

Interactions between improved rural access infrastructure and transport services provision

Phase 1 Scoping Report



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TRL

ReCAP GEN2136A

April 2019



TRL

Preferred citation: *Starkey, P. et al., TRL (2018). Interactions between improved rural access infrastructure and transport services provision: Phase 1 Scoping Report. ReCAP GEN2136A. London: ReCAP for DFID.*

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Cover photo: Paul Starkey: Rural road investment and transport services in Cox's Bazar, Bangladesh

Quality assurance and review table

Version	Author(s)	Reviewer(s)	Date
1.1	P Starkey, J Hine, R Workman and A Otto	G Morosiuk (TRL)	10 August 2018
		A Bradbury (ReCAP PMU)	17 August 2018
		Jasper Cook (ReCAP TP)	25 August 2018
1.2	P Starkey, J Hine, R Workman and A Otto		19 September 2018
2.1	P Starkey, J Hine, R Workman and A Otto		8 January 2019
		A Bradbury (ReCAP PMU)	22 January 2019
		J Haule (ReCAP PMU)	30 January 2019
		J Cook (ReCAP TP)	22 March 2019
2.2	P Starkey, J Hine, R Workman and A Otto		7 April 2019

ReCAP Database Details:

Interactions between improved rural access infrastructure and transport services provision

Reference No:	ReCAP GEN2136A	Location	UK with subsequent research and workshops in AfCAP and AsCAP countries
Source of Proposal	ReCAP PMU	Procurement Method	Open tender
Theme	Transport Services	Sub-Theme	Effective use of access
Lead Implementation Organisation	TRL Ltd	Partner Organisation	N/A
Total Approved Budget	£79,680	Total Used Budget	£65,744
Start Date	1 May 2018	End Date	31 March 2019
Report Due Date	7 th January 2019	Date Received	9 th January 2019

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Abstract

The 'Interactions: Maintenance-Provision of Access for Rural Transport Services (IMPARTS)' project is studying how investments in low-volume rural road (LVRR) construction (provision) and maintenance (preservation) affect rural transport services (RTS). Improved RTS are vital for access to opportunities including markets, health facilities, education and greater equity. While road investments are justified by RTS improvements, few road authorities collect 'before' and 'after' RTS information. Literature reviews confirm beneficial correlations between road investments and socio-economic impacts, but few cite RTS information. Good RTS data sets are rare. This report discusses key planning factors for infrastructure provision, preservation and transport services. Issues of old, overloaded vehicles and motorcycle taxis are discussed. Evidence shows many beneficial transport effects of road investments. Examples are discussed of unexplained changes in traffic and mobility patterns. A stakeholder workshop in Arusha, attended by 39 participants from 12 ReCAP countries, endorsed more integrated approaches. Roads authorities should seek to understand RTS issues and use RTS-related outcome indicators in planning. Phase 2/3 research activities are proposed, with detailed surveys on roads with good 'before-intervention' datasets. For efficiency, Phase 3 RTS consultations will start immediately. An important Phase 2/3 output will be guidelines on developing integrated provision-preservation-services continuum approaches, including necessary RTS datasets and strategies for improving RTS.

Key words

Transport services improvements; Transport services indicators; Traffic counts; Rural mobility; Rural road outcomes; Rural road impacts; Rural road preservation; Rural road provision

Research for Community Access Partnership (ReCAP)

Safe and sustainable transport for rural communities

ReCAP is a research programme, funded by UK Aid, with the aim of promoting safe and sustainable transport for rural communities in Africa and Asia. ReCAP comprises the Africa Community Access Partnership (AfCAP) and the Asia Community Access Partnership (AsCAP). These partnerships support knowledge sharing between participating countries in order to enhance the uptake of low cost, proven solutions for rural access that maximise the use of local resources. The ReCAP programme is managed by Cardno Emerging Markets (UK) Ltd.

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Acronyms, Units and Currencies

\$	United States Dollar	LSFRP3	Liberian Swedish Feeder Road Project Phase 3
4WD	Four-wheel drive	LVRR	Low-volume rural road
4x4	Four-wheel drive vehicle	MAD	Moroccan dirham
AADT	Annual average daily traffic,	MDA	Ministries, Departments and Agencies
ADB	Asian Development Bank	MDB	Multilateral Development Bank
AfCAP	Africa Community Access Partnership	MELTC	Mount Elgon Labour-based Training Centre
AFD	Agence Française de Développement	MoPW	Ministry of Public Works
AfDB	African Development Bank	MoTA	Ministry of Transport and Aviation
AIDS	Acquired immune deficiency syndrome	MOWHI	Ministry of Works, Housing and Infrastructure
ANE	Administração Nacional de Estradas	MPW	Ministry of Public Works
AsCAP	Asia Community Access Partnership	NTRC	National Transport Research Centre, Pakistan
BIDS	Bangladesh Institute of Development Studies	NGO	Non-governmental organisation
COTO	Committee of Transport Officials	NPV	Net Present Value
CSIR	Council for Scientific and Industrial Research	NRAP	National Rural Access Program, Afghanistan
DANIDA	Danish International Development Agency	NTA	National Transit Authority
DFID	Department for International Development, UK	O-D	Origin and Destination
DFR	Department of Feeder Roads	PCI	Pavement Condition Index
DoLIDAR	Department for Local Infrastructure Development and Agricultural Roads, Nepal	PCU	Passenger Car Unit
DRC	Democratic Republic of Congo	PMGSY	Pradhan Mantri Gram Sadak Yojana
DROMAS	District Road Management System.	PMU	Project Management Unit
DRSP	District Roads Support Programme	PO-RALG	President's Office, Regional Administration and Local Government (Tanzania)
DTMP	District Transport Master Plan (Nepal)	RAAN	Región Autónoma del Atlántico Norte, Nicaragua
eg	for example	RAI	Rural Access Index
ERA	Ethiopian Roads Authority	RAMS	Road Asset Management Systems
EU	European Union	RAP	Rural Access Programme (Nepal)
Fia	Federation Internationale de l'Automobile	RAS	Región Autónoma del Atlántico Sur, Nicaragua
FRAMP	Feeder Roads Alternative and Maintenance Program	RAWG	Rural Access Working Group
GBP	Great Britain Pound (UK pound sterling)	RDA	Road Development Agency, Zambia
GDP	Gross Domestic Product	ReCAP	Research for Community Access Partnership
GEM	Economic Growth through Effective Road Asset Management Project	RED	Roads Economic Decision (software)
GPRTU	Ghana Private Road Transport Union	RONET	Road Network Evaluation Tools
GIS	Geographical information system	RPCO	Regional Program Coordination Office
GIZ	Deutsche Gesellschaft für Internationale Zusammenarbeit GmbH	RTS	Rural transport services
GoK	Government of Kenya	RTSi	Rural transport services indicator
GPS	Global positioning system	SAPEC	Smallholder Agricultural Productivity Enhancement & Commercialization
HDM-4	Highway Development and Management Model	SDC	Swiss Development Cooperation
IDA	International Development Association	SDG	Sustainable Development Goal
IFRTD	International Forum for Rural Transport and Development	SIDA	Swedish International Development Agency
IMPARTS	Interactions: Maintenance-Provision of Access for Rural Transport Services	SLRA	Sierra Leone Roads Authority
IMT	Intermediate means of transport	SLoCAT	Partnership on Sustainable, Low Carbon Transport
IRR	Internal Rate of Return	SSA	Sub-Saharan Africa
IRAP	Integrated Rural Accessibility Planning	SSATP	Sub-Saharan Africa Transport Policy Program, World Bank, USA
IRAT	Improving Rural Access in Tanzania	Sum4All	Sustainable Mobility for All
IRD	Institute of Rural Development, Afghanistan	TARURA	Tanzania Rural and Urban Roads Agency
IRF	International Road Federation	ToR	Terms of Reference
IsDB	Islamic Development Bank	Tsh	Tanzania shilling
ITDP	Institute for Transportation and Development Policy	UK	United Kingdom
JICA	Japan International Cooperation Agency	UKAid	United Kingdom Aid (Department for International Development, UK)
KeNHA	Kenya National Highways Authority	UNJLC	United Nations Joint Logistics Centre
KeRRA	Kenya Rural Roads Authority	UNRA	Uganda National Road Authority
KfW	German development bank (originally 'Kreditanstalt für Wiederaufbau' now KfW)	URF	Uganda Road Fund
kg	kilogram	URRAP	Universal Rural Road Access Programme
km	kilometre	USAID	United States Agency for International Development
Ksh	Kenya shilling	USD	United States Dollar
LGED	Local Government Engineering Department	VAT	Value Added Tax
		VOC	Vehicle operating costs
		WRI	World Resources Institute

Executive Summary

The 'Interactions: Maintenance-Provision of Access for Rural Transport Services (IMPARTS)' research project is studying how the provision and maintenance of low-volume rural roads (LVRRs) impact rural transport services (RTS) and the mobility of people and their goods. The premise is that there should be an integrated approach to the provision-preservation-services continuum to ensure road investments are well-planned, cost-effective and appropriate to the transport needs of rural communities.

The report discusses the findings of a literature review and a scoping study involving contacts with all 17 ReCAP countries. One aim has been to find evidence of how rural transport services have responded to investments in road construction (provision) and maintenance (preservation) or to road deterioration due to inadequate maintenance. Transport services are essential for rural mobility in low-income countries with low vehicle ownership. A common assumption of road investment proposals is that rural mobility will be enhanced as transport services respond to road improvements by reducing tariffs (lower vehicle operating costs) and improving vehicle capacities/frequencies. Evidence is scarce as few rural road initiatives have baseline and post-investment datasets related to transport services. Few roads authorities use transport services data (other than traffic counts) in prioritising investments. Planning road provision and maintenance involves managerial, technical, economic and political issues. Despite good planning tools, methodologies and guidelines, political considerations frequently divert scarce maintenance resources.

Within rural communities, individuals are diverse, with different transport needs to access markets, healthcare, education, livelihood opportunities and other facilities. The wide range of transport services vehicles includes minibuses, taxis, trucks and motorcycles, with different advantages, price-ranges and infrastructure needs. Most transport services operate on hub-and-spoke systems. Small town hubs (with mixed passenger-freight transport services) differ markedly from inter-urban transport systems. Transport associations can assist self-regulation but may operate as cartels. Rural transport services often use old, overloaded vehicles, related to low profitability. Motorcycle taxis are newer, but also often overload. Motorcycle taxis are often the most common vehicles on rural roads. They are more expensive and responsive than conventional services and may travel to off-road villages.

Literature is cited showing many beneficial correlations between road investments and socio-economic development. Roads can lead to higher agricultural production, higher attendance at schools and health facilities and more economically important trips. However, very few of these studies have reported on transport services, relying on socio-economic, GIS or other data sources for their correlated outcomes.

Information is provided from several countries showing how road investments have led to higher numbers of vehicle movements (measured by traffic counts). Some price effects are noted, although prices are highly dependent on vehicle type, traffic volumes, distance and availability, with long-distance, larger vehicles providing economies of scale. Many studies observed unusual correlations and unexpected results; some may be due to externalities not related to the studied roads, including climate, national issues and traffic diversions from/to other roads. Some changes are unexplained due to insufficient stakeholder consultation.

An IMPARTS inter-regional workshop was held in Arusha, Tanzania, from 12th-13th November 2018 with 37 participants from 12 ReCAP countries. Most participants came from road agencies and actively engaged in interactions with rural transport services stakeholders and related discussions. They endorsed the need for more integrated approaches. Transport services outcome indicators could be included in road planning and Maintenance Management Systems. Suggestions were provided for IMPARTS Phases 2 and 3.

Proposals for Phases 2/3 are discussed in this report. Suitable 'before' datasets are available in Ghana, Nepal and Tanzania. Rapid appraisal surveys will identify current issues and survey requirements. Two roads in two of these countries will be selected for data collection. Phase 3 work will start in Phase 2, to increase opportunities to engage with transport regulators, associations and bus companies. The final outputs will include guidelines to assist stakeholders develop integrated provision-preservation-services continuum approaches, with attention to transport services. This will require capacity building and active cooperation between roads and transport authorities, with possible integration and lessons from the inter-disciplinary road safety sector. Guidelines will help stakeholders ensure rural access infrastructure is fit-for-purpose, suggest appropriate data collection and strategies for improving rural transport services.

1 Background

1.1 Project overview

The Research for Community Access Partnership (ReCAP), funded by UKAid, commissioned TRL to undertake this research study to gain, and to disseminate, a greater understanding of how investments in low-volume rural roads (LVRRs) impact rural transport services (RTS) and the mobility of people and their goods. This project is known as IMPARTS (Interactions: Maintenance-Provision of Access for Rural Transport Services). It is exploring the interaction between the effective use of rural access and its dependency on the appropriate provision and preservation of LVRRs, and the resultant changes in rural transport service provision that are brought about through improved sustainable road performance.

There is understood to be a strong correlation between poverty and connectivity. Road access in rural areas can improve social welfare by increasing the proximity to, and quality of, basic services, and broadening livelihood opportunities, including agricultural production and marketing. Improved accessibility through the provision of rural road infrastructure and transport services can improve health and education outcomes by increasing attendance at clinics and schools and improving staff retention. Rural communities benefit from road infrastructure to allow them to reach markets, medical facilities, schools and income-generating opportunities. However, most rural people in low-income countries do not own motorised transport and therefore depend on various types of transport services for their mobility, access to services and earning potential.

The many benefits of LVRR are largely dependent on a sustained level of infrastructure performance linked to there being appropriate and affordable transport services: rural roads must be fit for purpose in terms of facilitating the movement of people and freight. Currently, infrastructure provision and preservation are largely disassociated from service provision. Therefore, this project is examining the relationships between LVRRs and transport services, and the links between LVRR-investment planning for provision and preservation and the actual achievement in terms of rural transport provision.

1.2 Project context

At the heart of this research is the evidence-based understanding of the relationship between the provision of fit-for-purpose road networks and the provision of appropriate and sustainable transport services for people and freight. Rural people need mobility to access agricultural markets and retail outlets, health facilities, educational establishments, economic opportunities, socially important events and other destinations. Service providers and rural enterprises (public, private and NGO) also need to reach villages (for these organisations, it is the 'last mile' of their outreach or distribution, but for the villagers it is their 'first mile' to markets and services). In most countries, the main means of rural travel is land-based and this makes the provision and preservation of rural roads essential for poverty reduction and socio-economic development. Road building is expensive, and it is important that there is appropriate preservation of the significant public-sector investment in infrastructure through well-planned and implemented maintenance. It is also now well understood that 'roads are not enough'; rural people need means of transport and transport services in order that they, and their goods, can travel and make full use of the roads.

The overall aim of the project is to research changes occurring in rural transport provision consequent to the rehabilitation or upgrade and improved maintenance of LVRRs and networks, and to help identify and optimise transport solutions to poverty caused by poor access.

A secondary purpose of the project is to identify other constraints to the expansion and improvement of transport services caused by supply-and-demand relationships in the rural transport sector. Not all rural roads in motorable condition have regular, reliable, daily rural transport services. There can be a vicious circle of low density of demand (associated with low population density and exacerbated by weak institutional structures, poor competition and regulation) and poor transport services, leading to limited mobility and economic activity (Starkey et al., 2002). How can a virtuous circle be created on appropriately-maintained rural roads, with increasing transport demand and improving transport services?

Phase 3 of the project will review the circumstances in which private-sector operators (including formal-sector operators) can improve rural transport services provision. This phase will consider the enabling factors required to generate market-based solutions, within the provision-preservation-access use

continuum. The potential for public-private partnerships may also be explored in the context of RTS provision as part of this continuum where the road asset (provision and preservation) is generally the domain of the public sector, and the services that use the asset are generally private sector entities.

1.3 Research objective

The core objective is to examine the conditions in which rural transport services succeed or fail, and the relevance of infrastructure condition and level of service to that outcome.

Output: definitive guidelines on how the provision-preservation-access continuum can be improved in support of better livelihood opportunities for rural communities and have a positive impact on poverty reduction.

Impact: to improve accessibility and mobility for rural communities, and to improve the overall livelihood outcomes of those communities, and, in particular, vulnerable groups and individuals within those communities.

This research is exploring how infrastructure projects are planned, designed and implemented in relation to the end user and the extent to which projected demand for transport service provision is factored into the planning processes. Through literature reviews, stakeholder consultations and Phase 2 field work, this research will consider the experiences of selected LVRR projects in Africa and Asia to examine whether transport service objectives and accessibility outcomes are being achieved as a result of the planned investment in road infrastructure. In doing so, it will determine whether LVRRs are fit-for-purpose for the generated traffic post-construction, rehabilitation or upgrade, and under what conditions these roads may be over- or under-designed relative to potential and actual demand for passenger and freight trip-making.

The results of this research should eventually lead to:

- A good practice approach to the planning, design and maintenance of new, rehabilitated or upgraded LVRRs and networks that result in improved service access
- Better advice to road planners and engineers on how to engage with beneficiaries of the road infrastructure, including the end user (households, farmers, transport operators, etc.), at the design stage, to optimise integration between roads and transport services
- Evidence that can influence policy and strategy decisions at high level
- Assessment of the effectiveness of different engineering solutions on wider transport service provision and accessibility based on empirical evidence
- Better understanding of the role of the private sector in delivering RTS, the institutional limitations within government structures of ensuring appropriate RTS, and identifying enablers for public-private partnerships where appropriate.

1.4 Approach and key issues to consider

The overall ReCAP strategy is based on the concept of the rural access provision-preservation-services continuum (Visser, 2018). Therefore, central to this research study is the idea that access provision (building infrastructure), access preservation (maintenance) and transport services (mobility for people and goods) are all interlinked and essential for rural access. As will be elaborated in Section 2.1.1, rural people are diverse, with different mobility and transport needs for themselves and their freight. Passenger and freight transport can be provided by a wide range of vehicle types and operational systems, each with a mixture of advantages and disadvantages for the different categories of people, transport operators and rural communities. The various types of transport requirements and vehicle operations do not have the same infrastructure requirements or physical interactions with roads. Therefore, it is crucial that LVRR infrastructure and maintenance regimes are appropriate to the transport services vehicles in use, and other traffic, so they are 'fit-for-purpose' for providing affordable access to rural communities.

In this project, the provision-preservation-services topics are intentionally intertwined. However, in most countries, in the past, infrastructure topics (provision-preservation) have been studied and implemented without much attention to transport services issues. In this research, they are being studied together. The rural infrastructure issues include a number of factors. Firstly, the type of infrastructure available, so it is

expected that the majority of roads will be earth or gravel, but there is also a possibility that some of the roads are bituminous or concrete, and even individual sections with cobblestone or stone soling (usually for steep sections). The built parameters of the infrastructure are also important, for example the geometry, thickness of the gravel layer, alignment, gradient and the drainage, as well as the condition of the surface in terms of roughness, potholing, slipperiness and whether it is motorable all year. The RTS issues will include the types of transport modes available (e.g. motorcycles, taxis, minibuses, buses, two-wheel tractors, bicycles, carts etc), the fluctuation in numbers and trips within each mode, the cross-modal fluctuations, the reasons provided by stakeholders for these changes, and suggestions for infrastructure improvement to foster growth in RTS provision.

In assessing infrastructure-transport services interactions, it is important to take into account that the rural road network is constantly changing as a result of investment, weather or traffic. In some cases, the climate may impact negatively on accessibility, and such impacts could be increased (or decreased) through climate changes. For example, during heavy rains, roads and water crossing structures can be washed out preventing normal transport services, leaving communities stranded. Similarly, dry periods can result in excessive dust, reducing the safety and comfort of transport services. Adjacent, connecting and parallel roads may be improved, maintained or alternatively fall into serious disrepair. Where there are dense networks, traffic diversions will be spontaneous as transport services tend to avoid roads in poor condition and take advantage of roads in good condition (provided the transport demand is there). Experience suggests that it will be important to identify, and where possible keep track of, developments that occur on the surrounding network (Hine and Bradbury, 2016). Roads selected as 'controls' do not generally remain in constant condition. Hence, care is needed when interpreting changes in transport services patterns between roads identified for infrastructure-services interactions and their 'controls'.

1.5 Research methodology

To date, Phase 1 project activities have been concentrated on a literature review and stakeholder consultations, by email, telephone conversations and meetings. The aim has been to identify additional sources of information, exchange ideas and gauge interest in the research topic, the stakeholder workshop and engagement in advance of Phase 2 Research (which will involve some new data collection).

As far as practicable, the project will try to include time-series studies on the state of infrastructure at any point in time and the corresponding dynamics of transport services at that time. The data to be considered in the study are the 'before-improvement' and the 'after-improvement' state. Notwithstanding this, the 'after-improvement' state may consist of deterioration in the state of the infrastructure (e.g. increase in roughness of a re-gravelled section of road) and corresponding changes in transport services dynamics. As cycles of improvements and deterioration can span many years, this project duration will not be long enough to be able to witness full cycles of improvements and deterioration. However, through examination of records and interviewing of key informants, it should be possible to provide useful information for preparing guidelines and recommending policies relating to both infrastructure and transport services.

Sometimes, LVRRs have been built primarily to allow access for sector-specific commercial transport, such as vehicles of agricultural, forestry, fisheries, mining or retail enterprises and/or for sector-specific services. However, in most low-income countries, the provision of LVRR infrastructure has usually had an intrinsic aim to encourage the development of transport services to allow local people to access markets and services. This is particularly the case in previously unconnected rural areas where the populations are often the poorest and most deprived. Unfortunately, as will be made clear from the literature and from this research, the ways that transport services develop have not always been taken into account appropriately when infrastructure has been planned and prioritised. This can lead to good roads with little or no traffic, and poor roads that are over-used.

1.6 Information sources and constraints

1.6.1 Lack of integrated approaches to provision-preservation-services

In the following sections of this report, the information comes from various sources, including peer-reviewed publications. However, as we have learned from interactions with national stakeholders, development agencies and multilateral development banks, much of the data collected on rural roads and

rural transport services has never been formally published. It is retained in project reports, planning and evaluation documents and similar 'grey-literature'. We also add personal observations of the authors and other stakeholders contacted. These 'anecdotal' observations may not have the same scientific validity as research outputs, but they do assist with interpreting and explaining particular transport services situations. In this document, there are several examples where 'anecdotal' observations have seemed invaluable in allowing possible interpretations of changes in transport services. There are also other cases, where one wishes the people responsible for data collection had talked with local stakeholders and reported their 'anecdotal' findings, which might well have allowed more understanding of 'unexplained' changes in traffic or transport services.

The rural access continuum that includes provision-preservation-services has been adopted as central to ReCAP strategy (Visser, 2018) and is central to this study. Unfortunately, as will be apparent from the contents of this report, over the past few decades, national road programmes (and their supporting donors and development banks) have seldom embraced such an integrated approach. Road agencies have tended only to pay lip service to the importance of transport services. Reductions in vehicle operating costs and improvements in transport services have generally been cited as justifications for investments in access provision and access preservation. However, rarely have there been systematic studies relating to this, with pre-investment baseline data on transport services (modes, prices, frequencies, quality) followed by comparable post-investment data on transport services, repeated at intervals. Such studies would be invaluable in the context of this research, but such data sets have seldom been collected by road authorities.

One of the biggest problems is that very few road-related studies have included detailed observations on transport services, including operating fleets, frequencies, tariffs and loading levels. Most road-related projects undertake traffic counts, but these give little information on transport services provision. If the only information sources are basic traffic count data (insufficiently disaggregated for transport services vehicles), it is very difficult to make reliable assessments of changes in transport services, and this makes the present research challenging.

An example of insufficient disaggregation of traffic count data can be seen in some District Transport Master Plan (DTMP) documents in Nepal. Traffic is summarised as Passenger Car Units (PCUs), in which the numbers of buses, trucks, jeeps and motorcycles and other vehicles are combined together in one traffic measurement. In Morang District (DoLIDAR, 2017), traffic was summarised in the DTMP in four categories: i) Motorcycles, ii) Tractors, iii) Cars-Jeeps-Minibuses, and iv) Trucks-Buses. While this provides some information, without further details, it is difficult to gauge transport services, as trucks and buses have very different roles, and cars and jeeps can be transport services or can be government, NGO or private vehicles.

As will be discussed in Section 3 of this document, even 'good' traffic-count data sets relating to road investments in Tanzania and Kenya have not been sufficient to interpret how transport services have actually responded to the changes in road conditions on certain roads.

From the observations of team members and discussions with colleagues, in some countries, the planning links between infrastructure provision/maintenance and transport services can be distorted by political considerations and corruption. Even when there is a functional and appropriate rural road planning system in place, it can be vulnerable to overriding political needs and corruption associated with road budgets and contracting. Such distortions are seldom, if ever, evident within written reports.

Interpreting the interactions between access provision-preservation and transport services is not easy, due to the great variability of local circumstances and their changes over time. As an example, large year-by-year fluctuations have recently been observed on rural roads in Ethiopia with overall motorised traffic volumes increasing by 88% between 2015 and 2016 and then declining by 40% in 2017. Over the same period there were also major declines in bicycles, animal-drawn carts and pack animals as well as an increase in pedestrian traffic. The explanation almost certainly relates to periods of drought that have affected both farming incomes, the movement of crops, and also government measures to provide relief to adversely affected populations (Wabekbon, 2017).

1.6.2 Motorcycle taxis and compliance with regulatory standards

Following earlier developments in South East Asia, there has been a dramatic increase in motorcycle populations in Africa over the last ten years (often amounting to an increase of 40% per year). The trend is also seen in many parts of Asia. This has translated into a rapid increase in the availability of motorcycle taxis in many rural areas. Such long-term trends need to be carefully monitored and taken into account in analyses. The recent growth of motorcycle traffic in some countries has meant that motorcycles are often the most common vehicles on rural roads. However, motorcycles were not an important issue when many of the existing road standards were developed, transport services and road safety regulations were established, roads were built, maintenance planned and baseline-data obtained. In parts of Asia including Myanmar (Starkey and Cartier van Dissel, 2016) and parts of Africa, including Liberia (Cardno IT Transport, 2018), motorcycle trails have been constructed to allow transport services (motorcycle taxis) to carry people and goods between off-road villages and the road network. The complicated interactions between motorcycle-based transport services and infrastructure provision and preservation appear quite dynamic, and have yet to be fully researched and issues addressed.

There are numerous issues relating to RTS that require sensitivity when discussing with stakeholders and developing the guidelines. The issue of motorcycle trails can be sensitive if stakeholders consider them as a 'second-best', inferior option compared to rural roads (as opposed to complementary and synergetic infrastructure that can help to provide equity in rural mobility). Other key issues include compliance with safety standards, insurance, vehicle fitness and loading levels, regulatory enforcement and corruption. Regulatory compliance is often poor for many types of RTS, with passengers sometimes travelling on the roofs of jeeps and buses, hanging onto trucks, or sharing the driver's seat. Rural motorcycle taxis regularly carry multiple passengers. Some of the safety and regulatory issues that relate to motorcycles and three-wheelers on LVRRs are currently being researched under the ReCAP RAF2114A Project, and the outputs of this project are informing this research in appropriate ways (Bishop et al., 2018a; 2018b, 2019).

National authorities, including road safety authorities, tend to consider non-compliance as a black-and-white issue, requiring only enforced compliance. However, rural enforcement officials tend to be more understanding and lenient (and in some countries may also benefit from corrupt payments). The regulatory and compliance issues are often closely linked to the local provision-preservation-services interactions. Transport operators argue that they have to overload to make a profit on the poor roads. Passengers dislike overcrowding, but due to the scarcity of transport services, regard discomfort as better than not travelling at all. From personal observations, the oldest and most overloaded vehicles tend to be seen on rough rural roads, and newer vehicles complying with loading levels are more likely to be seen on better roads. This is not always the case, and correlation is not the same as causation. However, in general, better roads, together with an element of enforcement, do appear to lead to safer vehicles and less overloading. In rural areas, the comparative advantages of motorcycle taxis are emphasised on trails, poor roads (motorcycles can avoid many potholes) and for short, timely journeys. With improved roads, and increased transport services, there may be modal shift away from motorcycle taxis, towards more conventional transport. Investigations of the provision-preservation-services interactions associated with safety and compliance issues need to be tackled and reported sensitively, acknowledging the different stakeholders' opinions.

2 Overview of the Provision-Preservation-Services Continuum

2.1 Rural access and mobility

2.1.1 Need for rural mobility and transport services

Rural communities comprise a diversity of people including women, men, children, older persons, people with disabilities and families of different wealth, status, employment and interests. In various ways, they need access to daily necessities (water, food, energy, housing), to shops and markets (for household needs and for farm inputs and outputs), to educational establishments, to medical centres, to employment and livelihood options, to social gatherings (religious, cultural, sport and recreation) and to civic obligations and privileges. Access to information and communications is also increasingly recognised as being important for rural societies. Villages and their individuals need access to necessities, services and opportunities: this requires transport for people and for freight.

