Interactions between improved rural access infrastructure and transport services provision

Report of Tanzania Surveys

Paul Starkey, John Hine and Robin Workman

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For further information, please contact:
Robin Workman, Principal International Consultant, TRL: rworkman@trl.co.uk
TRL, Crowthorne House, Nine Mile Ride, Wokingham RG40 3GA, UK

ReCAP Project Management Unit
Cardno Emerging Market (UK) Ltd
Clarendon Business Centre
Level 5, 42 Upper Berkeley Street
Marylebone, London W1H 5PW

Cover photo. Paul Starkey: Motorcycles on the Chekimaji-Kawaya road, Hai District, rehabilitated under the IRAT programme in 2016, showing Vetiver bioengineering on the embankment sides and Mount Kilimanjaro in the background

Quality assurance and review table

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Abstract

The 'Interactions: Maintenance-Provision of Access for Rural Transport Services (IMPARTS)' project has been examining how investments in low-volume rural road (LVRR) construction (provision) and maintenance (preservation) affect rural transport services (RTS). Improved RTS are vital for enabling access to facilities including markets, health facilities, education and socio-economic opportunities. While road investments are often justified by envisaged RTS improvements, few road authorities collect 'before' and 'after' RTS information. This report summarises research findings following surveys of six roads in Tanzania that had received investments in the past decade, including five investments to remove 'bottlenecks' that had restricted all-season access. Historic traffic data sets available from before and after the investments were supplemented by 2019 data collected by this project. The specific road improvements are described and their effects on traffic flows and transport services have been analysed. All investments assured all-season access. However, sustained traffic growth was not apparent and new transport services routes had not developed. Most traffic on all roads comprised motorcycles, and motorcycle taxis were the only transport services on three roads, and on most sections of two other roads. One key issue was low transport demand due to small local populations compounded by the lack of people wanting through services. Transport services prioritise economic transport demand over road condition and will not operate over good roads and bridges if there are insufficient passengers. The study concluded that transport demand was the first limiting factor for RTS, with road condition an important but secondary consideration. Bottleneck alleviation is a useful road improvement strategy, but such investments may not change transport services patterns in areas of low transport demand and/or where there are nearby alternative routes. It is recommended that district transport plans are developed in consultation with stakeholders including transport services operators. Rural transport infrastructure should be appropriate for motorcycles and include motorcycle trails and trail bridges to ensure all villages can be reached by motorcycles.

Key words

Tanzania; Transport services; Motorcycle taxis; 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

AfCAP	Africa Community Access Partnership
ARMP	Annual Road Maintenance Plan
AsCAP	Asia Community Access Partnership
bn	billion
DFID	Department for International Development, UK
DROMAS2	District Road Management System version 2
eg	for example
EOD	Environmentally optimised design
GBP	UK pound sterling (Great Britain pound)
	In Jan 2020, GBP 1 = TZS 3000; TZS 1 = GBP 0.00033
GDP	Gross domestic product
GIS	Geographic information system
GPS	Global positioning system
HD	High definition
ICF	International Climate Fund
IMPARTS	Interactions: Maintenance-Provision of Access for Rural Transport Services
IRAT	Improving Rural Access in Tanzania
IRI	International Roughness Index
kg	kilogramme
km	kilometre
h	hour
LATRA	Land Transport Regulatory Authority
LVRR	Low-volume rural road
m	metre
M	million
mins	minutes
MoWTC	Ministry of Works, Transport and Communication
No.	number
OSM	Open Street Map
PO-RALG	President's Office for Regional Administration and Local Government
RAI	Rural access index
ReCAP	Research for Community Access Partnership
RTP	Rural transport premium
RTS	Rural transport services
RTSi	Rural transport services index
sq	square
SSA	Sub-Saharan Africa
SUMATRA	Surface and Marine Transport Regulatory Authority
TANROADS	Tanzania National Roads Agency
TARURA	Tanzania Rural and Urban Roads Agency
TRL	Transport Research Laboratory
Tsh / TZS	Tanzania shilling (TZS).
	In Jan 2020, TZS 1 = GBP 0.00033 = USD 0.00043; GBP 1 = TZS 3000; USD 1 = TZS 2300
UK	United Kingdom
UKAid	United Kingdom Aid (Department for International Development, UK)
USD	United States Dollar
	In Jan 2020, USD 1 = TZS 2300 TZS 1 = USD 0.00043
USDc	United States Dollar cents
VOC	Vehicle operating costs

Executive Summary

The ‘Interactions: Maintenance-Provision of Access for Rural Transport Services (IMPARTS)’ research project has been 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. 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 project has been commissioned by the Research for Community Access Partnership (ReCAP), funded by the Department for International Development (DFID) of the United Kingdom (UK).

The first project phase involved literature studies and consultations with ReCAP stakeholders in Africa and Asia. This confirmed that rural road investments can have beneficial impacts, with improved access to markets, healthcare, education and economic opportunities. While transport services provide a mechanism for achieving the impacts, little data is collected on rural transport services. There are few datasets spanning road investments, with ‘before’ and ‘after’ information on the quality and quantity of transport services and their tariffs. Within ReCAP countries, the best sequences of data that were identified were for rural road investments in Nepal and Tanzania. This project surveyed some of those roads again in 2019, to supplement the existing information and try to determine how the various road investments had influenced transport services. This report provides details of six roads surveyed in Tanzania. Five of the roads had received investments to remove ‘bottlenecks’ defined as sections of the road that severely restricted the all-season movement of traffic. These investments, and the related ‘before’ and ‘after’ traffic surveys, had been made in the context of the Improving Rural Access in Tanzania (IRAT) project, supported by DFID. The sixth road had been rehabilitated with trial sections as part of an AFCAP research project.

Investments included raised carriageways and culverts over low-lying land, some concrete strips and sections, and two bridges. On all the roads, most traffic (83%-95%) comprised motorcycles, many of which were motorcycle taxis. On roads without bus and minibus services, these provided 70%-89% of people’s motorised journeys, with men travelling much more than women. Only one road had regular bus and midi-bus services along the whole length. These did not change despite a 20 km rehabilitated section. Two other roads had minibus/minivan services on part of the road, but not on the whole road, despite several investments including a new bridge. The investments had allowed all the roads to become all-season but had not stimulated sustained traffic growth or new transport services.

The reasons for the limited impact were analysed, and possible reasons discussed with explanatory diagrammatic maps. On some roads there was an alternative and better route, and transport services preferred the better road as the transport demand along the poorer road was weak. Other roads did not seem to serve a purpose as through roads, due to lack of connectivity or due to alternative roads providing better access to people’s preferred destinations.

The evidence from all six survey roads and associated roads suggests that the key determinants of transport services are road condition and market demand. Provided the road is passable, transport demand is the most important. On rough roads, motorcycle taxis can travel faster and more easily than larger vehicles. With their small capacities they are well suited to low transport demand. The study showed that buses, minibuses, minivans and bajajis will travel on rough roads if they perceive high demand. A good road or a good bridge without appropriate market demand is insufficient to attract transport services.

It is concluded that there should be more involvement of local stakeholders in planning road investments. Transport services operators should be consulted about how they might respond to different investment options. This could be achieved during the preparation of district transport plans. The Tanzania Rural and Urban Roads Agency (TARURA) should engage more with transport services operators and include transport services information in its road database. With so many rural motorcycles, rural infrastructure should always be appropriate for their needs. Parallel concrete strips should be avoided. Cheaper narrower roads and bridges could be considered unless buses or midibuses are anticipated. All off-road villages should be accessible using motorcycles, and a TARURA ‘motorcycle trails and trail bridge’ unit should advise districts on appropriate investments that could be community-supported and implemented.

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. Road infrastructure allows rural women and men to reach markets 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 LVRRs 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 Research objective

The core research 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-services continuum can be improved in support of better livelihood opportunities for rural communities and have a positive impact on poverty reduction.

Impact: improved accessibility and mobility for rural communities, and improved overall livelihoods of those communities, in particular for vulnerable groups and individuals within those communities.

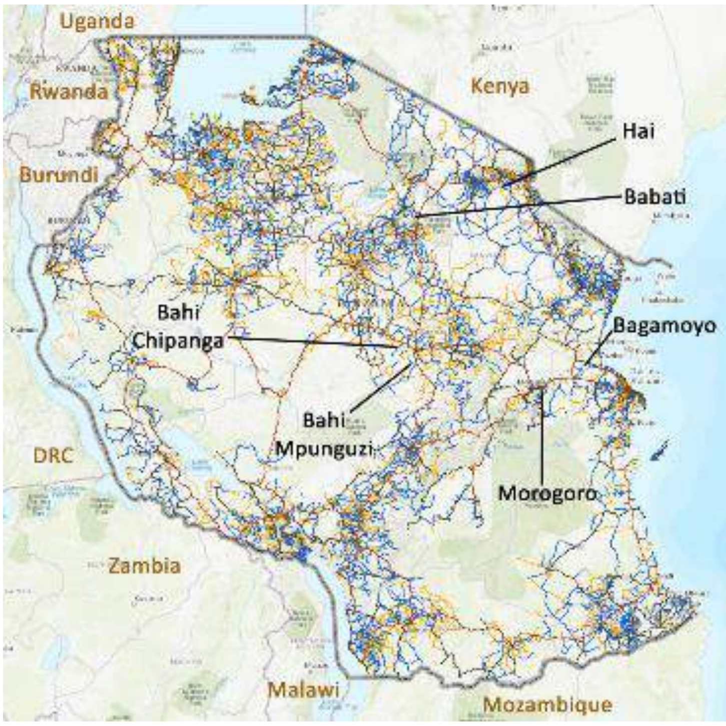
1.3 Activities and progress to date

Phase 1 of this IMPARTS project, which started in May 2018, involved a detailed literature review of the relationships between LVRRs, transport services and the outcomes and impacts for the rural populations (Starkey et al., 2019a). This cited impact studies from around the world on how rural road provision had affected the local populations through improvements in mobility, agricultural production, access to medical facilities, education and poverty reduction. However, despite the large number of rural road projects in Africa, Asia, Latin America and island states, the number of clear impact lessons was surprisingly few. Most impact studies attempted to correlate various ‘before’ and ‘after’ datasets obtained through socio-economic surveys. Only a very small number of published studies have looked at transport services and the mechanisms by which these impacts had been achieved. Through liaison with road authorities in all 17 ReCAP countries, it was learned that while road investments are often justified by predicted improvements in transport services, few (if any) road authorities regularly collect ‘before’ and ‘after’ information on transport service provision. Good datasets relating to rural transport services are rare. Even traffic counts on LVRRs that have been consistently implemented over a period of time are difficult to find.

A project inter-regional stakeholder workshop was held in Arusha, Tanzania, in November 2018 and was attended by 39 participants from 12 ReCAP countries (Starkey et al., 2019b). The participants, who were mainly engineers from roads authorities, were motivated to understand transport services issues, and endorsed the need for more integrated approaches with transport services data informing the planning of road investments (construction and maintenance). The workshop concluded that roads authorities should try to collect, and use in their planning, simple transport services outcome indicators (such as modal distribution, tariffs, frequencies and journey times). Unlike *impact* indicators that may take five years or more to respond to road investments, transport services *outcome* indicators respond rapidly to road improvements. Importantly, they also respond quite quickly to road deterioration due to inadequate maintenance. Such transport services outcome indicators could be incorporated into road planning and Maintenance Management Systems.

