and experts being identified.	Names of panellists are not disclosed. Similarly, consideration is given to having the thesis embargoed for some time.
Time limit for participants withdrawing their opinions ought to be specified.	Experts were notified and advised on whether (and when) they should withdraw their responses.
Risk assessment (health and safety) whilst undertaking research.	Risk assessment forms were not completed as data was collected mainly online. During case study country visits, precautions were undertaken with reference to guidance provided by the UK Foreign and Commonwealth Office.

Table 5-2 Key ethical issues (risks) and mitigation measures

5.2 First stage analytical process and results

This section analyses the responses to the Stage One questions and provides comments on their transferability into sharper and more detailed Stage Two questions.

5.2.1 Expert opinion on research aims and objectives

With reference to the research aims and objectives (see Section 1.3), respondents were asked to indicate whether an allocation formula is important in the distribution of road funds in SSA as a tool for achieving equity? There was unequivocal agreement by 81.8% of experts that formulae are important. However some experts acknowledge that the results of the formulae are sometimes not followed systematically. Interestingly, 11.4% of respondents stated that it depends on the country under consideration; which implies that some experts do not believe in formulaic allocations or formulae may not be suitable for some SSA countries. This may be possibly based on the notion that even when formulae are used, they are not equitable and are often manipulated. Similarly, the majority of experts (61.4%) agreed that the existing formulae and models used in SSA do not adequately take account of equity in road funds allocation and road scheme prioritisation; and although some formulae incorporate elements of equity, it is not ‘highly’ weighted and the governing factor is mainly economic efficiency. A number of experts also observed that although formulae may be fair, they are often overruled by political priorities. Experts were requested to comment on whether the equity factors used in existing road funds allocation formulae and decision support systems for road scheme prioritisation in SSA achieve their intended goals and whether they appropriately address equity. 13.6% of experts were in agreement; however, almost two-thirds of the participants (63.6%) stated that equity is not addressed adequately. In the same vein, an expert argued explicitly that *"there is no equity in Africa*" which to some extent sums up some aspects of this thesis (equity is negatively correlated with poverty).

Based on the author's experience combined with literature review evidence and the findings of the case study data analysis, the author proposed to experts possible factors that are important for road funds allocation and road scheme prioritisation and sought their views. Experts were requested to identify and vote for factors they considered to be most important and they also had the option of including additional factors they considered to be critical. The results are analysed in Table 5-3 below:

Salient factors to be considered in road fund allocations and road scheme prioritisation.	**Experts (No.)**
Network metrics (road lengths, condition, traffic volumes) and economic efficiency/viability	32
Social equity factors (distance to key amenities)	29
Population density	29
Regional connectivity	28
Rural Accessibility Index	21
Agricultural productivity, extraction of resources and tourism	20
Multi-dimensional Poverty Index	17
Terrain and rainfall levels (climate and hydrological issues)	15
Availability of transport services on the network	11
Community participation / stakeholder involvement	10
Uniform minimum threshold	9
Land surface area	8
Special fund for rural roads	8
Regional and ethnic balance	7
Equalisation fund (for poorer regions / remote areas)	6
Works implementation methods (contracting or force account)	5

Table 5-3 Ranked expert opinion on key factors for road funds allocation and road scheme prioritisation

A number of important issues are deciphered from Table 5-3; most experts chose economic efficiency and this is closely followed by social equity factors. Interestingly, although social factors may be best addressed with community participation, only ten experts selected it. In all case study countries (Chapters Seven to Twelve), multi-dimensional poverty is not embedded in the existing formulae; however, over one-third of experts (38.6%) are in its favour. Furthermore, it is widely acknowledged that there are major regional economic imbalances within individual SSA countries such as Uganda, Ghana and Zambia; and this is partly a colonial legacy, however, experts are not highly supportive of setting up a regional equalisation fund. In the same vein, it is argued in literature that rural roads are underfunded albeit experts are not highly in favour of setting up a special fund for rural roads which is indeed paradoxical.

Population density scores highly (29 votes) and is a good proxy for road usage; and although surface area appears a good measure for funds allocation, it is not deemed very relevant by experts. Furthermore literature review and expert opinion indicates that there is political interference in road funds allocation, however, it has not been suggested as an important factor. Another interesting observation from the data above is that agricultural productivity and resources extraction are important factors, however, in all case study countries, the aforesaid factors are not explicitly used in allocation formulae. In summary, the single most salient observation emanating from the analysis of expert opinion above is that funds allocation and road scheme prioritisation should take account of both economic efficiency and social equity. The results of Table 5-3 are taken forward in the Stage Two questionnaire but with only the top seven factors maintained as they have the highest votes and are considered to be most important.

5.2.2 Critique of expert views on macro level equity

Experts were requested to indicate what they considered to be the ideal split in expenditure between capital investment projects and road maintenance in the case study countries. However, based on literature review and case study data analysis, the author suggested possible ranges but also an option for an independent answer.

This question produced the most wide spread variation in responses and the largest proposition (with regards fixing the splits) albeit by only 18.18% of experts was for 30% capital and 70% maintenance as analysed in Table 5-4 overleaf. A large number of experts (22.73%) were not in favour of fixing the split. Furthermore, although 40.91% of experts who were in favour of fixing splits posited a range of 60% to 80% allocation for road maintenance; this would be politically untenable and would also be detrimental to the rural and remote regions which would be beneficiaries of new road links thus affecting Rawlsian equity. It is therefore considered prudent to set the upper limit of road maintenance expenditure at 50% (consistent with 36.35% of experts); especially for countries with less developed road networks.

Macro equity split		Experts (No.)			Percentage (all experts)
Capital Investment	Maintenance	Road Fund	Road Authority	All experts	
50%	50%	4		5	11.36%
40%	60%		1	6	13.64%
30%	70%	2	2	8	18.18%
20%	80%	1	2	4	9.09%
60%	40%	2	1	5	11.36%
70%	30%		1	5	11.36%
80%	20%			1	2.27%
Other		2	2	10	22.73%

Table 5-4 Summary of macro equity splits by experts (Stage one)

From Table 5-4, it is evident that a large number of experts associated with Road Funds and Road Authorities are all in favour of high allocations towards road maintenance. Nine panellists from Road Funds and six from Road Authorities proposed allocations towards maintenance to be above 40%. Interestingly, the weighted average for maintenance from panellists of Road Funds is 55% and that from Road Authority staff is 61% albeit great emphasis towards capital investments was expected from panellists associated with Road Authorities. Nevertheless, experts are generally not in agreement and most suggest that macro level allocations should be country specific and based on a needs assessment. A number of experts posited that the existing maintenance backlog should be cleared first prior to consideration of new road development. However, there are major challenges with the aforesaid views expressed by experts; firstly, most SSA countries do not have up to date network inventory and metrics for meaningful needs assessment; secondly, failure to allocate funds to new roads development is politically untenable and detrimental to inhabitants in remote regions without access roads (not equitable in a Rawlsian manner).

Experts also observe that allocations ought to be linked to network metrics (length and condition) and an expert writes that: *“percentages should not be set and network composition should be considered”*.The summarised expert views and suggested macro-equity splits are taken forward when developing the more detailed Stage 2 questionnaire albeit with revised answer options aligned to splits suggested by most experts and the views of experts who did not recommend (specify) macro-equity splits are also recognised.

5.2.3 Critique of expert opinion on meso level equity

The experts were requested to provide their views on the ideal equitable split of road maintenance funds between national roads (trunk/strategic network) and other roads (non-core road network). Just over one third of respondents (34.1%) posited that the split should be 60% national and 40% other. For the split between rural roads and urban roads, the majority of respondents (18.2%) suggested a split of 70% rural roads and 30% for urban roads. For the split between district roads and community access roads, over half of respondents (52.3%) posited 60% for district and 40% for community roads.

Responses to meso equity questions varied widely and experts were non-committal. The argument just like in macro equity analysis is that allocations should be based on needs assessment; however, challenges with this approach were highlighted earlier (see Section 5.2.2). The summarised expert views and suggested meso-equity splits are taken forward when developing the more detailed Stage 2 questionnaire albeit with revised answer options aligned to splits suggested by most experts and the views of experts who did not recommend (specify) meso-equity splits are also recognised.

5.3 Experts' analysis of key aspects of the research study

Experts were given an option (open question/blank space) to provide independent views on their understanding of equity and related issues as regards SSA road sector.

Equity: It is acknowledged by experts that equity goals are not major features in formulae; and in most SSA countries equity is not achieved in road scheme prioritisation and allocation formulae. An expert notes that: "*allocation mechanisms prioritise national roads which could be considered as economic equity (where road user charges are in effect then such allocations are fair)".* In contrast, a number of experts argue that equity is a very subjective matter as everyone has their own and often different opinion.

Formulaic allocations as regards equity: Experts observe that formula allocation is important as it ensures that allocation of funds is equitable and can minimise political intervention. Complicated formulae are considered not to be helpful and countries may have allocation formulae that may be fair but often over-ruled by political priorities and in most instances decisions do not follow results of formulae. An expert points out that: *“formulae ought to use a combination of factors but simple enough to be explained to opinion leaders”*.

Decision support systems: It is the experts’ view that decision support systems are rarely used appropriately in SSA and there is no systematic strategy. According to one of the experts, *“although HDM-4 which is widely used by road authorities in SSA has elements of equity, it tends to prioritise highly trafficked roads hence some social equity elements are lost”.* However, decision systems are better than nothing and should be developed to suit a specific country scenario and clearly explained.

Political interference and intervention: Almost all experts agree that political interference and intervention is ubiquitous, however, one panellist considers that: *“it may not be a bad thing as it can redress the social imbalance that the use of HDM results in. Moreover, policy drives allocations (aside from political intervention) and where policies are implemented consistently then this can be considered fair”*. Conversely, a number of experts observe that intervention prioritisation is often influenced by political interference and this is the biggest constraint to equitable and sensible allocation of resources. An expert points out that: *“often political priorities take preference over technical arguments making planning and resource allocation more difficult”*. Therefore, politics makes equitability difficult to achieve. Furthermore, another expert points out that based on his experience; *“the political factor has taken centre stage as Members of Parliament want development in their constituencies for them to be re-elected in the next election”*.

Equity in road scheme prioritisation: A number of experts suggest that prioritisation tools need to limit political decisions to a certain percentage of resources and prioritisation of main roads should be purely on economic criteria/efficiency whilst for rural roads should be based on multi-criteria/social equity. The community should be involved in road scheme prioritisation and preference should be made to rehabilitate and maintain core road infrastructure.

Data availability and validity: Experts concur that in SSA, there is no reliable baseline data to make informed decisions and there is a problem collecting data and ensuring relevancy and quality. One interesting observation about this view is that most experts already indicated that a needs assessment ought to be undertaken when addressing macro and meso equity; and this requires up to date data; however, in the same vein, experts acknowledge that data is not reliable. Furthermore, one expert cautions that: *“environmental issues and population factors in sparsely populated areas are not properly modelled”*.

National roads versus other roads: Experts agree that for national roads, economic efficiency important and for regional roads, connectivity is a key issue whilst for local and minor roads; social factors and poverty alleviation ought to be considered.

Road User Charges (RUCs): Where road users contribute directly to road funds, they should have a say in allocations. A panellist observes that: *"road funds (through RUCs) should cater for maintenance whilst government covers new developments"*.

5.4 Second stage analytical process and results

A Stage Two questionnaire was developed based on the answers provided as part of the first stage survey as well as information gathered from case study countries and literature review. About two thirds (65.9%) of the forty four Stage 1 experts continued with Stage 2. Table 5-5 below analyses the profiles of the experts.

Country experience	Experts (No.)	Professional affiliation	Experts (No.)	Employer classification	Experts (No.)
Uganda	12	Civil Engineer	12	Consulting	4
Ghana	1	Consultant	4	Development	5
Zambia	3	Donor	5	Road Fund	9
Kenya	3	Transport Planner	5	Road Authority	6
Tanzania	2	Academia	1	Ministry of Works	3
Namibia	2	Economist	1	Government	1
Zimbabwe	1	Road Fund Director	5	Contractor	1
South Africa	1	Ph.D. holder	1	Researcher	1
Americas	1	Accountant	1		
England	1				
Mozambique	1				
France	1				
Netherlands	1				
New Zealand	1				
Ethiopia	1				

Table 5-5 Stage Two expert profiles and country experience in funds allocation and road scheme prioritisation

A possible weakness of the Stage Two panel is that a relatively large percentage (37.5%) of the twenty nine experts have Uganda road sector experience. However, in order to mitigate against bias, one third of experts with Uganda experience who answered parts of the questionnaire incorrectly and those with limited experience in road funds allocation are excluded in the analysis. Therefore, the resultant Stage Two panel consists of twenty five experts. A critical review of the Stage Two findings from the experts with experience in fifteen countries (including regions) is provided below:

5.4.1 Resultant expert opinion on macro equity allocations

It was suggested by over one third of the experts (37.9%) that the split between capital investment and maintenance should be based on a needs assessment taking account of network metrics and road network composition. However, 20.7% of the experts were of the view that maintenance backlogs should be cleared first before capital expenditure. The author's opinion on the aforesaid views has already been discussed in Section 5.2.2. The remaining experts (41.4%) had varying opinions on the macro equity splits. However, some panellists concur that this is purely a policy matter and an Executive Director of one of the Road Funds points out that *"SSA governments need to give same priority to maintenance as they give to new projects and respect Road Investment Plans"*.

It can be concluded that a needs assessment is important albeit the task can be expensive to undertake and results may not be reliable. In the same vein, it is not possible to provide general macro equity splits for all countries as different countries have varying requirements and due regard must be given to local conditions. One expert notes that: *"some countries need to spend more on road development because their networks are undeveloped whilst others have built roads in recent years and need to maintain them"*. In the absence of a needs assessment, this thesis has posited coefficients and indices for macro equity assessment discussed in Chapter Six.

5.4.2 Meso level allocations derived from expert opinion

As part of the Stage One questionnaire, experts were asked to highlight the most important factors that should be considered when allocating road funds (see Table 5-3). During Stage Two, experts were requested to provide weightings for the most important factors (economic efficiency, social equity, needs basis and regional connectivity) when allocating funds for (i) national/trunk roads, (ii) rural/district roads, and (iii) urban roads. The determined weightings (scores) are used in the GP models developed in Chapter Six.

A matrix questionnaire was developed with three rows and four columns (see Table 5-6 overleaf) and experts were requested to provide weightings; and this culminated in a bespoke spreadsheet for data analysis. Experts were requested when providing weightings to ensure that the total in each column adds up to 100%. However, some of the experts erroneously provided scores horizontally whilst some scores did not sum up to 100%. The results of the four experts who completed the questionnaire incorrectly were discarded for this particular question.

To limit complexity and in line with attributes of good formulae (see Section 3.2), simple statistical analyses were undertaken to determine arithmetical average weightings for each factor and each road category; however weightings may also be determined at the 50th and 75th percentiles. The panels' proposition in the weighting of the critical factors per road category results into an allocation of 47.5% to national roads, 29.2% to rural roads and 23.3% to urban roads.

When the expert opinion results are cross referenced with literature review evidence as outlined in Table 6-2 in Chapter Six, the analyses support the argument that currently SSA allocations are biased towards national roads at the expense of rural roads which is not equitable in a Rawlsian manner.

The spreadsheet and methodology developed for analysing allocations can be customised to individual countries based on their experts' views; and additional factors can also be incorporated in the matrix.

Road network class	**Economic efficiency**	**Social equity**	**Needs basis**	**Regional connectivity**	**Derived allocation (%)**
National roads	0.52	0.28	0.49	0.60	47.46
Rural roads	0.20	0.45	0.24	0.27	29.18
Urban roads	0.27	0.26	0.26	0.13	23.36

Table 5-6 Average weightings of key factors in road maintenance funds allocation

The weightings above are used in Chapter Six when developing the weighted and lexicographic GP models for road scheme prioritisation and equity analysis.

5.4.3 Road scheme prioritisation based on expert opinion

It was previously determined that economic efficiency should be the major criterion for prioritisation of national roads whilst for rural and urban roads, social equity is most important. A re-designed and more detailed Stage 2 question required that experts provide a weighting of the most important factors in road scheme prioritisation for both capital investment projects and maintenance schemes for the various network classes: (i) national roads, (ii) rural roads, and (iii) urban roads. Table 5-7 below shows the panel's weights for the key factors considered important for road scheme prioritisation for new road projects (capital investment); and Table 5-8 shows the weightings for prioritisation of maintenance projects.

Since it is widely acknowledged by experts that there is political interference in road scheme prioritisation; it was considered prudent for experts to provide a weighting such that the interference may be 'controlled' to some extent. The spreadsheet developed for prioritising road schemes can be customised to individual countries based on their experts' views; and additional factors can also be incorporated in the matrix. The weightings for the most important factors to consider when prioritising new road projects are analysed in Table 5-7 below:

Critical factor	National roads	Rural roads	Urban roads
Economic efficiency	0.54	0.32	0.50
Social equity	0.14	0.36	0.27
Regional connectivity	0.22	0.16	0.11
Political factor	0.10	0.16	0.12

Table 5-7 Average weightings of factors in new road project selection

Analysis of the expert opinion results in Table 5-7 shows that for prioritisation of new national road projects, economic efficiency should be weighted at just over 50% followed by regional connectivity at just under 25%. For rural roads, about two-thirds of the weighting should be shared almost equally between economic efficiency and social equity. For urban roads, the most important factor is economic efficiency weighted at 50% followed by social equity at 27%. One interesting finding is that experts are willing (on prompting) to accept political interference and this is weighted at 10% and above.

The weightings for the most important factors to consider when prioritising road maintenance schemes are analysed in Table 5-8 below:

Critical factor	National roads	Rural roads	Urban roads
Economic efficiency	0.54	0.35	0.49
Social equity	0.15	0.35	0.28
Regional connectivity	0.22	0.17	0.11
Political factor	0.10	0.13	0.12

Table 5-8 Average weightings of factors in road maintenance scheme selection

Analysis of the expert opinion results in Table 5-8 shows that for prioritisation of road maintenance projects, economic efficiency should be weighted at just over 50% followed by regional connectivity at just under 25%. For rural roads, about three quarters of the weighting should be equally shared between economic efficiency and social equity. For urban roads, the most important factor is economic efficiency weighted at nearly 50% followed by social equity at 27%.

One interesting finding when Tables 5-7 and 5-8 are compared is that experts' weightings for prioritisation of new road projects and maintenance are not very different. The question design was on the incorrect presumption that there would be variations in the scoring. The expert weightings as determined in Tables 5-7 and 5-8 are used in Chapter Six when developing the weighted and lexicographic Goal Programming models.

5.4.4 Micro level allocations derived from expert opinion

For allocations at micro-level; the factors considered to be important were identified in the Stage One questionnaire. For regional allocations, experts believe that needs basis and economic productivity of a region plays an important role in allocations. Literature review and case study evidence shows that agricultural productivity, extraction of natural resources and tourism are not highly prioritised albeit expert opinion in Table 5-9 below highly rates the aforesaid factors. The spreadsheet developed for analysing regional allocations can be customised to individual countries based on their experts' views; and additional factors can also be incorporated in the matrix. The posited weightings by this study's panel as regards regional allocations (micro) are indicated in Table 5-9 below.

Factor	**Weighting**
Needs basis (road condition and length)	0.23
Agricultural productivity, extraction of natural resources and tourism	0.22
Population density	0.17
Social equity factors (multi-dimensional poverty index)	0.14
Rural Accessibility Index	0.14
Regional connectivity	0.10

Table 5-9 Average weightings of key factors for micro level allocations

From Table 5-9, it can be deciphered that needs assessment is most highly weighted; however, at micro-level (local regions, villages, sub counties), network metrics are not accurate and in most cases unavailable. The weightings as determined above are used in Chapter Six when developing the weighted and lexicographic Goal Programming models.

5.4.5 Key results of the face to face interviews

Three key experts were interviewed to obtain clarifications and deeper insight into the thesis aims, objectives and arguments; and below are some of the salient findings. An expert with significant road sector experience in Africa sums up the nature of the road sector problems in SSA by stating that:

> *"A major challenge persists in the face of sparsely located populations and lean economies in SSA, especially among other important competing needs such as education, health, agriculture, security and defence"*. Furthermore, *"SSA is synonymous with constrained budgets and maintenance backlogs so the issue ceases to be the formula rather current priorities of the planning entity"*.

In other words, although allocation formulae may be necessary, there are many other competing needs which may result into lack of appropriate consideration of Rawlsian equity in the SSA road sector.

With regards macro level equity, an expert observes that:

> *"…in Uganda the split in* [road sector allocations in] *FY 2014/15 is about 82:18 in favour of development. If maintenance were fully funded, then the split would be about 72:28 still highly skewed in favour of development...highway authority allocations in the UK are more like 90:10 or even higher in favour of maintenance. This occurs where networks are more fully developed, and therefore we would expect (or try to ensure) that the split in SSA countries moves towards maintenance over the long term".*

Therefore, according to the analysis by the above expert, there is still a need (for Uganda) to spend more funds on new road projects until the road network is fully developed. However, this thesis argues that road maintenance should be equally prioritised to enhance Rawlsian equity.

With reference to the crux of this study, an expert who has worked as a consultant in road sector reforms in various developing countries in the world including SSA states that:

> *"…this is a difficult and complex issue, with many identified factors interrelated and dependent upon others. At the end of the day in democratic countries, it is up to legislature to make a political decision based on clear information from professionals [on] the impact of the various factors and to live with the consequences".*

In other words, politicians should make decisions based on expert opinion although in SSA it is not always the case.

The interviews confirm the challenges associated with embedding principles of Rawlsian equity in road funds allocation and road scheme prioritisation in SSA which this thesis attempts to address.

5.4.6 Limitations of the expert opinion survey process and results

There are a number of limitations which need consideration. A large number of experts possess Uganda experience; however; the possibility of bias is mitigated by excluding one-third of representation during Stage Two analysis. The aforementioned notwithstanding, the challenges in the Uganda road sector have been found to be similar to the situations in most low income SSA countries. Furthermore, most of the panellists are Civil Engineers (see Tables 5-1 and 5-5) as they dominate key positions in road sector institutions and the panel reflected this.

5.5 Chapter summary

A two stage web-based questionnaire (survey) was used to seek opinions on allocation of road funds and road scheme prioritisation. The questionnaire was further supplemented with face to face interviews with three key experts. Weightings (rankings) have been analysed to guide SSA countries in the allocation of their road sector resources as well as road scheme prioritisation based on expert identified factors. Specific aspects of macro, meso and micro level equity have been addressed; and weightings (scores) to be used in the Goal Programming models have been derived. Most experts consider that the best way to address the equity challenges as defined by this thesis is to undertake a needs assessment; however, this can be costly and data is often unavailable or unreliable. Similarly, most experts agree that political interference is ubiquitous within the SSA road sector.

The key governing factors for funds allocations for road maintenance in SSA were identified as: economic efficiency, social equity, needs basis, regional connectivity and network metrics; and the most important factors that were identified to play key roles in prioritising roads in SSA are: economic efficiency, social equity, regional connectivity, and a political factor.

The main factors to consider in order to achieve a fair allocation formula for road funds at regional and district/local government include: social equity factors (multi-dimensional poverty), population density, rural accessibility index, network metrics, regional connectivity and agricultural productivity/extraction of natural resources.

Analysis of expert opinions has confirmed the complexity, subjectivity and challenges of appropriately incorporating Rawlsian equity in allocation formulae.

The factors and weightings (rankings) derived in this chapter based on expert opinion and supplemented with empirical evidence are used in the following Chapter Six to develop equity analysis parameters, new algorithms, formulae, frameworks, Rawlsian equity assessment tool and Goal Programming models for road funds allocation and road scheme prioritisation in SSA.

Chapter Six - New Equitable Formulae, Algorithms and Goal Programming Models for SSA Road Sector

6.1 Introduction

In Chapter Five, the two stage survey process was discussed and salient aspects of the results were analysed and critiqued with respect to equity. The author in this Chapter Six proposes new road funds allocation principles and road scheme prioritisation methods. Furthermore, the importance of prioritisation of road maintenance expenditure as a Rawlsian equity strategy is elucidated.

The new methods are applied in Chapters Seven to Twelve in the analysis of performance of Rawlsian equity in the case studies cognisant of the literature review evidence and expert opinion. Nevertheless, it is widely acknowledged that reliable road sector data in SSA can be difficult to obtain and is time sensitive. Moreover, quite often there are tendencies of road funds recipient agencies to exaggerate their network length and provide inaccurate road condition data such that central governments and Road Funds allocate them more resources. Furthermore, at lower local government levels such as in districts, town councils and villages; there is often lack of expertise and financial incentive to collect the network metrics data.

Most of the SSA road network comprises of gravel and earth roads; therefore, data collected in a given period will change rapidly following seasonal variations such as heavy rains (wet seasons) or periods of long drought combined with strong winds (dry seasons). A road classified to be in a fair or good condition can quickly move into poor condition following heavy rains. Data for paved road condition is more reliable; however, visual interpretation of whether a road is good, fair or poor can be subjective but International Roughness Index if used (analysed) correctly ensures objectivity.

This Chapter also discusses the rationale of selecting the case study countries whose data and processes will be assessed using the developed algorithms and models.

6.1.1 Rationale of high prioritisation of road maintenance expenditure to enhance Rawlsian equity

The benefits of timely road maintenance in SSA road sector include the protection of initial capital investment in road construction, reduction in transport costs, improved traffic safety, environmental sustainability and the facilitation of social and economic development. Furthermore, it is widely acknowledged that the Internal Rate of Return of road maintenance projects is much higher than that of new road projects.

Roads in SSA are supposed to be built for a specified design life but deteriorate quickly due to poor axle load control and lack of timely maintenance and this causes the road pavement to exhibit a number of failures. The deterioration gradually progresses until a time when maintenance intervention should be applied to remove the fatigue symptoms or control their worsening. The process iterates until the pavement reaches the end of its design life commonly referred to as terminal serviceability where it needs rehabilitation or reconstruction. However, timely road maintenance intervention delays the rate of total failure and protects the equity achievements derived from a road project. For gravel roads, periodic maintenance in the form of reshaping and regravelling should normally be undertaken every three years and for paved roads, resealing should be undertaken every seven years (or at 'half-life') to lengthen the life of the road. Nonetheless, routine maintenance should be undertaken throughout the year. The road deterioration cycle (Paterson, 1987) is analysed in Figure 6-1 below:

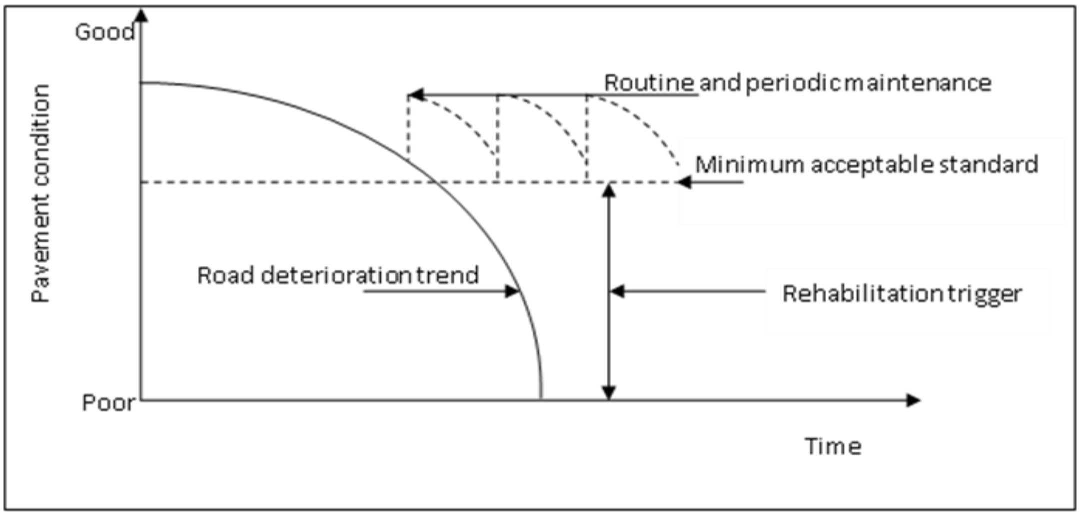


Figure 6-1 Pavement deterioration trend (Source: adapted from Paterson, 1987).

Timely and appropriate road maintenance mitigates against the loss of investment made during the initial road construction. According to Zietlow and Bull (2004), routine and periodic maintenance cost for the entire life of a road is estimated to be between 2% to 3% of the initial capital investment. However, delayed maintenance is most likely to cause this amount to increase. It is widely acknowledged that well maintained roads reflect in savings in vehicle operating costs. The World Bank (1988) observes that this is from reduced fuel and oil consumption, vehicle maintenance, tyre wear and vehicle depreciation.

According to Heggie (1995), each dollar spent on patching on an annualised basis, saves at least three dollars. Furthermore, Robinson et al., (1988) suggest that a tenfold or more return on each dollar invested in patching. Haworth (2014b) estimates that based on assessment of the ten year Roads Plan for Uganda, investment in maintenance and rehabilitation provides a higher return per dollar spent by a factor of five times, than investment in upgrading and capacity increases. Timely maintenance is therefore important from both the economic efficiency and social equity perspectives; and should lead to poverty reduction.

A significant number of road accidents and fatalities in SSA countries may be directly attributed to poor road design (inappropriate drainage facilities, sub-standard horizontal and vertical alignement); moreover, road safety audits are seldom undertaken especially for lower class roads. Furthermore, in Uganda and probably most SSA countries, speeding is the highest cause of fatalities, and these mostly occur on paved national roads, where road condition is good. Well designed road maintenance schemes can result in improved vehicle performance which is good for the environment due to reduced vehicular emissions. In contrast, poorly designed road maintenance schemes can also affect Rawlsian equity through environmental damage such as water pollution from oil spillage, poor air quality from dust pollution and excessive noise and vibration during the construction phase.

It has been widely reported that most countries in Africa have invested heavily in road construction over the last fifty years with financial and technical assistance of international funding agencies and development partners. However, due to constrained budgets, these countries have not allocated sufficient financial resources of their own to continue the investment in the maintenance of their networks. Consequently, the derived equity benefits are gradually eroded. In most SSA countries, a large percentage of capital road infrastructure expenditure is funded by development partners (donors) and they are now becoming increasingly reluctant to fund these projects unless credible arrangements for maintenance are in place. For example, funding of the Kampala flyover construction and road improvement project in Uganda by the Japanese International Cooperation Agency is tied to the Uganda government (Road Fund) guranteeing availability of maintenance funds. From the foregoing, it can be deduced that road maintenance expenditure should be highly prioritised as a goal in achieving Rawlsian equity considering that more of the populace benefit from road maintenance than capital investment road projects.

6.1.2 Ethos of algorithm development

The fundamental description of road fund allocation is the division of funds amongst the different agencies responsible for road development and maintenance. However the road sector inevitably has to compete for resources with other equally important sectors of the economy. According to Varian (1990), optimal resource allocation is achieved if there is increased productivity without negatively affecting other sectors. It requires rational assessment of merits and demerits of preferences. It involves setting priorities for competing sectors on the basis of an established criterion and procedure. The criterion is defined in terms of expected benefits and the procedure is normally determined with the application of formulae or algorithms.

6.2 Macro equity equilibrium

There is a justifiable need to open up and provide access to the various remote regions within SSA countries which are currently inaccessible thus the requirement for new road construction. However, experts posit that the split between maintenance budget of national and other roads should be based on needs of both categories and will differ from country to country (see Sections 5.2.2 and 5.4.1). Basing allocations on needs alone may not be easily achieved until implementing agencies have full and reliable data of the extent and condition of their networks and until there is sufficient technical expertise to analyse and interpret the aforementioned data and to plan and prioritise road projects. If up to date Road Maintenance Financing Strategic Plans outlining requirements over a period of say five years are available (with Rawlsian equity embedded), then funding ideally should be in accordance with the Plans including measures to clear the maintenance backlog. In 2008, a study conducted by the World Bank provides an analysis of road sector expenditures (macro equity) in 19 SSA countries as examined in Table 6-1 overleaf. Average expenditure on capital investment was 68.4% and 31.6% on maintenance.

6.2.1 Proposed macro equity assessment parameters

New parameters are proposed in this thesis for analytical assessment of macro equity based on comparative review of allocations between capital investment projects and maintenance schemes and they are referred to as *Macro Equity Coefficient (MEC)* and *Macro Equity Index (MEI)*. The proposed formula used to derive *MEC* is defined as the ratio of the Effective Road Maintenance Budget (ERMB) or Expenditure to the sum of the Effective Maintenance Budget and Effective Capital Investments Budget (ECIB) or Expenditure (equations 6.1 and 6.2 respectively). The proposed formula for *MEI* is the 'base 10' logarithm (common logarithm) of the inverse of *MEC* (equations 6.3 and 6.4). The aforementioned formulations are summarised below:

$$MEC_b = ERMB_b / \sum(ERMB_b + ECIB_b) \qquad (6.1)$$

$$MEC_e = ERMB_e / \sum(ERMB_e + ECIB_e) \qquad (6.2)$$

$$MEI_b = Log_{10}[MEC_b]^{-1} \qquad (6.3)$$

$$MEI_e = Log_{10}\,[MEC_e]^{-1} \qquad (6.4)$$

Where: '$_b$' is budget; and '$_e$' is expenditure.

It is proposed that in some cases whilst undertaking computational analysis of *MEC* and *MEI*, budgetary allocations for operational and administrative expenses (recurrent wage and non-wage components of budget) of the Road Authorities, implementing agencies, local authorities and Road Fund may be excluded in order to obtain effective budgets; however, they are usually small amounts.

Country	**Capital projects (%)**	**Maintenance (%)**	**Implications for equity**
South Africa	3%	97%	Bias towards maintenance with allocations (>50%).
Kenya	18%	82%	
Tanzania	48%	52%	
Benin	58%	42%	Major bias towards capital investment projects with allocations at more than 55%. Ghana allocates two-thirds of its budget to capital projects.
Malawi	59%	41%	
Zambia	60%	40%	
Cameroon	60%	40%	
Ghana	66%	34%	
Mozambique	66%	34%	
Lesotho	68%	32%	
Niger	78%	22%	Strong bias towards capital investment projects with allocations for capital expenditure at more than 75%.
Rwanda	79%	21%	
Ethiopia	84%	16%	
Uganda	86%	14%	
Madagascar	88%	12%	
Nigeria	92%	8%	
Senegal	94%	6%	
Cote d'Ivoire	94%	6%	
Chad	98%	2%	
Average	68.4%	31.6%	Author calculations (for comparison with *MEC*).
50^{th} Percentile	68.0%	32.0%	
75^{th} Percentile	87.0%	40.5%	

Table 6-1 Macro-level road sector expenditure in various SSA countries (Source: adapted from AICD, 2008, cited in Gwilliam et al., 2009)

A very low *MEC* value indicates skewed allocations towards capital investment projects; a *MEC* range of 0.25 to 0.50 (equivalent to 25% to 50% allocation for road maintenance) is considered in this thesis to be equitable in a Rawlsian manner based on a combination of literature review evidence and expert opinion survey results (see arguments in Section 5.2.2). Furthermore, as analysed in Table 6-1; the derived 50th Percentile (median) based on AICD data from 19 SSA countries results in an *MEC* value of 0.32 which almost at mid-point (0.37) of this thesis suggested range. An equitable *MEI* in accordance with this thesis should therefore range from 0.30 to 0.60 considering the ethos earlier discussed on the determination of *MEC*. The *MEC* and *MEI* values can be determined at both budgetary level and at expenditure level. The introduction of the logarithm component in the formula is to smooth out the results such that the *MEI* value lies between 0 and 1 in most cases. The recommended parameter ranges should be interpreted and applied with caution as they are most appropriate when the road sector authorities and implementing agencies are efficient and operating in a commercial manner with limited pilferage and good corporate governance. Furthermore, the factors are most appropriate when there are no recent studies on needs assessment; or in instances where data is unavailable or unreliable.

It is proposed that if a developing country's allocation is currently out of range of the *MEC* and *MEI* values, a needs assessment should be undertaken but in the interim the allocations should be 're-adjusted' over the years aiming for a gradual move from the lower to the upper band of the range. The time period for the gradual adjustments of the *MEC* and *MEI* values through the range should be based on local expert opinion; however, a period of between 5 to 10 years is considered reasonable depending on the performance of a country's economy and also in order not to unduly affect other sectors. Similarly, *Pareto optimality* should be considered such that capital investment budget lines are not worse off in an abrupt manner. Regular monitoring and evaluation is necessary to determine if the equity goals are being achieved and whether the assessment parameter boundaries need reviewing.

In road funds allocation, it is believed that a truly exclusive and optimal (ideal) solution only exists if a single criterion is considered in the analysis. However, in most decisions, considering one criterion alone is insufficient and several conflicting and often non-commensurable objectives should be considered (Loken, 2007). In Chapter Five, some experts suggested that allocations at macro-level could be purely a policy decision depending on the network characteristics of a country and opinions of the technocrats. However, this thesis argues that allocations should not be overly skewed towards capital investment projects. The process flow for decision making in macro level road funds allocation could incorporate some of the multi-criteria decision analytical process as analysed in Figure 6-2 overleaf.

6.3 Innovation in macro equity analysis by Goal Programming

Goal Programming (GP) is posited in the determination of allocations of road funds at macro-level and the expert based *MEC* ranges should be the target goals. In instances where there is no up to date network needs assessment and considering this study's expert opinion results, GP can be used in road sector budgets by setting targets for capital expenditure to be about 30% to 40% and maintenance expenditure to be about 60% to 70% (see Table 5-4). The aforesaid limits can then become the boundaries in attainment level. The ranges need to be considered cautiously considering the arguments in Section 5.2.2. Furthermore, the suggested ranges are generic and would need to be modified based on local expert opinion.

For a given country in SSA, important allocation criteria and the priority weights can be determined directly by policy makers, experts who may be contacted in surveys or through interest groups or determined indirectly. Taplin et al., (1995, p.60) point out that "methods of estimating weights from respondents include trade-offs, distributing points to criteria (rating), ranking, paired comparisons and formulation of scenarios to determine combination of weights". Furthermore, indirect methods include estimation of preferences revealed by previous choices, asking respondents to rank alternative projects (not criteria) and interactive estimation of weights in discussion (ibid).

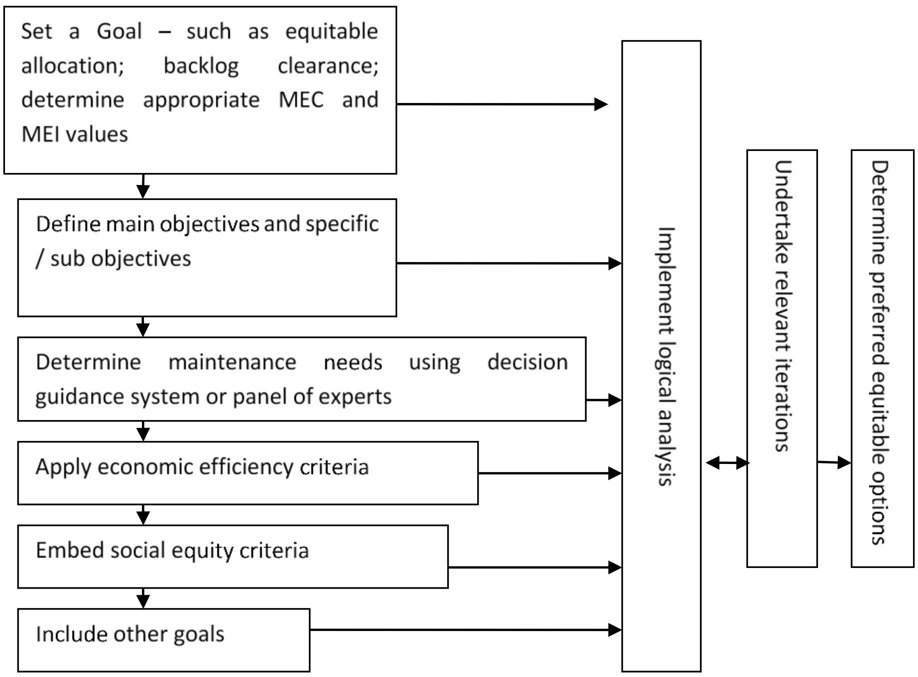


Figure 6-2 Typical flow chart for macro equity allocations (Source: adapted from Boamah, 2010, p.55).

6.4 Innovation in meso equity analysis by Goal Programming

In a study undertaken by Gwilliam et al., (2009), 60% of the Road Funds surveyed in SSA had established a clear percentage allocation of dividing funds between the different networks although allocations differed substantially across countries. On average, around 60% is allocated to the trunk road network, 20% to rural road network, 10% to urban road network and overheads typically 6% but also varies widely (ibid). However, Gwilliam et al., (2009) over estimate when determining overheads expenditure as a more precise value as derived in Table 6-2 overleaf is in the order of 3% instead of the reported 6%.

In order to embed principles of Rawlsian equity, new parameters are proposed in this thesis for meso equity analysis by comparing allocations of road maintenance between the core road network and non-core road network. The parameters are: *Core Road Network Meso-Level Equity Index* (*CRONEMI*) and *non-Core Road Network Meso-Level Equity Index* (*n-CRONEMI*). The proposed formula used to determine *CRONEMI* in this thesis is defined as the 'base 10' logarithm of the inverse of the ratio of the budget allocation for the strategic trunk road network to the total road maintenance budget (equations 6.5 and 6.6). The formula used to derive *n-CRONEMI* in this thesis is defined as the logarithm of the inverse of allocation for rural roads to the total road maintenance budget (equations 6.7 and 6.8).

$$CRONEMI_b = Log_{10}[CRN_b / \sum(CRN_b + nCRN_b)]^{-1} \qquad (6.5)$$

$$CRONEMI_e = Log_{10}[CRN_e / \sum(CRN_e + nCRN_e)]^{-1} \qquad (6.6)$$

$$n\text{-}CRONEMI_b = Log_{10}[nCRN_b / \sum(CRN_b + nCRN_b)]^{-1} \qquad (6.7)$$

$$n\text{-}CRONEMI_e = Log_{10}[nCRN_e / \sum(CRN_e + nCRN_e)]^{-1} \qquad (6.8)$$

Where: '$_b$' is budget; and '$_e$' is expenditure. CRN is the core road network (trunk roads) and nCRN is the non-core road network (other roads).

Table 6-2 overleaf shows an analytical assessment of the allocations to the various road network classes (meso level equity) by 15 SSA countries with Road Funds. On average, 60.47% of allocations were towards the core network and 37.6% non-core.

This thesis proposes that the *CRONEMI* value should range from 0.19 to 0.30 indicating a budgetary allocation to the core strategic highway network of about 50% to 65% of available maintenance funds which is considered equitable in a Rawlsian manner based on a combination of literature review evidence and expert opinion findings (see analyses in Section 5.2.3). As indicated in Table 6-2 overleaf; the derived 50th Percentile (median allocation) for national roads based on data from 15 SSA countries is 64% and results in a *CRONEMI* value of 0.19. The value of *n-CRONEMI* should range from 0.30 to 0.45 indicating a budgetary allocation to the non-core network ranging from 35% to 50% of the total road maintenance budget. This is also based on what is considered to be equitable taking account of a combination of literature review evidence and findings of the expert opinion surveys (see Section 5.2.3). As indicated in Table 6-2; the derived 50th Percentile (median allocation) for non-core road network is based on data from 15 SSA countries is 35% (25% rural and 10% urban) and results in an n-*CRONEMI* value of 0.46.

Country	**National Roads**	**Rural Roads**	**Urban Roads**	**Over Heads**	**Other**	**Implications for equity**
Rwanda	26%	10%	61%	3%		National roads generally take the largest share with overhead costs not varying majorly and are within 5%.
Mozambique	35%	25%	10%	2%	28%	
Ghana	37%	30%	25%	2%	6%	
Malawi	45%	25%	10%	5%	15%	
Zambia	50%	25%	25%			
Namibia	55%	33%	5%	2%	5%	
Kenya	56%	29%	10%	3%	2%	
Niger	64%	12%		5%	19%	
Cameroon	65%	12%	10%	4%	9%	
Ethiopia	65%	25%	10%			
Tanzania	69%	30%		1%		
Madagascar	72%	14%	11%	3%		
Chad	82%		14%	4%		
Cote d'Ivoire	90%		10%			
Benin	96%	1%		3%		
Average Allocation	60.47%	20.85%	16.75%	3.08%	12.0%	Author's statistical analyses.
50th Percentile (Median)	64.00%	25.00%	10.00%	3.00%	9.00%	
75th Percentile	71.25%	29.25%	12.50%	4.00%	17.0%	
$CRONEMI_b$	0.19					See equations 6.5 to 6.8.
$n\text{-}CRONEMI_b$		0.46				

Table 6-2 Meso-level allocations in various SSA countries and statistical analyses (Source: adapted from Gwilliam et al., 2009)

The limitations and caution in the interpretation and applicability of *CRONEMI* and *n-CRONEMI* values are similar to those for the coefficients and indices discussed in

Section 6.2.1. The suggested lower and upper limits of *CRONEMI* and *n-CRONEMI* values can be used as the target goals or attainment level boundaries in a GP model. The suggested *CRONEMI* range is 0.19 to 0.30; however, they are generic and require adaptation based on local expert opinion and network metrics.

6.5 Innovation in micro equity analysis by Goal Programming

Considering the expert opinion survey results (see Table 5-9), the main factors for a fair allocation formula for road funds at regional and district/local government were identified us: social factors (multi-dimensional poverty), population density, Rural Accessibility Index (RAI), network metrics, regional connectivity and agricultural productivity/extraction of natural resources. A GP model can be used for allocation of resources at regional level with the weighting of the goals as outlined below: social factors (0.14), population density (0.17), RAI (0.14), network metrics (0.23), regional connectivity (0.10) and agricultural productivity/resource extraction potential (0.22). The aforementioned weightings may also be used as lower limits of an efficiency boundary in a GP model. Furthermore, based on the list, the first level priority factors can be set and ought to include network metrics and agricultural/economic potential of a region whilst the remaining factors can all fall into the second priority level. The weightings and priority levels can be determined by experts in a given country in SSA.

6.5.1 Innovation in micro equity allocations using an equitable framework

An equitable and participatory framework approach in the allocation of road funds at regional and lower local government level using an iterative flow process is proposed in Table 6-3 overleaf and adjustments can be made depending on data availability.

Step	Description
1	Set equity as one of the primary goals of micro-level allocation preferably through legislation or Road Fund guidelines.
2	Create an equalisation fund of about 10% to 20% of the non-core road network budget (this should cover jurisdictions in the hard to reach areas and mitigate the north-south economic divide such as in Uganda and Ghana).
3	Allocate 5% to 10% to cater for Community Access Roads.
4	Allocate about 2% to 4% of the funds to road safety.
5	Divide the country (excluding water bodies) into four quadrants and each quadrant can be further sub-divided if necessary.
6	Allocate equally to each quadrant and equally within any sub-regions of the quadrant taking account of economic potential and availability of transport services.
7	For each quadrant and each jurisdiction; determine: (a) length of road network, (b) population of the various groups (women, elderly and children), (c) average distance to social facilities such as hospitals, boreholes, employment centres, and (d) surface area of each jurisdiction.
8	(a) Set criteria for determination of qualifying agencies to benefit from the equalisation fund; a Modified Equitable Rural Accessibility Index (MERAI) which does not only take account of the percentage of people within 2km of an all-weather road but also the availability of transport services on these rural roads and proximity of the population to key social facilities such as schools, health centres, employment centres and boreholes. (b) Allocate resources taking account of Multi-dimensional Poverty Index (education, health and standard of living) depending on data availability
9	Invite key stakeholders for discussion and encourage community participation in the allocations.
10	Re-run the processes until a fair consensus is reached.

Table 6-3 Proposed steps in micro-level allocations

6.5.2 Innovation in SSA road scheme prioritisation using Goal Programming

Road planning undertaken using traditional criteria considers road conditions or the required intervention level as the main criteria in order to establish a road maintenance plan; and only in some cases is the socio-economic importance of the road influence area and historical maintenance record taken into account (PIARC, 2013). Moreover, evaluation of low volume roads in developing countries is often challenging to undertake using standard cost benefit analysis as road user savings are negligible (Leinbach and Cromley; 1983).

It is argued in this thesis that road scheme prioritisation in SSA ought to be undertaken by GP rather than the use of 'data hungry' complex decision support tools. Taplin et al., (1995) posit that for each project, a score is obtained from decision makers or other respondents for each criterion and these scores are standardised into some numerical range and the merit of each project is measured by the sum of the priority weighted scores. Leinbach and Cromley (1983) propose a Goal Programming model to aid in the selection of rural road projects in Indonesia based on nineteen goals. However, these are too many goals.

According to Taplin et al., (1995), the state of Western Australia uses a rigorous cost benefit procedure to calculate Net Present Value (NPV) and Benefit / Cost ratio, but these simply enter the Multi-Criteria Analysis (MCA) as two among many criteria to be summarised in the final MCA score. NPV is used as a measure of economic benefit and Benefit Cost Ratio as a measure of efficiency of resource use.

In the context of SSA and cognisant of expert opinion, Goal Programming is proposed in this thesis to be used as follows when prioritising road schemes: (i) propose the priority level for each goal/objective, (ii) set the weight (score) on each goal. If a priority level has more than one goal, for each goal i decide the weight w_i to be placed on the deviation(s) d_i^+ and/or d_i^- from the goal, (iii) set up a lexicographic GP model and consider new objectives (minimise deviations), subject to all functional and goal constraints, and (iv) solve the linear program.

Weightings or scores can be determined based on expert opinion. The weights may be in terms of scores or an arbitrary monetary value. Allocation for road expenditure is politically sensitive and often professional advice is ignored. MCA offers the opportunity to provide analytical advice based largely on some of the factors that political decision take account and provides a systematic assessment of these factors. The proposed approach in this thesis takes two stages namely: strategic level prioritisation (planning and programming level) using weighted goal programming followed by detailed scheme selection at implementation level using lexicographic goal programming.

A scheme may score highly at strategic level but poorly at implementation planning level and vice-versa. Therefore, the decision maker needs to be aware of both scores prior to agreeing a preferred/optimal and equitable solution. The aforesaid may be considered as boundaries in the *Pareto* efficiency constraint.

Table 6-4 overleaf shows the proposed analysis framework at strategic planning and programming level using the experts suggested factors for SSA.

Road Name	Cost	NPV	B/C	Weighted score				Total score
				Economic efficiency	Social equity	Political factor	Region linkage	
R_1 to R_n								

Table 6-4 Proposed road scheme prioritisation in SSA at strategic level

Note: R_1 is Road 1, R_n is the n^{th} Road and B/C is benefit to cost ratio.

In the first option during prioritisation at strategic level, the principle is to limit the weighted sum of the penalties for deviating from the goals specified in a series of constraints as illustrated in the formulation below:

$$Minimise \sum_{i=1}^{n} w_i P_i d_i$$

$$Subject\ to \sum_{i=1}^{r} C_{in} X_i + d_i + IE_r + FA_r \geq AL_{in}$$

$$d_i \quad X_i \geq 0$$

Where, n is the number of goals (objectives), w_i is the weight applied to the i^{th} goal , d_i is the amount by which the solution falls short of the i^{th} goal, P_i is the priority factor of the i^{th} objective, IE_r is the implementation efficiency factor (absorption constraint) for the r^{th} road (i.e. capacity of contractor/implementing agency to undertake works efficiently in case of rehabilitation projects or availability of detailed engineering designs and clear project definition in case of new road projects), FA_r is the funding availability/project cost factor or cash flow constraint for the r^{th} road, C_{in} is the per unit consequence contribution of the i^{th} project (road) and X_i is support level of the i^{th} project (road). Therefore, the function $C_{in}X_i$ is a product of the combined prioritisation and consequence (lack of achievement) of the key factors (see worked example). AL_{in} is specified/optimal attainment level for i^{th} project/road. An alternative approach may be to maximise the weightings and priority factor rather than minimising such that the schemes are ranked based on the highest scores.

Having identified the road schemes at strategic level through a weighting GP model; the second option for the detailed selection of road schemes at implementation levels takes the form of a lexicographic GP model. The priority levels have been set based on expert opinion survey results (see Tables 5-6 and 5-7).