Poverty alleviation and socio-economic development require less rural isolation, improved mobility and greater access, achieved by complementary transport and infrastructure. Proximity and mobility are key issues. If the services that people need are nearby (proximity), they do not have to travel so much (mobility), as they can benefit from the mobility of the service-providers. Rural roads allow vehicles and services to reach villages, providing supplies for shops, medical facilities, schools, agricultural stores and other enterprises. Agricultural buyers can also reach villages. However, only towns or large villages can support the provision of a full range of services, and so most rural people do need to travel out of their villages to reach social and commercial services in local towns. They need means of transport to make use of roads in order to travel to towns and markets, and to access services and livelihood opportunities.

In low-income countries, most rural people cannot afford personal cars, and so require lower-cost means of personal transport or some form of public transport to carry themselves and their goods. Different types of people, and diverse individuals, have distinct transport priorities. Daily, long-distance commuter-type village-to-town transport tends to favour men, while women often require multi-purpose trips (e.g. to the school, clinic and market) and favour high-frequency, local transport service modes. Women tend to be more discouraged than men by overcrowded vehicles, unsafe practices and high fares. There are also people who do not use RTS, sometimes due to lack of resources or due to lack of suitable vehicle types (e.g. older persons and people with disabilities).

There is a diversity of different transport services modes, with a range of advantages and disadvantages for the various stakeholders. Their merits and demerits may be perceived differently by the various users, operators and regulating authorities. Depending on the country, motorcycles, rural taxis (including pickups and jeeps), minibuses, midi-buses and trucks (of various sizes) are generally the most widespread rural transport types. The operating costs, market-demand requirements and typical tariffs vary greatly between the modes, as do the infrastructure requirements and interactions. There can be changes in the modal distribution of transport service vehicles, as infrastructure or transport demand changes by seasons or over a period of years.

In addition to 'conventional' public transport vehicles, there are many intermediate means of transport (IMTs) that provide mobility for individuals, for families and their produce/goods and may also provide informal transport services to assist others. IMTs include bicycles, motorcycles, handcarts and animals (carts, riding and pack transport). Multipurpose farm vehicles, such as two-wheel tractors with trailers, may also be used for road transport, in some countries. All these IMTs have different capacities, speeds, costs, and advantages and disadvantages. For example, bicycles are widely used for rural transport and provide excellent personal mobility at a relatively low cost, but are less suited to long-distances or carrying loads, children or older persons and they offer no protection from the weather. Motorcycles overcome some of these problems (although not exposure to the weather) but are much more expensive, and may be difficult to afford, unless they can contribute towards income generation (e.g. as part-time or full-time motorcycle taxis).

Therefore, in most rural areas, there is a need for some forms of public transport services that will carry people, and their goods, at an affordable cost. Surveys of rural transport users (of different gender, age, occupation and abilities) in many countries have highlighted what rural people want from transport services (Starkey et al., 2002; Starkey, 2007a; Starkey, 2007b; Starkey et al., 2013b). Farmers and traders need access to markets to sell produce and buy inputs. They want transport services that allow them to travel with baskets, or sacks of produce, to and from such markets. Rural households and artisans need access to markets and stores to buy necessities and inputs, and again they want transport services that allow them to carry their purchases, which may include some building materials. Everyone needs to be able to access healthcare, but the greatest need is for children and women of reproductive age. Children, older persons and people with disabilities may need to travel with a parent or helper. Children need to access schools. Primary schools are often (but not always) within reasonable walking distance, but middle and secondary schools are often too far for a daily walk, and so require some form of transport, or boarding arrangements, either of which can impose financial burdens that limit access to education for some children. People may need to travel for employment on a daily or regular basis. For all these purposes, rural people need transport that is affordable, predictable and dependable, timely, safe and secure and that can carry people's goods and (when required) their supporting persons (parents/helpers). People also prefer transport that is uncrowded and clean and easy to enter and to alight from (Starkey, 2016b).

From this overview of the different needs for rural transport services, and the various forms of transport services available, it would seem that those responsible for infrastructure planning, provision and preservation would need to understand, through surveys and the collect data, how existing (and projected) transport needs are being fulfilled, and by what means of transport. However, as will be elaborated in Section 2.1.2 and in subsequent sections of this report, this is not generally the case. To understand how transport services are actually serving rural areas requires disaggregating ‘traffic’ and ‘passengers’ in ways that enable planners to interpret the interactions between transport services and infrastructure provision-preservation. Such interactions are crucial to Phases 1 and 2 of this research. In Phase 3, we will see how existing infrastructure can be more effectively employed, by facilitating better rural transport services.

2.1.2 Lack of integrated planning approaches

Rural transport investment has concentrated on the provision of road infrastructure and its maintenance (provision-preservation). In most countries, governments have funded such infrastructure investments from public funds, and have neglected transport services. In the twentieth century, in some countries, there were national bus services that served rural areas, but most succumbed to public-sector institutional inefficiencies and insufficient income to allow fleet renewal. Most countries now assume that the private sector will respond appropriately to the public-sector-funded provision-preservation investments and provide suitable transport services. However, seldom, if ever, do roads authorities verify that rural people do have appropriate access to means of transport or transport services. As this research highlights, many rural people suffer from inadequate mobility, and are unable to benefit fully from the provision-preservation investments. An integrated approach is needed to LVRR infrastructure provision-preservation and its use by motorised and non-motorised transport for the benefit of rural communities.

One reason for the lack of integrated provision-preservation-services approaches relates to a lack of integrated rural transport planning, monitoring and evaluation. The administrations responsible for infrastructure investments are seldom the same as those responsible for the licensing and regulation of vehicles and transport services. In many countries, transport provision-preservation and transport services are the responsibilities of different departments or even of different ministries. Road infrastructure is expensive, and roads ministries (or agencies) tend to be well-funded (relative to transport authorities) with many staff, including at the decentralised levels. In contrast, the departments or ministries responsible for road transport vehicles tend to be much smaller and less well-funded. They tend to operate within their limited resources by concentrating on urban and inter-urban roads, which have the highest densities of vehicles and transport services. They have few (if any) staff at devolved levels, and provide very little, if any, support for planning and regulating efficient rural transport services.

The dilemma is that rural road authorities have very little, if any, responsibility for, or training about, rural transport services. At the same time, transport services authorities have low budgets, few staff in rural areas, and little capacity for planning and regulating the specific challenges of achieving good rural mobility. Therefore, taking an integrated approach to transport provision-preservation-services is likely to require much capacity building and significant institutional cooperation and/or adjustments to responsibilities and budgets.

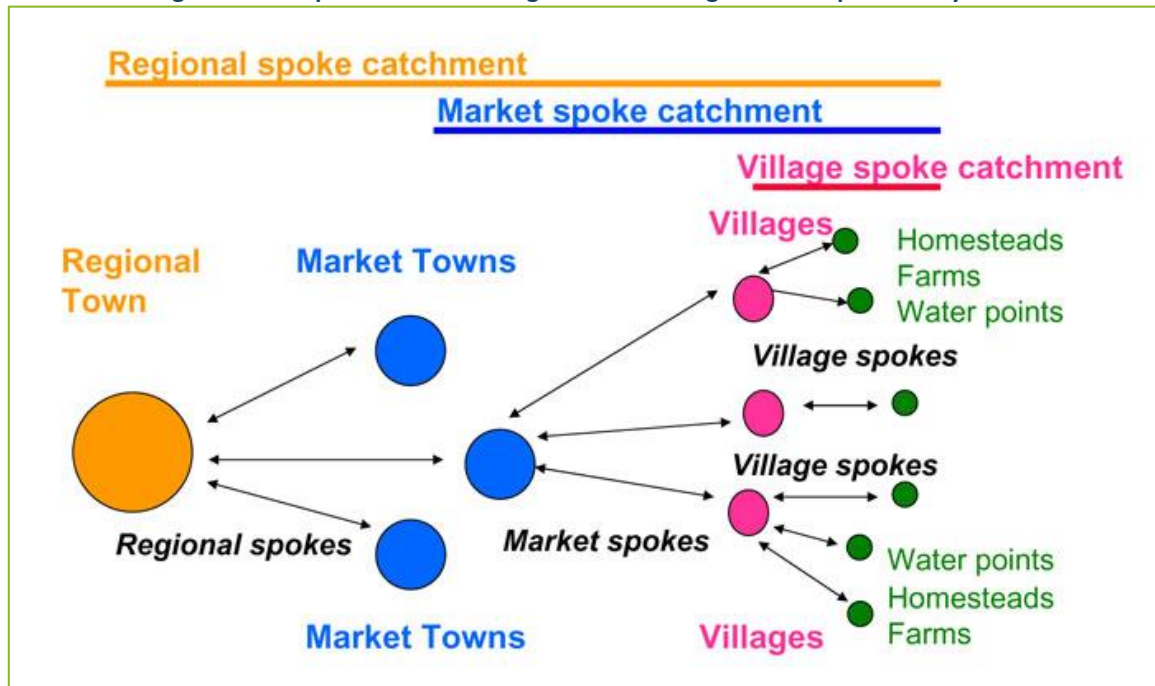
2.2 Rural transport hub and spoke systems

Transport services tend to operate from transport hubs of different sizes and scales. This is particularly clear for passenger transport services, but also affects the organisation of freight transport. In a simplistic form, the key transport hubs can be summarised as:

- City hub (with university, many schools, a large hospital, industrial area and possibly central government), with spokes (national roads) leading to . . .
- Regional or provincial towns (with a college, several schools, hospital, commercial area trading centre and probably regional/provincial authorities) with spokes (regional roads) leading to . . .
- Market towns or district towns (with secondary school, large health centre, large market and possibly district level government), with spokes (district or local roads) leading to . . .
- Large villages (with primary school, small health centre, small market) – with ‘spokes’ (perhaps paths and tracks) to outlying small villages, homesteads and fields (Starkey, 2007a).

Each of these hubs has a catchment area, and this is illustrated in Figure 1.

Figure 1 Conceptual model of a segment from a regional transport hub system



Source: Starkey (2007a)

The various hub and spoke systems have different characteristics, and transport services that reflect these. Transport between regional towns and a city is travelling along national roads, and with the large populations and relatively constant transport demand, it is possible to use high-capacity vehicles and provide regular services. With good roads and vehicles providing economies of scale, long-distance passenger bus fares tend to be low. With much freight to be moved, specialised freight companies serve the various freight transport markets, at relatively low cost, per tonne-kilometre. The regional hub and spokes are also primarily inter-urban transport using regional/national roads. With lower catchment populations, and lower transport demand, there may be smaller vehicles (e.g. midi-buses), lower frequencies and slightly higher prices. However, there will normally be several opportunities to travel each day.

The next level is the market town transport hub, with spokes linking the town to the surrounding villages. The current research is concentrating on this part of the transport system, with rural transport services that link villages to the local town and markets, using LVRRs. These roads have much smaller catchment populations, and the transport demand may not justify large vehicles or even daily services. Transport operators, based in the market town hub, may only provide services on market days. The roads are likely to be rougher and require more robust vehicles than those that operate on the national road network. With smaller vehicles and higher vehicle operating costs, tariffs are likely to be higher than on the inter-urban routes. With low passenger and freight demand, specialised passenger and freight vehicles may not be justified, and multipurpose vehicles that can carry both passengers and freight may be appropriate.

The final level is the village hub, with small roads, tracks or footpaths leading to outlying villages, homesteads, farms and perhaps sources of water and fuel wood. With short distances and very small catchment populations, there is very little economic transport demand to justify regular transport services. People will generally walk and carry or use intermediate means of transport (including motorcycles in some countries). There may be some vehicles that arrive, usually by arrangement, to transport agricultural produce over the 'first mile' and on to the market town.

It is crucial to identify the hub-and-spoke hierarchies in order to understand RTS. However, it must be recognised that the various systems do overlap in places, and that not all journeys from a village are along discrete LVRR market spokes. LVRRs tend to serve several villages, which may be clustered or spaced out along the road. Many LVRRs connect several villages to the national road network, with onward transport to the market town along national roads (in the same vehicle or with a transport interchange at the

junction). Some villages are located on the national road network, and villagers may be able to board inter-urban transport services.

2.3 Rural transport services

2.3.1 Buses, minibuses, taxis and passenger trucks

Rural transport services generally operate between villages, markets and towns, and carry both people and their goods. Some are based in the villages, and travel into the towns (picking up passengers along the route), and back, often with just one trip a day. Others are based in the towns and may operate on several different LVRR, particularly on relevant market days. Most RTS vehicles are small or medium (motorcycles, three-wheelers, cars, pickups, minibuses, 4WD estate wagons or light trucks). They are almost always operated by the informal private sector, and are owner-operated, or leased out by the owners on a daily or weekly basis (Starkey, 2016b).

While many countries have private companies owning fleets of urban buses, inter-urban transport (buses and minibuses) and/or urban taxis, it is unusual to come across owners of many rural transport vehicles. Some countries have parastatal bus services, but these mainly operate on national roads. In China, only formal bus companies are permitted to provide transport services. These companies find many village transport services to be unprofitable, and so they concentrate on inter-urban transport services, leaving many rural people to use personal motorcycles or clandestine services (Starkey, 2013). In Fiji, private bus companies operate some rural routes, serving multiple villages and travelling for much of their routes on national roads (Haworth and Starkey, 2009). Similarly, in several south Asian countries, including Nepal, Sri Lanka, Indonesia and Timor Leste, some privately-operated bus routes start in villages and travel to cities mainly on the national road network (MEH Consultants and Starkey, 2009; Starkey, 2009). This is also the case for many parastatal rural buses in India, and also for the private rural buses in Tanzania (Starkey, 2007b; Willilo and Starkey, 2012). New buses are expensive and for profitable operation need high loading levels and many hours a day of income generation. This makes them generally inappropriate for the market demand of small villages and the relatively short lengths typical of village-to-town roads. In Sri Lanka, a project to develop a community bus service proved unviable when it started with a modern bus, but then proved successful over many years, after switching to the use of a less expensive, older bus. The bus operated between a village and small town 13 km away, carrying 400-600 passengers a day (de Silva, 2014).

Where roads are in a relatively good condition, minibuses are a common form of rural transport. They can carry about 12-16 people (sometimes more are squeezed in) and will generally carry some goods, inside or on a carrier. If the transport demand is high, the larger midi-buses (25-35 seats) may be used, although these are more common on urban and inter-urban roads. Where roads are in poor condition, more robust vehicles are generally operated, including pickups, 4WD wagons and trucks. In some countries, including Burkina Faso, Colombia, Indonesia, Mozambique, Myanmar, Papua New Guinea and Timor Leste, pickups or light trucks are fitted with sideways-facing bench seats, which do not provide much comfort, but do permit the transport of significant loads in addition to the passengers. Almost all 'conventional' rural transport vehicles (as opposed to motorcycles and other IMTs) are purchased after they have already served for many years on other roads. They are frequently more than twenty years old. There tends to be 'stratified' markets, with initial use for (say) six to ten years in an industrialised country, then ten years, or more, of urban or inter-urban use in a low-income country, before being sold on to a rural transport entrepreneur.

2.3.2 Strategies to enable a daily profit

The use of old vehicles is one indication of the relatively low profitability of RTS. Indeed, in one randomised trial with a subsidised rural minibus service in Malawi, it was concluded that whatever level of pricing was set (e.g. low fares with high loading levels or higher fares with fewer passengers), the operator could not cover the operating costs incurred (Raballand et al., 2011). Due to the costs of running a vehicle on a LVRR, operators often try to maximise their income by taking more passengers than the vehicle was designed for (and regulations permit). It is not uncommon for eight or more people to travel in a five-seater rural taxi, or for passengers to travel on top of vehicles. As one transport operator explained when asked how many passengers he carried, 'that is difficult to say, because there is always room for one more'. Clearly there are many safety and regulatory issues related to such overloading. Another way of trying to maximise income is to wait until the vehicle has a profitable load. This is very common and makes rural transport services very

unpredictable. The bigger the vehicle, the more people are required before departure, which is one reason why buses (and even minibuses) may not be used on roads with low transport demand. It is quicker to get a 'full' load with a rural taxi and even quicker for a motorcycle taxi.

Waiting for a 'full' load is not compatible with predictable timetables and can lead to a descending spiral of transport services. If transport is unpredictable and can involve long waits, people are less likely to decide to travel, unless it is essential. This reduces market demand, which in turn increases waiting time and unpredictability, which further depresses the market. Numerous public transport systems in the world have managed to generate ascending spirals of passengers by increasing trip frequency, which can make people more likely to travel by that mode of transport. However, with timetabled services, operators cannot be sure of full loads on every journey. This is acceptable for transport companies provided their average loads are profitable. Operators in the informal rural transport sector seldom have the financial flexibility to risk not making a profit every day, and so seldom start a journey without a significant load. To help consolidate loads, some rural transport operators have relatively predictable starting times from the village (early morning) and return from the town (afternoon). If the demand is high, two or more vehicles may have the same pattern, so there may be three travel options per day in each direction, but all about the same time. This has been observed in Cameroon, Lesotho, Namibia and Tanzania (Kemtsop and Starkey, 2013; Starkey et al., 2009; Starkey et al., 2017b; Willilo and Starkey, 2013). This can be a gender issue, as it favours those who can spend all day in the market town, but not those who need to multi-task in different locations, and these are more likely to be women.

2.3.3 Motorcycle taxis

In many countries, motorcycles have become the most common vehicle on LVRRs and motorcycle taxis are often the main form of passenger and freight RTS, particularly on non-market days (Willilo and Starkey, 2012; Kemtsop and Starkey, 2013; Starkey, 2016a; Mustapha and Peters, 2017). Motorcycle taxi operators may pose many safety and regulatory issues that need to be addressed (Starkey, 2009; Starkey, 2016a; Bishop et al., 2018a and b). There are several comparative advantages of motorcycle taxis, compared to conventional transport services (Starkey, 2016a). Motorcycle taxis can:

- Leave speedily, with no waiting
- Avoid mud and potholes and so travel faster on very poor roads
- Adjust their timing to suit the customer
- Travel to specific destinations (not just transport terminals)
- Travel off the road to homesteads and off-road villages
- Respond to telephoned requests
- Provide many opportunities for local employment.
- Are not usually properly regulated

The main comparative disadvantages of motorcycle taxis are that they can be:

- Less safe and more accident-prone than other modes of transport
- More expensive, per passenger-kilometre
- Unprotected from the sun, rain and dust
- Intimidating for some passengers (e.g. the elderly, the sick, people with disabilities)
- Limited in their capacity for freight loads. (Starkey, 2016a).
- More prone to theft from passengers, drivers and thieves lying in wait for passing traffic

The issue of motorcycle comfort is ambiguous, depending on how crowded and cramped are the alternative options. While operators are almost always men, in some countries, women make up the majority of passengers (Olvera et al., 2012; Starkey et al., 2017a).

While there is some competition between motorcycle taxis and other rural transport services, the different vehicle types generally operate in complementary ways, with different 'niches' in the transport market. Operators of taxis and minibuses tend to consider motorcycles as providing beneficial 'feeder services', bringing passengers from villages to the main transport routes (Starkey, 2016b).

2.3.4 Intermediate means of transport

Intermediate means of transport (IMT) range from simple wheelbarrows and hand-carts, to bicycle-based and motorcycle-based technologies, and include pack transport and 2-wheel carts or 4-wheel wagons pulled by oxen, buffaloes, donkeys, mules, horses or camels (Riverson and Carapetis, 1991; Starkey, 2001; Starkey, 2002; Crossley, Chamen and Kienzle, 2009). Many types of IMTs provide local transport solutions over short distances, carrying people and goods around villages (and towns). Some also provide transport between villages and markets, either for individuals or as informal transport services. On many rural roads, IMTs (including motorcycles) constitute the majority of the traffic and together they may carry large numbers of people and significant quantities of freight (IT Transport, 2003; Starkey et al, 2013a). For example, a study carried out on a rural road in Cameroon showed there were 200 vehicle movements a day on non-market days (of which 100% were IMTs, mainly motorcycles but also bicycles) and 500 movements on market days (of which 93% were IMTs). It was estimated that IMTs (mainly motorcycles) accounted for 82% of annual passenger kilometres on that road and 74% of the annual small freight transport (Kemtsop and Starkey, 2013).

The spread and distribution of IMTs shows interesting patterns of adoption, with certain technologies, configurations and even predominant colours spreading in some provinces and countries, but not in others (Starkey, 2001). Two-wheel tractors (power tillers) pulling trailers have commonly been used by farmers for on-farm and for family use to access markets in China and south-east Asian countries. In Myanmar and Laos, some provide passenger transport services, although in most countries they are used mainly for freight transport (Starkey, 2016b). There is gradual growth of two-wheel tractor transport services in some Africa, for example in Tanzania, albeit from a low base-level.

IMTs can be relatively expensive compared to local incomes, and so rural people with resources are most likely to own them. The costs of ownership can be shared through informal tariffs and hire services. As in many transport and poverty situations, the poorest members of communities may not be able to afford either ownership or the informal fares and tariffs. Making credit, or raw materials, more easily available to manufacturers, stockists and potential users can greatly assist the diffusion of IMTs (Starkey, 2001; Porter, 2013). Targeting appropriate credit at users with insufficient resources, for example women or school children, can also improve uptake and improve mobility for disadvantaged people (Malmberg Calvo, 1994). For women, there may be local gender-based constraints that discourage personal mobility or particular types of transport (bicycles, motorcycles, certain animals). Local promotion schemes can help overcome prejudices. Intolerance to women using particular means of transport tends to decrease over time and with greater familiarity (Malmberg Calvo, 1994; Starkey, 2001; Porter, 2013).

National transport authorities have a tendency to neglect the importance of non-motorised intermediate means of transport for poor people. Such IMTs are often considered old-fashioned, inefficient and a temporary stage prior to more universal motorisation (Starkey, 2002). However, their ongoing importance in many areas can be very high, as they often provide crucial mobility to access healthcare, schools and markets.

In eastern and central Africa, bicycle taxis (sometimes known as boda-bodas) have provided important transport services, as well as employment opportunities for young men (Malmberg Calvo, 1994; Howe, 2002; Howe, 2003). In Luapula in Zambia, bicycle taxis regularly carried people for distances in excess of 30 km (Starkey, 2007b). Bicycle taxis are increasingly being replaced by motorcycle taxi services, which are more expensive but much quicker (Starkey, 2007b; Porter, 2013; Starkey et al, 2013a).

While this study is concentrating on the interactions between road provision and maintenance and the motorised public transport services operating on them, issues relating to intermediate means of transport will also be considered, particularly when these are used as transport services to take people and goods to markets, schools and health facilities. Traffic counts to be undertaken in Phase 2 will include pedestrians and IMTs providing transport services.

2.3.5 Transport services on waterways

While this research is concentrating on land transport issues, the importance of water transport in some countries is fully acknowledged. Waterways include rivers, lakes and canals. Marine coastal transport is important in some countries, as well as deep-sea marine transport in archipelagos. There are also ferries, of various sizes, that allow people and traffic to cross waterways (Rangaraj and Raghuram, 2007). These may

be hand-operated canoes, rafts or motorised vessels. On waterways, transport services are provided in various sizes of craft, ranging from small, private rafts or canoes to non-motorised and motorised transport services (Palmer, 1998; IFRTD, 2003; Parikesit et al, 2003; ADB, 2013b; Utomo and Mateo-Babiano, 2015). The interfaces between water transport and land transport are particularly crucial, be these small jetties or formal docks (Parikesit et al, 2003; ADB, 2013b; Starkey and Cartier van Dissel, 2016).

2.3.6 Operator associations and regulatory enforcement

The role of operator associations and cartels in RTS varies greatly between countries, but little research work has been carried out in low-income countries (Porter, 2013). In most countries, operators of each main type of transport do join together in associations. Some, particularly those for motorcycles and other intermediate means of transport, may simply be mutually beneficial saving schemes that help members in the case of accidents, sickness or family problems. Others can be strong, anti-competitive cartels. In Nepal, there are bus and truck operator cartels that stop non-members from operating, sometimes with intimidation and violence (Maunder et al., 1999; Starkey et al., 2013c). There are powerful national federations in Ethiopia, Ghana and Nigeria that control transport queuing, particularly at urban terminals (Lyon, 2006; Transaid, 2014; Afukaar et al., 2017a). On the positive side, such associations can prevent disorderly loading systems at terminals, can share the transport market between the members, can organise rotations between routes (Starkey, 2016b), can assist with maintaining safety standards (Molomo et al., 2013; Transaid, 2014) and can provide emergency medical transport (Adamu, 2012; Transaid, 2013). There have been examples of cartels in Cameroon and Nepal operating from different terminals, creating competition and leading to lower tariffs (Lisinge, 2001; MEH Consultants and Starkey 2009). On the negative side, cartels tend to be anti-competitive, maintaining high prices, discouraging fleet renewal and restricting new entrants to the market (MEH Consultants and Starkey 2009; Hine, 2014). In rural South Africa, it was found surprising that operator associations did not consider road condition a priority issue when determining tariffs, even though minibuses would only operate on paved roads (Venter et al, 2013). The conclusion is that the influences of transport associations need to be assessed when understanding how transport services react to changes in road condition.

It has been noted that the transport regulatory authorities are seldom pro-active in rural areas, but this does not prevent local enforcement officials (e.g. police, customs, agricultural inspectors, local government officers) from interacting with rural transport operators. In some countries, these officials actively enforce national regulations and so prevent overloading and dangerous practices. However, in many African and Asian countries, the officials permit the breaking of regulations in return for bribes, with market days being popular for 'enforcement barriers' across roads ('bribe barriers' may be more accurate where there are few attempts to enforce regulations). Such additional costs (which can be as high as 38% of operating costs) affect fares, profitability and the viability of rural transport services (Kemtsop, 2007).

2.4 Rural Access Index, 'Sustainable Mobility for All' and Road Seasonality

2.4.1 Rural Access Index (RAI)

The Rural Access Index (RAI) is the internationally recognised indicator of rural access that estimates the proportion of the rural population that has adequate access to the transport system. It is defined as the proportion of the rural population living within 2 km of an all-season road. Two kilometres is considered to represent a 20-25-minute walk (subject to the topography). When the RAI was first developed it was estimated that 900 million rural dwellers lived more than 2 km from an all-season road (Roberts et al., 2006).

An all-season road is one that is motorable all year by the prevailing mode of transport (typically a four wheeled vehicle such as a pickup or small truck) but may be temporarily unavailable during inclement weather (Roberts et al., 2006). The all-season road definition was specifically used to define the indicator as the design standards are lower (and cheaper) than those used for all-weather roads (that are motorable in inclement weather), making progress towards a higher RAI value more affordable for countries. Despite the clear original definition, it is unfortunate that the words 'all-season' and 'all-weather' have both been used in relation to the RAI in some websites and papers (Roberts et al., 2006). The RAI was adopted as a national indicator for the International Development Association (IDA), part of the World Bank Group. More recently

it was accepted as indicator 9.1.1. for the Sustainable Development Goals (SDGs), with the World Bank responsible for overseeing this indicator.

While the RAI is the internationally-recognised indicator of rural access, it does not take any account of transport services. Even if a village is located on an all-season road, this is no guarantee that there will be appropriate access to conventional transport services. Where the population density is very low, and transport demand is small, transport operators may not consider it worthwhile to run even a daily service. Many rural roads only have several public transport vehicles on market days, when transport demand justifies service provision. In 2000, surveys in Ghana and Malawi found that 30-40% of the rural population had to walk more than 4 km and sometimes up to 20 km to a vehicle pick-up point, often located at a road junction, to be guaranteed a reasonable chance of getting onto a transport services vehicle (Rutter and Hine, 2001). As motorcycle taxi services have now become more common, they frequently act as feeder services providing transport from people's homes, often located on tracks and paths, to where the transport services stop.

Following consultations between the World Bank, ReCAP and DFID, a World Bank team undertook a research project to develop new methods of estimating the RAI. The GIS-based methodology that was developed was tested in eight ReCAP countries (World Bank, 2016). The GIS techniques used had the great advantage of allowing RAIs to be easily calculated at a devolved level (e.g., for each District) making the RAI more useful as an indicator that could be used in rural planning. However, the definition of the 'new RAI' was modified slightly to be the percentage of the rural population within two kilometres of a 'classified' all-season road in 'good condition'. While there were attempts to define what constituted a 'good road' (using visual and roughness assessments), it proved difficult ascertain from existing databases, which roads fulfilled these criteria. Also, specifying that the roads had to be classified risked a key access indicator changing overnight in response to a changed classification, rather than any improved access. ReCAP stakeholders seemed particularly troubled by the differences between the published estimates of the old RAI and the new RAI. The discrepancies appeared to cast some doubt over the validity of the RAI as a global indicator of accessibility. Therefore, ReCAP initiated a review of all these RAI issues. This concluded that the original definition of the RAI should be retained, although various methods could be permitted (at least in the short term) to estimate RAI values (Vincent, 2018). Where the relevance of the RAI was being affected by motorcycles reaching large numbers of off-road villages, countries would be allowed (in the short term) to propose correction factors (Vincent, 2018). A follow-up ReCAP project is being conducted by TRL to ensure that rural road sector confidence in the RAI as a reliable indicator is rebuilt (GEN2033D)¹. Many countries will be encouraged to measure RAI values, with the aim of having such processes embedded within national data and statistics organisations, so that the RAI can be promoted to a Tier I SDG indicator, having recently been reclassified as a Tier II SDG indicator.