The second phase of this IMPARTS project (which included activities initially planned for a third phase) started in early 2019. Team members visited roads authorities and rural roads in Ghana, Nepal and Tanzania to select suitable research locations. Information and data on road planning and transport services in previous years was better in Nepal and Tanzania, and roads in these countries were selected for new surveys. The six roads selected in Tanzania, including some key features and existing data sources, are summarised in Table 1. Their approximate locations and their districts are illustrated in Figure 1.

Figure 1 Map of Tanzania showing roads and approximate locations of study roads



The research in Tanzania was undertaken in collaboration with the Tanzanian consultant, Hans Mwaipopo, who obtained the necessary research permissions. Following the development of the various survey forms, a senior enumerator, Stanley Soiti, was recruited to implement the surveys. He was trained to implement qualitative and quantitative surveys on the selected roads, allowing the implementation to start in September 2019. Supervisory visits were undertaken by Paul Starkey, Robin Workman and John Hine. This report contains findings from surveys carried out on the six roads in Tanzania.

1.4 Research tools and methods

1.4.1 Overview and timing

The various research instruments and survey forms were presented in detail in a previous report (Starkey et al., 2019c), and included traffic counts, user surveys, operator surveys and key informant interviews. These are summarised in Table 2. The surveys and traffic counts were carried out from 16 October 2019 to 18 December 2019. In addition to the quantitative data collection, there have been focus group discussions with key informants including vehicle operators and staff of the road authorities and people aware of the history of the road.

Table 1 Summary of the six roads surveyed in Tanzania

Road	Investments	Data sets	Present situation	Infrastructure issues	Transport services issues	Planning issues
'Bagamoyo road' Talawanda-Bago Road, Bagamoyo District, Pwani Region. 20 km road though rolling countryside. Pineapple farms near Bago. Mainly mixed agriculture but fairly low population density	AfCAP 20 km road rehabilitation in 2010-2011 including several different surface trails (bituminous seals, different gravels, engineered earth, geo-cell blocks, stone, parallel concrete strips)	Roughton, RTSi, Amend, Transaid 2019 IMPARTS surveys	All season road, quite smooth, most traffic motorcycles. No 3-wheelers, minibuses or buses	Opportunity to evaluate performance of different surfaces from engineering and users' perspectives. The parallel strips are proud due to design/erosion and so dangerous for the prevailing traffic (motorcycles and bicycles). Proud cross ties would make it very difficult for 3-wheelers	Mainly used by motorcycles and bicycles. How to get 3-wheelers and/or minibuses to operate on road? There had been minibuses after the initial investment but these stopped due to a difficult stone section and low demand. Infrastructure is no longer a limiting factor for minivans or minibuses, but the transport demand is insufficient to get them to start services. Some services tried through services as shortcut to Chalinze but insufficient local demand to justify the time on the rough road.	For many people in Talawanda, their preferred destination is not Bago (or Bagamoyo) but Lugoba, Chalinze or Mlandizi in the other direction
'Hai road' Chekimaji-Kawaya road in Hai District, Kilimanjaro Region. 11 km U-shaped road from Chekimaji to Kawaya. Connected to west to Boma N'gombe district town by 15 km rough road. Connected to east by 20 km rough road to Moshi town. Alternative through road across top of U. First 5 km rehabilitated section of road serves fertile farming area with rice production and one village.	2016 IRAT investment was rehabilitating first 5 km with an embankment and several culverts, to allow all-season motorability on a very difficult section of the road. New section is now best road in the local network	IRAT traffic counts before and after 2019 IMPARTS surveys	all season road with first 5 km very good and rest of road rough. Little traffic other than motorcycles. Only motorcycle taxis public transport. Connecting road to east is rough, but has motorcycles, Bajajis, minivans and minibuses operating regularly. Connecting road to west is rough but has minivans and minibuses to Moshi. Trucks of buyers use road at harvest time. Tourists use road to access hot springs.	Good quality 5 km road section produced allowing access to agricultural lands and one village, but connected to rough roads	Bajaji and minibus/minivan transport services from district town still stop at Rundugai, just before the new section and do not use the good new part of the road. Minivans and minibuses operate from Kawaya but go other way to Moshi. Operators in both directions say little reason to use the road as a) the village served has a small population and access to rice and agricultural fields does not require regular public transport. b) through traffic can bypass the road with a shorter route.	The local population and there are other ways of reaching the local villages. For many people in Kawaya, their preferred destination is not the district town, but Moshi, in the other direction. While the road provides all-season access to an irrigated agricultural area, agricultural traffic is very low, and has alterative routes.

'Babati road' Magugu-Mahole road in Babati District, Manyara Region. 18 km road from Magugu to Mahole (with weekly market) road. Relatively flat agricultural land with sugar cane plantation around 6 km-8 km. Extensive livestock grazing land in final 8 km and beyond	2016 IRAT investments of one 4 m box culverts, two 2m ring culverts and 800 m of embankment on a low-lying section c. 9 km from each end to allow all season motorability on a very difficult section that had been impassable in rainy season	IRAT traffic counts before and after 2019 IMPARTS surveys	All season road, with good short rehabilitated section across some swampy land, allowing all year access. Rest of the road is very rough, (eroded surface with over-size stone). Some new TARURA investments near both ends of the road.	Culverts successfully transformed road into all-season road. Non IRAT road sections very rough. Main traffic comprises motorcycles which prefer to use side trails. They also use a local footpath (motorcycle trail) in dry season to avoid several km of rough road sections	Motorcycle tariffs in rainy season reduced by intervention. Road mainly used by motorcycles. Bajaj and minibus/minivan/midibus transport services from Magugu to Mahole (the two ends of the road) take an alternative route that is 3 km longer, but half is bituminous and the other half is graded and smoother. The operators say there is little transport demand along road to justify the time and discomfort of using the rough sections.	Very little transport demand to use the bottleneck section due to an alternative route. Bottleneck removed one limiting factor, but not the roughness that inhibits transport 3- and 4-wheel transport services travel up and down the road.
'Bahi-Chipanga road' Chigongwe-Chipanga, Bahi District, Dodoma Region. 32 km road from Chigongwe (Singida Road) to Chipanga (clinic, monthly market). Low-population density, semi-arid area with grazing and some cultivation (sorghum, millet sunflowers).	IRAT 2016-2018 investment in two significant two-lane bridges at 10 km and 27 km from start and also 8.6 km of rehabilitation. Some recent rehabilitation work on first sections of the road before the bridges.	IRAT traffic counts before and after bridges were finished. 2019 IMPARTS surveys	Now all-season road. Most non-IRAT road sections rough so discouraging transport services, other than motorcycles. Minibuses and minivans provide shuttle services to Dodoma from Kigwe village 8km from start. One minibus and one midibus do daily return trips crossing first bridge to serve one village on road and one on connecting road. More trips on market day. No transport services other than motorcycle taxis serve upper half of road and very little traffic crosses second bridge each day.	Good quality bridges but connected by rough roads.	No obvious changes in transport services, except that motorcycles can operate all year round. Ambulances from Chipanga clinic can move on the road all year if required. Regular transport services connect Kigwe to the Dodoma northwest bus stand. Two daily vehicles serve villages beyond first bridge. Numerous extra public transport services on Kigwe market days. Low transport demand prevents the services extending their routes further up the road. Chipanga, at the 'end' of the road, is served by buses that travel to Dodoma by another better road to the different southwest bus stand. These do not have to pass a weighbridge. The heavily reinforced old buses fear they exceed limits if they passed the weighbridge on the Singida road, and so avoid the surveyed road.	There seems little justification for a two-lane bridge near Chipanga. Little traffic uses it. Dodoma is the main transport destination and this road connects two separate arterial routes to Dodoma. There is little transport demand for cross-district traffic. The road could usefully serve within-district traffic in the medium-to-long term if there were better connecting roads and much economic development. As Dodoma grows, this is possible.

'Bahi-Mpunguzi road' Mpunguzi-Mwitikira road Bahi District, Dodoma Region. 19 km road from Mpunguzi (twice monthly market on Iringa Road) to Mwitikira (large village). Flat land with semi-arid cropping (sorghum, millet sunflowers) with many vineyards near Mpunguzi. Livestock grazing. Road continues to many further villages	Finished in 2016, IRAT rehabilitated 22 km of road with embankment and culverts across low lying land.	IRAT traffic counts before and after. 2019 IMPARTS surveys	Now all-season road, although improved section had seldom been impassable for long but was difficult in the rainy season.	The 22 km is a good straight road but is now getting rough as fine parts of gravel have been washed away leaving stones. Motorcycles generally use the slightly smoother edges or travel on motorcycle tracks off the road (in the dry season)	No new transport services have started from Mwitikira. Motorcycles have reduced their tariffs. The existing three bus services to Dodoma starting in villages further up the road continue similar services but have reduced their tariffs. Mwitikira residents complain passing buses are already over-crowded by the time they reach their village and no minibuses or buses start in their village.	Seems logical investment but producing straight, smooth road increased vehicle speeds leading to many crashes (reported 7 deaths, two in car, 5 on motorcycles) on new rehabilitated road section apparently attributable to high speeds. Rough surface has now reduced speeds and so road appears safer
'Morogoro road' Mikese-Ngeregere Road, Morogoro District, Morogoro Region. Approx 35 km road from Mikese (near Morogoro on Dar es Salaam road) to Ngeregere (market town). Road rises in hilly terrain, from medium density rural population and mixed farming near start decreasing to low density shifting cultivation and finally protected forest (and military zone).	2014-2016 IRAT invested in six bottleneck interventions, including one concrete section on a steep hill section, one parallel concrete strip section on a steep hill, a drift, some lined drains and some gravel surfacing. All the road investments were in the final 15 km of the road (towards Ngeregere).	IRAT traffic counts before and after. 2019 IMPARTS surveys	All-season road with some very rough and badly eroded sections making. Dry-season travel slow. Rainy season travel difficult. At the time of the IRAT investments, the road started at Metegowa Simba closer to Morogoro, but the first road section was severed by the construction of a new railway. Traffic was diverted to a regional road from Mikese that crosses the survey road after about 10 km.	While some bottle-necks have been removed, the road still has many other bottlenecks of badly eroded sections (failed drainage and culverts). The parallel concrete strips are proud due to design/erosion and so dangerous for the prevailing traffic (motorcycles and bicycles). The proud cross ties would make it very difficult for 3-wheelers	Minibus and minivans provide services from the midpoint on the road to Mikese and Morogoro (travelling only on the first half of the road). Only motorcycles provide transport services on the last 15 km of the road (where the IRAT interventions were). Midibus services from Morogoro run on a national highway and good regional road to Ngeregere. The surveyed road offers a 20 km shorter route. But the transport demand to Ngeregere along the road is very low as few people live in the last 15 km and people in first half of the road want to travel to Morogoro. The poor condition and narrow width of the road do not attract the midibuses to use of the short cut, as the journeys would take longer and be more uncomfortable.	The first half of the road has transport demand to reach Morogoro. The population density and transport demand in the final 15 km (where the IRAT investments were) is very low. It was expected that some midibuses on the Morogoro-Ngeregere route would operate on the studied road as it is shorter. However, the road is rough and slow, narrow for midibuses and without local transport demand.