Table 6-5 overleaf analyses typical prioritisation of national roads (trunk or strategic highway network) in SSA using a lexicographic GP model at the four priority levels.

Expert Identified Priority Level 1				
Scheme	Goal is economic efficiency (weighted)	Measurement and assessment options (see Section 3.1.7 for typical parameters for measurement of economic efficiency).	Total Score	Attainment level
R_1 to R_n				
Expert Identified Priority Level 2				
Scheme	Goal is regional or international connectivity (weighted)	Measurement and assessment options could be: (i) distance reduction to neighbouring districts, (ii) travel time savings, (iii) territorial equity (iv) accessibility index, and (v) availability of transport services.	Total Score	Attainment level
R_1 to R_n				
Expert Identified Priority Level 3				
Scheme	Goal is social equity (weighted)	Measurement and assessment options could be: (i) population served, (ii) catchment area/regions served, (iii) employment created, (iv) travel time reductions to amenities, (v) multi-dimensional poverty, and (vi) Human Development Index.	Total Score	Attainment level
R_1 to R_n				
Expert Identified Priority Level 4				
Scheme	Goal is political balance (weighted)	Measurement and assessment options could be: (i) number of beneficiary constituencies, (ii) election pledge, (iii) regional balance, (iv) ethnicity balance, (v) marginalised population, and (vi) partisan political catchment.	Total Score	Attainment level
R_1 to R_n				

Table 6-5 Proposed road scheme prioritisation in SSA at implementation level

Note: R_1 refers to Road 1 and R_n is the n^{th} Road.

It is important that the scores in Table 6-5 are normalised (standardised) and the total score is adjusted based on the weightings for each priority level as determined by experts. A worked example combining both weighted and lexicographic GP for road maintenance scheme prioritisation (implementation level) based on the Uganda

National Roads Authority workplan for Kampala Station in FY 2014/15 is available at (http://dx.doi.org/10.6084/m9.figshare.1318405).

For district/regional and feeder roads; the process follows the same format as national roads and the same parameters are considered albeit the weighting and prioritisation levels change accordingly: priority level one - social equity (0.36); priority level two - economic efficiency (0.32), priority level three is shared between regional connectivity (0.16) and a political factor (0.16). The aforementioned factors and weightings are based on expert opinion survey results (as seen in Table 5-7).

For urban roads, the process follows the same format as national and district roads and the same parameters are considered albeit the prioritisation levels and weighting changes: priority level one - economic efficiency (0.49), priority level two - social equity (0.28), priority level three - political factor (0.12) and priority level four - regional connectivity (0.11) - (as seen in Table 5-8).

Tamiz et al., (1998) point out that if any objective is inefficient, then the entire model is inefficient; and if any objective is unbounded, then the entire model is unbounded, a possible indication of modeling errors. If one or more objectives are determined to be *Pareto efficient*, the next task is to place the inefficient objectives within an efficient boundary satisfactory to the decision maker; this is implemented by placing an upper and lower boundary on the deviational variables.

It is necessary to standardise the assessment of the various objectives as they are measured in different units. The incommensurability in a Weighted GP or within a priority level of a Lexicographic GP occurs when the deviational variables assessed in different units are added up directly (ibid). The simple addition will cause a bias towards the goals with a larger magnitude and potentially lead to incorrect conclusions. This problem can be solved by use of normalisation or standardisation techniques such as dividing the derived values for each goal through a constant pertaining to that objective to ensure that all objectives roughly have equal magnitudes. Alternatively, the decision maker may adopt percentage normalisation by converting the scores into percentages such that all deviations are measured on a percentage scale; other techniques include Euclidean normalisation, Zero-one normalisation and Summation normalisation (ibid).

Decision makers ought to be mindful of redundancy in the Lexicographic GP models. Tamiz et al., (1998) opine that this can be caused by: (i) too many priority levels when compared to number of goals, (ii) fixing targets equal to or close to the ideal values, and (iii) use of many two sided goals (one where both deviations are penalised, i.e. setting targets that are not to be missed either side).

If the process is followed as suggested in this thesis then it is likely that equality of transport opportunities and sustainable road projects can be achieved.

6.6 Goal Programming limitations

The planner using Goal Programming needs to have the ability to formulate alternative actions and consequences in a quantifiable manner; and the accuracy of measurements are critical in the determination of the ultimate solution (Leinbach and Cromley, 1983). Furthermore, Taplin et al., (1995) observe that for GP to provide the optimal solution, it is necessary to assume that the goals are reasonably independent and therefore approximately additive. Similarly, the choice of the Goal Programming variant should be consistent with the decision makers' structure of preference; and the use of a single GP variant is not always recommended and in real life cases, the best modelling option is to include several variants (Tamiz et al., 1998). The above limitations have been considered when developing the GP models.

6.7 Proposed measurement tool for Rawlsian equity in SSA road sector

Table 6-6 overleaf provides a bespoke performance assessment tool for Rawlsian equity in the SSA road sector based on the developed decision frameworks, coefficients and indices which are derived from expert opinion and literature review evidence (Sections 2.1.3 and 2.1.4). The assessment tool is used in analysing the performance of Rawlsian equity in the case study countries and culminates in the comparison provided in Table 13-1 in the concluding chapter.

6.8 Model and formulae validation in case study countries

In chapters Seven to Twelve, the developed models are applied using data from the case study countries to assess their performance as regards Rawlsian equity at macro, meso and micro levels whilst taking account of the literature review evidence and expert opinion survey results.

6.8.1 Ethos of selecting the case study countries

It is imperative that there is easy access to information from the selected case study countries and that the data to be collected is readily available; with a suitable political climate allowing experts to freely express their views. SSA covers 48 countries and it is not practical to use data from all the countries. Collection and data corroboration relies on a substantial amount of information available from government (ministries and departments) online portals albeit they are seldom updated. Furthermore, it should be noted that resources for conducting detailed project analyses (including data collection) are relatively scarce in developing countries (Jones et al., 2013). This scenario creates a credibility and validity issue particularly on the secondary data used and it is partly mitigated by use of various sources.

Equity type (research proxy)	**Summary equity description**	**Measure (target) and summary rating (results)**	
Horizontal (macro)	Fair balance between routine/periodic maintenance and capital investment (new road construction).	*Macro Equity Coefficient (MEC)*	
		≥ 0.5	very good
		>0.25, <0.5	good
		≤ 0.25	poor
Vertical (meso)	Fair balance between national roads and others (non-core) road network.	*Core Road Network Meso Level Index (CRONEMI)*	
		≥ 0.30	very good
		>0.19, <0.3	good
		≤ 0.19	poor
Vertical (micro)	Fair prioritisation of non-core network (rural, feeder, provincial, district, community and urban roads).	*Non-Core Road Network Meso Level Index (n-CRONEMI)*	
		≤ 0.30	very good
		>0.3, <0.45	good
		≥ 0.45	poor
Territorial (macro, meso and micro)	Prioritisation based on connectivity (regional and international). Corporate governance in road sector institutions encourages territorial equity.	Decision tool used correctly	good
		Connectivity considered	good
		Heavy political interference	poor
Spatial (macro, meso and micro)	Allocations/projects geographically balanced.	Appropriate formulae	good
Social (macro, meso and micro)	Allocation formulae consider appropriately social equity issues.	Equity highly prioritised in all processes	good

Table 6-6 Proposed measurement tool for Rawlsian equity in SSA road sector

It is vital that the case study countries selected are those which are most likely to illuminate the research questions but at the same time avoiding bias. Case study investigators can be prone to bias and preconceived ideas because they must understand issues before hand (Yin, 2009). Moreover, if a small number of cases are badly selected, and if a researcher over generalises findings, the researcher may overstate the relationship among the variables and even get the sign of the relationship wrong (Bennett and Elman, 2006). However, Herriot and Firestone (1983), cited in Yin, (2009, p.53), confirms that “evidence from multiple cases is often considered more compelling, and overall [the] study is therefore regarded as being more robust” . Furthermore, according to Bennett and Elman (2006, p.462) “a kind of Bayesian logic [may be used] to select cases on the basis of the inferential leverage they hope to gain from prior expectations about the likelihood or unlikelihood of the outcome occurring”. Moreover, a case selected for study because it has a positive outcome on the dependent variable may provide strong inferences about the validity of the theory (ibid).

Case study countries can also be selected because they have readily available and accessible evidence (Bennett and Elman, op. cit., 2006). As part of the research a ‘pilot-survey case’ country is used to test the data collection mechanism; and this was identified as Uganda since it has the newest Road Fund and most complex allocation formula. A pilot survey is “an operation designed to test a preliminary version of all aspects of a survey” (United Nations, 2000, p.24). Furthermore, a pilot case will help to refine data collection plans with respect to both content of the data and procedures to be used (Yin, 2009). Following pilot testing and undertaking adjustments, the other countries investigated are: Ghana, Zambia, Kenya, Tanzania and Namibia.

The reasons for selection of the identified countries are as follows: (i) a mix of SSA countries reflecting diverse road network characteristics and challenges, (ii) Francophone countries have been excluded due to the researcher’s currently limited knowledge of the French language, (iii) inclusion of a country from Southern Africa with relatively developed road network, (iv) coverage of a wide range of SSA inclusive of West Africa, East Africa and Southern Africa, (v) inclusion of low and high population density countries, (vi) selection of countries with varied topography and climatic conditions, (vii) inclusion of politically stable countries, (viii) inclusion of both landlocked and coastal countries, (ix) use of data from countries with established Road Funds and Road Authorities, (x) selection of some countries with Road Safety Authorities, (xi) inclusion of countries with varying GDPs and economic conditions, (xii) countries with readily available data, (xiii) inclusion of countries belonging to SSATPP, ARMFA and AFCAP; and (xiv) countries previously visited by the author (existing contacts for panel members).

Table 6-7 overleaf shows some of the parameters that are used in the critiquing and assessment of the equity aspects in the case study countries. However, data is collected from several sources and different reporting periods.

Figure 6-3 below (derived from Table 6-7 overleaf) shows the relationship between road density and population density of the case study countries which demonstrates a relatively good linear fit with regression analysis showing R^2 value of 0.84.

The positive correlation is also evident within the Kenya regions as observed by Howe (1971) who suggests correctly that road density can be predicted by population density.

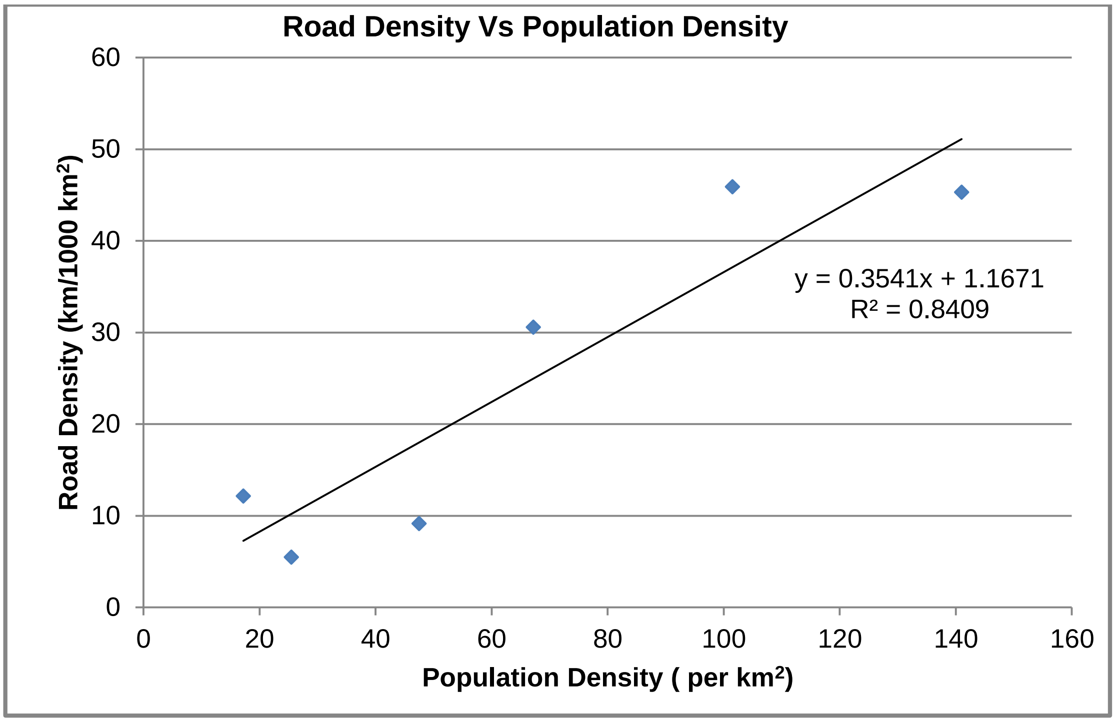


Figure 6-3 Road density versus population density of the case study countries

Parameters/ characteristics	Detailed study			Less depth study		
	Uganda	Ghana	Zambia	Kenya	Tanzania	Namibia
Population Density (per km^2)	141.0	101.5	17.2	67.2	47.5	25.5
Road Density (km/1000km^2 of arable land)	45.3	45.91	12.15	30.58	9.15	5.50
Trunk roads[1] (km)	21,000	14,460	20,524	14,228	12,786	4,781
Paved roads (%)	5.57	12.60	13.89	5.22	8.20	14.50
Unpaved roads -%	94.40	87.40	86.11	94.78	91.80	85.50
Rural roads (%)	39.48	60.00	86.61	10.71	63.59	25.00
National /trunk roads[1] (%)	19.2	21.31	10.07	3.54	11.63	10.00
RAI	27% (2003)	61% (2003)	64% (2003)	44% (1997)	38% (2000)	57% (2001)
Gini Index (2009)	44.3	19.2	57.5	42.5	37.6	59.7
GDP per capita[2] (US$)	589	1,902	1,473	976	599	5,920
GDP[2] (US$-bn)	19.88	40.71	20.68	40.70	28.24	12.89
GDP growth[3] (%)	3.4	7.9	7.3	4.6	6.9	5.0
Inflation[3] (%)	14.0	9.2	6.6	9.4	16.0	6.5
Corruption Index[4] (2014)	26	48	38	25	31	49
Road sector budget as %age of GDP[5]	3.19%	1.59%	2.97%	3.30%	3.60%	1.93%
Road maintenance budget as %age of GDP[5]	0.95%	0.56%	0.80%	0.78%	1.04%	1.26%

Table 6-7 Case study countries and key parameters (Source: www.indexmundi.com; www.worldbank.org).

Notes: 1. Definition (classification) of trunk/national road varies depending on country.

2. Namibia (2013 estimates), Ghana (2014 estimates), 2012 estimates (others).

3. 2012 values analysed.

4. Range is 0 to 100 (0 is highly corrupt and 100 very clean). www.transparency.org

5. See author analysis in Table 7-8 (Uganda), Section 8.3.1.1 (Ghana), Table 9-5 (Zambia), Table 10-4 (Kenya), Table 11-3 (Tanzania), and Table 12-2 (Namibia).

6.8.2 Ordering of case study countries and study depth rationale

The study commences with Uganda which is the pilot case and it has the newest Road Fund which was established in 2008 but operationalised in 2010 as a 1G Road Fund; and it has the most complex road maintenance funds allocation formula and one of the highest road densities (see Table 7-4). This is then followed by the other two detailed case studies of Ghana which has one of the oldest Road Fund established in 1985 and operates as a 2G Road Fund; and Zambia whose Road Fund was established in 1994 but also operates as a 2G Fund. The first cluster includes the pilot case and countries with relatively old Road Funds. The above countries are studied in detail and they also represent each of the key sub-regions in SSA and include both land locked and coastal countries.

The second cluster includes the less detailed case studies whose Road Funds are relatively new and were established and operationalised around the same time in 2000. The relatively less depth analysis does cover most of the important equity issues. The analysis commences with the East African countries of Kenya followed by Tanzania and then finally Namibia in Southern Africa. Namibia is considered last as it has a more developed economy and equity issues in other case study countries may not be particularly relevant to Namibia. All the lesser depth case study countries have 2G Road Funds and they include only coastal countries whose transport problems are likely to be less challenging compared to land-locked countries. It was considered prudent to commence with the detailed case studies prior to undertaking the less detailed case studies such that sharper analyses can be undertaken for the less depth case studies based on evidence obtained from the in-depth case studies. A top-down approach is used in the analysis of case study country data in the same format as the research scope outlined in Section 1.3 of this study. Analyses commence with macro equity followed by meso equity and finally micro equity inclusive of road scheme prioritisation.

6.9 Chapter summary

This Chapter has developed allocation principles, algorithms, Rawlsian equity measurement tool and Goal Programming models for road funds allocation in SSA at macro, meso and micro levels. Similarly, new road scheme prioritisation mechanisms have been proposed. The analysis is buttressed with literature evidence and expert opinion obtained through a two stage survey.

Goal Programming models (weighted and lexicographic) have been proposed for road scheme prioritisation and also for allocation of road maintenance funds based on weightings (rankings) provided by experts. Limitations of the Goal Programming process are also outlined. Mitigations for some of the limitations have been identified.

Goal programming gives an alternative way of addressing complex problem of road infrastructure funds allocation and it is a very flexible system which gives the option of using a wide variety of selection criteria; it can also be a useful tool for sensitivity analysis. Goal Programming minimises the weighted sum of deviations from specified target goals and the ultimate solution is normally a compromise between the competing but unsatisfied goals.

The Rawlsian equity assessment tool, frameworks and algorithms developed as part of this thesis will generally provide a robust preliminary estimate. However, they are not sacrosanct and need to be adjusted to individual countries based on their up to date network metrics. For example, in case of countries with relatively low road density, Priority Level 2 should be interchanged with Priority Level 1 in Table 6-5 such that the first priority is to improve connectivity after which economic efficiency is considered. Furthermore, countries with less developed road networks should target the lower values of the *macro equity coefficient* range whilst countries with more developed road networks should target the upper values (see Table 6-6).

The rationale for selecting the case study countries of Uganda, Ghana, Zambia, Kenya, Tanzania and Namibia has been discussed including the key parameters to be used in the analysis of equity.

This chapter further extends knowledge as regards addressing Rawlsian equity challenges through formulaic and standardised process which take account of opinions from experts with significant experience in the SSA road sector. The following Chapter provides an analysis of road sector issues in Uganda which is also the pilot case.

Chapter Seven - Uganda Case Study

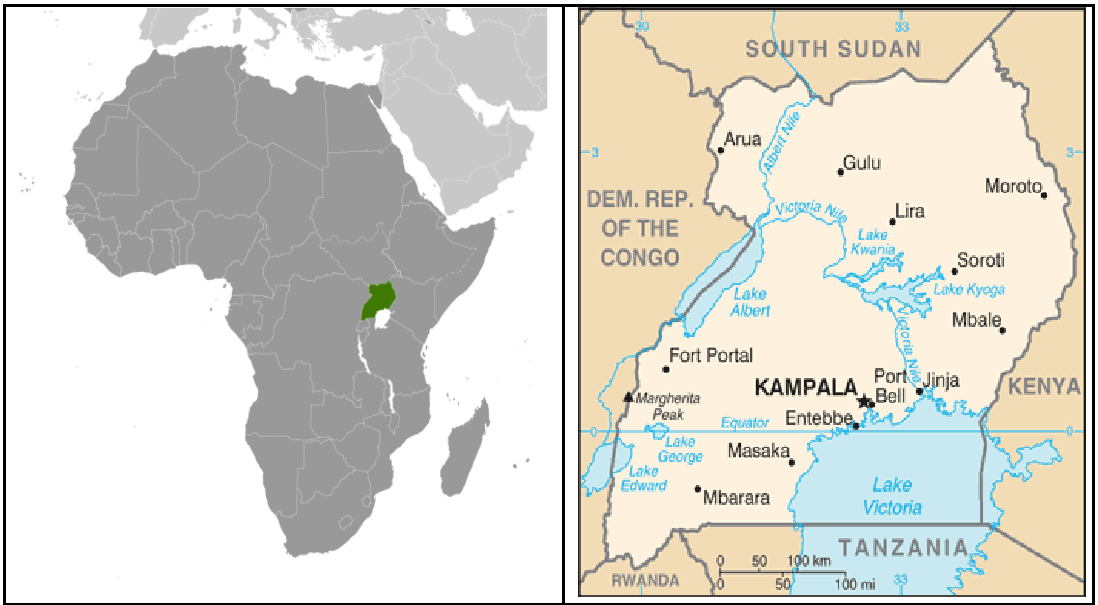
7.1 Introduction

In Chapter Six, GP models, equity analysis parameters, formulae and Rawlsian equity measurement tool were developed and these are applied in the case study countries from Chapter Seven to Twelve. The developed systems are recommended for application in the case study countries and require customisation depending on data availability and local expert opinion. In this Chapter Seven, a review and critique of road funds allocation and road scheme prioritisation processes in Uganda is undertaken. The analyses demonstrate that in general terms, there are major Rawlsian equity challenges in road funds allocation and road scheme prioritisation; albeit in some of the assessment years, the derived *Macro Equity Coefficient* values are within the acceptable range. Uganda allocates substantial financial resources to the road sector; however, the administrative structure is unique with many implementing agencies leading to high operating costs. Furthermore, the historically low allocations for road maintenance over the years has led to the escalation of the maintenance backlog. This thesis determines that the Road Fund allocation formula for maintenance funds does not take account of the north-south economic divide, is too complex and data intensive; and not consistent with some of the attributes of good allocation formulae analysed in Section 3.2. Furthermore, the review shows that road scheme prioritisation at all levels is unsystematic and highly political which affects equality of transport opportunities.

7.1.1 Topography, geography and climate

Uganda is a landlocked country mostly plateau with a rim of mountains and is located in East Africa; bordered by South Sudan to the north, Democratic Republic of Congo to the west, Rwanda to the south west, Tanzania to the south and Kenya to the east. The country is mainly agricultural and has a tropical climate and generally rainy with two dry seasons and is semi-arid to the north east; and has a total area of 241,038sq.km of which 18.23% is water and 81.77% is land (IndexMundi, 2014). Kampala is the capital city of Uganda and it is one of the fastest growing African cities with annual urban expansion rates of over 5% (Barrett and Kumar, 2008; Vermeiren et al., 2012). Despite the fast expansion rate of the capital city, it is widely acknowledged that there is little attention paid to systematic long term transport planning which will continue to affect equality of transport opportunities. Furthermore, the tropical climate characterised by seasons of heavy rains and long dry spells combined with a challenging terrain in some areas affects road maintenance and development as roads deteriorate much faster and some areas are subject to landslides.

According to Fan and Zhang (2008, p.475), “the mountainous and hilly topography in many parts of Uganda hinders development of roads…[and] the poorest communities are located in the most isolated areas”. However, such expositions tend to overlook the point that the mountainous terrain has not hindered road development per se but the costs of road construction in such terrain are more expensive when compared with flat terrain. Furthermore, the poor communities are located throughout Uganda and not necessarily in the most isolated areas. Figure 7-1 below shows the location of Uganda in a regional and local perspective.



Uganda (regional context)	Uganda (local context)

Figure 7-1 Maps showing location of Uganda (Source: IndexMundi, 2014).

7.1.2 Uganda politics and economy

Uganda’s economy has experienced varying growth rates since independence (from Britain in 1962); and for the period from independence up to 1971, GDP growth was about 5.2% p.a.; however, between 1971 and 1979, GDP declined by 25% due to the unstable political situation and economic mismanagement (NDP, 2010; World Bank, 2014a). Uganda currently belongs to the ‘Least Developed Countries’ and has one of the lowest per capita income in the World (Odero and Njenga, 2005; World Bank, 2014a). In spite of the aforesaid, a number of authors have reported that Uganda has experienced robust GDP growth (one of the fastest in SSA) and for the period 1987 to 1996, GDP grew at an average of 6.5%; further increasing to 7.2% p.a. between 1997 and 2000; 6.8% p.a. between 2000 and 2003 and then 8% for the period 2004 to 2007 (Raballand et al., 2009; Dorosh and Thurlow, 2011;

Ranganathan and Foster, 2012). However, the fast economic growth rate and increase in road sector funds has not resulted in a fast improving road network probably due to resources misappropriation; and equality of transport opportunities is still a challenge. Moreover, the GDP per capita of US$ 589 is the lowest of all case study countries (see Table 6-7).

7.1.3 The road sector in Uganda

Road transportation in Uganda is the most predominant form of movement for both cargo and passengers just like in other SSA countries (Odero and Njenga, 2005). Roads in Uganda carry 96.4% of total cargo freight and the rail network carries only 3.5% of freight cargo and only 26% of the railway is functional (NDP, 2010). It is suggested that the cost of carrying cargo by road is three times more than the cost of using rail (ibid). The justification of the aforesaid National Development Plan cost comparisons is not evident, however, the high cost differences may be applicable for long distances but less pronounced for short journeys.

Nearly all inland passenger travel in Uganda is by road with very limited travel by other modes which implies that road transport is extremely important. Nationally, it is estimated that the modal split in motorised travel (in vehicle-km) among the different motor vehicle classes is 11% motorcycles, 20% public transport, 21% commercial vehicles and 48% private vehicles (Ministry of Works, 2001, cited in Howe, 2003). As road transport is the predominant mode of transport, fair allocation of road funds and road scheme prioritisation is important to alleviate poverty, improve Rawlsian equity and ensure sustainability especially in rural Uganda. Fan and Zhang (2008, p.467) found out that “the majority of the poor in Uganda (95 percent) are concentrated in rural areas”. In the opinion of Raballand et al., (2009), road improvement can exert a direct impact on poverty. However, generalisation on this issue can be problematic particularly when road improvements are not accompanied by the requisite availability of affordable transport services on the network which is essential for improved accessibility.

A recent study by Mrawira (2014) shows that there is underfunding of maintenance against a backdrop of escalating needs in terms of size of network and scope of works. It can therefore be concluded that this has affected equality of transport opportunities and sustainability.

Ranganathan and Foster (2012) undertook an analysis of Uganda’s road indicators and benchmarked them against Africa’s low and middle income countries. Table 7-1 overleaf provides an assessment of the results.

Metric	Measure	Low Income countries	Uganda	Middle income countries	Implications for equity and remarks
Classified road network density	km/1000km^2 of land area	88	360	278	Total road density is high (about three times that of low income countries).
Total road network density	km/1000km^2 of land area	132	385	318	
GIS rural accessibility	%age of rural population within RAI range	25	26	31	RAI is almost similar to that of low income countries.
Over-engineering of primary network	% primary network paved (≤ 300 AADT)	30	12	18	Compares well with low and middle income countries.
Under-engineering of primary network	% primary network unpaved (≥ 300 AADT)	13	26	20	Many heavily trafficked roads unpaved (affects sustainability.
Classified paved road traffic	Average annual daily traffic	1,131	2,460	2,451	Traffic volumes are high particularly on the paved road network.
Classified unpaved road traffic	Average annual daily traffic	57	54	107	
Perceived transport quality	% firms identifying roads as business constraint	28	22	18	Compares favourably with low income countries.

Table 7-1 Uganda's road network indicators (Source: adapted from AICD road sector database, 2009, cited in Ranganathan and Foster, 2012)

Comparison of reference road indicators for both low and middle income countries as reported by Ranganathan and Foster (2012) in Table 7-1 for Uganda; with those reported in 2009 by Gwilliam et al., for Ghana (Table 8-1), Zambia (Table 9-1) and Kenya (Table 10-1) shows variations albeit the same data from the AICD database is used. This is one of the major challenges of cross country data comparisons; although the base measurement values may be valid, the data collection periods and assessment methods are most probably different or network metrics changed. Furthermore, comparison of Uganda's paved road traffic shows that it is about double that of each of the case study countries of Ghana, Zambia and Kenya.

7.1.4 Uganda road asset value

According to Mrawira (2014), the asset value of public roads in Uganda is about US $ 4.4billion and that if all the roads were restored to very good conditions; the full asset value would be US$ 6.2billion. This is based on the written down replacement cost method (replacement cost depreciated to the current condition of the asset). However, Mrawira fails to recognise that the estimated values may be flawed given that there is no accurate data on network metrics particularly for the unpaved network and as thus cost estimates ought to have been given ranges. The aforementioned notwithstanding, roads are arguably one of Uganda's most valuable assets which should be maintained adequately in an equitable manner to preserve the value thus contributing to sustainability. Table 7-2 overleaf shows Uganda's network metrics (length in Kilometres) and asset value (in US$M).

7.1.5 Uganda road network metrics

Uganda's road network is about 107,020km (with only 4% paved) comprising of 20,552km of national roads; 30,000km of district roads, 5,718km of urban roads and about 42,250km of community access roads (NDP, 2010; GoU, 2012; Mrawira, 2014). The Uganda National Roads Authority (UNRA) is responsible for both maintenance and capital investment projects (new road projects and rehabilitation) for the national (trunk) road network. The District, Urban and Community Access Roads (DUCAR) network is under the 111 district local governments and 22 municipalities; and Kampala Capital City Authority (KCCA) is responsible for city roads. The multiplicity of implementing agencies over the years has led to high operational costs thus reducing effective road expenditures and this affects sustainability of road projects. Moreover, there are currently proposals to increase the number of districts and municipalities; which will further increase operational costs and reduce effective road sector funds.

Road Class	**Length (km) ’000**	**Asset Value (US$M)**	**%age**	**Restoration need (US$M)**	**Implications for equity and remarks**
National roads					
Paved	3.554	2,432.90	55%	585.10	The value of unpaved roads is 17.7% that of paved roads.
Unpaved	17.001	430.70	10%	200.40	
Bridges	-	80.30	2%	67.10	Bridges have a lower value but provide territorial connectivity.
Kampala Capital City Authority					The network includes some of the most heavily trafficked roads. For unpaved roads; there is a need of sealing. The roads connect key facilities (hospitals, schools and employment centres).
Paved	0.431	331.39	8%	153.03	
Unpaved	0.674	11.05	0%	3.28	
Municipal roads					
Paved	0.745	342.51	8%	237.97	
Unpaved	3.755	70.07	2%	48.68	
District	30.0	275.47	6%	148.78	
Town Council	8.5	146.87	3%	95.06	
Community Access Roads	42.25	286.26	6%	251.46	The network is valued at 6.5% but comprises nearly 40% of the road network. The network is critical for social equity.
Total	106.63	4,407.52	100%	1,790.85	

Table 7-2 Uganda’s road asset value and network metrics (Source: adapted from Mrawira, 2014, p.59)

Uganda's road network details and implementing agencies are shown in Table 7-3 below and it can be deduced that there are many implementing agencies unlike in other case study countries (as discussed in Chapters Eight to Twelve).

Road Class	**Length (km)**	**Implementing Agency**	**Remarks and implications for equity**
National	20,552	Uganda National Roads Authority	The road network is about 19.2% of the entire road network but is allocated about 65% of maintenance budget which may not be equitable.
KCCA	1,218	Kampala Capital City Authority	About 60% to 80% of all vehicles in Uganda are within the capital city and the surrounding districts.
Municipal Council	4,500	22 Municipal Councils	Most roads in these urban centres are in poor condition and the annual maintenance funds allocations are inadequate creating backlogs.
Town Council	8,500	174 Town Councils	
District Roads	30,000	111 District Local Governments	These roads cover 71.2% of the total network and are critical in providing connectivity in rural areas and contribute to social equity but receive about 14% to 16% of maintenance funds, which is not equitable.
Community Access Roads	42,250	1,104 Sub-county local governments	
TOTAL	107,020		

Table 7-3 Uganda's road network classes and implementing agencies (Source: adapted from Kamuhanda and Schmidt, 2009; Vermeiren et al., 2012; OYRMP, 2013)

Caruthers et al., (2008), cited in Raballand et al., (2009, p.16), observe that Uganda's road density is among the highest in SSA as indicated in Table 7-4 overleaf. Furthermore, the worst districts in Uganda are in a better position than most districts/counties in other countries in terms of road density (ibid). This supports the notion that there is relatively good internal connectivity within Uganda when compared with other SSA countries. However, having a high density without appropriate and reliable transport services particularly in the remote rural areas and when large sections of the network are in poor conditions is unlikely to offer equality of transport opportunities or significantly improve Rawlsian equity.

Country	Density of classified roads	Density of all roads	Secondary density
Uganda	360	385	136
Rwanda	187	568	72
Malawi	141	165	71
Lesotho	175	196	50
Ghana	177	187	33
South Africa	167	300	31
Kenya	100	111	30
Tanzania	55	62	25
Cote d'Ivoire	80	82	24
Nigeria	135	174	23
Benin	75	142	21
Namibia	55	77	15
Madagascar	44	51	11
Cameroon	51	72	11
Senegal	81	94	10
Mozambique	37	61	6
Burkina Faso	27	39	6
Zambia	25	50	5
Ethiopia	21	46	5
Chad	22	27	5
Niger	11	13	2
Average	**96.48**	**138.19**	**28**
Median	**75.00**	**82.00**	**21.23**

Table 7-4 Road network density (in km/1000km^2) of selected countries in SSA (Source: Caruthers et al., 2008, cited in Raballand et al., 2009, p.16 and World Bank, no date, p.11)

7.1.6 Uganda key transport policy documents

The third ten-year (draft) **Road Sector Development Programme (RSDP3)** provides a blueprint for the development and maintenance of the Uganda roads sub-sector for the period July 2012 to June 2022. Prior to the commencement of this new programme, it is pointed out in RSDP3 (GoU, 2012, p.8) that “over the eight year period [from 2001/2] to 2009/10 approximately US$ 10m annually was spent on national road maintenance and US$ 80m on development”. It is evident from the aforesaid that the split between maintenance and capital investment projects was biased towards capital investments which affects sustainability and is not equitable in a Rawlsian manner. Nevertheless, Wepener et al., (2001) observe that GoU expenditure on road sector averaged US$ 44million p.a. for the period 1996/97 to 1998/99; which implies a doubling of expenditure on road sector from 2001 onwards as per RSDP2 and RSDP3 expenditure profiles. Expenditure on the road sector during 1996/97 to 1998/99 was 36% national road maintenance, 42% national road improvements, 18% district roads, 1% urban roads and 2% institutional and capacity building (ibid). The expenditure profile between 1996 and 1999 is reasonably fair in a Rawlsian manner as it does not overly disfavour road maintenance considering that the split in percentage terms between national roads maintenance and road development is not very wide. However, it is most probable that a needs assessment was not undertaken to logically guide allocations and expert opinion was not sought.

It is observed by Wepener et al., (2001) that during the latter part of the RSDP2 period approximately 1.3% of GDP was spent on the roads subsector and only 0.5% on road maintenance. During the period 2010 to 2014, expenditure on road maintenance averaged 0.95% (see Table 7-8), which is an improvement. Furthermore, Uganda's road sector expenditure as a percentage of GDP improved to about 2.2% as reported in 2009 by Gwilliam et al., (see Figure 7-2 overleaf); which is better than most SSA countries analysed. Pinard (2010, p.56) points out that "GDP per capita…[is] the factor most strongly correlated with the percentage of the main road network in good condition [in SSA], reflecting effort devoted to the paved roads network". This is a reasonable observation considering that countries with higher GDP per capita are likely to allocate more resources to the road sector.

The **National Development Plan** for the period 2010/11 to 2014/15 envisages improvement of the condition of the national road network from the current 60% in fair to good condition to 85%; upgrading and maintenance of DUCAR network; and modernisation of public transport systems in the Greater Kampala Metropolitan Area (NDP, 2010); however, the above targets were not achieved. Public transport is a major mode of movement and Fan et al., (2005), cited in Raballand et al., (2010), demonstrate that in Uganda each kilometre reduction in the distance to a public transportation facility reduces the probability of a house being poor by 0.22% to 0.33%. Nevertheless, the definition of public transport facility in Uganda requires cautious interpretation when analysing the quoted probabilities given that it is widely acknowledged that 'facilities' are generally haphazard and most are in a dire state particularly in rural areas and remote towns. Although equity is mentioned in the Plan, the major driving factor is economic efficiency.

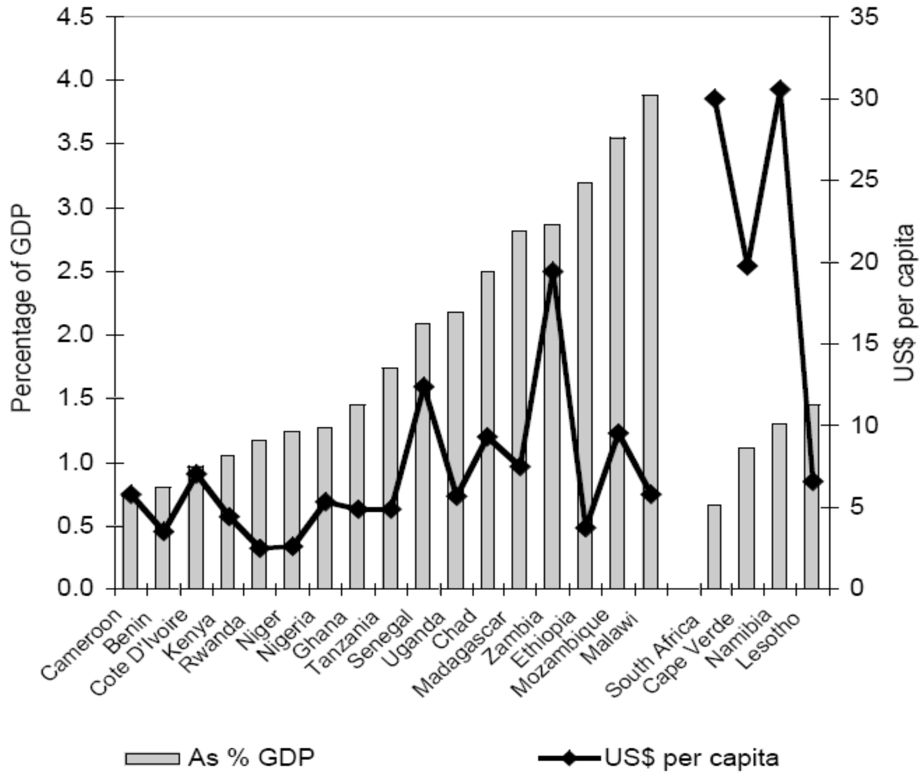


Figure 7-2 Road sector expenditure of various SSA countries (Source: Gwilliam et al., 2009, p.vii)

The **National Transport Master Plan (NTMP)** for the fifteen year period (2008 to 2023) but issued in 2009, proposes ambitious targets including: (i) upgrading national roads to 21% by 2015, (ii) rehabilitation of 11,067km of roads mostly with low cost sealing, and undertaking periodic maintenance on 4,500km each year. It is widely acknowledged that progress on the achievement of most NTMP targets has been very slow and the targets are too ambitious given the constrained road sector budgets and corporate governance challenges in the road sector institutions.

The Uganda Road Fund (URF) has a 5-year **Road Maintenance Financing Strategic Plan** and a **Corporate Plan** for the period 2014/15 to 2018/19 but currently operates as a 1G Road Fund and its financial resources are appropriated by Parliament in accordance with Section 21 (1c) of the URF Act 2008. However, the Road Fund Act clearly had the intentions of 2G operation. Nevertheless, the funds released by the Ministry of Finance to the Road Fund to be disbursed to implementing agencies are never adequate, not reliable and funds are seldom released in a timely manner. Furthermore, it is challenging to implement the fundamentals of the Strategic Plan as it is hinged on 2G operational status which has not yet been achieved.

The Uganda National Roads Authority has a draft **5-year Strategic Plan (FY 2014/15 to 2018/19)** in place. However, the institution has been dogged with convoluted corporate governance issues and operated without a Board for almost a year; consequently, the Plan has never been approved. Furthermore, due to uncoordinated planning, the strategic plan of the Road Fund and that of the Road Authority are not in sync thus affecting targets set in both documents. The uncoordinated planning affects sustainability of road projects and subsequently hinders equality of transport opportunities.

7.2 The implementing agencies, roads financing and road safety

7.2.1 Uganda National Roads Authority

The Uganda National Roads Authority (UNRA) was established by an Act of Parliament in 2006, with a responsibility of maintaining, developing and managing the national road network. UNRA became operational in July 2008 to manage a network of around 10,500km. In July 2009, a further 11,000km of district roads were unsystematically 'upgraded' to national roads; consequently doubling UNRA's network and management responsibilities. However, funding and technical capacity did not increase proportionately which affects efficiency and subsequently equality of transport opportunities.

7.2.2 Non-core road network agencies

The District, Urban and Community Access Roads (DUCAR) agencies currently include 111 districts, 22 municipal councils, 174 town councils and 1,104 sub-counties. Consequently, there are many implementing agencies which increases operational costs and reduces effective maintenance funds which then affects equality of transport opportunities. Moreover, there are proposals to further increase the number of DUCAR agencies during FY 2015/16.

7.2.3 Kampala Capital City Authority

Kampala Capital City Authority (KCCA) manages Kampala city roads and was created by an Act of Parliament in 2010 and became effective on 1st March 2011. The Act effectively changed the status of the predecessor Kampala City Council from a local government to a central government corporate entity. The revised set up is likely to lead to improved efficiency particularly in the road sector.

7.2.4 Uganda Road Fund

The Uganda Road Fund (URF) was established by Act of Parliament in August 2008 with a mandate to finance road maintenance of public roads through the principle of

RUCs. The Fund commenced its operations in January 2010 by inheriting a road financing plan for the second half of FY 2009/10 from Ministry of Finance which is the main financing agency for road maintenance.

Prior to the formation of URF, the Ugandan government allocated substantial resources to the road sector. The World Bank (no date, p.5) reports that the road sector budget in 2005/06 and 2006/07 was 2.3% of GDP rising to 2.7% of GDP in 2007/08 and 3.6% of GDP in 2008/09 (comparison with Figure 7-2 as reported by Gwilliam et al., in 2009 shows inconsistencies). Nevertheless, absorption of the funds was a major challenge as only 48.3% of the budget was absorbed by UNRA in 2008/09; furthermore, before formation of UNRA (when Ministry of Works was the main implementing agency), absorption in 2005/06 was 34.3% (ibid, p.6).

Mrawira (2014, p.65) points out that “between 1997/98 and 2007/08, the national road network owing to funding shortfall, had accumulated a maintenance backlog of 3,500km (33%) out of the 10,000km (Phase 1 network)”. Furthermore, the district roads in the category of poor to very poor condition escalated from 30% to 55% over the said period” (ibid). The sector performance report for 2013/14 puts this figure at 35% which shows an improvement.

Previous research by Fan et al., (2004), cited in Raballand et al., (2009), shows that government expenditure on roads has a significant impact in poverty reduction in rural Uganda. The aforesaid supports the notion of equitable allocation of road funds to ensure equality of transport opportunities which is likely to contribute to poverty alleviation and enhance Rawlsian equity.

Table 7-5 overleaf shows the Medium Term Expenditure Framework (MTEF) projections to FY 2015/16, which indicates that the available funding will only meet 33.5% of needs, leaving funding of 66.5% of needs unmet which escalates the maintenance backlog and is unsustainable.

In FY 2011/12, URF received US$M 107.57 under the MTEF for road maintenance against total requirements estimated at US$M 272.43. In FY 2013/14 allocations to maintenance were US$M 119.46 against needs of US$M 345.08; and the unfunded maintenance needs of the entire public roads network for that year amounted to US$M 415.9 (69.1% of total road maintenance needs unmet). The analysis shows that the unmet needs average at 66.53% and maintenance backlog is therefore increasing (cumulatively) over the years which affects macro-equity equilibrium.

Carruthers et al., (2008), cited in Raballand et al., (2009), estimate that Uganda should spend almost 4% of its GDP annually on roads. However, considering the

2014/15 budget, the road sector was allocated UGX 2.233 trillion (US$M 875.9) which is about 4.1% of GDP. Comparative values for FY 2010/11 to 2013/14 are analysed in Table 7-8 averaging at 3.2%; however, this is below Zambia's average expenditure of 3.7% of GDP for the same period (see Table 9-5). Conversely, Uganda's expenditure on road maintenance at 0.95% of GDP is higher than that of Zambia at 0.65% of GDP.

Funds requirements in US$M						
Financial Year	2010/11	2011/12	2012/13	2013/14	2014/15	2015/16
Needs						
Maintenance	238.04	272.43	344.65	345.08	346.06	341.06
Backlog	198.56	216.33	307.53	256.63	231.93	217.94
Subtotal	436.60	488.70	652.10	601.70	577.90	558.90
MTEF projections						
URF	107.57	107.57	107.57	119.46	132.41	165.17
Other	45.57	45.57	66.22	66.34	67.64	70.89
Subtotal	153.14	153.14	173.79	185.80	200.05	236.06
Un-met needs						
Un-met needs total	283.46	335.56	478.31	415.90	377.85	322.84
Percentage of unmet needs	64.92%	68.66%	73.34%	69.12%	65.38%	57.76%

Table 7-5 Road maintenance needs versus planned expenditure (Source: adapted from Mrawira, 2014)

Note: Analysis based on mid-rate average exchange rate of FY 2013/14 (1US$ = 2,538.34UGX), Source: Bank of Uganda (www.bou.or.ug), no account of inflation.

In Table 7-5, the 'other' component includes rehabilitation such as Peace Recovery Development Programme, Rural Roads Programme and other capital investment programmes but excluding major upgrading works.

Table 7-6 overleaf shows capital investment expenditure (development) and maintenance expenditure for UNRA for the period 2008/09 to 2013/14 in US$M. It can be deduced from the analysis that there is an inequitable split of funds between maintenance (Road Fund) and capital investment (development) projects. Throughout the assessment years, expenditure on capital investments far outstrips maintenance and is unsustainable thus affecting equality of transport opportunities.

Analysis of Table 7-6 shows that the national roads budget has more than tripled over the six year period although there are equity challenges (see Table 7-8).

Budget line		Financial Year					
		08/09	09/10	10/11	11/12	12/13	13/14
Recurrent	Wage	5.27	7.41	6.85	6.82	9.26	7.21
	Non-Wage	43.99	27.75	3.59	4.94	1.23	7.18
Road Fund (maintenance)		0	26.22	70.13	66.58	71.65	99.51
Development (GoU)		132.1	156.22	100.89	170.38	320.55	489.79
Development (Donor)		96.7	75.56	93.07	85.45	204.05	257.64
Supplementary						3.94	
GoU Total		181.32	217.60	181.44	248.72	402.70	603.56
Donor and GoU Total		278.03	293.16	274.50	334.17	606.75	861.31

Table 7-6 National roads budget for the period 2008/9 to 2013/14 in US$M (Source: adapted from MoWT, 2013a, p.36)

Note: Analysis based on mid-rate average exchange rate of FY 2013/14 (1US$ = 2,538.34UGX), Source: Bank of Uganda (www.bou.or.ug), no account of inflation.

Figure 7-3 below shows the budgetary allocations to Uganda Road Fund over the last five years which indicates an upward trend in available maintenance funds.

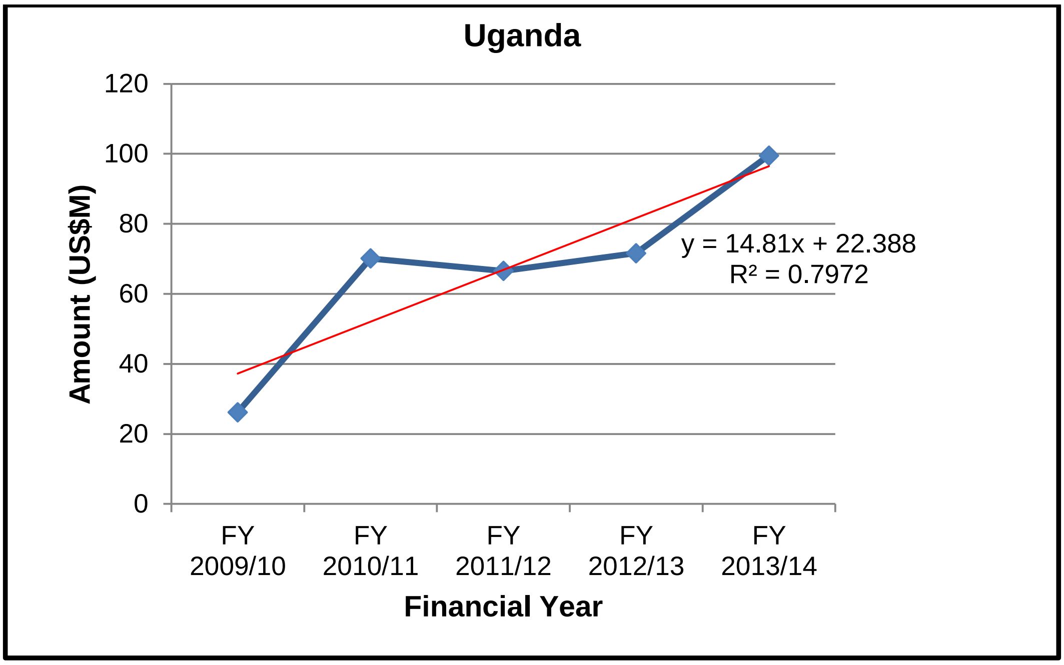


Figure 7-3 Trend of Uganda road maintenance financing (FY 2010/11 to FY 2013/14)

Analysis in Figure 7-3 does not take account of indexation for inflation and the unutilised road sector funds which are returned by implementing agencies to Treasury at the end of each FY. Considering the relatively good line of fit with linear regression analysis showing R^2 value of 0.80; there is every indication that allocations will increase in future years albeit it is challenging to predict future economic performance; moreover, the Uganda Shilling depreciated (against the US$) by over 16% in the first half of 2015. Road maintenance expenditure as a percentage of GDP for the period 2010/11 to 2013/14 is analysed in Table 7-8 (Section 7.3.1).

7.2.5 National roads maintenance funding needs in Uganda

Mrawira (2014, pp.74-75) uses HDM-4 to analyse Uganda's national roads maintenance needs for three scenarios: (i) unconstrained maintenance needs, (ii) sustainable asset conditions maintenance needs, and (iii) declining asset conditions need. In the unconstrained maintenance needs scenario, an average of US$M 120 p.a. for routine and periodic maintenance of national roads (excluding bridges and structures) is proposed. However, it is believed that with the current staffing capacity constraints at UNRA, it would be challenging to adequately absorb such levels of funding. Furthermore, it is suggested that "due to the high economic benefits of upgrading high trafficked gravel roads, the unconstrained analysis also proposes an ambitious US$ 3.88 billion over the 5 year period (US$M 775 per year) for upgrading to tarmac" (ibid., p.74). It is indeed prudent to upgrade to tarmac the heavily trafficked gravel roads as perennial re-gravelling is uneconomical. In Uganda, good gravel is becoming scarce; and it is washed away during heavy rains and by the large volumes of traffic and strong winds during the dry seasons; and this is unsustainable. Furthermore, the perennial grading prior to regravelling lowers road levels consequently turning them into 'mini-rivers' during periods of heavy rain.

Use of 'appropriate' or 'low cost seals' ought to be encouraged. Pinard (2014) observes that unpaved roads are dusty, a health hazard, affect pedestrian/vehicle safety; crops, natural habitats and contribute to vehicle damage. Furthermore, unpaved roads require continuous use of a non-renewable resource (gravel) and this is inherently unsustainable and environmentally damaging. Moreover, approximately 175million cubic metres are used annually in Southern Africa Development Cooperation region for gravelling purposes (ibid). An equitable allocation of road funds towards maintenance will enable sealing of some of the gravel and earth roads which will in the long run reduce the length of the unpaved road network to the benefit of the socially marginalised groups living in rural areas where most of the network is gravel and earth roads. Considering that between 12mm and about 25mm of the gravel thickness is lost from gravel roads annually under environmental and traffic actions then about 1 to 2million cubic metres (2 and 4million tonnes) of gravel needs to be replaced annually to maintain the status quo for national roads in Uganda.