2.4.2 Sustainable Mobility for All

Sustainable Mobility for All (SuM4All) is a multi-agency platform established through a World Bank initiative. It is promoting mobility in the context of the SDGs, and aims to encourage (through advocacy, actions and financing) the achievement of the transport-related SDGs in all countries through passenger and freight transport that is equitable, efficient, safe and green. Its 18-member steering committee includes multilateral development banks (MDBs), UN Agencies, bilateral donors, the private sector (Michelin, FIA) and other influential transport stakeholders such as ReCAP, SLoCAT, IRF, WRI and ITDP. ReCAP is included as a key stakeholder for 'Universal Access' in rural settings. Sustainable Mobility for All has produced a Global Mobility Report 2017 (SuM4All, 2017) indicating two SDG targets relating to universal access, which are:

- SDG Target 9.1: Develop quality, reliable, sustainable and resilient infrastructure, including regional and trans-border infrastructure, to support economic development and human well-being, with a focus on affordable and equitable access for all.
- SDG Target 11.2: By 2030, provide access to safe, affordable, accessible, and sustainable transport systems for all, improving road safety, notably by expanding public transport, with special attention

¹ GEN2033D: Consolidation, Revision and Pilot Application of the Rural Access Index (RAI)
<http://www.research4cap.org/SitePages/RAI.aspx>

to the needs of those in vulnerable situations, women, children, persons with disabilities, and older persons.

As this current research and this report concerns the interaction between infrastructure provision and preservation (SDG Target 9.1) and transport services provision (SDG Target 11.2), there are clearly elements of relevance and mutual interest between this research and Sustainable Mobility for All. This is particularly true as ReCAP is influential in the Rural Access Working Group (RAWG) established as part of the Sustainable Mobility for All initiative. RAWG, with the support of consultants, has been working on a Rural Access Chapter, to be part of the Sustainability for All 'Global Roadmap of Action' scheduled to be launched in 2019. This document will contain relevant information relating to strategies for rural access provision and preservation, as well as discussion of some key issues relating to rural transport services (including motorcycle taxis). Important to this research is the promotion of an integrated approach to the provision-preservation-services continuum, encompassing capacity building concerning rural transport services and participatory approaches to understanding rural transport services stakeholders. One of the options for a rural transport services indicator (to complement the RAI infrastructure indicator) is the 'rural transport premium', which is the ratio between rural transport tariffs and long-distance national tariffs (an indicator which was first developed for ReCAP's own logframe).

In the light of the overlap of interests between this current research project and the work of RAWG and Sustainable Mobility for All, the research team will continue to monitor relevant developments and, where appropriate, encourage the mutual sharing of information with relevant stakeholders.

2.4.3 All-season and all-weather roads and transport services

In addition to the relevance of 'all-season' and 'all-weather' road status for the RAI, such practical considerations are likely to greatly influence how transport services develop. Where roads are vulnerable to closure and disruption (during poor weather or for part of a season), transport operators will be aware of the potential costs when vehicles are stranded or when they cannot travel, sometimes for several days. This may make fares more expensive for vehicles that operate on seasonal roads. All-weather roads tend to have higher standards and significantly greater construction costs, and can be used on all days of the year, including during heavy rain. All-weather roads are generally better for transport services, as transport operators can rely on the road to be open every day and can run a regular service. Costs are more predictable. Many all-weather roads are paved and therefore tend to be smoother, which not only leads to lower operating costs, it enables operators to use less-robust (and cheaper) vehicles, for example minibuses rather than 4WD vehicles. However, the expense of all-weather roads restricts their use for connecting all villages in low-income countries.

2.5 Planning of rural road provision and maintenance

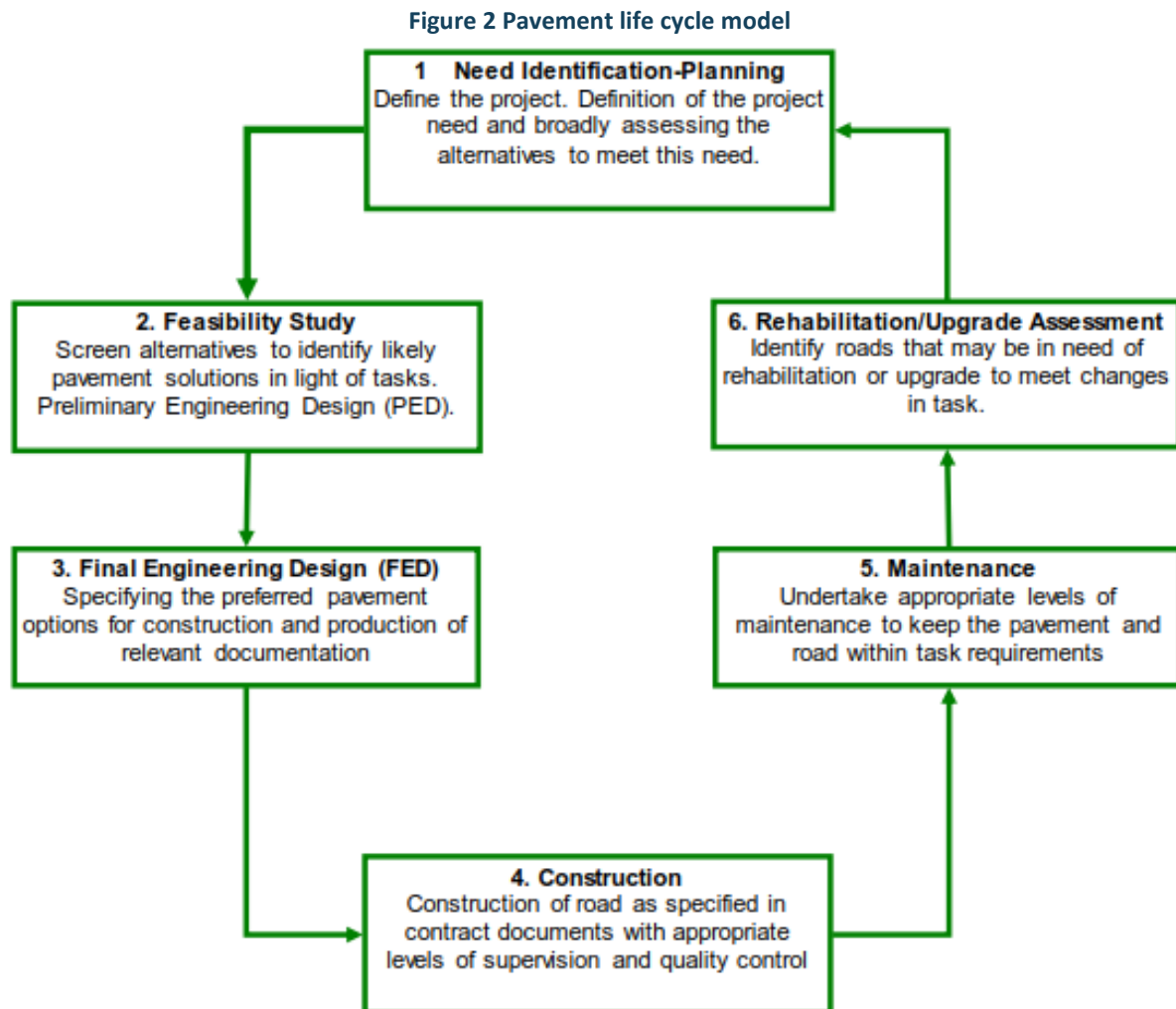
Rural network planning involves a sequence of activities. A possible 'route map' of the stages is shown in Figure 2. In many cases, road infrastructure investments consist of upgrading existing infrastructure from earth to gravel road standard or from gravel to a sealed road standard. This implies the entry for such a project is stage 6 in Figure 2. For tracks and completely new roads the entry point for the project is stage 1. The key issue that this project will aim to address is to find out the extent to which key transport services stakeholders have been involved in the life cycle. If transport services operators and users have been considered and have been engaged in determining the LVRR life-cycles, it will be important to identify at what stages they were consulted and how transport services issues were incorporated into the final 'route maps' and life-cycle planning and implementation.

From the literature and from consultations with ReCAP partners (discussed in Section **Error! Reference source not found.**5 of this document), it appears there is a great variety in how different countries plan their rural road construction, rehabilitation and maintenance. One common feature appears that, in recent decades, transport services have very seldom, if ever, been taken into account by the authorities responsible for LVRRs. Traffic levels and the predicted growth in traffic is generally considered, but this alone is not sufficient to predict how transport services and the attendant benefits will actually develop.

There have been some attempts to remedy the lack of consideration of transport services, most notably by the Asian Development Bank (ADB). The ADB has developed and published a Sustainability Appraisal Framework for Transport (Veron-Okamoto and Sakamoto, 2014). This specifically considers passenger and

freight transport services from economic, social and sustainability perspectives in appraising transport investments. The ADB has also made some LVRR infrastructure investment funding conditional on some consideration of transport services (Starkey, 2013; Starkey and Cartier van Dissel, 2016). While such recent innovative approaches are very welcome, it may be noted that the associated transport services studies have generally been undertaken by consultants, and the extent of subsequent embedment within roads authorities has still to be gauged.

A recent tranche of a financing loan for the huge PMGSY rural-road-building programme in India specifically mentions transport services in the context of gender empowerment (World Bank, 2018). One aim was to encourage or facilitate women to become entrepreneurs in rural transport services, although no evidence was presented concerning any previous experiences in this area.



Source: Cook, Petts and Rolt (2013)

Planning of rural roads can be carried out at national or local levels, depending on the institutional framework in place. The benefits of decentralised planning are often promoted because it is easier to include the views and needs of local communities when the planning processes take place locally. From the perspective of this research, data held at local level is likely to be harder to access than that held centrally.

For the prioritisation of road provision or road maintenance, a number of criteria can be identified and assessed on a relevant scale (e.g. 1-10 or Good-Fair-Poor or High-Medium-Low). Following this a weighting is applied and each proposed intervention is prioritised.

There are certain common criteria that are used, which include for road provision:

- The cost of the intervention, and possibly some estimation of the life-time cost of the asset
- The condition of the road (if it already exists), or the maintenance burden that would be expected over the life of the road
- The potential for providing accessibility to services, such as education, health and local markets

- The potential for economic development of an area, which often uses agricultural potential but can also be a variety of economic activities, such as commercial enterprises or mining
- The population served is also a common criterion for planning road interventions
- Many economic models use generated traffic as criteria for investing in roads, and this is also used in many of the basic prioritisation systems.

and for road maintenance:

- The cost of the maintenance intervention
- The condition of the road
- The potential for retaining or improving accessibility to services
- The effect on vehicle operating costs

Bhandari et al. (2016) conducted an online survey on the key criteria to use when assessing rural road projects. Their proposed list of thirteen criteria, which included economic, social and environmental issues, was ranked by 84 respondents from Nepal and elsewhere. Table 1 summarises the ranking of factors by the respondents. There were minor differences between perceived priorities for the Nepali and ‘international’ respondents, with non-Nepalese giving higher priorities to the costs of construction and maintenance. Neither traffic levels nor transport services were suggested by the authors as possible criteria, although travel times and vehicle operating costs were proposed as economic criteria.

Table 1 Ranked possible assessment criteria for planning rural roads

Assessment criteria	Mean Likert score*
Population served per km	9.3
Access to medical and other services	9.1
Possibility of landslide, erosion or flooding	8.9
Impacts on natural environment	8.7
Road as a community priority	8.6
Access to educational Services	8.3
Accident costs	8.2
Encroachment of historical and cultural areas	8.2
Road maintenance costs	7.9
Road construction costs	7.1
Travel time costs	7.0
Vehicle operating costs	6.6
Pollution costs	6.2

* Likert scale from 0 (not important) to 10 (extremely important)

Source: after Bhandari et al. (2016)

In Liberia, the Liberian Swedish Feeder Road Project (LSFRP) uses seven initial criteria (see Table 2) which are then considered against the investment costs relative to the catchment population. Transport services are not specifically considered (LSFRP3, 2018).

Table 2 Selection criteria proposed for LVRR upgrading in Liberia

Evaluation criteria	Maximum score
Agriculture and land use	20
Markets	20
Schools	10
Clinics	10
Connectivity with other towns and roads	10
Current condition and passability	20
Future maintenance cost	10
Total	100

Source: LSFRP3 (2018)

In Nepal, each district prepares a District Transport Master Plan (DTMP), which lists and assesses all roads (and identified potential roads) in that district (DoLIDAR, 2012). The DTMP uses information gathered at community level and data from local government and service providers. The plan assesses road construction, rehabilitation and maintenance options. Roads are prioritised using nine different criteria, including those mentioned earlier in this section. Assessments of traffic are not required for roads unless

they are part of a strategic road network (key inter-urban roads). Traffic is not assessed in terms of transport services, but information is collected from stakeholders to give an indication of likely wear and tear on the road. The classes of vehicles, and their suggested weighting, are shown in Table 3.

Table 3 Suggested vehicle categories and weights for traffic assessment on strategic roads in Nepal

Type	Weight
Motorcycle	0.5
Car-Jeep- Minibus	1
Tractor	2
Truck-Bus	4

Source: DoLIDAR (2012)

However, in Nepal, on ‘village roads’, the LVRRs that connect villages to the district/national road network, are **not** included in the DTMP. These are the responsibility of Village Development Committees (VDCs), a lower level of devolved administration. There do not appear to be comparable guidelines for prioritising village roads in Nepal.

Some VDCs (or other organisations or communities) in Nepal construct or rehabilitate village roads without engineering designs (Rural Roads Forum, 2008). These are often constructed by bulldozer and may have excessive gradients (up to 20%) and be made without any drainage or structures, limiting the types of vehicles that are able to use them. Without drainage, they often only last for one or two years before they become unmotorable by any vehicle. These roads are often then included in subsequent local planning for rehabilitation or upgrading, but the inherent problems of steepness and lack of engineered alignment still persist. In order to make these roads fully motorable by a range of transport services, significant realignment and upgrading is often necessary.

This type of problem is faced where the demand for rural roads is high, which is more common in Asia than Africa (Hine, 2014) due to population densities and other factors. It is possible that demand for rural roads will outstrip the capacity to construct them. However, if an alignment exists (even a poor alignment), it may reduce the issues of land compensation and resettlement that are associated with new alignments. As land issues are often a serious problem for road construction, the existence of an alignment may make it easier for government or donor funding to be used for ‘rehabilitation’ or ‘upgrading’. Such roads can also be politically motivated, and as such may not meet the criteria for a new road but are then eligible for rehabilitation. This scenario is unlikely to favour the future development of transport services.

In addition, rural roads will often have to cross water courses, necessitating the provision of bridges, culverts, causeways and other drainage structures. Good structures are vital for the operation of transport services. If any of these structures fail, it can be catastrophic for the road and render it impassable for long periods of time. Drainage structures must be inspected regularly for structural integrity and signs of scour, blockage or erosion. Timely maintenance can prevent long delays caused by failed structures.

The alignment of the road will also have an effect on the maintenance that is carried out and ultimately on the transport services that will develop. If a road is too steep or too winding it will limit the types of vehicles that are able to ply effectively. If roads are designed to be too steep or winding they also become more vulnerable to damage through washout and erosion. An example of this has been identified in the ReCAP ‘First Mile’ project, where access roads in Meru County in Kenya were constructed from the main access road towards farms in the bottom of a valley. Due to the steep alignment of the roads and the erodible soils in the area, the roads were washed out very quickly and conventional vehicles are no longer able to ply, as can be seen in Figure 3 (Workman et al., 2018).

Figure 3 Low volume road in Meru County, Kenya, that failed due to inadequate drainage



Photo: Robin Workman

2.6 Road geometry and fit-for-purpose standards

Hongve and Pinard (2016) pointed out that very little research has been done in the area of geometric design standards for low-volume roads. The existing standards are based on a design-speed concept that leads to uneconomically high standards. They are not based on real accessibility needs and ‘fit-for-purpose’ designs. They further point out that for the lowest class of road, it is generally sufficient to design for use by cars and 4x4 utility vehicles (that are commonly used for rural transport services). Such roads do not need to be built to the higher specification required when designing for 7-tonne, 2.6 m wide trucks (as used for higher classes of road). Table 4 illustrates the proposed standards for the lower design classes of roads. This suggests that LVRR do not need to be wider than 3.5 m.

Table 4 Proposed geometric standards for basic access LVRRs

Road Function	Design class	Traffic (ADT)	Surface type	Roadway width (m)	Passing places
Basic access	D	100–300	Paved/Unpaved	4.5–5.5	As required
Basic access	E	100–300	Paved/Unpaved	3.5–4.5	As required
Basic access	F	100–300	Earth/Gravel	3.0–3.5	As required

Source: Hongve and Pinard (2016)

Naturally, there is a risk of infrastructure damage if large trucks do use the lower classes of road to transport heavy loads of natural products and resources such as crops, timber, stone, sand or minerals. Therefore, the likelihood of heavy freight movements needs to be considered, as well ensuring their standards are fit-for-purpose for the local transport services.

In order to be cost effective in the provision of year-round access, it is important to keep in mind the philosophy of using designs, standards and construction materials that are ‘fit for purpose’. This will involve making the best use of materials that are locally available. It is inappropriate to transport over long distances materials whose properties far surpass the requirements. It is important to use materials in such a way that they are neither sub-standard nor wastefully above the standards demanded by their engineering task.

2.7 Loss of roads due to lack of maintenance

2.7.1 Overview of key issues

Road maintenance has proved to be a major challenge to roads organisations in low-income countries. There are many reasons for this that have been discussed in length at numerous international forums. The issues can be broadly divided into four themes (listed below), all of which, it will be argued, can lead to the loss of roads through lack of effective maintenance.

- Managerial
- Technical
- Economic
- Political
- Financial

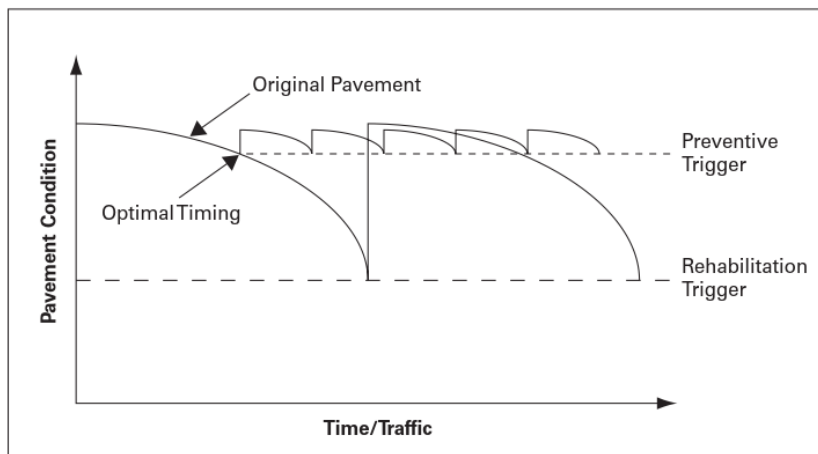
As stated in an Indian PMGSY maintenance policy guide, rural road maintenance is not a complicated technical issue (ILO, 2014). Problems are generally caused by organisational and financial constraints. There are basic maintenance procedures and guidelines that, if followed, will allow countries to maintain roads effectively and keep them open all year round. The main mechanism of deterioration on unpaved roads is through environmental effects, rather than traffic, because traffic levels are low. The surface is not protected from the elements and is vulnerable to erosion through the action of water. Traffic can exacerbate erosion not only through the churning of wet surface layers but also through dust creation in dry conditions as the tyres disturb the surface.

The principle is that if roads are maintained regularly and effectively, they are more likely to be fit-for-purpose throughout their design life. This has been recognised and studied for many decades. Research was undertaken on unpaved road deterioration by TRL in 1977 (Jones, 1977). One of the first definitive studies on this subject was a World Bank study (Harral and Faiz, 1988) which gave many examples of the consequences of road neglect through lack of maintenance. The authors argued that the road building boom of the 1960s and 1970s was unsustainable in low-income countries in terms of maintenance into the 1980s and beyond. They recognised the fact that road deterioration accelerates with time, so that when road maintenance is neglected there comes a time when a road is not possible to maintain, but has to be reconstructed, which is not a cost-effective use of the original funds. Such sentiments are being re-stated in modern contexts, including the huge PMGSY rural-road-building programme in India (ILO, 2014).

A specific study undertaken by Paterson (1991) considered the effects of lack of maintenance on roughness levels and materials loss on gravel roads. Some high-income countries have carried out research to quantify the optimal maintenance regime for unpaved roads (Martin, 2016; Saha and Ksaibati, 2017). These strategies are in contrast to the often ad-hoc approaches to maintenance in low-income countries and the consequent loss of assets over time through ineffective maintenance.

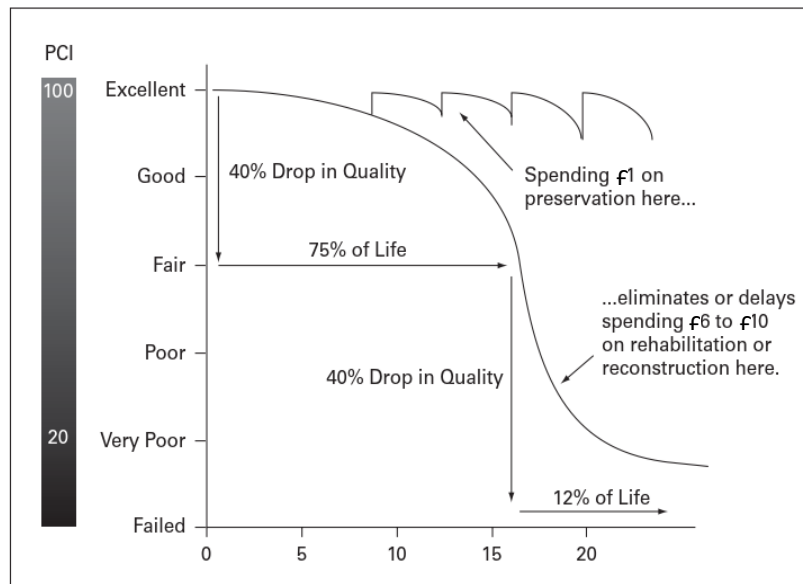
Figure 4 shows the ideal pavement preservation concept, whereby preventive maintenance will be triggered at regular intervals in order to maintain the quality of the pavement over time and not allow it to deteriorate to the point whereby it needs rehabilitation (Galehouse et al., 2006). If rehabilitation does become necessary, the road can be restored to its original condition. However, the costs of that rehabilitation are likely to be much higher than the regular preventive maintenance would have been had it been applied at the required intervals. This is shown in Figure 5, which illustrates the benefits of routine maintenance in terms of the Pavement Condition Index (PCI), a function of the road condition and related costs, over time.

Figure 4 Pavement preservation concept with preventive treatments to reduce rehabilitation requirements



Source: adapted from Galehouse et al. (2006)

Figure 5 Pavement Condition Index (PCI) over time, with different maintenance options.



Source: adapted from Galehouse et al. (2006)

2.7.2 Managerial

Each country has its own standards for road maintenance. One of the most developed in Africa is the TRH-22 document for roads in South Africa (COTO, 2013), underpinned by other research (Henderson and VanZyl, 2017). This sets out maintenance procedures and standards for asset management of paved and unpaved roads and is often referred to by many other countries in the region. It includes an advanced system for road inspections, and maintenance planning and prioritisation. Specific maintenance guidance is also contained in the Ethiopia Low Volume Road Manuals (Ethiopian Roads Authority, 2016) and new, or updated, guidance is being produced constantly.

Planning of maintenance is increasingly being undertaken by using Road Asset Management Systems (RAMS). These are computer-based systems for storing inventory and condition information and often include various tools to prioritise and plan interventions (Parkman, 1998). Unfortunately, such systems do not generally include data relating to transport services.

The development and implementation of such systems varies between countries. There are several issues with such tools, namely:

- They are expensive to procure, install and implement. The software is often developed by international commercial enterprises, which leads to high costs.
- Intensive training is required, but staff often rotate within the organisation or leave, and the skills are consequently lost. It is then expensive to bring in the developer of the software to do more training.
- Software support is inadequate (or not provided), so when problems arise they can result in the system becoming inoperable.
- RAMS are often developed by international companies commercially, so there is little capacity development locally in terms of sustainable knowledge transfer. Uptake and embedment can be poor.
- The RAMS can be too inflexible and do not allow the user to take into consideration all of the local issues for road maintenance planning, including political ones. This can lead to the system being ignored or circumvented.

There are other simpler and cheap/free spreadsheet-based tools that exist (e.g. RED from the World Bank) but they lack the crucial tie-in with Geographic Information Systems (GIS) that make a big difference in network management.

Despite these issues there have been some successes. A notable example in Africa is Tanzania, where the DROMAS database has been developed in-country (by international consultants) over the course of several years. The Tanzania Rural and Urban Roads Agency (TARURA) has taken ownership of the system and is using it to complete a full inventory of all rural roads in Tanzania. TARURA has started to use it for planning purposes.

In contrast, there are examples of commercial companies installing RAMS in low-income countries with little or no effect. In Vanuatu, a Spanish consultant was engaged to develop a RAMS and implement it in 2005. However, it was established, with minimal local involvement and training, in 'Linux' rather than in a Windows environment. As a result, not a single piece of data was entered and within 5 years the system was completely obsolete (Workman, 2010).

2.7.3 Technical

Many countries have recently developed technical specifications and standards for maintaining low volume rural roads, e.g. Ethiopia (Ethiopian Roads Authority, 2016). In some cases, these are specific to this standard of road, and in other cases they use adopted standards from a higher class of road. Sometimes they are 'borrowed' from another country, usually a neighbouring country where the materials and environment are similar. In all cases, reference can be made to some sort of guidance and standards.

Technically, the problem arises when these standards are inappropriate or impractical. One of the most common problems is the provision of suitable materials. Many specifications have traditionally been based on European or American specifications, for convenience, although increasingly countries are carrying out research into using local materials for roads. If the standards for materials are too high, it may mean that materials have to be hauled for long distances. This is clearly not feasible for gravel roads and would restrict the maintenance that needs to be carried out, as haulage costs can be very expensive. Using local materials can reduce the cost of the road significantly (Bennett et al., 2002; Paige-Green, 2006).

Water is the main enemy of roads, so effective drainage is a key aspect of road construction and maintenance. As the road surface is often unpaved on rural roads, it is very vulnerable to water ingress. The road must be designed to shed water as quickly and efficiently as possible. This involves constructing the road with a camber or crossfall so that the water flows away from the road. Water should not be allowed to pond on the surface, which causes saturation of the gravel, thus reducing its bearing capacity and ultimately leading to formation of potholes.

If the technical standards and specifications are inappropriate for the local conditions, it will make maintenance more difficult and costly. Fortunately, many countries are developing their own research capability so that they are increasingly able to identify more appropriate materials, designs and procedures for rural road maintenance.

Where there may be technical issues that affect road maintenance, in practice, the problems of inadequate maintenance more often lie with economic and political issues. The technical issues can generally be solved, although climate change is adding another dimension to road maintenance.

2.7.4 Economic

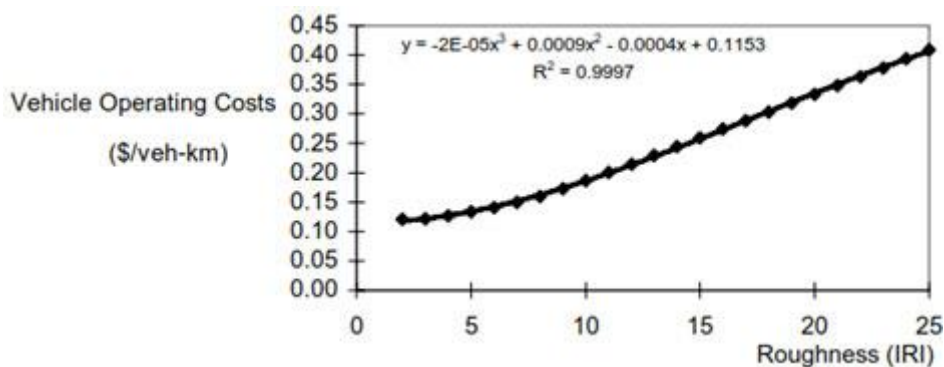
Given the high cost of road assets (often some of the most expensive assets provided by governments), maintaining roads is a costly exercise. Nevertheless, many authors have argued that it is more expensive in terms of the whole life of a road to ignore maintenance (Harral and Faiz, 1988; Paterson, 1991; Heggie and Vickers 1998; Galehouse et al., 2006; ILO, 2014; Babashamsi et al., 2016). This has been illustrated in Figure 4 and Figure 5. The political tendency is to concentrate on new road construction, rather than maintenance (as is discussed in Section 2.7.5). However, new road construction adds to the overall maintenance burden. Many countries in sub-Saharan Africa cannot adequately finance road maintenance to an appropriate (Gwilliam et al., 2008), and from a budgetary perspective, it may not seem sensible to build yet more roads and add to that maintenance burden. The effect is that the overall rural road network asset value decreases along with its performance level and the rehabilitation backlog grows incessantly.