Table 2 Road survey data collection for the six Tanzania roads

Indicator	Disaggregation	Data collected	Instrument	Sample size in Tanzania	Comments
Modal share of passengers and freight	All public transport and freight modes. Passenger, Gender, Age (children), Freight	No. passengers per day per mode Estimated accompanied and unaccompanied freight per day per mode	Traffic counts with passenger counts and freight estimates	12-hour traffic counts, two days at strategic points.	Where practicable, one count was on a market day and one on a non-market day
Passenger trips Passenger fares Passenger opinions and Passenger preferences	All public transport modes, Passengers for: Gender, Age (students, older persons), Occupations (students, farmers, commuters, etc), Disabilities	Typical origin and destinations and travel frequencies Modes used, Fares paid Transport options, Transport preferences, Opinions on different modes, Safety issues Accessibility issues	User questionnaires with purposive sampling at roadsides and villages to ensure respondent diversity	40 per road	Where practicable, an approximate gender balance was achieved among the respondents
Vehicle operating costs and profitability Regulatory and safety issues	All public transport modes operating on road	Vehicle operating costs (VOC) components (daily fuel, ownership/hire costs, maintenance, etc). Tariffs charged, typical loads and trips per day, daily income. Regulatory charges etc.	Operator questionnaires	Where practical, 100% of public transport vehicles operating on the surveyed roads, with a maximum of ten operators for each transport type per road and 20 overall per road	
Local perceptions of socio-economic impacts of existing transport modes	All public transport modes Education Health	Opinions of local professionals and leaders about advantages and disadvantages of different transport modes	Key informant interviews	6 per road (including teachers, medical staff, agricultural extensionists, local dignitaries)	
Local perceptions of regulatory issues of existing transport modes	All public transport modes	Opinions of local police, enforcers and leaders about regulatory issues among the different transport modes	Key informant interviews	Up to 3 per road (if available)	There were few local enforcement officials or people responsible for local regulation
Road condition and maintenance	All local road authorities if more than one responsible	Information from local technicians/engineers with key informant interviews and visual inspections of the roads via drive-through surveys	Key informant interviews as well as visual condition surveys	One key informant interview per road with local technician or engineer	There was only one engineer available with knowledge of, and responsibilities for, each road

1.4.2 Quantitative surveys

The same methodology was used at each location, with interviews with 40 transport users, about six key informants and ten operators of transport services. Local district engineers were also interviewed. In the traffic surveys, 12-hour counts of all vehicle types and pedestrians were carried out at 15 sites (including 'control' roads). The control roads were those designated as such by the IRAT programme, since previous traffic count records were available to help understand trends. In total, 33 traffic counts were undertaken. For most locations the counts were undertaken over two days covering a market and a non-market day. In the Hai District location counts were carried out over three days.

Table 3 Summary of survey data collected for the six Tanzania roads

Survey	Approach	Total People Interviewed		
		Male	Female	Mean Age (approx.)
Users survey	Roadside interview of users	153	87	32
Key informants	Interviews of key opinion leaders	28	8	38
Transport operators	Interviews of transport operators	60	0	26
Road engineering issues	Interviews of road engineers	6		
Traffic survey	Roadside counts (33)			

In the following sections of the report, the 2019 survey data for five roads has been compared with survey data collected from surveys carried out by IRAT in 2015, 2016 and 2017 (Cardno, 2017). The data from the sixth road in Bagamoyo District has been compared with data collected under two projects of the AFCAP1 research programme (Roughton 2012, 2013a, 2013b and Willilo and Starkey, 2012). In each case, where necessary, the market and non-market day data was weighted so that a like-for-like comparison could be made.

1.4.3 Engineering aspects

Observations were made on the survey roads to determine key characteristics of the road that could have influenced the development of transport services. The assessments were undertaken using the following technologies, as illustrated in Figure 2:

- Visual assessment using standard data-collection forms on a drive-through survey.
- Videos of the road were taken using GPS enabled DashCams, which provided high definition video images of the road from inside the vehicle. The speed and GPS tracks have been embedded within the video and are extracted to produce a track that can be used in various software, including GIS and Google Earth. Finally, an accelerometer within the DashCam records the X, Y and Z movement of the camera within the vehicle, which can provide an indication of the roughest parts of the road. The 'Z' reading is the most important as it shows the 'up and down' movement of the instrument, relative to the earth. Some work has been carried out to correlate these readings with roughness, but there is not yet an established scale. This does however allow the engineer to compare 'Z' readings along a road, and even between roads when the vehicle and instrument are constant, which can be useful in identifying condition on different sections.
- Roughness in the form of the International Roughness Index (IRI) was recorded using the World Bank smartphone app RoadLab. However, the results from this app are unreliable at slow speeds on fair and poor unsurfaced roads, and the app does not record below 15 km/h. However, this information (or lack of it) has some value and can act as a check of the visual assessment.

Figure 2 Vehicle set up for drive-through survey with DashCam and smart phones with apps

1.4.4 Rural Transport Premium

One of the ways of comparing rural transport services on different roads, within and between countries and over time is through transport tariffs, such as passenger fares. One specific indicator for such comparisons is the 'Rural Transport Premium'. This is the ratio between the cost of per passenger-km of the available public transport services on low-volume, rural roads and the cost per passenger-km of standard-class, long-distance bus services. Being a ratio, there are no units or exchange rate issues, and many potential difficult issues, such as changes in fuel prices over time, the cost of living or idiosyncratic local pricing systems should be cancelled out. There will always be a Rural Transport Premium as long-distance buses are likely to be cheaper, per passenger-km, as they invariably run on better infrastructure (national trunk roads) and benefit from two economies of scale (larger loads and longer distances). Rural transport services typically use smaller vehicles for shorter distances on poorer roads. As roads improve, vehicle operating costs come down, and fares tend to decrease, particularly if there is competition. If the roads are good, and transport demand is high, rural transport operators will tend to use larger-capacity vehicles, which also allows prices to come down. In subsequent sections of this report, the Rural Transport Premium or RTP indicator will be used to compare how transport services have changed over time.

2 Institutional context

2.1 Tanzania geographic and socio-economic context

Tanzania has an area of 945,000 sq km, and an estimated population of 59 million (World Population Review, 2020). Tanzania has land borders with eight other countries (see Figure 1) and is divided into 26 regions. There are four city-, 22 town- and 106 district-authorities. Over the past decade Tanzania has experienced an economic growth of 6.5%, far above the average for other Sub-Saharan Africa (SSA) countries. However per capita GDP remains low at USD 1,105 in 2019, below the average of USD 1,553 for SSA (World Bank, 2020). Despite increasing urbanisation, more than 70% of the population live in rural areas.

2.2 Road network and the Rural Access Index

Tanzania's total road network is approximately 145,000 km of which 36,258 km of trunk and regional roads (World Highways, 2020) are managed by Tanzania National Roads Agency (TANROADS). The rest of the network (109,000 km) is managed by the recently established Tanzania Rural and Urban Roads Agency (TARURA) which reports to the President's Office for Regional Administration and Local Government (PO-RALG). However, a review of the network is ongoing and the most recent estimate for rural roads is close to 130,000 km, significantly higher than the official figure of 109,000 km. This includes classified and unclassified roads, so the project will review the classifications for roads and recommend which roads should be re-classified.

The Rural Access Index (RAI), is a measure of rural access and was recently incorporated as Sustainable Development Goal 9.1.1, with the World Bank as the custodian. The definition of RAI is the proportion of the rural population that live within 2 km of an all-season road. The RAI for Tanzania was most recently measured in 2016 as 25%, which is a relatively low figure, although there is some doubt over the accuracy of this figure. A more recent assessment using open source data (not ratified by the Government of Tanzania) put the RAI at 59%. Although this figure is much higher, it was calculated using OpenStreetMap (OSM) and WorldPop, which is an open source population dataset, reconciled to the national census. In any case this demonstrates that rural access is a challenge in Tanzania and there is much work to do to connect remote communities to the road network. This highlights the need for appropriate road planning and design to develop an all-season network that serves communities appropriately and will encourage affordable and relevant transport services.

2.3 Road authorities

2.3.1 TANROADS

TANROADS was established on 1st July 2000 and is responsible for the national road network. The Agency's responsibility is the development, maintenance and management of the national road network and government owned airports. Their main office is in Dar es Salaam and they have several regional offices around the country. According to the TANROADS website (TANROADS, 2020) the national road network covers a total of 35,000 km, out of which 12,786 km are trunk roads and 22,214 km are regional roads. Out of the total, 73.9% are still unpaved, but, according to the TANROADS website, there are ambitious aims to pave the entire national network by 2021. TANROADS estimate that 26% of the regional road network is in poor condition.

2.3.2 TARURA

TARURA is a relatively new organisation, being officially inaugurated on 2nd July 2017, and is an Executive Agency under the PO-RALG. TARURA was formed with the responsibility of managing the development, rehabilitation, maintenance, axle load control, environmental and road reserve management of the rural and urban roads network in Tanzania. Its mandate is to facilitate improvements of the rural and urban road networks, enabling people to transport crops and other items from rural to urban areas. It was intended to help to transform the livelihoods of people, reducing the risks and time they spend on rural roads. TARURA estimate that 43% of district roads are in poor condition. TARURA have their head office in Dodoma and have regional representation across the country. The Vision and Mission of TARURA are:

Vision: To be a leading institution in the management of rural and urban roads network.

Mission: To plan, design, construct and maintain the rural and urban roads network in a cost-effective manner for sustainable social economic development.

2.3.3 PO-RALG

Before 2017 rural roads were managed directly by PO-RALG, who remain as the overseeing body to TARURA. PO-RALG is based in Dodoma and is mandated to develop or oversee:

- Formulation, monitoring and evaluation of decentralisation by devolution
- Rural and urban development policies and their implementation
- Regional administration
- Administration of primary and secondary education.

The primary functions of PO-RALG include monitoring, coordinating and overseeing the implementation of the development and maintenance of rural infrastructure, including rural roads. In order to facilitate rural and urban development policies and their implementation, PO-RALG has been developing programmes to support rural roads through collaboration with various donors and funding sources, for example the Roads Fund, DFID, World Bank, European Union, Feed the Future and ReCAP. IRAT was developed and implemented under the PO-RALG.

In order to assist PO-RALG in managing their network, a database called the District Road Management System version 2 (DROMAS 2) was developed and populated. The database includes road network and mapping features, as well as providing information for the Annual Road Maintenance Plan (ARMP) and contract management tools. Network features include:

- Road name, code and class
- Road length and dimensions
- Pavement type and construction status
- Structures such as bridges, culverts, retaining walls and side drains
- Road furniture.