In the sustainable asset conditions maintenance needs scenario for Uganda; which envisages optimal maintenance funding where the level of spending will ensure that the current asset conditions do not decline, the required budget is US$M 440 per year (Mrawira, 2014). The routine and periodic maintenance needs are US$M 112 per year and the upgrading program would be US$M 328 per year (ibid). The aforementioned expenditure is within range of the current budgets and as thus is implementable albeit inequitable. With reference to the third scenario of declining asset conditions maintenance needs (or ‘business as usual’), it is consistent with the current expenditure on road maintenance at about US$M 107 per year. Such a scenario would lead to loss of asset value; therefore, there is indeed a need to increase maintenance budgetary allocations albeit in an equitable and *Pareto optimal* manner without unduly disadvantaging capital investment projects. The URF 5-Year Road Maintenance Strategic Plan summarises the optimal road maintenance needs for national roads as indicated in Table 7-7 below.

A major weakness of the Mrawira (2014) analysis of the national roads maintenance requirements is that all roads are assumed to be in a maintainable state; however, it is not the case.

Type of works	Paved roads	Unpaved roads	Total (US$M/year)
Maintenance	55.36	11.77	67.13
Rehabilitation	31.76	13.20	44.96
Upgrading			218.35
Total			330.43

Table 7-7 National roads optimal maintenance requirements (Source: adapted from Mrawira, 2014, p.79)

7.2.6 Maintenance requirements for the non-core road network in Uganda

Mrawira (2014) uses RONET to evaluate various maintenance standards alternatives to determine the long term impact of DUCAR network maintenance from which it can be concluded that the total requirement is US$M 407.7 over a 5-year period. However, such levels of funding cannot be currently absorbed by the implementing agencies given the government bureaucracies, convoluted procurement processes, lack of fiscal discipline and requirement that works are undertaken by Force Account. Furthermore, technical capacity is lacking due to insufficient number of appropriately qualified (and well remunerated) staff. Nevertheless, Odero and Njenga (2005) suggest that the use of labour based methods in Uganda generates about two times more GDP through indirect effects and there is a significant saving in foreign exchange. Therefore, labour based methods provide a vehicle for enhancing equality of opportunities.

7.2.7 Road safety and equity

In the developing world, it is mainly the poor, children, pedestrians and non-motorised (intermediate modes of transport) users who are most affected by road safety and this creates a Rawlsian equity imbalance thus affecting equality of opportunity. Road safety is a major challenge in SSA countries with vehicles in poor mechanical conditions, driving standards are very poor with few explicitly defined road traffic regulations and less enforcement of these regulations due to lack of resources and high levels of corruption (Nordfjaern et al., 2012; Nordfjaern et al., 2014). In urban areas, especially the main city Kampala and its conurbations, there are significant vehicle pedestrian conflicts and the proliferation of 2-wheel motorbike taxis *(boda-bodas)* has led to many injuries. Moreover, in rural areas, drivers tend to conduct more risky behavior than in urban areas (ibid). Indeed, in Uganda, vehicle overloading is ubiquitous and quite often in rural areas there is mixing of animals with passengers which is dangerous. According to the 2013 World Health Organisation Global Status Report on Road Safety, Uganda had the highest fatalities per 100,000 population in the Eastern Africa region at 28.9 compared to 22.9 in Tanzania, 21.3 in Burundi, 20.9 in Kenya and 19.9 in Rwanda (GoU, 2013).

Pedestrians and cyclists are very vulnerable to accidents in SSA. Road traffic crash fatalities in Uganda grew from just over 600 in 1991 to over 3,343 in 2011, with slight decline to 2,937 in 2013 (Uganda Traffic Police - UTP, 2013). Furthermore, of the fatalities in the year 2013, 1,181 were pedestrians, 525 were passengers, 897 were motorcyclists and their passengers, 224 were pedal cyclists and 110 were drivers. It is important to observe that pedestrians represent the most vulnerable road user group in terms of fatalities closely followed by motor cycle riders and passengers.

A study by Bishai et al., (2003) shows that budgetary expenditure on road safety in Uganda is $0.09 per capita and public spending on road safety amounts to 1% of health budget which is tantamount to 1.1% of expenditure on the defence budget; which demonstrates the lack of prioritisation of road safety. Road accident injuries represent a heavy burden on the Uganda health system. Although the number of victims is less than that of HIV/AIDS and malaria, road accidents consume more resources. It was estimated that the total direct and indirect cost of road accidents to the Ugandan economy in the year 1998, was about 2.3% of the total GDP (Haworth, 2014a). Based on this percentage of 2.3% of GDP, the loss due to road accidents in 2013 can be estimated at US$M 460.69 which is detrimental to the economy.

Road safety in Uganda is not a high priority which affects equity and equality of safe transport opportunities. Moreover, Odero and Njenga (2005) observe that the marginalised poor communities especially in urban areas are the most likely beneficiaries of improved road safety. However, even the rural dwellers also benefit from safety improvements particularly those living alongside ‘on-road’ settlements.

There are generally fewer explicitly defined road traffic regulations and an overall lack of proper driver training in SSA (Nordberg, 2000, cited in Nordfjaern, 2012). Furthermore, Mecky (1984), cited in Nordfjaern, (2012), observes that many motorists especially younger drivers in SSA countries tend to drive without driving licences. The aforesaid notwithstanding; it is widely acknowledged that in Uganda, a large number of motorists with valid licences often acquire them without having undergone the prerequisite driver training and testing. Furthermore, accident statistics in SSA are very prone to under reporting and consideration of equitable road funds allocations and road scheme prioritisation cognisant of road safety is necessary to achieve Rawlsian equity.

7.3 Uganda road sector equity analysis and allocation formulae

This section analyses the equity aspects in the allocation of road funds in Uganda at macro, meso and micro levels. A number of authors draw our attention to the general north-south economic divide in Uganda with the south being more prosperous than the north which experienced internal conflict and was neglected for a long time (Dorosh and Thurlow, 2011; Ranganathan and Foster, 2012). To improve territorial equity, there is need for special consideration for internal connectivity within the northern region and also improvements of linkages between the south and north to stimulate trade and reduce poverty and inequalities. This view is also supported by Raballand et al., (2009) who recommend that roads rehabilitation in Uganda should be done in some districts in the north and funds allocation should be reduced for some districts in the south west. However, it is almost certain that this is major challenge considering the strong political links in western Uganda which have occurred over the last thirty years.

7.3.1 Background to macro level equity in Uganda

An exploration of the historical expenditure on road maintenance versus capital investments (new road projects and rehabilitation) in US$M for the period 2010/11 to 2013/14 is analysed in Table 7-8 overleaf.

Allocation category	**2010/11**	**2011/12**	**2012/13**	**2013/14**	**Implications for equity**
UNRA capital investment	193.93	255.82	524.59	747.42	A general upward trend in the roads budget is evident (negligible capital investment on DUCAR).
UNRA and DUCAR road maintenance	153.15	174.12	173.80	185.81	
Road maintenance expenditure as a percentage of total budget	30.6%	28.8%	19.9%	16.6%	Allocation of funds for road maintenance dropped by 14% over 4 years.
Road maintenance expenditure as a percentage of GDP	0.95%	1.12%	0.87%	0.86%	On average Uganda spends about 0.95% of GDP on road maintenance.
Road sector expenditure as a percentage of GDP	2.16%	2.77%	3.49%	4.34%	Expenditure in all the years (apart from 2013/14) were below recommended value of 4% (see Section 7.2.4).

Table 7-8 Uganda capital investment versus maintenance expenditure (Source: adapted from MoWT, 2012, 2013a and 2013b)

Note: Analysis based on mid-rate average exchange rate of FY 2013/14 (1US$ = 2,538.34UGX), no account of inflation. GDP values in USD Billions: 2014 (21.48bn), 2013 (20.03bn), 2012 (15.49bn), 2011 (16.03bn). Source: Bank of Uganda (www.bou.or.ug)

Just like most SSA countries, Uganda's expenditure on road maintenance is significantly lower than that of capital investment projects and over the years there has been a gradual downward trend in percentage allocation to road maintenance as shown in Table 7-8 (although road maintenance expenditure as a percentage of GDP has been relatively uniform particularly in FYs 2012/13 and 2013/14). The allocations between capital investments and maintenance as determined by the Ministry of Finance may not be based on any logical scientific assessment. A possible explanation for this situation is that the Road Authority and other agencies are supposed to implement the incumbent government's political manifesto which is more geared to capital investment projects for political gains. This implies that the Ministry of Finance inevitably allocates more funding towards capital investment projects. Politics and road development programmes in Uganda are extremely interwoven.

Analysis of UNRA data undertaken by the author shows that although 1,527km of national roads were bituminised from 2009 to 2014, about 1,882km of paved roads deteriorated due to lack of maintenance, which is tantamount to a negative progress of 355km of backlog (Naimanye and Haworth, 2015). It can be argued that Uganda is repeating mistakes of other SSA countries by constructing new roads whilst existing roads are deteriorating thus escalating the maintenance backlog and depreciation of the road asset value and subsequently affecting equality of transport opportunities. In contrast, Vermeiren et al., (2012) assert that construction of new roads or major rehabilitation may be justified to improve mobility, reduce congestion and ease participation in the formal economy. However, Raballand et al., (2009) are of the view that maintenance of existing rural roads in Uganda should be given priority rather than opening of new roads. Therefore, there is a need to achieve a good macro equity balance as argued in this thesis. Gwilliam et al., (2009, p.26) point out that "a strong capital bias is evident in road sector spending [in SSA]"; furthermore, the bias is more pronounced in low income countries, those with difficult geographical environments and those without Road Funds.

7.3.2 Macro level equity analysis

An analysis of macro equity in Uganda is undertaken using equations 6.1 to 6.4 developed in Chapter Six (see Section 6.2.1). To recap, *Macro Equity Coefficient (MEC)* is the ratio of the Effective Road Maintenance Budget (ERMB) or Expenditure to the sum of the Effective Maintenance Budget and Effective Capital Investments Budget (ECIB) or Expenditure and *Macro Equity Index (MEI)* is the 'base 10' logarithm (common logarithm) of the inverse of *MEC.*

The Uganda Road Fund provides a budgetary allocation of about 1.7% for its administrative expenses, about 4% for operational expenses of UNRA and 4.5% for operational expenses of the remaining implementing agencies (OYRMP, 2014; URF, 2014). The aforementioned operational costs may be excluded to determine effective budgets; however, they are not substantial.

Table 7-9 overleaf provides an analysis of macro-equity for the Uganda road sector for the period 2010/11 to 2013/14 in US$M.

Category	**2010/11**	**2011/12**	**2012/13**	**2013/14**
UNRA capital investment (new road projects and rehabilitation)	193.93	255.82	524.60	747.42
UNRA road maintenance (Road Fund)	70.13	66.58	71.65	99.51
Road Maintenance (KCCA, Districts, Municipalities, Town councils, sub-counties) and other programs	83.02	107.53	102.15	86.30
Total Road Maintenance	153.15	174.12	173.80	185.81
MEC	0.31	0.29	0.20	0.17
MEI	0.51	0.54	0.70	0.78

Table 7-9 Uganda road sector macro equity analysis (Source: adapted from MoWT 2012 and MoWT, 2013a)

Note: Analysis based on mid-rate average exchange rate of FY 2013/14 (1US$ = 2,538.34UGX), Source: Bank of Uganda (www.bou.or.ug), no account of inflation.

From Table 7-9, it can be inferred that the *MEC* and *MEI* for FY 2012/13 and FY 2013/14 are not within range of the recommended values of 0.25 to 0.50 (see Section 6.2.1). However, the computations for FYs 2010/11 and 2011/12 are within range and are considered acceptable and equitable in a Rawlsian manner. Indeed, the *MEC* value for FY 2010/11 is close to the 50th Percentile (see Table 6-1).

7.3.3 Meso level equity analysis

This section considers the fairness of the vertical allocation of maintenance funds between the various classes of roads. It assesses allocations between national/trunk roads (strategic core road network) and the non-core road network (other roads).

Table 7-10 overleaf shows a comparison of the allocations in US$M between the core road network and non-core road network for the period 2010/11 to 2014/15.

Financial Year	UNRA (core road network)		DUCAR (non-core road network)		Grand Total (US$M)	Ratio of UNRA to total budget
	Total (US$M)	Percentage	Total (US$M)	Percentage		
2010/11	72.6	66.5%	36.4	33.5%	109.00	0.66
2011/12	71.6	66.6%	35.9	33.4%	107.50	0.67
2012/13	71.6	66.6%	35.9	33.4%	107.60	0.67
2013/14	100.4	73.6%	35.9	26.4%	136.30	0.74
2014/15	108.1	65.2%	57.7	34.8%	165.90	0.65

Table 7-10 Allocation of Uganda road maintenance budget between the road networks in US$M (Source: adapted from MoWT, 2012 and 2013a)

Note: Analysis based on mid-rate average exchange rate of FY 2013/14 (1US$ = 2,538.34UGX), Source: Bank of Uganda (www.bou.or.ug), no account of inflation.

Table 7-10 shows that the trend in allocations between the core and non-core road network in Uganda over the five years averages at 67.8% to the strategic core road network and 32.2% to the non-core network. There is no documented scientific basis justifying the aforementioned split apart from the fact that national roads carry more traffic and they have a higher asset value when compared with the non-core road network. To further demonstrate the irrationality in allocations, during FY 2013/14, a directive was given by Cabinet to allocate an additional UGX 72bn (US$M 28.8) to UNRA to be expended on maintenance of the paved road network thus overly 'distorting' the historical split and disregarding the allocation formula. However, allocation of additional resources to the paved network may not be equitable and instead the funds could have been allocated to the unpaved network to seal some sections of the network with low cost seals to ensure sustainability and equity. Further 'distortion' of the allocation formula occurred in the last quarter of FY 2014/15 when UGX 10bn (US$M 3.3) was unsystematically reallocated from UNRA to KCCA.

Analysis of meso level equity is undertaken using equations 6.5 to 6.8 (see Section 6.4). To recap, *Core Road Network Meso-Level Equity Index* (*CRONEMI*) is defined as the 'base 10' logarithm of the inverse of the ratio of the budget allocation for the strategic trunk road network to the total road maintenance budget and *non-Core Road Network Meso-Level Equity Index* (*n-CRONEMI*) is the logarithm of the inverse of allocation for rural roads to the total road maintenance budget. The allocations of Uganda Road Fund for maintenance at meso level for the period 2010/11 to 2013/14 in US$M are analysed in Table 7-11 below to determine the *CRONEMI* and *n-CRONEMI* values.

Item	FY 2010/11		FY 2011/12		FY 2012/13		FY 2013/14	
	Funds US$M	% of Total	Funds US$M	% of Total	Funds US$M	% of Total	Funds US$M	% of Total
National roads	72.60	66.54	71.65	66.60	71.65	66.59	100.34	73.64
District roads	15.11	13.85	14.87	13.82	16.01	14.88	16.01	11.75
Community access roads	2.76	2.53	2.72	2.53	2.74	2.55	2.74	2.01
Town councils	6.87	6.30	6.76	6.29	6.79	6.31	6.79	4.98
Municipals and capital city authority	10.06	9.22	9.91	9.21	10.40	9.66	10.38	7.61
Regional mechanical workshops	1.69	1.55	1.67	1.55				
Total for non-core network	36.50	33.46	35.92	33.39	35.95	33.66	35.92	26.36
Grand Total	109.1		107.57		107.61		136.27	
$CRONEMI_e$	0.18		0.18		0.18		0.13	
$n\text{-}CRONEMI_e$	0.47		0.47		0.47		0.58	

Table 7-11 Meso level analysis of road maintenance funds allocation in Uganda (Source: adapted from OYRMP 2011, 2012, 2013 and 2014)

Note: Analysis based on mid-rate average exchange rate of FY 2013/14 (1US$ = 2,538.34UGX), Source: Bank of Uganda (www.bou.or.ug), no account of inflation.

In Table 7-11, national roads allocation is for the expanded road network of 21,000km; district roads allocation caters for routine and periodic maintenance in the 111 local governments; community access roads allocation is for the removal of bottlenecks on the sub-county road network whilst the municipal allocation is for the 22 municipalities and Kampala Capital City Authority. Regional mechanical workshops allocations cover maintenance of district equipment at three regional workshops. However, funding by URF to the three workshops ceased in FY 2011/12 due to the rigid interpretation of the URF Act.

From Table 7-11, it is determined that the *CRONEMI* and *n-CRONEMI* values are all out of the recommended equitable ranges which indicates that the non-core road network which serves the majority of rural dwellers are not equitably funded in line with Rawlsian principles. As seen in Section 6.4, the recommended *CRONEMI* value should range from 0.19 to 0.30 and the *n-CRONEMI* value should range from 0.30 to 0.45.

Several studies have shown that government expenditure on rural infrastructure especially rural feeder roads and community access roads plays a major role in agricultural productivity growth and reduction in rural poverty (Fan and Zhang, 2008; Raballand et al., 2009). Therefore, rural roads should also be highly prioritised.

7.3.4 Critique and analysis of micro level equity

The following sections consider the fairness of the vertical allocation of maintenance funds between the various local authorities responsible for the non-core road network and prioritisation of road schemes. A critique of the old and new formula as used by the Uganda Road Fund is also provided. The 'old formula' used in road funds allocation in Uganda took account of population, surface area, previous asphalt and a uniform factor (OYRMP, 2011).

The population and surface area factors seem reasonable; however, the major weakness is that they do not take account of sparsely populated areas which may have large community road networks. Furthermore, the surface area factor may lead to allocations to jurisdictions with a large surface area but with short road network length. Use of total population of a jurisdiction without breaking it into age groups may be misleading given that 49% of Uganda's population is below 15 years (Ranganathan and Foster, 2012). An 'effective population' group as a proxy for road usage is a far better parameter for actual road usage. However, prior to formation of the Road Fund, allocations to districts were based on network length and agricultural productivity played no role (World Bank, no date).

7.3.5 Critique of Uganda allocation formula (2008/09 to 2013/14)

One Year Road Maintenance Plans for the period 2009 to 2014 show that the Road Fund allocated road maintenance funds to the various designated agencies using formulae illustrated in the equations in Figure 7-4 for districts, Figure 7-5 for urban areas (municipalities) and Figure 7-6 for community access roads (sub-counties).

$$A = U + P + S$$

Where:

$A = Road\ maintenance\ funds\ allocation\ for\ district\ X$

$U = Uniform\ allocation/equity = 20\%\ of\ \frac{Z}{number\ of\ districts}$

$P = Population\ factor\ allocation = 60\%\ of\ Z \times \frac{Px}{\Sigma P}$

$S = Surface\ area\ factor\ allocation = 20\%\ of\ Z \times \frac{Sx}{\Sigma S}$

$Z = Total\ road\ maintenance\ funds\ for\ all\ districts\ in\ Uganda$

Figure 7-4 Uganda Road Fund old allocation formula for district roads (Source: adapted from OYRMP, 2011, 2012, 2013 and 2014)

The equity component in the district formula is the ‘uniform allocation’ factor as the funding is equally shared irrespective of district population or surface area; however, this only has a weighting of 0.2. It can be argued that the weighting for uniform allocation should have been much higher, in the order of 40% to 50% to ensure appropriate consideration of principles of Rawlsian equity. Furthermore, there is no clear scientific justification for the weighting of 0.6 for population and 0.2 for surface area; moreover, there is no evidence that expert opinion was sought to determine the weightings which would have provided a more reliable formula.

As previously discussed data collection is a challenge in Africa and in the case of Uganda, data for districts such as population and surface area is thought not to be accurate as districts were recently split up to create additional districts on the premise of bringing services closer to the people and up to date data may not be available. Furthermore, it is argued that the district feeder road allocation maintenance formula should be revised to take account of agricultural economic potential (Raballand et al., 2009, World Bank, no date).

The equation in Figure 7-5 below shows the urban roads allocation formula.

$$Ax = PAsp + (Z - PAsp) \times \frac{Px}{\Sigma P}$$

Where:

$Ax = Road\ maintenance\ funds\ allocation\ to\ (urban)\ agency\ X$

$PAsp = Allowance\ for\ previous\ asphalt\ (value\ of\ existing\ tarmac)$

$Px = Population\ of\ (urban)\ agency\ X$

$\Sigma P = Total\ population\ of\ all\ (urban)\ agencies$

$Z = Total\ allocation\ available\ for\ all\ (urban)\ agencies$

Figure 7-5 Uganda Road Fund old allocation formula for urban roads (Source: adapted from OYRMP, 2011, 2012, 2013 and 2014)

It is widely acknowledged that the 'previous asphalt' parameter is extremely subjective as accurate data is not available and would also be challenging to collate. Another serious weakness of the urban roads formula is that there is no explicit equity consideration.

The equation in Figure 7-6 shows the community access roads allocation formula. However, the allocation formula for sub counties does not explicitly take account of equity. Furthermore there is no clear scientific justification for the weighting of population at 0.85 and surface area at 0.15. The formula favours highly populated areas. Similarly, the weighting of the aforementioned factors is not consistent with the districts formula.

$$A = P + S$$

Where:

$A = Road\ maintenance\ funds\ allocation\ to\ Sub - county\ X$

$P = Population\ factor\ allocation = 85\%\ of\ Z \times \frac{Px}{\sum P}$

$S = Surface\ area\ factor\ allocation = 15\%\ of\ Z \times \frac{Sx}{\sum S}$

$Z = Total\ allocation\ available\ for\ all\ sub - county\ community\ roads$

Figure 7-6 Uganda Road Fund old allocation formula for community access roads (Source: adapted from OYRMP, 2011, 2012, 2013 and 2014)

Another major weakness with the 'old formula' is that there is no consideration of network length and it does not take account of the north-south economic divide.

7.3.6 Critique of Uganda new allocation formula (2014/15 onwards)

The ‘new allocation formula’ based on Section 22 (2) of the URF Act 2008 allocates resources by surface type globally; then surface type to the various road classes and vertically to the various jurisdictions/local governments. Equity is addressed by applying an ‘arbitrary’ factor or constant.

The new formula is data intensive especially in a country where reliability of data some of which is collected by semi-skilled staff is questionable. As pointed out by Raballand et al., (2010, p.9), “data on the extent of road networks [for countries in SSA] are sometimes unreliable”. The aforesaid is true particularly for the unclassified road network; however, the classified road network data is often more reliable.

The first step of the new formula requires the determination of the roads in maintainable state and the remaining stages are as follows: (i) allocate available funding to surface types; (ii) allocate the funding per surface type between the road network jurisdictions, and (iii) allocate the funding per road network and surface type to the designated authorities within each district, town councils, municipals, and sub-counties (URF, 2012).

The three road surface types considered are: paved, gravel and earth; and the five road network jurisdictions include national, district, town council, municipal and community (sub-county roads). It is recommended that funds should be allocated to roads in maintainable condition or state and determining threshold values for road condition based on roughness to screen roads in maintainable state (ibid). In contrast, Raballand et al., (2010) argue that in Uganda, road condition plays almost no role when maintenance funds are allocated (as seen in Section 7.3.5). However, this was valid prior to the establishment of a new formula which now takes account of road condition to some extent. The Stage1 formula for allocation to road surface types is illustrated in the algorithm in Figure 7-7 below.

$$M_S = \left\{ K_{11}\left[a_{11}\left(\frac{PCU\_KM_S}{\sum_{S=1}^{3} PCU\_KM_S} \right) + a_{12}\left(\frac{ESAL\_KM_S}{\sum_{S=1}^{3} ESAL\_KM_S} \right) \right] + K_{12}\left[\frac{AV_S}{\sum_{S=1}^{3} AV_S} \right] + K_{13}\left[\frac{Copt_s * L_S}{\sum_{S=1}^{3} Copt_s * L_S} \right] \right\} * B$$

Figure 7-7 Uganda Road Fund allocation formula for surface types (Source: URF, 2012)

Where: M_S is allocation to road surface type ‘*s*’, *B* is total available budget to URF, PCU_KM_S is total traffic volume in passenger car units kilometres for each road surface type ‘*s*’ (*s* = paved, gravel or earth), $ESAL\_KM_S$ is total traffic loading in equivalent standard axle loads kilometres for each road surface type ‘*s*’, AV_S is asset value of road surface type '*s*', $Copt_s$ is relative weight for optimal maintenance cost for road surface type '*s*', L_s is total length of road surface types, a_{11} is coefficient for the impact of traffic volume (default value is 0.7), a_{12} is coefficient for the impact of traffic loading (default value is 0.3), K_{11} is traffic impact factor (default value is 0.5), K_{12} is asset value factor (default value is 0.15) and K_{13} is maintenance cost and road length factor (default value is 0.35).

The first stage formula is entirely based on economic efficiency and there is no equity consideration. Furthermore, it is a complex and data intensive formula and this is exacerbated by the fact that accurate data collection in SSA is difficult and determination of variables such as vehicle traffic and loading on earth roads for the various jurisdictions is very challenging. This view is supported by Howe (2003, p.163) who points out that "the size and growth of the national motor vehicle fleet in Uganda are uncertain due to inconsistencies in official statistics". This makes it complex to accurately determine and validate traffic flows. Currently, there is more certainty as regards growth rate but not the size.

The other major weakness of the Stage 1 formula is that it is not easy to explain the parameters to some numerate professionals and even more difficult for the politicians to understand the fundamentals of the formula. Similarly, there is no explanation (justification) for the determination of the coefficients default values. In the same vein, the Stage 1 formula fails to take account of administrative expenses of the Roads Authority and Road Fund or allowances for any special interventions or services such as road safety, axle load control and ferry operations which is a major shortcoming.

Another weakness of the Stage 1 approach is that it mainly takes account of traffic loading; asset value and maintenance costs which tend to favour paved roads at the expense of unpaved roads. However, in all SSA countries, unpaved roads constitute the largest component of the network and they link the rural communities where most people reside. Furthermore, Pinard (2014) argues that pavement deterioration is driven primarily by environmental factors (particularly moisture), with traffic loading being a lesser influential factor in deterioration, and drainage being of paramount importance. The greatest contributor to pavement deterioration in Uganda can be attributed to the lack of appropriate axle load control policies and enforcement which leads to heavily loaded vehicles weakening and destroying pavements (Wepener et al., 2001). This is in addition to the poor workmanship and convoluted corruption in the road sector which leads to substandard works.

The Stage 1 formula allocates lesser funds for gravel roads and earth roads making long lasting intervention measures unachievable thus encouraging re-gravelling which is unsustainable. Gravel and earth roads have low (initial) costs and are relatively easy to construct but they are expensive to maintain (DfID, 2003); typically US$ 1,600/year per kilometre and each km of gravel road typically loses more than 70 cubic metres of material per year (Pinard, 2014). The Stage 2 formula for allocation to the various road networks is illustrated in the algorithm in Figure 7-8.

$$M_{Sj} = \left\{ W_j \left[a_{21} \left(\frac{PCU\_KM_{Sj}}{\sum_{S=1}^{5} PCU\_KM_{Sj}} \right) + a_{22} \left(\frac{ESAL\_KM_{Sj}}{\sum_{S=1}^{5} ESAL\_KM_{Sj}} \right) \right] \right\} * M_s$$

Figure 7-8 Uganda Road Fund allocation formula for road networks (Source: URF, 2012)

Where: M_s is allocation to road network *'j'* (*j* = national, district, urban, municipal or CAR), M_s is allocation to road surface type '*s'* (obtained from Stage 1), PCU_KM_s is total traffic volume in passenger car units kilometres for each road surface type *s* (s is paved, gravel or earth), $ESAL\_KM_s$ is total traffic loading in equivalent standard axle loads kilometres for each road surface type *'s'*, a_{21} is coefficient for the impact of traffic volume (default value is 0.7), a_{22} is coefficient for the impact of traffic loading (default value is 0.3), and W_j = relative weight based on perceived proportional contribution of each road hierarchy and functional class priority for promoting economic efficiency for road network *j* (default values are 0.35 for national, 0.25 for town council and municipal, 0.25 for district, and 0.15 for Community Access Roads).

The Stage 2 formula is based on economic efficiency and there is no particular reference to equity. Furthermore, it is also complex and data intensive. Similarly, there is no explanation (justification) for the determination of the coefficients default values. The Stage 3 formula for allocation to the various jurisdictions (designated agencies) is illustrated in the algorithm in Figure 7-9.

$$M_{SZ} = \left(\left\{ K_{31} \left[a_{31} \left(\frac{PCU\_KM_{SZ}}{\sum_{Z=1}^{N} PCU\_KM_{SZ}} \right) + a_{32} \left(\frac{ESAL\_KM_{SZ}}{\sum_{Z=1}^{N} ESAL\_KM_{SZ}} \right) \right] + K_{32} \left[\frac{L_{SZ}}{\sum_{Z=1}^{N} L_{SZ}} \right] \right\} * CF_Z * UF_Z + K_{33} \right) * M_{Sj}$$

Figure 7-9 Uganda Road Fund allocation formula for the various jurisdictions (Source: URF, 2012)

Where: M_{sz} is allocation to designated authority *'z'* for road surface type *'s'*, M_{sj} is allocation to road network jurisdiction *j* and road surface *s* (obtained from Stage 2), $PCU\text{-}KM_s$ is total traffic volume in passenger car units kilometres for each road surface type *'s'* and designated authority *z*, $ESAL\text{-}KM_s$ is total traffic loading in equivalent standard axle loads kilometres for each road surface type *'s'* and designated authority *'z'*, L_{sz} is total length of road surface type *'s'* under designated authority *'z'*, CF_z is climatic factor for area *'z'*, UF_z is unit cost factor for area z, a_{31} is coefficient for the impact of traffic volume (default value is 0.7), a_{32} is coefficient for the impact of traffic loading (default value is 0.3), K_{31} is traffic impact factor (default value is 0.6), K_{32} is length impact factor (default value is 0.15), K_{33} is equity factor (default value is 0.25).

The Stage 3 formula is also mainly based on economic efficiency albeit a climatic factor is introduced; however, it is not logical to exclude the climatic factor in earlier stages given that drainage and moisture content are critical in the longevity of a pavement. A factor to take account of equity is also introduced; however, it is not clear how the default factor is derived and it is not highly weighted in the formula. Similarly, there is no explanation (justification) for the determination of the coefficients default values. The Stage 3 formula for allocation to the various jurisdictions (designated agencies) for community access roads is illustrated in the algorithm in Figure 7-10.

$$M_{SZ} = \left(\left\{ K_{41} \left[\frac{POP_z}{\sum_{z=1}^{N} POP_z} \right] + K_{42} \left[\frac{L_{SZ}}{\sum_{Z=1}^{N} L_{SZ}} \right] \right\} * CF_Z * UF_Z + K_{43} \right) * M_{Sj}$$

Figure 7-10 Uganda Road Fund allocation formula for community access roads (Source: URF, 2012)

Where: M_{sz} is allocation to designated authority *'z'* for road surface type *'s'*, M_{sj} is allocation to road network jurisdiction *'j'* (*j*=community access roads) and road surface *'s'* (obtained from Stage 2), POP_z is population of area *'z'*, L_{sz} is total length of road surface type *'s'* under designated authority *'z'*, CF_z *i*s climatic factor for area *'z', UF_z* is unit cost factor for area z (default value is 1.0), K_{41} is population impact factor (default value is 0.45), K_{42} is length impact factor (default value is 0.35) and K_{43} is equity factor (default value is 0.20).

The community access roads formula introduces an equity coefficient; however, it is data intensive and data collection in SSA is a challenge especially for community access roads. In all the three stages of the formula processes; there is no consultation with key stakeholders which is a major weakness of the formula. Several studies have shown that involvement of the community in the planning, management and maintenance ensures that the roads meet the needs of the people and are maintained regularly after construction (Symington, 2001; DfID, 2003).

Perhaps the most serious disadvantage of the new allocation formula throughout all the three stages is that it does not take account of the large north-south economic divide in Uganda. According to Dorosh and Thurlow (2011, p.121), "…if Uganda continues on its current growth path of Kampala-centred growth [which is in the south], regional inequality will worsen and poverty rates will remain very high [especially] in the northern region". In the same vein, the new allocation formula does not take account of Rural Accessibility Index (RAI). However, Raballand et al., (2009) argue that RAI should not be a government objective because the benefit of such investment is minimal. Achieving RAI of less than 2 kilometres would require massive investments which are not sustainable (ibid). Despite Uganda's major investment in rural roads, the RAI has not yet reached 30%; therefore thousands of additional kilometres of new roads would need to be built to achieve RAI of 100% (ibid); which would not necessarily enhance Rawlsian equity if there are no transport services.

The World Bank (no date) recommends that road funds allocations to districts should take account of agricultural output or potential; however, both the 'old' and 'new' formulae do not address this important factor. Another weakness of the new allocation formula throughout the three stages is the lack of road safety considerations. Furthermore, there is no allocation for tourism roads in the wildlife parks as is the case in Kenya and Zambia.

According to Raballand et al., (2010), optimal road maintenance funds allocation by districts in Uganda should be a function of agricultural potential, district population, district area, length and condition of district road network. The aforesaid is reasonable; however, a better addition and improvement would be to include a tourism and mineral extraction component.

An excel workbook showing application of the new Road Fund allocation formula using the existing network metrics and budgets for FYs 2014/15 and 2015/16 for the designated agencies is available at:(http://dx.doi.org/10.6084/m9.figshare.1396244).

7.3.7 Road scheme prioritisation in Uganda

Interviews with key staff from the Road Authority indicate that road scheme prioritisation is supposedly undertaken using HDM-4 and dTIMS. The aforementioned tools were discussed in Section 3.4. However, it is widely acknowledged that national road prioritisation for both maintenance and development projects in Uganda to a great extent is non-systematic and highly political.

At local government level and before the operationalisation of the Road Fund, district roads were prioritised using the Rehabilitation and Maintenance Planning System

(RAMPS). The system is an updated and expanded data management and planning tool based on the Routine Maintenance Planning System (ROMAPS) introduced in the districts in 1997. Since operationalisation of the Road Fund in 2010, district and urban roads are now prioritised by District Road Committees established under Section 25 (2) of the URF Act and mainly comprise of Members of Parliament and local leaders. It is believed that there is no scientific basis in road scheme selection process and road schemes are prioritised in accordance with the requirements of the local leaders and therefore selection is used to maintain and strengthen political allegiance or personal benefits. This affects equality of transport opportunities and leads to unsustainable road developments. A new and improved method for road scheme prioritisation using Goal Programming is proposed in Section 6.5.2; and a worked example using data from the Uganda National Roads Authority is available at: (http://dx.doi.org/10.6084/m9.figshare.1318405).

7.3.8 Micro level equity analysis

An equitable approach in the allocation of road funds in Uganda at the lower local government level (micro equity) should incorporate the framework illustrated in Table 6-3 (see Section 6.5.2) and adjusted depending on data accuracy and availability.

7.3.9 Summary Rawlsian equity analysis for Uganda road sector

An analysis of Uganda's road funds allocation and road scheme prioritisation processes cognisant of the principles of Rawlsian equity is summarised in Table 7-12 overleaf based on the various theoretical equity categories analysed in Table 2-2.

7.3.10 Uganda case study limitations

The budgets allocated to agencies do not necessarily result into actual releases although this is not important as intention is measured. Furthermore implementing agencies are required to return all unused funds to the Treasury at the end of the FY in accordance with the Public Finance and Accountability Act, 2003 (GoU, 2003). Data provided from official sources may not be accurate. There are instances where the surface areas of districts and municipalities as provided by the statistics bureau have varied year after year even when there has been no change in district or municipality boundaries. This view is supported by Howe (2003) who observes that there are inconsistencies in official government statistics. Currency conversions have been based on FY 2013/14 average exchange and indexation for inflation has not been undertaken. There is off-line budget support to the road sector through development partners which may not be captured properly in the official government statistics. Furthermore, due to disjointed planning, several other ministries are also responsible for road projects albeit funding is small and should not affect conclusions.

Equity type (research proxy)	**Uganda performance (Rawlsian)**
Horizontal (macro)	Over emphasis on capital investment in most years albeit the *MEC* values for FY 2010/11 and 2011/12 are within range. The north-south economic divide is not fully addressed albeit efforts to economically uplift the northern region are being made targeted development Projects. Summary rating is **poor**.
Vertical (meso)	Rural inhabitants do not benefit from many road projects due to bias towards national roads with UNRA receiving over 65% of allocations. Remote areas and roads in difficult terrain areas do not receive adequate funding. There is no authority responsible for rural roads. Summary rating is **poor.**
Vertical (micro)	Existing formula provides a minimum allocation for all sub-counties. Road scheme selection is politically influenced and not to the benefit of all. Summary rating is generally **good.**
Territorial (macro, meso and micro)	Roads are prioritised based on the ruling party's political manifesto which does not explicitly address connectivity. Results of decision support tools are seldom used. Allocation of the special intervention Fund for sealing town council roads is regionally balanced. Summary rating is generally **good.**
Spatial (macro, meso and micro)	All individuals and regions do not benefit equally from road infrastructure funds allocation. There is an over emphasis for paving and developing roads in Western Uganda due to the regions political clout. Summary rating is generally **poor.**
Social (macro, meso and micro)	Road scheme prioritisation and investment decisions at all levels do not explicitly take account of social-equity issues; however, Road Fund allocation formula provides for a minimum amount for each sub-county. No specific allocation for tourism roads and a Road Safety Authority is not in place. Summary rating is generally **poor.**

Table 7-12 Uganda road sector equity performance

7.4 Chapter summary

This Chapter has provided an analysis of the road funds allocation and road scheme prioritisation in Uganda and the intrinsic aspects of Rawlsian equity. The authority responsible for national roads is the Uganda National Roads Authority and the roads in Kampala are under the jurisdiction of Kampala Capital City Authority. District roads are under district local governments whilst municipality roads are controlled by municipal councils. Town council roads are controlled by town councils whilst community access roads are under sub-county local governments. The structure of the administration of roads in Uganda is quite unique with many implementing agencies thus increasing administrative and operational costs which ultimately affects equity; moreover, the number of implementing agencies is bound to increase.

The Uganda Road Fund is responsible for funding of routine and periodic maintenance of all public roads but still operates as a 1G Road Fund. This study shows that with the current mismatch in expenditure, the road maintenance backlog is escalating. The research limitations notwithstanding the findings of this study demonstrate that the allocation of funds between maintenance and capital investments is not equitable in a Rawlsian manner apart from FYs 2010/11 and 2011/12 where the derived *Macro Equity Coefficient/Index* values are within the acceptable range. Similarly, using algorithms, formulae and frameworks developed in Chapter Six; the analysis shows that there are inequities and inequalities at meso and micro levels in all assessment years which affects equality of transport opportunities and sustainability. Uganda's road sector Rawlsian equity performance is summarised in Table 7-12 and a comparison with other case study countries is provided in Table 13-1 which shows that in general terms, Uganda performs poorly.

An analysis of the old and new allocation formula of the Road Fund shows major weaknesses as regards equity. Although the old formula was simple, it has serious weaknesses as regards equity. The new formula is too complex and data intensive and has major weaknesses in connection with key social aspects and does not consider the historical north-south economic divide. Furthermore, road scheme prioritisation is haphazard and highly political. Uganda has a relatively poor corruption perception index and the lowest GDP per capita of all case study countries. Uganda is the only case study country with a 1G Road Fund which affects flow of funds for road maintenance. The other major weakness is that there is no autonomous agency dedicated to road safety. Moreover, unlike Zambia and Kenya (Tables 9-8 and 10-5 respectively); there is no road funds allocation for tourism roads; and analysis of Uganda's paved road traffic (Table 7-1) shows that it is about double that of Ghana (Table 8-1), Zambia (Table 9-1) and Kenya (Table 10-1).

This chapter extends the knowledge of equity in road funds allocation and road scheme prioritisation using data from Uganda. The next chapter analyses road funds allocation and road scheme prioritisation in Ghana.

Chapter Eight - Ghana Case Study

8.1 Introduction

A review and critique of road funds allocations and road scheme prioritisation in Uganda was undertaken in Chapter Seven and challenges were examined. This Chapter delves into Ghana's road sector and further extends understanding of equity in road funds allocation and road scheme prioritisation. The analyses demonstrates that in general terms there are Rawlsian equity challenges in road funds allocation and road scheme prioritisation. Nevertheless, in some of the assessment years, the derived *Macro Equity Coefficient* values are within the acceptable range and are therefore equitable. Ghana allocates substantial financial resources to the road sector and they have generally increased over the years albeit the allocations (in percentage terms) for the various implementing agencies vary over the years in an unsystematic manner. Furthermore, the review shows that there are weaknesses with the existing road prioritisation mechanisms although Ghana generally performs better than Uganda.

8.1.1 Topography, geography and climate

Ghana is a coastal country of mostly low plains with a dissected plateau in south central area and is located in West Africa; bordered by Burkina Faso to the north and northwest, Ivory Coast to the west, Togo to the east and the Gulf of Guinea to the south. Ghana's territory is dominated by the Volta River within whose catchment the entire territory is nested (Foster and Pushak, 2011). The country is mainly agricultural and has a tropical warm climate and comparatively dry long southeast coast; it is hot and humid in southwest, and hot and dry in the north (IFRTD, 2010; IndexMundi, 2014). Ghana has a total area of 238,533sq.km of which 4.61% is water and 95.39% is land (ibid). The capital city of Ghana is Accra and it experienced a growth rate of 4% per year (Barrett and Kumar, 2008). This is in sync with growth rates of other capital cities in SSA. Accra's population doubled in fifteen years and the size of the capital city has expanded almost three fold reaching 344sq.km in 2005 (ibid). Figure 8-1 overleaf shows the location of Ghana from a regional and local perspective.

8.1.2 Ghana politics and economy

Ghana has had varying growth rates since independence from Britain in 1957; and it also experienced a long period of political instability, mass emigration and economic decline in the 1980's (Foster and Pushak, 2011). According to the World Bank (1970), GDP growth averaged about 2.4% for the period 1960 to 1968. However, the country is now on an upward trend economically with a GDP growth rate of 7.9% (World

Bank, 2014a); and this is in line with existing trends in SSA countries. As pointed out by Foster and Pushak (2011, p.2), “Ghana is a relatively well-off low-income country well on its way to reaching middle-income status”. Moreover, the economy has been sustained by a quarter century of relatively good management, a competitive business environment, and continuous improvements in poverty levels (IndexMundi, 2014). In contrast, there is only limited evidence to demonstrate that the improved economy has translated into much improved transport conditions particularly for the majority of the populace and equity of transport opportunities is still a challenge hitherto.

Ghana (regional context)

Ghana (local context)

Figure 8-1 Maps showing location of Ghana (Source: IndexMundi, 2014)

Historically, Ghana has had abundant natural resources (World Bank, 1953); however, the financial gains from the resources have not been distributed equitably thus the north-south economic divide which is also partly a legacy of colonialism. Recent reports show that agriculture accounts for roughly 25% of GDP and employs about 60% of the country’s active population; and the services sector accounts for half of GDP whilst gold and cocoa production and individual remittances are major sources of foreign exchange (Foster and Pushak, 2011; IndexMundi, 2014).

Given the importance of agriculture in terms of employment, road infrastructure for agricultural production areas should be allocated sufficient resources to offer equality of opportunities and improve Rawlsian equity. Economic growth is expected to be further boosted by oil production at Ghana's offshore Jubilee field which began in mid-December 2010. Furthermore, sound macro-economic management along with higher prices for oil, gold and, cocoa helped sustain high GDP growth in 2008-12, despite the general slowdown in the global economy during that same time period (ibid). The World Bank reports GDP growth in 2013 at 7.6% and this would imply that there are more financial resources for infrastructure development including roads; however, they would need to be allocated equitably to ensure sustainable developments.

Several studies have shown that there is a marked north-south economic divide with the affluent regions located in the south and high poverty levels in the sparsely populated north (World Bank, 1953; Foster and Pushak, 2011; World Bank 2011b; GSS, 2013; theidlgroup, 2014). This is similar to the situation in Uganda.

The Ghanaian government is trying to address the historical imbalance through the creation of Savannah Accelerated Development Authority aimed at enhancing the socio-economic development of the Savannah belt through strategic investment in resource development.

8.1.3 The road sector in Ghana and implementing agencies

The development and distribution of Ghana's road network, as in most former British colonies in SSA was aimed at serving colonial interests and the bulk of colonial capital investment went into building roads in the gold-rich Ashanti and Western regions and the cocoa growing areas of Eastern, Central, Western and Ashanti (World Bank, op. cit., 2011b). Therefore, from the onset, Ghana's road transport investment policy was not equitable in a Rawlsian manner.

Road transport in Ghana is the most predominant form of movement for both cargo and passengers; and carries over 95% of all passengers and freight traffic and reaches most communities including rural areas (GoG, 2006).

Two ministries are responsible for Transport in Ghana namely: (i) Ministry of Transport (MoT) established in February 2009 after realignment of the previous Ministry of Aviation and Ministry of Harbours and Railways; and (ii) Ministry of Roads and Highways-MRH (GoG, 2011). MoT has oversight responsibility for the transport sector except road infrastructure which is under MRH (ibid).

Following reforms in the road sector, Ghana now meets almost all of the best practice for road sector institutions (Foster and Pushak, 2011); however, this has not necessarily resulted into equitable allocation of road funds. According to Serageldin (1991, p.4), "the core of the problem of road maintenance [in SSA] is not rooted in technical matters but is political and institutional". Therefore, having all road sector reforms in place without the necessary paradigm shift in decision making by politicians is likely to exacerbate inequities and lead to unsustainable road projects.

In 2010, Ghana's road network consisted of 66,220km made up of 42,192km of feeder roads, 12,400km of urban roads and 11,628km of trunk roads (GoG, 2010). However, three years later in 2013, the road network in Ghana comprised: 14,460km of trunk roads, 12,682km of urban roads and 40,713km of feeder roads (GRF, 2013). Just over forty years before, the total road network comprised of 32,187km of which 3,975km was paved, 10,943km gravel or laterite surfaced and the remainder unimproved earth roads (World Bank, 1970). Therefore, the total road network has more than doubled over the forty year period.

The implementing agencies in Ghana are: Ghana Highway Authority (GHA) established in 1974 and is responsible for planning, developing and maintaining the Trunk Roads; Department of Urban Roads (DUR) which is responsible for maintenance and development of roads in the cities such as: Accra, Kumasi, Tema, Sekondi, Takoradi, Tamale, Koforidua; and Municipal towns. Following full implementation of the Local Government Act (Act 462), DUR now operates road units and manages all 10 regional capitals in Ghana. The Department of Feeder Roads (DFR) is responsible for the construction and maintenance of feeder roads (GRF, 2013, theidlgroup, 2014). The implementing agencies report to the Chief Director of the Ministry of Roads and Highways (MRH) who works directly under the political Minister for Roads and Highways.

A truly commercial approach would be for the agencies to report to their independent Boards. Nevertheless, the Ghana Highway Authority has a Board but its independence is questionable because it is appointed by the Government.

Other implementing agencies which are considered later in Table 8-14 include: Driver and Vehicle Licencing Authority (DVLA) and National Road Safety Commission (NRSC).

The current road network links all districts and regions and is considered adequate to meet the minimum requirements for sub-regional integration (MoFEP, 2012). Furthermore, Foster and Pushak (2011, p.10) highlight the point that "the road network quality [in Ghana] is quite reasonable, with 75 percent of the paved network in good or fair condition and, more impressive, 74 percent of the unpaved network [is] in good or fair condition". This is a very marked improvement from the mid-1980s considering that Kocks Consults (1986), cited in Gronau, (1991), reported that at that time 15% of the roads could be deemed in good condition, 40% in fair condition and 45% in poor condition.

The road condition improvement is probably as a result of improved and more reliable funding through full 2G operationalisation of Ghana Road Fund. In contrast, other studies have shown that there is poor connectivity in rural areas with RAI of 25% (MoFEP, 2012; theidlgroup, 2014).

Starkey et al., (2002) point out that achieving good overall rural accessibility would require more than doubling the length of the classified network. Therefore, this should not be a major goal for Ghana but Rawlsian equity needs prioritisation. Moreover, Raballand et al., (2010) argue that RAI should not be used as a priority tool for rural road planning and perhaps the index should be increased to 5km to mitigate unnecessary rural road development.

Gwilliam et al., (2009), cited in Foster and Pushak, (2011), undertook an analysis of Ghana's road indicators and benchmarked them against Africa's low and middle income countries; and Table 8-1 overleaf provides an analysis of the results.

Comparison of road indicators for both low and middle income countries as reported in 2009 by Gwilliam et al., and analysed in Table 8-1 (for Ghana) and Table 9-1 (for Zambia) shows that the base reference metrics vary significantly.

As explained in Section 7.1.3, this is one of the major challenges of cross country data comparisons (the data collection and assessment periods are most probably different or the number of countries identified as middle income countries changed or network metrics were revised).

Comparison of Ghana and Zambia road indicators shows that the paved and unpaved road density for Zambia is far lower than that of Ghana which also translates in a better RAI for Ghana. In terms of connectivity, it would imply that Ghana has better internal connectivity compared with Zambia. However, the percentage of the paved road network in good or fair condition in Zambia is marginally higher than that of Ghana.

Metric	Measure	Low Income countries	Ghana	Middle income countries	Implications for equity and remarks
Paved road density	km/1000km^2 of arable land	86.6	158.1	507.4	Paved road density is nearly double that of low income countries.
Unpaved road density	km/1000km^2 of arable land	504.7	804.0	1,038.3	Unpaved road density is higher than that of low income countries.
GIS rural accessibility	%age of rural population within 2km of all season road	21.7	24.0	59.9	RAI is low partly due to the sparsely populated northern Ghana.
Paved road traffic	Average annual daily traffic	1,049.6	1,314	2,786.0	Ghana has higher paved traffic volumes when compared to low income countries.
Unpaved road traffic	Average annual daily traffic	62.6	40.4	12.0	
Paved network condition	% in good or fair condition	80.0	75.0	79.0	Unpaved network condition is better than that of low income countries.
Unpaved network condition	% in good or fair condition	57.6	74.0	58.3	
Perceived transport quality	% firms identifying roads as a constraint	23.0	17.6	10.7	

Table 8-1 Ghana's road network indicators (Source: adapted from Gwilliam et al., 2009, cited in Pushak and Foster, 2011)

8.1.4 The Ghana Road Fund

Ghana has one of the oldest Road Funds in Africa although it is acknowledged that it is hitherto prone to governance challenges. In 1985 an administrative order (legislative instrument) was given to establish the Road Fund with the aim of generating and managing revenue thus providing a secure source of funding for road maintenance, and it previously operated as a 1G Road Fund (GRF, 2013). GRF is mainly responsible for collecting and allocating funds for routine and periodic maintenance to the various implementing agencies. However, allocating funds for road improvement and maintenance is a perennial problem in most of SSA and is the case with Ghana despite the country approaching middle income status (theidlgroup, 2014). GRF also funds road safety through the National Road Safety Commission albeit road safety is still a cause of concern. The increasing death toll on Ghana's roads has terrible impacts on communities and families (GoG, 2011). Furthermore, overloading is rampant leading to increases in the Equivalent Standard Axle Loading thus heightening the rate of deterioration of the roads (Gronau, 1991); and this affects equality of transport opportunities and sustainability of roads.

GRF revenue comprises fuel levy on diesel and petrol, tolls (road, bridge and ferry), road user fees, vehicle registration fees and international transit fees on foreign vehicles entering Ghana (GRF, 2013). Over the period 2002 to 2007, GRF contributed US$M 571.85 towards the maintenance, rehabilitation and upgrading component of the RSDP. Table 8-2 below analyses the contribution from the various revenue sources:

Source	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**%**
Fuel levy	46.48	72.42	78.40	108.80	111.28	116.95	93.44
Road tolls	0.85	1.18	1.15	1.15	1.09	1.04	1.13
Bridge tolls	0.42	0.66	0.56	0.63	0.62	0.62	0.61
Ferry tolls	0.00005	0.0087	0.014	0.027	0.046	0.013	0.02
Road use fees	1.21	1.36	1.39	1.45	1.57	1.83	1.54
Registration fees	1.52	1.64	1.95	2.14	2.38	2.97	2.20
International transit fees	0.67	1.17	1.01	1.10	1.07	1.01	1.05
Total	51.15	78.44	84.47	115.30	118.06	124.43	

Table 8-2 Ghana Road Fund collections for the period 2002 to 2007 in US$M (Source: adapted from GoG, 2006; GoG, 2007)

From Table 8-2, it can be deduced that levy on diesel and petrol makes the largest contribution despite the fact that the levy has not changed during the assessed period for political reasons. Collections of fuel levy increased over the years and those of other charging instruments did not vary significantly. However, relying on fuel levy as the main source of revenue has equity implications as governments are usually reluctant to increase levies possibly due to potential political backlash. Table 8-3 below analyses GRF revenues for the period 2008, 2010, 2011 and 2012.