Methods of planning rural road investments generally depend on estimating current and likely future traffic volumes. If traffic volumes are very low (i.e. below 20 four-wheel vehicles per day), the provision of basic all-season access is likely to be the main objective. Here ranking and cost-effectiveness criteria are most

useful. As has been discussed, basic vehicle access is required for social reasons, including access to health centres, clinics and schools. Where basic vehicle access is non-existent or threatened, a conventional economic cost benefit will not be able to satisfactorily capture the social benefits (TRL, 2004). However, where basic motor vehicle accessibility is established throughout the year, the economic cost-benefit analysis based on transport cost savings is considered more appropriate. Models such as HDM-4 and the Road Economic Decision Model (RED) use this approach for planning roads by comparing changes in road investment and maintenance costs with forecast changes in vehicle operating costs. There are a range of sources of information on the appropriate procedures and models to use, including Lebo and Shelling (2001), TRL (2004) and Hine (2014). Specific modelling procedures are outlined in World Bank (2000) for HDM-4, World Bank (2006) for the Road Economic Decision Model (RED) and BUET (2018) for rural road planning in Bangladesh.

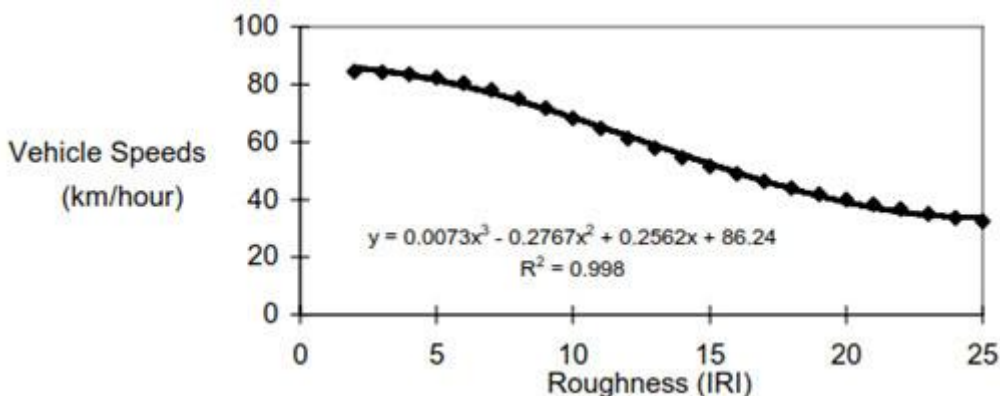
Research has been undertaken into appropriate levels of expenditure on unpaved roads, relative to traffic levels (Archondo-Callao, 2004). Economic models are often used to predict the cost of constructing or maintaining roads, with the RED (Roads Economic Decision) model considered more appropriate for LVRRs than HDM-4. The Internal Rate of Return (IRR) and Net Present Value (NPV) are calculated, based on a variety of criteria. Figure 6 shows how vehicle operating costs (VOCs) increase as the condition of the road decreases (and roughness goes up). Figure 7 shows how vehicle speeds decrease in relation to condition (roughness). Figure 8 illustrates how both vehicle operating cost and travel speeds are affected by road roughness. This effectively shows how roads in poor condition (with high roughness) can increase vehicle operating costs. This of course would also affect the type of vehicles that use these roads, and therefore the transport services that operate on these roads.

Figure 6 Relationship between road roughness and vehicle operating costs



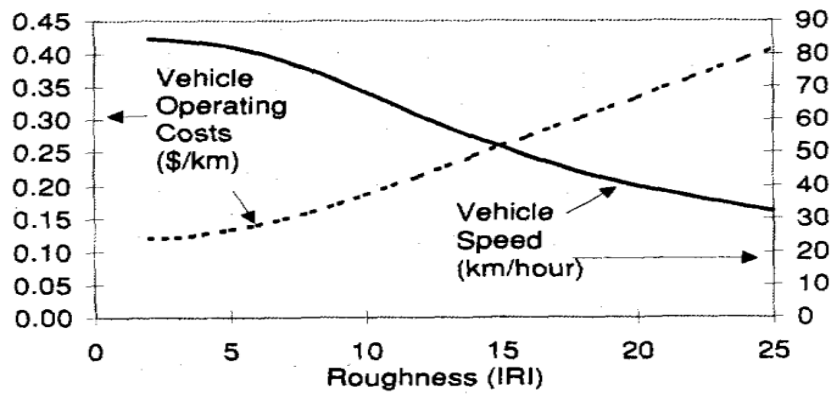
Source: Archondo-Callao (1999)

Figure 7 Relationship between road roughness and vehicle speeds



Source: Archondo-Callao (1999)

Figure 8 Typical relationships between roughness, vehicle operating costs and vehicle speeds



Note: Based on passenger car, with a two-lane road on flat terrain. Source: Archondo-Callao (1999)

The World Bank Transport Note TRN-21 (Lebo and Schelling, 2001; 2005) advises on the most appropriate economic appraisal methodology for the assessment of low volume roads, which is considered in this document to be those roads that carry 200 vehicles per day or less. Such roads are considered to provide ‘basic access’, which is also defined in this document as ‘the minimum level of infrastructure required to sustain socio-economic activity’. This document notes that a range of tools may be necessary to accurately assess the wider economic benefits of rural roads. It also recognises that traffic often consists of a range of motorised and non-motorised vehicles, making it difficult to quantify the overall benefits, particularly if economic models are used that are appropriate for busier roads. It also recognises that the costs of carrying out such a broad-based analysis can be high, and so such studies may not be possible for every situation (Lebo and Schelling, 2001).

2.7.5 Political

Politically, the construction of new roads is seen as more important than maintenance interventions on existing roads. There is a tendency to focus on new construction at the expense of regular maintenance, as an ADB survey confirmed (ADB, 2013a). As discussed in Section 2.7.4, it is not technically appropriate or an economically-justified strategy to prioritise new construction over maintenance, if indeed this is what is happening, but it is nevertheless commonly implemented. Bell (2012) questioned the huge long-term road maintenance implications of the massive PMGSY road-building programme that will connect all Indian villages to the road network, and there are already fears of an unsustainable maintenance backlog (ILO, 2014).

Another factor is that maintenance is more difficult, and administratively onerous, to arrange and to follow-up, than rehabilitation or new construction. Maintenance can involve many small contracts and/or the employment and supervision of labour, whereas road building can be in the form of a few large contracts. There is also greater opportunity for rent-seeking from the larger contracts, which is also a key factor in many countries with endemic corruption.

The changes in the political environment around roads has changed little (Wales and Wild, 2012). There has been a move in some countries to create independent road agencies to help improve the efficiency of the sector and try to limit rent-seeking activities within the traditional road ministries (see below). However, there has been little visible success in changing the fundamental bias against maintenance work (as opposed to new construction). Other poor practices such as collusion in tendering and poor monitoring and evaluation also seem to have persisted, despite these changes.

Wales and Wild (2012) concluded that there are very different characteristics and political incentives surrounding road construction and road maintenance, which explains why the different priorities and effects of both aspects are so visible. It is clear that more in-depth research is necessary into the political economy of road sector operations and its overall dynamics in low-income countries.

2.7.6 Financial

The rehabilitation and construction of rural roads is undertaken through government- and donor-financed programmes. A number of major government-financed programmes have been undertaken in recent years as for example the Prime Ministers Rural Road Programme (PMGSY) in India, or the Universal Rural Road Access Programme (URRAP) in Ethiopia. Similarly, donor- and government-funded road programmes have also been undertaken to meet agricultural and social objectives (as for example the Agricultural Growth Program and Productive Safety Net Program in Ethiopia) or the DFID-funded Rural Access Programme (RAP) in Nepal, which was primarily designed to meet social objectives.

In most low-income countries, maintenance finance is a major issue for rural roads. Road maintenance can be part of donor-funded rural road programmes, as for Rural Access Programme (RAP) in Nepal. However, for the most part, it is dependent on local finance. In the last 20 years, road funds have been a particularly important source of funding for road maintenance. However main and secondary roads are generally the first priority for maintenance funding. Countries differ in the extent to which rural road maintenance can be funded through road funds. For example, for the road fund in Ethiopia there is no specific provision for local government roads: any funding has to come out of the allocation to the regions. Whereas in Zambia, 40% of the road fund is directed towards feeder roads. In general, there is insufficient funding to meet the needs of the maintenance of the whole network and low volume rural roads tend to suffer the greatest deficit. Although routine maintenance may be covered, there is usually a major gap in the funding of periodic maintenance (Benmamaar, 2006).

In a number of countries, rural road maintenance is a community responsibility. For example, in Vietnam and Ethiopia communities are expected to provide free labour and/or funding for rural road maintenance. However, the issue is contentious. Experience from Ghana and elsewhere, suggests that, with respect to ongoing routine feeder road maintenance, voluntary community labour is neither predictable nor reliable, nor amenable to the management of the relatively intensive and repetitive tasks required by routine maintenance performance standards (World Bank, 1991).

2.7.7 Motorcycle trails, trail bridges and small-scale infrastructure

In some countries, including Bangladesh, Myanmar and Vietnam local authorities and/or community groups have constructed low-cost trails to connect off-road villages to the road network. These trails can be earthen, or made from concrete, bricks or stones. They are suitable for pedestrians, bicycles and motorcycles (and sometimes tricycles). In many African countries, there have been informal initiatives by people in off-road villages to ensure they can be reached by motorcycles (Porter, 2002). In Liberia, it has been proposed that all off-road villages should be connected to the road network by motorcycle trails (Cardo IT Transport, 2018). Connecting off-road villages in this way, can transform rural mobility, allowing people and goods to be carried by motorised transport (Jenkins and Peters, 2016; Peters et al, 2018). Motorcycle trails also allow service providers, such as vaccination teams and NGOs specialising in water and sanitation, to easily reach off-road villages (Peters et al, 2018). Motorcycle trails are seen as complementing the road network and are an additional, low-cost level of rural infrastructure investment (SuM4All, 2019).

Trail bridges, usable by pedestrians, bicycles, motorcycles and pack animals, reduce rural isolation further (Trail Bridge Unit, 2008; Helvetas, 2017; Sapkota, 2017). There are guidelines and engineering resources on the design and construction of a range of trail bridge options (ILO/ASIST, 200; IT Transport, 2004);

While this research is concentrating on road-related infrastructure, it is acknowledged that footpaths and trails are often extremely important for linking villages to the road network. This is particularly true in mountainous countries such as Lesotho and Nepal (Starkey et al, 2009). Governments and projects can invest in footpaths and trails: for example, a labour-based rural transport project in Peru rehabilitated and maintained 7000 km of trails, primarily used by women and children (McSweeney and Remy, 2008). There are engineering solutions and guidelines available to improve their walkability and safety (IT Transport, 2002; USDA, 2007).

3 LVRR Provision-Maintenance and Effects on Access and Transport Services

3.1 Correlating road access, community benefits and poverty reduction

It has widely been assumed that if there are roads in good condition, market forces will lead to transport demand being met by private transport operators. Howe (2001) pointed out that there was a real danger in making 'transport' synonymous with 'roads'. Tsumagari (2007) analysed fifteen years of World Bank investments in rural transport and concluded that 98% of the 'transport' investment was simply investments in roads and not 'transport'. The great majority of public sector and donor agency investment in rural transport is for roads. It is therefore not surprising that infrastructure-related topics continue to dominate international conferences and the attention of national and international personnel engaged in 'rural access'.

It is now widely agreed that 'roads are not enough' (Dawson and Barwell, 1993) and the positive approach of the ADB, and other agencies, in promoting this was mentioned in Section 2.5 of this report. Despite the increasing understanding that rural people need rural roads with good public transport services, very few road projects have studied changes in transport services over time. Many road impact studies have measured development outcomes (agriculture, health, education and the benefits of labour-based employment) associated with road investments. However, the great majority have concentrated on social surveys and traffic counts, in order to identify beneficial correlations in data sets. Some have noted the relevant transport services and related issues, but very few (if any) have followed the development of transport services over time, in relation to changes in road conditions.

In their analysis of the effects of rural roads on poverty reduction, Starkey and Hine (2014) reviewed over 100 documents relevant to improving rural conditions through transport interventions. The great majority of these related to rural roads, with little attention to transport services. Using data sources and statistical analyses, many publications demonstrated how, in many countries, rural roads have stimulated agricultural markets, enhanced attendance at health facilities, increased enrolment in schools, increased staff attendance at rural schools and health facilities and generally had beneficial effects on rural development and poverty reduction (Starkey and Hine, 2014).

The large PMGSY road building programme in India (and the related socio-economic surveys) has produced huge amounts of data, and interesting correlations, showing the beneficial (and some problematic) implications of road provision. Bell and van Dillen (2012) surveyed previously-isolated villages in Orissa that had recently been connected to the road network by the PMGSY rural roads investment programme. They were able to quantify increases in 'farm gate' prices of rice (5%) with greater benefits for vegetables and other crops and lower costs for fertilisers and chemicals (Bell and van Dillen, 2012). Aggarwal (2014), analysing other Indian PMGSY data sets, also concluded that connecting villages with all-season roads increased the use of fertilisers and 'improved' crop varieties.

Bell and van Dillen (2012) also examined the health benefits of connecting the Orissa villages by all-season roads. The survey data sets and short time span were not able to identify statistically-significant effects relating to disease morbidity and mortality, but they clearly demonstrated that sick people were increasingly taken to distant hospitals rather than being treated in village health centres. From qualitative surveys, the local people were convinced that their well-being was better, lives had been saved and the death rate was lower (Bell and van Dillen, 2012). The same study was able to quantify the effect of road access on education, and particularly the attendance of teachers. Several of the new PMGSY roads connected villages that already had primary schools, and so village primary school attendance was largely unaffected by the new road. However, days lost due to teacher absence decreased fourfold (a statistically significant difference). A similar effect on improved secondary teacher attendance was seen in a surveyed village with a secondary school that had been recently connected by an all-season road; overall secondary school attendance and retention was deemed to benefit from the new roads (Bell and van Dillen, 2012). Mukherjee (2012), analysing a different PMGSY survey database, suggested school attendance increased by 22% as a result of the new village access roads. Enrolment from disadvantaged groups increased significantly, but so did enrolment from other groups (Mukherjee, 2012). However, Aggarwal (2014) also identified a drop in enrolment for 14-20-year-olds, which was thought to be related to greater employment opportunities for young people associated with improved road access (with a risk that short-term economic

gains for the individuals, and their families, would lead to lower, lifetime earnings due to the unfinished education).

All these PMGSY studies were based on analyses of socio-economic survey data sets, correlating road provision with agricultural, educational, health and other parameters. The ways in which transport services responded was seldom mentioned or studied. Similar findings can be found relating to other countries and regions. For example, rural roads can be linked to increased agricultural production and marketing in Ethiopia (Dercon et al., 2009), increased school attendance in Peru (McSweeney and Remy, 2008), increased teacher attendance in Morocco (Levy, 2004), and better access to health care in West Africa (Transaid, 2013). While Babinard and Roberts (2006) stressed the beneficial effects of rural roads for access to maternal health services, Molesworth (2006) pointed out that rural roads can also lead to some negative health outcomes, including the spread of HIV/Aids and addictive drugs. There are also numerous studies showing the benefits to rural communities of labour-based employment for road construction and preservation, although these seldom have direct links to changes in transport services (Starkey and Hine, 2014).

Several studies have pointed out that the benefits of rural road investments have not been uniform, and rural people with some resources and higher status have benefitted more than the very poor (Gannon and Liu, 1997; Windle and Cramb, 1997; Jacoby, 2000; Bryceson et al., 2008; Hettige, 2006; Gachassin et al., 2010; Mu and van de Walle, 2011; Khandker and Koolwal, 2011; Starkey et al., 2013c). Duncan (2007) summarised well the issue of non-equal benefits by saying that rural poverty should be considered a household phenomenon, and not a village one. Villages are not homogenous and building roads to connect villages will allow the more well-off households to benefit most. Poorer households will benefit significantly, but they may not have the resources to make full use of the new opportunities. Transport interventions are unlikely to resolve the chronic problems of the poorest people, who may even be further marginalised by the changing economic circumstances (Duncan, 2007). Roads reduce poverty and provide economic opportunities, but poverty elimination needs to be addressed in parallel with any road investments.

It should be stressed that while many of the positive outcomes may have been achieved due to the provision of transport services, most impact studies have concentrated on correlating the road investments with particular socio-economic outcomes. The great majority of impact studies have not directly measured the specific changes in rural transport services related to the rural road investments.

3.2 Road infrastructure and the rural economy

A lack of rural transport is recognised to be a major constraint to development and an important contributor to poverty in many regions. A disproportionate proportion of poor people live in rural locations. While 58% of the population of low-income countries live in rural areas, 78% of the extreme poor (Olinto et al., 2013), and 85% of the multidimensional poor, measured by the Multidimensional Poverty Index (MPI), are located in rural areas (Alkire et al., 2014).

There is a substantial volume of literature that examines the impacts of rural roads. A recent systematic review of the impact of rural roads (Hine et al., 2016) was carried out that initially screened 5,500 references, based on titles and abstracts. Of these, 120 references were examined in detail of which 56 studies were analysed and the findings presented. Overall, it was found that rural road investment had important positive impacts on rural incomes and consumption, agricultural output, marketing and employment. Health and education were also positively affected although there was also some evidence of an increase in communicable diseases. Despite the volume of literature, only a few studies provided hard evidence on transport costs (7 studies) and traffic volumes (5 studies). These are discussed in more detail in subsequent sections of this report.

An important finding of the systematic review (Hine et al., 2016) was that the studies were very weak in their analyses of different engineering solutions, road standards and the effects of road length in relation to the provision of transport service. Only two studies provided guidance as to the standard of road interventions that would maximise income generation and reduce poverty. Of these, Fan et al. (2004) suggested that money spent in Uganda on feeder roads (i.e. basic access roads) would lift three times as many people (per unit of investment spent) out of poverty compared with building higher standard gravel

(murram) or sealed roads. The other analysis related to China (Fan and Chan-Kang, 2004) and suggested that lower-quality roads would be much more effective (per unit of investment spent) in reducing poverty than higher-standard ones. However, in both these cases, the function of roads cannot be separated from their engineering design. Escobal (2002) explored the effects of improving trails as well as LVRRs in Peru. In this case both types of infrastructure provided positive effects on incomes, but the change was only statistically significant for the rural roads.

Many of the studies examined in the systematic review (Hine et al., 2016) considered that transport costs and traffic volumes were the main indicators of the means by which road improvements affect the rural economy and social outcomes. However, the actual mechanisms by which road investments lead to the improved outcomes (such as the roles of transport services) were not explored. Effectively, rural roads were treated as a 'black box' in the analyses. Hence, it is hoped that this study can help fill a gap in the literature by more closely identifying how infrastructure affects the nature of transport services and traffic volumes.

3.3 Destinations, trip distance, mode of transport and gender

It is important to consider journey purpose and trip length when estimating the likely impact of infrastructure changes on travel and the use of transport services. Rural communities can have quite a wide diversity in destinations and modes of transport. Nearly all rural passenger trips are based on their homes, with the journeys made to or from home.

Table 5 lists, for different regions in Ethiopia, the most frequent destinations, the mode of transport used, trip distance and journey time. This shows that for the shortest journeys (e.g. to collect water, go to farm, school, religious centre or health post) people overwhelmingly walk, while for intermediate distance journeys (i.e. health centre, market, district centre) motorcycles are more frequently used. For the longest journeys (to hospital or to larger city) people tend to use minibuses and larger buses (with much of their travelling on the national road network). The actual pattern varies from country to country and location to location and sometimes for longer journeys, two (or more) modes of transport may be used.

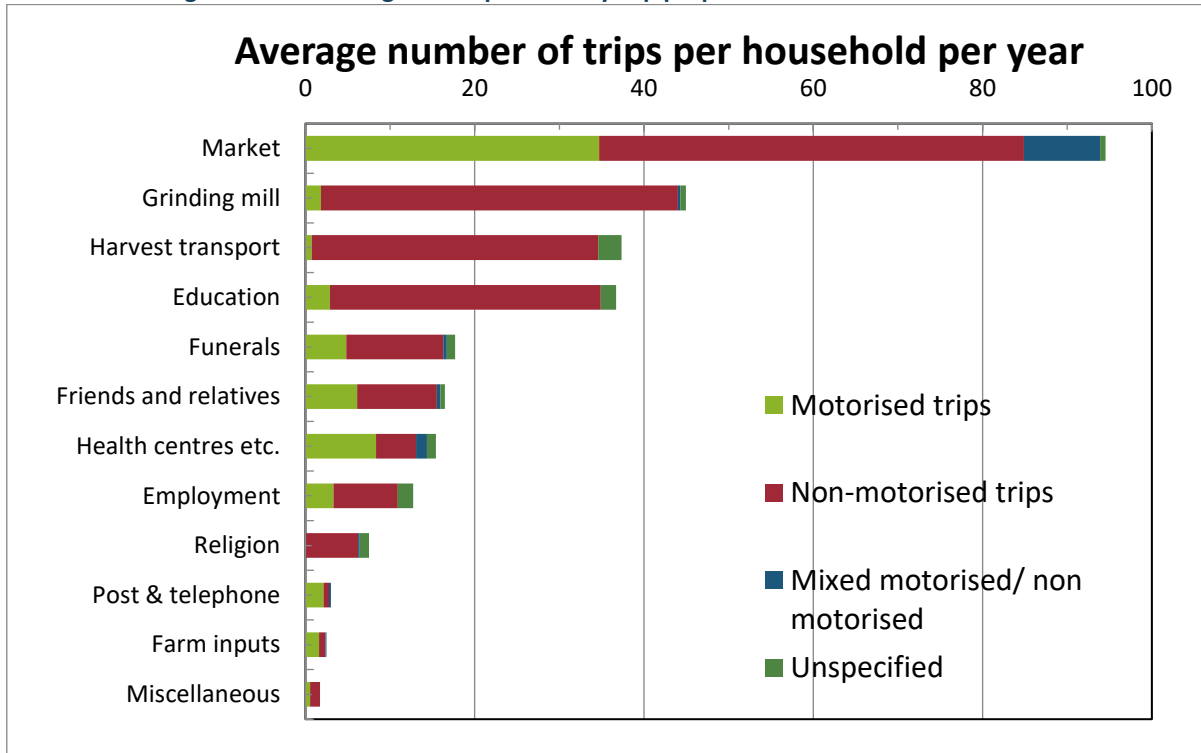
Table 5 Data on trips, relative frequency and mode of transport in four regions in Ethiopia

Destination	Relative frequency %	Means of transport used			Distance km		Time Taken minutes	
		Walking %	Motorcycle/ bajaj %	Bus/ minibus %	Project Area	Control Area	Project Area	Control Area
Most visited market	15.8	56	16	14	7.7	9.3	70	98
Nearest hospital	3.6	17	14	67				
Nearest clinic	3.6	56	23	15	8.2	11	70	128
Nearest health post	6.2	97	1.3	0	1.9	3.1	18	34
Nearest health centre	6.8	59	18	9.9	6.8	7.4	58	65
Farm land	9.6	99	0	0				
School	5.7	96	1.8	1.4	1.5	2.5	16	28
Safe water	8.6	97	0	0	1.2	1.4	13	15
Religious centre	11.2	98	0.9	0.5	1.5	1.9	16	21
Recreation place	2.4	67	12	13	4.8	9.8	44	120
Most visited relatives	7.7	60	12	24	19	20		
Kebele centre	8.9	88	4.2	5.1				
Woreda centre	8.1	29	25	35				
Regional centre	1.7	6.3	7.8	84				

Regions surveyed were: Amhara, Tigray, SNNP and Benishangul-Gumuz. Source: after WT Consult (2015).

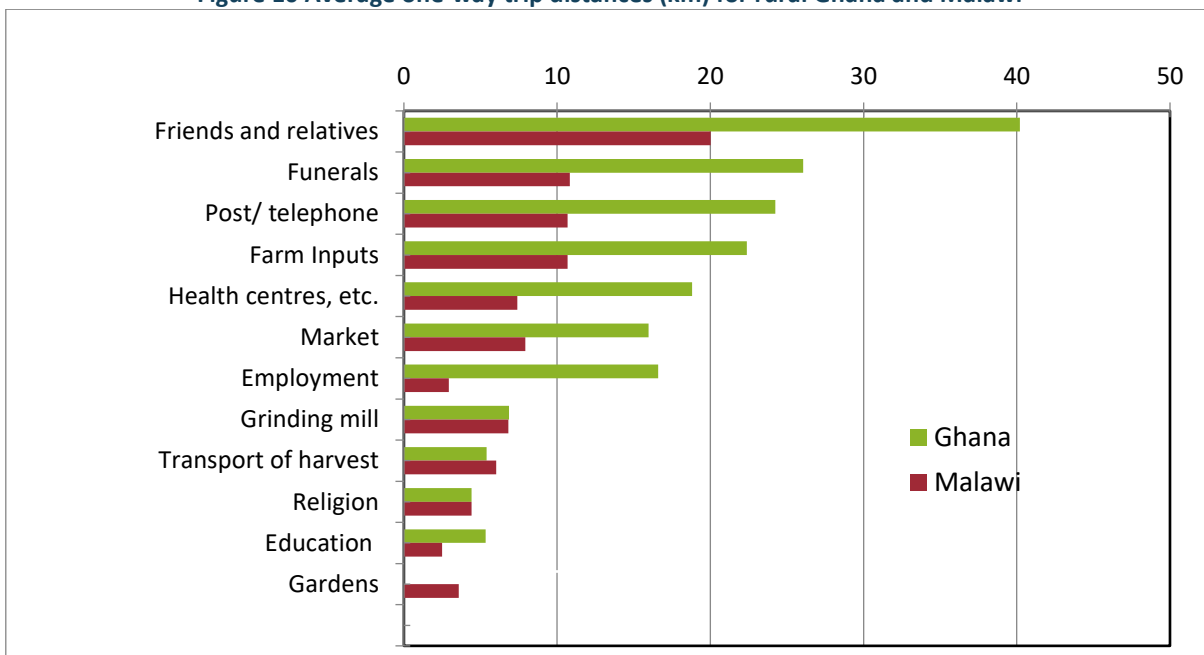
Another example of different frequencies of travel by journey purpose is given in Figure 9 for rural Ghana. Figure 10 gives trip distances, by trip purpose, for rural Ghana and Malawi. In Ghana, motorised trips are predominantly made to markets, hospitals or visiting friends and relatives. Short-distance trips tend to be for visits to school, market, grinding mill and for religious purposes.

Figure 9 Out of village travel patterns by trip purpose and mode for rural Ghana



Source: Rutter and Hine (2001)

Figure 10 Average one-way trip distances (km) for rural Ghana and Malawi



Source: Rutter and Hine (2001)

It has long been recognised that there are marked gender differences in trip patterns within villages and away from villages. In a study of the Thuchi-Nkubu area of Kenya, Airey and Cundill (1998) pointed out that males dominated for many journeys away from their home/village. In 1989, these included journeys for paid work (77% men), personal business (79%), visits to the bank (77%), shopping (61%) and for social purposes (66% men). Women only dominated for health journeys (60% women) and for petty trading of commodities (77% women). The figures reflect the norms of Meru society but are not so dissimilar to that found in rural areas in many countries.

Recent data from a survey of rural roads in Tanzania (see Table 6) suggests that while women outnumber men as pedestrians, the reverse is the case for those travelling by motorcycle and bicycle.

Table 6 Gender and loads of pedestrians and travellers on bicycles and motorcycles on LVRRs in Tanzania

	Motorcycles	Bicycles	Pedestrians
Male	108	45	27
Female	15	5.5	28
Child	2.3	2.0	18
Load	12	6.8	6.7

Note: figures are median averages of the numbers of men, women, children and the total loads they carried from 6-hour morning surveys conducted during 3-day traffic counts at 44 locations in rural Tanzania. Loads were defined as goods appearing to weigh more than 5 kg. Source: after Cardno (2017)

Other focus-group interview surveys from Tanzania have drawn attention to the fact that women and older people are much more reluctant to use motorcycles or climb up onto pickups than men. Nevertheless, in remote parts of Liberia, particularly where there may be no alternative motorised transport, women have been found to be the major users of motorcycle taxis, even to get to maternity clinics (Starkey et al., 2017a).