These details can be entered as attributes, but photographs can also be linked to the database.

2.3.4 Tanzania Roads Fund Board

A Roads Tolls Act was initially established in 1985 in Tanzania and provided for the imposition and collection of tolls for the use of public roads. These tolls were treated as normal government revenues. The Roads Fund was established under two separate declarations in 1991 and 1992. This fund was to be used to meet maintenance costs for regional core roads as well as to fund the rehabilitation and maintenance of urban and district roads. Funds were to be derived from duties levied on petrol and diesel, and levies on motor vehicles such as licences and registration.

The Roads Fund Board was established by an act of parliament in 1998 and came into operation in the year 2000. Its main functions are to ensure continued collection and transfer of funds and tolls to the Fund's account, and to apply those funds for approved purposes including disbursing them to the road agencies. It has the mandate to advise the Roads Minister on new sources of roads and fuel tolls, adjustment of rates of existing roads and fuel tolls and on regulations for the collection of road and fuel tolls for the purpose of ensuring adequate and stable flow of funds to road operations. It also has the responsibility to monitor the use of the funds disbursed to road agencies to ensure that they are used for the intended purpose of the Fund.

The allocation of funds from the Roads Fund to the main roads agencies in Tanzania is currently:

- TANROADS 70%
- TARURA 30%.

2.4 The road investment projects that provided baseline data

2.4.1 Improving Rural Access in Tanzania (IRAT) Programme

The primary aim of the Improving Rural Access in Tanzania (IRAT) programme was to provide sustainable access for rural communities and support local roads institutions to manage the district road network. This was focused on improving poor sections of rural roads that were hindering access with the goal to enable all-season access for communities to service centres, such as schools, health care, local government administration, markets, and connect to the national transport network. IRAT was initiated in 2013 and the final report was produced in 2018 (Cardno, 2018). GBP 25 million of funding was received from DFID. Further funds, equivalent to GBP 10.4 million, was also received from the International Climate Fund (ICF) and this was mainly used for additional structures. IRAT was implemented countrywide in 37 districts over five phases.

In the first instance the roads were selected because they had accessibility issues, or 'bottlenecks'. Bottlenecks were defined as a road network condition that either prevents or severely restricts the passage of appropriate public transport or commercial goods vehicles. There is no evidence that the development of transport services was considered as a factor in the selection of roads, as the selection was based on engineering considerations. Transport surveys were undertaken, including on control roads that were selected for their likelihood to receive diverted traffic. These surveys collected a wide range of traffic, origin-destination and fare/load/tariff data. The IRAT report states that the selection of roads was based on the number of people impacted for the most economic and efficient costs (Cardno, 2018).

2.4.2 Design, Construction and Monitoring of Demonstration Sites for District Roads Project

The aim of the Africa Community Access Programme (AFCAP1) project TAN008 in Tanzania was specifically to improve sustainable access to opportunities for poor rural communities in Tanzania, by providing all-weather access using Environmentally Optimised Design (EOD) methods (Roughton, 2013a). The project was intended to be a research trial to assess various EOD methods on rural roads. Different surfacing options were selected to provide solutions to specific problems along the road, with the principle to reduce the demand for gravel, provide a smoother running surface to reduce vehicle operating costs, reduce travel times and dust pollution. The planning and monitoring were based on the technical aspects of the surfacing, rather than the potential development of transport services.

The road surfaces were designed with a 6% camber on gravel sections, and a 4% camber on paved sections. An overall pavement width of 3 m was adopted for all sections, with 1 m gravel shoulders and passing bays at regular intervals. It was found that cross drainage was adequate, but side drains were improved as part of the project (Roughton, 2012).

2.5 Transport services types and their regulation

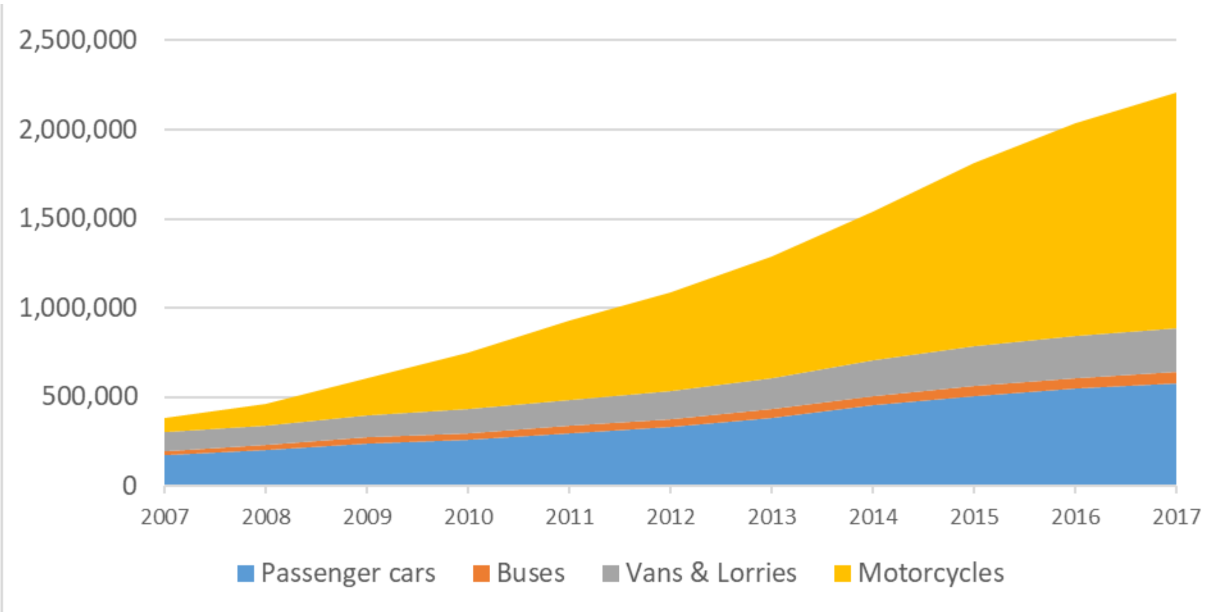
2.5.1 Land Transport Regulatory Authority

The Land Transport Regulatory Authority (LATRA) was established in April 2019 as the regulatory authority for road and rail transport on the Tanzania mainland. Prior to 2019, the Surface and Marine Transport Regulatory Authority (SUMATRA), established in 2001, was responsible for regulating both water and land transport. LATRA is responsible for issuing vehicle licences and driving licenses. It also regulates public transport vehicles. It only has about 40 professional staff, so there are between one and three people in each region, and no representation at the district level.

2.5.2 Transport fleet

As with other African countries there has been a substantial increase in vehicle populations in recent years. In the period from 2010 to 2015 Tanzania had a growth rate of 10.7% for commercial vehicles, 14% for passenger cars, and 26.1% for motorcycles (MoWTC Tanzania, 2016). The growth of the vehicle fleet in Tanzania is illustrated in Figure 3.

Figure 3 Growth of vehicle numbers in Tanzania, showing modal increase in motorcycles



Source: MoWTC Tanzania (2016 and 2017)

2.5.3 Transport services in rural Tanzania

Buses are licensed by routes and have timetable requirements. Buses on national routes are fitted with GPS tracking devises, and their locations and speeds can be followed within the LATRA database. This surveillance is said to have resulted in less speeding and better fuel consumption. Most buses operate on national, regional or urban roads, but some bus routes start in villages and travel into regional towns or cities, returning the same day, or the next day. Such rural routes tend to be quite long, and are often over 100 km. The buses that operate such rural routes tend to be old vehicles in quite poor condition (see Figure

4). They generally have a robust roof-rack and are strongly reinforced with steel to hold them together (see Figure 5). They have about 60 seats but, unofficially, they may carry over 100 passengers, plus much freight on the roof rack or (in some buses) in low-level compartments.

Figure 4 A 60-seater bus that operates on an unpaved regional road to and from a Dodoma bus terminal

Figure 5 Inside a 60-seater showing some heavy duty, steel poles

Operating on poor roads, the rural buses have high clearance, which makes the first step quite difficult to access. This is exacerbated by the subsequent steps that can have steep rises, small treads and changing angles in a sharp turn. While some buses have strong hand rails to grasp (see Figure 6, centre), others have no hand rails or very thin rails that are less easy to grasp (see Figure 6, right).

Figure 6 Steps to access 60-seater buses tend to be high with tight bends and insufficient handrails

Midibuses, minibuses and minivans, all known locally as 'daladalas' are licensed for routes and they should have their routes painted on the front of the vehicles. They do not have to follow timetables. They mainly operate to and from transport terminals (hubs) in provincial or district towns and may travel to other towns (along regional or national roads) or may serve some large villages. They are generally self-regulated by associations based in their terminal hub and these control loading and queuing, with vehicles keeping to rotas. Toyotas are the most common make of all types of daladalas, with midibus operators using Coasters (about 30 seats), minibuses commonly being 16-seater Hiaces and minivan operators often using 6/8-seater Noahs.

Figure 7 Coaster midibus (left), Hiace minibus (centre) and Noah minivan (right)

Three-wheeler autorickshaws, known locally as bajajis (after a famous Indian make of autorickaws), operate in most towns and cities as point-to-point taxi services. They may also pick up passengers along main routes, operating as communal taxis. They have been growing in number throughout Tanzania, and some operate on rural roads, either as point-to-point chartered taxis or as route-based transport services, between large villages and markets.

Figure 8 Rural autorickshaws (left) and rural motorcycle taxis (right)

By far the most important form of rural transport services are motorcycle taxis, known as boda-bodas or piki-pikis. These operate in urban areas, and also from hubs in villages, or at junctions where rural roads meet national or regional roads. Officially, operators should wear helmets and have one available for passengers, but compliance is low. Motorcycle taxis are allowed to carry one passenger, but many carry two or more passengers. Motorcycle taxis also transport freight, and mixed loads.

Until a few years ago, bicycle boda-bodas were common in rural areas, but these have largely been replaced by motorcycle taxis. It is now rare to see passengers on bicycles, but there are some areas where bicycles are rented out for short-term use.

Vehicles that provide small scale freight services include animal-drawn carts, motorcycle three-wheelers (known as toyos, after a Chinese make) and two-wheel tractors. While these may sometimes carry passengers, they are not considered passenger transport services. Pack donkeys are common in some areas, but they are mainly for personal use. Small-scale freight services are also provided by pickups, light trucks and four-wheel tractors with trailers. Heavier trucks are mainly used for construction materials and inter-urban transport, but some trucks come into rural areas to buy agricultural produce.