Revenue Source	**2008**		**2010**		**2011**		**2012**	
	US$M	%	US$M	%	US$M	%	US$M	%
Fuel levy	66.14	60.6	81.97	42.04	89.50	36.6	98.96	34.44
Tolls	12.94	11.9	19.27	9.88	24.04	9.83	27.39	9.53
Vehicle registration fees	17.99	16.5	35.82	18.37	52.32	21.4	69.74	24.27
Road use fees	11.40	10.4	45.42	23.29	65.24	26.7	79.38	27.63
International transit fees	0.618	0.57	12.51	6.41	13.38	5.47	11.87	4.13
Total US$M	109.09		194.99		244.8		287.34	

Table 8-3 Ghana Road Fund collections for the period 2008, 2010, 2011 and 2012 in US$M (Source: adapted from GRF, 2013)

Note: Analysis based on interbank market rate of January 2012 (1US$ = 1.6475GH₵). Source: Bank of Ghana (www.bog.gov.gh), no account of inflation.

During 2009, the total collections were US$M 82.46 with fuel levy amounting to US$M 77.33 (93.78%) of collections (GRF, 2013). Furthermore, it can be deduced from Table 8-3 that fuel levy contributes the largest source of revenue albeit the percentage has declined over the years. Revenue from tolls has been increasing over the years which may be due to an increase of tolled roads/bridges whilst vehicle registration fees have increased over the years as a result of increasing vehicle population. Similarly, road use fees have increased over the years and there is a marked increase in the percentage contribution of transit fees since 2008.

8.1.4.1 Critique of Ghana allocation formula

Foster and Pushak (2011) observe that Ghana allocates its road fund resources much more evenly with rural roads receiving 30% and urban roads 25% of total. However, this may not necessarily be equitable if a needs analysis indicates different allocations. In 1997, Mwale reported that GHA was allocated 58%, DFR received 20% and DUR 22%; however, fifteen years later in 2013, budgetary allocation for rural roads was 26.90%, and 26.46% for urban roads (GRF, 2013); which is still not equitable in a Rawlsian manner as there is a marked bias towards the trunk (national) road network under GHA.

Historical allocations during 2009, 2010, 2012 and 2013 are analysed in Table 8-14 (see Section 8.3.2) showing annual changes (in percentage terms) for the various implementing agencies and there is no discernible formula. The yearly variations are also observed by Boamah (2010, p.62) who notes that GRF in consultation with the Ministry of Roads and Transport (MRT) through a sub-committee allocates funds between the various road classes in a haphazard manner without merit leading to fluctuations year after year and therefore agencies are unaware how much will be allocated at different times. This is typical of other SSA countries as allocations are in many instances politically maneuvered (theidlgroup, 2014). Furthermore, due to insufficient resources, trade-offs have to be made when making decisions on funds allocation.

In the opinion of Foster and Pushak (2011), Ghana allocates substantial resources to the road sector and spends on average 1.5% of GDP on roads which when compared to other countries in SSA is quite high (as seen in Figure 7-2); however, the analysis in this thesis (see Table 6-7) shows that Ghana's expenditure is the lowest of all case study countries (variations are possibly due to different analysis periods). However, as observed in Section 1.2.2, clearing the maintenance backlog in most SSA countries would require close to 5% of GDP per annum if clearing is spread over 5 to 10 years.

The Ghana Road Fund allocations have proved somewhat erratic over time but are mainly based on the needs of the network submitted by agencies and government policy.

8.1.5 Ghana road asset value

According to analysis by Andreski (2005), the 2004 estimated asset value of public roads in Ghana is US$ 4.6billion. As seen in Section 7.1.4, this is about the same as the current asset value for Uganda roads as reported by Mrawira (2014). However determination of asset value is a challenge given the inaccuracies associated with data on network metrics in SSA. Moreover, the unpaved network whose value is more challenging to determine forms the largest part of Ghana's network as it does in Uganda.

In 2004, GRF expenditure on maintenance was about US$M 85 which is about 1.8% of asset value. This implies that Ghana's spending on maintenance was below the UN Economic Commission for Latin America and the Caribbean (ECLAC) recommended values of between 2.5% and 3.5% of asset value (Schliessler and Bull, 2004). The 2013 estimated value of Ghana roads is over US$ 6billion (GRF, 2013); which would indicate an increase in value of over 30% in ten years. Considering ECLAC recommendations, the required expenditure would be between US$M 150 to 210 and the reported GRF collections in 2012 were US$M 287.34 which is within the required range of maintenance funds.

8.1.6 Ghana key transport policy documents

The **Road Sector Development Programme (RSDP)** was the first integrated programme for trunk, feeder and urban roads to be implemented by the Ghanaian government and targeted to the road subsector. RSDP was the 3-year (2002 to 2004) slice of the Road Sector 5-year Strategic Plan for the period 2002 to 2006 (GoG, 2006). It provided an integrated approach to road maintenance, rehabilitation, construction, safety and management by the MoT, GHA, DFR, DUR, NRSC and the DVLA (ibid). Furthermore, the financial outlay for the programme was about US$ 1.2billion and funding was covered by the Road Fund, Consolidated Fund and Donor Funds; whilst the planning and budgeting of road schemes was based on HDM-4 (ibid).

In 2007, the Government of Ghana (GoG) explained that the objectives of RSDP were to: (i) achieve sustainable improvements in the supply and performance of roads and road transport services in a regionally equitable manner, (ii) clear backlog of road maintenance geared towards network stabilisation and achievements of road condition mix of 59% good, 27% fair and 14% poor within the duration of the RSDP; and (iii) provide an enabling environment (accessibility) for growth and achievement of the Ghana poverty reduction strategic goals.

From the above objectives, it is implied that the infrastructure funds allocation was meant to be equitable over the RSDP period which is a plausible policy initiative. Furthermore, it is observed that the programme achieved improvements in road conditions and for the period 2002 to 2004, the percentage of roads in good condition increased from 30% to 40%, the fair condition roads increased from 21% to 30% whilst the poor condition roads reduced from 49% to 30% (ibid). The improvements notwithstanding the programme experienced major challenges including: (i) utilisation of management tools (ii) planning, budgeting and programming issues, (iii) project preparation and execution delays, (iv) lengthy procurement processes, (v) poor contract administration, and (vi) lack of adequate counterpart funding for compensation (GoG, 2007). The challenges imply that some of the intended equity goals may not have been achieved thus affecting equality of transport opportunities and sustainability of road projects. The Ghanaian RSDP ended in 2007 and follow up programs which had commenced earlier culminated into: (i) National Transport Policy, (ii) Institutional Study of the Transport Sector, and (iii) Monitoring of the impact of RSDP on poverty reduction. Table 6-4 below examines the RSDP (2002 to 2004) component and cost elements.

Activity	**km**	**Indicative cost (US$M)**	**% of total**	**Implications for equity and remarks**
Routine maintenance	27,250	101.37	8.5	There is a good balance between capital projects and maintenance with a *MEC* of 0.48.
Periodic maintenance, minor rehabilitation and upgrading, bridges and culverts	18,667	416.03	34.9	
Major rehabilitation, reconstruction and upgrading	923	559.20	47.0	
Traffic management and safety		11.00	0.9	An allocation of less than 1% shows that road safety is not highly prioritised although it benefits the most vulnerable and poor road users.
Institutional strengthening		55.40	4.7	
Programme operation		11.00	0.9	Operational costs of less than 1% appear reasonable and in line with ARMFA recommendations.
Total project costs		1,191.00	100	
Total financing required		1,191.00	100	

Table 8-4 Road Sector Development Programme 2002 to 2004 (Source: adapted from programme appraisal document, cited in GoG, 2006)

The **Road Sector Strategic Plan** covered the period 2002 to 2006 and initially required US$ 1.051billion; however, it was scaled down to reflect revised funding portfolio (GoG, 2008). Analysis of the aforesaid plan shows that: (i) routine maintenance funding did not vary significantly over the years, (ii) periodic maintenance and rehabilitation expenditure reduced over the years, and (iii) upgrading costs had peaks in 2003 and 2006 which could be attributable to elections or periods leading to elections.

The **Transport Sector Development Programme** was a 5 year programme developed by the transport sector ministries (MoT and MRH) for the period 2008 to 2012 and covered all modes of transport and had a budget of US$ 4.82billion (GoG, 2010). The estimated cost of the progamme between 2008 and 2013 was US$ 3.13billion; 67.5% of the total amount was for the road sector, 28.13% for the MoT and its agencies and 4.37% for inter-Ministerial collaborative activities (ibid). The road sector had the largest share signifying its importance in poverty alleviation.

The **National Transport Policy-NTP (2008)** underpins the development and improvement of transportation in general and was the first attempt at defining a more coordinated approach with the aim of setting out a blue print for the sustainable development of Ghana's transportation system (GoG, 2009; theidlgroup, 2014).

8.2 Ghana road sector expenditure

Table 8-5 below examines the expenditure Ghana's three main implementing agencies during 1995 and 1996 in million Cedis.

Agency	**1995**		**1996**		**Remarks on equity**
	Total Inflow	% share of total inflow	Total Inflow	% share of total inflow	
GHA	113,401	60.4	117,991	63.8	Expenditure on the core road network exceeds that of both urban and feeder roads combined but feeder roads constitute about 60% of road network.
DUR	49,519	26.4	39,203	21.2	
DFR	24,807	13.2	27,872	15.0	
Total	187,727	100	185,066	100	Expenditures in both years is almost similar.

Table 8-5 Ghana's road sector expenditure during 1995 and 1996 in Million Cedis (Source: adapted from GoG, 1997)

As reported by the Ghanaian Ministry of Finance in 1997, the actual expenditure in 1996 on roads excluding spillovers was 185,000million Cedis comprising of 144,407million Cedis on development projects and 40,593million Cedis on maintenance which again shows a strong bias towards capital investment projects. In Table 8-5, the Cedi has not been converted to US$ due to lack of a readily available exchange rate for that period; however, the imbalance would still be similar in percentage terms (even when the exchange rate is applied).

8.2.1 Agency plans and programmes (2002 to 2007)

An analysis of expenditure for the strategic plans for the trunk, feeder and urban roads is considered below:

8.2.1.1 Trunk Roads Strategic Plan

The medium strategic plan for Ghana Highway Authority (GHA) required an annual average of US$M 187.50 to execute the medium term programme (GoG, 2006, GoG, 2007); as indicated in the analysis in Table 8-6 below:

Year	Expenditure on various activities (US$M)						
	Maintenance		Capital investment		Other		Total
	Routine	Periodic	Upgrading	Construction	Bridges/ culverts	Admin	
2002	14.0	54.0	7.0	139.0	6.0	10.0	230
2003	14.0	30.0	22.0	84.0	6.0	10.0	166
2004	14.0	71.0	13.0	80.0	6.0	10.0	194
2005	14.0	71.0	11.0	76.0	6.0	10.0	188
2006	14.0	26.5	20.0	83.0[1]	7.0	9.0	160
2007	15.0	27.5	25.0	80.0[1]	4.0	12.0	164
Total	85.0	280.0	98.0	542.0	35.0	61.0	1101

Table 8-6 Expenditure programme on various activities for GHA for the period 2002 to 2007 (Source: adapted from GoG 2006, p.9; GoG , 2007, p.7)

Note 1: Includes traffic management and safety, consultancy services, environmental and social management.

Analysis of Table 8-6 shows that the budget for routine maintenance remained constant whilst the upgrading and reconstruction costs far exceeded maintenance costs which is not equitable in a Rawlsian manner.

8.2.1.2 Feeder Roads Strategic Plan

The Department for Feeder Roads (DFR) developed a medium term programme in line with the MoT 5-year rolling strategic plan and about US$M 100 was required annually (ibid); as analysed in Table 8-7 overleaf.

Year	Expenditure on various activities (US$M)						
	Maintenance		Capital investment	Other			Total
	Routine	Periodic	Construction	Bridges/ culverts	Admin	Consulting /Training	
2002	10.58	57.62	0.60	12.22	2.30	5.07	88.39
2003	12.22	64.01	0.60	12.59	2.13	3.60	95.15
2004	13.51	62.49	0.60	14.85	2.01	2.03	95.49
2005	14.35	67.61	0.60	9.79	1.87	0.88	95.10
2006	14.84	62.59	0.60	42.37	3.00	5.84	129.24
2007	15.48	69.99	0.60	29.92	3.16	3.48	122.63
Total	80.98	384.31	3.60	121.74	14.47	20.90	626.00

Table 8-7 Expenditure programme on various activities for DFR for the period 2002 to 2007 (Source: adapted from GoG, 2006, p.9; GoG, 2007, p.7)

From Table 8-7, it can be deduced that the budget over the years increased with increasing network length; however reconstruction costs remained uniform over the period. Allocations are reasonably equitable in a Rawlsian manner as they are skewed towards maintenance which should improve equality of transport opportunities; however, communities with no road connections would most probably benefit from new roads.

It is probable that allocations are over-skewed towards maintenance because the GRF mainly funds road maintenance projects. However, intervention prioritisation also depends on the needs of the network as presented by the implementing agencies.

However, it is important to realise that during that period, the MRH was trying to achieve a balanced network condition mix of good, fair and poor roads in all agencies. This perhaps drove the fund allocation processes and there is an overall upward trend in the total budgets.

8.2.1.3 Urban Roads Strategic Plan

The urban roads strategic plan sought to maintain and preserve roads which had been recently improved whilst reconstructing those which had deteriorated or operating at full capacity and the cost required annually was US$M 113.36 (ibid); as analysed in Table 8-8 overleaf.

Year	Expenditure on various activities (US$M)					
	Maintenance		Capital investment	Other		Total
	Routine	Periodic	Construction	Traffic and road safety	Admin	
2002	9.45	34.19	59.30	4.40	8.21	115.55
2003	10.77	37.87	67.30	4.80	6.72	127.46
2004	12.00	41.00	43.00	7.40	9.10	112.50
2005	14.00	46.00	44.00	6.90	10.91	121.81
2006	7.57	23.35	46.52	8.65	2.40	89.50
2007	8.42	27.4	54.42	9.34	2.15	101.73
Total	62.21	209.81	315.54	41.49	39.49	668.54

Table 8-8 Expenditure programme on various activities for DUR for the period 2002 to 2007 (Source: adapted from GoG, 2006, p.10; GoG, 2007, p.8)

From Table 8-8, it can be deduced that the budget for reconstruction exceeds that of maintenance in all years apart from 2004 and 2005 which is not equitable in a Rawlsian manner and affects equality of transport opportunities; and leads to unsustainable road developments. In terms of total yearly allocations, the budget varied from year to year and there is no clear trend although the network increased in length. However, the variation depends on the mix of maintenance activities selected for the budget year and the length and condition of the road network in good, fair and poor condition.

8.2.2 Historical expenditure on road maintenance

The Ghana Road Fund (GRF) provides funding to support the road maintenance component of the Road Sector Development Programme. However, other activities such as road rehabilitation, upgrading, traffic management are also undertaken which has imposed severe strain to the Road Fund which is unable to fully fund periodic maintenance (GoG, 2006).

An analysis of the GRF releases as reported by Government of Ghana in 2007 for the five year period commencing 2002 shows that:

(i) For routine maintenance: more funds were released for the core road network (GHA) when compared with the non-core network (DFR and DUR); however for the feeder roads there was generally an upward trend. Considering that the non-core road network provides transportation facilities for the majority of the rural dwellers, reduced funding affects equality of transport opportunities;

(ii) For periodic maintenance: total funds released for trunk roads did not vary majorly when compared with urban roads. This is considered equitable in a Rawlsian manner and is likely to lead to sustainable road projects; and

(iii) Overall, releases to GHA are more than those of other agencies to the tune of more than 20%.

8.3 Ghana road sector equity analysis

8.3.1 Macro level equity analysis

This section analyses Ghana's road sector capital investment expenditure against maintenance at agency level using equations 6.1 to 6.4 for *MEC* and *MEI* as derived in Section 6.2.1).

8.3.1.1 Macro level equity analysis of the Ghanaian implementing agencies (2005 to 2007)

The GHA programme during 2005 and 2006 is analysed in Table 6-9 below:

Activity	**Approved Programme / Budget**			
	2005		**2006**	
	Km	Total (US$M)	Km	Total (US$M)
Routine maintenance	12,168	13.74	12,168	16.56
Periodic maintenance	387.00	16.85	239.00	20.49
Rehabilitation	228.00	18.25	699.50	71.22
Development	200	165.54	200	203.65
Recurrent expenditure		5.14		4.67
Grand total		219.52		316.59
MEC		0.14		0.12
MEI		0.85		0.92

Table 8-9 GHA programme for 2005 and 2006 (Source: adapted from: GoG, 2006, p.35).

The *MEC* and subsequently the *MEI* values for Ghana Highway Authority expenditure in 2005 and 2006 are out of range when compared with the median allocation (50th percentile) which is tantamount to *MEC* value of 0.32 as analysed in Table 6-1 and the thesis suggested range of 0.25 to 0.50; showing a major bias towards capital investment which is likely to lead to unsustainable road projects.

However, results need to be interpreted cautiously as this does not necessarily mean that the allocation is inequitable especially if it was based on a thorough needs assessment taking into account network metrics of the various road classes (see expert opinion analyses in Section 5.2.2).

The Department of Feeder Roads analysis of macro equity for 2005 and 2006 is provided in Table 8-10 below:

Activity	**Approved Programme Budget**			
	2005		2006	
	Km	Total (US$M)	Km	Total (US$M)
Routine maintenance	24,000	16.06	26,580	18.14
Periodic maintenance	1,682	12.43	1,759	15.84
Rehabilitation	1,900	35.27	1,072	61.62
Development	20	9.88	20	12.50
Reconstruction	20	1.48	20	0.00[1]
Bridge construction (No.)	20	9.88	136	12.50
Consultancy services		4.07		4.57
Admin/institutional support		1.97		2.26
Grand total		79.68		114.93
MEC		0.37		0.30
MEI		0.43		0.52

Table 8-10 DFR programme 2005 and 2006 (Source: adapted from GoG, 2006, p.36)

Note: 1. data is incorrect.

The *MEC* and subsequently the *MEI* values for Department of Feeder Roads expenditure in 2005 and 2006 are within range of the median (50th percentile) allocations summarised in Table 6-1 implying a fairer allocation between capital investments and maintenance which is likely to lead to sustainable developments.

An exploration of the macro-equity in the Department of Urban Roads budget for 2005 and 2006 is provided in Table 8-11 overleaf. The *MEC* values for the Department of Urban Roads expenditure in 2005 and 2006 are within range this thesis suggested *MEC* range of 0.25 to 0.50 (see Table 6-6).

Activity	Approved Programme Budget			
	2005		2006	
	Km	Total (US$M)	Km	Total (US$M)
Routine maintenance	4,255	7.71	3,449	7.65
Periodic maintenance	734.27	21.09		29.80
Rehabilitation	205.67	10.62	91.15	15.95
Major rehabilitation and reconstruction		90.71		66.08
MEC		0.32		0.45
MEI		0.49		0.35

Table 8-11 DUR programme 2005 and 2006 (Source: adapted from GoG, 2006)

The derived *MEC* value for 2005 equals the 50th percentile allocation as analysed in Table 6-1; implying a fair allocation between capital investments and maintenance. Table 8-12 below analyses the 2007 approved programme for all road agencies.

Activity	GHA		DFR		DUR		Total	
	km (‘000)	US$M	km (‘000)	US$M	km (‘000)	US$M	km (‘000)	US$M
Routine maintenance	12.17	23.55	26.6	14.66	4.02	8.32	42.8	46.53
Periodic maintenance	0.22	10.88	2.16	33.22	2.08	23.56	4.46	67.66
Rehabilitation / upgrading	0.49	85.46	1.30	55.46	0.2	11.16	1.99	152.08
Rehabilitation/ reconstruction					4.00	33.29	4.00	33.29
Road safety				9.61		15.97		25.58
Total (US$M)		119.8		112.95		92.30		325.14
MEC		0.29		0.42		0.34		0.35
MEI		0.54		0.37		0.46		0.45

Table 8-12 Ghana road sector macro equity analysis for 2007 (Source: adapted from GoG, 2007)

From Table 8-12 it can be deduced that: (i) all agencies expended more resources on periodic maintenance when compared with routine maintenance, (ii) rehabilitation, reconstruction and upgrading were allocated the largest share of the available funds for all implementing agencies, and (iii) analysis of *MEC* and *MEI* shows that they are within this thesis acceptable range for *MEC* of 0.25 to 0.50 and are therefore equitable in a Rawlsian manner.

With a GDP of US$ 20.41bn in 2007 (World Bank, 2014a), analysis of Table 8-12 shows that Ghana spent 0.56% of GDP on road maintenance and 1.59% of GDP for the whole road sector. However, expenditure on road maintenance as a percentage of GDP is the lowest of all case study countries (see Table 6-7).

8.3.1.2 Macro equity analysis of the Ghanaian implementing agencies (2009 and 2010)

Considering the 2009 and 2010 approved programme for Ghana Highway Authority as reported in 2010 by GoG (see Appendix A), it can be concluded that: (i) higher expenditure was incurred on routine maintenance when compared to periodic maintenance, and (ii) just like in 2005, 2006 and 2007; expenditures for 2009 and 2010 show a bias towards capital investment projects. The GHA - *Macro Equity Coefficient* for 2009 and 2010 is 0.16 and 0.26 respectively whilst the *Macro Equity Index* for 2009 and 2010 is 0.80 and 0.58 as analysed in Appendix A. The values for 2010 are within this thesis acceptable range and are therefore equitable.

Analysis of the Department of Feeder Roads programme for the 2009 and 2010 as reported in 2010 by GoG shows that: (i) expenditure between periodic maintenance and routine maintenance varies year to year with no clear pattern, and (ii) DFR allocated more resources to maintenance when compared to GHA albeit capital investments take over 65% of resources. The DFR *Macro Equity Coefficient* for 2009 and 2010 is 0.23 and 0.35 respectively whilst the corresponding *Agency Macro Equity Index* for 2009 and 2010 is 0.65 and 0.46 as analysed in Appendix A. The values for 2010 are within this thesis acceptable range (0.25 to 0.50) and the *MEC* value is close to 50th percentile as analysed in Table 6-1. However, the 2009 values are just out of range and are therefore inequitable.

Analysis of the 2009 approved programme for Department of Urban Roads as reported in 2010 by GoG shows that: (i) there is more expenditure on periodic maintenance when compared with routine maintenance, and (ii) DUR allocated more resources to capital investments taking over 72% of resources. The DUR - *Macro Equity Coefficient* for 2009 is 0.28. The corresponding *Macro Equity Index* for 2009 is 0.56 as analysed in Appendix A. The *MEC* for 2009 is within the target range of 0.25 to 0.50 and is therefore equitable in a Rawlsian manner.

8.3.2 Meso level equity analysis

This section considers the fairness of the vertical allocation of maintenance funds between the various classes of roads. It assesses the distribution between trunk roads (strategic core road network under GHA) and the non-core road network (feeder roads under DFR and urban roads under DUR). In economic terms, the costs of improving low volume roads with comparatively low population densities are rarely justifiable as the economic cost-benefit appears marginal (theidlgroup, 2014). However, rural transport investment has an important role to play in tackling poverty and achieving the Millennium Development Goals.

Table 8-13 below provides an analysis of the meso-level equity for 2005, 2006 and 2007 approved programme for Road Agencies. *Meso Level Equity Coefficient (MLEC)* is defined as the ratio of the agency budget to total road sector budget.

Year	**GHA**		**DFR**		**DUR**		**Total**	**%age of GDP**
	US$M	*MLEC*	US$M	*MLEC*	US$M	*MLEC*	US$M	
2005	219.52	0.57	79.68	0.21	49.26	0.12	384.46	4.33%
2006	316.59	0.64	114.93	0.23	66.08	0.13	497.60	4.63%
2007	119.8	0.37	112.95	0.35	92.30	0.28	325.14	1.59%

Table 8-13 Ghana road sector meso equity analysis for 2005 to 2007 (Source: adapted from GoG, 2006 and 2007)

Notes: GDP values in US$ billions: 2005 (8.88bn), 2006 (10.73bn), 2007 (20.41bn). Source: Bank of Ghana (www.bog.gov.gh), no account of inflation.

From Table 8-13, it can be concluded that in 2007, the allocations between DFR and GHA did not vary significantly and appear reasonable and equitable. However, analysis of 2005 and 2006 data shows that allocations between GHA, DFR and DUR varied widely year to year and this scenario potentially affects equality of transport opportunities; moreover allocations as a percentage of GDP declined significantly between 2006 and 2007. Analysis of Ghana Road Fund disbursements for the various implementing agencies in FYs 2009, 2010, 2012 and 2013 is provided in Table 8-14 overleaf to determine the *MLEC* values.

From Table 8-14, it can be deduced that disbursements varied from year to year and there is no systematic trend in the changes. The total allocations as a percentage of GDP during 2009, 2012 and 2013 do not vary widely. The *MLEC* values should be about 0.64 for the strategic highway network, 0.25 for feeder roads network and 0.10 for urban roads based on the 50th percentile rates analysed in Table 6-2 and assuming about 12% allowance for overheads. The feeder roads *MLEC* is reasonable, the GHA is too low and for urban roads too high.

Agency	2009		2010		2012		2013	
	GH₵' 000	*MLEC*	GH₵ ' 000	*MLEC*	GH₵ ' 000	*MLEC*	GH₵ ' 000	*MLEC*
GHA	33,732.5	0.24	94,676.4	0.34	44,900	0.22	68,500	0.30
DFR	37,140.9	0.27	69,096.3	0.25	41,500	0.20	61,800	0.27
DUR	32,317.6	0.23	74,929.8	0.27	40,700	0.20	60,800	0.26
NRSC	1,409.2	0.01	1,800.0	0.01	2,300	0.01	3,500	0.02
DVLA	692.4	0.01	2,007.6	0.01	2,280	0.01	3,861	0.02
GRF	754.2	0.01	3,422.1	0.01	10,265	0.05	18,775	0.08
MRT	11,221.9	0.08	1,310.6	0.01	8,300	0.04	12,500	0.05
Other	21,770.6	0.16	29,730.9	0.11	54,570	0.27		
Total GH₵	139,039		276,974		204,815		229,736	
Total US$- bn	0.084		0.168		0.124		0.139	
As a %age of GDP	0.29%		0.64%		0.31%		0.34%	

Table 8-14 Ghana road sector meso equity analysis for 2009, 2010, 2012 and 2013 (Source: adapted from GoG, 2007; GRF, 2013)

Notes: 'Other' refers to payment of GRF indebtedness to SSNIT (debt covers expenditure on all three road agencies GHA, DUR, and DFR plus interest on loan). Analysis based on interbank market rate January 2012 (1US$ = 1.6475GH₵). GDP values in US$ Billions: 2009 (28.53bn), 2010 (25.98bn), 2012 (39.52bn), 2013 (41.66bn). Source: Bank of Ghana (www.bog.gov.gh), no account of inflation.

A possible weakness of the road funds allocation in Ghana as shown in Table 8-14 is that there is no dedicated allocation for tourism roads as is the case with the Zambia Road Fund and Kenya Road Fund (see Tables 9-2 and 10-2 respectively). However, Kenya and Zambia may have classified roads as tourism roads due to the contribution of the sector to GDP, which is the not the case in Ghana. Figure 8-2 overleaf provides an analysis of funds allocation over a four year period between 2009 and 2013.

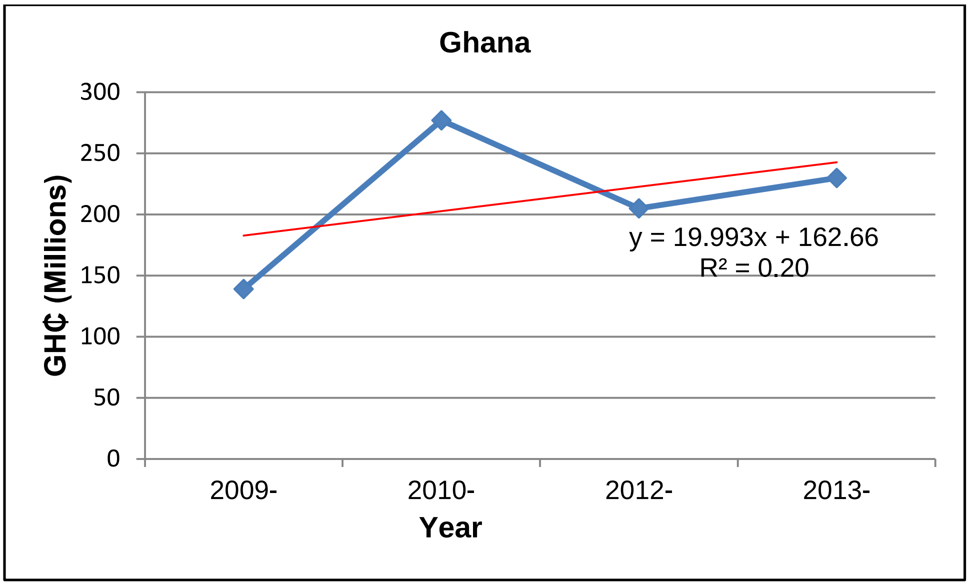


Figure 8-2 Trend in allocations by Ghana Road Fund 2009 to 2013

Figure 8-2 shows that the total road fund allocations to the implementing agencies have generally increased over the years with allocations peaking in 2010; however, there is no clear trend to accurately predict the future as linear regression analysis indicates that there is a relatively poor fit with R^2 value of 0.20. Caution needs to be taken when interpreting the results as a small sample of four FYs has been analysed and indexation for inflation has not been undertaken. In any case, it is challenging to obtain a predictive equation of cash flow over the years as there are several interrelated dependent variables. The aforesaid notwithstanding; in future, resources would need to be distributed equitably to ensure equality of transport opportunities and sustainable developments.

8.3.3 Ghana micro level equity analysis

Ghana does not have a specific allocation formula to address micro-level equity and the main agencies utilise HDM-4 in the prioritisation and allocation of resources which does not take account of non-monetary benefits. However, the allocation to the various implementing agencies has a high potential for political interference and there is a general bias of government actions and business growth towards benefiting urban areas more than rural areas (theidlgroup, 2014). Furthermore, the “political elites, given their short-term approach to public policy, their preference for maintaining the status quo, and their general need to satisfy the more…[vociferous] urban population generally results in a focus on urban areas with rural areas coming in as a secondary concern” (ibid., p.7); as shown by the *MLEC* values. The approach necessary to achieve fairness in the vertical allocation of the feeder roads budget between the various regions in Ghana should follow the framework developed in

Table 6-3 which also incorporates a Multi-dimensional Poverty Index that takes account of education, health and standard of living. Table 8-15 below analyses the network parameters, demographics and poverty levels in the Ghana regions during 2006.

Region	Land Area (km^2 '000)	Multi-dimensional Poverty Index	Population (millions)	Rural population (%)	Feeder roads length ('000km)	Poor and fair condition roads (%)
Greater Accra	3.24	0.072	4.01	9.5	1.34	72.5
Eastern	19.32	0.147	2.63	56.6	3.99	40.7
Volta	20.57	0.187	2.12	66.3	3.21	77.9
Ashanti	24.39	0.121	4.78	39.4	5.45	66.4
Central	9.83	0.155	2.20	52.9	3.10	73.8
Western	23.92	0.164	2.38	57.6	5.46	60.9
Brong Ahafo	39.56	0.217	2.31	55.5	7.20	58.4
Northern	70.38	0.371	2.48	69.7	6.16	66.3
Upper West	18.48	0.341	0.70	83.7	3.01	48.3
Upper East	8.84	0.335	1.05	79.0	2.08	31.5
Total	18.48		24.66		40.99	60.3

Table 8-15 Proposed parameters for measurement of micro level equity in Ghana's DFR programme in 2006 (Source: adapted from GoG, 2006; GSS, 2012; GSS, 2013)

Considering the expert identified factors and weightings derived in Table 5-9 combined with the parameters for each region as analysed in Table 8-15, regional funds allocation for feeder roads could be undertaken taking account of a uniform factor weighted at 22% being a proxy for agricultural productivity (which is a function of rural road length), a population factor weighted at 17%, network length/road condition factor at 23%, a land surface area factor at 10% being a proxy for regional connectivity and an equity factor weighted at 14% taking account of the Multi-dimensional Poverty Index of each region and 14% for road condition being a proxy for accessibility.

In Ghana, provision of community access roads infrastructure is not the responsibility of any ministry or department (theidlgroup, 2014). An equitable and participatory approach in the allocation of road infrastructure funds in Ghana at the micro level for the local governments should follow the process suggested in Table 6-3 but adjusted depending on data availability. Nonetheless, participatory approaches need to be undertaken with caution. As previously discussed in Section 3.3.2, the Department for International Development funded a management support team to DFR which used a Roads Prioritisation Methodology (RPM) that was highly participatory but also expensive and did not survive beyond the programme period (ibid).

8.3.4 Road scheme prioritisation in Ghana

In Ghana, decision making tools are seldom used effectively to manage, measure, plan, budget for and prioritise the rural road network to enable evidence based policy discussion (theidlgroup, 2014). This view is also supported by Boamah (2010) who argues that there is no investment analysis, which results in inconsistent and distorted road maintenance programmes. However, she further notes that different tools are used by the implementing agencies in road maintenance budgeting and prioritisations namely: Pavement Maintenance Management Programme by GHA; Maintenance Management System by DUR and Maintenance Performance Budgeting System by DFR.

In terms of investment analysis, Boamah (2010) observes that economic evaluation is undertaken for individual road projects using CBA for GHA and DUR network; and various appraisal methods are applied for feeder road projects which include: (i) accessibility improvement index, (ii) road area prioritisation model, and (iii) road maintenance prioritisation model.

There are various weaknesses with existing prioritisation mechanisms in Ghana particularly as regards formula design, complexity, data types and accuracy requirements (ibid). The Ghana Feeder Road prioritisation framework is discussed in Section 3.3.2; however, a better approach for road scheme prioritisation using a Goal Programming model is proposed in Section 6.5.2 and is recommended for the Ghana road sector.

8.3.5 Summary Rawlsian equity analysis for Ghana road sector

An analysis of Ghana's road funds allocation and road scheme prioritisation is summarised in Table 8-16 overleaf based on the various theoretical equity categories discussed in Table 2-2.

Equity type (research proxy)	Ghana performance (Rawlsian)
Horizontal (macro)	There is a generally a fair balance between capital investment and maintenance in most of the analysed years based on acceptable *MEC* range. The north-south economic divide is partly addressed through creation of Savannah Accelerated Development Authority. Macro equity splits vary year to year in an unsystematic manner. Summary rating is generally **good.**
Vertical (meso)	Rural inhabitants do not largely benefit due to bias towards national roads under GHA. No special intervention fund for rural roads, tourism and agricultural roads. Summary rating is **poor.**
Vertical (micro)	There is no discernible formula in allocations and road scheme selection is political - the majority of the populace do not benefit. Summary rating is **poor.**
Territorial (macro, meso and micro)	Road maintenance budgeting and prioritisation undertaken using Pavement Maintenance Management Programme, Maintenance Management System, and Maintenance Performance Budgeting System. Road scheme prioritisation in some instances takes account of international connectivity. Summary rating is generally **good.**
Spatial (macro, meso and micro)	All individuals and regions do not benefit equally from road infrastructure funds allocation particularly the northern region. Summary rating is generally **poor.**
Social (macro, meso and micro)	Road scheme prioritisation processes at all levels do not explicitly take account of social-equity issues. No specific allocation for tourism roads; and existing allocation mechanisms do not explicitly take account of multi-dimensional poverty. Summary rating is generally **poor.**

Table 8-16 Ghana road sector equity performance

8.3.6 Ghana case study limitations

The budgets allocated to agencies do not necessarily result into actual releases; and the full expenditure on the road sector over the analysed years cannot be easily captured as several other ministries (apart from MRH) undertake road sector projects and these include: Ministry of Food and Agriculture; Ghana Cocoa Board and the Millennium Development Authority. In some instances the Department of Feeder Roads is unaware of some road investment projects undertaken by the Ministry of Local Government until such a time when the schemes have been handed over to them for maintenance. In the analysis, no account has been taken of the effect of inflation; and where the Ghanaian Cedi has been converted to US$, the Bank of Ghana interbank market rate for January 2012 has been used.

8.4 Chapter summary

The road sector in Ghana is governed by the Ministry of Roads and Highways (MRH) and the implementing agencies include: Ghana Highway Authority (GHA), Department of Feeder Roads (DFR) and Department of Urban Roads (DUR). The Ghana Road Fund (GRF) operates as a true 2G Road Fund and is responsible for funding of routine and periodic maintenance of public roads upon submission of certified payment certificates. The authorities funded by GRF include: GHA, DFR, DUR, National Road Safety Commission and Driver Vehicle Licencing Authority. A review of key transport policy documents indicates that economic efficiency and road network modernisation are paramount. Furthermore, there has been unplanned expansion of the road network; and existing road prioritisation mechanisms do not explicitly address the north-south economic divide.

The research limitations notwithstanding the findings of this study demonstrate that the allocation of funds between maintenance and capital investments are generally equitable in a Rawlsian manner as demonstrated by *Macro Equity Coefficient/Index* values for Department of Feeder Roads and Department of Urban Roads being within the acceptable range in 2005 and 2006. The same applies to Ghana Highway Authority for the 2009 and 2010 analysis. However, there are inequities at micro level and new allocation and road scheme prioritisation processes discussed in Chapter Six are recommended and they will in general terms provide a robust preliminary estimate; nevertheless, they can be further adapted to local needs based on expert opinion. Ghana's road sector Rawlsian equity performance is summarised in Table 8-16 and a comparison with other case study countries is provided in Table 13-1 which shows that Ghana's overall performance is relatively good.

Compared to Uganda, Ghana's road sector set up is more advanced and more resources are allocated as a result of having a truly 2G Road Fund. Nevertheless, expenditure on road maintenance as a percentage of GDP is the lowest of all case study countries. The analysis in this study shows that the asset value of Ghana's road network in 2004 is almost the same as that of Uganda in 2014. Furthermore, comparison of Ghana and Zambia road indicators (Tables 8-1 and 9-1 respectively) shows that paved and unpaved road density for Zambia is far less than that of Ghana which also translates in a better Rural Accessibility Index for Ghana. The next chapter discusses road sector funds allocation and road scheme prioritisation in Zambia.

Chapter Nine - Zambia Case Study

9.1 Introduction

In Chapter Eight, a review and critique of road funds allocations and road scheme prioritisation in Ghana was undertaken. This Chapter delves into Zambia's road sector and extends understanding of equity in road funds allocation and road scheme prioritisation. The analyses demonstrate that there are serious Rawlsian equity challenges in road funds allocation and road scheme prioritisation albeit Zambia allocates significant financial resources to the road sector. Furthermore, the Road Authority (Road Development Agency) and Road Fund (National Road Fund Agency) have experienced major corporate governance issues over the years particularly during periods following changes in government. Similarly, the review shows that political interference in road scheme prioritisation is commonplace.

9.1.1 Topography, geography and climate

Zambia is a landlocked country mostly on high plateau with some hills and mountains and is located in Southern Africa; bordered by eight countries namely: Democratic Republic of Congo to the north, Angola to the west; Namibia, Botswana, Zimbabwe and Mozambique to the south; Malawi to the east and Tanzania to the north east.

The country is mainly agricultural and has a tropical climate with rainy season from October to April and has a total area of 752,618sq.km of which 1.23% is water and 98.77% is land (IndexMundi, 2014). The total population in 2013 was about 13.88million of which 46% were urban dwellers with the remainder in rural areas; and average population density was about 18.5 people per square km (ibid). Zambia's population is predicted to reach 15.5million in 2015 and is expected to double by 2030; however, the country has a young and dependent population. Considering the large rural population, adequate resources should be allocated to rural roads which benefit the majority of the populace. The capital city of Zambia is Lusaka and the country comprises of 73 districts in ten provinces, although the number is likely to grow due to declaration of new districts following the 2011 general elections.

Figure 9-1 overleaf shows the location of Zambia from a local and regional perspective.

9.1.2 Politics

Zambia is a multi-party democracy following the end of one party rule in 1991 (MoCT, 2002; IndexMundi, 2014). The colonial government constructed main roads and railways from the north to the south passing through neighbouring countries in order to transport copper to the seaports in South Africa, Angola and Mozambique; construction of international links was export oriented as opposed to creating Zambia as a regional economic hub (ibid). It can therefore be argued that the road network was not designed with equity in mind from the onset which affects equality of transport opportunities and most probably led to unsustainable road projects.

Zambia (regional context)	Zambia (local context)

Figure 9-1 Maps showing location of Zambia (Source: IndexMundi, 2014)

9.1.3 Economy

Zambia's economy has experienced varying growth rates since independence from Britain in 1964. In the 1980s and 1990s, declining copper prices, economic mismanagement, a prolonged drought and relatively high levels of external debt slowed the economy (ibid). The Ministry of Communications and Transport points out that: "in 1995, Zambia's GDP recorded a negative growth rate of 2.3%; however, in 1996 and 1997 there was an increase in the GDP growth rate of 6.6% and 3.3% respectively…followed by a negative growth rate of 2.0% in 1998" (MoCT, op. cit., 2002, p.4).

Various reports show that Zambia has experienced good economic growth in the recent past with real GDP growth for the period 2005 to 2012 at more than 6% per year (Foster and Dominguez, 2011; SNDP, 2011; NRFA, 2013, IndexMundi, 2014). However, the good growth rates have not necessarily enhanced equality of transport opportunities. Poverty remains a huge problem in Zambia despite the stronger economy and rural Zambians lag behind their African peers on just about every aspect of infrastructure in a country where 70% of the population depends on agriculture for its livelihood (ibid). Furthermore, Foster and Dominguez (2011, p.5) investigations reveal that “Zambia’s economic activity and population is heavily concentrated along the central copper belt running from Lusaka in the south up to Ndola in the north on the Congolese border”. In terms of lack of territorial equity, the main economic developments are concentrated in the four provinces of Copper belt, Central, Lusaka and Southern which are along the railway line. The other six provinces namely Eastern, Northern, North-Western, Western, Muchinga and Luapula are predominantly rural and have had slower development. Recently, there have been major mines establishments such as Lumwana and Kalumbila likely to be among the largest conglomerates in Africa. Nevertheless, the economic divide in the regions further exacerbates poverty and the lack of equality in transport opportunities.

9.2 The road sector in Zambia

9.2.1 Introduction

Road transportation in Zambia is the most predominant form of movement and carries about 80% of both cargo and passengers (MoCT, 2002). A large part of the network was constructed between 1965 and 1975 and was not designed to take advantage of the strategic regional location of Zambia (ibid). Furthermore, the infrastructure was eroded through lack of proper maintenance. The main problems stipulated in the country’s Transport Policy were institutional and financial relating to: (i) inadequacy of the roads institutional framework, (ii) inadequate and erratic flow of funding, (iii) poor terms and conditions of employment for those charged with roads management, (iv) weak management systems and lack of clear roles for the key actors in the road sector, and (v) lack of managerial accountability (MoCT, 2002; Evdorides and Robinson, 2009). The aforementioned scenario is similar to conditions in the other SSA countries during the period prior to road sector reforms resulting in unsustainable road projects.

Despite relatively low road densities, Foster and Dominguez (2011) note that Zambia’s primary and secondary networks provide basic regional and national connectivity linking the provincial capitals to Lusaka and Lusaka to the main international borders. Furthermore, Zambia is one of the few countries in the region with a road sector budget in excess of what is needed to maintain the main road network, and adequate to address the rehabilitation backlog; and the establishment of a 2G Road Fund has resulted in a stable allocation of resources to the sector (ibid). Cognisant of the aforesaid, there is still a bias towards capital investment projects and provision of connectivity to Lusaka does not necessarily offer equality of transport opportunities as the majority of the population do not benefit from such links.

Gwilliam et al., (2008), cited in Foster and Dominguez, (2011), undertook an analysis of Zambia's road indicators and benchmarked them against Africa's low and middle income countries and the results are reviewed in Table 9-1 overleaf.

Some of the weaknesses with reference data for low and middle income countries as shown in Table 9-1 for Zambia and Table 8-1 for Ghana were highlighted in Section 7.1.3. Comparison of Zambia's indicators with those of Uganda, Ghana, Kenya and Tanzania shows that Zambia has the lowest Rural Accessibility Index (RAI) and this can be attributed to the low unpaved road density; and vastness of the country with a sparse population.

According to Foster and Dominguez (2011, p.9), "there is evidence of overinvestment in Zambia's main road network [and]…three-quarters of the primary and secondary road network is paved". This is against a low paved traffic road density of 736.6 vehicles per day which is 53.2% of the corresponding value for low income countries as shown in Table 9-1. However, over-investing in new paved roads to the detriment of maintenance is not sustainable as the existing roads deteriorate and become more costly to rehabilitate. Zambia's rural road network appears to be neglected and rural accessibility is poor with RAI at 16.8% which is about half of the African average (ibid). It can therefore be concluded that rural roads which serve the majority of the people are not adequately catered for which affects equality of transport opportunities and exacerbates multi-dimensional poverty.

Kaliba et al., (2009) observe that the Zambian Ministry of Finance and National Planning allocated substantial financial resources to the road sector; US$M 118.7 was spent on road projects in 2005, US$M 227 in 2006 and US$M 197 in 2007. Similarly, Raballand et al., (2013, p.6) observe that there "has been a surge in road allocation[s]: from 2009 to 2012, the total road allocation (both domestic and donor funds) increased fourfold: from 280million US$ to 890million US$…[and] this places a significantly higher burden on road institutions". Apparently, the main drivers for selection of road projects tend to be poverty reduction and support to economic growth (ibid). In contrast, expert opinion from panellists with Zambia experience indicates that despite the increased resources, there is political interference in the project selection process and provision of equality of transport opportunities is still a major challenge which subsquently affects Rawlsian equity.

Metric	Measure	Low Income countries	Zambia	Middle income countries	Implications for equity and remarks
Paved road density	km/1000km^2 of arable land	97.6	56.3	146.8	Road densities are generally low.
Unpaved road density	km/1000km^2 of arable land	128.2	95.0	257.8	
GIS rural accessibility	%age of rural population within 2km of all season road	19.7	16.8	22.9	RAI is low partly due to the sparsely populated areas in rural Zambia.
Over-engineering of network	% of main road network paved despite low traffic	15.0	65.0	20.0	Indicator will be exacerbated by major projects (see Section 9.2.7).
Paved road traffic	Average annual daily traffic	1,408.2	736.6	2,558.3	Zambia generally has lower traffic volumes when compared to other low income countries.
Unpaved road traffic	Average annual daily traffic	54.2	45.2	14.9	
Paved network condition	% in good or fair condition	67.9	83.0	82.0	Unpaved road condition is far worse than that of the paved network possibly caused by inequitable expenditure.
Unpaved network condition	% in good or fair condition	61.4	25.0	57.6	
Perceived transport quality	% firms identifying roads as a constraint	27.4	10.6	4.8	

Table 9-1 Zambia's road network indicators (Source: adapted from Gwilliam et al., 2008, cited in Foster and Dominguez, 2011)

9.2.2 Road network characteristics and road sector agencies

In 2002, Zambia had a gazetted core road network of approximately 37,000km of which 6,476km were bituminous; gravel and earth roads accounted for 8,478km and

21,967km respectively; and there were about 30,000km of un-gazetted community roads comprising tracks, trails and footpaths (MoCT, 2002). Three main agencies are responsible for the road sector namely: (i) National Road Fund Agency (NRFA), under custody of the Ministry of Finance is responsible for funding capital works and road upgrades and maintenance. (ii) Road Development Agency (RDA) falling under Ministry of Transport, Works, Supply and Communication, is responsible for the planning and management of road construction and weighbridges, and (iii) Road Transport and Safety Agency (RTSA), falling under Ministry of Transport, Works, Supply and Communication is responsible for vehicle testing, collection of road license fees, issuing of cross-border permits, collection of road user fees, and enforcement/fines. However, in 2007, the Minister of Works and Supply appointed all the 73 district councils including Zambia Wildlife Authority (ZAWA) as Local Roads Authorities – LRA (RDA, 2007). Furthermore, the Ministry of Local Government and Housing (MLGH) is also responsible for part of the network. Table 9-2 below analyses the Zambian road network metrics for the various classes. It can be deduced that 8.7% of the network is paved; and 83% is in good to fair condition (see Table 9-1).

Road classification	**Responsible Agency**	**Core Road Network (km)**			**Rest of Network**	**Total (km)**
		Paved	Unpaved	Total		
Trunk	RDA	3,024	92	3,116		3,116
Main	RDA	2,205	1,496	3,701		3,701
District	RDA/MLGH	1,362	12,345	13,707		13,707
Urban	RDA/MLGH	2,812	2,785	5,597		5,597
Primary feeder	RDA/MLGH		14,333	14,333		14,333
Secondary feeder	RDA/MLGH				10,060	10,060
Tertiary feeder	RDA/MLGH				4,424	4,424
Park roads	RDA/ZAWA				6,607	6,607
Community roads	RDA/MLGH				6,026	6,026
Total		9,403	31,051	40,455	27,117	108,025

Table 9-2 Zambia's road network lengths and implementing agencies (Source: adapted from NRFA, 2013)

9.2.3 Road Development Agency

The RDA was established by the Public Roads Act No. 12 of 2002 to provide care, maintenance and construction of public roads in Zambia and became fully operational at the end of 2006 (RDA, 2006). It is charged with managing and developing the entire road network in the country. However, several authors report that the road sector in Zambia has experienced technical capacity issues and governance challenges over the years (Kumar, 2000; Raballand et al., 2013). Furthermore, contract data analysed by the World Bank points to possible cartelization among contractors as well as collusion between supervision consultants and contractors (ibid); and this is likely to affect Rawlsian equity in the road sector. In 2009, the market share of contracts (in excess of 70%) was concentrated among the top five contractors (ibid); this does not create a fair or level playing field and is likely to lead to unsustainable road projects.

The budgetary allocation in the 2012 Road Sector Annual Workplan (RSAWP) was ZMK 4.272 trillion comprising funding from Government of Republic of Zambia (33%), Road Fund (19%) and external support (48%); however by November 2012, only 28.4% of the funds had been disbursed owing to absorption issues (NRFA, 2012; RDA, 2012).

The 2013 RSAWP had a total budgetary resource allocation of ZMK 3.288 trillion intended to mainly address road infrastructure maintenance, rehabilitation, upgrading, bridge construction and maintenance; however it is noted that “the 2013 RSAWP displays [strong] bias towards major up-grading works under the link Zambia 8000 project in the form of multi-year contracts that will be carried over from 2013 and beyond” (RDA, 2012, p.5). This is likely to lead to unsustainable developments and affecting equality of transport opportunities.

The Zambian government funded up to 75% for the 2013 RSAWP (48% from Consolidated Fund and 27% from NRFA) with 25% sourced from loans and grants from cooperating partners including multilateral development banks (ibid). The 2013 RSAWP had a total budget of ZMK 3.288 trillion of which ZMK 2.644 trillion representing 81% was administered by the RDA on various core road network projects. In 2013, upgrading works had a total share of 20.12% of the total budgetary allocation and rehabilitation took 19.3% (ibid); indicating a bias towards capital investment which is not equitable in a Rawlsian manner. Detailed analysis of the 3.288 ZMK trillion 2013 road sector annual workplan (Appendix B) as reported by RDA (2012, p.8) shows that: (i) RDA was allocated over 83.1% of the resources; some of which was to cover the major projects such as “Link Zambia 8000” whilst NRFA (administrative costs), National Construction Council (NCC) and ZAWA had the lowest allocations; and (ii) an allocation of 4.8% for RTSA appears reasonable when compared with other budget lines.

The RDA points out that the 2013 RSAWP attempted to equitably distribute the development and maintenance budget among the ten provinces albeit about 16% was allocated to Lusaka Province due to the reconstruction / rehabilitation of Lusaka City roads under the "L400 project" (RDA, 2012).