A recent study in Amhara and Tigray in Ethiopia by MetaMeta and Mekelle University (2016) suggested that male-headed households were three times more likely to own intermediate means of transport such as a bicycle, cart or wheelbarrow than female-headed households. Men also had higher incomes and were likely to make more frequent trips and to pay for transport (as opposed to walking). This finding is in line with experience in many other countries.

3.4 Transport fares and freight tariffs

One of the main ways in which improved infrastructure can be expected to promote an increase in transport services is through a reduction in transport costs. Road-planning models are often used to predict vehicle speeds and operating costs based on road condition and alignment. For LVRRs, the Roads Economic Decision (RED) is often preferred over the Highway Development and Management (HDM-4) model, of which it is a derivative. While the assumptions of HDM-4 do not always make it suitable for the economic evaluation of LVRRs (it does not consider socio-economic factors, and traffic volumes may not create sufficient VOC savings necessary to justify investments), the road improvement and deterioration relationships in HDM-4 can be used to model their influences on vehicle operating costs. With improved roads, vehicle speeds increase and vehicle maintenance costs fall, as shown in Figure 8.

If completely new vehicle access is provided, there is considerable potential for freight transport costs to fall, and correspondingly travel and transport volumes to increase. For example, the cost of head loading in Africa, appears to be in the region of 10 to 30 times the cost of transport by truck when expressed per tonne-km (Hine et al., 1983). From studies carried out in Ghana and elsewhere it was estimated that it takes two person-days to move one tonne-km; using a minimum wage rate this was calculated to be around US\$2 to US\$2.5 per tonne-km. In comparison it was estimated that on rural roads trucking would cost US\$0.2 per tonne-km at 1991 prices (Lebo and Schelling 2001). Thus, moving goods by head loading was estimated to cost 10 to 12 times as much per tonne-km than by truck. An earlier analysis found that head loading charges of moving a bag of maize in rural Ghana were in the region of 30 times more expensive, per tonne-km than typical distance movement by a full, medium truck (Hine et al., 1983). Starkey et al. (2002) indicated a cost of US\$1.5 per tonne-km for head loading, compared with US\$0.7 per tonne-km for pickups and US\$0.5 per tonne-km for light trucks. A study in Nepal suggested bus tariffs for small freight (ranging from US\$0.30 to US\$1.0 per tonne-kilometre) were one tenth of the cost of the transport charges of porters (Starkey et al., 2013c).

The actual tariffs or fares that are charged by the various modes of transport in different locations will depend on a range of technical and market factors. For example, in Myanmar motorcycles can cost as much as US 30 cents per passenger-km, compared with conventional buses which may cost as little as US 1.6 cents per passenger-km (Starkey and Cartier van Dissel, 2016). In contrast, Starkey et al. (2017) reported that on unpaved roads in Liberia, motorcycle fares may just be slightly higher (US 7 cents per passenger-km) than those of minibuses (US 5 cents per passenger-km). Motorcycle fares per person can be reduced if they are carrying several passengers.

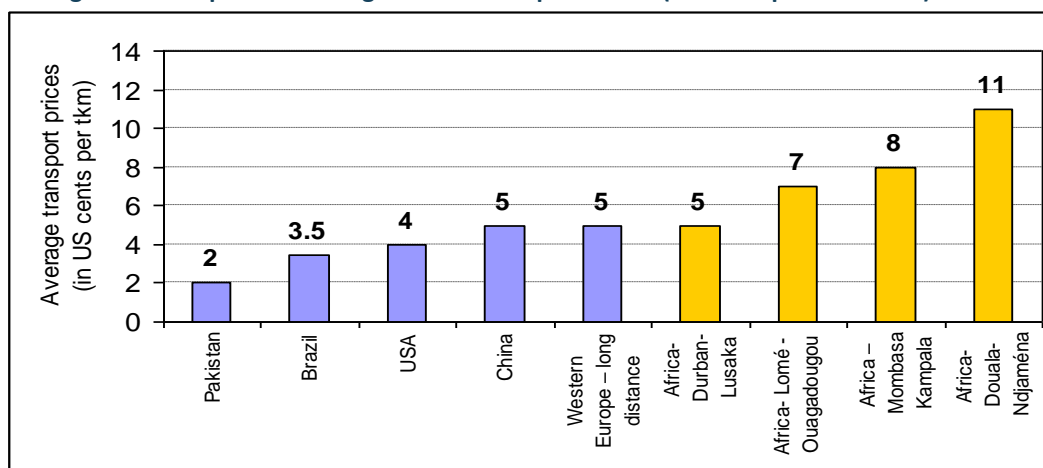
In general, larger vehicles have lower transport costs (per tonne-km, or per passenger-km) than smaller vehicles. Improved roads may permit larger vehicles to pass, for example, by increasing the carriageway

width, or by strengthening structures thus permitting heavier gross vehicle weights. However, to exploit this advantage and make larger vehicles economic, larger loads are required and the vehicles need to travel a reasonable distance. If demand is low (hence it may take a long time to fill larger vehicles) and trip distances are short, then smaller vehicles will continue to have an economic advantage in terms of total transport costs. It can be expensive for a vehicle and the crew to wait a long time for the vehicle to fill up, and these costs need to be spread over the journey distance undertaken. As an example it was found that rural trucks in Liberia carried large numbers of different items and only made four loaded trips per month, undertaking only 14,000 km per year (Starkey et al., 2017a), while in other countries a truck may typically travel 120,000 km per year.

A number of studies have pointed to the large differences in both short- and long-distance freight transport tariffs between Africa (where prices tend to be high) and Asia (where prices tend to be low) and other parts of the world. Figure 11 provides an example from a study carried out by Teravaninthorn and Raballand (2009).

Figure 11 shows a five-fold difference in long-distance freight tariffs, with a high of US 11 cents per tonne-km in West Africa. In the Liberian example (quoted in the previous paragraph), truck tariff rates were even higher at US 24 cents per tonne-km. Although differences in road quality were considered, the main differences in transport tariffs were attributed to other factors. The study by Teravaninthorn and Raballand (2009) found relatively little difference in operating costs between countries. Therefore, the high tariff rates found in Africa were ascribed to monopolistic practices by transport associations (such as the Ghana Private Road Transport Union), where competition is restricted by maintaining queuing systems at truck and bus terminals. As noted, shorter-distance freight tariffs on LVRRs are likely to be higher than longer-distance transport in trucks. Examples of tariffs on LVRRs in three African countries are shown in Table 7.

Figure 11 Comparison of long distance transport tariffs (US cents per tonne-km) in 2007



Source: Teravaninthorn and Raballand (2009)

Table 7 Fares and freight costs on rural transport services on LVRRs in Kenya, Tanzania and Cameroon

Road location (all roads were graded, all-season roads)	Transport mode	Passenger fares (US cents per passenger-km)	Small freight costs (US cents per tonne-km)
Kilolo, Iringa, Tanzania,	Bus	4	45
	Midi-bus	5	46
	Minibus	5	43
Gitugi, Murang'a, Kenya	Midi-bus	6	68
	Minibus	10	103
Pitoo, Northern Cameroon	Open truck	8	86
	Minibus	6	138
Kilolo, Iringa, Tanzania,	Motorcycle	34	602
Gitugi, Murang'a, Kenya	Motorcycle	18	116
Pitoo, Northern Cameroon	Motorcycle	13	151

Source: Starkey et al. (2013b)

Differences in longer-distance passenger fares have been found to vary, between countries, much less than freight tariffs. For example, it was found that typical long-distance passenger fares were around US 2.5 cents per passenger-km in Tanzania in 2010, while in India they were found to be around US 1 cent per passenger-km (Hine, 2014). Costs for long-distance transport in Myanmar are shown in Table 8.

Table 8 Costs of inter-urban transport on narrow paved highways in Myanmar

Transport mode	Tariff <i>US cents per passenger-km</i>
<i>Shan State</i>	
Bus	2
Minibus (rear seat)	5
Minibus (front seat)	6
Car (rear seat)	6
Car (front seat)	8
<i>Ayeyarwady Region</i>	
Bus (49 seats)	1.6
Midi-bus (25 seats)	1.3
Minibus (12 seats)	2.5
Minibus (8 seats)	3.3

Note: fares for journeys of 60-130 km. Source: Starkey and Cartier van Dissel (2016)

3.5 Transport price elasticities

One way to predict a response from improved infrastructure on travel patterns is to make use of known transport price elasticities, which relate a change in travel volume to a change in the price of travel. Transport price elasticities are defined by a proportionate change in transport demand divided by the proportionate change in the transport price. These ratios can be used to predict how the volume of travel and transport may respond to a predicted decline (or rise) in fares and tariffs (or to the cost of running privately-owned vehicles). A study of high-income country data found that the elasticities for cars ranged between -0.1 to -1.1 and for buses from -0.1 to -1.3. For aggregated commodities carried by truck, the range was -0.7 to -1.1 (Oum et al., 1990). To interpret these figures, if an elasticity was -0.7 then a 10% decline in fares and tariffs brought about by a road investment should be consistent with a 7% rise in traffic volume.

It is important to point out that the transport fares and tariffs relate to the whole journey. So for a journey of 200 km, improving 100 km can be expected to have a much bigger impact on traffic than just improving 10 km. It is also important to realise that price elasticities are not necessarily fixed, although they will tend to lie within a certain range. The elasticities can vary from case to case, according to the composition and patterns of travel and the local economy, and the responses can change over time.

In the UK, transport price elasticities are reported to be currently around -0.5. Fouquet believes that transport elasticities decline with an increase in income. It is suggested that transport elasticities in low-income countries (where data is not so easy to find) are likely to be higher than in high-income countries. However, a study of public transit in India found price elasticities of between -0.35 and -0.52. The relatively low values may be explained by a single mode of transport (buses) that is dominated by commuting work journeys that are likely to have low elasticities (Deb and Filippini, undated).

Lipmann (2017) pointed out that a particular price increase (or decrease) is likely to have very different effects on people of different incomes. This is another reason to suspect that price reductions for lower income people will generate a higher response (i.e. give a higher elasticity) than for richer people. It is argued that where different modes of transport are in play, higher elasticities may result.

Lipmann (2017) also suggested that different activities may be ranked according to their implicit value to the user. So emergency and commuting trips are high value and are less sensitive to price, while social, shopping and recreational trips may have lower value and be more sensitive to price. It is argued that price elasticities tend to be lower if only one mode of transport is observed, a saturation effect can occur. However, if different competing modes are introduced then new opportunities arise and price elasticities will tend to be higher.

It is acknowledged that estimated transport price elasticities are not yet used widely in planning and evaluating LVRRs in low-income countries. However, their measurement/estimation could be a tool in understanding changes in transport services in response to road investments, and the responses of rural people to different modes of transport services and their tariffs.

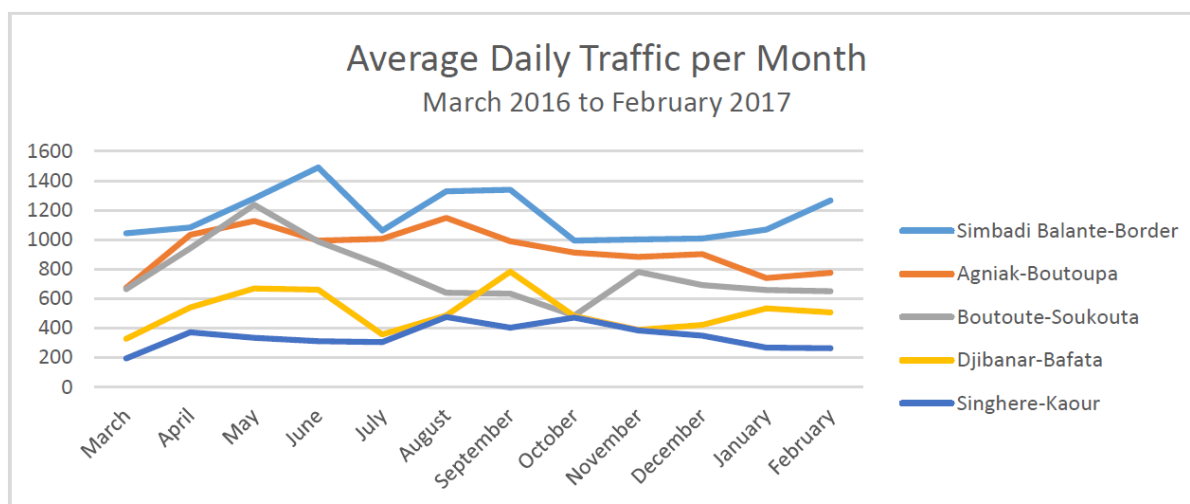
3.6 Traffic variability and growth

Traffic volumes on rural roads in low-income countries are subject to a high degree of variability. Being dependent on the season (particularly with regard to crop harvesting and marketing), the weather, market days, holidays and events such as marriages and funerals. Road condition and maintenance activity also, of course, have an important effect. Howe (1972) found that there tends to be an inverse relationship between traffic volumes and variability. So, the lower the volume the greater the variability. For this reason, Howe (1972) recommended that LVRR traffic counts are taken twice per year, for a week each time.

An example of year-round traffic variability for five roads in Casamance, in southern Senegal, is shown in Figure 12. In this example, 37% of traffic were pedestrians, 33% non-motorised vehicles, 28% motorcycles, 2% public and light vehicles and only 0.2% were trucks. For the larger, motorised traffic, the effects of harvest periods (notably cashew) were more important than the effects of the seasons (SFL, 2017).

As was discussed in Section 2.3.3, there has been a dramatic increase in motorcycle traffic in Africa where growth rates of 60% per year in motorcycle registrations have been recorded (Tanzania, 2010). In some areas of Africa rural traffic composition has also been changing with the introduction of light three-wheeled passenger and freight vehicles. These developments follow the previous trends in Asia.

Figure 12 Traffic variability for rural roads in Casamance, Senegal



Source: SFL (2017)

Very significant fluctuations in traffic volumes have been observed recently in Ethiopia. Part of the explanation almost certainly relates to periods of drought that affected farm incomes and the movement of crops, and also government measures to provide relief to adversely-affected populations.

In their analysis of traffic volumes for Oromia, Harar, Dire-Dawa and Gambella, in Ethiopia, Wabekbon (2017) calculated non-motorised and motorised traffic volumes for 77 rural roads for 2015, 2016 and 2017. Non-motorised traffic volumes are presented in

Table 9. In the period between 2015 and 2017 while bicycles, pack animals and animal carts declined, pedestrian flows increased by 72%, accounting for nearly 80% of movements in 2017. Overall movements increased by 32%.

Table 9 Average daily non-motorised traffic for Oromia, Harar, Dire-Dawa and Gambella Regions in Ethiopia

Mode	2015	2016	2017
Bicycle	14	20	3
Animal cart	81	64	28
Pack animals	196	170	147
Pedestrians	522	593	897
Others	8	112	50
Total	820	960	1,125

Source: Wabekbon (2017)

Motorised traffic volumes for the same regions are shown in Table 10. The table shows major changes in traffic flows between the three years. In particular, motorcycle traffic increased by over 242% between 2015 and 2016, and then declined by 32%. While overall traffic volumes increased by 88% between 2015 and 2016, it then declined by 40%. The most likely explanation for this unusual pattern of behaviour is the drought.

Table 10 Average motorised traffic volume for Oromia, Harar, Dire-Dawa and Gambella Regions in Ethiopia

Mode	2015	2016	2017
Motorcycles	28.9	99.1	66.2
Bajaj three-wheelers	9.8	14.7	7.0
Cars	1.7	0.2	0.0
Pickups/4WD	5.0	4.3	1.7
Mini buses	6.7	3.9	1.8
Large buses	2.7	1.5	0.3
Small trucks	4.7	5.1	4.1
Heavy trucks	5.6	0.9	0.4
Truck with trailer	0.2	0.2	0.0
Total	73.7	138.7	83.7

Source: Wabekbon (2017)

An example of rural road traffic volumes, composition and growth rates for Vietnam is given in Table 11, in which very high motorcycle and cycle traffic volumes are shown. Bicycle traffic is relatively more popular in the flatter, delta areas. Motorcycles and cars had the highest traffic growth rates while buses, tractors / congong (locally-made vehicles used for short-distance transport) and animal carts had the lowest growth rates.

Table 11 Average daily traffic volumes on commune roads with growth rates for different regions of Vietnam

Vehicle type	North East	Red river delta	North Central Coast	South Central Coast	Central Highlands	Mekong Delta	Average Traffic Growth 2008-2014 %
Bus	3	0	2	0	14	2	1.2
Light truck <5T	14	27	28	3	35	5	6.8
Truck >5T, 2 axles	12	1	12	4	37	1	5.6
Truck >5T, > 3 axles	0	0	2	0	10	0	5.6
Car	5	4	6	5	10	2	8.7
Tractor/congong	29	17	6	0	32	0	0.8
Motorcycle	826	726	121	313	244	852	9.2
Bicycle	454	1299	65	465	79	339	5.6
Animal/Hand cart	21	9	268	0	0	15	-0.2
Pedestrian	281	320	39	301	285	81	

Sources: Rural Road Surfacing Trial Research Programme (2008, 2009)

3.7 Road engineering solutions and their effects on transport costs and services

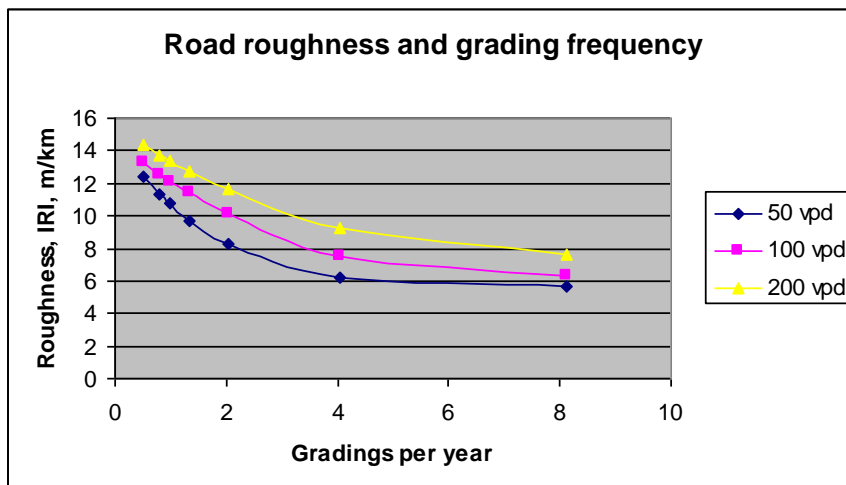
There is a wide range of road engineering interventions and, clearly, the impact on transport services will vary according to the intervention. Replacing a footpath with a motorable track has the potential to give rise to a change in transport mode (from headloading to truck transport) and produce very large reductions in transport costs. The effects, in transport cost terms, could be 100 times greater than replacing the same length of a motorable track with a standard gravel road (Hine et al., 1983). Although the effects may not be as great, replacing a footpath with a motorcycle trail (these are currently being introduced in Liberia) could also induce a substantial switch in transport mode. In this case, to identify the economic impact it would be necessary to consider the opportunity cost of travel time to the local community. Studies by IT Transport (2003) estimated the value of travel time for different transport options in rural Ghana and Tanzania. However, further work is required to fully capture the value of time for motorcycle passengers compared with walking and travelling by bus and minibus.

The Improving Rural Access in Tanzania (IRAT) road programme (described in more detail in Section 4.1.1), introduced a series of interventions to remove transport bottlenecks such as culverts, bridges, slippery slopes and low-lying ground. These interventions could be expected to primarily affect wet season movements. However, as the investments are still quite new, this will need to be verified through surveys.

Improving existing poor-quality roads by engineered gravel roads is the most common road investment in Africa and Latin America. However, it appears that there has been little systematic work on the likely effects on the composition of transport services. The HDM-4 model (introduced in Section 3.4) can be used to estimate effects on transport costs through predictions of changed alignment and reduced road roughness.

Road roughness can be changed either by building a new running surface or by more frequent road maintenance. An example of the effects of different maintenance policies derived from HDM-4 is shown in Figure 13. This indicates that by increasing grading frequency on a gravel road, road roughness will fall, and in turn this will have an effect on vehicle operating costs. Hence, it is very important to take into account the maintenance of the road.

Figure 13 Road roughness and grading frequency (derived from HDM-4)



Source: Ethiopian Roads Authority (2002)

In terms of driver acceptability, roughness is not the only consideration for unpaved roads. In the Kenya Roads 2000 study, gravel roads replaced earth roads in low lying areas where thick mud hindered movement in the wet season, and in hilly areas where they replaced very slippery roads. Although the new gravel roads became very rough over time (because over-sized material was used in their construction and fine materials were subsequently washed out), it was found that operators much preferred travelling (safely) on the rough roads, rather than travelling (unsafely) on very slippery hilly roads.

Generally, a paved road will have lower vehicle operating costs than a gravel road. Substantial differences in transport fares and tariffs were found between gravel and paved roads in the Kenya Roads 2000 programme (described in more detail in Section 4.1.3). The Kenyan study suggests that where there is both sufficient demand and a good paved road surface, then this will tend to encourage conventional passenger

services, rather than motorcycle transport. In contrast improving gravel road access in rural Tanzania (where traffic volumes are lower) has had the effect of increased modal share by motorcycles, bicycles and pedestrians rather than larger conventional vehicles (as is shown in Table 12).

4 Roads-Services Interactions: Effects of Road Condition and Maintenance

4.1 Positive improvements in transport services following road investments

4.1.1 Tanzania: LVRR infrastructure investments increases traffic and reduce tariffs

The Improving Rural Access in Tanzania (IRAT) programme, with DFID-funding, was designed to improve rural accessibility through a programme of removing bottleneck constraints on the rural road network. In this context 'bottlenecks' are areas where the road condition is poor enough to restrict traffic movements. The programme started in 2013 and finished in 2018. Interventions were not designed to improve whole lengths of roads, rather just to address particular trouble-spots such as culverts, bridges, slippery slopes and low-lying sections subject to flooding. In analysis of passenger fare comparisons on completed or substantially completed roads, it was found that average fares were reduced by Tsh 1,000 (US 40 cents) per passenger between 2015 and 2017.

To monitor the work, five rounds of traffic counts covering both wet and dry seasons were carried out in 2015, 2016 and 2017. The final traffic count report provides data on 15 bottleneck road interventions (infrastructure improvements) covering both project and control roads. Some roads had several bottleneck interventions. Table 12 provides traffic count data for 10 road interventions and associated control roads that were completed between 2015 and 2017 (Cardno, 2017).

Table 12 Tanzanian IRAT Road Project: traffic data for 10 completed roads and associated controls

Traffic	Average numbers of different vehicle types and pedestrians			
	10 project roads		Control/connecting roads	
	2015	2017	2015	2017
Cars	2.5	4.7	17.5	22.3
Pickups and 4WD	8.8	3.3	17.5	10.7
Minibuses	1.1	0.9	3.2	9.4
Large buses	0.0	0.0	0.0	0.0
Trucks	0.2	3.4	3.4	8.2
Tractors	2.9	1.3	2.3	1.8
All motorised (excluding motorcycles)	22.7	17.3	48.7	22.3
Motorcycles	86.0	174.8	292.2	301.8
Bicycles	52.0	93.4	195.6	99.7
Pedestrians	184.1	185.9	212.8	129.4
Animals	1.4	0.2	6.4	0.0

Note: The numbers are average daily counts of the vehicle types specified.

Surveys were conducted in Jul-Sep 2015 and Aug-Oct 2017. Source: after Cardno (2017)

Table 12 illustrates the complicated nature of demonstrating improvements in transport services, particularly if one uses only traffic counts without surveying the transport services and learning how they have responded. On the ten project roads, traffic decreased from 2015-2017, with the notable exception of motorcycles that doubled in numbers. However, the decrease in non-motorcycle traffic was less than that on the control roads. The control roads did not experience a significant growth in motorcycles, perhaps because they already had high levels of motorcycle use. It is very difficult to interpret the changes from the traffic statistics: one really needs to understand what has been happening over time by talking with transport operators and transport users. It would be interesting to learn what has happened (and will happen) in subsequent years. Such before and after comparisons are likely to be more valuable than any contrasts with the control roads, as these will not have been identical. The control roads may have had other crucial influences that could only really be understood through discussions with transport operators and users.

4.1.2 House travel patterns and fares related to road improvements in Meru, Kenya

Household panel data were collected in 1983, 1986 and 1989 from 12 rural communities situated on feeder roads and tracks in the different agro-ecological zones affected by the upgrading of the main Embu–Meru road in Kenya (Airey and Cundill, 1998). In 1983, the average trip was 42 km long and cost Ksh 17 (Ksh 0.4 per km). By 1989, the average trip was 37 km and cost Ksh 14 (Ksh 0.38 per km) at 1983 prices, so very little change in terms of the cost per km. Fares on gravel or earth roads were 60% higher than fares on all-weather, sealed roads. In the wet season, the former rose a further 39% but there was no change on the sealed roads. In 1983, there were five household travel journeys per month, this rose to 11.2 in 1986 and declined to 8.4 in 1989. During the period there were major fluctuations in rainfall and the world prices of coffee and tea that peaked in 1986. These factors may partly have explained the decline in trip making in 1989 (Airey and Cundill, 1998).

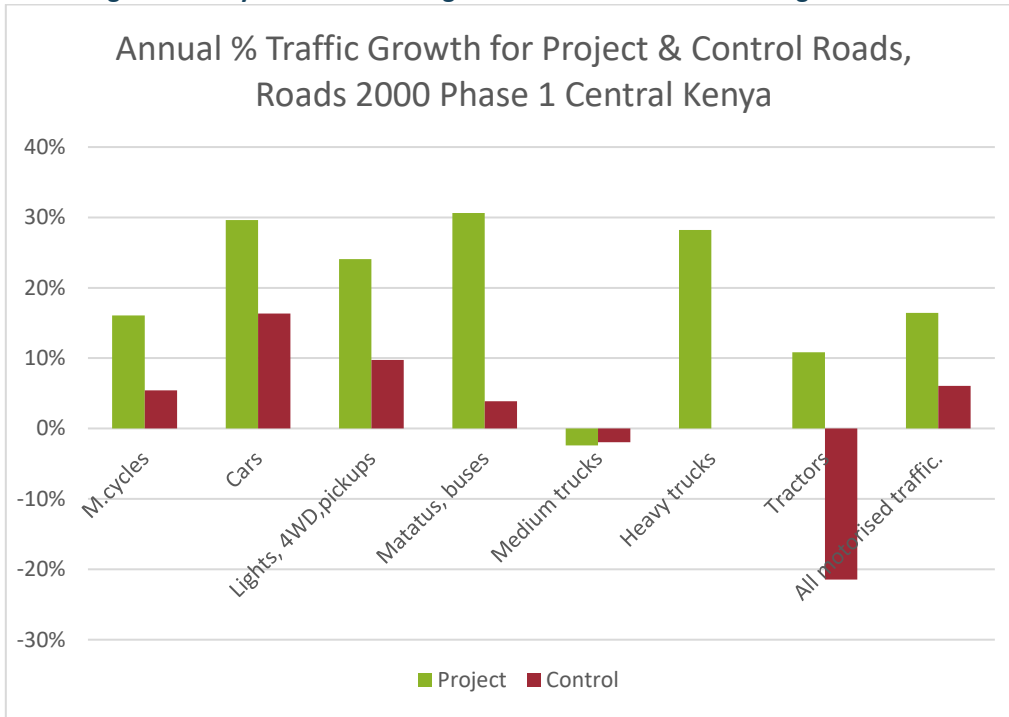
4.1.3 Kenya Roads 2000 road improvements leading to traffic growth and fare reductions

To understand the impact of the Kenya Roads 2000 Nyanza Programme, traffic counts and transport user surveys were carried out in 2007 and 2009 on 8 project roads and 3 control roads in Nyanza Province (Ahmed, 2010). On average, there was a 157% increase in motorised passenger movements on the project roads compared with a 32% decline on the control roads. Similarly, there was 41% increase in motorised freight volumes on project roads compared with an 84% decline in control roads. During the period of the study there was a massive increase in, and switch towards, motorcycle travel. This was ascribed to the 2008 removal of VAT on motorcycles in Kenya. For project roads, motorcycles increased from 26% to 73% of total motorised traffic, while for control roads the increase was from 11% to 83% of total motorised traffic. The absolute decline in passenger and freight movements and motorised traffic (from an average of 64 to 56 vehicles) and non-motorised traffic volumes (from 177 to 89 vehicles) on the controls was not explained. A decline in the quality of the control roads, together with some traffic diversions may have taken place (Ahmed, 2010).

Overall, average tariffs on improved roads rose faster than prices on control roads. This was probably due to the shift towards motorcycles, which provided more expensive (but probably quicker door-to-door) transport services (Ahmed, 2010).