Figure 9 Motorcycle three-wheeler or 'toyo' (left), 2-wheel tractor (centre) and light truck (right)

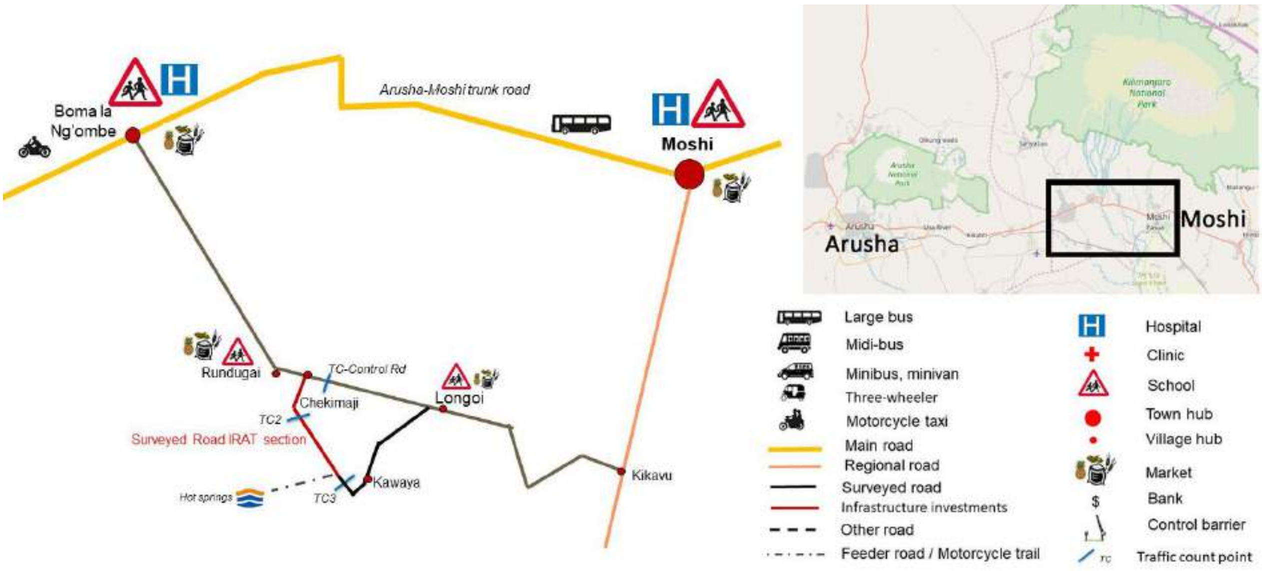
3 Chekimaji-Kawaya Road, Hai District

3.1 Road geography, history and condition

3.1.1 History and context

The 11.5 km road from Chekimaji to Kawaya Kati (road number 35283 in the DROMAS2 database) is a U-shaped feeder road starting and ending on the Boma Ng'ombe-Rundugai-Chekimaji-Kikavu collector road (road number 35001 in the DROMAS2 database). A diagrammatic map showing the road and its context in northern Tanzania is shown in Figure 10.

Figure 10 Diagrammatic map, showing road location and context



The entire length used to be an earth road, with small culverts. Past Chekimaji village, the road passes through a low-lying swampy, rice-growing area that used to be passable only in the dry season. The condition along the first 5 km of the road before construction is shown in Figure 11.

Figure 11 Chekimaji to Kawaya road before construction, including in the rainy season (right)

Source: unpublished IRAT reports

Between October 2015 and March 2016, the first 4.8 km was rehabilitated under the IRAT programme. This involved four box culverts, one concrete ring culvert and 3 km of embankment raised by 1.5-1.8 m. Photos taken during construction are shown in Figure 12.

Figure 12 Chekimaji to Kawaya road during construction showing raised embankment and two box culverts

Source: unpublished IRAT reports

The result of the construction is a good 6-7 metre wide all-season road, running through a low-lying rice-farming and agricultural area with some informal irrigation channels, as illustrated in Figure 13.

Figure 13 Chekimaji to Kawaya road showing raised embankment though rice-growing swampy area

Several culverts, larger than the previous ones, were needed to allow water flows between the swampy areas separated by the embankment. Some of these are shown in Figure 14.

Figure 14 Three of the culverts included in the IRAT rehabilitation

The rehabilitated section is still in reasonable condition. The continuation of the road into Kawaya, and beyond, is still a very poor, earth road, as shown in Figure 15.

Figure 15 Road section within Kawaya and Kawaya Kati that has not been rehabilitated

As one of the failed culverts on this section was replaced in 2019 by a wider culvert (see Figure 16). This suggests that not only are some TARURA maintenance tasks taking place on this poor section of the road, but that further upgrading investments are envisaged in the future.

Figure 16 Road within Kawaya showing a failed culvert (June 2019, left) and the new culvert (Nov 2019)

3.1.2 Alignment

The Chekimaji–Kawaya road starts at junction with Boma Ng'ombe-Rundugai-Chekimaji-Longoi-Kikavu road (road number 35001 in the DROMAS2 database), as shown in Figure 17.

Figure 17 Junction between Boma Ng'ombe-Chekimaji-Kikavu road (left) and rehabilitated road to Kayawa (right)

The road ends at Longoi that is also on the Boma Ng'ombe-Rundugai-Chekimaji-Longoi-Kikavu road, and that end of the road is shown in Figure 18.

Figure 18 End of the road at the junction with Boma Ng'ombe to Kikavu road (left) and Longoi village (right)

A map showing the context of the road and a GPS trace of the IRAT section can be seen in Figure 19. There are two sections of the road. The rehabilitated section is 4.8 km and forms a homogenous section in terms of engineering features and condition. The second section of 6.7 km is also a relatively uniform earth road.

Figure 19 Map showing GPS trace of the Chekimaji-Kawaya road

3.1.3 Road status and condition

This road is shown as being in good condition in 2019/20 on the DROMAS2 database. The surface on the rehabilitated section is gravel that has been sourced locally from within a few kilometres of the road. The width is approximately 6 m, with some areas being slightly wider, up to 7 m. In general, there is a reasonable camber on the rehabilitated carriageway in most areas. The surface is relatively smooth, although motorcycles follow the even smoother trajectories they have created though repeated use, as shown in Figure 20 and Figure 21.

Figure 20 Gravel road surfaces at around 1 km and 4 km from the start

The rehabilitated section has lost much of its camber along the embankment and standing water is more prevalent after rain. Small areas of standing water can be seen where the surface has rutted slightly, as shown in Figure 21, although there were no soft spots at the time of the survey. Corrugations are starting to appear in some areas, but this is not yet a problem. As the rehabilitated section progresses towards Kawaya it narrows, down to 4 or 5 m in places.

Figure 21 Gravel road surface showing puddles (centre) and smooth tracks worn by motorcycles (left and right)

In the swampy, rice-growing area, the carriageway is elevated on an embankment, from 0.5 m to 1.0 m above the surrounding land. This avoids problems with water ingress to the base and subsequent softening and loss of strength of the road structure. Some of the embankment has been planted with vetiver, as a bioengineering measure to reduce erosion, as shown in Figure 22.

Figure 22 Road embankment showing vetiver grass planted for erosion control

Drainage is quite effective, and the condition of the side drains is good, although they are quite overgrown and there are few culverts. There is no obvious structural damage to the new road structure through water ingress. The output of a culvert at 4.7 km has not drained away quickly enough when the waterway is in spate and this has allowed water to erode a section of the embankment, as shown Figure 23.

Figure 23 Culvert around 4.7 km showing eroded embankment caused by high water levels after heavy rains

The IRAT intervention ends at 4.8 km, and the road continues as an un-rehabilitated road with an earthen surface which is very rough, but passable, partly because the surrounding land is at a slightly higher-elevation, rain-fed farming area. This has no shape and little drainage, so during the wet season it becomes muddy and difficult to pass, as shown in Figure 15. The overall condition of the IRAT rehabilitated section is fair to good, but the subsequent section is poor.

3.1.4 Road maintenance

There appears no visual evidence of regular maintenance on the rehabilitated section of the road, although the area at 4.7 km has recently had repairs as water associated with the final culvert had eroded the embankment, as show in Figure 23 and Figure 24.

Figure 24 Road embankment near 4.7 km and the final culvert showing water erosion and repair

3.1.5 Key informant interview on engineering issues

A road technician from the local TARURA engineering unit was interviewed. He confirmed that before IRAT carried out these improvements in 2016 the road was not motorable during the rainy season due to flooding. Since the works the road is in good condition and is motorable throughout the year. At present there are no access issues and private vehicles and transport services are able to ply without hindrance. The road does receive a maintenance budget and routine maintenance is implemented each year, at the approximate value of TSh 7.5 million annually. Local rural communities are engaged to participate in the maintenance, especially when labour is used.

The routine maintenance includes grass cutting, bush clearance and desilting of side drains and culverts. The main perceived benefit of the routine maintenance was increased visibility due to bush clearance. In terms of transport services, the technician confirmed that more vehicles were using the road, and that there was a greater variety of vehicles being used. There are no other problems with the road and the local roads authority is happy with the current status of the road.

3.2 Socio-economic and transport context

The 4.8 km rehabilitated section of the road has few houses nearby. There are some dwellings close to the first kilometre within Chekimaji which is an extensive, but low-density village. Thereafter, the embankment road traverses swampy ground with irrigation channels where rice and other crops are grown. This road provides all season access to this agricultural area. It also provides Kawaya village with a shorter link to Boma Ng'ombe than that provided by the other half of the U-shape. Besides providing access to the agricultural land, it also provides an alternative route to the hot springs between Rundugai and Kawaya that are visited by tourists. Tourists generally arrive in a minivan or 4-wheel drive vehicle hired in Moshi. The less affluent 'back-packer' tourists tend to hire a bajaji from Boma Ng'ombe.

Apart from some poor earth roads to the hot springs, agricultural areas and the back of Rundugai, the only access to this road is from the Boma Ng'ombe-Rundugai-Chekimaji-Longoi-Kikavu road (DROMAS Road 35001), and therefore the condition and transport services along this road largely determine how traffic patterns on the rehabilitated road section evolve. The road from Boma Ng'ombe to Rundugai is very rough, with one water-crossing that can be difficult after heavy rains. This is illustrated in Figure 25 and Figure 26.

Figure 25 Road from Boma Ng'ombe to Rundugai, showing minivan and rough surface

Figure 26 Road from Boma Ng’ombe to Rundugai, showing a drift and a problem water crossing

Because the road is rough, bicycles, motorcycles and bajajis travel off the road onto earth side-tracks when possible, as illustrated in Figure 27. These vehicles have to re-join the road at drifts to cross the waterways.

Figure 27 Road from Boma Ng’ombe to Rundugai, showing side tracks used by motorcycles and bajajis

Despite the roughness of the road between Boma Ng’ombe and Rundugai, the road is busy, particularly on Mondays when there is a market in Rundugai, as shown in Figure 28.

Figure 28 Rundugai market served by transport services

Transport services on Rundugai market day include minibuses, minivans, bajajis and motorcycle taxis, as shown in Figure 29. On other days, the main transport services are bajajis, motorcycle taxis and one minibus. The minibus starts at Rundugai and goes via Boma Ng’ombe to Moshi, returning in the evening.

There are 20 bajajis that operate a route-based service between Boma Ng'ombe and Rundugai, carrying four passengers and charging Tsh 2000 per passenger. Motorcycle taxis also charge Tsh 2000 on this route, while the minibus charges Tsh 1000. There is an informal network of bajaji operators that control queuing. Each bajaji operator is generally able to make 6-7 trips a day, with 20 trips on the market day.