Table 9-3 below analyses the allocations to the various regions; and it can be deduced that the poorer regions of Zambia which are located in North Western and Northern provinces received the least allocations and this is not equitable in a Rawlsian manner and affects equality of transport opportunities.

Province	**Amount (ZMK Millions)**	**Percentage**
All	823,333.79	25.0%
Central	165,179.83	5.0%
Copper belt	279,289.77	8.5%
Eastern	328,360.00	10.0%
Luapula	164,627.11	5.0%
Lusaka	523,004.50	15.9%
North Western	140,101.31	4.3%
Northern	135,185.03	4.1%
Southern	198,228.05	6.0%
Western	261,780.74	8.0%
Muchinga	269,838.26	8.2%

Table 9-3 Zambia road sector funding among the ten provinces during 2013 (Source: adapted from RDA, 2012, p.11-12)

9.2.4 Road Transport and Safety Agency

The Road Transport and Safety Agency (RTSA) is under Ministry of Works, Transport, Supplies and Communication. The agency is responsible for implementing policy on road transport and traffic management, road safety and enforcement of laws regulating road transport and safety. The programming, procurement, monitoring and evaluation of road transport regulations and safety programmes is approved by the Committee of Ministers on Road Maintenance Initiative.

RTSA has implemented several road safety programmes including sensitisation on the road use, Highway Code, undertaking school campaigns among others. The revenue collection improved from 18billion in 2004 to 102billion in 2007. However, it appears that the increased collections have not proportionately resulted into safer roads as the accident situation has not significantly improved.

Zambia has a history of high road traffic accident incidence and this is mainly attributed to over speeding; and road traffic accidents have been ranked third highest cause of death after HIV/AIDS and Malaria (RTSA, 2010). Furthermore, the estimated cost of traffic accidents is in excess of 3% of GDP which is higher than that of Uganda (see Section 7.2.7).

9.2.5 The National Road Fund Agency

Early in the 1990's, Zambia formed a Committee of Ministers for the Road Maintenance Initiative with a view to improving road conditions. It comprised of the Ministers responsible for Finance, Transport, Works, Local Government, Water and Energy, Agriculture, Tourism and Legal Affairs. In line with the Road Maintenance Initiative, the Committee convinced government to introduce a road user tariff, in the form of fuel levy, with effect from 1st May 1993 (WSP International, 2003). The initial levy was set at 1 US cent per litre of diesel and gasoline (ibid). The collection of the levy had a legal basis, and was collected by the Zambia Revenue Authority (ZRA).

The National Road Fund Agency (NRFA) Act No. 13 of 2002 established a direct route for the levy to the Road Fund. The main functions of NRFA are to manage and administer the Road Fund; to coordinate and manage various donor financed programmes; and to manage the ten year Road Sector Investment Programme. Interviews with NRFA staff indicate that the agency also processes payments of contractors who are contracted by RDA to undertake road projects. However, this has brought the NRFA under criticism because of lack of distinction as a financing agency. Moreover, as of 2010, there was a backlog of payments arising from commitments beyond budgeted funds; and this slows project implementation.

ZRA is the collecting agency for fuel levy and remits the funds to the consolidated account of the Ministry of Finance and National Planning. Interviews with stakeholders show that the fuel levy that is channeled to NRFA and determined by the Ministry of Finance and National Planning was about 7.5% for diesel and 15% for petrol during 2010. RTSA is the collecting agency for licensing fees for vehicles and drivers, registration fees, fines and cross border fees. The collections are deposited in a transit account at the Central Bank from where the funds are transferred on a monthly basis to the Consolidated Fund. A recent Tolls Act of 2011 and Statutory Instrument No. 73 of 2013 empowers RDA to collect toll fees at designated points.

Section 13 of the Zambian Public Finance Act 2004, requires all general revenues and other public monies to be deposited to the Consolidated Fund; this provision prohibits agents collecting revenues on behalf of the NRFA from depositing revenues into an autonomous Road Fund. In order to override this provision in the Public

Finance Act, a statutory instrument was issued by the Minister to allow funds to be deposited in the Road Fund Account in the Central Bank. Despite all this, the Ministry of Finance and National Planning has not granted the Road Fund the status of full autonomy and it is unlikely to happen in the near future. Moreover, the Ministry of Finance expressed some reservations to implement full independence of the Road Fund which among others include the interest to control government resources and expenditure and to manage both the fiscal and monetary policies of government in totality. However, an information sharing mechanism to enable NRFA to track the revenue deposited into the Consolidated Fund is in place. Although this does not guarantee that the funds are remitted intact to NRFA, the Road Fund uses this information to demand and ensure that all RUCs collected by agents and owed to the Fund are accounted for and transferred to the NRFA account in the Central Bank.

Several reports indicate that the Road Fund Board is composed of 11 members with 7 being from the private sector and road user groups representatives (Kumar, 2000; Evdorides and Robinson, 2009; NRFA, 2012; NRFA, 2013). A major weakness of this set up is that NRFA has a rather large Board (Uganda Road Fund has 7 members although Kenya Roads Board has 13 members); and stakeholder interviews indicate serious governance issues within the Zambian road sector institutions. The NRFA operates as a 2G Fund by collecting its own revenue; however, it now manages capital investment funds thus tending towards 'third generation status'. In a study which set out to assess the performance of Road Funds in SSA, Kumar (2000, p.38) observes that "the establishment of the [Zambian] road fund has contributed to an increase in resources for road maintenance from an annual average of less than ZMK10 billion (US$ 5million) for the period 1988-94 to ZMK 23 billion (US$ 9million) in 1998". The aforesaid notwithstanding, by 1998 only 30% of road maintenance needs could be met from Road Fund revenue (ibid). Therefore, the establishment of the Road Fund ensured increased allocations to the road sector and there was a marked improvement in the road condition.

Increased funding in road maintenance through the launch of the national program in road maintenance saw an increase in the percentage share of paved roads in good condition from 20% in 1995 to 45% in 2001 (an increase of 25%); whilst the percentage of poor condition roads decreased from 51% to 29% which is equivalent to a reduction of 22% (ibid).

Analysis of the Zambian road condition data for 1984, 1995, 1998 and 1999 as reported in 1999 by the National Roads Board, cited in Kumar, (2000), shows that the road condition in 1984 was far better than in the rest of the assessment years and for the period 1995 to 1999; the network in good condition increased over the period whilst the percentage of roads in poor condition declined. It can therefore be deciphered that the establishment of the Road Fund led to improved road conditions following a period when it had declined.

Furthermore, investigations by Kumar (2000) reveal that during the three year period from 1997 to 1999, road expenditure as a proportion of total public expenditure increased from 5% in 1997 to 10% in 1999 while the percentage share of road maintenance expenditure as a total of roads expenditure declined from 16% to 8%. This demonstrates a sharp decline in road maintenance allocations with a bias towards capital investment which affects sustainability of road projects and equality of transport opportunities; and is not equitable in a Rawlsian manner.

9.2.5.1 Critique of Zambia allocation formula

In 2000, Kumar reported that under the policy guidelines of NRB, 40% of the road fund is supposed to be allocated for maintenance of Trunk, Main and District roads; 40% for feeder roads; and the remaining 20% for urban roads; however, due to political interference in favour of urban roads (particularly) in Lusaka and the lack of technical capacity in district councils; actual disbursements have favoured urban roads at the expense of feeder roads. Table 9-8 shows an analysis of the allocation formula as of 2013 which indicates that 83.1% of financial resources were allocated to RDA for trunk roads and 9.3% was allocated to the Ministry of Local Government and Housing; furthermore, 2% was allocated to Local Road Authorities for urban roads, 4.8% to RTSA and the remainder was almost equally shared between NRFA, ZAWA and National Construction Council (NCC). Allocations are inequitably skewed towards the national road network under RDA; and disfavours the rural road network that serves the majority of the populace which include the rural poor.

Analysis of road sector allocations (Appendix B) for 1997, 1998 and 1999 as reported by Kumar (2000, p.44) shows that: (i) although budgetary allocations are supposed to be ‘formula-based’, releases are not equitable and fluctuate yearly with a bias towards urban, main, trunk and district roads at the expense of feeder roads; and (ii) the releases over the years have been less than budgetary figures possibly indicating absorption constraints or reduced collections.

Table 9-4 overleaf analyses the total NRFA budget, receipts and disbursements from 2006 to 2012 in Kwacha (Trillions). From Table 9-4, it can be deduced that the budget for the road sector increased by nearly five times over the seven year period and absorption capacity has generally improved although there was a sharp decline between 2010 and 2012; and this may be attributed to the change in government which subsequently led to a change in the management of both NRFA and the RDA. Furthermore, part of the budgetary increases may be attributable to inflation.

Item	2006	2007	2008	2009	2010	2011	2012	Total
Budget	0.86	0.79	1.21	1.36	1.29	3.04	4.27	7.88
Revenue	0.82	0.46	0.92	0.89	1.09	3.06	2.23	9.48
Releases	0.54	0.45	0.92	1.18	1.12	2.20	2.56	8.97
Collection efficiency of NRFA (revenue/budget) %	95	59	76	66	84	101	52	74
Absorption capacity of implementing agencies (allocations/budget) %	63	57	76	87	87	72	60	70

Table 9-4 Zambia's National Road Fund Agency receipts and disbursements for the period 2006 to 2012 in Kwacha Trillions (Source: adapted from SNDP, 2011; NRFA, 2012 NRFA, 2013)

9.2.6 Key transport policy documents and road projects

This section provides a review of some of the key transport policy documents in Zambia relevant to the understanding of the equitable allocation principles for road infrastructure funds. In 2002; the Zambian government issued a '**Transport Policy'** to promote a coherent policy framework (MoCT, 2002; Evdorides and Robinson, 2009; RTSA, 2011; NRFA, 2013). This led to the establishment of the key road sector agencies namely: RDA, NRFA and RTSA described in Sections 9.2.3 to 9.2.5. Following approval of the policy by Government, three Acts were presented to Parliament and were approved in 2002; these established RTSA, through Road Traffic Act No.11 of 2002, RDA through the Public Roads Act No. 12 of 2002, and NRFA through the National Road Fund Act No. 13 of 2002 (ibid).

In the **Fifth National Development Plan (NDP)** which ran from 2006 to 2010, the Zambian government stressed the need for strengthening economic infrastructure as one of the critical vehicles for the realisation of the Plan's objective; it was planned that roads in maintainable condition should improve from 51% in 2005 to 90% by 2010 and spending on rural feeder roads should be enhanced (Ministry of Finance and National Planning, cited in Kaliba et al., 2009). The NDP targeted to raise spending on road infrastructure to at least 2% of GDP (ibid). During the fifth NDP rehabilitation works on paved roads was targeted at 1,007km out of which 940 km was completed by 2009 representing 94%. With regard to unpaved roads, 8,355km was rehabilitated against a target of 5,971km (SNDP, 2011).

The **Sixth NDP** covers the period 2011 to 2015 and the resources allocated to roads in Trillion Kwacha are 3.044 in 2011, 4.81 in 2012, 4.274 in 2013, 4.835 in 2014 and 4.88 in 2015 (SNDP, 2011).

The first **Road Sector Investment Programme (ROADSIP I)** for the period 1997 to 2003 covered a core road network of 35,000km at a cost US$M 500 whilst the second **Road Sector Investment Programme (ROADSIP II)** was aimed at bringing the core road network of 40,454km to maintainable standard and the envisaged total cost was US$ 1.6billion (RDA, 2006; RDA, 2007; RDA, 2008; NRFA, 2013). ROADSIP II covered the period 2004 to 2013 and was aimed at contributing to the reduction of poverty through improved accessibility and mobility thus providing people with opportunities by connecting them to markets and resources thus facilitating self-development (ibid).

All the above key policy documents are targeted towards network modernisation and capital investment projects; and Rawlsian equity is not embedded explicitly.

9.2.7 Key road sector projects

The Government of Republic of Zambia initiated the '**Link Zambia 8000'** Project launched in September 2012 and is within the accelerated road construction programme aimed at transforming Zambia from a landlocked country to a truly 'land-linked' country; and it involves upgrading to bituminous standard about 8,000km of roads thereby linking districts and provinces throughout Zambia (NRFA, 2012; NRFA, 2013). The project is estimated to cost 21 Trillion Kwacha (US$ 4bn).

'Pave Zambia 2000' was also launched in 2012 and encompasses segmented paving of about 2000km of urban roads which are in poor condition and require rehabilitation; the project is expected to take five years at total cost of 1.65billion Kwacha (US$M 307) and also provide over 20,000 jobs for the youth (ibid). The creation of jobs through construction projects offers enhancement of equality of opportunities although not directly linked to transport.

Furthermore, in 2012, the **"Lusaka 400"** project was launched and is aimed at enhancing connectivity within the city. The project covers 400km of Lusaka urban roads which are to be upgraded/rehabilitated at a cost of US$M 300; 15% of the cost is covered by the Zambian government with the remaining majority from a China Exim Bank loan.

The equity aspects of all the above projects are not explicitly pronounced and by purposeful design, the projects are mainly new road construction programmes.

9.3 Zambia road sector expenditure

9.3.1 Historical expenditure

Table 9-5 overleaf analyses the road sector expenditure and road sector workplan in Zambia from 2006 to 2014 which averages at 2.97% of GDP (see Figure 7-2 for results corroboration); whilst maintenance expenditure averages at 0.80% of GDP. The road sector budget in Zambia has been on an upward trajectory with significant increases in 2008 and 2011 which occurred during periods leading to elections and immediately after change in political leadership. Road sector expenditure as a percentage of GDP was 4.45% in 2012; which is close to Gronau's recommended expenditure for backlog removal (see Section 1.2.2).

Figure 9-2 below shows that the road sector budget has generally increased over the years and there is every indication that the trend shall continue as linear regression analysis indicates that there is a relatively good fit with R^2 value of 0.76. However, indexation for inflation has not been undertaken.

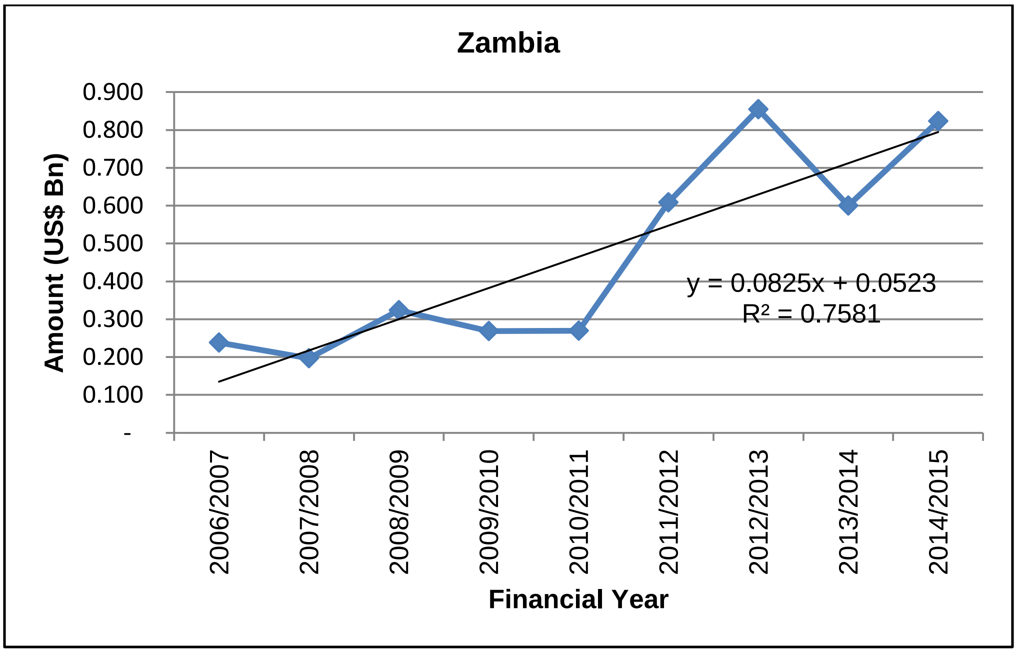


Figure 9-2 Trend of Zambia road sector expenditure 2006 to 2015.

Analysis of Figure 9-2 reveals that there has been a sharp increase in the road sector funds allocation from the period FY 2010/11 to FY 2012/13 followed by a gradual decline in FY 2013/14. The sharp increases are most probably attributable to the ongoing major road construction discussed in Section 9.2.7.

Item	Annual Workplans budget in Billion Kwacha								
	2006	2007	2008	2009	2010	2011	2012	2013	2014
RM[1]	77.9	67.6	47.9	22.0	33.6	68.0	129.3	70.0	103.1
PM[1]	176.9	177.8	415.3	465.9	369.2	491.9	837.8	403.3	504.3
Road cycle	3.00			7.00	24.55	21.0	10.0	10.0	8.00
Feeder roads	141.5								
Maintenance Expenditure									
Total: ZMK-trillion)	0.399	0.245	0.463	0.495	0.427	0.581	0.978	0.483	0.615
Total (US$-bn)	0.111	0.061	0.124	0.098	0.089	0.116	0.195	0.088	0.103
% of GDP	1.55	0.57	1.07	0.67	0.69	0.72	1.01	0.43	0.46
Total Road Expenditure									
Total (ZMK-trillion)	0.86	0.79	1.210	1.357	1.295	3.044	4.273	3.299	4.943
Exch. Rate – NRFA	3.60	4.00	3.74	5.05	4.80	5.00	5.00	5.50	6.00
Total (US$-bn)	0.238	0.197	0.324	0.269	0.270	0.609	0.855	0.600	0.824
GDP (US$-bn)	7.18	10.7	11.54	14.64	12.81	16.19	19.2	20.6	22.38
Total (% of GDP)	3.31	1.84	2.81	1.84	2.11	3.76	4.45	2.91	3.68

Table 9-5 Zambia road sector annual workplans 2006 to 2014 (Source: adapted from NRFA, 2014)

Notes: 1. RM is routine maintenance and PM is periodic maintenance.

9.4 Zambia road sector equity analysis

This section analyses the equity aspects in the allocation of road infrastructure resources in Zambia at macro, meso and micro levels. It is important that allocation of funds for maintenance and capital investment is analysed prudently.

9.4.1 Zambia macro level equity analysis

Governments around the world and more so in SSA face incentives to upgrade roads rather than maintain them as new road projects enhance political visibility albeit economic feasibility is questioned since the costs of upgrading are high whereas the economic benefit may be limited especially in regions where traffic is minimal (Raballand et al., 2013). Furthermore, "…despite [the nascent] political discourse on the priority given to maintain the existing network [in Zambia], from 2008 to 2011 around 11% [of the budget] was committed to maintenance and 73% to upgrading to bituminous standard" (ibid., p.10). The aforementioned scenario is not in line with the principles of Rawlsian equity and is likely to affect equality of transport opportunities.

According to a study by the African Development Bank, the expenditure on maintenance in SSA "ranges from barely [US]$200 per kilometre in Chad to more than [US]$6,000 per kilometre in Zambia…[and] spending per kilometre of main network tends to be about twice that of the rural network" (AfDB, 2011, p.215). Similarly, there is pronounced capital bias in road spending with investment accounting for two-thirds of total spending in the resource-rich and low income countries; particularly those without adequate institutional mechanisms for funding road maintenance (ibid). However, timely maintenance is important for asset preservation and to ensure sustainable developments.

An exploration of macro level equity based on the historical expenditure on road maintenance versus total road sector expenditure during 1997, 1998 and 1999 is analysed in Table 9-6 overleaf and there is a clear bias towards capital investment projects which affects equity and sustainability.

This thesis suggested range for *MEC* is 0.25 to 0.50 and the 50th percentile rate derived from Table 6-1 is 0.32. From Table 9-6, it is determined that the *MEC* and *MEI* values for 1997, 1998, and 1999 are out of range of the recommended values; and are therefore not equitable in a Rawlsian manner.

Year	**1997**	**1998**	**1999**	**Remarks on equity**
Road expenditure as a proportion of total public expenditure	5.1%	6.8%	9.9%	Budgetary allocation for the road sector increased albeit allocation for maintenance decreased showing a bias towards capital projects.
Road maintenance as proportion of total road expenditure	16%	11%	8%	
MEC	0.16	0.11	0.08	Values out of equitable range.
MEI	0.80	0.96	1.10	

Table 9-6 Zambia road sector macro equity analysis 1997 to 1999 (Source: adapted from Kumar, 2000)

An exploration of macro level equity based on the historical expenditure on road maintenance versus total road sector expenditure during 2006 to 2014 is analysed in Table 9-7 below which in general terms shows a bias towards capital investment projects; however for the period 2006 to 2010, the *MEC* and *MEI* values are within the recommended ranges and are therefore equitable in a Rawlsian manner.

Year	**Annual workplans budget in US$ (Billions)**		**Equity parameters**	
	Maintenance expenditure	Total road expenditure	*MEC*	*MEI*
2006	0.111	0.238	0.30	0.52
2007	0.061	0.197	0.31	0.51
2008	0.124	0.324	0.38	0.42
2009	0.098	0.269	0.36	0.44
2010	0.089	0.270	0.33	0.48
2011	0.116	0.609	0.19	0.72
2012	0.195	0.855	0.23	0.64
2013	0.088	0.600	0.15	0.83
2014	0.103	0.824	0.12	0.90

Table 9-7 Zambia road sector macro equity analysis 2006 to 2014 (Source: adapted from NRFA, 2014)

9.4.2 Meso level equity analysis

This section considers the fairness of the vertical allocation of maintenance funds between the various classes of roads in Zambia. It assesses the distribution between national roads (strategic core road network) and the non-core road network (other roads).

In a survey carried out in three villages in Zambia, Ethiopia and Vietnam, Bryceson et al., (2008) found out that rural road investment has the potential to facilitate development and poverty alleviation conditional to: (i) existing density of rural road network, (ii) level of social and economic infrastructure provision, (iii) level of ownership and access of wheeled or motorised vehicles in the rural population, and (iv) level of purchasing power of rural households to access public transport. Efforts to improve mobility for the rural poor are a vital component of poverty reduction but such enhancements cannot be achieved by road improvements alone and there is need for better access through wheeled or motorised transport to utilise the roads (ibid).

New parameters which are variants to the meso level formulae developed in Section 6.4 are proposed for analysis of Zambia's meso-level equity. The proposed equation used to derive *Local Roads Equity Factor* (*LREF)* is defined as the ratio of the *Local Roads Budget (LRB)* under LRA to *Total Effective Road Sector Budget (TERSB)* excluding RTSA, NCC and ZAWA (equation 9.1). The proposed equation for Local Roads Equity Index (*LREI)* is the 'base 10' logarithm of the inverse of *LREF* (equation 9.2). The aforementioned formulations are summarised below:

$$LREF = LRB / TERSB \qquad (9.1)$$

$$LREI = Log_{10}\,[LREF]^{-1} \qquad (9.2)$$

A low *LREF* value indicates low allocations to district roads. Appropriate ranges for meso level equity are identified through the expert survey results in Section 5.4.2 and Table 6-2 based on analysis of data from 15 SSA countries.

Table 9-8 overleaf analyses the 3.288 trillion Kwacha (US$M 633) 2013 road sector annual workplan allocations under the various implementing agencies which indicates that funding to the 73 districts which mainly cover the non-core road network is the lowest; indicating a bias towards the strategic and trunk road network which is not equitable in a Rawlsian manner.

Agency	Total allocation (ZMK, Millions)	Percentage	Implications for equity and remarks
LRA	66,337.02	2.0%	Covers the 73 districts.
MLGH	306,823.68	9.3%	Mainly rural roads.
NCC	6,000	0.2%	RDA was allocated over 83.1% to cover the major projects such as Link Zambia 8000. NRFA, NCC and ZAWA had the lowest allocations. An allocation of 4.8% for RTSA appears comparatively reasonable.
NRFA	8,000	0.2%	
RDA	2,654,163.22	80.7%	
RDA/MLGH	79,719.46	2.4%	
RTSA	157,100.00	4.8%	
ZAWA	9,785.00	0.3%	
LREF	0.0213		Author analysis (see Equations 9.1 and 9.2).
LREI	1.67		
Total	3,288,928.39		

Table 9-8 Zambia road sector meso equity analysis for 2013 (Source: adapted from RDA (2012, p.8); remarks and analysis by Author)

9.4.3 Micro level equity analysis

This section considers the fairness of the distribution of project funds across provinces in Zambia. Raballand et al., (2013) observe that during the period 2008 to 2011, the Western province received the largest share of allocations (about 30%), followed by the Northern (27%) and Eastern provinces (14%), while the copper belt province got the lowest (less than 2%). Some provinces benefitted from both donor funding and NRFA. The Northern, Eastern and Western provinces have been top beneficiaries of NRFA funding and from donors whilst copper belt, central and southern have received lower allocations (ibid). However, the aforementioned figures vary widely when compared with allocations in 2013 as shown in Table 9-3. This would indicate that the allocation process is probably unsystematic and does not take account of regional balance which exacerbates poverty and inequality. Moreover, Cuesta (2013, p.2) points out that “composition and distribution of public spending and tax burdens affect poverty and inequality”.

As previously mentioned, the RDA explains that the 2013 RSAWP attempted to equitably distribute the development and maintenance budget among the ten provinces albeit 16% was allocated to Lusaka Province due to the reconstruction / rehabilitation of Lusaka City roads under the ‘Lusaka 400’ project (RDA, 2012).

Table 9-9 below analyses what the revised allocations would be if distribution was based on population and surface area assuming an equal weighting of 50% for each factor. However, the suggested weightings may be revised based on local expert opinion.

Region	**(ZMK - bn)**	**%-age**	**Population**	**Area (km^2) '000**	**Area factor (50%)**	**Population factor (50%)**	**Total**	**New %-age**
All	823.3	25.0					823.3	25.0
Central	165.2	5.0	1,307,111	94.4	154.6	123.1	277.7	8.44
Copper Belt	279.3	8.5	1,972,317	31.3	51.3	185.7	237.0	7.21
Eastern	328.4	10.0	1,592,661	51.5	84.3	149.9	234.3	7.12
Luapula	164.6	5.0	991,927	50.6	82.8	93.4	176.2	5.36
Lusaka	523.0	15.9	2,191,225	21.9	35.9	206.3	242.2	7.36
North Western	140.1	4.3	727,044	125.8	206.1	68.5	274.6	8.35
Northern	135.2	4.1	1,105,824	77.7	127.2	104.1	231.3	7.03
Southern	198.2	6.0	1,589,926	85.3	139.7	149.7	289.4	8.80
Western	261.8	8.0	902,974	126.4	207.0	85.0	292.0	8.88
Muchinga	269.8	8.2	711,657	87.8	143.8	67.0	210.8	6.41
Total							3,289	

Table 9-9 Zambia micro equity analysis for 2013 (Source: adapted from RDA, 2012, p.11-12, analysis by Author)

Table 9-9 shows that the allocations would most likely be more equitable in a Rawlsian manner had they been based on population and surface area. The aforesaid criteria have been identified through literature and expert opinion surveys (Table 5-3) and they are suitable parameters for equitable allocations. An alternative equitable approach in the allocation of road infrastructure funds at the micro level (districts) may follow the process outlined in Table 6-3.

9.4.4 Road scheme prioritisation

Baldwin (2008), cited in Raballand et al., (2013), observes that project selection in Zambia often depends on political party support and road scheme allocation may to some extent be used as a reward for political loyalty. The author's experience and interviews with stakeholders indicate that this is similar to the situation in other SSA countries such as Uganda, Kenya and Ghana.

According to Raballand et al., (2013, p.2), "Governments [especially in SSA] usually see road building as an important tool to maintain the political unity of the country…[and] road building funds are usually not based on a systematic prioritisation with a sound modeling process". Furthermore, major road infrastructure identification and prioritisation is politically maneuvered with political-economic explanations from project planners and promoters deliberately and strategically overestimating benefits and underestimating costs when forecasting the outcomes of projects (Flyvbjerg, 2009).

In the case of the RDA in Zambia, political interference is usually recorded in project selection through unplanned projects; over the period 2008 to 2011, just over half of the total value of projects was for planned projects within the workplan (ibid); which is unsustainable and likely to lead to resource wastage.

In the period leading to the 2011 elections, the Zambian government announced a US$M 170 programme to rehabilitate urban roads. These were roads added to RDA's workplan without normal selection process (ibid). This scenario is similar to other SSA countries especially during periods leading to elections and it can be argued that the practice is unethical and tantamount to corruption. However, what is ethically acceptable or desirable is conveniently made dependent on society's judgment (Cuesta, 2013).

It is also suggested by Kumar (2000, p.42) that 'decisions on maintenance and development expenditures, as well as on key strategic issues [such as] prioritising investments in low volume roads [in Zambia], have not been based on sound decision criteria." The aforesaid notwithstanding, increase in investment in the rehabilitation of urban roads is contrary to RDA's strategy documents which emphasise maintenance.

Despite the reservations outlined above, it is stated by the RDA (2012) that the criteria for selection of roads for the 2013 RSAWP was based on the following principles: (i) priority to maintenance of newly rehabilitated/improved roads, (ii) priority to completion of on-going works, (iii) use of the Highway Management System results based on traffic levels and economic analysis for Trunk, Main and District roads. For lower rural roads, prioritisation is carried out using a multi-criteria analysis as per ROADSIP II, (iv) ensuring roads are not developed in isolation without any connectivity to other road sections, (v) political guidance, (vi) opening up new areas particularly through feeder roads and tourist roads; agricultural farming blocks, and (vii) projects funded by cooperating partners are selected on the basis of high economic return or social benefits established through comprehensive techno-economic feasibility studies.

The prioritisation principles as outlined in the RSAWP for 2013 may be considered to be equitable to some extent provided that the level of political interference is mitigated to ensure sustainable developments. Alternative prioritisation mechanisms using Goal Programming are proposed and recommended in this thesis as outlined in Section 6.5.2.

9.4.5 Summary Rawlsian equity analysis for Zambia road sector

An analysis of Zambia's road funds allocation and road scheme prioritisation is summarised in Table 9-10 overleaf based on the various theoretical equity categories discussed in Table 2-2.

9.4.6 Zambia case study limitations

The budgets allocated to agencies do not necessarily result into actual releases. Furthermore, Road Fund resources are also used for both capital investment and maintenance and it is challenging to accurately differentiate actual expenditures on maintenance versus capital investment. Moreover, there is off-line budget support to the road sector which may not have been captured in the analysed documents.

Indexation for inflation has not been undertaken; moreover, the Zambian currency (Kwacha) was rebased in 2013 and the analyses need to be treated with caution. However, lack of indexation for inflation is mitigated by the use of percentages rather than absolute figures. Furthermore, the allocation formula for the National Road Fund Agency was derived from one FY as outlined in the allocations for the FY 2013/14 Road Sector Annual Workplan.

Equity type (research proxy)	**Zambia performance (Rawlsian)**
Horizontal (macro)	There is a generally a fair balance between capital investment and maintenance in most of the analysed years based on acceptable *Macro Equity Coefficient* range (2006 to 2010). However, of recent, the 'Lusaka 400', 'Pave Zambia 2000' and 'Link Zambia 8000' have led to escalation of capital expenditure. Allocation splits in percentages terms (between capital investment and maintenance) vary year to year in an unsystematic manner. Summary rating is generally **good.**
Vertical (meso)	Rural inhabitants do not benefit from many road projects due to bias towards national roads under RDA (80.7% allocation). Regional allocations vary from year to year and do not address the economic imbalance in the regions. Summary rating is **poor**
Vertical (micro)	There is no discernible formula in regional allocations. Road scheme selection is politically driven and the majority of the populace do not benefit. Summary rating is **poor.**
Territorial (macro, meso and micro)	Project selection depends on political party support and to some extent used as a reward for political loyalty. Road scheme prioritisation in some instances takes account of international connectivity. However, as the RDA reports to the President's office; there may be challenges in achieving territorial equity. Summary rating is generally **good.**
Spatial (macro, meso and micro)	All individuals and regions do not benefit equally from road infrastructure funds allocation particularly the rural provinces of Eastern, Northern, North-Western, Muchinga and Luapula. Summary rating is **poor.**
Social (macro, meso and micro)	Road scheme prioritisation and investment decisions at all levels do not explicitly take account of social-equity issues. However, a Road Safety Authority exists. Existing allocation mechanisms do not take account of multi-dimensional poverty. Summary rating is generally **poor.**

Table 9-10 Zambia rod sector equity performance

9.5 Chapter summary

This chapter has provided an analysis of the road funds allocation and road scheme prioritisation in Zambia with regards to the key equity aspects. The main road sector institutions include: National Road Fund Agency (NRFA), Road Development Agency

(RDA), Road Transport and Safety Agency (RTSA); and local road authorities include: Zambia Wildlife Authority (ZAWA), Lusaka City Council and district local governments and provinces. The National Road Fund Agency is responsible for controlling the budget of all road sector projects in the country and operates as a true 2G Road Fund under the Ministry of Finance although there have been tendencies to 'third generation' due to management of capital investment funds. Interviews with stakeholders indicate that the RDA currently reports directly to the President's office but still remains under the Ministry of Transport, Works, Supply and Communication for administrative arrangements. However, this scenario has very serious governance implications and potential for affecting the quality of works performed.

Investigations through this research have shown that Zambia is one of the few countries in the region with a road sector budget in excess of what is needed to maintain the main road network, and possibly adequate to address the rehabilitation backlog. Road sector expenditure in 2012 was 4.45% of GDP (the highest of all case study countries). However, allocation of funds between maintenance and capital investments is not equitable in a Rawlsian manner with a bias towards capital investments although in some of the assessment years, the derived *Macro Equity Coefficient* is within this thesis's suggested range.

There are inequities at micro level and new allocation and road scheme prioritisation processes discussed in Chapter Six are recommended and they will in general terms provide a robust preliminary estimate; however, they can be further adapted to local needs based on local expert opinion surveys. Zambia's road sector Rawlsian equity performance is summarised in Table 9-10 and a comparison with other case study countries is provided in Table 13-1; which shows that Zambia has a generally poor performance.

The study shows that there is political interference in the allocation of roads resources and road scheme prioritisation. Some of the conclusions as outlined in the Uganda and Ghana case studies are also applicable to Zambia. Unlike the previously studied countries, Zambia is peculiar in that it has explicitly allocated resources for the wildlife parks by designating ZAWA as a local road authority. However, Zambia allocates substantial financial resources which are not being absorbed by the implementing agencies. Similarly, it is the only study country where the Roads Authority is under the President's Office. Comparison of Zambia road indicators (Table 9-1) with those of Uganda (Table 7-1), Ghana (Table 8-1), Kenya (10-1) and Tanzania (11-1) shows that Zambia has the lowest Rural Accessibility Index. The next chapter discusses road sector funds allocation and road scheme prioritisation in Kenya.

Chapter Ten - Kenya Case Study

10.1 Introduction

A review and critique of road funds allocations and road scheme prioritisation in Zambia was undertaken in Chapter Nine. This Chapter delves into Kenya's road sector and further extends understanding of equity in road funds allocation and road scheme prioritisation. The analysis shows that Kenya has the highest unpaved road density of all the case study countries. The review further shows that Kenya has a simple road funds allocation formula embedded in law albeit non-scientific and rigid.

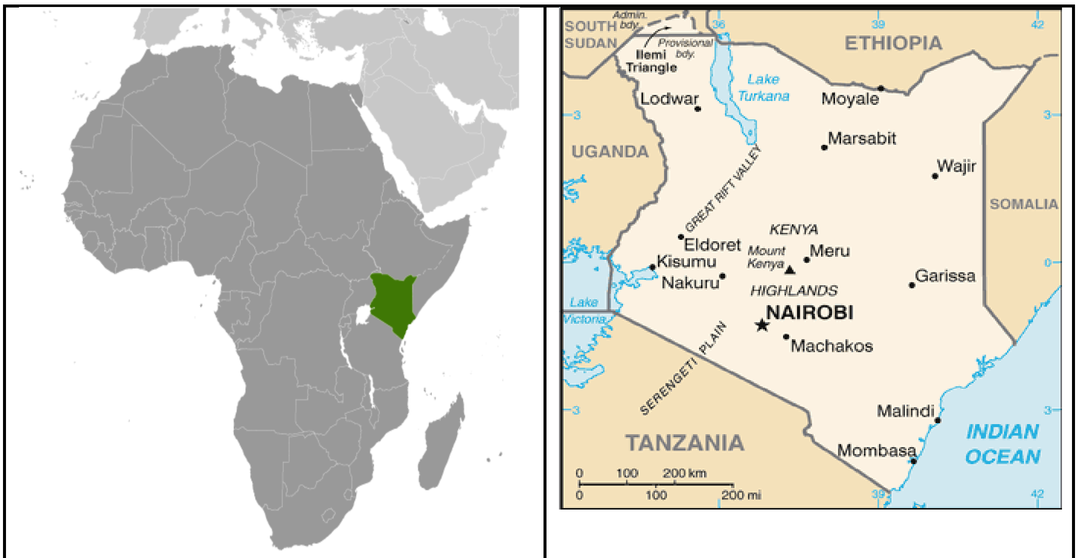
Kenya is the first of the three case study countries in this thesis to be analysed at a lesser depth (micro equity partly analysed) and it is found that there are Rawlsian equity challenges at macro level and a good performance at meso level. Compared with other case study countries analysed in this study, Kenya generally has a good Rawlsian equity performance.

10.1.1 Topography, geography and climate

Kenya is a coastal country located in East Africa with low plains that rise to central highlands bisected by the Great Rift Valley with a fertile plateau in the west; it is bordered by Somalia and the Indian Ocean to the east, Tanzania to the south, Uganda to the west; South Sudan and Ethiopia to the north. The country's highlands comprise one of the most successful agricultural production regions in Africa and the climate varies from tropical along the coast to arid in the interior; and Kenya has a total area of 580,367sq.km of which 1.93% is water and 98.07% is land (IndexMundi, 2014). The total population in 2009 was about 38.9million of which 22% were urban dwellers with the remainder in rural areas (ibid). Therefore an equitable road funds allocation should be skewed to rural dwellers who form the majority of the populace albeit mindful of population density. The capital city of Kenya is Nairobi and it holds with its immediate environs about 10% of the country's population (Kumar and Barrett, 2008). Figure 10-1 overleaf shows the geographical location of Kenya from a local and regional perspective.

10.1.2 Politics

Kenya gained independence from Britain in 1963 and is now a multi-party democracy following a period when it was a de-facto one party state from 1969 until 1982 (IndexMundi, 2014). However, the country experienced its worst political violence during 2007 after the general elections.



Kenya (regional context)	Kenya (local context)

Figure 10-1 Maps showing location of Kenya (Source: IndexMundi, 2014)

10.1.3 Economy

According to analysis by the International Forum for Rural Transport reported in 2009, Kenya is the most industrialised country in East Africa and the GDP composition during 2009 was: agriculture (21.4%), industry (16.3%) and services (62.2%); and agriculture employed 80% of the population and accounted for 50% of all exports. Therefore, an equitable allocation of road funds ought to take account of agricultural productivity given its importance and employment coverage. During the five year period from 2003 to 2007, Kenya's economy grew at an average annual rate of 5.3%, higher than the 2.3% recorded in the previous decade (Briceno-Garmendia and Shkaratan, 2011). It can therefore be argued that Kenya's road infrastructure should be at par or better than neighbouring countries which have smaller economies.

10.1.4 The road sector in Kenya

Road transportation in Kenya is the most predominant form of movement carrying about 93% of land freight and passenger traffic and comprises a total road length of about 161,451km of which 14,561km is paved and 146,890km unpaved (KRB, 2014). Interviews with Kenya government officials revealed that the length of network under the various authorities comprises: Kenya National Highways Authority - KeNHA (14,228km), Kenya Rural Roads Authority - KeRRA (131,791km), Kenya Urban Roads Authority - KURA (10,849km), and Kenya Wildlife Services - KWS (4,583km) as shown in Table 10-2. The aforementioned figures for the network metrics were also confirmed through literature review.

Briceno-Garmendia and Shkaratan (2011, p.6) observe that “the length of the trunk network is more than adequate…[and] even if Kenya’s road density indicators look relatively low…the trunk road network provides basic regional and national connectivity, linking the capital to the coast, to international border crossings, and provincial capitals in the interior”. However, the foregoing assertions are contradicted in the same research paper which cites Gwilliam et al., (2009) showing that Kenya’s road density is high when compared with low income countries (see Table 10-1). Furthermore, as analysed in Table 7-4, Kenya’s road density values are higher than the median of 21 SSA countries.

Kenya faces a huge rehabilitation backlog that needs to be addressed before the trunk road network can be considered to be in a maintainable condition (ibid). Furthermore, as of 2006, levels of road sector expenditure of around 1% of GDP (see Figure 7-2) were below regional standards and fell substantially short of what would be needed to clear the rehabilitation backlog in a reasonable period of time (ibid). However, of recent, expenditure in the sub-sector has risen since 2008 and currently stands at KShs 130bn or 3.3% of GDP (less than Uganda - see Table 7-8). In spite of this, interviews with Kenya Roads Board (KRB) officials reveal that required annual spending of about 4.5% of GDP is necessary in order to clear the backlog in the next ten years. The aforesaid is also supported by Gronau (1991) who suggests that most SSA countries would require expenditure of 5% of GDP per annum to clear maintenance backlog in 5 to 10 years. Nevertheless, it is most probable that the implementing agencies would not adequately absorb such levels of funding.

In 2003, the World Bank reported that Kenya’s road sector was in a dire situation with frequent allegations of rampant corruption, inefficiency and resource wastage. The governance challenges most likely affect equality of transport opportunities and lead to unsustainable road projects.

Gwilliam et al., (2009), cited in Briceno-Garmendia and Shkaratan, (2011), undertook an analysis of Kenya’s road indicators and benchmarked them against Africa’s low and middle income countries; and the results are reviewed in Table 10-1 overleaf.

Comparison of road indicators for both low and middle income countries as reported in 2009 by Gwilliam et al., and analysed in Table 8-1 (for Ghana), Table 9-1 (for Zambia) and Table 10-1 (for Kenya) shows that the reference metrics used for assessing Kenya and Ghana are the same whilst those of Zambia vary significantly. As previously analysed, this is one of the major challenges of cross country data comparisons. Comparison of Ghana, Zambia and Kenya road indicators shows that unpaved road density for Kenya is far higher than that of Ghana and Zambia which also translates into a better Rural Accessibility Index for Kenya. However, the percentage of paved network in good or fair condition in Zambia and Kenya is almost the same and marginally better than that of Ghana.

Metric	Measure	Low Income countries	Kenya	Middle income countries	Implications for equity and remarks
Paved road density	km/1000km^2 of arable land	86.6	152	507.4	Road density is high when compared to low income countries.
Unpaved road density	km/1000km^2 of arable land	504.7	930	1,038.3	
GIS rural accessibility	%age of rural population within 2km of all season road	21.7	32	59.9	RAI is relatively high when compared with low income countries.
Paved road traffic	Average annual daily traffic	1,049.6	1,108	2,786.0	Traffic volumes are high on paved roads but low on unpaved roads.
Unpaved road traffic	Average annual daily traffic	62.6	38	12.0	
Paved network condition	% in good or fair condition	80.0	84	79.0	Road network condition is good and exceeds low income countries; which may be attributable to large financial resources due to KRB's 2G status.
Unpaved network condition	% in good or fair condition	57.6	63	58.3	
Perceived transport quality	% firms identifying roads as a constraint	23.0	37	10.7	

Table 10-1 Kenya's road indicators (Source: adapted from Gwilliam et al., 2009, cited in Briceno-Garmendia and Shkaratan, 2011, p.7)

10.1.5 Road safety and equity

The World Bank (2003) reports that Kenya has successfully completed the road sector reforms. However, this overlooks the point that at that time there was no dedicated authority in charge of road safety in Kenya. This view is also supported by

Kumar and Barrett (2008, p.81) who point out that “the institutional framework for traffic safety is flawed…[and] policy making related to traffic safety and management is not reflected in transport planning, traffic engineering, operations management and vehicle inspection”. Nevertheless, in February 2013 the Kenya National Transport and Safety Authority was established by legislation to respond to road safety issues.

10.1.6 Road network characteristics and implementing agencies

The Road Maintenance Levy Fund was introduced in 1993 to provide for sustainable road maintenance funding and in 1999; the Kenya Roads Board (KRB) was established under an Act of Parliament (Kumar, 2000; GoK, 2012; KRB, 2012b). The Kenya Roads Act was enacted in 2007 and established: Kenya National Highways Authority (KeNHA) with responsibility for class A, B and C roads; Kenya Rural Roads Authority (KeRRA) responsible for rural and small town roads; and Kenya Urban Roads Authority (KURA) responsible for roads in cities and municipalities (ibid). More recently, the Kenya National Transport and Safety Authority was set up.

The percentage of the network in a fair to good condition is better than that of many countries in SSA and as of 2012, the surface condition of Kenya’s roads was 11% (good), 33% (fair) and 56% poor (KRB, 2012a). However, this is a decline in road condition when compared to the figures reported by Gwilliam et al., in 2009 (see Table 10-1). Table 10-2 overleaf analyses the road network metrics and the responsible authorities as of 2014.

10.1.7 The Kenya Roads Board

The first authority in the road sector to be created was the Kenya Roads Board-KRB (the Road Fund) in 1999 under the Kenya Roads Board Act and it is financed by a Road Maintenance Levy. Several reports indicate that the funds to KRB flow to the road sector without interruption (World Bank, 2003; Evdorides and Robinson, 2009). Nevertheless, KRB has a rather large Board of 13 members (when compared with Uganda Road Fund) which is likely to increase administrative costs.

Interviews with Kenyan officials reveal that the Fund also receives income from a transit and an Agricultural Cess (tax on all crop and livestock produce marketed within and on transit). In 2011, an investigation into Kenya’s infrastructure by Briceno-Garmendia and Shkaratan reveals that the Road Fund meets most of the good practice design criteria and that the fuel levy is adequate to fund the country’s road maintenance requirements and the associated revenues are being fully captured by the sector. KRB was re-aligned to fund maintenance of all public roads as a result of the Kenya Roads Bill drafted in 2007, and became law in 2009.

Agency	Paved	Unpaved	Total	Remarks
KeNHA	8,341	5,887	14,228	The national paved road network length is higher than that of unpaved roads.
KeRRA	4,152	127,639	131,791	KeRRA controls the largest network (rural roads).
KURA	2,062	8,787	10,849	The paved urban road network is about 20% of the total urban network.
KWS (other classes)	6	4,577	4,583	The total road network under KWS is comparable to that of KURA albeit the financial allocations differ significantly.
KWS (classified)	8,879	53,066	61,945	
KWS (unclassified)	2,318	96,623	98,941	
Total network	11,197	149,689	160,886	

Table 10-2 Kenya's road network classification (Source: adapted from KRB (2014); Author's remarks)

10.1.7.1 Critique of Kenya allocation formula

Kenya's allocation formula is embedded in law and the allocations are as follows: KeNHA (40%), KeRRA (32%), KURA (15%), KRB (2%), KWS (1%) and the Ministers/development fund (10%). The 32% allocation to KeRRA is equally allocated to all 290 constituencies (see Table 10-5).

The allocations seem to unduly favour KeNHA and may not necessarily be equitable or based on actual needs although rural roads also receive substantial resources when compared with neighbouring countries such as Uganda and Tanzania. The component of Minister's Fund is allocated between the authorities at the discretion of the Minister responsible for roads; however, the allocation may not be equitable and is politically manipulated. Furthermore, creating a Minister's fund is a recipe for corruption as its distribution is most probably political in order to enhance popularity for the incumbent government. Another weakness of the allocation formula is that administrative expenses of KRB are embedded in the formula; however, these operational expenses of KRB should be based on need rather than a fixed amount as the Road Fund may allocate itself more resources than can be absorbed especially when there are significant increases in revenue collection. It is acknowledged that the road funds allocation formula for Kenya is simpler and more straight forward when compared with that of Uganda. Nevertheless, KRB's allocation formula is rigid and non-scientific; and is not based on expert opinion which subsequently affects equity.

10.1.8 Kenya National Highways Authority

Interviews with stakeholders reveal that in 2010, expenditure on national road maintenance in Kenya amounted to US$ 10,322 per km, compared with around US$ 3,760 per km in Uganda which could mean that Kenya is undertaking more periodic maintenance works on national roads. Comparable expenditure on rural and urban roads (through KeRRA and KURA) was US$ 1,128 per km, compared with US$ 626 per km for the DUCAR network in Uganda. The aforementioned figures are a testament to the success of the reforms in Kenya for mobilising resources for road maintenance. However, there are still Rawlsian equity challenges in Kenya's road sector.

The budget allocation for FY 2012/13 was KShs 78.628bn comprising of a development budget of KShs 65.152bn, maintenance budget of KShs 11.98bn and operational costs of KShs 1.491bn (KeNHA, 2013). However, "the funds currently allocated for road maintenance and development are inadequate to cater for the road network needs" (GoK, 2012, p.27). Table 10-3 overleaf analyses KeNHA's achievements on road interventions for the period 2009 to 2013 in lane kilometres.

10.1.9 Kenya Rural Roads Authority

KeRRA was created in 2009 to manage construction and maintenance of rural roads. The reform process started as early as 1992 when it was identified that there were problems with road funding, ownership, and responsibilities, with the result that road maintenance was not commercial. The total network under the responsibility of KeRRA is 131,791km as indicated in Table 10-2.

10.1.10 Kenya Urban Roads Authority

KURA is responsible for roads in 45 Municipal Councils and Nairobi City Council. It takes care of 10,849km of roads, of which 2,062km are currently paved. Only those roads with a Right of Way of 9m (width) are considered as part of the network eligible for funding. Interviews with KURA officials indicate that the new road sector authorities had made an impact in effective management of roads. The introduction of the Road Maintenance Levy in 1993 was also a major turning point; and the establishment of the levy was a condition of funding by Development Partners.

Description	2009/10	2010/11	2011/12	2012/13	Remarks for equity
Road reconstruction and rehabilitation	254.5	96.1	167.28	217.1	In 2009/10, capital expenditure was 50% higher than in 2010/11 and over 25% in FYs 2011/12 and 2012/13.
Roads upgraded to bitumen standards	265.2	119.8	174.7	168	
Periodic maintenance and spot improvement	296	812.15	1,621.20	2,490	The network undergoing maintenance increased from a very low level in FY 2009/10. It seems that in 2012/13 the entire network received routine maintenance which is plausible.
Routine maintenance	1,821	4,525.75	26,495.1	26,657	

Table 10-3 Kenya National Highways Authority achievements in lane kilometres, 2009 to 2013 (Source: adapted from KeNHA, 2013, p.36)

10.2 Kenya road sector expenditure

This section provides an analysis of the historical expenditure in Kenya's road sector. Every financial year, KRB advises all road agencies on their annual allocations from the Fund. Based on these ceilings all road agencies prepare annual road maintenance works programmes. All the constituency workplans are presented to the Constituency Roads Committee members for approval. All workplans are analysed and consolidated together by KRB to form the Annual Public Roads Programme (APRP). After approval by the Board, the APRP is presented to the Ministers responsible for Roads and Finance for their signature.

10.2.1 Historical expenditure

Table 10-4 below analyses the historical expenditure for the period 2001 to 2013 which indicates that there has been a general upward trend in road funds allocation; however, there was a sharp increase from FY 2005/2006 onwards.

Financial Year	Amount (KShs)	Amount (US$)	GDP (US$ billions)	Expenditure (%age of GDP)
2001/2002	7,736,761,082	115,474,046	12.99	0.89%
2002/2003	7,651,571,502	114,202,560	13.15	0.86%
2003/2004	8,400,000,000	125,373,134	14.90	0.84%
2004/2005	9,443,805,001	140,952,313	16.10	0.87%
2005/2006	10,110,430,489	150,901,948	18.74	0.80%
2006/2007	16,089,145,000	240,136,493	28.53	0.84%
2007/2008	18,777,357,978	280,259,074	31.96	0.88%
2008/2009	21,516,021,052	268,977,168	35.90	0.75%
2009/2010	23,572,551,889	294,656,898	37.02	0.79%
2010/2011	23,390,000,000	275,176,470	40.00	0.69%
2011/2012	24,100,000,000	264,774,650	41.95	0.63%
2012/2013	24,490,000,000	269,059,385	50.33	0.53%

Table 10-4 Kenya Roads Board collections/expenditure (Source: adapted from KRB, 2012c and 2014b)

Table 10-4 shows that the road fund collections have increased over the years and there is every indication that the trend shall continue as illustrated in Figure 10-2 overleaf considering that linear regression analysis shows that there is a good fit with R^2 value of 0.79. Interestingly, expenditure as a percentage of GDP averages at 0.78% (see Table 10-4). Part of the budgetary yearly increases may be attributable to inflation. Although funds have increased annually, the exchange rate creates variations. Nevertheless, resources would need to be distributed equitably to ensure equality of transport opportunities. Analysis of the trend shows that there was a steep increase around 2007 which may be attributed to a period leading to elections.