A post-evaluation study of the Roads 2000 programme was undertaken for the Agence Francaise de Développement (AFD) and the Government of Kenya (Hine and Bradbury, 2016). Two rounds of survey data were collected on eight project roads and four control roads. The ‘before’ studies were undertaken in 2010 or 2012 and the ‘after’ studies in 2016. For nearly all categories of traffic, growth rates were much higher on project roads than on control roads. The road interventions had included both new gravel roads and new Low Volume Sealed (LVS) roads. Traffic growth rates for different types of vehicles are shown in Figure 14. In contrast to other studies, motorcycle growth rates were less than for buses, matatus, cars and light vehicles.

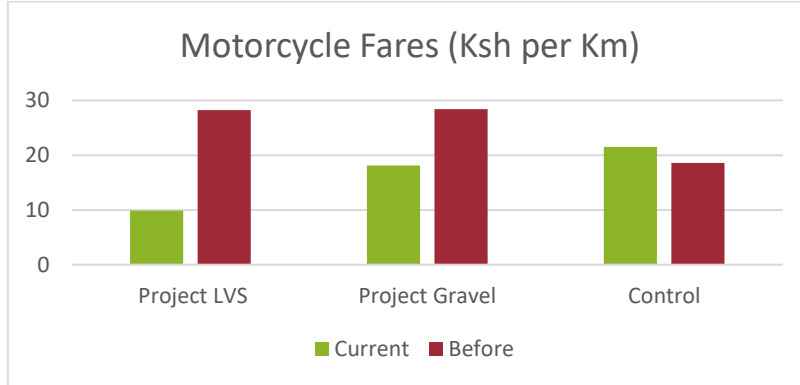
Figure 14 Kenya Roads 2000 Programme Phase 1. Annual traffic growth rates



Source: Hine and Bradbury (2016)

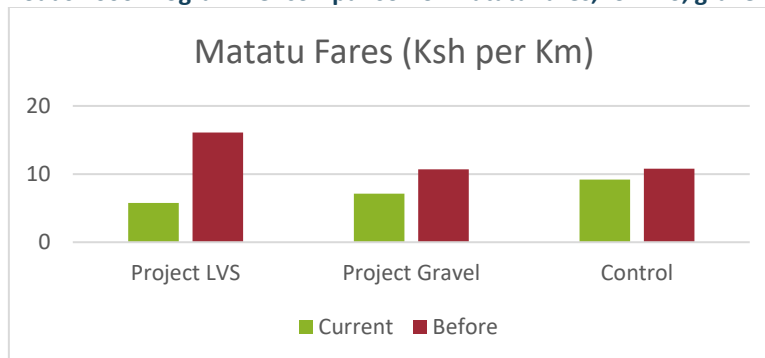
Fares for motorcycles, matatus and freight charges are given in Figure 15, Figure 16 and Figure 17. It can be seen that fares are lower in real terms after the road interventions, with substantial reductions for LVS roads. LVS roads also have lower fares and freight charges than gravel roads. The reason for the large decline in freight charges on control roads was unexplained (Hine and Bradbury, 2016).

Figure 15 Kenya Roads 2000 Programme: comparison of motorcycle fares, for LVS, gravel and control roads,



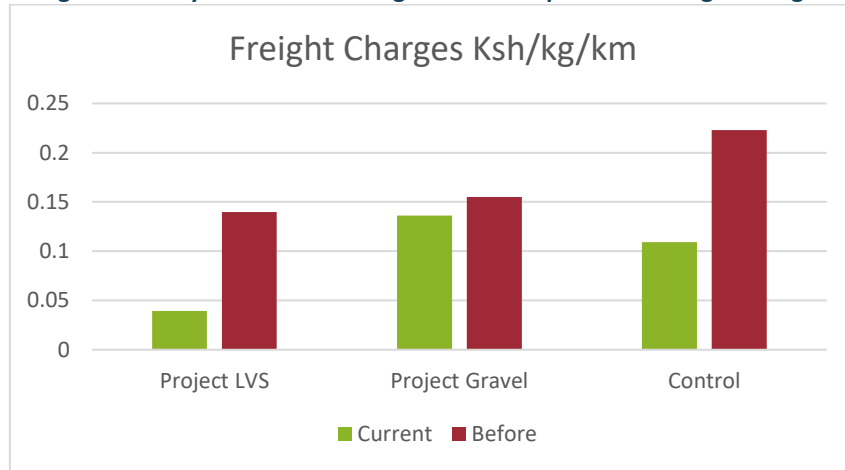
July 2016 prices. Source: Hine and Bradbury (2016)

Figure 16 Kenya Roads 2000 Programme: comparison of matatu fares, for LVS, gravel and control roads



July 2016 prices. Source: Hine and Bradbury (2016)

Figure 17 Kenya Roads 2000 Programme: comparison of freight charges



July 2016 prices. Source: Hine and Bradbury (2016)

4.1.4 Ethiopia: effect of road improvements on traffic and transport services

The Ethiopian Roads Authority carried out an analysis based on traffic surveys using data for 25 national road sections with improvements, compared with 97 sections where no improvement took place. In this case generated traffic was calculated by subtracting the traffic growth on roads where no interventions took place from the traffic growth on the improved roads. In this example (which did not relate to LVRRs), it was found that for the average road improvement, buses had higher generated traffic (at 18%) than other vehicle classes. Cars were observed to have 10% and rigid trucks 14% generated traffic following road improvements, while articulated trucks were found to have the lowest amount of generated traffic at 4% (Ethiopian Roads Authority, 2005). This case study has been included here, as an example of how generated traffic effects, including for different transport services vehicles, can be measured for road investments across a network.

4.1.5 Morocco: increased traffic and reduced freight tariffs

In a study in Morocco, 189 household interviews involving participant recall were carried out in 1995, covering 3 project roads and 3 controls. Once project roads were improved to paved standard, truck tariffs halved, declining from MAD 300 to less than MAD 150 (Moroccan dirhams). There was an average traffic growth of 13% per year for project roads compared with a national trend of under 8%. Prior to the improvements, all three project roads had been closed at times during the rainy season (one for 60 days, one for 90 days and one for the all the rainy season), but after the investments there were no longer any seasonal road closures (Levy et al., 1996).

4.1.6 Nicaragua: large increase in motorised traffic volumes on project roads

In Nicaragua, in order to evaluate rural infrastructure interventions, a survey was undertaken in 2009 (796 observations) in three regions of the country (Las Segovia, RAAN and RAS). They used a reconstructed baseline from 2005 for 31 municipalities and 110 communities. Matched control data were used in the analysis. Between 2002 and 2008, motorised traffic volumes increased by 312% for projects in the Las Segovias area. Although no traffic data was collected for comparison communities, qualitative fieldwork found no indication of increased traffic for the comparisons (Orbicon and Goss Gilroy, 2010).

4.1.7 Household travel patterns changing with road investments in Indonesia, Sri Lanka, Philippines

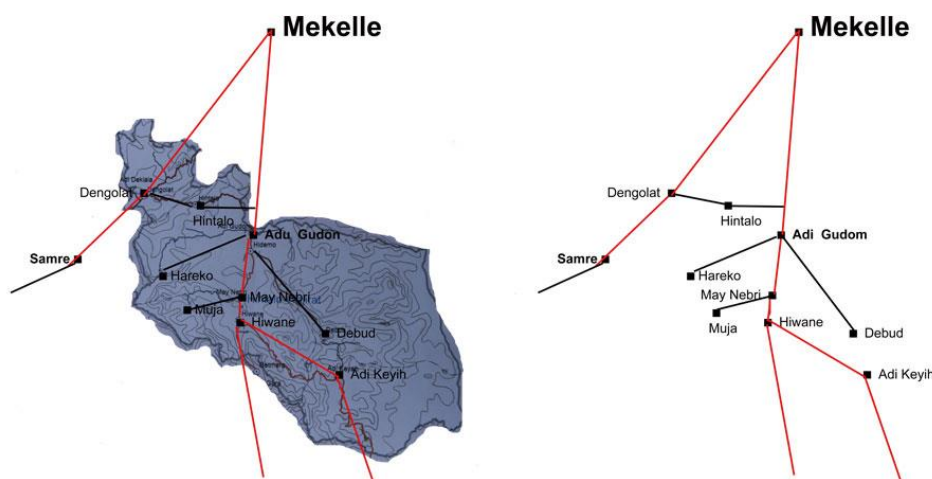
The Asian Development Bank (ADB) commissioned a cross-sectional study using participant recall involving 457 household interviews from 6 road rehabilitation project areas in Indonesia, Sri Lanka and the Philippines (Hettige, 2006). Project households reported an average of 12 external trips per month, with an average of 40 minutes per trip. Control households reported 9.9 external trips per month, with an average of 109 minutes per trip (Hettige, 2006). The conclusion was that the road investments had reduced travel time and stimulated more travel movements.

4.2 Unexpected or less positive scenarios

4.2.1 Ethiopia: a new road that did not conform to local travel patterns

Starkey (2007) reported an example from Hintalo Wajirat district (woreda) in Ethiopia, where district officers were concerned that their major investment in a road joining two parts of their district had generated very little traffic, and no regular transport services. The district lies to the south of Mekelle, the capital town of Tigray Region. Much of the district lies around the national road running north-south (Mekelle to Addis Ababa) and most district spoke roads feed into this combined national and regional spoke. Most of the district is therefore part of the transport catchment area of this national/regional spoke to and from the regional town of Mekelle. While there were small local markets within the district, travel to and from Mekelle was important for many people in the district and there were frequent transport services along the regional spoke roads. Through the northwest of the same district runs another regional spoke to and from Mekelle, which also had frequent transport services. Therefore, this northwest part of the district was in a different transport catchment area for the regional town of Mekelle, and its population used this other regional road to travel to the large town. These two separate road catchments had been recently connected by a good district road that runs from Dengolat via Hintalo to the district town of Adi Gudom. This is illustrated in Figure 18.

Figure 18 Example of a little-used within district (woreda) road through Hintalo in Ethiopia



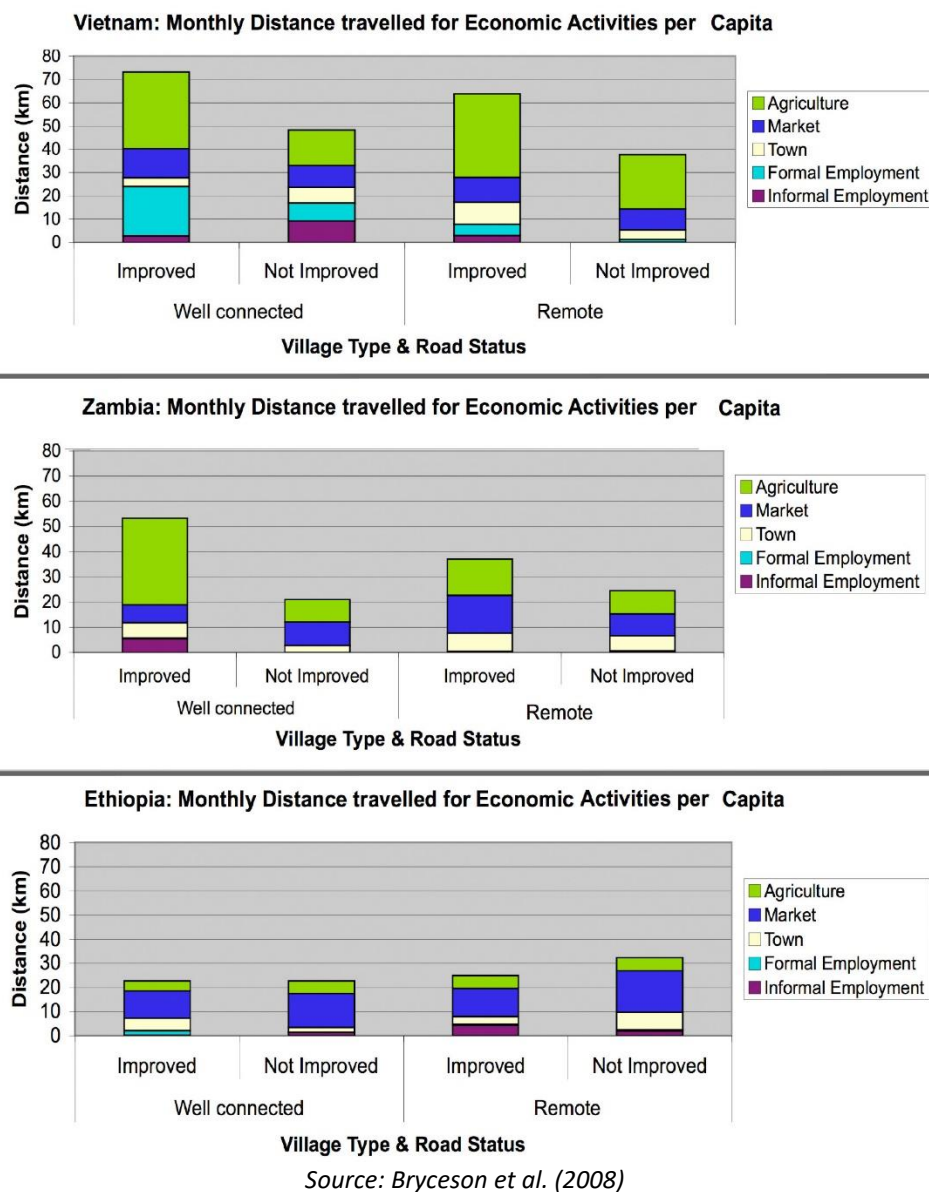
Notes. The two maps of Hintalo Wajirat district (woreda) in Tigray, Ethiopia, show the busy national/regional spokes (in red) and some district roads (in black). The villages in the northwest are on a different regional spoke to those in most of the district. The district is part of two separate transport catchments of the Mekelle regional hub. The cross-district road through Hintalo has little traffic, as few people need to travel across the district. Source: Starkey (2007).

However, this road, one of the best in the district, had hardly any traffic on it. Very few people wanted to travel across the district, and there were no regular transport services. Therefore, to go across the district by public transport from Dengolat to Adi Gudom (i.e. between the two regional spoke roads), it was still necessary to go into Mekelle on one spoke, and out on the other main road. That is because the traffic is mainly flowing along the various spokes of the Mekelle regional hub and spoke system. In this case, two distinct economic and transport catchment areas of the district are entirely logical, but do not coincide with the district boundaries. In this district, appreciating how the different hub and spoke systems were operating would be crucial to understanding the existing patterns of rural transport services and how they might be improved.

4.2.2 Ethiopia, Vietnam and Zambia: problems of using one access indicator in different settings

Another example that explores the complex relationship between road improvements and travel patterns was provided by Bryceson et al. (2006). Using social surveys and recall techniques in rural villages in Ethiopia, Vietnam and Zambia, they gained information about how often people travelled, for what purposes and their travel times. Some of their results that focus on people's travel for 'economic reasons' (e.g. agriculture, market, town visit or employment) are summarised in Figure 19.

Figure 19 Monthly per capita economic journey distance traveled on four types of road



In each country (Vietnam, Zambia and Ethiopia) they interviewed people in villages in the catchment areas of road investment projects in well-connected areas. As ‘controls’ they also interviewed people in villages in non-project areas that were also in well-connected areas. They created a ‘double difference’ by also looking at road projects in remote areas as well as in non-project control villages that were also remote areas. The authors found that for Vietnam and Zambia, monthly distances travelled by people in villages on improved roads were significantly higher than for people in villages on unimproved roads. This implied that the improved roads had stimulated more economic activity and travel, both in the well-connected and the remote areas. However, for Ethiopia the reverse was found, the road investment did not seem to have generated additional economic travel in either the remote or the well-connected areas. A possible explanation given was that for Vietnam and Zambia the villages were more commercially orientated, producing surpluses for sale. Hence people were able to respond to changes in accessibility. While for Ethiopia, the villages were more subsistence based and hence people may not have been able to respond (Bryceson et al., 2008). Clearly circumstances vary from location to location and it is important to try and match the nature of any ‘control’ used.

This lesson also shows the importance of identifying indicators of outcomes or impacts that will work in different situations. In the case described here, the particular indicator was ‘economic’ travel distance per month, which clearly was not appropriate to capture the road impacts in Ethiopia (assuming there were impacts). This research did not specifically look at transport services and their changes in response to road investments and their impacts on the rural population.

4.2.3 Ghana: transport services not responding as much as expected

A recent AfCAP transport services diagnostic study in Ghana interviewed stakeholders along a 15 km all-weather road between the small village of Hatorgodo and the small town of Abor, which lies on the national highway in southeast Ghana (Afukaar et al., 2017a). Despite the road seal being in good condition, the road had no regular minibus services on non-market days. Motorcycle taxis were still the main means of transport on this road, several years after the upgrade. The authors questioned why that road had been selected for expensive investment, when the transport demand on non-market days seemed too low to justify daily minibus services. It would be interesting to obtain more evidence relating to the transport services situation on that road and the various planning and evaluation processes relating to the road upgrade.

The same AfCAP study noted that in the northwest of Ghana, the minibus and taxi transport services between Wechiau and Wa opted for a poorer road with high transport demand rather than a better road that had been prioritised for maintenance by the road authority, but which passed fewer villages (Afukaar et al., 2017b). Again, more information relating to the decision-making processes relating to these examples could feed into the lessons relating to planning road investments and the provision-preservation-services continuum.

4.2.4 Liberia: road condition and access to health services

A recent World Bank study looked for correlations between road data (road density and road quality) and attendance at five health facilities in Liberia (Ilimi and Rao, 2018). The correlations came from survey data entered into national GIS databases. The study found that transport connectivity, especially greater road density, can increase access to health care. This supports many other studies that have found positive correlations between rural road provision and access to medical facilities. This part of the study fits into the anticipated benefits of road provision, albeit simply by correlation, as the study did not look at all the means of transport used or transport services.

The unexpected result was that the authors found no significant correlation between health access and road condition. They concluded there was no significant health access effect related to road quality (i.e. effective road maintenance). In order to understand this unusual result, they suggested that the underlying data was significantly skewed, since the vast majority of roads in Liberia were in poor condition (Ilimi and Rao, 2018).

The authors did not mention or discuss transport services in Liberia. However, transport services are extremely important in bringing people to medical facilities as most rural people in Liberia do not have access to personal motorised transport, and ambulance services in rural areas are minimal. Understanding how rural transport services operate in Liberia may help to explain the authors' surprising conclusion that, from the available data sets, road condition (as opposed to road provision) did not appear to be correlated with access to health care in rural Liberia.

A previous survey of five medical facilities in Liberia (Starkey et al., 2017a), had found that the majority of all attendees travelled to health centres and hospitals by motorcycle taxi (59%) or on foot (29%). This was the case even for a maternity hospital. One of the characteristics of motorcycle taxis is that they are able to provide transport services on poorly-maintained roads, even those that become impassable for rural taxis. By weaving irregular trajectories along roads, they are generally able to avoid large potholes and usually travel faster than conventional vehicles on poorly-maintained roads. Understanding this aspect of transport services, could allow the surprising lack of correlation between road condition and travel to health centres in Liberia to be explained.

It is likely that people's access to health services would be negatively correlated with poor road condition for 'conventional' transport services. However, because there are many motorcycle taxis in Liberia that can provide timely services on poor roads, people can still access health care. This does not make motorcycle taxis ideal vehicles for rural transport as there are many regulatory and safety issues, and some people, including the seriously-ill, would not wish to travel to health centres on motorcycles. Nevertheless, where roads (and/or transport demand) are not fit-for-purpose for conventional public transport services, motorcycle taxis can provide invaluable access to healthcare and to other services.

4.2.5 Tanzania: unexpected traffic growth differences between IRAT project and control roads

The work of the DFID-supported Improving Rural Access in Tanzania (IRAT) programme was discussed in Section 4.1.1. From 2013 to 2018, IRAT invested in improving rural accessibility through a programme of removing bottleneck constraints on the rural road network. Some results showing improvements in traffic levels were presented in Table 12.

Using the data presented in Table 12, Table 13, shows how the traffic flows compared between the ten IRAT project roads and their associated control roads.

Table 13 Tanzanian IRAT Road Project: The ratio of traffic flows between 2015 and 2017

Mode	Project roads	Control roads
Motorised (excluding motorcycles)	0.76	1.56
Motorcycles	2.03	1.03
Bicycles	1.80	0.51
Pedestrians	1.01	0.61

Note: Ratio obtained by 2017 traffic divided by 2015 traffic, so growth is represented by numbers greater than 1. Source: after Cardno (2017)

Table 13 shows that traffic volumes of motorcycles, bicycles and pedestrians grew much faster, on average, on the project roads, compared to the control roads. However, motorised traffic excluding motorcycles grew more, on average, on control roads. This is naturally a surprising result.

To try to understand this further, an additional ‘double-difference’ analysis was undertaken, pairing project roads and control roads (first difference), in 2015 and 2017 (second difference). This is shown in Table 14. Here the ratios of traffic growth on project roads are divided by the corresponding traffic growth on control roads. Where the ratio is greater than one (>1), this means that traffic has proportionately grown more on the project road than on the control road. Where it is less than one (<1), the opposite is the case.

Table 14 Tanzanian IRAT Project: Double-difference analysis of project and control roads

Transport type	Project ratio divided by control ratio		
	Number of roads		Median
	More on project > 1	More on control < 1	
Motorised (excluding motorcycles)	5	5	1.23
Motorcycles	7	3	2.10
Bicycles	9	1	1.82
Pedestrian	8	2	1.66

Source: Cardno (2017)

For motorcycles, out of ten paired observations, seven roads had higher growth on the project road compared with the control road (and on three control roads, growth was higher than that of the related project roads). Higher growth figures are also shown for bicycles and pedestrians for project roads rather than control roads. However, the figures for ‘all motorised traffic excluding motorcycles’ are evenly matched (with the ratios for 5 above one and for 5 below one). The median figure is the median ratio of the data set. Hence, with a median of 2.10, motorcycle traffic (in the median case) would be more than double than would have been expected from the growth in traffic on the control roads. However, for the ‘all other motorised transport’ it was just 1.23, a small, median growth.

Why did the motorised traffic not respond on all project roads compared with their control roads? There are various explanations, including that the time was short, and it can take transport services months or years to respond fully. Yet, there were some rapid responses on many of the project roads. It could be that the controls were not appropriately paired or that surprising things happened on the control roads (or other roads that diverted traffic to them). However, the controls do appear to have been selected appropriately, and there are no reports of particular issues that seriously affected the control roads in positive or negative ways. There may have been a motorcycle taxi effect, but it is not clear why that would be different between the various roads. It remains to be seen how traffic and transport services will respond in the coming years.

One clear lesson is that road investment projects need more than traffic count data to understand the impacts of their investments: they need to engage with transport services operators and users to understand the issues on particular roads (whether project roads or control roads). With such information it might be possible to explain the differences highlighted here and learn what interventions might be appropriate to increase transport services provision.

5 Dialogue with ReCAP Stakeholders

5.1 Current issues and interests in AfCAP and AsCAP countries

The team contacted all ReCAP countries to gauge interest in the project and to explore the possibility of finding appropriate and reliable data sets on which to base the research. The data that will be required for this research includes:

- Information on engineering interventions that have taken place to rehabilitate or upgrade a road.
- Details of maintenance policy and interventions on a road. This can cover well-maintained roads, interventions that maintain the status quo in terms of road condition and roads that receive minimal maintenance and have therefore deteriorated as a result.
- Transport services information on the selected roads that show before and after information such as classified traffic counts, with as much qualitative information as possible. This could include determining personal mobility patterns, public transport frequency, tariffs, loading levels, etc.

It would also be beneficial to have 'control' roads, which are similar and in the same location, but where no interventions have taken place. As well as providing a baseline, this could allow us to see other roads where traffic could, and maybe has, diverted during investment interventions.

5.2 Information sources

Due to the nature of rural roads and rural road planning, it is accepted that very few roads authorities or projects collect the type of before and after data in the amount of detail that is required for this research. It was therefore challenging to find appropriate data sets upon which to base the research.

Of the 17 ReCAP countries we reached out to, most responded with basic information on their road network and typical rural transport services, and some identified potential data sets for research, although none actually provided any data. Most countries were contacted by email, and some were followed up by telephone and/or SMS. Although there is potentially a lack of hard information on the development of transport services following a road intervention, a lot of anecdotal feedback was received, which can be drawn on if necessary.

The team have also contacted multilateral and bilateral donors and independent practitioners, which include the World Bank, Asian Development Bank (ADB), African Development Bank (AfDB) and Islamic Development Bank (IsDB), where there was thought to be a possibility of data sets being available. In most cases the data is retained at country level, and usually by the host road authority. There is often some data quoted in reports and publications, but the actual data sets only seem to be available at country offices or with project partner organisations. Where the team have knowledge of, or contacts in, local road projects, these have been followed up as well.

In addition to identifying appropriate data sets, it will be necessary to gain permission to use the data that has been identified. In most cases it is expected that this will not be a problem, but processes will need to be followed. In some cases, this process may require support from the PMU to validate the purpose and status of the research. Initial contact with the potential trial countries indicates that this should not be a problem, but the necessary processes will be followed.

Given the scenarios cited in Sections 3 and 4, it is logical to expect that transport services should be better and/or cheaper on rural roads following an investment intervention. As was illustrated in Figure 8, as road conditions improve, the speed of vehicles can increase, and the cost to operate them declines. Hettige (2006) provides a number of interesting case history examples of transport services developing in Indonesia, Philippines and Sri Lanka.

The development of transport services has been documented in a number of reports. A GIZ project in Laos measured the development of motorised traffic, which had quadrupled just two to three years after the project completed, although non-motorised traffic still dominated (Schmid et al., 2013). A number of case studies are quoted in the project reports, but they do not specifically address transport services development, although it may be possible to gather data on this from the projects directly.

As part of the present research, there have been more positive examples from ReCAP country partners than negative examples or status quo scenarios (although the small numbers and self-selecting responses cannot be considered significant).

5.3 Positive feedback scenarios

From the feedback received, there was a consistent perception that improved roads lead to improved transport services. Although this is mainly anecdotal, it does present some interesting aspects of the development of transport services on rural roads.

5.3.1 Bangladesh

Respondents from Bangladesh confirmed that there was a general perception that transport services improved following road rehabilitation interventions. Bangladesh has a very comprehensive database for the core network, but the lowest levels of low volume rural roads are not so well covered in terms of condition, asset management and traffic counts. Also, there is very high connectivity, with a relatively dense rural network. For this reason, it is expected to be difficult to interpret changes in transport services as a result of specific road interventions and be able to attribute them to particular projects. There are usually more than one alternative route so it would be a challenge to accurately interpret the data. For these reasons Bangladesh is not expected to be a good source of data for this project.

5.3.2 Nepal

The respondents were not able to provide definite examples, but it was noted that transport services had been improved with road investment. The District Roads Support Programme (DRSP) in Nepal carried out an independent review in 2009 (Stickland, 2009), which noted that although 'traffic' had increased, the increase was extremely modest and that both freight and passenger services were limited. Traffic was in the region of 5–15 vehicles per day, including some motorcycles, which were mainly used locally.

The majority of DRSP roads are new construction with a new alignment, thus the baseline for motorised traffic would be zero. For example, the most heavily trafficked road was Sindhuli-Bhimstan road in Sindhuli district, which is relatively flat and showed an average of 29.5 vehicles per day over the week when classified traffic counts were undertaken. However, this included an average of 22.7 motorcycles, which operated locally, so the generated four-wheel traffic was actually less than seven per day. The most important development was an established bus service that ran a return service twice per day. Despite this road opening up previously remote areas, some people were still walking for four hours to reach the bus, which highlights the accessibility issues in mountainous areas.

The study road in Okhaldhunga is in a hilly area and generated fewer than 10 vehicles per day, with one return bus service per day and additional trips as per the demand, but with very few motorcycles.

Mude-Melung road in Sindhupalchowk district generated less traffic overall, but relatively more bus services and significantly fewer motorcycles, at an average of just 5.3 per day. This could be because the road is in a hilly area and is more remote, so motorcycles could be less useful.

An evaluation was carried out on the DRSP work in 2013 which considered the impacts of the project, with a focus on the socio-economic aspects and how people had benefited from the employment and improved access (Starkey et al., 2013c). This report also includes data on transport services provision, including frequencies and tariffs on five roads, and the sustainability of the approach used, which could be useful for this research.

5.3.3 Tanzania

Some examples from the IRAT project have already been discussed in Section 3 and Section 4 and further relevant data is available. The team are confident that relevant data will be available in Tanzania and will be accessible through established contacts.

5.3.4 Ghana

During the IMPARTS workshop the ReCAP participants from Ghana came forward to offer access to relevant data that is linked to World Bank projects in that country. Following discussions, it was decided that this data could be appropriate for IMPARTS research.