Figure 29 Examples of vehicle types using Boma Ng'ombe to Rundugai road, Hai District

3.3 Survey findings

3.3.1 Traffic and trip making

Traffic counts were undertaken on three days in 2019 at the same three places where traffic counts had been conducted in 2015, 2016 and 2017. The three locations (which are shown in the diagrammatic maps in Figure 10 and Figure 30) were on the rehabilitated section (Table 4), beyond the rehabilitated section (Table 5) and on the through road that has been considered a control road (Table 6).

Table 4 Traffic volumes on the Chekimaji to Kawaya Kati road (rehabilitated section completed 2016), Hai District

	Average day-time traffic volumes by vehicle type			
Month and year	*Aug 2015*	*Sep 2016*	*Aug 2017*	*Dec 2019*
Survey days	*Th,Fr,Sa*	*Tu,We,Th,Fr*	*We,Th,Fr*	*Tu,Th,Mo*
Cars	0.0	4.2	21.7	4.3
Pickups and utility vehicles	0.0	5.2	20.7	3.7
Minivans, minibuses	0.0	0.0	20.3	4.4
Large buses	0.0	0.0	0.0	0.0
Trucks	0.0	2.3	30.0	2.4
Tractors	0.3	3.6	27.0	0.0
Animal transport	2.0	1.0	28.0	0.7
Motorcycles and bajajis	13.3	151	257	246
Motorcycles				240
Bajajis				6.7
Bicycles	33.7	109	190	55
Pedestrians	258.7	283	832	408
All motorised, excluding motorcycles	0.3	15.3	119.7	14.8

Source of 2015-2017 data: Cardno (2017)

Table 5 Traffic volumes on the Chekimaji to Kawaya Kati road (non-rehabilitated section), Hai District

Month and year **Survey days**	*Aug 2015* *Th,Fr,Sa*	*Sep 2016* *Tu,We,Th,Fr*	*Aug 2017* *We,Th,Fr*	*Dec 2019* *Tu,Th,Mo*
Cars		13.4	19.3	1.7
Pickups and utility vehicles		18.9	25.7	4.0
Minivans, minibuses		4.1	17.7	2.7
Large buses		0.0	0.0	0.0
Trucks		2.7	7.3	1.3
Tractors		21.6	21.3	2.0
Animal transport		2.1	16.3	1.0
Motorcycles and bajajis		186.2	506.7	172.0
Motorcycles				170.7
Bajajis				1.3
Bicycles		128.2	517.0	32.0
Pedestrians		184.5	608.7	103.0
All motorised, excluding motorcycles		60.7	91.3	11.7

Source of 2015-2017 data: Cardno (2017)

Table 6 Traffic volumes on the Rundugai-Chekimaji-Longoi-Kikavu road (control road), Hai District

	Average day-time traffic volumes by vehicle type			
Month and year **Survey days**	*Aug 2015* *Th,Fr,Sa*	*Sep 2016* *Tu,We,Th,Fr*	*Aug 2017* *We,Th,Fr*	*Dec 2019* *Tu,Th,Mo*
Cars	18.7	22.0	29.3	8.7
Pickups and utility vehicles	18.0	36.3	37.3	17.3
Minivans, minibuses	1.3	9.0	21.3	15.0
Large buses	0.0	0.0	0.0	1.7
Trucks	68.3	14.0	38.7	15.4
Tractors	3.3	9.3	7.3	2.0
Animal transport	5.0	3.3	5.0	5.0
Motorcycles and bajajis	266	390	428	591
Motorcycles				575
Bajajis				16
Bicycles	96	125	148	123
Pedestrians	258	242	411	527
All motorised, excluding motorcycles	109.6	90.6	133.9	60.1

Source of 2015-2017 data: Cardno (2017)

In all four years, the control road (the shorter, through road) has always had the most traffic. On all three roads, the main traffic comprises motorcycles, followed by pedestrians and bicycles. In 2019, motorcycles accounted for 90% of the movements of motorised vehicles. In the earlier traffic counts, bajajis were counted as motorcycles, but in 2019, these vehicle types were disaggregated. In 2019, bajajis accounted for only 2.5% of the combined 'motorcycles and bajajis' count. Bajajis were reported to have been gradually increasing in numbers, and so it may be assumed that in the earlier years, nearly all vehicles in this combined category were motorcycles.

There are quite large variations between the years, and this is quite usual on rural roads where differences relating to seasons, markets, festivals, harvest times, traffic diversions and other events can create surges in traffic. Due to the relatively low traffic volumes, these surges can represent quite high percentage changes in the traffic. The traffic counts implemented in August 2017 seem to have had high levels of traffic and pedestrian movements on the surveyed road and its continuation, but these high traffic counts were not repeated in December 2019. While the August count would have been in the dry season, coinciding with some crop harvests, the December count was during the rainy season. In December, the roads connecting with Moshi and Boma Ng'ombe had some difficult sections, which might have discouraged some drivers from using the road, particularly car owners.

The differences between the traffic counts on the improved section and beyond the improved section suggest that not all the vehicles travel beyond the end of the improved section. Some (mainly motorcycles) may have stopped to allow access to the agricultural fields, while some others (including some chartered utilities and bajajis) may have taken tourists to the hot springs.

The pedestrian counts were highest at the two traffic counts nearest the start of the road (on the improved section and on the control road). These were both within walking distance (about 2 km) of Rundugai, with its market and small stores.

The road investment has certainly increased traffic volumes on the improved section, but the growth has not been fast, due to the poor condition of the subsequent section and the existence of an alternative, shorter route (the control road). The only transport services on this route are motorcycle taxis and hired vehicles (point-to-point charters of bajajis, minivans and utilities). Other transport services have not yet developed due to the lack of a significant 'destination', other than small villages, agricultural fields and the hot springs. This is discussed in more detail in section 3.4.

Users were asked how they thought traffic had changed since the IRAT rehabilitation and in the past year. Their responses are summarised in Table 7. It was generally agreed that motorcycles had increased most, including in the past year. Bicycles and pickup/utilities had also increased a little, since the rehabilitation and in the past year. People felt there had been a small growth in the use of other types of vehicles, including bajajis, cars, minivans/minibuses and trucks, and no growth at all in large buses.

Table 7 Users perception of change in vehicle numbers and passenger flows (Hai District)

	Perception of change (scale -10 to +10)			
	Since IRAT rehabilitation		**In past year**	
	Vehicle numbers	*Passengers*	*Vehicle numbers*	*Passengers*
Motorcycles	5.9	5.8	5.6	5.8
Bicycles	4.4	3.8	3.3	3.3
Pickups or utilities	3.8	4.1	3.8	3.4
Bajajis	1.5	1.4	1.5	1.3
Cars	1.3	0.9	1.3	1.1
Minivans or minibuses	1.3	1.1	1.0	0.8
Trucks	1.1	0.8	0.5	0.1
Large buses	-0.1	0.0	0.0	-0.1

Table 8 presents an analysis of people's movements disaggregated by vehicle type, gender and age based on the traffic count data for 2019. On all roads, most of the travellers' movements (75-85%) involved motorcycles or walking, with other motorised transport being highest (at 16%) in the control road, followed by the unimproved section. Most of the travellers counted were men (58%) followed by women (27%) and children (14%). These gender/age differences were greater for motorcycles and other wheeled transport (men 66%, women 25% and children 9%), but less for pedestrians (men 40%, women 32% and children 28%), and this may be partly due to children walking to school.

Table 8 Analysis of people's movements at three points on the Chekimaji-Kawaya-Longoi triangle (Hai District)

Analysis of people's movements based on 12-hour traffic counts, Nov 2019							
	Men	Women	Children	Total travellers	% of movements	Loads	% with loads
On improved section							
Motorcycles	268	91	10	369	40%	52	22%
Cyclists	58	5	3	66	7%	11	20%
Bajajis	8	14	2	24	3%	1	20%
Other transport	35	24	11	70	8%		
Pedestrians	171	149	64	384	42%	24	6%
Total	**540**	**283**	**90**	**913**		**88**	
Beyond improved section							
Motorcycles	221	41	3	265	56%	28	16%
Cyclists	30	2	1	33	7%	5	16%
Bajajis	2	2	0	4	1%	0	0%
Other transport	27	7	38	72	15%		
Pedestrians	49	30	24	103	22%	1	1%
Total	**329**	**82**	**66**	**477**		**33**	
On through road (control)							
Motorcycles	594	213	83	890	45%	283	48%
Cyclists	113	64	27	204	10%	20	16%
Bajajis	26	23	4	53	3%	3	19%
Other transport	185	112	23	320	16%		
Pedestrians	187	145	195	527	26%	93	18%
Total	**1105**	**557**	**332**	**1994**		**396**	
Combined counts (all roads)							
Motorcycles	1083	345	96	1524			
Cyclists	201	71	31	302			
Bajajis	36	39	6	82			
Other transport	247	143	72	462			
All wheeled transport	**1567**	**598**	**205**	**2370**			
Percent by gender/age	66%	25%	9%				
Percent using motorcycles	69%	58%	47%				
All pedestrians	**407**	**324**	**283**	**1014**			
Percent by gender/age	40%	32%	28%				
All travellers	**1974**	**922**	**489**	**3384**			
Percent by gender/age	58%	27%	14%				

3.3.2 Trip making, fares and user satisfaction

Forty users of transport services were interviewed. Most people (75%) gave their occupation as farmers. Other occupations included teachers, college students and shop workers. Their main reasons for travelling by transport services were to visit the local market or shops. Other travel purposes reported are shown in Table 9. Surprisingly, only one person mentioned travel to a health centre.

Table 9 Reasons for taking transport services reported on the Chekimaji to Kawaya road, Hai District

Journey purpose	Women	Men	All
Local market or shops	7	15	22
Visiting friends or relations	1	5	6
Farming	1	3	4
Visit to town shops, banks, offices	2	2	4
Sell produce	0	2	2
Health	1	0	1
Funeral/wedding	1	0	1
Total	**13**	**27**	**40**

Most journeys by public transport involve motorcycle taxis, and users were asked about their trip frequency, journey times and tariffs paid. The mean values reported are summarised in Table 10. The average fares for motorcycles along the road work out at about USDc 21 per passenger-km.

Table 10 Mean values of data from user survey on motorcycle trip distances, journey times, fares and freight tariffs

Statistic *(N = 48)*		**Mean value**
Average dry season trip distance	*km*	8.9
Average wet season trip distance	*km*	8.3
Average dry season trips/month	*trips/month*	3.2
Average wet season trips/month	*trips/month*	2.7
Average dry season fare paid	*Tsh*	3667
Average wet season fare paid	*Tsh*	3667
Dry season fares	*US cents per passenger-km*	20.7
Wet season fares	*US cents per passenger-km*	22.0
Journey time dry season	*mins*	24.2
Journey time wet season	*mins*	27.6
Accompanied freight	*kg*	48
Accompanied freight tariff	*Tsh*	3000
Note: the slight differences in dry and wet season fares per passenger-km are due to the slightly shorter reported distances travelled in the wet season.		