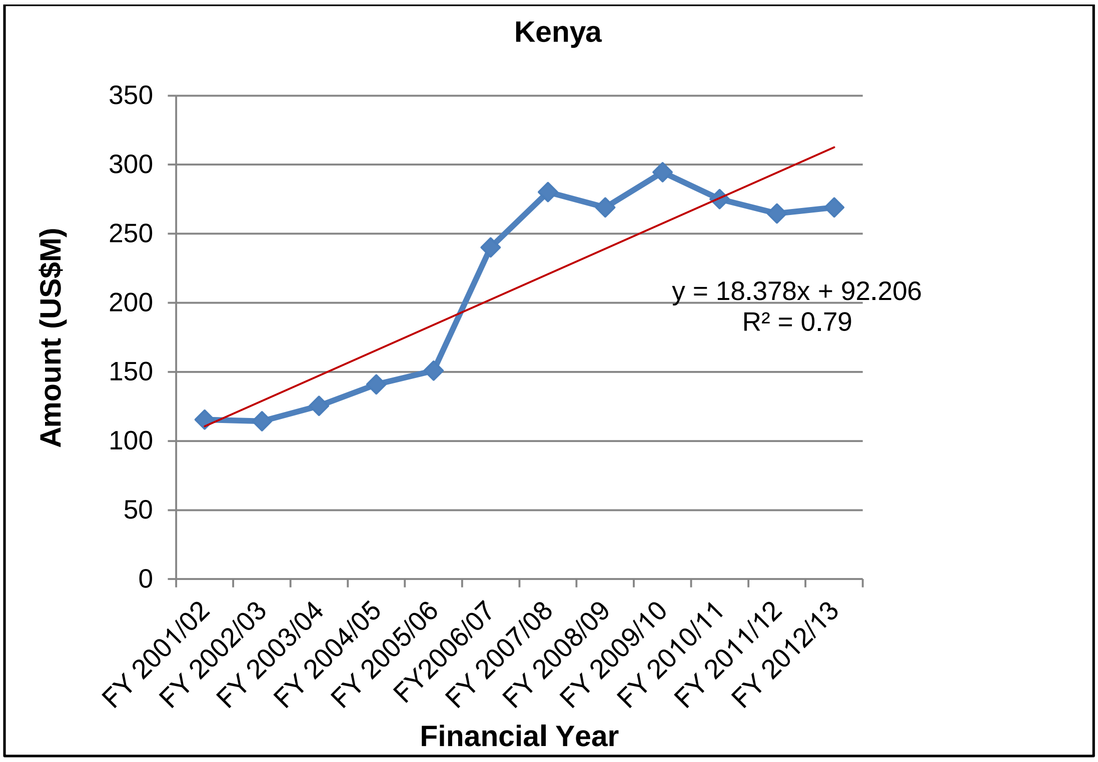


Figure 10-2 Trend of Kenya road fund expenditure 2001 to 2013

10.3 Kenya road sector equity analysis

This section analyses the equity aspects in the allocation of road funds in Kenya at macro and meso levels. Micro-level allocations have been considered in limited depth due to inconsistencies in data and the recent changes in local government as a result of the new constitution.

10.3.1 Macro level equity analysis

Historically, Kumar (2000, p.34) points out that in Kenya "inadequate road maintenance has been a significant problem [and]…the expansion of the network has intensified the problem of inadequate maintenance funding". The Kenya National Highways Authority budget allocation for FY 2012/13 was KShs 78.628billion comprising of a development budget of KShs 65.152bn, maintenance budget of KShs 11.98bn and operational costs of KShs 1.491bn (KeNHA, 2013). An analysis of macro equity for KeNHA budgetary allocation for FY 2012/13 results into a *MEC* value of 0.15 and *MEI* of 0.82 which is not within the suggested equitable *MEC* range of 0.25 to 0.50 derived in Chapter Six based on expert opinion surveys.

10.3.2 Meso level equity analysis

Table 10-5 overleaf analyses allocations for FYs 2008/9 to 2013/14 in KShs (Billions). From Table 10-5; the derived *CRONEMI* for all years is 0.40 whilst the *n-CRONEMI* is 0.32. The thesis posited range of *n-CRONEMI* is 0.30 to 0.45. Therefore, Kenya's values are within the acceptable range and are equitable based on Rawlsian principles. The definitions and interpretations of the aforementioned terms and equitable ranges were covered in detail in Section 6.4.

Expenditure	**08/09**	**09/10**	**10/11**	**12/13**	**13/14**	**Remarks on equity**
KRB operations (2%)	0.37	0.39	0.41	0.49	0.52	Within the ARMFA limits of 2% to 4%.
KeRRA (22%)	4.18	4.40	4.62	5.28	0.56	Constituency roads.
KeRRA (Districts) - 10%	1.90	2.00	2.10	2.40	2.56	Critical links - rural roads.
KURA - 15%	2.80	2.80	3.09	3.60	3.84	Urban roads.
KeNHA - 40%	7.75	7.75	8.55	9.99	10.69	A, B and C roads.
KWS - 1%	0.186	0.20	0.21	0.24	0.26	Tourism roads.
Development -10%	1.86	1.96	2.06	2.40	2.56	Minister for Roads.
Total	19.00	20.00	21.00	24.4	26.18	

Table 10-5 Kenya Road Fund allocations in KShs-Bn (Source: adapted from Annual Public Roads Programme FY 2007/08 to FY 2013/14)

10.3.3 Road scheme and intervention measure prioritisation

It is reported by KRB (2012d) that the broad priorities on classes A, B and C roads for the 2012/13 APRP were as follows: (i) undertake routine and periodic maintenance on all maintainable roads, (ii) complete ongoing projects, (iii) rehabilitate deteriorated sections of the network to bring them back to maintainable standards, and (iv) upgrade highly trafficked sections of the network to bitumen or gravel standards. Considering the priorities above, KeNHA is expected to identify and prioritise roads for maintenance intervention on the basis of economics and CBA. The prioritisation approach is appropriate if implemented as proposed; however, a better proposition would be to have clear equity goals. New processes which explicitly take account of equity using GP models are proposed in Section 6.5.2.

10.3.4 Kenya case study limitations

The budgets allocated to agencies do not necessarily result into actual releases; however, this is not too important as the intention is being measured. Furthermore, Road Fund resources are also used for both capital investment and maintenance. There is off-line budgetary support to the road sector, however, this is small. The Kenya Shilling exchange rate with the US$ has varied over the years and analyses need to be treated with caution although this is mitigated by the use of percentages rather than absolute values. Furthermore, indexation for inflation has not been undertaken. Due to data limitations, micro equity analysis is excluded for lower local governments. However, micro equity allocations should follow the framework as posited in Table 6-3 and adjusted depending on data availability.

10.3.5 Summary Rawlsian equity analysis for Kenya road sector

Kenya's road funds allocation and road scheme prioritisation is analysed in Table 10-6 below based on the various theoretical equity groups discussed in Table 2-2.

Equity type (research proxy)	**Kenya performance (Rawlsian)**
Horizontal (macro)	Major bias towards capital projects. The road sector investment plan is not followed systematically. Summary rating is **poor.**
Vertical (meso)	Rural areas benefit due to the establishment of KeRRA (allocated 32% KRB funding). Summary rating is **very good.**
Vertical (micro)	All the 290 constituencies benefit equally from KeRRA funding. Summary rating is **very good.**
Territorial (macro, meso and micro)	Road scheme prioritisation in some instances takes account of regional and international connectivity; and KeNHA uses CBA. The 10% allocation under the Minister for Roads most probably does not cover all regions. Summary rating is generally **good.**
Spatial (macro, meso and micro)	All regions do not benefit equally from road funds allocation particularly the rural districts. Summary rating is generally **poor.**
Social (macro, meso and micro)	Road scheme selection at all levels does not explicitly take account of social-equity issues. A Road Safety Authority was recently established. Summary rating is generally **poor.**

Table 10-6 Kenya road sector equity performance

10.4 Chapter summary

This section has provided an analysis of Kenya's road sector which shows that capital investment expenditure is higher than maintenance which is likely to lead to an increase in maintenance backlog. Kenya Roads Board (KRB) allocations are embedded in a formula within the Act which makes it transparent but is non-scientific and rigid; this makes it unable to respond to actual agency needs. However, the KRB formula is simple and easy to explain unlike that of Uganda. The prioritisation framework for road schemes and intervention measures appears equitable if implemented as proposed.

Kenya's road sector expenditure has increased over the years (currently at 3.3% of GDP) and this trend is likely to continue. Nevertheless, the major weakness of Kenya's Road Fund (KRB) formula is the creation of an allocation under the Minister of Roads which is likely to regularise political interference in resource allocations as scheme selection may not be transparent. However, it seems that of late the Minister of Roads allocation has been utilised mainly to address urgent and emergency works and less driven by political considerations albeit the danger still exists. Furthermore, KRB has a rather large board of 13 members which may lead to corporate governance challenges and high administrative costs.

The study shows that there is political interference in the allocation of roads resources and road scheme prioritisation. Some of the conclusions as outlined in the previous case studies are also applicable to Kenya.

Unlike Uganda and Ghana; the KRB allocates funds for tourism roads. Nevertheless, there are inequities at macro, meso and micro levels and new allocation and road scheme prioritisation processes discussed in Chapter Six are recommended and they will in general terms provide a robust preliminary estimate; however, they can be further adapted to local needs based on expert opinion. Kenya's road sector Rawlsian equity performance is summarised in Table 10-6 and a comparison with other case study countries is provided in Table 13-1; which shows that Kenya has a very good performance in general terms.

Analysis of Kenya's road indicators (Table 10-1) shows that unpaved road density is far higher than that of Ghana (Table 8-1) and Zambia (Table 9-1) which also translates in a better RAI. However, the percentage of paved network in good or fair condition in Kenya is almost the same as that of Zambia and marginally better than that of Ghana.

This Chapter has contributed to the understanding of Rawlsian equity in Kenya's road funds allocation and road scheme prioritisation. The following Chapter discusses road funds allocation and road scheme prioritisation in Tanzania.

Chapter Eleven - Tanzania Case Study

11.1 Introduction

In Chapter Ten, a review and critique of road sector allocations and road scheme prioritisation in Kenya was undertaken. This Chapter delves into Tanzania's road sector and further extends understanding of equity in road funds allocation and road scheme prioritisation.

Tanzania is the second country in this thesis to be analysed at a lesser depth (micro equity partly analysed) and it is found that there are equity challenges although Tanzania has an operational 2G Road Fund which has had stable corporate governance for a long time. The Road Fund uses a simple allocation formula albeit rigid and has not been reviewed in nearly twenty years; and equity is not embedded as an allocation factor. Analysis in this thesis shows that the performance of the Tanzanian road sector is generally good when compared with Uganda and Zambia.

11.1.1 Topography, geography and climate

Tanzania is a coastal country located in East Africa with plains along the coast and a central plateau with highlands in the north and south; it is bordered by the Indian Ocean to the east, Mozambique to the south, Malawi and Zambia to the south west, Democratic Republic of Congo to the west, Burundi and Rwanda to the north west, Uganda to the north and Kenya to the north east. The climate varies from tropical along the coast to temperate in the highlands and politically, the country includes the islands of Pemba and Zanzibar (IndexMundi, 2014).

The country has a total area of 947,300sq.km of which 6.49% is water and 93.51% is land; and the total population in 2013 was about 48.26million of which 26.7% were urban dwellers and the remainder in rural areas (IFRTD, 2009). Tanzania is the largest and most populous of all the case study countries. However, it can be argued that an equitable road funds allocation should be skewed to rural dwellers given that they are the majority of the populace albeit consideration should also be given to population density. The capital city of Tanzania is Dodoma whilst Dar es Salaam is the major commercial city and is one of Africa's busiest ports with a population estimated to be increasing at a rate of 4.3% annually (Kumar and Barrett, 2008). Figure 11-1 overleaf shows the geographical location of Tanzania from a regional and local perspective.

11.1.2 Politics

Tanganyika and Zanzibar gained independence from Britain in 1961 and 1963 respectively; and the two nations merged in 1964 to form Tanzania (GoT, 2012; IFRTD, 2009; IndexMundi, 2014). In 1995, one party rule ended following the first democratic elections held in the country since 1970 (ibid).

Tanzania (regional perspective)

Tanzania (local perspective)

Figure 11-1 Maps showing location of Tanzania (Source: IndexMundi, 2014)

11.1.3 Economy

Tanzania's economy has maintained average growth rate of 7% between 2003 and 2007 when compared with 3.7% from 1990 to 2002 (Shkaratan, 2012). Compared to other countries in the region, Tanzania has had a long stable political environment which has created an enabling environment for supporting the road sector. This is also further manifested in the stability in the governance of the Roads Fund Board.

GDP composition during 2005 was: agriculture (46%), industry (17%) and services (37%); agriculture employs 80% of the population and accounts for 50% of all exports (World Development Indicators, 2005, cited in IFRTD, 2009). Given the substantial contribution of the agricultural sector, a fair allocation of road funds should take account of agricultural productivity of the various districts and regions. GDP per capita is in the same range as Uganda but much lower than other case study countries (see Table 6-7).

11.2 The road sector in Tanzania

As is the case with the rest of SSA, road transportation in Tanzania is the most predominant form of movement for both freight and passengers. The public road network in mainland Tanzania is classified as national roads and district roads; national roads comprise of trunk roads and regional roads whilst district roads comprise of collector, feeder and community roads (RFB, 2014).

Ministerial responsibility for the road sector has changed over the years. During 1961, it was under the responsibility of Ministry of Communications, Energy and Works; from 1965 to 1975, it was under the Ministry of Communications, Labour and Works; from 1989 to 1990, the responsibility passed to the Ministry of Communications and Works; from 1990 to 1995, it became Ministry of Works; for the period 1995 to 2005, the responsible ministry was Communications and Transport; for the period 2006 to 2010, the responsibility was under Ministry of Infrastructure development; and from 2010 to date, the responsibility is under Ministry of Works (GoT, 2013). It can be argued that the changes in responsible ministries were aimed at enhancing efficiency; however, the changes could also have affected institutional memory and sustainability and equity in road maintenance and development planning.

The Ministry of Works has the oversight responsibility for the management and development of transport. The Tanzania National Roads Agency (TANROADS) has the responsibility for the management of trunk and regional road network of mainland Tanzania and it manages about 35% of the total road network (IFRTD, 2009). District, urban and feeder roads are the responsibility of the Prime Minister’s Office for the Regional Administration and Local Government - PMORALG (ibid).

Analysis by IFRTD (2009) shows that indicators of human development in Tanzania indicate an escalating disparity between rural and urban dwellers and this is mainly influenced by population patterns, different endowment in resources and distribution of infrastructure. Furthermore, only 38% of the rural population has reliable access to transport with a mean distance of 5.4km to public transport and this is contrasted to Dar es Salaam where the mean distance is 0.5km while in other urban areas it is 0.8km (Thum, 2004, IFRTD, 2009). This implies that the majority of rural dwellers (62%) have long distances to walk in order to access public transport which is tantamount to a walking time of about one hour. Similarly, with about 87% of the poor living in rural Tanzania, rural connectivity enhancements through development of effective rural transport systems would have a major effect in reducing the rural - urban divide and poverty (ibid). From the aforesaid, an equitable allocation of road funds should consider improvements that benefit rural dwellers; subsequently enhancing equality of transport opportunities and sustainability.

A study into Tanzania’s infrastructure by Shkaratan (2012) shows that the country has made good progress in road sector reforms and network quality. Reforms implemented have led to the establishment of a 2G Road Fund and the fuel levy is commensurate with maintenance needs making the country among the few African countries that appear to be allocating adequate resources towards road maintenance (ibid). Similarly, the main and rural road networks are in good condition compared with those of the neighbouring countries albeit the widespread evasion of the fuel levy prevents the Road Fund from functioning as it was intended (ibid). Furthermore; the road maintenance backlog is escalating as a result of escalation in the rate of expansion of the new road network. Tanzania's trunk road network is adequate and although road density indicators are low when compared with low and middle income countries in Africa; the trunk road network provides basic regional and national connectivity. Nonetheless, a road safety agency is not in place which affects equity.

Gwilliam et al., (2009), cited in Shkaratan, (2012), undertook an analysis of Tanzania's road indicators and benchmarked them against Africa's low and middle income countries; and the results are analysed in Table 11-1 overleaf. Comparison of reference road indicators for both low and middle income countries as reported in 2009 by Gwilliam et al., for Tanzania (Table 11-1), for Ghana (Table 8-1), Zambia (Table 9-1), and Kenya (Table 10-1) and with those by Ranganathan and Foster (2012) in Table 7-1 for Uganda; shows variations albeit the same reference data from the AICD database is used. Reference data as outlined in the analytical tables for Uganda and Zambia are not consistent with those of Ghana, Kenya and Tanzania; which is a challenge with cross-country data comparison.

Comparison of Tanzania's road indicators with those of Uganda, Ghana, Zambia and Kenya shows that Tanzania has the best paved network condition and this is most probably attributable to the stable 2G Road Fund. In contrast, Tanzania has the lowest paved road density (and a very low overall density) possibly as a result of the vastness of the country (see Tables 7-4 and 11-1). Analysis of the district road survey data of 1997, cited in Kumar, (2002), shows that: (i) 38.3% of the trunk road network is paved and road network in fair to good condition was 69.5%, and (ii) 32.8% of the regional road network is in fair to good condition whilst only 0.3% of the network is paved. The aforesaid figures can be contrasted with the road condition for 2004 as reported by the Ministry of Communications (2004), cited in Thum, (2004), which shows that: (i) for the trunk road network, 77% was in fair to good condition, and (ii) for regional roads, the corresponding percentage is 69%. It can therefore be concluded that between 1997 and 2004; on average the road condition in Tanzania improved by 38%. This is most likely attributable to increased resources of Roads Fund Board and absorption efficiencies in implementing agencies during the aforesaid period.

Metric	Measure	Low Income countries	Tanzania	Middle income countries	Implications for equity and remarks
Paved road density	km/1000km^2 of arable land	86.6	47.1	507.4	Road density is low when compared to low income countries.
Unpaved road density	km/1000km^2 of arable land	504.7	482.6	1,038.3	
GIS rural accessibility	%age of rural population within 2km of all season road	21.7	24.0	59.9	RAI is higher than that of low income countries.
Paved road traffic	Average annual daily traffic	1,049.6	1,797	2,786.0	Traffic volumes are higher than those of low income countries.
Unpaved road traffic	Average annual daily traffic	62.6	99.8	12.0	
Paved network condition	% in good or fair condition	80.0	94.7	79.0	Road network is good and exceeds that of low and middle income countries.
Unpaved network condition	% in good or fair condition	57.6	69.1	58.3	
Perceived transport quality	% firms identifying roads as a constraint	23.0	14.1	10.7	Tanzania performs better than low income countries.
Over engineered network	% of total network	26.0	22.0	20.0	Value is higher than that of middle income countries.

Table 11-1 Tanzania's road network indicators (Source: adapted from Gwilliam et al., 2009, cited in Shkaratan, 2012)

According to the Roads Fund Board (2006), cited in Benmaamar, (2006), there was a significant improvement in road condition over the period 2001 to 2005 and this is attributable to: (i) increase in the institutional capacity through establishment of the Road Fund and Road Authority, (ii) increase in financial management and capacity, and (iii) increase in execution capacity.

11.2.1 Road network characteristics and road sector agencies

Table 11-2 below analyses the composition of the Tanzanian road network in 2009.

Road category	Paved (km)	Unpaved (km)	Total	Remarks and implications for equity
Trunk	3,917	6,027	9,944	These roads are under the management of TANROADS and over 85% are unpaved.
Regional	327	18,629	18,956	
District	0	29,537	29,537	These roads are under the management of PMORALG and the local authorities; only 1.4% of the network is paved.
Feeder	0	21,191	21,191	
Urban	790	5,107	5,897	
Total	5,034	80,491	85,525	94% of the network is unpaved.

Table 11-2 Tanzania's network metrics (Source: adapted from Tanzania Road Fund, 2009, cited in IFRTD, 2009).

In 2013, the network comprised of a total of 12,786km of trunk roads, 22,214km of regional roads whilst the district roads which include collector, feeder and community roads comprised of 52,581km administered by local government authorities (GoT: 2012, 2013).

11.2.2 The Roads Fund Board of Tanzania

The Roads Fund Board (RFB) in its current form came into operation in 2000 and is mandated to use at least 90% of its resources for maintenance and emergency repair of the classified road network and related operational costs in mainland Tanzania and not more than 10% for road development (Evdorides and Robinson, 2009). This is as laid out in the Road and Fuel Tolls Act, Cap 220 (revised edition 2006). However, RFB ought to use all its available resources towards maintenance whilst development projects should be funded through the Consolidated Fund (Ministry of Finance) to ensure efficient use of resources; and also following the user pays (fee for service) principle.

11.2.3 Critique of Tanzania allocation formula

The RFB disburses funds to three implementing agencies namely: (i) Tanzania National Roads Agency - TANROADS, (ii) local authorities under the Prime Minister's Office for Regional Administration and Local Government – PMORALG; and (iii)

Ministry of Works. TANROADS currently receives 63% of the distributable amount after RFB has covered its own administration costs, PMORALG receives 30% and Ministry of Works receives 7% (ibid). The allocations are inequitably skewed towards the national road network under TANROADS and are not based on needs assessment or expert opinion. Although the allocation formula is simple, it does not adequately cater for the rural road network under PMORALG which benefits the majority of the populace including the rural poor. Furthermore, RFB does not fund community access roads and tourism roads. The aforesaid notwithstanding, the formula is reasonably fair (see Section 11.5.2). The Roads Fund Board receives resources from: (i) fuel levies on diesel and petrol, (ii) transit fees, (iii) vehicle overloading fees; and (iv) monies from any other sources determined by Parliament (ibid). Table 11-3 below analyses the revenue collected by Road Fund from FY 2000/2001 to FY 2013/2014 which shows that collections tripled between 2008 and 2014 although it is most probable that road condition did not improve proportionately.

Financial Year	**Total (TShs)**
2000/2001	47,252,075,508
2001/2002	52,881,380,629
2002/2003	59,390,122,255
2003/2004	67,342,261,562
2004/2005	73,204,121,369
2005/2006	73,081,566,023
2006/2007	101,215,098,315
2007/2008	207,767,969,569
2008/2009	255,563,765,110
2009/2010	266,549,505,179
2010/2011	325,771,280,255
2011/2012	406,767,248,684
2012/2013	447,818,013,582
2013/2014	641,158,141,471

Table 11-3 Tanzania Roads Fund Board collections (Source: RFB, 2014)

Data from RFB shows that the road fund collections have increased over the years and there is every indication that the trend shall continue as illustrated in Figure 11-2 overleaf considering that linear regression analysis shows that there is a good fit with R^2 value of 0.86. However, indexation for inflation has not been undertaken. Despite the uncertainty associated with predicting future collections, resources would need to be distributed equitably to ensure equality of transport opportunities and sustainable developments.

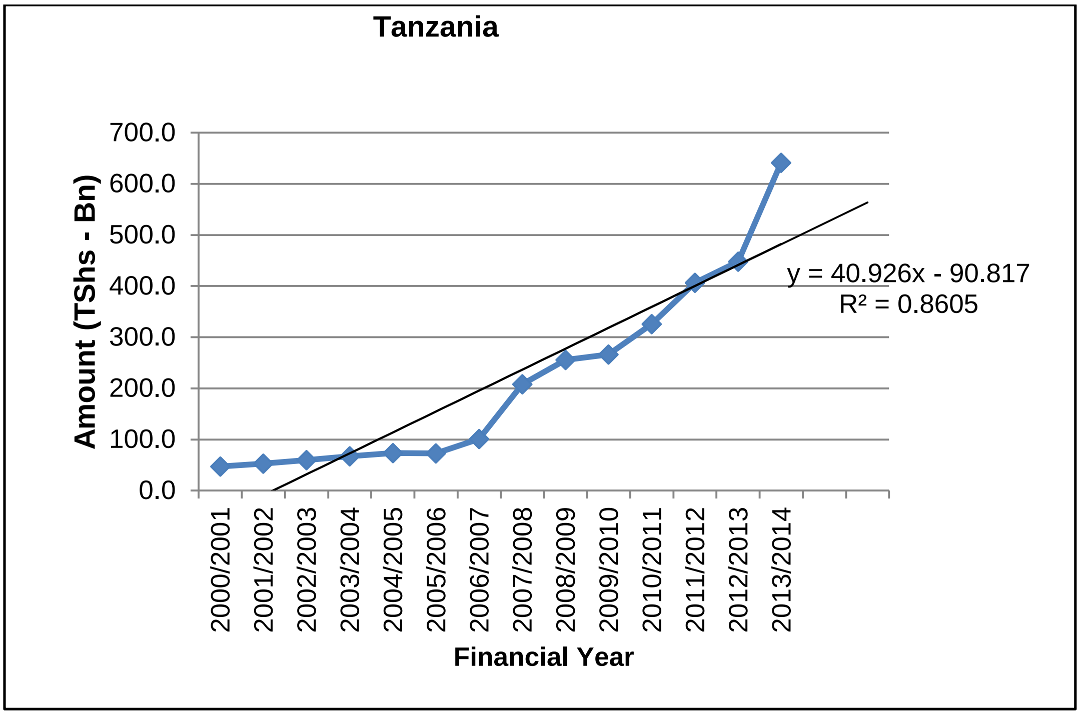


Figure 11-2 Trend of Tanzania Roads Fund Board collections from 2000 to 2014

Shkaratan (2012) explains that RFB is among the few African Road Funds which meet SSATPP's seven criteria for appropriate design: (i) a clear legal foundation, (ii) separation of functions, (iii) application of road user charges, (iv) direct transfer of funds, (v) representation of road users on the board, (vi) clear revenue allocation rules, and (vii) independent auditing of accounts. During the period 2007/10, the gap between road fund collections and cost of road network maintenance widened as a result of currency depreciation and growing costs of road works; and by FY 2009/10 RFB revenues were barely sufficient to cover 58% of total maintenance needs (ibid). Moreover, as of 2006, RFB was collecting only 39% of the required amount of fuel levy; one of the worst collection rates in SSA but spending remained adequate as a result of additional resources from the public budget (ibid). Of recent, this issue has been resolved and there has been a steep increase in collections as analysed in Figure 11-2.

Evdorides and Robinson (2009, pp.51-52) point out that "the estimated asset value of Tanzania's road network is about US$2.6 billion [and] the road fund allocates around US$ 66 million per annum to the network which is about 2.6 percent of the asset value". This can be compared with the Economic Commission for Latin America and the Caribbean (ECLAC) recommendation of 2.5% to 3.5% (ibid). It can be deduced that resource allocation is adequate albeit at the lower end of the ECLAC range. The Tanzania estimated road asset value of US$ 2.6billion in 2009 can be compared with that of Uganda of US$ 4.4billion in 2014 and that of Ghana of US$ 4.6billion in 2004. However, interviews with RFB staff in 2015 indicate that the estimated road asset value was about US$ 6.0billion in 2011.

In 2002, Kumar observed that setting up the Road Fund with dedicated financing from road user fees had made available more money for road maintenance than in the past. Therefore thirteen years ago, the monies were insufficient to address all maintenance needs but were not being utilised efficiently. Literature review and interviews with RFB staff indicate that the situation has since changed.

11.2.4 Prime Minister's Office for Regional Administration and Local Government

The Prime Minister's Office for Regional Administration and Local Government (PMORALG) is responsible for the management, development and maintenance of the district, feeder and urban roads. Evdorides and Robinson (op. cit., 2009, p.51) points out that "10% of the allocation to PMORALG is earmarked for development and the remainder for maintenance; however, it is observed that "this causes problems at this level since around 70% of local roads are in poor condition and the bulk of the work needed is in fact rehabilitation or improvement".

RFB pays money directly to each of the 166 districts for maintenance according to a formula agreed with PMORALG (although not based on needs or expert opinion). The previous formula took account of population, road length and 'equity' being the largest factor as each council got an equal share. Despite incorporation of equity in the formula, the allocations may not have been commensurate with needs or absorption capacity of agencies leading to wastage of resources. However, interviews with RFB staff in December 2014 indicate that the formula has now been revised and takes account of road length, pavement type and road condition. The new formula is based on needs but it is still necessary to explicitly embed principles of Rawlsian equity.

11.2.5 The Tanzania National Roads Agency

The Tanzania National Roads Agency (TANROADS) is responsible for the maintenance and development of the national and regional road network; it was set up under the Executives Agencies Act 1997 and it became operational in 2000 (Kumar, 2002; Thum, 2004; Evdorides and Robinson, 2009, IFRTD, 2009; GoT, 2013). TANROADS manages about 35% of the entire road network of 85,000km. Interviews with officers from TANROADS indicate that they receive budget estimates from Ministry of Finance/RFB and then prepare a business plan and submit to the

RFB for approval. Funds are disbursed to TANROADS on a monthly basis although physical and financial accountability is provided on a quarterly basis. TANROADS road administrative units are broken into five regions across the country. Every FY, regions sign performance agreements with the centre at TANROADS which spells out physical works and financial requirements. As of 2011; RFB was able to meet about 56% of the total maintenance needs of the country which is good when compared with other case study countries such as Uganda.

11.3 Road sector achievements and challenges

Interviews with RFB staff and literature review indicate that there has been an increase in the level of collections from TShs 3.7billion in FY 1991/92 (when fuel levy was initiated) to TShs 47.3billion in FY 2000/01 (when the board started its operations) to TShs 641.2billion in FY 2013/14. Maintenance budgets which were not fully achieved in previous years (before board started its operations) are now met 100% and the flow of funds is now stable and on a monthly basis. The board publishes releases of roads funds to implementing agencies in public newspapers half yearly. The road network condition has improved due to increased activities of maintenance and the board carries out technical and financial audits which should ensure value for money and enhance Rawlsian equity.

Absorption capacity is a challenge following the increase in RFB budget and by the end of FY 2007/08; TANROADS physical and financial performance was 93% and 81% respectively thus superseding the target of 75%. PMORALG did not meet the target as the physical and financial performance was 45% and 63% respectively. There is a substantial amount of road maintenance which has not been done. The estimate of the road maintenance backlog in 2010 was at US$M 1,400 and still increasing. Discussions with officers from Tanzania Revenue Authority indicate that fuel exemptions increased from TShs 1.103billion to TShs 6.3billion during FYs 2004/5 to 2005/6 respectively. In 2010, estimates put the fuel levy exemptions to about TShs 23billion. There are indications that not all the exempted entities use all the fuel solely for the intended purposes. Furthermore, overloading is a major problem and it is reported that during FY 2007/8, 18% of all heavy vehicles that were checked and weighed at the toll stations were found to be overloaded. Currently, there is no road safety agency in place which is likely to exacerbate overloading.

11.4 Tanzania road sector expenditure

This section provides a detailed analysis of the historical expenditure in the Tanzanian road sector. The World Bank (2011c) reports that road sector expenditure in 2009/10 was 3.60% of GDP; which is high when compared with other case study countries (see Table 6-7). However, the aforesaid figures are not consistent with analysis by Gwilliam et al., (2009) as shown in Figure 7-2; which posits Tanzania's road sector expenditure at about 1.75% of GDP.

As early as 1985, Tanzania had put in place the concept of road users paying for the use of roads (Thum, 2004). RUCs consisting of an access tariff (license fee) and road use tariff (fuel levy) are collected by various agencies and managed by the Road Fund (ibid). Table 11-4 below shows an analysis of the road funds collection for the period 1999 to 2004.

	1999	**2000**	**2001**	**2002**	**2003**	**2004**
RFB collections – TShs (Millions)	38,015	47,252	52,881	59,390	64,510	65,386
	Percentage of total					
Fuel levy	96%	95%	95%	94%	96%	95%
Transit charge	2%	2%	3%	3%	2%	
Overloading fee	2%	3%	3%	3%	2%	
Allocation – TShs (Millions)	36,107	40,031	50,739	60,074	64,510	

Table 11-4 Tanzania Road Fund collections 1999 to 2004 (Source: adapted from Ministry of Works, 2004, cited in Thum, 2004, p.10)

From Table 11-4, it can be deduced that road fund collections over the six year period increased by 72% and fuel levy was the greatest contributor every year at an average of 95%. However, indexation for inflation has not been undertaken considering that inflation did not increase significantly over the period.

The road maintenance budget for TANROADS in FY 2013/14 was TShs 314,536million from the Roads Fund Board comprising components for trunk roads; regional roads; emergency/contingency; PMMR (Performance based Maintenance and Management of Roads) project; weighbridges maintenance and improvement; headquarter based activities; administration costs, supervision costs and weighbridges operational costs (TANROADS, 2014).

Table 11-5 below analyses the breakdown of FY 2013/14 workplan on the various expenditure heads; and it can be deduced that regional roads had the highest allocation of 51.54% and this is most probably attributable to the large network which constitutes about 88% of the total network under TANROADS. Furthermore, operational costs of TANROADS are within the widely acknowledged and recommended ARMFA ranges for road authorities which are in the order of 10% of total expenditure; and are therefore reasonable.

Works components	**Amount (TShs in Millions)**	**Percentage**
Trunk roads	101,315.714	32.21%
Regional roads	162,103.560	51.54%
Emergency and urgent	6,871.541	2.18%
PMMR project	2,324.837	0.74%
Weigh bridge maintenance and improvements	3,500.000	1.11%
Headquarter based activities	4,470.000	1.42%
Total works	280,585.652	89.21%
Non works		
Administration costs	10,650.000	3.39%
Supervision costs	13,500.000	4.29%
Weighbridge costs	9,800.000	3.12%
Total non-works	33,950.000	10.79%
Total Road Funds	314,535.652	100.00%

Table 11-5 Analysis of 2013/14 TANROADS workplan (Source: adapted from TANROADS, 2014, p.1)

Table 11-6 overleaf provides an analytical comparison of FYs 2010/11 to 2013/14 activity based expenditure (TShs, billions) for TANROADS.

From Table 11-6, it can be deduced that all expenditure items increased over the years but with the rate of escalation of periodic maintenance expenditure higher than that of routine maintenance; and this can be attributable to the need to preserve asset value and delay the need for rehabilitation/reconstruction. Furthermore, operational costs have increased over the years but at a much slower rate when compared with other expenditure heads.

Activity	FY 2010/11	FY 2011/12	FY 2012/13	FY 2013/14
Routine maintenance	34.63	39.06	52.57	57.82
Periodic maintenance	83.08	90.77	129.66	154.62
Spot improvement	7.64	12,.64	17.64	21.43
Bridge maintenance	14.21	16.35	21.03	29.54
PMMR project	10.27	6.00	6.71	2,.32
Weighbridge repairs			3.50	3.5
Emergency and contingencies	4.06	3.35	4.70	6.87
Headquarter based maintenance activities	2.80	3.45	4.27	4.47
Subtotal – works component			240.08	280.58
Administration and supervision	15.97	16.57	21.90	24.15
Weigh bridge operational costs	4.80	6.50	6.00	9.80
Sub-total – non works			27.90	33.95
Budget deficit FY 08/09		2.74		
Grand Total	177.46	197.43	267.98	314.53

Table 11-6 Analysis of 2010/11 to 2013/14 TANROADS workplan (Source: adapted from TANROADS, 2012, 2014)

In 2012, TANROADS reported that the maintenance budget for FY 2011/12 was TShs 197.4billion while estimated needs as at February 2011 were TShs 283billion which implies that about 68.9% of the maintenance needs were met. This seems inconsistent considering that RFB raised over TShs 406.8billion in FY 2011/12 and using the allocation formula, TANROADS should have received 256.3billion (63% of collections). In the same vein, the budget for FY 2013/14 was TShs 314.5billion while estimated maintenance needs as at January 2013 were TShs 391billion (RFB collections in FY 2013/14 were TShs 641.2billion implying TANROADS should have received TShs 404billion). Therefore, the FY 2013/14 budget adequately covered about 80% of the maintenance needs (TANROADS, 2014). However, for maintenance activities; routine maintenance was allocated TShs 58billion (58%) against needs of TShs 100billion; periodic maintenance was allocated TShs 155billion (83%) against needs of TShs 187billion (ibid). The lack of funds to cover all maintenance requirements implies that the road maintenance backlog is escalating which will affect the sustainability of roads and equality of transport opportunities.

11.5 Tanzania road sector equity analysis

This section analyses the equity aspects in the allocation of road funds in Tanzania at macro, meso and micro levels. Thum (2004) observes that inadequate allocations of resources and weak legal and institutional structures have contributed to deteriorating Tanzania's roads. "In Tanzania (as in most African countries) road building has been given a higher priority than road maintenance, with scant attention to the imperatives of recurrent costs of road management once the road has been constructed" (ibid., p.10).

11.5.1 Macro level equity analysis

Gwilliam and Kumar (2003) observe that studies of road systems in developing economies have consistently shown that road maintenance is underfunded and often inefficient as demonstrated by low productivity in the implementation of works that receive funding. However, it is widely acknowledged that with recent maturity of road institutions following road sector reforms, the situation will most probably change. Kumar (2002) observes that in 2001, TANROADS received a total of TShs 81.6billion, of which TShs 14.9billion was for periodic and routine maintenance, TShs 52.5billion for other development works and TShs 14.2billion for agency costs. The derived *Macro Equity Coefficient (MEC)* for TANROADS in 2001 is 0.18 and the *Macro Equity Index (MEI)* is 0.74. The aforesaid values are far out of range when compared with expert based suggestions (see Section 5.2.2) and the 50th percentile rates derived from the 19 SSA countries (as seen in Table 6-1); and are therefore not equitable based on Rawlsian principles.

11.5.2 Meso level equity analysis

The Roads Fund Board allocates 63% of its funding to TANROADS for maintenance of the trunk and regional road network, 7% to Ministry of Works for development projects on the trunk and regional roads and 30% to PMORALG for local authority roads inclusive of 1% for operations (Kumar, 2002; Evdorides and Robinson, 2009). Almost 85% of the available funding for local authorities is distributed equally to urban/municipal councils albeit needs of local authorities are not uniform and are influenced by factors such as length and quality of road network, topography, economic potential, location, population and size (ibid). Considering the Roads Fund Board allocations at meso level, the derived *CRONEMI* value is 0.2 and *n-CRONEMI* is 0.52. The values are within this thesis suggested ranges and are therefore equitable (see Section 6.4) in a Rawlsian manner.

Prior to full road sector reforms, a review of Road Funds undertaken by Heggie and Balcerac de Richeour (1995) indicated that in Tanzania, the Ministry of Finance paid 20% into a Road Fund managed by the Prime Minister's office (which deals with district council roads) and 80% into a Road Fund managed by the Ministry of Works (which deals with main and regional roads). At that time, seventeen urban and eighty four rural districts were beneficiaries of the 20% allocation and the formula was based on population density, road density and stage of development; and the formula was designed to operate with reasonable data. Population density was a proxy for trip generation rates; road density was used as separation parameter to differentiate between rural and urban districts whilst the stage of development parameter was a proxy of commercial activity (ibid). Allocations favoured trunk roads at the expense of rural roads albeit the majority of the populace derives most benefit from rural roads.

11.5.3 Critique of micro level equity

Table 11-7 below analyses the funds allocated to the various TANROADS regions during 2000 when the Road Fund had just commenced operations.

Region	**Programmed funds (TShs - Millions)**	**Funds provided (TShs - Millions)**	**%age of programmed funds**
Arusha	1,224	1,876	153%
Dar es Salaam	1,450	1,641	113%
Dodoma	814	1,675	206%
Mara	708	613	87%
Mbeya	1,311	1,069	82%
Mtwara	891	655	74%
Mwanza	874	598	68%
Buvuma	1,008	1,139	113%
Total	8,280	9,266	112%

Table 11-7 TANROADS workplan and allocations to the various regions (Source: adapted from Kumar, 2002, p.18).

From Table 11-7, it can be deduced that there are major variations between planned allocations and actual releases which may not be equitable; as major urban regions such as Dar es Salaam, Dodoma and Arusha are allocated more resources when compared to rural regions such as Mara and Mtwara.

11.5.4 Road scheme prioritisation

Road scheme prioritisation by TANROADS is undertaken using HDM-4. A better proposition would be to have a system with explicit equity goals particularly for rural roads (see Section 6.5.2). There is political interference in road scheme prioritisation and no decision tool is used for district road scheme prioritisation albeit planning and reporting is to be undertaken using the District Road Management System.

11.5.5 Tanzania case study limitations

The Tanzania case study has limitations which need consideration. Financing of roads development is through various channels: Consolidated Fund (for development projects), Road Fund and donor support. Furthermore, Road Fund resources are also used for both capital investment and maintenance and it is challenging to accurately differentiate actual expenditures on maintenance versus capital investment.

11.5.6 Summary Rawlsian equity analysis for Tanzania road sector

Tanzania's road funds allocation and road scheme prioritisation is analysed in Table 11-8 below based on the various equity categories discussed in Table 2-2.

Equity type (research proxy)	**Tanzania performance (Rawlsian)**
Horizontal (macro)	There is a bias towards capital investment based on *MEC* analysis of the assessment year. Summary rating is **poor.**
Vertical (meso)	Allocations are skewed towards national roads (63%) but rural roads benefit from the 30% allocation to PMORALG although equity is not embedded. Summary rating is **poor.**
Vertical (micro)	All the 121 councils benefit from PMORALG with an equity component in funding formula. Summary rating is **good.**
Territorial (macro, meso and micro)	Road scheme prioritisation is undertaken using HDM-4 and takes account of connectivity. Summary rating is **good.**
Spatial (macro, meso and micro)	All regions do not benefit equally from road funds allocation particularly the rural districts. Summary rating is **poor.**
Social (macro, meso and micro)	Road scheme prioritisation and at all levels does not explicitly take account of social-equity issues. Summary rating is **poor.**

Table 11-8 Tanzania road sector equity performance

11.6 Chapter summary

The main authorities responsible for roads include: Tanzania National Roads Agency Prime Minister's Office for Regional and Local Governments, Roads Fund Board and the Ministry of Works. The Roads Fund Board is responsible for controlling the locally generated revenue for some of the road sector projects in the country and operates as a 2G Road Fund under the Ministry of Finance. There are inequities and inequalities at macro and micro level. The Road Authority currently receives 63% of the distributable amount after the Roads Fund Board has covered its own administration costs. Local government roads receives 30% and the works ministry is allocated 7%. Road fund collections have increased over the years and the Fund is now able to meet most of the maintenance needs. Road sector expenditure as a percentage of GDP is generally high when compared with other case study countries.

A formula is used to allocate resources at district level and previously took account of population, road length and ‘equity’ being the largest factor as each council got an equal share. The arrangement is rigid and did not reflect actual need or capacity to spend. The formula was recently revised and now takes account of road length, pavement type and road condition; however, equity needs to be embedded explicitly.

Comparison of Tanzania’s road indicators (Table 11-1) with those of Uganda (Table 7-1), Ghana (Table 8-1), Zambia (table 9-1) and Kenya (Table 10-1) shows that Tanzania has the best paved network condition and this is most probably attributable to the stable 2G Road Fund. However, Tanzania has the lowest paved road density.

Unlike Uganda, the Road Fund in Tanzania is a true 2G Road Fund able to raise its own funds and the allocation formula is simple making it easy to explain to politicians; furthermore, the formula is more equitable albeit not based on expert opinion or network needs assessment. Governance in Tanzania’s road sector institutions is more stable when compared with Zambia, Kenya and Uganda. Nevertheless, there is no road safety agency which affects Rawlsian equity.

To address the equity challenges, new allocation and road scheme prioritisation processes discussed in Chapter Six are recommended and they will in general terms provide a robust preliminary estimate; however, they can be further adapted to local needs based on expert opinion. Tanzania’s road sector Rawlsian equity performance is summarised in Table 11-8 and a comparison with other case study countries is provided in Table 13-1; which shows a generally poor performance for Tanzania. The following chapter discusses allocations in Namibia which is the last case study country.

Chapter Twelve - Namibia Case Study

12.1 Introduction

A critique and review of road sector allocations in Tanzania was undertaken in Chapter Eleven. This Chapter delves into Namibia's road sector and further extends understanding of equity in road funds allocation and road scheme prioritisation.

Namibia has the most advanced road network when compared with other case study countries. Furthermore, it has the most systematic allocation and road scheme prioritisation processes. The research finds that Namibia is the only case study country that allocates more resources to road maintenance (preservation) when compared with capital investment road projects. Furthermore, the study shows that Namibia's road sector Rawlsian equity performance is very good. The aforesaid notwithstanding, Namibia has the most unequal society in all the case study countries (based on Gini coefficient). Namibia is the last case study and is analysed at a lesser depth (micro equity partly analysed).

12.1.1 Topography, geography and climate

Namibia is a hot and dry coastal country located in Southern Africa mostly on high plateau with Namib Desert along the coast and Kalahari Desert in the east; it is bordered by South Africa to the south, Botswana to the east, Zambia to the north east, Angola to the north and the South Atlantic Ocean to the west. The country has a total area of 824,292sq.km of which 0.12% is water and the rest is land and the total population in 2013 was about 2.18million; approximately two-thirds of the population live in rural areas mainly in the north and northeast, the remaining one third live in urban areas, including the capital Windhoek, and coastal towns such as Swakopmund, Walvis Bay and Luderitz (IndexMundi, 2014). Considering that the majority of the population resides in rural areas, it can be argued that a fair allocation of road infrastructure funds should be geared to links that serve rural areas rather than urban centres; subsequently enhancing Rawlsian equity.

Namibia is one of the least densely populated countries in SSA with an average density of approximately 2.5 people per sq.km, compared to 34 people per sq.km for the region as a whole (World Bank, 2009). Given the vast size of the country and sparse population, equitable allocation of road infrastructure funds is likely to be a challenge; and principles applicable in other SSA countries which are more densely populated may not be appropriate for Namibia. Figure 12-1 overleaf shows the geographical location of Namibia from a regional and local perspective.

	
Namibia (regional context)	Namibia (local context)

Figure 12-1 Maps showing location of Namibia (Source: IndexMundi, 2014)

12.1.2 Politics and economy

Namibia was the last colonised country in SSA to become independent on 21st March, 1990 following nearly 70 years of South African rule; however, it is now a lower middle income country with one of the highest levels of per capita income in SSA (Runji, 2003; World Bank, 2009). The country has enjoyed political and economic stability since gaining independence; and it has one of the most liberal constitutions in Africa (ibid). Furthermore, the outgoing President Hifikepunye Pohamba won the 2014 ‘Mo Ibrahim Prize for African Leadership’ (BBC News, 2015). The long period of political stability in Namibia unlike in other SSA countries created an enabling environment for road infrastructure development and maintenance. Prior to independence, apartheid policies resulted in a highly polarised society with income and wealth skewed towards the minority white elites creating one of the most highly inequitable societies in the world with a Gini index of 0.6 (World Bank, 2009). It could be argued that the road infrastructure may not have been planned and maintained in an equitable manner to the detriment of rural dwellers when compared to other SSA countries which did not experience apartheid.

Namibia’s economy is closely linked to South Africa and since independence the country has experienced steady growth, moderate inflation, strong external surpluses and low debts (World Bank, 2009). Namibia’s GDP growth averaged 4.2% over 2005 to 2007 (ibid); however, the level of growth for the foregoing period is lower than for all other case study countries. The GDP per capita of US$ 5,920 is higher than the combined GDP per capita of all the other case study countries (see Table 6-7).

12.1.3 The road sector in Namibia

Road transportation in Namibia is the most predominant form of movement given the large size of the country and its sparse population. The country has an extensive road network and as of 2002, about 13% of the country's 42,000km was paved, a metric that compares poorly with middle-income countries as a whole where 44% of roads were paved (Bogetić and Fedderke, 2006; World Bank, 2009). Road density in terms of population (road-kilometres per 1,000 people) is one of the highest in the world at 21 road-km per 1,000 people compared to 4.9 for lower middle income countries (ibid). In contrast, when road density is analysed based on road-kilometres per 1,000sq.m, the density is low as a result of the large coverage of the country with a very small population. The aforesaid metrics are a result of the low population and large surface area. As a consequence, the road network is developed to respond to regional integration and social impact needs.

Considering the extremes of road density, equity in road funds allocation is likely to be a challenge. Nonetheless, the country is well endowed with respect to basic transport infrastructure and has a well-developed and built major roads network (World Bank, 1995; Runji, 2003).

According to Van Zyl et al., (2011), due to the low traffic volumes on a high percentage of Namibia's road network, rehabilitation and periodic maintenance by resealing and regravelling are not economically justified when analysed based on Cost Benefit Analysis. In 2011, the Namibian rural road network consisted of 6,128 km surfaced roads and 35,901km of unsealed roads and 60% carried less than 50 vehicles per day whilst 85% carried less than 200 vehicles per day (ibid). However, expenditure on the maintenance of unpaved roads is in excess of what can economically be justified given the low traffic volumes; and expenditure on periodic maintenance of the paved road network is below what is necessary to maintain it on a sustainable basis (World Bank, 1995). Based on the foregoing, it is most probable that the road maintenance backlog is escalating which affects equality of transport opportunities.

The Namibian road sector went through major reforms during the period 1995 to 2000 which led to the restructuring process of the Ministry of Works, Transport and Communications (MWTC) especially the Department of Transport (DoT) which brought about three new entities, the Roads Authority (RA), the Road Fund Administration (RFA) and the Roads Contractor Company - RCC (Runji, 2003; Tekie, 2005). Therefore the road sector reforms in Namibia are complete with all the necessary institutions in place albeit road safety is handled within the existing road sector institutions.

12.1.4 Road network characteristics and implementing agencies

The Namibian Road Fund Administration Business Plan for 2011 shows that the road network comprised of 10% (trunk), 25% (feeder) and 65% (district) roads. However, the feeder and district roads comprised of 90% of the total road network which would necessitate equivalent high level funding. It should also be borne in mind that 42.6% of the trunk and main road network is paved (see Table 12-1 overleaf); and this is a very high percentage when compared with other case study countries.

12.1.5 The Namibia Road Fund Administration

The Road Fund Administration (RFA) was established by the RFA Act, 1999 (Act 18 of 1999) and came into operation on 1st April 2000 to manage the Namibian road user charging system and a Road Fund; and to secure and allocate sufficient funding for the payment of expenditure as authorised in terms of the Act, with the aim of ensuring a safe and economically efficient road sector (Runji, 2003; Evdorides and Robinson; 2009, RFA, 2011). It is observed that the “RFA Act mandates the RFA autonomously, independently and expertly to fulfill the two main functions of: (i) regulating the economically efficient level of road funding, and (ii) imposing equitable road user charges on road users with the ultimate objective that such revenue should enable funding of the roads infrastructure at the economically efficient level” (RFA, 2011, p.39). RFA covers both maintenance and road development and operates as a true 2G Road Fund with all the necessary enabling systems in place. The road user charging system provides for the independent regulation of road funding in accordance with economic efficiency criteria and full cost recovery from road users, and comprises the determination of the amount and manner of funding and the imposition of RUCs to collect the funds as determined.

12.1.5.1 Critique of Namibia allocation formula

Namibia’s allocations are based on HDM-4 and RMS analysis including discussions with stakeholders; however, the allocation for national roads is about 80% and for other roads (district and feeder roads) are allocated 20%. The allocation formula although biased towards national roads is not very rigid considering that it is subject to consultations with all key stakeholders throughout the process. This goes a long way in ensuring equality of transport opportunities and sustainable developments; albeit the non-core road network requires adequate prioritisation based on principles of Rawlsian equity.