5.4 Unexpected or less positive scenarios

As expected, there were fewer negative or unusual scenarios related to the development of transport services on improved roads. Literature (Hettige, 2006) identifies a number of negative issues that have been experienced, including increases in noise and dust pollution, more traffic collisions and hence safety issues, loss of land and disruptions to natural drainage. There were also less direct, but nevertheless still important, issues that were facilitated by new or improved roads, such as increased crime, exposure to drugs and prostitution, robbery, human trafficking and out-migration. The dynamics of food provision and cost will also change, especially if farmers can get a better price for their produce in external markets, rather than locally.

5.4.1 Nepal

The Nepal respondent fed back that a major issue in Nepal at present is the frequency of road crashes which are largely caused by poor roads or transport services. Safety is often a function of speed and tends to be a less important issue for unpaved, poorly maintained roads simply because vehicles cannot travel quickly enough to pose a threat to pedestrians. However, for mountainous roads there is the real risk of vehicles leaving poorly maintained roads and causing injury or death.

Although the results from the DRSP review and evaluation mentioned in Section 5.3.2 showed increased traffic, it could be argued that the generated traffic was less than would be expected. It is noted in the report that the better-off in society benefited more in the long term from the transport services that developed, whereas the poorest people would benefit more in the short term from employment on the road. Even though traffic development was very modest, the report concluded that most, if not all, people benefited from the road in some way.

A negative aspect of the transport services was that cartels controlled the bus services, keeping them to a minimum thus creating overloading, as well as overcharging, in order to maximise profits. A common issue from road construction in Nepal is the reduction in work for porters, although this was not raised as an issue during the surveys on any of the roads; possibly because other, easier, work became available as a result of the road.

Most of the profits from transport services were not retained within the district, as the vehicle owners were from outside. Local people could not afford to establish bus or other services. Even increases in the price of land benefited only a few rich landowners.

5.4.2 Ghana

The team is aware of data that should be available in Ghana that seemed to show less development of transport services than would be expected, following an intervention. Examples have been mentioned in Section 4.2.3.

5.4.3 Tanzania

Some examples from the IRAT project have already been discussed in Section 3 and Section 4.1.1. Not all traffic increases on project roads were positive relative to the control roads. Further relevant data is available and new data could be collected.

5.5 IMPARTS Inter-regional stakeholder workshop

5.5.1 Summary of workshop activities and deliberations

The inter-regional workshop for Phase 1 was held in Arusha, Tanzania, from 12th-13th November 2018 with 37 participants from 12 ReCAP countries. A separate detailed [Workshop Report](#) (including copies of all presentations) has been produced and is available on the ReCAP website (Starkey et al, 2018b).

The workshop was designed to share the Draft Scoping Report containing our initial findings including the results of the literature review, to discuss Phase 2 and 3 research options and to obtain institutional support from government ministries, departments and agencies (MDAs) in ReCAP partner countries. All AfCAP and AsCAP countries were invited to nominate participants in the fields of rural roads and transport services. Most of the 29 AfCAP and three AsCAP participants who attended work for roads authorities. To maximise professional synergies and exchanges, the workshop included contributions from three other ReCAP projects and was timed to allow participation in a PIARC international conference, Transport in the Fourth Revolution: The Dynamical Low-Income World, held in Arusha from 14-16th November 2018.

The workshop started with IMPARTS presentations on RTS, LVRR infrastructure issues affecting RTS and survey evidence of LVRR outcomes and impacts, including changing traffic volumes and RTS. Three invited ReCAP projects ('Motorcycle safety', 'First Mile' and 'Rural Access Index') made presentations. Day one concluded with exploratory group discussions on the issues raised, including how road agencies should engage with, and plan for RTS; road, RTS baseline and outcome information to be collected; and country-based data, expertise, and research/training needs. All groups agreed that roads authorities should consider RTS in investment planning. They would need relevant data on roads, socio-economic contexts, economic activity and RTS, including modes, passenger/freight volumes, tariffs, loading and safety. Road agencies lack data on RTS and need capacity building and funding to adopt a continuum approach to road planning.

The second day started with three groups visiting LVRRs and learning of road agency practices. Participants interviewed transport operators (motorcycle taxis and minibuses) and different transport users. On return, they discussed their findings and the implications of road condition on RTS and users, the implications for road planning and the data needed to understand LVRR-RTS interactions. Groups were very motivated, presenting many interesting observations and suggestions. Poor roads in the rainy season restricted minibus operations, and on all roads motorcycle taxis were the most numerous vehicles. While motorcycles now seem irreplaceable on poor roads, passengers indicated they would happily shift to regular minibus services if roads were improved. All groups agreed that an integrated approach to road planning was required, with improved understanding of the local environment, stakeholder consultations and data collection on transport needs and RTS. This requires institutional collaboration, capacity building and funding.

Participants selected four topics to be addressed by the concluding discussion groups:

- The **policy group** discussed how integrated LVRR-RTS planning strategies could be achieved. Institutional collaboration or integration is needed and capacity building on RTS issues and funding is required. Relevant RTS data could be included in Maintenance Management Systems.
- The **infrastructure group** discussed appropriate infrastructure where motorcycles are the main RTS. LVRR standards need to consider motorcycle use (including width, gravel and concrete strips/edges). Motorcycle trails could be inexpensive and valuable and are increasingly important, with policy and planning implications. Guidelines and advice are required.
- The **indicator group** considered useful planning and evaluation data options and easily-collected outcome indicators. Most were RTS-specific relating to transport modes, volumes, fares and tariffs, obtainable from traffic counts and surveys of operators and users. Safety was important, but a difficult indicator due to data reliability and traffic speeds.
- The **transport services group** proposed multi-sector RTS Logistic Strategies to identify and promote transport demand. Options to fund investments included RTS funds, PPPs and credit to help start-ups as demand develops. Road Funds could support (and mandate) an integrated approach to stimulating RTS.

- **Final discussions** endorsed the need for an integrated approach to LVRR and RTS, requiring high-level policy support, institutional cooperation, capacity building and modest funding.

5.5.2 Implications of workshop discussions for Phase 2 and 3 Research

Based on the workshop interactions and the potential availability of relevant data, three trial countries have been proposed for Phase 2 data collection: Ghana, Nepal and Tanzania. Further details are provided in Section 6. The final decision on countries and data sets will be made early in Phase 2 following initial fact-finding visits to the proposed countries that allow the team to evaluate the data and determine what new information needs to be collected, and the most suitable methodologies and sample sizes to employ. The aim is to come to an agreement on one or two data sets per country that can be used for the research, so the final data sets will be decided upon when they have been investigated for quality and relevance. A number of criteria have been set for the selection of such databases, in order to ensure that the data is appropriate and relevant for the purpose. These criteria are:

- Must be based on reliable processes
- Must be assessed before the intervention
- Must also be assessed after the intervention

It should be noted that the team intend to base the research on the monitoring of outcomes, as suggested in the technical proposal and endorsed during group discussions at the inter-regional workshop. Rural road improvements have often been treated as uniform interventions that generally ignore the intermediate mechanisms by which engineering changes affect transport outcomes and, in turn, influence impact. This research will concentrate on the outcomes, in terms of changes to transport services and the mobility of rural people and their goods. Outcomes are the most appropriate and practical level to consider changes in accessibility and engineering standards and how they affect transport outcomes and potential impact.

5.5.3 Positive reactions from ReCAP partner organisations

The 'divide' between roads and transport services authorities that has been discussed in this report was exemplified by the self-selected attendance at the workshop. Although all ReCAP representatives had been asked to nominate one 'roads' expert and one 'transport services' expert, almost all the nominations were for 'roads' people with very little knowledge or experience of transport services issues. This is not surprising, given that, in previous years, most ReCAP contacts and research partners have been roads authorities. The participants clearly understood this issue, and several of the workshop conclusions related to the need for an integrated approach to provision-preservation-services, for greater cooperation between roads and transport authorities and for capacity building relating to transport services within roads authorities. The high levels of involvement by the staff of the many roads authorities in the workshop presentations, field visits and discussions (as confirmed by the anonymous evaluation forms) suggested that there really is strong interest in developing more integrated approaches.

Several ways of moving towards more integrated provision-preservation-services were explored. There were clear lessons from the field visits where poor levels of road maintenance had restricted the operation of minibuses, so that motorcycle taxis were the dominant means of transport on some roads. Participants discussed how infrastructure designs needed to be 'fit-for-purpose' for motorcycles, where these were the main means of transport: issues included avoiding concrete strips, considering gravel specifications most suitable for motorcycles and facilitating motorcycle trails to link off-road villages to the road network. There was much interest in 'measuring' how transport services respond to infrastructure investment (and deterioration) with particular emphasis on outcome indicators that could be measured easily and regularly, and could be incorporated into the Maintenance Management Systems of roads authorities. It was acknowledged there would have to be more integrated approaches to stimulating demand for and start-up funding for improved rural transport services, with Road Funds potentially being highly influential in encouraging and/or facilitating strategies for greater cooperation and integration.

Engagement with ReCAP stakeholders during the workshop endorsed the findings of IMPARTS Phase 1 research and the clear need for integrated provision-preservation-services approaches. The workshop conclusions confirmed that road agencies had to engage with transport services issues and needed capacity building and modest funding to achieve this. The workshop evaluation showed participants (mainly roads engineers) had learned particularly about transport services issues, the need for an integrated approach

and the importance of collecting relevant data linked to the roads/transport services interactions that could be used as outcome indicators. The participants also engaged with the issues to be address in Phases 2 and 3, with valuable suggestions and offers of collaboration.

6 Proposal for Phase 2 and 3 Research

6.1 Research questions and an integrated approach to Phases 2 and 3

Phase 2 research will gather evidence of interactions within the rural access provision-preservation-services continuum, including how communities are affected by changes to transport services as a result of improving or deteriorating road infrastructure. We will consider how transport services are taken into account when making infrastructure-related decisions on rural roads, and whether these are ‘fit-for-purpose’ in terms of allowing appropriate rural transport services. We will consider the constraints to transport services and what other interventions might be considered to maximise the benefits of rural road infrastructure investments. The key research questions for Phase 2 in the ToR are:

- Have changes to passenger and freight transport service provision brought about benefits or disbenefits for the rural poor and low-income communities?
- Are the applied engineering solutions sustainable and fit-for-purpose in terms of improving wider transport service provision and accessibility? What are the effects of poor maintenance and road deterioration on rural transport service provision following road rehabilitation/upgrading?
- What other constraints to transport service expansion exist, especially where investment has been made to improve the road infrastructure?

The approach, research methods and work plan relating to Phase 2 research is discussed in Section 6.3.

Phase 3 research will seek to explore solutions to transport services issues, with a meaningful investigation into the motivations of the transport sector to provide transport services to rural areas. This will be set in the context of government structures that regulate such services. The key research questions in Phase 3 are:

- What is preventing these services being scaled-up and extended to remote areas where they would have most impact?
- Are rural transport subsidies an option in low income countries?
- What can be learnt from rural transport service operations and the institutional environment in which they function in Africa and Asia?

The approach, research methods and work plan relating to Phase 3 research is discussed in Section 6.4.

In line with the ToR, the phases are presented as discrete, consecutive research periods, with their own milestones. However, in practice the Phase 3 tasks will start within Phase 2. This will enhance the efficiency of the team and increase the involvement and research ownership of the Phase 2 countries. In attempting to answer the third Phase 2 research question, concerning what factors besides road investments, limit rural transport services, we will be contacting transport services authorities, private sector operators and transport associations. This will provide opportunities to explore with these, and other stakeholders the Phase 3 research questions. Furthermore, to increase synergies further, team members will be exploring the Phase 2 and Phase 3 research questions as they take part in other relevant research in ReCAP countries. Team members are likely to be working in several ReCAP countries in the coming year, including Ghana, Liberia, Malawi, Mozambique, Myanmar, Nepal, Pakistan and Tanzania. This will allow additional evidence to be collected, with possible examples to be investigated and developed during the Phase 3 research.

6.2 Research framework

To carry out an analysis of the effects of changes in road infrastructure condition on transport services, it is desirable to have a wide range of data available relating to the infrastructure, the transport services and other relevant factors affecting transport demand and traffic on the roads being studied. Some of the categories of desirable information are provided in Table 15, Table 16 and Table 17. These illustrate

potentially valuable analytical parameters, although it is recognised that such comprehensive data sets seldom, if ever, exist for LVRRs.

Appropriate data on infrastructure condition, before and after intervention is required, together with before and after transport services and traffic data. A good understanding of the road construction and maintenance over the period under research is important. Table 15 lists key LVRR infrastructure information that will be required (or desirable). Where possible it will be useful to collect information on any changes in adjacent and surrounding road infrastructure to account for traffic diversions. The engineers on the team will be able to collect this information from the local roads organisation and via site visits, using basic equipment or visual surveys.

Table 15 Examples of infrastructure-related information required or desirable

Criteria	Information required or desirable
Date and source of information	Include key dates for recent and past interventions
Location	Country, Region, District, Road name, GPS coordinates
Terrain	e.g. flood plain, flat, rolling, hilly, mountainous
Climate	e.g. rainfall intensity and distribution, extreme events, envisaged climate change scenarios
Infrastructure classification and type	e.g. feeder / district road, vehicle track, earth / gravel road, stone surface, bituminous / concrete road, motorcycle trail, pedestrian path
Assumed purpose of the road	Road 'task', e.g. to increase access to markets and services for the rural population, and/or access for agricultural, forestry, mining or commercial enterprises
Key features	e.g. very steep gradient, seasonal flooding, missing bridge
Infrastructure Function	A rural road, linking local villages to local town or the road network; a secondary road taking a mixture of local and regional traffic
Road parameters	Geometry, length, width, vehicle lanes, design standard, drainage types
Structures	List key structures present and absent
Earlier and latest condition	e.g. roughness data, or poor, medium, good surface, etc.
Current and previous passability	e.g. all year vehicle passability is possible; four wheeled vehicles cannot pass for three months in rainy season; most vehicles cannot pass for a week during rainy season; only pedestrians or motorcycles can pass
Maintenance practice	e.g. emergency, routine, grading, resurfacing, etc.
Description of infrastructure changes	e.g. road rehabilitation, a new bridge was built, road upgrading through paving, a new gravel road was constructed
Main sources of transport demand and traffic origin	e.g. linking communities to markets, nearby towns, mines, forestry, large scale commercial agriculture, linking with regional capital, long distance traffic using roads, etc.
Possibilities for traffic diversion and external transport infrastructure	e.g. Not possible as no nearby alternative routes, Diversion is possible because of dense network, An alternative route was upgraded and diversion away from this road was likely, An alternative route fell into disrepair and so traffic has diverted to this road

The team will consider, where possible and where data is available, the planning of the infrastructure intervention. This will include many of the aspects of the road mentioned above, but the team will particularly look for any evidence that the future transport services were considered during the planning of the road.

To understand how transport services respond to changes in LVRRs, it will be desirable to have good data on various transport services parameters and indicators. Some of the types of data that are useful for understanding rural transport services are shown in Table 16. Some of these indicators are from the AfCAP-funded Rural Transport Services Indicator Project (Starkey et al., 2013a and 2013b). This project developed a rapid appraisal methodology that allows researchers to quickly obtain small, but very relevant, data sets that can highlight issues requiring more detailed data collection. However, there are very few comprehensive LVRR transport services data sets available. Most LVRR projects have simply used traffic counts as a proxy for transport services. Several examples of the problems of understanding transport

services changes using only traffic count data have been discussed in Section 1.6.1 (Lack of integrated approaches to provision-preservation-services) and Section 4.2.5 (Tanzania: unexpected traffic growth differences between IRAT project and control roads) of this report. If there is a good understanding of the prevailing traffic and transport services situations, it is possible to extrapolate some transport services information from traffic counts. However, for a good understanding of the changes to transport services over time, traffic counts have to be supplemented by more detailed transport services surveys, with appropriate sample sizes. Such surveys, focussed on the outcomes of LVRR investments on transport services, will form part of the Phase 2 research.

There is a wide range of external factors that will influence the composition and growth of traffic and transport services. Despite changes in LVRRs due to investment (or neglect), transport demand and transport services may be even more affected by factors that have nothing to do with that particular road, and its condition. Issues such as diversions between roads, national droughts and changing prices and availability of motorcycles in Ethiopia and Kenya have been discussed in Section 4 of this report. Table 17 identifies some of the key external factors. These include data on sector trends (i.e. traffic growth rates) as well as regulatory changes and local industrial and agricultural developments.

Table 16 Examples of before and after traffic and transport-services-related data required or desirable

Note: where appropriate, data to be disaggregated for vehicle type and user gender

Criteria	Information required or desirable
Traffic volumes and composition	Traffic data should be disaggregated for different types of motorised transport. Depending on local vehicle types these should include motorcycles, three-wheelers, 2-wheel tractors, cars, pickups, Jeep/4x4s, minibuses, midi-buses, buses, light, medium and heavy trucks and 4-wheel tractors
Traffic volumes and composition	The data collected should include non-motorised transport including pedestrians, bicycles, tricycles and animal-powered transport
Traffic volumes and composition	Where possible, traffic data should be disaggregated by vehicle function (especially private use/transport services), loading level, gender (operators and passengers) and origin/destination.
Factors affecting traffic count volumes on specific days	Season and weather, market days, important local events (wedding, funeral, sports fixture, religious festival), school holidays, national holidays, elections, strikes, demonstrations, disease outbreaks, etc.
Vehicle Operating Cost Components	Key components such as: vehicle purchase prices; vehicle age; fuel, lubricants, tyres and maintenance costs; crew costs; insurance; road taxes; association and terminal fees; bribes and barrier fees.
Freight Charges	Charges expressed per tonne/km
Fares for using RTS	Fares expressed per passenger/km
Availability of service	Number of travel opportunities per day
Predictability of service	Availability of timetable (formal/informal)
Waiting time for services	Roadside/terminal waiting time for users
Space on service	User perception of likelihood to get onto the first available service
Travel speed of service	Average time taken to travel between two locations
Disruption of services	Differences in travel time and waiting time due to seasonal service disruption
Safety, security and comfort of service	User perception of accident risk, security risk, comfort, crowding and travel conditions (heat, noise, etc.).
Access for older persons and people with disabilities	Convenient access to transport services for older persons and people with disabilities; application of 'universal design' in rural transport services and related infrastructure
Small freight transport by service	e.g. cost of 20-50 kg of accompanied goods
Medium freight transport by service	e.g. cost of 200 kg of unaccompanied goods
Mobile phones and RTS	User ability to use mobile phones to access services and/or obtain information regarding service
Facilities at terminals and roadside stops	Existence/satisfaction with 'bus shelters' and facilities at roadside stops
Courier facilities	Existence of/satisfaction with courier services provided by transport operators
Market trends	Trends in passenger and freight volumes and numbers of transport services vehicles in operation

Source: After Starkey et al. (2013a)

Table 17 Some external and regulatory factors affecting traffic volumes and transport services

External and regulatory factors	Information to consider
National trends in population and/or urbanisation	Useful background to transport demand
National trends in Gross Domestic Product (GDP)	Useful background to transport demand
Economic factors including inflation and availability of credit and foreign exchange	Factors affecting ability to purchase transport services vehicles (including investments of urban operators who may supply second-hand vehicles for rural operators)
Recent factors affecting incomes, agricultural output, and/or population movements	Factors such as droughts, diseases such as Ebola, or civil unrest, or civil war in neighbouring countries, can be important influences
National trends on vehicle types, availability and registrations	Growth rates of different vehicle types (including motorcycles and electric vehicles), registrations and traffic volumes, including changes relating to import and use of old vehicles
Operation of regulatory barriers	Addition or removal of barriers for police, customs, forestry, axle load, etc., and changes in the 'barrier fees' extorted (where relevant)
Operation of formal transport services	New routes or fares of formal bus services
Operation of agricultural marketing boards, agricultural processing, timber concessions	New procedures for the marketing depots and/or collection of large-scale agricultural commodities
New industrial developments	The opening of a new cement factory, quarry, petroleum distribution centre or artisanal mining
Changes in rural and urban markets	Significant urban market development can stimulate the growth of rural 'feeder' markets
Legal and regulatory framework of vehicles and relevant changes in enforcement on national roads and LVRR	Legality of motorcycle taxis and enforcement issues
	Legality of use of three wheelers and enforcement
	Controls in passenger fares and tariffs and enforcement
	Controls in authorised vehicle types and routes and enforcement
	Changes in safety criteria and enforcement
	Changes in vehicle loading/enforcement
	Changes in axle load controls and enforcement
	Changes in vehicle insurance and enforcement
Operation of transport associations and unions	Changes in regulation of heavy vehicles using specific routes and enforcement
	Changes in fees, membership and controls
	Introduction or removal of bus, truck or motorcycle association parks

The three tables presented here constitute a 'wish list' and in practice it may not be possible to collect all the identified data requirements. It is understood that detailed transport services data linked to road investment data is very rare. It is possible that some indicative estimates of impact may be identified through using the 'double-difference' post-evaluation technique. With this methodology, comparisons are made of transport services data relating to 'before' and to 'after' road investment (one difference) and for both 'project' roads (with investments) and 'control' roads (without road investments, the second difference).

It should also be recognised that the three tables are a work in progress. It is unlikely that all the desirable data categories will be available in existing data sets, or that they can be collected during Phase 2 field work. It is also unrealistic to suggest that road authorities and/or transport authorities should start to collect all this information for all new road investment projects.

It was clear from the inter-regional workshop that staff of rural roads authorities in ReCAP countries are interested in becoming more involved in transport services issues. This might involve the collection of data relating to transport services that can be used for planning, monitoring and evaluation purposes. Phase 2 research will provide an opportunity to focus on collecting highly relevant and realistic data sets that provide sufficient information to allow relevant indicators to be measured reliably. In the final IMPARTS Guidelines, there will be recommendations on the type and quantity of information (and appropriate indicators) that should be collected by roads and transport authorities to understand transport services within the provision-preservation-services continuum.

6.3 Phase 2 research methodology and work plan

6.3.1 Initial appraisal visits

The Phase 2 research will start in each selected country with initial discussions with the relevant roads and transport authorities and examination of the existing data sets that are available. If possible, we will interview the people involved in the original data collection. This will help to confirm the validity of the data and understand exactly how it was collected and to what standard. In line with the desirable infrastructure-related data suggested in Table 15, relevant information will be gathered concerning the infrastructure investments and their characteristics (paved/unpaved, construction materials, surface treatments, drainage etc.), planning policies, maintenance regimes and other pertinent background relating to the road network and any roads pre-selected for appraisal surveys (their perceived functions, investment histories and other parameters). Important aspects of this investigation will include the key decisions taken at the time of investment, such as the surface type, i.e. whether to seal or not, and the type of seal to be used, i.e. low cost seal or a more substantial surfacing. Also, how these decisions were arrived at, i.e. was there a logical decision process and was it based on any established protocol, was the decision arbitrary or linked to fitness for purpose.

Similarly, some basic information will be collected relating to transport services regulation and relevant externalities as suggested in Table 17. Appropriate information will be collected about the different forms of transport services relative to the road intervention, including:

- The type of operator
- Systems of ownership
- Type, age and condition of vehicles
- Finance mechanisms
- Routes
- Frequencies
- Reliabilities
- Seasonalities
- Fare structures
- Regulatory mechanisms.

Then there will be appraisal visits to selected sites of road investments to ask the local stakeholders (transport operators, users and regulators, disaggregated as appropriate) 'what has changed and why?' in terms of the transport services following road investments (or neglect). The appraisal visits will involve a member of the international team, the local researcher and if possible, representatives of the road agency and transport authority. The visit will use rapid appraisal methodologies, similar to the RTSi, methods, described in Starkey et al. (2013a). However, at this stage there will not be systematic attempts to complete data sets, but rather these visits will inform the researchers (and local partners) about the key issues, the types of changes that have occurred (in the infrastructure and the transport services), the timescale, and suggested causal links. Through roadside interviews with transport users (disaggregated), transport operators (different types), and other stakeholders (police, clinics, schools, market officials, etc) a picture will be built up. The various ideas and responses will be triangulated to investigate discrepancies (e.g. different understandings of frequencies, tariffs and safety) and different peoples' perceptions of what had changed and why, following road investment (or neglect). Naturally, questions will be asked relating to fluctuations in transport services due to markets, weather, seasons and other issues. These rapid appraisals will allow finalisation of the choice of roads to be surveyed and detailed planning of the subsequent surveys, including traffic counts, survey questions to be asked and sample sizes. Essential details of the road

construction itself will also be collected, such as the design (geometry, pavement layers, materials, drainage, etc.) and the road surface condition at the time (if available).

In each country, the initial appraisal survey team will visit three-to-five roads preselected during initial discussions that appear to have reasonable 'before' data and a good prospect of appropriate 'after' data being collected. If possible, at least one road will be selected that appears to have some 'unexpected' outcomes (e.g. less traffic generated than had been expected). These examples may well lead to new insights for the researchers and the local road and transport authorities.

Subject to local stakeholder agreement, the roads likely to be visited for initial appraisals will be:

Ghana: World-Bank-supported feeder roads (mentioned in Section 5.4.2) and examples of unexpected outcomes in Volta Region and Upper West Region reported by the ReCAP transport services study (Afukaar et al., 2017a and 2017b) and discussed in Section 4.2.3.

Nepal: DoLIDAR/DRSP-constructed roads in Dolakha, Kavre, Ramechhap, Okhaldhunga, Sindhuli and/or Sindhupalchowk Districts as discussed in Sections 5.3.2 and 5.4.1.

Tanzania: IRAT spot improvement investments, as discussed in Sections 4.1.1 and 4.2.5.

In all three countries, there should be interesting examples to study of transport services improving significantly following different types of road investment and some 'unexpected' outcomes that we may be able to interpret and learn from. If suitable roads and past data sets are available, we will try to find examples where transport services have deteriorated significantly due to poor maintenance.

For resource reasons, following the three appraisals, two countries will be selected for more detailed surveys, each with two selected roads to survey. One key criterion for the selection will be the level of interest in, and 'ownership' of, the subsequent survey work by the local partner (roads agency and/or transport authority). High levels of interest and motivation will assist greatly with embedment of the research results and survey practices. Other key criteria will be the quality of the past data and the expected value of the anticipated research lessons.

6.3.2 More detailed surveys

On the selected roads, the data to be collected from surveys will depend on two main factors: the data in earlier studies and the need to capture a new 'snapshot' of the current provision-preservation-services situation. To demonstrate 'before and after' changes it may be possible to replicate questions used in previous years. Additionally, or alternatively for some issues, it may be possible to gather data on changes and possible causalities through people's recall abilities, particularly through focus-group discussions.

6.3.3 Key indicators that are easily measurable

During the inter-regional workshop, one group discussed 'key indicators of transport services that are easily measurable'. The emphasis was on 'outcome' indicators that change quite rapidly (in one-to-three years) rather than impact indicators (that often change over timescales of five years or more). Changes to transport services (fares, freight tariffs, frequencies, modal composition, loading levels) are considered to be outcome indicators that can be easy to measure through small surveys, including traffic counts, operator and user surveys. Changes to incomes, agricultural production, public health, housing and educational levels are generally considered impact indicators which require quite large-scale surveys to obtain reliable data. Although impact indicators are important, the large amount of data needed is expensive to collect, and the indicators tend to change gradually over periods of 5-10 years, and this limits their widespread application in planning rural transport services.

Various measures of transport services (modal split, passenger and freight volumes, prices, frequency, reliability, seasonality, etc) are easy to measure and generally reliable as indicators of road use and outcomes of road investments. Safety is clearly important but a difficult indicator to measure. Police and hospital records of crashes can be difficult to access and are seldom accurate when it comes to individual roads. The recall of community leaders, focus groups, transport operators and transport users can be used to assess crashes. However, it is generally found that despite the appearance of dangerous practices on LVRRs, serious crashes are rare, compared to the crash rates on national roads and in urban/peri-urban

areas. In general, crash severity increases with speed, and so road investments and improvements in road conditions actually reduce safety, making it a ‘perverse’ indicator to measure, albeit an important one.

Transport planning software, such as the Highway Development and Management Model (HDM-4) and Road Economic Decision Model (RED), (a simple spreadsheet based derivative of HDM-4) includes estimates of vehicle operating costs (VOCs). However, the VOCs of informal sector operators are notoriously difficult to capture accurately, with second-hand vehicles and ‘make-do and mend’ approaches that often operate on several different roads. Thus, while HDM-4 can be calibrated for rural roads, model calculated VOCs are not suggested as easily-measurable outcome indicators. Although HDM-4 is used to appraise rural roads its greater complexity, and data demands, make it more appropriate higher volume roads, or for upgrading of LVRRs. RED is more used for low volume unpaved roads. As HDM-4 includes sets of road deterioration relationships it can be used to test different maintenance and design strategies of both paved and unpaved roads.

Other suggested outcome indicators for rural roads were visible enterprises along the road, numbers and size of market stalls and employment levels and supervisory visits in local schools and clinics. These are all expected to increase as road and transport services improve, and then subsequently decrease as roads and transport services decline due to poor maintenance.