Examples of the average reported motorcycle taxi fares are shown in Table 11. While the reported fares between Chekimaji and Kawaya seem to be have decreased substantially, the fares between Checkimaji and Rundugai appear to have doubled, and the fare from Kawaya to Boma Ng'ombe has increased a little. One issue seems to be the journey distances, with short journeys being much more expensive per passenger-km than longer journeys. Competition is another factor that affects fares, and the competition on the busy Rundugai-Boma Ng'ombe road appears to result in the lowest tariff per passenger-km. This is discussed in further in section 3.4.

Table 11 Examples of average reported motorcycle taxi passenger fares around the surveyed roads (Hai District)

Route	**2016 Fare** *(Tsh)*	**2017 Fare** *(Tsh)*	**2019 Fare** *(Tsh)*	**2019 fare** *(USDc per passenger-km)*
Checkimaji-Rundugai (2-3 km)	1500	1000	2500	36
Chekimaji-Kawaya (6-7 km)	5000	3500	2667	19
Kawaya-Boma Ng'ombe (20 km)		5000	5900	13
Rundugai-Boma Ng'ombe (12 km)			2000	7

Based on an average motorcycle taxi tariff of USDc 20.7 per passenger-km and the reported long-distance bus fares of USDc 1.86 per passenger-km (as presented in Section 9.13), the Rural Transport Premium was found to be 11.1. This was the highest RTP of the six roads surveyed. This high value was attributed to relatively short journeys and lack of competition. The tariffs and RTP were much lower on the very rough but busy adjoining Rundugai-Boma Ng'ombe road (the tariffs on this road can be seen in Table 11).

Transport users were asked of their level of satisfaction with various aspects of the different transport services they had used. The five-point Likert scale responses were converted to scores out of ten, and then ranked, as show in Table 12. Interestingly, the safety and security of motorcycles, bajajis and pickups/utilities were rated highly as were journey time and fares. So, there appears to be much satisfaction with motorcycles, despite their high fares, and they do not appear to be considered particularly risky. Nevertheless, there were many aspects of motorcycles that scored below 5 (equivalent to 'OK, acceptable'), notably freight issues and predictability. The motorcycles on this road had the lowest overall users' satisfaction score of all the roads surveyed. Bajajis were slightly less popular, partly due to their lack of predictability and availability. Pickups were slightly more popular, due partly to better satisfaction with their freight services. For all transport services, there was dissatisfaction with their availability and predictability.

Table 12 User satisfaction with different services on the Chekimaji to Kawaya road, Hai District

Satisfaction with aspects of transport services provided by different vehicles					
Ranked characteristic	*Score **	**Ranked characteristic**	*Score **	**Ranked characteristic**	*Score **
Motorcycle taxis *(N=40)*		**Bajajis** *(N=37)*		**Pickups/utilities** *(N=26)*	
Safety	7.0	Journey times	7.1	Journey times	7.0
Passenger fares	6.9	Passenger fares	7.0	Safety	6.8
Journey times	6.9	Safety	7.0	Security	6.8
Security	6.9	Security	7.0	Passenger fares	6.5
Small freight service	4.9	Dust and noise	5.1	Small freight service	6.3
Dust and noise	4.8	Bumpiness comfort	4.7	Bumpiness comfort	6.2
Courier services	4.6	Courier services	3.7	Dust and noise	6.2
Small freight charges	4.5	Pickup point facilities	3.7	Seat space	6.1
Medium freight services	4.4	Seat space	3.5	Seat type	5.8
Bumpiness comfort	4.1	Seat type	3.3	Small freight charges	5.7
Pickup point facilities	3.7	Access for vulnerable	3.1	Medium freight services	5.7
Seat type	3.3	Small freight charges	3.0	Comfort with baggage	5.6
Frequency	3.2	Small freight service	2.9	Courier services	5.2
Medium freight charges	3.2	Comfort with baggage	2.9	Medium freight charges	4.9
Access for vulnerable	3.1	Medium freight services	2.4	Pickup point facilities	4.0
Predictability	2.7	Medium freight charges	2.2	Access for vulnerable	3.6
First vehicle	2.7	First vehicle	2.0	Frequency	1.6
Seat space	-	Predictability	1.8	Predictability	1.5
Comfort with baggage	-	Frequency	1.7	First vehicle	1.5
Overall average score	**4.5**	**Overall average score**	**3.9**	**Overall average score**	**5.1**
** Average satisfaction score out of ten (10 = very satisfied: 3 = dissatisfied)*					

3.3.3 Vehicle costs and operations

Motorcycle taxis operators were surveyed to ascertain details of their working patterns and their operating costs. The responses are summarised in Table 13 and Table 14.

Table 13 Operational data, driver status and last trip for motorcycle taxis (Hai District)

Statistic		Motorcycle taxis
Respondents	*N*	*10*
Year of manufacture		2015
Current value	*USD*	969
Vehicles owned by driver	*%*	70%
Average age of driver	*years*	25
Drivers with licence	*%*	0%
Time operating motorcycle taxis	*years*	2.9
Fuel		Petrol
Annual distance	*km*	12,500
Last trip:	*km*	6.4
Last trip: passengers	*no.*	1.3
Last trip: freight	*kg*	0
Last trip: revenue	*USD*	1.30

The motorcycle taxis covered about 12,500 kilometres a year which is quite low and reflects the short trip length that appears common along and around the surveyed road (the last trip length averaged 6.4 km). The operators are young (average 25) but not especially so. Most (70%) owned their own motorcycles that were worth about USD 1,000.

Table 14 Estimated operating costs and revenues for motorcycle taxis (Hai District)

Reported estimates of operating costs and revenues		
	Tsh/year	*USD/year*
Fuel	1,560,000	678
Maintenance	196,750	86
Tyres	107,910	47
Insurance	0	0
Registration	0	0
Operating licence	0	0
Association	24,000	10
Fines	0	0
Assistants	0	0
Total	**1,888,660**	**821**
Revenue	3,876,000	1685
Balance	1,987,340	864
Calculated net income per month to operator and capital costs	**165,612**	**72**

The reported net income of motorcycle taxi operators was only USD 72 a month, and their estimated annual revenues and net income were the lowest for all six roads surveyed. This is despite the reported fares per passenger-km being the highest of the six roads. The short trip distances appear to be a factor. It may be that in an area of relatively low transport demand, operators feel obliged to charge high prices for short journeys, but this itself may weaken demand. The net result is relatively low incomes for the motor taxi operators around the surveyed roads in Hai District.

3.3.4 Motorcycle operators' perceptions on the causes of change in transport demand

Motorcycle operators were asked about how the road conditions, people's travel patterns and competition from other vehicles were affecting their market. The results are summarised in Table 15. There was agreement that the improved road condition had been a positive influence, and the fact that there were no buses operating on the surveyed roads. There were more people travelling, increasing their market, but were also more personal motorcycles being used, leading to reduced demand. Only a few drivers thought that their market was affected by changes in minibus or minivan operation. Among the specific problems identified by motorcycle drivers were the low numbers of passengers on non-market days and the fact that the improved section of road does not reach to Kawaya village centre.

Table 15 Motorcycle taxi operator's perceptions of the causes of change in traffic volumes (Hai District)

Factors cited	% of drivers answering 'yes' *N = 10*
Road condition improving?	100%
Less use of large buses?	100%
More people travelling?	90%
More personal motorcycles?	80%
Less use of minivans/minibuses?	30%
Road condition deteriorating?	10%

3.3.5 Drivers and operators' associations and regulatory compliance

Although motorcycle taxis associations are common in the towns of Tanzania, on only two of the six rural roads studied were motorcycle taxi operators members of associations. Four of the ten operators interviewed on the Chekimaji-Kawaya road were members of an informal association. This was a mutual society that supported members if they were sick or had a crash. Their association did not intervene in the case of police action, negotiate with officials or control fares and operational practices.

The operators of motorcycle taxis did not consider that police checks were a problem or an issue on the surveyed road. Traffic police tended to operate on the busy Arusha-Moshi trunk road, and rarely came to the area. None of the motorcycle drivers interviewed had driving licences or paid for insurance. The use of crash helmets was low on all the traffic count roads (about one in four drivers). On the most remote road section though Kawaya (beyond the IRAT section), helmet use was particularly low, at about 10% of drivers (see Table 16). The highest level of compliance (about 29% of drivers) was on the through road from Boma Ng'ombe to Kikavu, and the users of this road were the most likely to reach the main road at Boma Ng'ombe or Moshi.

Table 16 Analysis crash helmet use at three points on the Chekimaji-Kawaya-Longoi triangle (Hai District)

Road section	No of motorcycles	No of travellers	No of helmets	% of people wearing helmets	No of helmets worn per motorcycle*
Improved section	240	370	44	12%	0.18
Beyond improved section	171	265	17	6%	0.10
Through road	575	889	166	19%	0.29
All travellers (3 roads)	988	1524	227	15%	0.23

** Note: The number of helmets worn were recorded for each motorcycle. If there was only one helmet worn, observations suggest that it was probably worn by the driver, although occasionally it may have been one of the passengers wearing the helmet.*

3.3.6 Road infrastructure

Key informants were asked about their perceptions of the adequacy of the road. The five-point Likert scale responses were converted to scores out of ten, and then ranked, as show in Table 17. There was general agreement that the road structures, width and surface were reasonably good. Less good were the alignment and poor road connections, and these two may be linked to the fact that the improved section does not connect to good through roads. There had been no provision for pedestrians, and this was seen to be an issue, including the lack of shelters. The overall ranking of satisfaction with the road was second highest of the six roads surveyed. The key 'road surface' attribute received the highest ranking of all six roads.

Table 17 Opinions on road infrastructure from key informants on Chekimaji to Kawaya Kati road (Hai District)

Road attribute	Score out of 10
Structures	6.8
Width	6.3
Surface	6.2
Alignment	5.0
Road connections	3.7
Pedestrian access	2.5

The key informants were asked about other issues, and they were unanimous in saying that the common rural road problems such as rough surfaces, dust and muddy sections were not an issue on the improved section. This is shown in Table 18. The key informants agreed with the operators that harassment from police or officials was not a problem on that road, but there was a feeling that traffic moved too fast on that improved section, putting pedestrians and cyclists at risk.

Table 18 Response of key informants to identified issues on Chekimaji to Kawaya Kati road (Hai District)

Key issues	Yes	No
Lack of shelter for pedestrians	6	0
Traffic too fast	4	2
Poor junction layout	3	3
Poor driver behaviour	3	3
Pedestrians/cyclists at risk	3	3
Road too narrow	1	5
Poor alignment	1	5
Surface too rough	0	6
Too dusty	0	6
Subject to flooding	0	6
Slippery or muddy	0	6
Too steep	0	6
Road works obstacles	0	6
Harassment from police/officials	0	6

Motorcycle taxi operators were asked their perceptions of negative road factors that were affecting their business. Again, their responses were scored and ranked, as shown in Table 19. The responses suggested that the road was not seen as being difficult, and the problems identified would have been in the second, unimproved section. Of the six roads surveyed, this road in Hai District received the second-best overall ranking by drivers. The key 'road roughness' attribute received by far the best (or lowest adverse) score of the six roads.