12.1.6 The Namibia Roads Authority

The Roads Authority (RA) is responsible for the management of the national road network and was established by the Roads Authority Act 1999 (Act 17 of 1999) and it commenced operations on 1st April 2000 (Runji, 2003). The RA Act specifies the functions as managing the national road network; make recommendations to the Minister regarding the application of the Act and advising the Minister or approved authority on matters regarding planning, design, construction and maintenance of all roads (GRN, 2003).

Van Zyl et al., (2011) explain that funding to the RA originates from three main sources which are:

(i) the RFA - responsible for the funding of economically viable projects on the existing road network;
(ii) government through the Department of Transport for new development and maintenance or rehabilitation projects not economically viable; and
(iii) donor funding - Ad hoc allocations for specific projects (mainly new developments).

The RA funding mechanism is similar to that of other Road Authorities in SSA. Table 12-1 below shows the RA road network length in km.

Surface	**Classification**				**Remarks**
	Trunk	Main	District	Total (km)	16% of the network under the Roads Authority is paved; which is the highest value of all case studies.
Bitumen	4,777.8	2,089.4	298.0	7,165.2	
Gravel	3.2	8,895.3	17,022.6	25,921.1	
Salt	0.0	125.9	178.3	304.2	
Earth	0.0	236.4	11,304.8	11,541.2	
Total	4,781.0	11,347	28,803.7	44,931.7	

Table 12-1 Namibia Roads Authority network 2013 (Source: adapted from Road Referencing System, GRN, 2015)

12.2 Namibia road sector expenditure

This section provides an analysis of the historical expenditure in the Namibian road sector. The HDM-4 model is utilised by the RA to enable modeling of the complex interaction between vehicles, the environment and the pavement structure and surface. The RFA relies on the economic optimisation analyses performed by the RA; however, the RFA may perform technical audits to verify the analyses. This complex interaction between various distress types and the environment is reflected in the pavement performance models used in HDM-4 which enables determination of the optimal requirement in terms of funds for the various roads. An assessment is then made of the funds the RFA is expected to collect in an optimal scenario. Given that in most cases there is a mismatch between the anticipated optimum funds to be collected and the funding requirements, an assessment is carried out to determine where the available funds should be invested to achieve an economically efficient road network given the available funds and condition of roads as determined through the HDM-4 Model and the RMS analysis. The priority in fund allocation is to preserve the roads with the most significant impact on the economy which are national roads and those that link with borders. However, rural roads should also be equally prioritised to enhance Rawlsian equity.

12.2.1 Historical and planned expenditure

The section below provides an analysis of the historical expenditure for both road network preservation and development in Namibia. Table 12-2 below provides an analysis for the period 1998/99 to 2003/04; which shows that expenditure averaged at 1.93% of GDP which is low when compared to other case study countries apart from Uganda (see Table 6-7). Analysis of Figure 7-2 (Gwilliam et al., 2009) suggests Namibia's road sector expenditure as a percentage of GDP to be about 1.3%.

Program Item	**Expenditure in US$M**				
	1998/99	2000/01	2001/02	2002/03	2003/04
Capital expenditure	15.472	25.357	11.317	30.313	39.410
Asset preservation	26.483	42.192	47.572	51.868	61.208
Total	41.955	67.549	58.889	82.181	100.618
Total as %age of GDP	1.09%	1.77%	1.51%	2.31%	2.99%
Preservation as %age of GDP	0.69%	1.10%	1.22%	1.46%	1.82%
MEC	0.63	0.62	0.81	0.63	0.61
MEI	0.20	0.20	0.09	0.20	0.21

Table 12-2 Namibia road sector expenditure 1998/99 to 2003/04 (Source: adapted from Evdorides and Robinson, 2009, p.41)

Notes: GDP (US$ billions): 1999 (3.83bn), 2000 (3.82bn), 2001 (3.90bn), 2002 (3.55bn), 2003 (3.36bn). Source: www.worldbank.org

From Table 12-2, it can be deduced that there was a steady expenditure increase over the years apart from 2001/02 where it reduced for capital expenditure. Similarly, the total road sector budget increased over the years apart from 2001/02 where there was a marginal decrease.

Table 12-3 below analyses the national roads expenditure for the five year period 2003 to 2008 in Namibian dollars (millions); and it can be deduced that: (i) the highest expenditure in all the years is on maintenance followed by rehabilitation, (ii) the administrative costs of the Road Authority are high and this may be a result of the large network and vastness of the country, and (iii) total expenditure over the years is within range of preceding years except for rises in 2004/5 and 2005/6. In addition, the derived *MEC* and *MEI* values indicate that Namibia allocates more resources to road maintenance programs than development projects.

National road network budget breakdown					
Program item	2003/2004	2004/2005	2005/2006	2006/2007	2007/2008
Administration	84.39	108.57	78.65	86.51	95.17
Planning and compensation	4.79	5.28	5.81	6.39	7.03
Rehabilitation-ongoing	130.61	209.64	112.42	35.96	
Rehabilitation-new	3.00	9.625	1.21		
Development -ongoing	18.5	20.35	13.43	0.40	
Development-new	35.80	118.20	121.11		
Labour based works-ongoing	24.83	7.72	7.04	5.99	
Labour based works-new	0.9	7.82	4.07	11.70	12.87
Project Planning	2.90	2.25	3.15	2.13	2.34
Maintenance	367.25	407.00	447.70	492.47	541.72
RMS	6.80	7.15	8.47	9.32	10.25
MEC	0.68	0.54	0.65	0.93	
MEI	0.17	0.27	0.19	0.03	

Table 12-3 Namibia road sector expenditure 2003 to 2008 (Source: adapted from RFA 5-year business plan, cited in GRN, 2003, p.50)

The RFA (2011) provides a summary of the business plan targets for road preservation over the business plan period 2011/12 to 2015/16 from which it can be deduced that: (i) for unpaved road maintenance; gravelling has the highest funding allocation as a result of the large rural road network; (ii) for paved roads; routine and periodic maintenance is budgeted to be funded at optimal level, and (iii) for paved road rehabilitation; allocations are far below optimal level. With reference to the paved roads, the reality is that funding varies and lies between 50% and 75% of the theoretical optimal levels suggested by economic analyses. Analysis of the summary of business plan expenditure based on funding from the road user charging system for the period 2010/11 to 2015/16 as reported by the Road Fund Administration in 2011 shows that national roads take the highest share at 80.5%. Similarly, road maintenance takes the largest share of financial resource which is not the case with other SSA countries. Despite the foregoing, Namibia's road network is deteriorating due to lack of adequate resources. The administrative costs which include RUCs management are very high when compared to other SSA countries.

12.3 Namibia road sector equity analysis

A public expenditure review undertaken by the World Bank in 1995 shows that provision and maintenance of road transport infrastructure in Namibia is the largest item in the public expenditure for the transport sector. Similarly, in FY 1993/94, about 87% of expenditure by the Department of Transport was on roads; however, the World Bank report also shows that the network is very extensive and maintained to a high standard. The section below provides an equity analysis of Namibia's allocations at macro, meso and micro-level.

12.3.1 Macro level equity analysis

Tables 12-2 and 12-3 provided an analysis of macro-level equity for the period 1998/99 to 2003/2004 and 2003/2004 to 2006/2007 respectively. Analysis of the *MEC* and *MEI* values shows that Namibia allocates substantial resources to road maintenance above the recommendations of the expert opinion surveys and literature review (over and above the 50th percentile rates). However, Namibia has an advanced economy with a well-developed road network when compared to other SSA countries. This most probably explains the significant allocation towards maintenance. The allocation over and above literature review recommendations supports the notion by most experts that macro level allocations should be based on network metrics and should be country specific.

12.3.2 Meso level equity analysis

Table 12-4 overleaf provides a meso level equity analysis of the five year Road Authority business plan for 2010/11 to 2015/16 in Namibian Dollars (Millions). New parameters which are variants to the meso level formulae developed in Section 6.4 are proposed for analysis of Namibia's road sector. A *Local Roads Equity Factor* and

Local Roads Equity Index are proposed (see equations 9.1 and 9.2). From Table 12-4, the *LREF* (ratio of local/urban roads to total) is 0.054 whilst the *LREI* (common logarithm of the inverse of *LREF*) is 1.27. A low *LREF* value indicates low allocations to local roads. Appropriate ranges for meso level equity are identified through the expert opinion survey results in Section 5.4.2 and Table 6-2 based on analysis of data from 15 SSA countries.

Year	**10/11**	**11/12**	**12/13**	**13/14**	**14/15**	**15/16**	**%age**
Administration	192.98	229.76	236.41	274.60	287.42	295.37	16.4%
Planning	25.03	20.53	11.40	13.40	13.40	14.40	0.9%
RMS	11.29	14.92	15.11	14.87	14.65	16.56	0.9%
Maintenance	607.63	696.78	696.44	731.27	767.84	806.23	45.9%
Rehabilitation	10.26	119.45	212.95	243.70	205.50	200.00	12.2%
Development	113.92	138.22	152.48	33.75	2.5	0	4.1%
Subtotal (bn)	0.96	1.22	1.32	1.31	1.29	1.33	80.5%
Transport information, road safety	71.98	77.53	81.88	86.58	91.60	96.96	5.4%
Urban roads							
Maintenance	80.30	79.47	82.95	86.60	90.43	94.44	5.4%
Planning	0.2	0.2	0.2	0.2	0.2	0.2	0.0%
Sub total	80.50	79.67	83.15	86.80	90.63	94.64	5.4%
RUCs admin/ other costs	340.37	193.82	155.70	153.04	113.79	86.03	8.7%
Total (bn)	1.45	1.57	1.65	1.64	1.59	1.61	100%

Table 12-4 Namibia Road Authority expenditure plan 2010/11 to 2015/16 (Source: adapted from RFA, 2011, p.16)

12.3.3 Critique and analysis of micro level equity

The majority of regions in Namibia are in need of improved local transport access. A robust prioritisation method was proposed in the masterplan to define a regional priority index (GRN, 2003); as shown in equation 12.1 below:

$$R_n = P_n\,(a \times Idp + b \times Ise + c \times Ia) \times 10^{-6} \qquad (12.1)$$

Where R_n is region ranking factor of region n, P_n is population of region n, *Idp* is agricultural development potential index, *Ise* is socio-economic index, *Ia* is accessibility index and the coefficients *a, b, c* are weighting constants (a+b+c=1.0). The formula is plausible but equity aspects depend on the values of *b* and *c*.

The major weakness of equation 12.1 is the importance attributed to population as a criterion and does not consider population density. Similarly, allocations based on the aforementioned formula means that regions with a low population will in most cases receive the lowest allocation. A better approach to overcome this problem is to consider population as a weighted index. In the same vein, an improved method could include computations based on a Human Development Index for each region, to reflect social needs or use of a Multi-dimensional Poverty Index. Human Development Index has three fundamental parameters: (i) life expectancy at birth; (ii) education attainment inclusive of adult literacy rates; and (iii) per capita/household incomes (UNDP, 2014); the index is derived from the geometric mean of normalised indices for each of the three dimensions; and ranges from 0 to 1.0 and the greater the value, the higher the level of human progress. It is pointed out by the Namibian Government that the National Transport Development Plan of the year 2000 proposed an approach for allocating funds for intra-regional roads to regions which is based on the area as well as the average level of 'under-servedness' based on population density, length of road network, distance to service centres, the availability of education and health facilities (GRN, 2003). The level of 'under-servedness' is expressed as an index (0-10), and the regions with the highest level of 'under-servedness' receive the highest score.

12.3.4 Road scheme prioritisation

Namibia uses RMS in identifying and prioritising periodic maintenance, upgrading of the unsealed road network and rehabilitation of paved surface roads (Tekie, 2005; Van Zyl et al., 2011). The approach is equitable as it is partly based on a needs assessment and stakeholder consultations. However, consideration should be given to the use of the prioritisation methods suggested in this thesis (see Section 6.5.2).

12.3.5 Namibia case study limitations

The Namibia case study has limitations which need consideration. The collection forecasts and budgets allocated to agencies do not necessarily result into actual releases. Road Fund resources are also used for both capital investment and maintenance and it is challenging to accurately differentiate actual expenditures on maintenance versus capital investment. Namibia has a good road network and management systems when compared with other SSA countries.

12.3.6 Summary Rawlsian equity analysis for Namibia road sector

An analysis of Namibia's road funds allocation and road scheme prioritisation is summarised in general terms in Table 12-5 overleaf based on the various theoretical equity categories discussed in Table 2-2.

Equity type (research proxy)	Namibia performance (Rawlsian)
Horizontal (macro)	Namibia allocates substantial resources towards maintenance when compared with capital investment. Summary rating is **very good.**
Vertical (meso)	Allocations are biased towards national roads (80%). Summary rating is **poor.**
Vertical (micro)	Allocation formula takes account of equity by use of a socio-economic index. Summary rating is **good.**
Territorial (macro, meso and micro)	Road scheme prioritisation is undertaken using HDM-4 and RMS. Prioritisation takes account of regional and international connectivity. Summary rating is **good.**
Spatial (macro, meso and micro)	All individuals and regions do not benefit equally from road infrastructure funds allocation particularly the rural districts. Summary rating is generally **good.**
Social (macro, meso and micro)	Road scheme prioritisation and investment decisions at all levels do not explicitly take account of social-equity issues. Summary rating is generally **poor.**

Table 12-5 Namibia road sector equity performance

12.4 Chapter summary

Namibia has an advanced economy and a GDP per capita higher than many countries in SSA albeit road sector expenditure as a percentage of GDP is generally low. The road network is well developed and is of good standard. It is a vast country but sparsely populated with a high *Gini* coefficient due to the apartheid regime that existed until 1990; however, Namibia has a stable political environment. Prioritisation of road schemes is undertaken using HDM-4 and RMS. The macro and meso allocation algorithms and concepts proposed in Chapter Six are recommended for Namibia and they can be adapted to local needs based on expert opinion. Options for adjusting factors for allocations at micro-level are proposed which include use of the Human Development Index and Multi-dimensional Poverty. Namibia is the only case study country where allocations for road maintenance exceed those of capital projects. Nevertheless, RMS records indicate that the road network is deteriorating.

Namibia's road sector Rawlsian equity analysis is summarised in Table 12-5 and a comparison with other case study countries is provided in Table 13-1 which shows a generally good performance. The following final chapter summarises the thesis by analysing the research aims and objectives and how they have been achieved.

Chapter Thirteen - Conclusions

13.1 Introduction

This final chapter draws conclusions from the study by revisiting the aims and objectives of the research outlined in Chapter One and explaining how they have been addressed in order to advocate for equitable road funds allocation and road scheme prioritisation in Sub Saharan Africa (SSA). Experts agree with the author that this is the very first documented attempt at addressing the equity problem of road funds allocation and road scheme prioritisation in SSA as defined by this thesis.

In order to attempt embedding principles of Rawlsian equity in the SSA road sector, the crux of this study was to develop equity-centred assessment parameters and propose Goal Programming as a method for determination of road funds allocation and road scheme prioritisation; based on weightings (rankings) provided by experts but buttressed with literature review evidence and the author's experience as a Road Fund manager in Uganda. Experts who participated in the face to face interviews concur that the proposed Rawlsian equity assessment tool (Table 6-6) for the SSA road sector is unique.

A review of the contribution of the thesis in light of the research objectives is discussed in this chapter including a summary of the findings for each aim and objective. The limitations of the research are explained along with identification of further areas for future research. The chapter also concludes with recommendations and some final reflections on the whole study.

13.2 Knowledge contribution of the Thesis

13.2.1 Re-examining the objectives of the research

This study set out to investigate and develop new formulae and processes for road funds allocation and road scheme prioritisation which consider the principles of Rawlsian equity given their importance and limited consideration in developing countries particularly those located in SSA (see Section 1.3).

Whilst recognising the importance of equality of transport opportunities and sustainable road projects, the main goal of this study was to develop equitable principles, formulae, algorithms and Goal Programming (GP) models for road funds allocation and road scheme prioritisation in SSA; based on expert opinion and empirical data. Application (testing) of the developed processes has been undertaken through statistical analyses of road sector budgets and expenditures together with road scheme prioritisation processes used by Road Funds and Road Authorities in the case study countries of: Uganda, Ghana, Zambia, Kenya, Tanzania and Namibia.

It is believed that equitable road funds allocation in SSA has challenged experts for a long time as they often have varying opinions and rarely collectively consult. Furthermore, in some cases there are inconsistencies in data from the various sources within individual countries; and cross country comparisons are challenging to undertake. A panellist who is currently a Policy Advisor in one of the case study countries concludes that:

> *"Sources of funds are important and can influence allocation mechanisms. Where road users contribute directly to road funds and maintenance, it seems fair that they have a say in allocation. Where government funds road maintenance from the Consolidated Fund [Treasury], then surely it has the right (and certainly the power) to allocate funds as it wishes (which may not be equitable or efficient!)".*

The findings of this thesis contribute to the discourse with a view of narrowing the knowledge gap in this area. The originality of this thesis revolves around developing over-arching equity driven multi-criteria allocation algorithms, Goal Programming models and Rawlsian equity assessment tool using factors and weights (scores) derived from expert surveys from practitioners with significant practical African experience; and supplemented with empirical analyses from literature evidence. Forty four experts with experience from seventeen countries constituted the Stage One panel and fifteen of these panellists had experience from other developing regions apart from SSA (see Table 5-1). Twenty nine experts continued with the Stage Two survey and their experience encompassed fifteen countries; and ten of these countries are in SSA (see Table 5-5).

In order to systematically work towards achieving the main research goal, Chapter One included an analysis of the research problem and motivation including the scope and benefits of the study. Chapter Two of the thesis delved into literature review of equity and its fundamentals and it was determined that equity revolves around the distribution of impacts (benefits and costs) and whether that distribution is fair and appropriate. Equity is often referred to as fairness or social justice but sometimes confused with equality. However, the evidence from this study suggests that there is no ideal standard measure of equity and its interpretation varies depending on context. Similarly, there are different classifications of equity and these have been compared and contrasted with the study's categories of equity (macro, meso and micro). In Chapter Two, the author identified the three main equity theories namely:

egalitarian, utilitarian and Rawlsian; and it was further determined that the thesis should be based on Rawlsian equity in SSA road sector as it is not highly prioritised and this affects equality of transport opportunities.

A literature review of algorithms, decision support systems (including relevancy and transferability) and allocation formulae was then undertaken in Chapter Three. It was determined that ‘algorithms’ are essentially procedures (steps) for solving problems and they take on various forms. Some of the existing decision support tools for road funds allocation and road scheme prioritisation were also analysed and they incorporate algorithms; however, in most cases, economic efficiency is the primary criterion considered when allocating road funds and road scheme prioritisation whilst principles of Rawlsian equity are seldom highly prioritised. The most obvious but fundamental finding from this study is that best practice road funds allocation formulae should be simple and use a few factors as possible or combination for which data is readily available albeit there is no ‘one size fits all’. The allocation formulae, GP models and road scheme prioritisation algorithms developed in this thesis will always (in general terms) provide a robust preliminary estimate. However, they require adaptation to country specific road network metrics in consultation with key stakeholders and local expert opinion should be sought.

The literature review of equity and algorithms in Chapters Two and Three respectively culminated in the identification of the research gap which this thesis has attempted to narrow.

In Chapter Four, an exploration of the principles and ethos behind some of the available research types was undertaken and it became evident that whilst developing equitable algorithms for road funds allocation and road scheme prioritisation, it is prudent to use a variety of methods which deal with numbers as road funds allocation is expressed numerically; and to ensure that social impacts such as multi-dimensional poverty are considered appropriately, opinions of experts ought to be critically examined and incorporated. Chapter Four culminated in the proposition to use a combination of both quantitative and qualitative methods; and incorporating expert opinion surveys. The research methodology review enabled the identification and justification of the multiple case study approach which was then used to test the developed algorithms and Rawlsian equity assessment tool.

Chapter Five analysed and critiqued expert opinion on road funds allocation and road scheme prioritisation from road sector experts with significant experience in SSA and other developing countries. Cognisant of their opinions combined with the author’s SSA experience, a matrix was developed to assist policy makers in developing countries in the allocation of their road funds as well as road scheme prioritisation (see Section 5.4). The study finds that the key important criteria for road funds allocations are: economic efficiency, social equity, needs basis, regional connectivity and network metrics. Similarly, the most important factors that were identified to play key roles in prioritising roads in SSA are: economic efficiency, social equity, regional connectivity, and political consideration. Furthermore, in order to achieve a fair allocation formula for road funds at regional and district/lower local government level; key criteria should include: social factors (multi-dimensional poverty and human development index), population density, Rural Accessibility Index (modified), network metrics, regional connectivity and agricultural productivity/extraction of natural resources.

Another interesting finding is that despite the importance of the aforementioned factors, a number of the experts opined that SSA countries should allocate their entire road sector funding towards road maintenance and clearing the existing backlog prior to consideration of capital investment projects. However, as observed by other experts, this is politically untenable and can also be detrimental to social equity particularly for rural dwellers and those located in areas with no (limited) access. The majority of Stage Two experts posited that a network needs assessment ought to be undertaken; however, although this is probably the most logical approach, it can be very expensive, time consuming and often data collected is inaccurate particularly for the non-core road network. Moreover, the road condition especially for gravel and earth roads which constitute the largest part of the network in all SSA countries evolves rapidly following seasonal changes. Therefore, a needs assessment is likely to be required every year which can be very expensive and diverts financial resources which ought to be allocated to physical works.

The author in Chapter Six develops equity-centred GP models, Rawlsian equity assessment tool, allocation algorithms and decision frameworks for analysis of road funds distribution in SSA at macro, meso and micro levels (including road scheme prioritisation); and they are based on literature review evidence and expert opinion. The equity coefficients and indices were developed using 50th percentile (median) rates derived from historical expenditure profiles of a number of SSA countries and taking account of expert opinion. Weighted and lexicographic GP models are proposed for road funds allocation at macro, meso and micro levels and road scheme prioritisation; and a worked example using data from the Uganda National Roads Authority was provided (see Sections 6.3 to 6.5). This is comparable to work in this area undertaken in Indonesia by other scholars such as Leinbach and Cromley (1983). Furthermore, limitations of the GP process are also elaborated and a bespoke spread sheet is developed which gives decision makers the opportunity to provide scores and weightings for the various factors which results in allocation percentages for macro, meso and micro funds distribution.

From Chapter Seven to Twelve, equity features of road funds allocation formulae and road scheme prioritisation processes in the case study countries were critiqued using equations, formulae, frameworks/tools and algorithms developed in Chapter Six. In depth investigations were undertaken for Uganda (pilot case), Ghana and Zambia; whilst Kenya, Tanzania and Namibia were examined at less depth but covering all important aspects. In order to achieve generalisation of the developed algorithms and formulae, it was deemed prudent to test (validate) the systems using a combination of both coastal and land-locked countries and the coverage encompassed: East Africa, West Africa and Southern Africa. In all the case study countries, Road Funds and Road Authorities are in place but with varying maturity levels. The study also provides evidence to the widely acknowledged view that in most SSA road sector institutions, there are corporate governance challenges and road funds allocations and road scheme prioritisation is often non-systematic and subject to political manipulation despite existence of formulae and decision support systems.

It is believed that convoluted corruption and maladministration within some of the road sector institutions in the case study countries affects equality of transport opportunities and project sustainability which is detrimental to Rawlsian equity. Furthermore, the findings of this study show that there are major challenges in achieving equality of transport opportunities and this leads to unsustainable road projects. Nonetheless, there is a strong and urgent case for a complete paradigm shift in road sector transport policy in SSA to mitigate resource wastage.

Finally in this Chapter Thirteen, the findings are brought together. The aims and research objectives are reviewed in detail below whilst recognising the need to achieve equality of transport opportunities based on the principles of Rawlsian equity (maximin).

13.2.2 Aim one

The first aim of the study was to examine and critique the allocation of funds between capital investment projects (new road construction and major rehabilitation) versus maintenance (periodic and routine maintenance); and this horizontal split is termed as macro level equity. Three key objectives under macro equity were identified and they are evaluated in the following paragraphs:

The first objective under Aim One of the study was to determine whether an allocation framework or formula is necessary and justifiable for allocating between capital investment road projects and maintenance schemes. Literature review evidence and expert opinion based on this research justify the need for allocation formulae and frameworks as best practice tools particularly when formulae are consistent with policy. To some extent, formulae assist in shielding Road Fund managers from political interference. However, there is no overarching formula and allocations should be country specific and ideally based on the network needs following a study. In the absence of such a study; allocations ought to be based on the macro equity coefficients and indices posited in this thesis which have been derived by comparing/analysing data from nineteen SSA countries and expert opinion. Furthermore, evidence from this study shows that in some case study countries, macro level allocations oscillate widely from year to year without any proper scientific basis. However, as discussed in Section 8.1.5, the United Nations Economic Commission for Latin America and the Caribbean recommends annual expenditure on road maintenance of between 2.5% and 3.5% of asset value.

The second objective under Aim One was to use the developed Goal Programming (GP) models and assessment parameters to analyse and critique existing equity principles of the case study data countries cognisant of expert opinion. This study has determined that Rawlsian equity is not highly prioritised and SSA governments do not have explicit equity goals and in some cases equity is completely ignored. The research finds that the overriding factor in road funds allocation is economic efficiency. Furthermore, evidence from this research shows that there is a high appetite for capital investment road projects particularly during periods leading to elections as these schemes are vote winners and are therefore favoured by politicians. To the general public, the benefits of capital investment road projects are more obvious and immediately visible when compared with maintenance of existing roads. However, the Internal Rate of Return of road maintenance projects is far much higher than that of new road projects.

Analysis of historical expenditure/budget data in the case study countries has been undertaken using the developed equity assessment parameters. Subsequently, the developed GP models have been recommended albeit they require adaptation to individual countries.

The final objective under Aim One was to demonstrate to key stakeholders such as governments, funding agencies, politicians and decision makers that continued prioritisation of expenditure on capital investment projects at the expense of maintenance of existing road infrastructure gradually leads to an overall increase in maintenance backlog, higher vehicle operating costs and is not equitable as capital investment projects are often expensive and usually funded from government borrowings and do not benefit the majority of the population. Through this study, it has been demonstrated that the macro level inequities have been extant from times when SSA countries gained independence and the imbalance may have been exacerbated by the colonial regimes whose planning and expenditure on roads was resource exploitation driven and not equity-centred. There is evidence of escalating backlog as a result of the mismatch in funding and this is leading to the deterioration of roads (loss of asset value) and is unsustainable and affects equality of transport opportunities. Moreover, the mismatch imposes an unnecessary financial burden of rehabilitation in the long term. In some SSA countries, the rate (number of kilometres) at which roads are falling into the maintenance backlog category far outstrips new construction (see Section 7.3.1); and this is an inefficient way of use of resources.

13.2.2.1 Aim one hypothesis and conclusions

The hypothesis under the first aim was that most SSA countries have a strong bias towards capital investment road projects to the detriment of road maintenance schemes which leads to the loss of asset value and is not fair to the majority of the people who potentially would benefit from road maintenance projects. Through literature review, case study data statistical analyses and expert opinion, it has been demonstrated that the hypothesis is valid for all case study countries with the exception of Namibia which is a more advanced economy with more professional planning processes and a good road network. It is most probable that equitable allocation between capital investment and road maintenance is not well understood as politicians are biased towards capital investment projects for short term political gains and this affects equality of transport opportunities and is a hindrance to sustainable developments.

In order to improve equity under Aim One, the developed Rawlsian equity assessment tool should be used; and countries with less developed road networks should target the lower values of the macro equity coefficient range whilst countries with more developed road networks should target the upper values.

13.2.3 Aim two

The second aim was to perform an analysis and critique of the allocation of road maintenance funds between the various road network classes. This vertical split is termed as meso-level equity and the following paragraphs show how the key objectives under this aim have been addressed.

The first objective under Aim Two was to investigate reasons why key stakeholders are seldom in agreement on the allocation principles for maintenance funds under the various road network classes and determine whether the existing models and formulae achieve their intended goals with particular emphasis on equity. Analysis of data from case study countries indicates that various formulae and factors are used in allocations. Furthermore, survey results show that experts provide different scores and weightings for the criteria based on their perception, interpretation and opinion as regards meso level equity. The most probable reason why stakeholders are in disagreement is that they rarely collectively consult and there is lack of sufficient accurate historical data to make meaningful evaluations. Furthermore, the lack of agreement may be partly due to the knowledge that ultimately allocations will be politically driven. With regards the extent of equity incorporation in existing models and formulae used in SSA, expert opinion is that they do not achieve their intended equity goals although they are better than not having any assessment tool in place.

The second objective under Aim Two was to use evidence from literature supplemented by expert opinion; and propose appropriate equitable allocation algorithms, GP models and assessment parameters for allocation of road maintenance funds among the various road network classes. To this effect, GP models, Rawlsian equity assessment tool, allocation spreadsheets and indices/coefficients have been developed. However, there is no uniform formula and allocations should be country specific based on the network needs following a study whenever possible. In the absence of such a study; allocations ought to be based on the meso equity indices posited in this thesis which have been derived by analysing data from fifteen SSA countries and expert opinion. The study finds that in most case study countries, meso level allocations vary from year to year without any proper scientific basis; however, there is a strong bias towards national roads particularly for countries without Road Authorities responsible for rural roads.

The final objective under Aim Two was to critique existing methods and propose modifications and improvements to the underlying principles in existing decision support systems and subsequently develop equitable formulae which use accurate data that is readily available, defensible, representative and easy to collect in SSA. The study finds that the existing methods and models are data intensive and availability and reliability of data in SSA is a challenge. Some of the formulae used in case study countries (such as Uganda) whose factors (variables) are backed by legislation do not have the attributes of good allocation formulae as determined from literature review (see Section 3.2). Furthermore, in almost all road funds allocation formulae used in case study countries, priority is given to economic efficiency criterion and equity is not highly weighted. Modifications have been proposed for some of the existing formulae and allocation processes to incorporate equity through the use of GP models.

13.2.3.1 Aim two hypothesis and conclusions

The hypothesis under the second aim was that there is an over emphasis in allocation of resources towards the trunk (national) or strategic highway network (based on economic efficiency criteria) at the expense of rural and provincial/district roads albeit the later are used by the majority of the populace, are important primary networks for movement of agricultural produce and also link communities to key amenities such as employment centres, schools and health facilities. Through the literature review, case study data statistical analyses and interpretation of expert opinion, it has been demonstrated that the hypothesis is valid for all case study countries. The mismatch can to a great extent be resolved by use of the suggested targets for core road network meso level index developed in this thesis which is based on empirical analyses from fifteen SSA countries. Furthermore, the use of a GP model whilst highly prioritising social equity (multi-dimensional poverty) is likely to go a long way in mitigating the inequities of rural dwellers who mainly benefit from rural roads maintenance.

13.2.4 Aim three

The third and final aim was to investigate and critique the equity aspects of road scheme prioritisation and allocation of road funds within the following categories: (i) capital investment schemes; (ii) road maintenance schemes, and (iii) various local government jurisdictions such as: regions, districts, provinces, municipalities, town councils and sub-counties. This diagonal split of road funds among capital investment, road maintenance, network classes and jurisdictions is referred to as micro-level equity. The key objectives under the diagonal funds allocation are evaluated in the following paragraphs:

The first objective under the final aim was to review using literature and case studies some of the existing prioritisation models and allocation mechanisms and provide a critique with reference to transferability (relevancy in SSA context), complexity, data intensity and equity; and subsequently propose modifications and new equity indices which incorporate reliable and readily available data. The study finds that the standard prioritisation models which are widely used on World Bank projects are

HDM-4 and RONET and a review has been undertaken (see Table 3-5). However; they are data intensive tools which are heavily weighted towards economic efficiency and prioritise high traffic volume roads hence some social equity elements are lost. In instances when they are used, their results are often not followed and prioritisation is politically influenced; thus the need for simpler methods as proposed in this thesis. Furthermore, HDM-4 requires laborious calibration to country conditions which can be time consuming.

The second objective under the third aim was to propose new formulae and algorithms for road scheme prioritisation and allocations to various jurisdictions which are fair. To this effect a participatory allocation framework (which also takes account of regional balance and multi-dimensional poverty) and a GP model based on expert identified factors and weightings (scores) has been developed.

The third objective under the final aim was to logically and systematically develop new rational and participatory prioritisation frameworks that can be used by funding agencies and policy makers in the comparative assessment of road funds allocation and road scheme selection. New frameworks have been developed for road funds allocation and road scheme prioritisation and are multi-criteria and participatory (see Tables 6-3 and 6-5; and Figure 6-2).

13.2.4.1 Aim three hypothesis and conclusions

The final hypothesis was that decision makers appear not to be fully conversant with the governing principles of road scheme prioritisation and often do not follow analytical results. Based on the statistical analyses of expert opinion survey results, this part of the hypothesis has some weaknesses as decision makers are very conversant. However, they acknowledge that resource distribution amongst various jurisdictions is non-systematic, often unfair and partly aimed at political patronage. Road schemes are selected mainly on political basis with limited consideration of stakeholder participation and equitable allocation principles. Subsequently, this affects equality of transport opportunities and is unsustainable. The GP models and Rawlsian equity assessment parameters suggested in this thesis if applied correctly will go a long way in mitigating the inequities.

13.3 Key findings emanating from the research

The following key results have been drawn from the combined examination of literature, case study data and the two stage expert survey supplemented with face to face interviews.

13.3.1 Macro level equity

There is no ‘one size fits all’ as regards equitable allocation of funds between capital investment road projects and road maintenance. This research has shown that the existing macro-level percentage split in road funds allocations varies from country to country and in some cases it also varies on a yearly basis within each country. There is no systematic trend or agreed formula for macro-level allocations in the study countries.

In some countries such as Uganda and Zambia; this research has determined that during the periods leading to elections, there is an escalation in capital investment project expenditures at the expense of maintenance which affects equality of transport opportunities and creates unsustainable road projects. Indeed some roads which were not previously evaluated and prioritised for inclusion in road sector development (investment) plans suddenly appear for implementation in the form of government directives.

In principle, a network needs assessment should be undertaken to determine the macro level allocations albeit data reliability in SSA is a challenge. In countries with relatively modern road networks, there is a justifiable case for allocating more resources towards maintenance of existing roads as is the case with Namibia. However, in the other case study countries with less developed networks; it is necessary to open up new roads to link communities and improve Rawlsian equity. Despite the foregoing, the existing road network should not be allowed to deteriorate beyond maintainable standard and the entire network should throughout the year receive routine maintenance which should have a high component of labour-based works as this has more trickle down financial effect. Periodic maintenance should be carried out on the key routes including those of social and regional importance. Furthermore, it is also logical to seal (tarmac) gravel roads preferably with low cost seals to limit long-term costs on a whole life costing basis; as good gravel is increasingly becoming scarce. Moreover, perennial grading prior to re-gravelling is likely to lower the road levels often turning the low lying roads into ‘mini-rivers’ during heavy rain seasons.

In the absence of a country wide road sector financing/investment plan based on needs or if accuracy of data is doubtful and in some instances data is obsolete; the macro equity coefficient and macro equity index posited in this study which were based on expert opinion and 50th percentile rates from nineteen SSA countries will always provide a robust preliminary estimate in general terms. Furthermore, GP can be applied on the determination of allocations of road infrastructure funds at macro-level. Based on the survey of expert opinions in this study, GP can be used in road sector budgets to ensure capital investment expenditure is within the 30% to 40% range whilst maintenance expenditure is within the 60% to 70% range (see Section 5.2.2).

Considering macro level allocations, one expert observes that:

> *"…to some extent policy drives allocations and where policy is implemented consistently then there is some degree of fairness".*

13.3.2 Meso level equity

As was the case with macro-level equity; in meso-level equity, there is no 'one size fits all' as regards equitable allocation of funds between the various road network classes. This study has shown that the percentage distribution in allocations varies from country to country and in some cases on a yearly basis within the country. Formulae are used in meso-level allocations; however, they are heavily weighted towards national/trunk roads at the expense of rural roads. Ideally, a network needs assessment should be undertaken to determine the meso level distribution as it will depend on the length and condition of the various network classes. An expert with consultancy experience in several developing countries including Kenya, Zambia and Uganda explains that:

> *"In Uganda the proportion of [maintenance funds allocation to] national roads has moved from 67% to 74% to 65% over the last three years, but in each year the absolute allocation has increased. Typically 50% of the road network (hierarchically) carries 90% of the traffic, so you would expect the allocation to be skewed towards national roads, as it is in both Uganda and Zambia. In the former, the split is not made at first; it is a result of the allocation. In Zambia, the split is a policy decision. Interestingly, the results are similar. In Kenya, however, the split for national roads is 40% (policy decision). This seems to be lower than elsewhere as there is a national agency responsible for local roads. This seems to have more clout in its ability to attract funds".*

In the absence of a needs assessment for the various road network classes or where data is obsolete; the meso equity indices posited in this study will always provide a robust preliminary estimate. Furthermore, GP can be applied in the determination of allocations for road infrastructure funds at meso-level. In addition, a bespoke spreadsheet has been developed which incorporates input from expert opinion to determine equitable allocations for the various road network classes.

13.3.3 Micro level equity

Micro level equity concerns road scheme prioritisation for both capital investment projects and maintenance schemes; and regional/lower local government level allocation of funds as discussed below:

13.3.3.1 Road scheme prioritisation

The results of this investigation show that road scheme prioritisation in SSA is heavily politically influenced. However, almost all experts concur that for national roads, prioritisation for both capital investment and maintenance schemes should be based on economic efficiency. In contrast, it is argued in this thesis that Rawlsian equity should play a major role in national roads prioritisation. For rural roads, experts propose that some element of social equity (multi-dimensional poverty) should be considered and for regional roads the governing criterion should be connectivity. If the aforesaid is followed then there would be some good degree of enhancement of equality of transport opportunities and the developments will most probably become sustainable. It is however noted that almost all SSA economies have a large component of agriculture albeit existing allocation formulae do not consider or highly prioritise agricultural productivity factors. Weighted and lexicographic GP models suitable for use by decision makers in SSA countries and which incorporate expert opinion have been developed to mitigate the inequity in allocations and the haphazard road scheme prioritisation (see Section 6.5.2). Two stages have been proposed (strategic planning level and implementation level). The developed GP models for road scheme prioritisation are a confluence and extension of the work undertaken in this area by Leinbach and Cromley (1983) in Indonesia and Taplin et al., (1995) in Western Australia. However, to ensure *Pareto efficiency*, the new algorithms incorporate boundaries in the form of an implementation efficiency factor (absorption constraint), funding availability factor (cash flow constraint) and are based on the expert panel identified equity criteria.

13.3.3.2 Micro level allocations to lower local governments

Various methods have been proposed (recommended) depending on data availability for a given country. The general framework process follows ten steps as described in detail in Table 6-3. In summary: (i) set equity as a goal, (ii) create an equalisation fund, (iii) provide an allocation for rural community access roads, (iv) allocate funds for road safety, (v) split the country into quadrants, (vi) allocate equally to each quadrant, (vii) for each quadrant determine network metrics and social characteristics, (viii) set criteria for determination of qualifying agencies to benefit from the equalisation fund, (ix) involve stakeholders, and (x) re-run the processes until equity is achieved.

13.3.4 Comparative assessment of Rawlsian equity performance of case study countries

Table 13-1 below compares the qualitative performance of Rawlsian equity in the road sector of the case study countries in general (overarching) terms using the tool developed in Table 6-6. Horizontal and vertical equity are based on the coefficients and indices developed in this thesis; territorial, spatial and social equity considers case study data (formulae, road selection methods) and also takes account of the SSA road sector equity imbalances analysed in Section 2.1.4.

Equity category		Uganda	Ghana	Zambia	Kenya	Tanzania	Namibia
Horizontal (macro)		poor	good	good	poor	poor	very good
Vertical	Meso	poor	poor	poor	very good	poor	poor
	Micro	good	poor	poor	very good	good	good
Territorial	Macro	good	good	good	good	good	very good
	Meso	good	good	good	good	good	good
	Micro	poor	poor	poor	good	poor	poor
Spatial	Macro	poor	poor	poor	good	good	good
	Meso	poor	good	poor	poor	poor	good
	Micro	good	poor	poor	poor	poor	poor
Social	Macro	poor	good	poor	good	good	poor
	Meso	poor	poor	poor	poor	poor	poor
	Micro	good	poor	good	poor	good	poor

Table 13-1 Summary Rawlsian equity performance of the road sector in the case study countries

Analysis of Table 13-1 shows that in general terms, Kenya and Namibia's road sector performance is the most equitable; followed by Ghana and Tanzania. Uganda and Zambia have the worst performance. Although Zambia allocates significant resources to the road sector when compared to other case study countries, they are biased towards new road construction; furthermore, the corporate governance challenges in some of the road sector institutions are a major contributory factor to the poor Rawlsian performance. In the case of Uganda, the poor performance is attributed to the complex road maintenance funds allocation formula, lack of a 2G Road Fund, unsystematic road scheme prioritisation processes and the corporate governance challenges in some of the road sector institutions.

Kenya's good performance is attributable to the existence of a 2G Road Fund, a road safety agency, an authority dedicated to rural roads and a relatively fair albeit rigid allocation formula. Namibia's good performance is a result of the good road management systems and expertise, 2G Road Fund, stable political environment and good corporate governance. Despite Ghana having one of the oldest Road Fund in SSA and other road sector institutions in place, its relatively poor performance is attributed to corporate governance challenges which result in yearly fluctuations in allocations; and inappropriate use of decision support tools. Although Tanzania's road sector institutions have had stable governance for a long time, the poor performance is caused by the over emphasis of allocations towards national roads, lack of regional balance in allocations, political interference in road scheme prioritisation, a rigid allocation formula and lack of a road safety agency. Furthermore, the Tanzania Roads Fund Board does not allocate resources to community access roads and tourism roads.

13.4 Limitations of the research

The study identified that there are several equity categories and there are challenges relating to uniform interpretation and applicability (transferability). Furthermore, equity definition varies with contextual setting. Transport equity measurement and analysis is a complex phenomenon due to the various equity categories, different interpretation mechanisms, numerous impacts and data sources and a wide range of parameters that may be considered. There is no clear definition in practise or theory, of what constitutes a fair distribution of benefits from road maintenance or capital investments projects; and the same applies to macro, meso and micro level equity.

The research has been undertaken using data from SSA countries and expert opinion was obtained from practitioners with experience mainly in Africa. Prudence is required when applying the developed tools and resultant findings of this thesis to other developing regions in the world, however, the underlying principles are likely to replicate. Cross country comparisons are challenging due to factors such as: different reporting periods (FYs), different data collection and measurement methods, currency rebasing, varying inflation rates, different currencies and different road sector institutions with varying levels of maturity. Furthermore, currencies in some cases have not been converted to a uniform currency (such as US$) given the historical nature of the data and highly fluctuating monthly/yearly exchange rates. However, this limitation has been mitigated through standardisation by use of percentages rather than absolute figures when undertaking comparisons. In some case studies the sample years analysed cover a short period, however, the findings have been supplemented by expert opinion surveys.

About 30% of the Stage One panellists were from Uganda albeit a large percentage had working knowledge and experience from other SSA countries. In order to mitigate against potential bias, some of the results of the Stage One panellists with Uganda experience were not used in the Stage Two analysis. The aforesaid notwithstanding, all other case study countries had at least one highly experienced expert in Stage Two. The survey panel was selected mainly from Road Funds and Road Authorities in Africa who subscribe to ARMFA and AFCAP. The questionnaire was in English and none of the panellists was from a Francophone country. However, most of the findings are expected to replicate in the majority of developing countries. Furthermore, given that a large number of experts are employed by Road Funds; they may be biased towards increased funding for road maintenance when compared with capital expenditure although results indicate otherwise (see Table 5-4). Similarly, most of the panellists are Civil Engineers; however, this is believed not to create any biases in responses.

Some of the findings of this study may not be applicable to the Republic of South Africa which has a far advanced road network and management systems which are almost at par with the developed world. Use of GP models should be undertaken with caution. Analyses should be undertaken before and after solving the problem to mitigate against modeling pitfalls by use of methods such as: normalisation, *Pareto* efficiency detection and restoration techniques (Tamiz et al., 1998). In the same vein, when using Lexicographic models, they should not include an excessive number of priority levels as this creates redundancy problems (ibid).

It should be noted that some Road Funds (such as Tanzania and Zambia) allocate a small amount of their revenue to capital investments (new road construction projects); however, this does not affect the overall equity analysis conclusions.

The limitations analysed above are not believed to be detrimental to the conclusions and recommendations of this study.

13.5 Identification of areas of further research and future directions

In order to enhance Rawlsian equity, areas of further research in the case study countries could include determination of the actual funds that are effectively used in road maintenance and capital investments cognisant of the convoluted corruption, leakage, administration overheads and wastage. Year on year analysis of expenditures in the case study countries may also be undertaken with inflation indexation. Increases in funds allocations for maintenance may not result in more benefits for the populace if the funds are expended through consumptive budget line items in the form of administrative and operational costs. Research is also necessary in identifying feasible alternative charging instruments for Road Funds as they should not heavily rely on fuel levy due to fluctuating oil prices, reducing travel (due to online business) and new vehicle technologies. Furthermore, there may be a need to establish a linkage between sources of road funds (by road class) and allocation (whether through road user charges or general taxation).

There may be a need to accurately determine and consider the off-line budget support for the road sector in the analysis of equity. Although the road sector budgets in most countries are on the upward trend, it may be appropriate to determine the ideal budget allocation for the road sector based on GDP; in order to have sustainable road projects and to clear the maintenance backlog in a timely manner. There may also be a need to collect data from several sources to assist in triangulation.

Where equity has been incorporated in formulae; there is a need to undertake further research by monitoring and evaluating the formulae allocation principles to determine which factors most influence the equality of transport opportunities and sustainability. Furthermore, there is need to research the socio-economic impact of maintenance underfunding in the case study countries over the last five to ten years; the evidence from the research will most probably assist in advocating for a paradigm shift. In order to cover most of the developing regions in the world, future research in this area could be strengthened by inclusion of panellists from Francophone countries and other developing regions (such as Latin America and South East Asia) and longer analysis periods may be considered depending on data availability.

13.6 Summing up, final reflections and recommendations

This research study set off with a rather ambitious proposition to develop equity-centred formulae and algorithms that can be widely used in SSA countries and other developing countries thus advocating for equality of transport opportunities and sustainable road developments. However, there is no ‘one size fits all’ and interpretation of equity is very challenging with varied expert opinions. What seems equitable in one country may not be equitable in the other. Moreover, principles of Rawlsian equity are not highly prioritised in most aspects of SSA life including the road sector. Road transport is by far the most predominant form of transport in SSA and most people live in rural areas with agriculture being the largest contributor to economic activity; however, none of the case study allocation formulae explicitly address road sector needs for such regions. It is believed that road planning and maintenance has been inequitable from the onset, a consequence of the colonial legacy which also created major economic divides within countries albeit existing allocation formulae fail to explicitly mitigate this problem.

For the case of Uganda, Naimanye and Haworth (2015) observe that the road sector budget has grown from a figure of US$ 49.7million (0.8% of GDP) in 1987 to about US$ 743.3million (3.46% of GDP) in FY 2014/15. Therefore, there has been a significant increase in allocations to the road sector by fifteen-fold although it has mainly gone towards new road construction. It is believed that Uganda is approaching a critical stage in road network development and it is important that the newly built roads are maintained (ibid). The road maintenance budget needs to be increased to US$ 197million annually over the medium term, requiring an increase in the overall road sector budget of US$ 63million. If the overall sector budget cannot be increased in this way then the planned number of new roads to be upgraded may need to be reduced in the medium term by about 50km to 80km every year and the funds are reallocated towards road maintenance (ibid). However, this has to be accompanied by institutional technical capacity enhancements and efficiency improvements.

The author's final observation is that road sector budgets in SSA are on an upward trend and comprise a large percentage of SSA countries' annual budgets. In spite of that, it is believed that the tendencies of autocratic governance systems in some road sector institutions, convoluted corruption, short political horizon (due to short election cycles) and submissiveness of managers of road sector institutions to their appointing authorities (politicians); the unsatisfactory equity status quo is likely to continue. Taking account of the aforesaid, SSA countries are likely to continue prioritising resource allocations to 'vote winning and publically favoured' capital investment projects at the expense of maintenance which is not equitable in a Rawlsian manner. Therefore, despite increases in road sector budget allocations, the maintenance backlog is likely to continue increasing in most SSA countries. Furthermore, the sustainability of roads is being worsened by the ubiquitous poor road sector planning. Similarly, it appears that the momentum in road sector reforms in SSA is waning due to declining interest from development partners and Road Funds need to be innovative to ensure long term relevancy.

In summary, if there is no paradigm shift, road funds allocation and road scheme prioritisation in SSA is generally likely to continue being haphazard, politically driven and biased towards new road construction and national roads which affects equity and equality of transport opportunities. Therefore, this study has recommended new parameters/algorithms; a Rawlsian equity assessment tool and GP models that can assist in mitigating the road sector inequities in SSA and other developing regions.

Appendix A
Ghana Allocations (2009 and 2010)

Ghana Highway Authority

Activity	**Total budget (US$M)**	
	2009	2010
Routine maintenance	26.89	17.50
Periodic maintenance	12.41	9.34
Major works	36.73	75.39
Development	269.72	
Recurrent expenditure	98.21	
Grand Total	345.75	102.2
MEC	0.16	0.26
MEI	0.80	0.58

Source: adapted from GoG (2010, pp.25-26)

Department of Feeder Roads

Activity	**Total budget (US$M)**	
	2009	2010
Routine maintenance	8.36	25.06
Periodic maintenance	15.17	5.43
Rehabilitation	73.51	50.06
Development	6.9	6.62
Recurrent expenditure	1.53	3.56
Grand Total	105.5	90.7
MEC	0.23	0.35
MEI	0.65	0.46

Source: adapted from GoG (2010, pp.35-36)

Department of Urban Roads

Activity	**Budget 2009**
	Total US$M
Routine maintenance	3.37
Periodic maintenance	10.66
Rehabilitation	30.63
Development	12.0
Recurrent expenditure	6.11
Grand Total	56.6
MEC	0.28
MEI	0.56

Source: adapted from GoG (2010, p.44)

Appendix B
Zambia Allocations (1997, 1998, 1999 and 2013)

Zambia road sector allocations (1997 to 1999)

Road Type	**1997**		**1998**		**1999**	
	planned	actual	Planned	Actual	planned	actual
Main, Trunk and District roads	40%	27%	40%	30%	40%	33%
Feeder roads	40%	20%	40%	15%	40%	12%
Urban roads	20%	53%	20%	54%	20%	55%
Total expenditure (US$M)	7.4	4.9	14.4	10.9	18.1	5.2

Source: Kumar (2000, p.44)

Zambia 2013 Road Sector Annual Workplan

Agency	**Total allocation (ZMK, Millions)**	**Percentage**
LRA	66,337.02	2.0%
MLGH	306,823.68	9.3%
NCC	6,000	0.2%
NRFA	8,000	0.2%
RDA	2,654,163.22	80.7%
RDA/MLGH	79,719.46	2.4%
RTSA	157,100.00	4.8%
ZAWA	9,785.00	0.3%
Total	3,288,928.39	

Source: RDA (2012, p.8)

List of References

AAPOR (2011) The American Association for Public Opinion Research, *Standard Definitions: Final Dispositions of Case Codes and Outcome Rates for Surveys*, 7th Edition. AAPOR.

ADB (1997) *Guidelines for Economic Analysis of Projects*, Asian Development Bank, Manila.

ADLER, H. A. (1987) *Economic Appraisal of Transport Projects; A Manual with Case Studies*. EDI Series in Economic Development Baltimore. Revised and expanded edition: John Hopkins for the World Bank.

AfDB (2011) *Flagship Report, Broadening the Agenda*. [online]. Available from: www.infrastructureafrica.org/library/doc/762/flagship-report-chapter-roads-broadening-agenda [Accessed 25 May 2014].

ALKIRE, S. and FOSTER. J. (2011) Understandings and misunderstandings of multidimensional poverty measurement. *Journal of Economic Inequality*, **9**, pp.289-314.

ALKIRE, S. and SANTOS, M. E. (2010) *Acute multidimensional poverty: A new index for developing countries*, United Nations Development Programme Human Development Report Office Background Paper no. 2010/11. [online]. Available from: http://dx.doi.org/10.2139/ssrn.1815243 [Accessed 17 April 2014].