Based on the workshop discussions and previous research (Starkey et al. 2013a; Starkey et al. 2018), the ‘current situation’ data-collection will emphasise possible outcome indicators that are directly linked to transport services on the target roads and related mobility issues. Some of these could then be used by roads and transport authorities to monitor rural transport services, to assist planning and ensuring roads are ‘fit for purpose’. Some examples are provided in Table 18. While some of these indicators (such as tariffs) are likely to be relevant in all countries, others (such as indicator crops, or motorcycle taxis as an indicator of youth employment) may be more country specific. Other possible indicators will be considered, including recent World Bank and RAWG suggestions for time-based, mobility-related indicators.

For the purposes of this research, we will have to consider the ‘before’ data sets, as we identify suitable indicators for particular roads. However, thinking towards the final guidelines, we may be able to suggest a larger menu of possible indicators that could be usefully adopted by roads and/or transport authorities. For this reason, we may be able to assess the apparent measurability and relevance of various outcome indicators that the local partners consider of particular relevance.

Table 18 Examples of possible outcome indicators and related issues

	Indicator	Data source	Comments
Outcome: Improved transport services			
	Number of transport services vehicles of each type per day	Traffic counts (market day and non-market days) complemented by operator surveys	Easily measurable. Highly relevant for movements of people and goods. Likely to increase as roads improve. Likely to be increases in all transport types with gradual shift to larger-capacity vehicles.
	Modal split of overall passenger and freight movements	Traffic counts (market day and non-market days) complemented by operator surveys	Easily measurable. Highly relevant for movements of people and goods. Likely to be gradual mode shift to larger vehicles that allow economies of scale.
	Numbers of women, men and children on each vehicle type per day	Disaggregated passenger counts (market day and non-market days)	Easily measurable. Highly relevant for movements of people and goods. Likely to increase as roads improve
	Fares per passenger kilometre for each vehicle type	Surveys of transport users and transport operators	Easily measurable. Highly relevant for movements of people. Likely to decrease in as roads improve although influenced by fuel prices and exchange rates
	Rural transport premium (ratio of on-road passenger fares to long distance fares)	Surveys of transport users and transport operators	Easily measurable. Highly relevant for movements of people. Likely to decrease as roads improve. Being a ratio, this should not be affected by devaluation or fuel prices.
	Freight charges per tonne-kilometre for each vehicle type	Surveys of transport users and transport operators	Rural freight costs are extremely variable within and between transport modes, often with a spread of two orders of magnitude. Freight costs are highly relevant for movements of goods and likely to decrease as roads improve. However, the great variability of costs makes this indicator very difficult to estimate.
Outcome: Improved local healthcare			

	Percentage of professional jobs in local clinics filled	Key informants at local clinic and/or local community	Easily measurable. Highly relevant to quality of health services. Likely to increase as roads improve, although also dependent on funding.
	Number of support visits per year from referral hospital and Ministry of Health	Key informants at local clinic and/or local community	Easily measurable. Highly relevant to quality of health services. Likely to increase as roads improve.
	Number of referrals undertaken per month to referral hospital and means of transport used	Key informants at local clinic and/or local community	Easily measurable. Highly relevant to quality of health services. Likely to increase as roads improve with more referrals in ambulances or conventional vehicles.
Outcome: Improved educational system			
	Percentage of professional teaching jobs in local elementary schools filled	Key informants at local elementary schools and/or local community	Easily measurable. Highly relevant to quality of elementary teaching. Likely to increase as roads improve, although also dependent on funding.
	Number of support visits per year Ministry of Education	Key informants at local elementary schools and/or local community	Easily measurable. Highly relevant to quality of elementary teaching. Likely to increase as roads improve
	Percentage of elementary school leavers going onto junior high school in the last year	Key informants at local elementary schools and/or local community	Easily measurable. Highly relevant to educational levels of communities. Likely to increase as roads improve where transport has been a constraint to high school attendance. However, in some countries, with the 'tapering' of attendance in elementary schools, the numbers involved may be small
Outcome: Improved agricultural production and marketing			
	Number of agricultural stalls (including ground spots) at local markets, disaggregated by gender of sellers	Market day surveys	Easily measurable. Highly relevant to agricultural production and marketing. Numbers likely to increase as roads improve
	Number of vehicles attending local markets disaggregated by vehicle type	Market day surveys	Easily measurable. Highly relevant to agricultural production and marketing. Numbers and vehicle sizes likely to increase as roads improve
Outcome: Improved business environment and employment opportunities			
	Number of road-side enterprises, disaggregated for agricultural sales, retail and 'productive' (local manufacture)	Visual inspection along road and business survey Disaggregated for gender of entrepreneur where practicable	Numbers and business type easily measurable if clear guidelines. Highly relevant to local economy. Likely to increase as roads improve. Gender less easy in a short survey but can be tested.
	Number of non-agricultural stalls (including ground spots) at local markets, disaggregated by gender of sellers	Market day surveys	Easily measurable. Highly relevant to retail opportunities. Numbers likely to increase as roads improve
Outcome: Economic empowerment for women			
	Numbers/proportion of female users of different motorised transport modes	Traffic counts	Easily measurable. Highly relevant. With economic empowerment numbers of women travelling is likely to increase.
	Numbers/proportion of female stall keepers at local markets	Market surveys	Easily measurable. Highly relevant. With economic empowerment numbers of women trading in markets is likely to increase.
	Numbers/proportion of female businesses along the road	Visual inspection along road and business surveys	Easily measurable. Highly relevant. With economic empowerment numbers of women establishing road-side businesses is likely to increase.
Outcome: Economic empowerment for youth			
	Number of motorcycle taxis operating along road	Traffic counts and operator surveys	Easily measurable. Highly relevant. Motorcycle taxis are a major new source of rural employment for young men in some countries.
Outcome: Road safety			
	Reported accidents and causes	Interviews with drivers triangulated with clinics and police/community leaders	Not easily measurable. Very relevant. Probably accidents increase as roads improved due to higher speeds. To be tested as an indicator.
	Use of safety helmets by motorcycle drivers and passengers	Traffic counts.	Easily measurable. Relevant for safety. Unlikely to change due to road. Any changes would be an outcome of a separate educational or enforcement programme. To be tested.

Source: After Starkey et al. (2018)

6.3.4 Questionnaires and sample sizes

Final details of survey methodologies and sample sizes will be determined after our initial appraisal surveys, and our diagnostic of the key data collection that will be required on each road, including the technical aspects of the road intervention and its success, or otherwise. We will finalise these survey details in liaison with the PMU. The World Bank (Starkey et al., 2007a) and RTSi (Starkey et al., 2013a) rapid appraisal survey methodologies suggest about 75 stakeholders per road studied, to gain mainly qualitative data and the prevailing tariffs and the market share of different types of vehicle and operational systems. Both the methodologies have questionnaire templates and suggested categories of people to survey, that can be modified to suit local situations. Where more quantitative evidence is required, such appraisals will be complemented by additional, highly-focused quantitative data-collection surveys. Once we have highlighted issues requiring quantitative data, the sample sizes will depend on the information sources and their variability and the extent of disaggregation required. For key stakeholders, such as vehicle operators, it depends on the diversity, disaggregation and specific information required. Within one sub-category, there are generally diminishing returns on obtaining new information above 10 respondents (although higher numbers of repetitions can increase confidence in the sample. If specific quantitative information on issues is required, then samples of 200 or more may be required. Socio-economic issues requiring quantified data would normally need samples of approximately 200 respondents, with more if there is much variability and disaggregation.

The traffic count methodology and the numbers of counts will be determined following the initial appraisal visits. On low-volume rural roads, it is often appropriate to have two 12-hour counts, one on a 'normal' day and one on a busy day (e.g. market-day). If practicable, they should be disaggregated by transport type, gender and loading. Local information is needed to determine whether additional hours or days would significantly improve the reliability and value of the data, and whether any such improvements would be cost-effective, relative to additional counts elsewhere on the surveyed roads or on other roads.

A summary of the road maintenance policy and interventions undertaken on the road will be obtained and discussed with the authorities. Such information would ideally include objective data on road condition, such as roughness measured reliably by equipment that is appropriate for the particular conditions. It is recognised that roughness, especially smartphone roughness, is unreliable, particularly for unpaved roads in fair to poor condition. Additionally response type roughness measurement is vulnerable to vehicle characteristics, vehicle condition and driver behaviour, so roughness will be carefully investigated and assessed before it is considered for inclusion in the study. In the absence of such information, it is hoped that visual surveys will have been undertaken, which when carried out in accordance with set regulations can provide accurate assessments of road condition. This should be available from the local roads authority responsible for monitoring and maintenance of the road. It would be desirable to access the actual condition survey data, rather than just the headline conditions, in order to understand how it was collected and how reliable it would be, given that it is likely to be largely subjective.

The two local researchers will be responsible for survey implementation, with enumerators to assist with traffic counts and quantitative data collection surveys. Each of the local researchers will be supervised with two separate visits from international team members who will also engage in qualitative data collection and discussion with relevant stakeholders associated with the road, the roads authority, the transport authority and operator associations. The international team members will endeavour to continue to stimulate and maintain interest in the research within the relevant authorities, and the final visits will include a debriefing presentation of initial observations and apparent lessons.

6.3.5 Data analysis and Phase 2 reporting

The analysis of the survey data will start prior to the second supervisory visit to ensure quality control and identify any gaps in the information that need to be filled. As per the suggested milestones, the team will prepare a progress statement (scheduled in the ToR for month 12) and the Phase 2 report (scheduled in the ToR for month 16). There will be a conference presentation/paper, which may well be at the T2 conference due to be held in Maputo in July 2019. Due to resource issues, no regional workshops are envisaged in Phase 2.

6.4 Phase 3 research

6.4.1 Phase 3 activities and methodology

Phase 3 research will start in Phase 2, with early contacts being made with the transport services authorities and other stakeholders in the three selected countries to discuss how they feel about the research questions and possible ways in which rural transport services could be improved. Ghana has a powerful transport association, the Ghana Private Road Transport Union (GPRTU), which involves some self-regulation of its members in terms of routes and queuing practices. We will talk with representatives to find out what their interest might be in discussing possible Phase 3 indicative interventions. Nepal also has powerful associations, with different cartels for buses, trucks, jeeps and three-wheelers. Again their levels of interest in Phase 3 research issues will be discussed. Tanzania also has transport associations that control queuing at bus stations (including minibuses), and contacts will be made to assess possible options. All three Phase 2 countries have formal sector private bus companies, operating long-distance express bus services on national roads. Some of these will be contacted to discuss their interest in rural transport service operations, and any perceived constraints or restrictions related to RTS provision. Experiences in Tanzania and Ghana will also be assessed relating to schemes to get the informal private sector urban transport operators to collaborate in formal sector companies to allow them to operate in the Bus Rapid Transit catchment areas.

Various relevant contacts will be made with other countries, to learn of examples of attempts to get informal sector transporters to formalise and/or combine as companies or cooperatives such as the transport operators' Savings and Credit Cooperative Organisations (SACCOs) in Kenya. There will also be contacts with some public sector bus companies. Sierra Leone has invested in its parastatal bus company that provides good services on many national routes. Mozambique has a parastatal 'Post-bus' service on many national routes, providing passenger and freight transport. We will try to contact such services to find out how they (and the relevant overseeing ministries) regard the opportunities to provide rural transport services. We will try to find more information about the minibus trial in Malawi (reported by Raballand et al, 2011) that attempted to see if good quality rural transport services could be economically viable.

Phase 3 will also need to involve detailed discussions at all levels, from community to policy makers. To determine the factors that prevent transport services being scaled-up will require investigations at community and local government level in the first instance. Interviews with all classes of transport operators will be key to understand their motivations in scaling up and servicing rural areas. There will clearly be differences in benefits to the transport operators and transport users, so understanding these in terms of how the most impact could be achieved is important.

The issue of rural transport subsidies will be very country specific, but will require consultation with policy makers at local and central level, as well as transport services operators and users of the service. There will be government regulations already in place that should determine the extent to which this will be possible, although this should not necessarily dictate the possibility of using subsidies to stimulate rural transport service provision.

The detailed research methodology for Phase 3 will depend to a large extent on the discussions and findings during Phase 2. However, for reasons of time and resources, much will be based on more detailed reviews of the literature and discussions with key stakeholders including transport regulators, transport operators and those with practical experience of transport services initiatives (or comparable initiatives in similar sectors).

During the inter-regional workshop, one group discussed 'What planning mechanisms or incentives can be used to improve the quality and quantity of rural transport services?' The group considered issues affecting transport services from the operators' perspectives (e.g. transport demand, quality of the infrastructure), and the users' perspectives (e.g. socio-economic needs for mobility and transport tariffs, reliability and efficiency). The group came up with some options to improve rural transport services that could be explored with relevant stakeholders. These included the following:

- There should be an integrated, multi-sectoral approach to developing a Rural Transport Services Logistics strategy, which could identify areas with real and intrinsic demand for rural transport services, where investment in transport services would be profitable, for the private sector or

Public Private Partnerships (PPP). Many ministries concerned with rural areas should be involved with local stakeholders in developing Rural Transport Logistics Strategies. They would include, where appropriate, Ministries of Public Works, Transport, Agriculture, Health, Labour, Industry, Trade (inland trade corridors), etc. Such a transport strategy should be linked to integrated land-use planning in rural areas, with an intention to stimulate the market demand, for example by stimulating increased agricultural production.

- To fund improvements in rural transport services, one option would be to encourage private firms to invest in rural transport services as part of their corporate social responsibility (CSR).
- To create synergies between road investments and transport services performance-based contracts for rural road maintenance should be considered, where possible with labour-based practices. These could be linked to certain transport services provisions, to motivate the road contractors to directly engage with transport service providers.
- With the successful establishment of road funds, similar funds could be established to promote transport services.
- To assist potential investors in rural transport services, there could be scoping data available on actual and latent transport demand and willingness to pay (WTP). There could be inducements to the private sector, including potential guarantee schemes for loans to invest in vehicles and initial operations.
- Public-private partnerships (PPP) could be established to fund the initial viability gaps of new rural transport services, allowing start-up enterprises in areas of below-optimal demand, that could become profitable once people adapt to the new services, leading to increased demand and operational profitability.
- There was general agreement that the way forward would be easier if roads agencies were actively involved in the planning of improved transport services. There should be clear planning links between road construction, maintenance and rural transport services. Road funds could not only support this, they could make financial disbursements conditional on such integrated approaches.

Other potential ideas include:

- Regulate or self-regulate for route sharing, so that access to the more profitable routes is conditional on some services on less-profitable routes (Starkey et al, 2002; Starkey, 2016b).
- Increasing road linkages and route inter-connectivity (Starkey et al, 2002).
- Developing planned and timetabled hub and spoke systems based on market town hubs (Haworth and Starkey, 2009; Starkey, 2013; Starkey, 2016b).

In the timescale of this research there would not be time to inaugurate any actual schemes, but it would be possible to obtain some stakeholder options through face-to-face discussions (preferred) and/or electronic surveys. The aim would be to prepare guidelines with some brief case studies, various recommended options, and the apparent acceptability and/or viability for the various types of stakeholder contacted.

6.4.2 Phase 3 reporting

There will be a series of milestone outputs in Phase 3. There will be an Interim Progress Statement (scheduled in the ToR for month 18), and a conference paper and presentation (an Abstract has been accepted for the World Road Conference in Abu Dhabi in October 2019). The Phase 3 report with the conclusions relating to promoting better transport services is scheduled in the ToR for month 21. Due to resource issues, there will not be a separate inter-regional workshop, so there has been no allowance made for attendance at such an event during Phase 3. However, the team may report on a workshop event organised at another gathering (such as a ReCAP Inter-Regional Implementation Meeting or IRIM in early 2020). The IMPARTS Guidelines based on Phases 1-3 will be prepared (scheduled in the ToR for month 22). The team believes that the Phase 3 report and the Final report can be combined, so that Phases 2 and 3 are both covered in this Final report (scheduled in the ToR for month 24). This would then provide the reader with an overview of both phases in one report. The Guidelines at the end of Phase 3 and the second peer-reviewed journal paper could also be a combined deliverable (also scheduled in the ToR for month 24). This would make the delivery of the project outputs more efficient.

6.5 Merging of Phases 2 and 3

It is clear from the content of Section 6 that there will be a significant amount of overlap between phases 2 and 3. In order to save costs and make the delivery of the project more efficient, whilst enhancing the chances of completing the project on time, it is proposed to effectively merge Phases 2 and 3. They will remain the same in terms of reporting, but this would allow some of the Phase 3 tasks to commence during Phase 2 and would minimise the possibility of delays to the programme.

6.6 Payment Schedule

If the various proposals made in Section 6 are accepted, the payment schedule proposed would be as shown in Table 19. In order to reduce costs, the number of deliverables has been reduced to seven, from the previous 11. Two workshop reports are no longer necessary, and one progress statement and the final report have also been omitted. This will be facilitated by the merging of Phases 2 and 3. This is likely to increase project efficiency for the research team (and the PMU) while not diminishing any of the important research outputs.

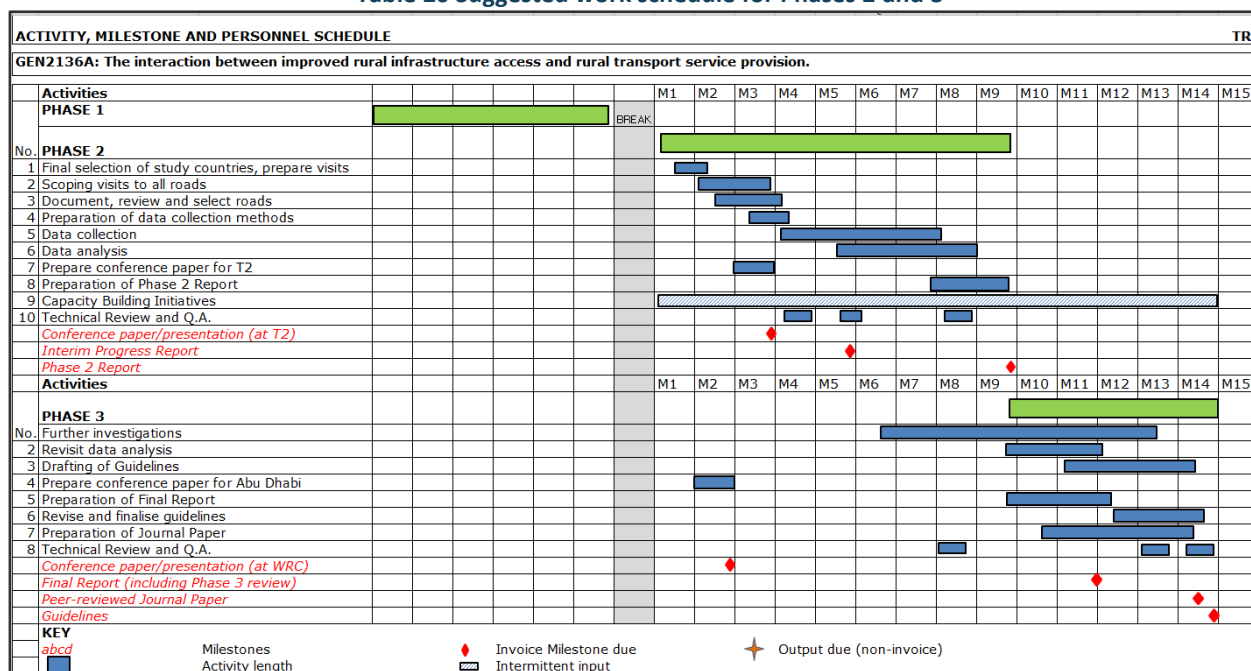
Table 19 Proposed milestones and their timing for Phases 2/3

No.	Output	Payment Deliverable	%	Month No.	Date
1	Conference paper (PIARC WRC, Abu Dhabi))	1	10%	2	April 2019
2	Conference paper (T2 Mozambique)	2	10%	3	May 2019
3	Brief Progress Statement	3	15%	5	July 2019
4	Phase 2 report	4	20%	9	Oct 2019
5	Final report, including Phase 2 and 3 outcomes	5	20%	11	Jan 2020
6	Peer reviewed scientific paper	6	5%	14	Apr 2020
7	Guidelines	7	20%	14	Apr 2020

6.7 Programme

The suggested programme for Phases 2 and 3 is provided in Table 20.

Table 20 Suggested work schedule for Phases 2 and 3



7 Conclusions and Recommendations

7.1 Need for a more integrated provision-preservation-services approach

This project has two major underlying topics that are intertwined in the rural access provision-preservation-services continuum, which in the past have been examined separately. In this research, they are being studied together, with the rural infrastructure issues including type of construction, the built parameters and maintaining the condition of the infrastructure, against the rural transport services issues including the types of transport modes available, the fluctuation in numbers and trips and the reasons provided by stakeholders for these changes.

There is a great deal of evidence, some of it reviewed here, that road provision and preservation, when accompanied by appropriate means of transport and transport services, can lead to significant social and economic benefits in terms of agricultural production, healthcare, education, employment and poverty reduction. The benefits may not be shared equally (with those having access to more resources benefitting most), but rural communities as a whole benefit greatly, and this reduces the equity gap between rural and urban populations.

However, there are also examples of motorable roads, with surprisingly few vehicles using them. On LVRRs, it appears quite common for transport services to respond to the transport demand on market days only, so that they do not meet the much lower, but still important, demand on non-market days. In some countries, the problem has been reduced by the presence of motorcycle taxis. While these can be beneficial for rural communities, they do not necessarily meet the needs of the poorest and most vulnerable people living in these communities, and they raise many safety and regulatory issues.

This report has cited several examples of impact evaluations relating to rural roads. Most of these have contained some surprising data-correlation findings that could not be explained. Some have suggested possible reasons for the unexplained changes to traffic volumes, travel patterns and tariffs charged. However, the great majority of roads projects have not collected adequate data relating to transport services. It is proving surprisingly difficult to identify good data sources for this research. Many roads authorities and/or projects have not been systematically recording, storing and sharing even the most basic information about how traffic has changed over time, from baseline to completion of construction works, until well into the routine maintenance phase. More importantly, for this research, almost no authorities or projects, of which we are aware, have systematically collected detailed transport services information over time, such as modal splits, fares and freight tariffs, loading levels, frequencies, quality and safety.

7.2 Increasing transport services understanding in roads authorities

The rural access provision-preservation-services continuum is central to this study. Unfortunately, in the past few decades, national road programmes (and their supporting donors and development banks) have seldom embraced such an integrated approach. In many cases it may not be within the mandate of the relevant agency to carry out this function. Reductions in vehicle operating costs and improvements in transport services have generally been cited as anticipated outcomes of, and justifications for, investments in access provision and access preservation. However, only very rarely have there been systematic studies relating to this, with pre-investment baseline data on transport services followed by comparable post-investment data on transport services, repeated at intervals.

To assess the impact of infrastructure investments, it would be valuable to have data relating to each mode of transport, and the modal splits for passenger and freight movements. Such studies would be invaluable in the context of this research, but such data sets have seldom been collected by road authorities. While traffic count data are sometimes collected, information is rarely systematically recorded or sufficiently disaggregated for different transport services. It is quite difficult to make reliable assessments of changes in transport services if the only information sources are basic traffic count data.

As has been pointed out, while traffic count data is better than no information, traffic counts would be more valuable if they were clearly disaggregated in terms of transport services vehicles and their loads. The traffic on LVRRs is (by definition) small and so it is not too onerous to obtain such information. Indeed, because many conventional rural transport services keep to relatively predictable patterns basic information on transport services can often be obtained from discussions with local stakeholders. Such

non-counting traffic estimations are part of the DTMP methodology in Nepal (DoLIDAR, 2012). One of the subsequent recommendations of this research should be guidance on the key transport services data that road authorities (or transport authorities) should routinely collect as part of an integrated approach to the provision-preservation-services continuum, supported by relevant legislation.

There may be three key reasons why most road authorities and projects have not adopted an integrated approach to the provision-preservation-services continuum:

- Myth of private sector optimisation
- Lack of professional training/understanding about transport services
- Separation of responsibilities between roads authorities and transport authorities.

For many years, there has been an incorrect assumption in the roads authorities (and supporting donor agencies) that the private sector will respond to road investments by providing appropriate transport services. There is much evidence, some of which has been cited in this report, that this is not the case for a very large number of LVRRs in the world. In high-income countries, rural transport services are often non-existent unless there are subsidies. In low-income countries, rural transport services may be non-existent (particularly on non-market days) or the private sector response has been to use aged, overloaded vehicles with relatively high tariffs. Phase 3 of this research will investigate possible solutions to this dilemma, including the issues of subsidies or public-private partnerships.

Most road agencies are staffed largely by engineers, who have little or no experience in issues relating to transport services. There is almost no institutional learning or memory in road authorities that relates to transport services. Perhaps lessons can be learned from the road safety sector that has managed to develop a relatively integrated approach, with social science issues such as human decision-making being undertaken (and published) within engineering-based institutions and journals.

The institutional divide between roads authorities and transport authorities is a major constraint, but one that can be overcome in various ways. One option would be to greatly improve funding to transport authorities to enable them to be actively engaged in rural transport. Another option would be to combine the authorities as roads-and-transport authorities, to facilitate an integrated approach. Whatever the existing institutional structures, there needs to be an active policy, made at a high level, to promote a more integrated approach to roads and transport, and related strategies to ensure that this happens.

Given the much greater human and financial resources available to the roads authorities, they should take an active lead in this. Again, lessons from the road safety sector can be drawn, as road safety authorities generally involve both roads and transport expertise. An example of a possible way forward at a devolved level exists in Bangladesh where they have local road safety committees, facilitated by the roads authority. This could be a way to start working with transport services stakeholders, investigating many issues relating to transport services (safety, comfort, tariffs, organisation, frequency, user satisfaction, etc.), in cooperation with the transport authorities. The aim would not only be to improve safety, but for all parties involved to gain a much greater understanding of transport services issues.

7.3 Lessons learned and Phase 2 and 3 research proposals

The research undertaken so far has included a wide-ranging review of previous research, both historical and contemporary, on the interactions between infrastructure interventions and the development of transport services. There have been examples of positive, unexpected and negative scenarios of how transport services change following road investments or following the neglect of road assets. Managerial, technical, economic and political issues can affect decisions relating to investment in road provision and road maintenance, that can lead to better (or worse) road conditions, that affect transport services.

A wide range of different rural transport services, and their particular roles, has been reviewed, including intermediate means of transport and the growing importance, in some countries, of motorcycle taxis. Issues include the complementary nature of some transport services, the roles of associations and cartels and the widespread practice of using old and overloaded vehicles. Many examples have been provided where transport services are not performing satisfactorily, and this needs to be fed into the larger picture of rural roads, transport services provision and socio-economic development.

The research undertaken so far has provided an insight into the continuum between planning the provision of rural access and the effective delivery of rural transport services. This provides good background for the research in Phases 2 and 3 with many issues and dynamics to consider. Among the questions to be explored further will be:

- How changes to rural transport services have affected rural people, and how can these changes be 'measured' in ways that can contribute systematically to the planning of road provision, maintenance and transport services?
- How rural infrastructure engineering, including road design and maintenance, can be sustainable and fit-for-purpose for appropriate transport services?
- What are the key constraints to improving rural transport services, besides road infrastructure, and how could these be addressed, including issues relating to regulation, financing and encouraging engagement beyond the small-scale enterprises of most existing operators?

It has been proposed in this report that Phase 2 research will start by examining existing datasets obtained early in the road investment processes in Ghana, Nepal and Tanzania. The pre-identified roads will be visited to allow a rapid appraisal of the current situation and apparent issues.. Detailed studies will then be carried out on two roads in each of two countries, the final country selection being based on local engagement with the research, the quality of the datasets and the relevance and value of the anticipated research finding.

During Phase 2, it is proposed that a start is made on Phase 3 issues, relating to how can rural transport services be improved. One Phase 2 research question is linked to this, in trying to establish the critical issues besides road infrastructure that are restricting the development of transport services. While Phase 3 is more concerned with looking at potential mechanisms to get more actors and funding into the provision of rural transport services. Therefore, the team will use Phase 2 country visits to engage relevant stakeholders including transport authorities, transport associations, parastatal bus companies and private sector transporters. The aim will be to explore the desirability, affordability and viability of a range of options, some of which were suggested during the IMPARTS inter-regional workshop.

As Phase 2 finishes, with several relevant outputs, including workshop presentations, the research will concentrate on the Phase 3 issues, leading up to the preparation of the IMPARTS Guidelines. They will recommend ways to improve rural access through fit-for-purpose infrastructure, better transport services and integrated approaches. The guidelines are likely to include recommendations to integrate the planning, design and implementation of rural infrastructure provision-preservation and appropriate rural transport services. They are likely to include guidelines on suitable data sets required for appropriate planning, possible inter-disciplinary and inter-institutional steps towards the integrated approach, and potential investments and/or regulatory processes to make transport services, as well as roads, 'fit-for-purpose'.

The final report will summarise the key findings of the Phase 2 and 3 research.

8 References

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