ANDRESKI, A. (2005a) *Case Study of Road Funds in Ghana, Malawi & Tanzania*. [online]. Available from: http://www.ittransport.co.uk/documents/Case%20Study%20of%20%20Road%20Funds%20in%20Malawi%20Tanzania%20and%20Ghana.doc [Accessed 14 April 2014].

ANDRESKI, A. (2005b) *Road Asset Valuations*. [online]. Available from: www.itttransport.co.uk/documents/Road%20Asset%20Valuation.doc [Accessed 13 February 2014].

ANDRESKI, A. (2008) *Case Study of Road Funds in Ghana, Malawi and Tanzania*, Senior Roads Executive Programme, University of Birmingham.

ANTAMENG, M. (2001) *A National Policy Framework for Financing District Road Maintenance in Indonesia*, Ph.D. thesis, Department of Civil Engineering, University of Leeds.

ARCHONDO-CALLAO, R. (1999) *Roads Economic Decision model (RED) for Economic Evaluation of Low Volume Roads*. SSATP Technical Note 18.

ARMFA (2013) *Association of Road Maintenance Funds of Africa.* [online]. Available from: www.armfa.org [Accessed 15 December 2013].

ASCHAUER, D. (1989) Is Public Expenditure Productive? *Journal of Monetary Economics*. **23**, pp.177-200.

AusAID (2003) Australian Agency for International Development. *The Logical Framework Approach*. Australian Government. [online]. Available from: http://portals.wi.wur.nl/files/docs/ppme/ausguidelines-logical%20framework%20approach.pdf [Accessed 17 January 2014].

BALLANTYNE, E. E. F. (2013) *The benefit of integrating freight logistics into urban transport demand management measures and policies.* Ph.D. thesis, Institute for Transport Studies, University of Leeds.

BANISTER, D. (1994) *"Equity and Acceptability Questions in Internalising the Social Costs of Transport,"* OECD, Paris. [online]. Available from: www.oecd.org [Accessed 29 August 2014].

BARRETT, F. and KUMAR, A. (2008) *Stuck in traffic: Urban transport in Africa, Africa infrastructure country diagnostic*. [online]. Available from: http: www4.worldbank.org/afr/ssatp/resources/Stuck-in-Traffic.pdf [Accessed 31 March 2014].

BBC NEWS (2015) *Mo Ibrahim Prize: Namibia President Pohamba gets $5m award*. [online]. Available from: www.bbc.com/news/world-africa-31692093 [Accessed 2 March 2015].

BEENHACKKER, H. L. and LAGO, M. (1983) *Economic Appraisal of Rural Roads: Simplified Operational Procedures*, World Bank Staff Working Paper No. 610, The World Bank, Washington DC.

BENMAAMAR, M. (2006) *Financing Road Maintenance in Sub-Saharan Africa; Reforms and Progress Towards Second Generation Road Funds*; SSATP Discussion paper no. 6, The World Bank, Washington DC.

BENNETT, A. and ELMAN, C. (2006) Qualitative Research: Recent developments in case study methods, *Annual Reviews Political Science.* **9**, pp.455-476.

BERG, B. L. (2007) *Qualitative research methods for the social sciences*, Boston, USA, Pearson International.

BEYAZIT, E. (2011) Evaluating Social Justice in Transport: Lessons to be learned from the capability approach, *Transport Reviews.* **31**(1), pp.117-134.

BICKEL, P; BURGESS, A; HUNT, A; LAIRD, J; LIEB, C; LINDBERG, C. and ODGAARD, T. (2005) *Developing Harmonised European Approaches for Transport Costing and Project Assessment, State of the art in project assessment.* [online]. Available from: http://www.heatco.ier.uni-stuttgart.de/hd2final.pdf [Accessed 15 January 2014].

BIERNACKI, P. and WALDORF, D. (1981) Snowball Sampling: Problems and Techniques of Chain Referral Sampling: *Sociological Methods and Research*. **10**(2), pp.141-163.

BISHAI, D; HYDER, A. D; GHAFFAR, A; MORROW, R. H. and KOBUSINGYE, O. (2003) Rates of public investment for road safety in developing countries: case studies of Uganda and Pakistan, *Health Policy and Planning*. **18**(2), pp.232-235.

BLACK, P. E. (2007) *Dictionary of Algorithms and Data Structures*. [online]. Available from: http://www.nist.gov/dads/HTML/algorithm.html [Accessed 10 January 2014].

BMJ (1995) Qualitative Research: Reaching the parts other methods cannot reach: an introduction to qualitative methods in health and health services research; *British Medical Journal*; BMJ1995, 311:42.

BOAMAH, P. A. (2010) *Development of Models for Optimal Road Maintenance Fund Allocation*. A case of Ghana; Ph.D. thesis, School of Civil Engineering, University of Birmingham.

BOGETIĆ, Z. and FEDDERKE, J. W. (2006) *International benchmarking of infrastructure performance in the Southern African customs union countries*, World Bank Policy Research Working Paper 3987, The World Bank, Washington DC.

BONNEY, R. S. P. and MILLARD, R. S. (1966) Planning and research for road transport in developing countries; *Civil Engineering Problems Overseas,* conference proceedings, pp.191-205.

BOOTH, D. and GOLOOBA-MUTEBI, F. (2009) *Aiding Economic Growth in Africa: The Political Economy of Roads Reform in Uganda*, Working Paper 307, Overseas Development Institute.

BRADBURY, A. S. C. (2006) Transport, mobility and social capital in developing countries. *Proceedings of the Institution of Civil Engineers, Engineering Sustainability.* **159**(ES2), pp.79-86.

BRAMS, S. J; EDELMAN, P. and FISBURN, P. C. (2000) *Fair Divisions of Indivisible Items*: Economic Research Reports, C.V Starr Centre for applied economics.

BRAMS, S. J. and FISHBURN, P. C. (2000) Fair Division of Indivisible Items between Two people with Identical Preferences: Envy-freeness, Pareto Optimality, and Equity; *Social Choice and Welfare.* **17**, pp.247-267.

BRICENO-GARMENDIA, C. M. and SHKARATAN, M. (2011) *Kenya's Infrastructure: A continental perspective*, Policy research working paper, 5596, WPS 5596, The World Bank, Washington, DC.

BRÖCKER, J; KORZHENEVYCH, A. and SCHÜRMANN, C. (2010) Assessing spatial equity and efficiency impacts of transport infrastructure projects, *Transportation Research Part B.* **44**, pp.795-811.

BROWN, J. and BARBER, A. (2012) Social infrastructure and sustainable urban communities. *Proceedings of the Institution of Civil Engineers, Engineering Sustainability.* **165**(ES1), pp.99-109.

BRUNO, J. and STEIGLITZ, K. (1972) The Expression of Algorithms by Charts, *Journal of the Association for Computing Machinery*. **19**(3), pp.517-525.

BRYCESON, D. F; BRADBURY, A. and BRADBURY, T. (2008) Roads to poverty reduction? Exploring rural roads' impact on mobility in Africa and Asia. *Development Policy Review*. **26**(4), pp.459-482.

BRYSON, G. L; TURGEON, A. F. and CHOI, P. T. (2012) The science of opinion: survey methods in research: *Canadian Journal of Anaesthesia*. **59**, pp.736-742.

BUEHLER, J. W. and HOLTGRAVE, D. R. (2007) *Challenges in defining an optimal approach to formula-based allocations of public health funds in the United States*, BMC Public Health. [online]. Available from: www.biomedicalcentral.com [Accessed 20 February 2014].

BULLMAN, N. J. (1982) *Highway Investment in Developing Countries. Proceedings of conference held at Royal Conference Centre, London 17-18th May 1982,* Overseas Unit, Transport and Road Research Laboratory (TRRL).

BURGIN, M. S. (2005) *Super-recursive algorithms*, Monographs in Computer Science, Springer.

BURGIN, M. S. and ADES, M. J. (2009) *Monte Carlo Methods and Super-recursive algorithms; Proceedings of the 2009 Spring Simulation Multi Conference (Article 140),* Society for Computer Simulation International.

BURNINGHAM, S. and STANKEVICH, N. (2005) *Why road maintenance is important and how to get it done*, Transport Note No. TRN-4. [online]. Available from:

http://www4.worldbank.org/afr/ssatp/Resources/SSATP-TechnicalNotes/ATTN18.pdf [Accessed 17 January 2014].

BUTTON, K. J. and GILLINGWATER, D. (1986) *Future Transport Policy*, Great Britain, Biddles Ltd, Guilford and Killis Lynn.

CALDERÓN, C. and SERVÉN, L. (2008) *Infrastructure and Economic Development in Sub-Saharan Africa. Policy Research Working Paper 4712*, The World Bank, Washington DC.

CAMEMARK, C. J; BIDERMAN, J. and BOVEK, D. (1976) *The Economic Analysis of Rural Road Projects,* World Bank Staff Working Paper No. 241, The World Bank, Washington DC.

CAR-HILL, R. and SHELDON, T. (1992) Rationality and the use of formulae in the allocation of resources to health care: *Journal of Public Health Medicine.* **14**(2), pp.117-126.

CASTELLS, A. and SOLE-OLLE, A. (2005) The regional allocation of infrastructure investment: The role of equity, efficiency and political factors*, European Economic Review.* **49**(5) pp.1165-1205.

CHAVIS, L. (2010) Decentralizing development: Allocating public goods via competition: *Journal of Development Economics.* **93**, pp.264-274.

COHEN, J. (1979) Non-Deterministic Algorithms; *Computing Surveys*. **11**(2).

COLANTONIO, D. (2010) Urban social sustainability themes and assessment methods. *Proceedings of the Institution of Civil Engineers, Urban Design and Planning.* **163**(DP2), pp.79-88.

CROPP, N. (1998) Social Utility of Rawls' Theory of Justice: Can It Help Us to Avoid Unjust Systems, The. *UCL Jurisprudence Rev*., 188.

CUESTA, J. (2013) *Social spending, distribution and equality of opportunities, opportunity incidence analysis*, Policy research working paper WPS6489, The World Bank, Washington DC.

DALVI, M. Q. (1987) The Mobility Problem of the Third World, *Moving People in Tomorrow's World.* pp.151-167, Thomas Telford Limited.

DARTON, R; FORDER, J; NETTEN, A; BEBBINGTON, A; HOLDER, J. and TOWERS, A. (2010) Slicing up the pie: Allocation of central government funding of care of older people; *Social Policy and Administration*. **44**(5), pp.529-553.

DE BEUCKELAER, A. and WAGNER, S. M. (2007) Qualitative and quantitative international research: The issue of overlooking alternative explanations; *Journal of Purchasing and Supply management*. **13**, pp.213-2015.

DE SILVA, H. and TATAM, C. (1996) An empirical procedure for enhancing the impact of road investments; *Transport Policy*. **4**(3), pp.210-211.

DELBOSC, A. and CURRIE, G. (2011) Using Lorenz curves to assess public transport equity, *Journal of Transport Geography*. **19**(6), pp.1252-1259.

DETR (1998) *A new deal for transport*: *Better for everyone*, New Approach to Transport Appraisal. DETR, London. Great Britain.

DfID (2000) *Sustainable livelihood guidance sheets*. [online]. Available from: http://www.eldis.org/vfile/upload/1/document/0901/section1.pdf [Accessed 20 January 2014].

DfID (2003) *Community participation in road maintenance; Guidelines for planners and engineers*, 1st Ed, DfID research scheme number: R6476.

DfID (2004) *Overseas Road Note No. 22: A guide to pro-poor transport appraisal,* Department for International Development, London. Great Britain.

DfT (2011) *Summary guidance on social and distributional impacts of transport interventions. Transport analysis guidance (TAG). TAG Unit 2.13*. Department for Transport. [online]. Available from: http://www.dft.gov.uk/webtag/documents/project-manager/pdf/unit2.13.pdf [Accessed 18 October 2013].

DINGEN, R. (2000) *A guide to integrated rural accessibility planning in Malawi*, International Labour Organisation, Zimbabwe.

DOROSH, P. and THURLOW, J. (2011) Agglomeration, Growth and Regional Equity: An analysis of agriculture-versus urban-led development in Uganda. *Journal of African Economies.* **21**(1), pp.94-123.

DOWNS, T. J. (2008) Transforming impact assessment for sustainable development and poverty eradication, *Proceedings of the Institution of Civil Engineers, Engineering Sustainability.* **161**(ES1), pp.39-53.

DUGUNDJI, E. R; PAEZ, A; ARENTZE, T. A. and WALKER, J. L. (2011) Transportation and social interactions: *Transportation Research Part A*. **45**, pp.239-247.

EDELMAN, P. and FISHBURN, P. (2001) Fair Division of indivisible items among people with similar preferences, *Mathematical Social Sciences*. **41**(3), pp.327-347.

EDMONDS, G. A. (1983) Rural transport policy in developing countries. *Highway Investment in Developing Countries*. pp.119-124, Thomas Telford Limited. London, Great Britain.

ERICKSON, J. (2010) *Lecture Notes – Algorithms*: [online]. Available from:

http://www.cs.uiuc.edu/~jeffe/teaching/algorithms/ [Accessed 30 October 2013].

EVDORIDES, H. and ROBINSON, R. (2009) *Restructuring road institutions, Finance and management*, Vol 2: Case studies. University of Birmingham, Birmingham, Great Britain.

FAN, S. and ZHANG, X. (2008) Public expenditure, growth and poverty reduction in rural Uganda. *Journal compilation*, African Development Bank.

FEITELSON, E. (2002) Introducing environmental equity dimensions into the sustainable transport discourse: issues and pitfalls, *Transportation Research Part D.* **7**, pp.99-118.

FLYVBJERG, B. (2009) Survival of the unfittest: why the worst infrastructure gets built – and what we can do about it; *Oxford Review of Economic Policy*. **25**(3), pp.344-367.

FOSTER, V. and DOMINIGUEZ, C. (2011) *Zambia's Infrastructure; A continental perspective;* Research working Paper WPS5599. The World Bank, Washington DC.

FOSTER, V. and PUSHAK, N. (2011) *Ghana's Infrastructure: a continental perspective*, Policy Research working paper, WPS5600; The World Bank, Washington DC.

GEORGE, K. and SHORLEY, J. (1978) *The allocation of resources: theory and policy*, George Allen & Unwin. Surrey, UK.

GEURS, K. T; BOON, W. and VAN-WEE, B. (2009) Social Impacts of Transport: Literature Review and State of the Practice of Transport Appraisal in the Netherlands and the United Kingdom, *Transport Reviews*. **29**(1), pp.69-90.

GILL, F. J; LESLIE, G. D; GRECH, C. and LATOUR, J. M. (2013) Using web-based survey tool to undertake a Delphi study: Application for nurse education research, *Nurse Education Today.* **33**, pp.1322-1328.

GoG (1997) *Ghana's Road Sector Expenditure, Ministry of Finance*, Accra, Ghana.

GoG (2006) *Government of Ghana, Road Sector Development Programme*, *2006 Review Report*, Accra, Ghana.

GoG (2007) *Government of Ghana, Road Sector Development Programme, 2007 Review Report*, Accra, Ghana.

GoG (2010) *Government of Ghana, Medium Term National Development Policy Framework, Ghana shared growth and development agenda (2010-2013)*, Accra, Ghana.

GoG (2011) *Government of Ghana, Ministry of Transport, 3rd Draft Sector Medium-Term Development Plan (SMTDP): 2012 – 2014* [online]. Available from: www.ndpc.gov.gh [Accessed 16 April 2014].

GoK (2012) *Policy on aligning the roads sub-sector with the constitution, Ministry of Roads*. [online]. Available from: www.kenha.co.ke/pdfs/Roads%20Policy.pdf [Accessed 25 June 2014].

GOODWIN, P. and WRIGHT, G. (2009) *Decision analysis for management judgement*, 4th Ed., John Wiley & Sons Ltd. Chichester, UK.

GoT (2012) *Tanzania in Figures 2012.* [online]. Available from: www.tanzania-gov.de/images/downloads/tanzania_in_figures-NBS-2012.pdf [Accessed 29 July 2014].

GoT (2013) *Road Administrations in Tanzania.* [online]. Available from: http://www.piarcseminararusha.or.tz/arusha/ENG%20JOSEPH%20M.%20NYAMHANGA%20ROADS%20ADMINISTRATION%20IN%20TANZANIA.PDF [Accessed 12 July 2014].

GoU (2003) *Public Finance and Accountability Act.* [online]. Available from: www.finance.go.ug/dmdocuments/PFAA2003.pdf [Accessed 1 April 2014].

GoU (2012) *Road Sector Development Programme (RSDP3)*, Kampala, Uganda.

GoU (2013) *Annual Transport Sector Report 2013*, Ministry of Works and Transport, Kampala, Uganda.

GREED, C. (2012) Planning for sustainable transport for people's needs, *Proceedings of the Institution of Civil Engineers, Urban Design and Planning*, **165**(DP4), pp.219-229.

GRF (2013) *Ghana Road Fund, Presentation to Uganda Road Fund delegates, 2013*, Accra, Ghana.

GRN (2003) *Namibia Medium to Long Term Roads Master Plan – Volume 2*, Government of the Republic of Namibia, Windhoek, Namibia.

GRN (2015) *Road Referencing System,* Namibia Roads Authority, Government of the Republic of Namibia, Windhoek, Namibia.

GRONAU, R. (1991) *Are Ghana's roads paying their way; Assessing road use cost and user charges in Ghana*, Working papers, WPS 773, The World Bank, Washington DC.

GSS (2012) *Ghana Statistical Service, 2010 Population and Housing Census, Summary report of final results.* [online]. Available from: http://www.statsghana.gov.gh/docfiles/2010phc/Census2010_Summary_report_of_final_results.pdf [Accessed 14 April 2014].

GSS (2013) *Ghana Statistical Service, 2010 Population and Housing Census Report, Non-monetary poverty in Ghana*. [online]. Available from: http://www.statsghana.gov.gh/docfiles/2010phc/Non-Monetary%20Poverty%20in%20Ghana%20(24-10-13).pdf [Accessed on 14 April 2014].

GWILLIAM, K. (2011) *Africa's Transport Infrastructure: Mainstreaming maintenance and management*: [online]. Available from: https://openknowledge.worldbank.org/handle/10986/2275 [Accessed 11 November 2013].

GWILLIAM, K; FOSTER, V; ARCHONDO-CALLAO, R; BRICENO-GARMENDIA, C; NOGALES, A. and SETHI, K. (2009) *The burden of maintenance: Roads in Sub-Saharan Africa,* Africa infrastructure country diagnostic, Background paper 14 (Phase 1), The World Bank, Washington, DC.

GWILLIAM, K. and KUMAR, A. (2003) How effective are second-generation road funds? A preliminary appraisal, *The World Bank Research Observer*. **18**(1), pp.113-128.

GWILLIAM, K. and SHALIZI, Z. (1996) Sustainable transport: Priorities for policy reform. *Development in Practice*. The World Bank, Washington DC.

GWILLIAM, K. and SHALIZI, Z. (1999) Road funds, user charges and taxes. *The World Bank Research Observer*. **14**(2), pp.159-85.

HAHN, R. W. and TELOCK, P. C. (2005) Using information markets to improve public decision making. *Harvard Journal of Law & Public Policy*. **29**(1), pp.213-289.

HARRISON, R. L. (2013) Using mixed methods designs in Journal of Business Research, 1990-2010; *Journal of Business Research*. **66**, pp. 2153-2162.

HAWKINS, J. and WELLS, J. (2007) How infrastructure procurement can enhance social development, *Proceedings of the Institution of Civil Engineers, Management Procurement and Law*. pp.33-38.

HAWORTH, S. (2014a) *Government of Uganda Cabinet Paper*. Unpublished.

HAWORTH, S. (2014b) *Ministry of Works and Transport,* Uganda. Unpublished.

HECKATHORN, D. D. (2011) *Sociological Methodology: Comment – Snowball versus respondent driven sampling*. **41**, pp.355-366.

HEGGIE, I. (1995) *The case for commercially managed road fund*, The World Bank, Washington, DC.

HEGGIE, I. G. and BALCERAC de RICHEOUR, A. (1995) *African Road Funds - What works and why*?; Sub-Saharan Africa Transport Policy Program; SSATP Working paper no. 4, The World Bank. Washington, DC.

HEGGIE, G. I. and VICKERS, P. (1998) *Commercial Management and Financing of Roads,* World Bank Technical Paper 409, The World Bank, Washington, DC.

HILLMAN, M. (1975) Social goals for transport policy, Institution of Civil Engineers, *Transport for Society,* pp.13-20.

HINE, J. (2003) *Are social benefits the missing component of road appraisal?* [online] Available from: http://www.transport-links.org [Accessed 15 December 2013].

HINE, J. (2014) *The Planning and Prioritisation of Rural Transport Infrastructure & Services*, Sub-Saharan Africa Transport Policy Program, The World Bank. Washington, DC.

HINE, J; ELLIS, S. and KORBOE, D. (2000) *Ghana Feeder Road Prioritisation.* [online]. Available from: http://www.piarc.org/ressources/documents/actes-seminaires0102/c3c20-cambodge02/9127,2.2_TC3-20_2002_Hine.pdf [Accessed 15 January 2014].

HINE, J; RIVERSON, J and KWAKYE, E. (1983) *Accessibility, transport costs and food marketing in the Ashanti Region of Ghana*. TRRL Report SR 809, Transport and Road Research Laboratory, Crowthorne, UK.

HOWE, J. (1971) *Rural road distribution in Kenya*. RRL Report LR 414, Road Research Laboratory, Crowthorne, UK.

HOWE, J. (1999) Sustaining Africa's rural road networks: The Asset Management Approach. *World Transport Policy and Practice*. **5**(1), pp.11-16.

HOWE, J. (2003) ‘Filling the middle’: Uganda’s appropriate transport services; *Transport Reviews*. **23**(2), pp.161-176.

IFRTD (2009) *International Forum for Rural Transport Development; Kenya web page*. [online]. Available from www.ifrtd.org [Accessed 10 January 2014].

IFRTD (2010) *International Forum for Rural Transport Development; Ghana web page*. [online]. Available from: www.ifrtd.gn.apc.org [Accessed 2 April 2014].

INDEXMUNDI (2014) *IndexMundi Country Profiles and Statistics.* [online]. Available from: www.indexmundi.com [Accessed 10 February 2014].

INNES, J. and STODDARD, S. (1988) Formula Allocation as a Policy Tool: Politics and measurement, *Planning Outlook.* **31**, pp.95-102.

JABINE, T. B; LOUIS, T. A. and SCHIRM, A. L. (2001) *Choosing the right formula: Initial report; Panel on formula allocations. National Research Council of National Academies*. [online]. Available from: www.nap.edu/catalog/10178.html [Accessed 21 February 2014].

JOHNSON, R. B. and ONWUEGBUZIE, A. J. (2004) Mixed methods research: A research paradigm whose time has come. *Educational Researcher*. **33**, pp.14-26.

JONES, P. and LUCAS, K. (2012) The social consequences of transport decision-making: clarifying concepts, synthesising knowledge and assessing implications. *Journal of Transport Geography.* **21**, pp.4-16.

JONES, S; TEFE, M. and APPIAH-OPOKU, S. (2013) Proposed framework for sustainability screening of urban transport projects in developing countries: A case study of Accra, Ghana; *Transportation Research Part A*. **49**, pp.21-34.

KALIBA, C; MUYA, M. and MUMBA, K. (2009) Cost escalation and schedule delays in road construction projects in Zambia; *International Journal of Project Management*. **27**, pp.522-531.

KAMUHANDA, R. and SCHMIDT, O. (2009) Matatu: A case study of the core segment of the Public Transport market of Kampala, Uganda. *Transport Reviews.* **29**(1), pp.129-142.

KARLAFTIS, M. G. and VLAHOGIANNI, E. I. (2011) Statistical methods versus neural networks in transportation research: Differences, similarities and some insights; *Transportation Research Part C.* **19**, pp.387-399.

KELLEY, K; CLARK, B; BROWN, V. and SITZIA, J. (2003) Good practice in the conduct and reporting of survey research; *International Journal for Quality in Health Care*. **15**(3), pp.261-266.

KeNHA (2013) *Annual Report 2012/13: Kenya National Highways Authority*. [online]. Available from: www.kenha.co.ke [Accessed 25 June 2014].

KERALI, H. G. R. (2000) *Overview of HDM-4, Volume 1;* The World Road Association (PIARC), Paris.

KHAN, M. U. (2012) Rural road management in Botswana, *Proceedings of the Institution of Civil Engineers, Transport.* **167**(2), pp.111-122.

KHORRAMSHAHGOL, R. and OKORUWA, A. A. (1994) A goal programming approach to investment decisions: A case study of fund allocation among different shopping malls, *European Journal of Operational Research*. 73, pp.17-22.

KIDDER, L. and JUDD, C. M. (1986) *Research methods in social relations* 5th Ed, Holt, Rinehart and Winston; New York, USA.

KIRKWOOD, G. (1977) *Pareto Optimality and Equity In Social Decision Analysis.* Technical Report 77-5. Department of Industrial and Operations Engineering, University of Michigan.

KNUTH, R. (1998) *The Art of Computer Programming.* Vol 1-3 2nd Ed, Addison-Wesley.

KONSULT (2012) *The KonSULT Knowledgebase.* [online]. Available from:

http://www.konsult.leeds.ac.uk [Accessed 15 October 2013].

KRB (2007) *Annual Public Roads Programme, Kenya Roads Board*. [online]. Available from: www.krb.go.ke/wdownloads/0708summary.pdf [Accessed 23 June 2014].

KRB (2008) *Annual Public Roads Programme, Kenya Roads Board*. [online]. Available from: www.krb.go.ke/wdownloads/0809summary.pdf [Accessed 23 June 2014].

KRB (2009) *Annual Public Roads Programme, Kenya Roads Board*. [online]. Available from: www.krb.go.ke/wdownloads/0910summary.pdf [Accessed 24 June 2014].

KRB (2010) *Annual Public Roads Programme, Kenya Roads Board*. [online]. Available from: www.krb.go.ke/wdownloads/1011summary.pdf [Accessed 24 June 2014].

KRB (2011) *Annual Public Roads Programme, Kenya Roads Board*. [online]. Available from: www.krb.go.ke/wdownloads/1112summary.pdf [Accessed 25 June 2014].

KRB (2012a) *Annual Public Roads Programme, Kenya Roads Board*. [online]. Available from: www.krb.go.ke [Accessed 10 June 2014].

KRB (2012b) *Kenya Roads Board; Annual Plan 2012*. [online]. Available from: www.krb.go.ke [Accessed 10 June 2014].

KRB (2012c) *Kenya Roads Board; Presentation to Uganda Road Fund delegates*, Nairobi, August 2012.

KRB (2012d) *Kenya Annual Public Roads Programme*. [online]. Available from: www.krb.go.ke/wdownloads/1213summary.pdf [Accessed 23 June 2014].

KRB (2014) *Kenya Roads Board; 2014 Road network inventory*, Nairobi, Kenya.

KRB (2014b) *Kenya Roads Board;* Nairobi, Kenya.

KREISEL, G. (1953) A variant of Hilbert's theory of the foundation of arithmetic. *British Journal for the Philosophy of Science*. **4**(14), pp.107-129.

KUMAR, A. (2000) *Assessment of selected road funds in Africa: Case study of Benin, Ethiopia, Ghana, Kenya and Zambia*; SSATP Working paper No. 51; The World Bank, Washington DC.

KUMAR, A. (2002) *A review of road sector reforms in Tanzania*, Sub-Saharan Africa Transport Policy Program; SSATP Discussion paper no. 2, The World Bank, Washington DC.

KUMAR, A. and BARRETT, F. (2008) *Stuck in Traffic: Urban Transport in Africa*: Africa Infrastructure Country Diagnostic, The World Bank, Washington DC.

LEBO, J. and GANNON, C. (1999) "*Setting Priorities for Rural Transport Infrastructure Investments",* Transport Division, World Bank. Washington DC.

LEINBACH, T. R. and CROMLEY, R. G. (1983) A Goal Programming Approach to Public Investment Decisions: A case study of rural roads in Indonesia; *Social – Economic Planning Sciences*. **17**(1), pp.1-10.

LI, Y. and DACOSTA, M. (2013) Transportation and income inequality in China: 1978-2007; *Transportation Research Part A*. **55**, pp.56-71.

LITMAN, T. (2002) Evaluating Transportation Equity. *World Transport Policy and Practice.* **8**, pp.3-21.

LITMAN, T. (2013) *Evaluating Transportation Equity, Guidance for incorporating distributional impacts in transportation planning,* Victoria Transport Policy Institute. [online]. Available from: http://www.vtpi.org/equity.pdf [Accessed 15 October 2013].

LOKEN, E. (2007) Use of multi criteria decision analysis methods for energy planning problems; *Renewable and Sustainable Energy Reviews*. **11**, pp.1584-1595.

LOUIS, T. A; JABINE, T. B. and GERSTEIN, M. A. (2003) *Statistical issues in allocating funds by formula; Panel on formula allocations*. National Research Council of National Academies. [online]. Available from: www.nap.edu/catalog/10580.html [Accessed 22 February 2014].

LUCAS, K. (2006) Providing transport for social inclusion within a framework in the UK. *Transportation Research Part A: Policy and Practice.* **40**(10), pp.801-809.

MARTENS, K. (2012) Justice in transport as justice in accessibility: applying Walzer's 'Spheres of justice' to the transport sector. *Transportation.* **39**(6), pp.1035-1053.

MARTENS, K; GOLUB, A. and ROBINSON, G. (2012) A justice-theoretic approach to the distribution of transportation benefits: Implications for transportation planning practice in the United States. *Transportation Research Part A*. **46**, pp.684-695.

MAY, A. D. (1997) *Transport Policy*. In O'FLAHERTY, C. A. (Ed.) Transport Planning and Traffic Engineering. Oxford, Butterworth Heinemann.

MERIAM-WEBSTER (2014) *Merriam Webster's Dictionary*. [online]. Available from:

http://www.merriam-webster.com [Accessed 24 January 2014].

MEYER, M. D. and MILLER, E. J. (2001) *Transportation planning and decision making*, Chapter 2, pp.41-87 in: Urban Transportation Planning: A decision oriented approach. McGraw Hill. USA.

MoCT (2002) *Zambia Transport Policy*, Ministry of Communication and Transport, Lusaka, Zambia.

MoFEP (2012) *Ghana Infrastructure Plans*; consultative group meeting, Ministry of Finance and Economic Planning. [online]. Available from: www.mofep.gov.gh [Accessed 16 April 2014].

MONZÓN, A; ORTEGA, E. and LÓPEZ, E. (2013) Efficiency and Spatial Equity Impacts of High-Speed Rail Extensions in Urban Areas. *Cities.* **30**, pp.18-30.

MoWT (2012) *Annual sector performance report for FY 2011/12*. MoWT, Kampala, Uganda.

MoWT (2013a) *Annual sector performance report for FY 2012/13*. MoWT, Kampala, Uganda.

MoWT (2013b) *Works and Transport Sector Ministerial Budget Policy Statement FY 2012/13*. Kampala, Uganda.

MoWT (2013c) *Draft Urban Transport Policy for Kampala.* Kampala, Uganda.

MRAWIRA, D. (2014) *Five Year Road Maintenance Financing Strategic Plan for Uganda Road Fund for the period FY 2014/15 to FY 2018/19*. Kampala, Uganda.

MUGENDA, O. M. and MUGENDA, A. G. (2003) *Research methods, Quantitative and qualitative approaches*, African Centre for Technology Studies, Nairobi, Kenya.

MWALE, S. M. (1997) *Road sector reform: A tale of two countries (Part I) Ghana: serendipity or foresight?*, Africa Transport Technical Notes, No.6, SSATP.

NAIMANYE, A. G. and HAWORTH, S. (2015). *Imbalanced financing of road maintenance when compared with new road construction – a cause of concern*. Draft Cabinet Paper. Government of Uganda. Unpublished.

NDP (2010) *The Uganda National Development Plan.* [online]. Available from: www.opm.go.ug [Accessed 7 March 2014].

NORDFJAERN, T; JORGENSEN, S. and RUNDMO, T. (2012) Cultural and socio-demographic predictors of car accident involvement in Norway, Ghana, Tanzania and Uganda. *Safety Science.* **50**, pp.1862-1872.

NORDFJAERN, T; SIMSEKOGLU, O. and RUNDMO, T. (2014) Culture related to road traffic safety: A comparison of eight countries using two conceptualizations of culture. *Accident Analysis and Prevention.* **62**, pp.319-328.

NRFA (2012) *Annual Report of the National Road Fund Agency*, Lusaka, Zambia.

NRFA (2013) *Presentation to Uganda Road Fund delegates (17July 2013)*, National Road Fund Agency, Lusaka, Zambia.

NRFA (2014) *Road Development Agency workplans, National Road Fund Agency*, Lusaka, Zambia.

NTMP (2009) *National Transport Master Plan including a transport master plan for the Greater Kampala Metropolitan Area (2008 – 2023)*. Ministry of Works and Transport, Entebbe, Uganda.

OAKLEY, T. (2011) *Highway Capital Maintenance*, In: Walsh, I (ed), ICE Manual of Highway Design and Management , London, Thomas Telford Ltd. pp.49-50.

ODERO, K. and NJENGA, P. (2005) *Pro-poor transport policies: experiences and lessons from Four East and Southern African Countries*, International Forum for Rural Transport and Development.

ODOKI, J. B. and ANYALA, M. (2010) *Determination of maintenance needs of Ghana's road network*, Ministry of Roads and Highways, Accra, Ghana.

OECD (1994) *Road Maintenance and Rehabilitation Fund Allocation Strategies*, Report for Organisation for Economic Co-operation and Development, France.

OECD (2014) *OECD Foreign Bribery Report:* An Analysis of the Crime of Bribery of Foreign Public Officials, OECD Publishing, France.

OKOLI, C. and PAWLOWSKI, S. D. (2004) The Delphi method as a research tool: an example, design considerations and applications; *Information and Management*. **42**(1), pp.15-29.

OYESHILE, O. A. (2008) A critique of the maximin principle in Rawls' Theory of Justice; *Humanity and Social Sciences Journal* **3**(1), pp.65-69. [online]. Available from: http://www.idosi.org/hssj/hssj3(1)08/8.pdf. [Accessed 7 October 2014].

OYRMP (2011, 2012, 2013, 2014) *One Year Road Maintenance Plans for 2011, 2012, 2013 and 2014.* Uganda Road Fund, Kampala, Uganda.

PARKIN, S. (2000) Sustainable Development: the concept and practical challenge, *Proceedings of the Institution of Civil Engineers*, *Civil Engineering*, pp.3-8.

PATERSON, W. D. O. (1987) *Road Deterioration and Maintenance Effects*; Models for Planning and Management. 1st ed. The World Bank. Washington, DC.

PATON, M. (1987) *How to use qualitative methods in evaluation*, Sage publications. London, UK.

PEARCE, D; ATKINSON, G. and MORATO, S. (2006) *Cost-Benefit Analysis and the Environment*: Recent Developments, OECD, Paris. France.

PENDAKUR, V. (2005) *Non-Motorised Transport in African Cities, Lessons from Experience in Kenya and Tanzania.* SSATP Working Paper No. 80.

PETTS, R. (2013) *How much should developing countries spend on Road Maintenance?*. Africa Community Access Programme Steering Group; DfID. UK.

PIARC (2013) *Best practices for the sustainable maintenance of rural roads in developing countries; Technical Committee A.4 rural road systems and acceptability to rural areas*. [online]. Available from: www.piarc.org [Accessed 9 August 2014].

PINARD, I. M. (2010) *Progress on commercialised road management in Sub-Saharan Africa*: Phase 1, SSATPP, The World Bank, Washington, DC.

PINARD, I. M. (2014) *African Community Access Programme; Seminar on progress of research by AFCAP*, Kampala, Uganda.

PLACE, F; ADATO, M. and HEBINCK, P. (2007) Understanding rural poverty and investment in agriculture: An assessment of integrated quantitative and qualitative research in Western Kenya, *World Development*. **35**, pp.312-325.

PORTER, G. (2002) Living in a Walking World: Rural Mobility and Social Equity Issues in Sub Saharan Africa, *World Development Report*. **30**(2), pp.285-300.

PORTER, G. (2007) Transport planning in sub-Saharan Africa. *Progress in Development Studies.* **7**(3), pp.251-257.

RABALLAND, G; BRIDGES, K; BEURAN, M. and SACKS, A. (2013) *Does the semi-autonomous agency model function in a low-governance environment?* The case of the Road Development Agency in Zambia. Policy research working paper 6585; The World Bank. Washington, DC.

RABALLAND, G; MACCHI, P; MEROTTO, D. and PETRACCO, C. (2009) *Revising the roads investment strategy in rural areas: An application for Uganda*, Policy Research Working Paper 5036. The World Bank. Washington DC.

RABALLAND, G; MACCHI, P. and PETRACCO, C. (2010) *Rural road investment efficiency, Lessons from Burkina Faso, Cameroon and Uganda*. [online]. Available from: http://gtkp.com/assets/uploads/20100915-100131-1147-WorldBank_RuralRoadInvestmentEfficiency_2010.pdf [Accessed 30 March 2014].

RANGANATHAN, R. and FOSTER, V. (2012) *Uganda's Infrastructure: A continental perspective,* Policy research working paper, 5963, WPS 5963, The World Bank. Washington, DC.

RDA (2006) *Annual Report 2006 for Road Development Agency.* [online]. Available from: www.rda.org.zm/index.php/reports/annual-reports/doc_download/20-annual-report [Accessed 25 May 2014].

RDA (2007) *Annual Report 2007 for Road Development Agency.* [online]. Available from: www.rda.org.zm/index.php/reports/annual-reports/doc_download/19-annual-report [Accessed 25 May 2014].

RDA (2008) *Annual Report 2008 for Road Development Agency.* [online]. Available from: www.rda.org.zm/index.php/reports/annual-reports/doc_download/18-annual-report [Accessed 25 May 2014].

RDA (2012) *2013 Road Sector Annual Workplan for Road Development Agency*. [online]. Available from: www.rda.org.zm/index.php/programmes/doc_download/61-annual-workplan-2013 [Accessed 23 May 2014].

RFA (2011) *Road Fund Administration; Five Year Business Plan, April 2011 to March 2016.* Windhoek, Namibia.

RIOJA, F. K. (2003) Filling Potholes: Macroeconomic effects of maintenance versus new investments in public infrastructure; *Journal of Public Economics.* **87**, pp.2281-2304.

ROBINSON, R. (2008) *Restructuring Road Institutions, Finance and Management:* Vol 1: Concept and Principles; University of Birmingham, UK.

ROBINSON, R; DANIELSON, U. and SNAITH, M. (1998) *Road Maintenance Management Concepts and Systems*, London Basingstoke: Macmillan Press.

ROBINSON, R. and STIEDL, D. (2003) Decentralisation in developing countries: a model for road administration. *Proceedings of the Institution of Civil Engineers*, *Transport.* **156**, pp 65-71.

ROBSON, C. (2002) *Real world research: a resource for social scientists and practitioner-researchers*. Blackwell, Massachusetts, USA.

ROE, P. G. (2000) Qualitative research on intra-urban travel: an alternative approach: *Journal of Transport Geography*. **8**, pp.99-106.

ROSTOW, W. W. (1960) *The Process of Economic Growth*, 2nd Ed, Oxford Clarendon Press.

RTSA (2010) *Revised Corporate Plan 2010-2013*, Road and Transport Safety Agency, Lusaka, Zambia.

RTSA (2011) *Annual Report 2011 for Road and Transport Safety Agency*, Lusaka, Zambia.

RUNJI, J. (2003) *Road sector reform in Namibia*, paper presented at the Senior Road Executive seminar, Pretoria, South Africa. [online]. Available from: http://siteresources.worldbank.org/INTROADSHIGHWAYS/Resources/338993-1115316483571/21-namibia_reform.pdf [Accessed 27 July 2014].

SAATY, T. (1980) *The Analytical Hierarchy Process*. Wiley, New York, USA.

SACHS, J. D. (2005) *The end of poverty: Economic possibilities of our time*. [online video]: www.columbia.edu/cu/news/media/05/349_the_end_of_poverty/ [Accessed 10 February 2014].

SANDHOLM, T. W. (1999) *Distributed rational decision making*. in G. Wieb, Ed, Multi agent systems: A modern approach to distributed artificial intelligence. MIT. Press.

SAUNDERS, M; LEWIS, P. and THORNHILL, A. (2000) *Research methods for business students*. Pearson Education Limited, Essex, England.

SCHLIESSLER, A. and BULL, A. (2004) *Road Network Management: Roads – a new approach for road network management and conservation*, UN Economic Commission for Latin America and the Caribbean. [online]. Available from: http://zietlow.com/docs/lib-eng.pdf [Accessed 14 April 2014].

SERAGELDIN, I. (1991) *Road rehabilitation and maintenance in Sub-Saharan Africa; Donors technical conference on road maintenance and rehabilitation in Sub-Saharan Africa*, Brussels, Belgium.

SHI, J. and ZHOU, N. (2012) A quantitative transportation project investment evaluation approach with both equity and efficiency aspects. *Research in Transportation Economics.* **36**, pp.93-100.

SHKARATAN, M. (2012) *Tanzania's Infrastructure: A continental perspective*, Policy research working paper, 5962, WPS 5962, Washington DC. The World Bank.

SNAITH, M. S. and KHAN, M. U. (2008) Deleterious effects of corruption in the roads sector, *Proceedings of the Institution of Civil Engineers, Transport.* **161**(TR4), pp.231-235.

SNDP (2011) *Sixth National Development Plan 2011-2015.* [online]. Available from: http://siteresources.worldbank.org/INTZAMBIA/Resources/SNDP_Final_Draft_20_01_2011.pdf [Accessed 23 May 2014].

SODERBAUM, P. (1982) Positional analysis and public decision making; *Journal of Economic Issues.* **16**(2), pp.391-400.

SODERHOLM, P. (2001) The deliberative approach in environmental valuation; *Journal of Economic Issues.* **35**(2), pp.487-495.

SOHAIL, M. and MAUNDER, D. (2007) Partnering to improve public transport in developing countries, *Proceedings of the Institution of Civil Engineers, Transport*. **160**, pp.179-189.

SSATPP (1997) *Giving Rural Communities Access to Goods and Services, Technical Note 9*, The World Bank. Washington, DC.

SSATPP (1999) *Road Sector Performance Indicators for African Countries,* Africa Transport Technical note No. 17. The World Bank. Washington, DC.

STARKEY, P; ELLIS, S; HINE, J. and TERNELL, A. (2002) *Improving Rural Mobility: Options for developing motorised and non-motorised transport in rural areas*. World Bank Technical paper, The World Bank. Washington, DC.

SUTCH, M. (2011) *Highway Capital Maintenance*, in Walsh, I (ed), *ICE Manual of Highway Design and Management* , Thomas Telford Ltd. pp.49-50. London, UK.

SYMINGTON, R. (2001) Community participation in road maintenance, *Proceedings of the Institution of Civil Engineers*. **145**, pp.317-319.

TAMIZ, M; JONES, D. and ROMERO, C. (1998) Goal programming for decision making: An over view of the current state-of-the-art; *European Journal of Operational research.* **111**, pp.569-581.

TANROADS (2012) *Tanzania National Roads Agency*. [online]. Available from: www.tanroads.org [Accessed 10 February 2014].

TANROADS (2014) *Tanzania National Roads Agency, Maintenance budget for FY 2013-14.* [online]. Available from: http://tanroads.org/projects/budget%20fy%202013-14.pdf [Accessed 29 July 2014].

TAPLIN, J. H. E; QIU, M. and ZHANG, Z. (1995) Policy-sensitive selection and planning of road investments with a goal program. *Transport Policy.* **2**(4), pp.251-256.

TAYLOR, S. J. and BOGDAN, R. (1998): *Introduction to qualitative research methods: A guidebook and resource*, John Wiley and Sons. USA.

TEKIE, S. B. (2005) *Asset management: An essential ingredient for road network management by roads authorities - the Namibian Experience*; Proceedings of the 24th Southern African Transport Conference (SATC 2005); Pretoria, South Africa.

THEIDLGROUP (2014) *"More than just roads": Analysing Governance in the Rural Transport Secto*r, Working paper number 4. [online]. Available from: http://www.theidlgroup.com/documents/report_4.pdf [Accessed 3 May 2014].

THOMOPOULOS, N. and GRANT-MULLER, S. (2013) Incorporating equity as part of the wider impacts in transport infrastructure assessment: an application of the SUMINI approach. *Transportation.* **40***,* pp.315-345.

THOMOPOULOS, N; GRANT-MULLER, S. and TIGHT, M. R. (2009) Incorporating equity considerations in transport infrastructure evaluation: current practice and a proposed methodology, *Evaluation and Program Planning.* **32**, pp.351-359.

THUM, C. (2004) *United Republic of Tanzania - Transport Sector Snapshot (A work in progress)*; Findings from a world bank Transport Sector Mission to Tanzania (3rd to 14th May, 2004); The World Bank. Washington DC.

TOUTKOUSHIAN, R. K. and MICHAEL, R. S. (2007) An alternative Approach to measuring Horizontal and Vertical Equity in School Funding. *Journal of Education Finance*. **32**, pp.395-421.

TRL (1998) *Guidelines for the design and operation of road management systems, Overseas Road Note 15*, DfID and TRL, Berkshire, UK.

TRRL (1982) *The TRRL Road Investment Model for developing countries (RTIM 2), TRRL Laboratory Report 1057*, Berkshire, UK.

TRRL (1988) *A view of road maintenance economics, policy and management in developing countries; Research report 145*. Berkshire, UK.

TUDELA, A; AKIKI, N. and CISTERNAS, R. (2006) Comparing the output of cost benefit and multi-criteria analysis: An application to urban transport investments. *Transport Research Part A.* **40**(5), pp.414-423.

UNDP (2014) *United Nations Development Programme*. [online]. Available from: www.undp.org [Accessed 1 August 2014].

UNITED NATIONS (2000) *United Nations Statistical Commission and Economic Commission for Europe. Conference of European Statisticians. Statistical standards and studies – No. 53*. Terminology on statistical metadata. [online]. Available from: www.unece.org/fileadmin/DAM/stats/publications/53metadaterminology.pdf [Accessed 15 February 2014].

URF Act (2008) *Uganda Road Fund Act; 2008*; Uganda Printing and Publishing Corporation, Entebbe, Uganda.

URF (2012) *Study on the budget allocation formula; AH Consulting*. [online]. Available from: http://www.ugandaroadsector.org/reports/Budget%20Allocation%20Formula%20Study%20FINAL.pdf [Accessed 22 January 2014].

UTP (2013) Uganda Traffic Police, *Uganda Accident Statistics for 2013*, Kampala, Uganda.

VAN DER TAK, H. G. and RAY, A. (1971) *The economic benefits of road transport projects*, World Bank staff occasional papers No. 13, The World Bank, Washington DC.

VAN WEE, B. and GEURS, K. (2011) Discussing equity and social exclusion in accessibility evaluation, *European Journal of Transport and Infrastructure Research*, **11**(4), pp.350-367.

VAN ZYL, G. D; SCHOMMARTZ, H. and SOPHIA TEKIE. (2011) *Managing road maintenance towards appropriate standards in Namibia*; Paper ICMPA146, 8th International Conference on Managing Pavement Assets.

VARIAN, H. R. (1990) *Microeconomic Analysis*, Norton & Company. Second Edition.

VERMEIREN, K; VAN ROMPAEY, A; LOOPMANS, M; SERWAJJA, E. and MUKWAYA, P. (2012) Urban growth of Kampala, Uganda: Pattern analysis and scenario development; *Landscape and Urban Planning*. **106**, pp.199-206.

VRIJE UNIVERSITEIT VAN AMSTERDAM (1994) *User guide for DEFINITE*, Amsterdam, The Netherlands.

WATSON, P. (1998) *Developing Africa's Transp*ort, Africa Transport Technical Note (no number), SSATPP, The World Bank. Washington, DC.

WEPENER, D. A; KRUGER, P; BOTHA, W. J. and TULYA-MUHIKA, S. (2001) *Road management and financing - the Uganda experience in the implementation of Road User Charges*; 20th South African Transport Conference; South Africa.

WILLETTS, R; BURDON, J; GLASS, J. and FROST, M. (2010) Fostering sustainability in infrastructure development schemes. *Proceedings of the Institution of Civil Engineers, Engineering Sustainability*, **163**(ES3), pp.159-166.

WOODSIDE, A. (2010) Bridging the chasm between survey and case study research: Research methods for achieving generalization, accuracy, and complexity; *Industrial Marketing Management.* **39**, pp.64-75.

WORLD BANK (1953) *Gold Coast - Economic report*. Europe series; EA9, The World Bank. Washington, DC.

WORLD BANK (1970) *Ghana - current economic position and prospects. Vol. 7 (AW18)*. [online]. Available from: http://documents.worldbank.org/curated/en/1970/10/1769420/ghana-current-economic-position-prospects-vol-7-10 [Accessed 3 April 2014].

WORLD BANK (1988) *Road Deterioration in Developing Countries*. The World Bank. Washington, DC.

WORLD BANK (1995) *Namibia Public Expenditure Review, Report No. 13558-NAM*, The World Bank. Washington, DC.

WORLD BANK (2003) *Kenya Transport Sector Memorandum; Report No: 26444-KE,* The World Bank. Washington, DC.

WORLD BANK (2005a) *Transport Notes*: *Transport Note No. TRN-9*: The World Bank. Washington, DC.

WORLD BANK (2005b) *Transport Notes*: *Transport Note No. TRN-26*: The World Bank. Washington, DC.

WORLD BANK (2008) *A user guide to Road Management Tools*, Sub-Saharan Africa Transport Policy Program,The World Bank. Washington, DC.

WORLD BANK (2009) *Namibia Country Brief, Report 48596*, The World Bank. Washington, DC.

WORLD BANK (2011a) *Curbing Fraud, Corruption, and Collusion in the Roads Sector*, World Bank integrity Vice Presidency, The World Bank. Washington, DC.

WORLD BANK (2011b) *Republic of Ghana, Tackling Poverty in Northern Ghana; Report No. 53991-GH*, The World Bank. Washington, DC.

WORLD BANK (2011c) *United Republic of Tanzania, Public Expenditure Review 2010,* Report No. 64585-TZ. [online]. Available from: http://sitesources.worldbank.org/INTTANZANIA/Resources/Tanzania_PER_2010.pdf [Accessed 15 March 2015].

WORLD BANK (2014a) *World Bank Country Profiles*. [online]. Available from: www.worldbank.org [Accessed 5 February 2014].

WORLD BANK (2014b) *World Tables, 1993*. [online]. Available from: www.data.worldbank.org/country/uganda [Accessed 23 March 2014].

WORLD BANK (no date) *Uganda Public Expenditure Review*; strengthening the impact of the roads budget, Report No. 55672-UG. The World Bank. Washington, DC.

WORLD COMMISSION ON ENVIRONMENT AND DEVELOPMENT - WCED (1987) *Brundtland Report, Our common future*. Oxford University Press, Oxford, UK.

WSP International (2003) '*Feasibility Study for Periodic Maintenance of Trunk, Main and District Roads in Zambia, for the Ministry of Works & Supply, Roads Department*, Lusaka, Zambia.

YIN, R. Y. (2009) *Case study research, design and methods*, 4th Ed, Vol. 5, Sage publications, California, USA.

ZEHENDNER, E; ABSI, N; DAUZERE-PERES, S. and FEILLET, D. (2011) Solving the Resource Allocation Problem in a Multimodal Container Terminal as a Network Flow Problem; *Computational Logistics*. **6971**, pp.341-353.

ZIETLOW, G. J. (2011) *Financing and Management of Roads in Sub-Saharan Africa - A Hopeless Case?* [online]. Available from: http://www.zietlow.com/gtz/Africa%20road%20reform.pdf [Accessed 7 January 2014].

ZIETLOW, G. J. and BULL, A. (2004) *Reform of Financing and Management of Road Maintenance: A New Generation of Road Funds in Latin America,* XXI World Road Congress, 3 - 9 October -Kuala Lumpur, Malaysia.