Table 19 Motorcycle operators' perceptions of road factors adversely affecting their business

Negative road factors affecting motorcycle taxi businesses	
	(Max adverse score 10)
Risk of vehicle damage	5.8
Risk of getting stuck	4.8
Road too muddy	4.4
Road roughness	3.8
Slippery when wet	3.8
Dust	3.2
Uncomfortable	3.1
High travel times	3.1
High operating costs	3.0
Average Score	**3.9**

Users were asked which transport service vehicles they thought appropriate for various driving conditions. The results are summarised in Table 20. Motorcycles were clearly most popular for both smooth and rough roads, while pickups/utilities were considered more suitable when the road is wet. Minivans were hardly mentioned, and this can be assumed to be because they do not normally operate on the study roads.

Table 20 Users' perceptions of which vehicles were best for different road conditions on road in Hai District

	Vehicles best on smooth roads	Vehicles best on rough roads	Vehicles best when road is wet
Motorcycle	32	32	10
Pickup or utility	0	4	29
Bajaj	4	4	0
Car taxi	3	0	0
Minivan or minibus	1	0	1
Total	**40**	**40**	**40**

3.3.7 Perceptions of motorcycle taxi operators concerning motorcycle trails

In this area, motorcycle taxi operators regularly went 'off-road' both to reach houses or villages and to take 'short cuts'. Most indicated that they did not regularly use 'side-tracks' beside the road. This would be expected if they mainly operated eastward, towards Moshi, as there are not many side-tracks along those roads. However, the road to Boma Ng'ombe has side tracks that are regularly used by motorcyclists and bajajis (as shown in Figure 27), so there may be some misunderstanding in the interviews. When asked to rate the importance of motorcycle trails, all ten operators gave the maximum score of very important for connecting to villages. They also endorsed trails as being important/very important for access for shops, markets, businesses, clinics and schools.

3.4 Changes, possible explanations and transport services impact

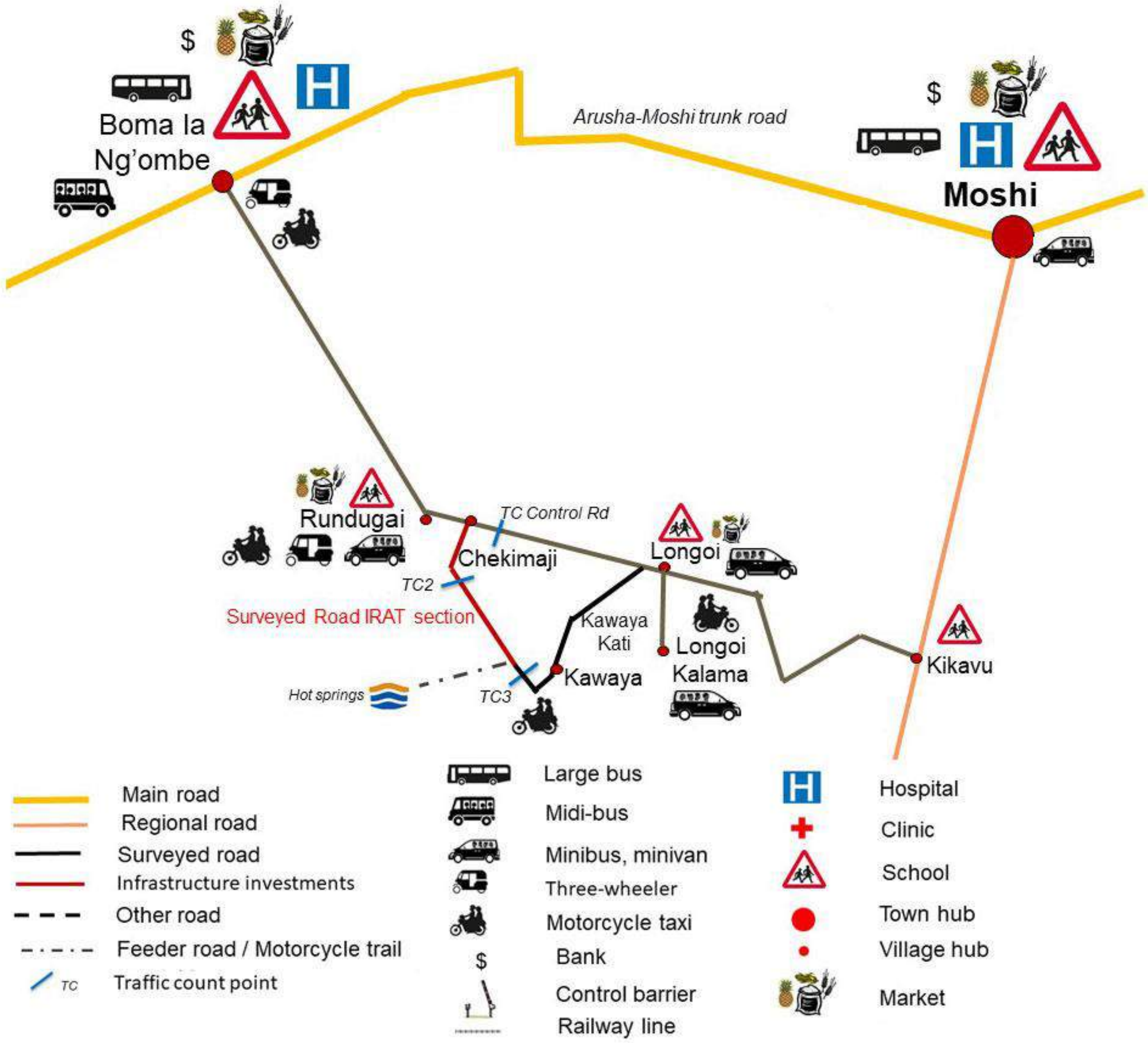
The IRAT intervention provides 4.8 km of good, all season road and has led to increased traffic flows, particularly in the rainy season when the road used to be flooded and difficult to pass. The rehabilitated section now is the best part of the local road network between Boma Ng'ombe and Kikavu. Nevertheless, the road is mainly used by motorcycles (in common with most rural roads in Tanzania). While some motorcycles are for private use, most are operating as point-to-point taxis. Motorcycle taxis continue to be the main transport services in the area, and on the improved section of the road, they are the only transport services regularly operating. The road investment has led to some reduction in motorcycle tariffs for journeys that include the improved section, but fares along this section remain high. High fares discourage travelling, keeping demand low. This is reflected in the low revenues reported by the operators of motorcycle taxis, which reported the lowest levels of income of the six roads studied.

The key issue appears to be a low density of population and consequently the small transport demand. The poor condition of the connecting roads is also a factor affecting transport services, but the limiting factor appears to be the transport demand. The diagrammatic map of the connecting roads (Figure 30) illustrates the main transport destinations and the types of transport services available. There is a large weekly market at Rundugai and a smaller market at Longoi. The town of Boma Ng'ombe has a market every day and also shops, banks and government offices. Moshi, the fifteenth largest town in Tanzania, has several daily markets and many more facilities. Both these destinations have bus stations served by inter-city buses along the trunk road, and minibuses and minivans serving villages along the road and in the surrounding area.

On the road from Boma Ng'ombe to Rundugai, there is one minibus that operates a daily early morning service to Moshi, via Boma Ng'ombe, returning in the afternoon. Throughout the day, bajajis operate a regular route-based service between Boma Ng'ombe and Rundugai. The motorcycle taxi operators based in Boma Ng'ombe and Rundugai provide faster, point-to-point services between these and other destinations. The motorcycle taxis and bajajis match each other's fares at Tsh 2000 per passenger. This is twice the fare of minibuses (Tsh 1000 per passenger) but minibuses are not generally available. On market days, there are many additional vehicles, including some minivans and minibuses. Bajajis tend to do 6-7 trips on normal days but as many as 20 return trips on market days. Rundugai itself does not have a large population, but it has become a transport hub, and people from many villages walk to Rundugai to find waiting transport.

At the other end of the road, at Longoi, there is a transport terminal served by seven minivans and three minibuses that travel to and from Moshi. Some start and finish at Longoi Kalama, which is 3 km south of Longoi. The transport services operate throughout the day, leaving when they have a full or reasonable load, which may take over half an hour at off-peak periods. The minibuses and minivans charge Tsh 2500 to Moshi. The first section of the road to Kikavu is in poor condition, with some difficult slow sections. The road after Kikavu has a good bituminous surface.

Figure 30 Diagrammatic map of the study road and connecting roads summarising key destinations



The extensive village of Kawaya lies around the middle of the studied road. It is a straggling village in an agricultural area, with no clear centre and few facilities other than a primary school and a few small stores. Motorcycle taxis provide point to point services to various destinations including Boma Ng'ombe and Moshi. Fares are high, being about Tsh 5,000 to Boma Ng'ombe and up to Tsh 10,000 to Moshi, even though the distances are similar. The high fares to Moshi are partly because it is more difficult to get passengers on the way back, as there are quite regular minivan services to Longoi charging only Tsh 2,500. Another reason is the competition with Bajaji's on the Rundugai-Boma Ng'ombe section that keeps fares on that 12 km section down to Tsh 2,000. When people in Kawaya need access to shops, they tend to walk to Longoi (or take a motorcycle taxi) and take a minivan from there to Moshi. If they need to go to Hai (that has the district medical facilities), the cheapest option is to walk to Rundugai and take a bajaji or motorcycle taxi (both Tsh 2,000). They can take a motorcycle taxi to Rundugai (about Tsh 3,000) and then take a bajaji, but it is much quicker to take the motorcycle taxi all the way to Boma Ng'ombe, which works out at the same price (Tsh 5,000).

For short journeys between villages, motorcycle taxis seem to charge a minimum price of Tsh 2,000 a journey, even if it is only two kilometres. This makes the short-distance motorcycle taxis fares very expensive at USDc 44 per passenger-km. On the route with competition with bajajis, their tariffs are much lower at USDc 7 per passenger-km. Motorcycle taxis fares are cheaper per person if two passengers travel together and are often two-thirds of the normal price.

Since there are route-based transport services (minivans and bajajis) near both ends of the roads, it is interesting that they have not extended their current routes and started to operate along the good, rehabilitated section. It is not road condition keeping them away as the roads they currently ply to Boma Ng'ombe and Moshi are significantly poorer. Bajajis and minivans are willing to travel to Kawaya if they are chartered. The problem they perceive is low transport demand, and they do not think the extra distance, travel time and waiting time would be justified by the small number of people wishing to travel.

The new section of road has provided better access to a farming area with irrigated rice and other crops. However, people going to their fields may be travelling short walking distances or may travel with their own vehicles (bicycles or motorcycles). The further development of the agricultural area is unlikely to create a demand for regular passenger transport services. The road has also made it easier for trucks to reach the agricultural areas around Kawaya to purchase crops (such as onions) and to transport rice.

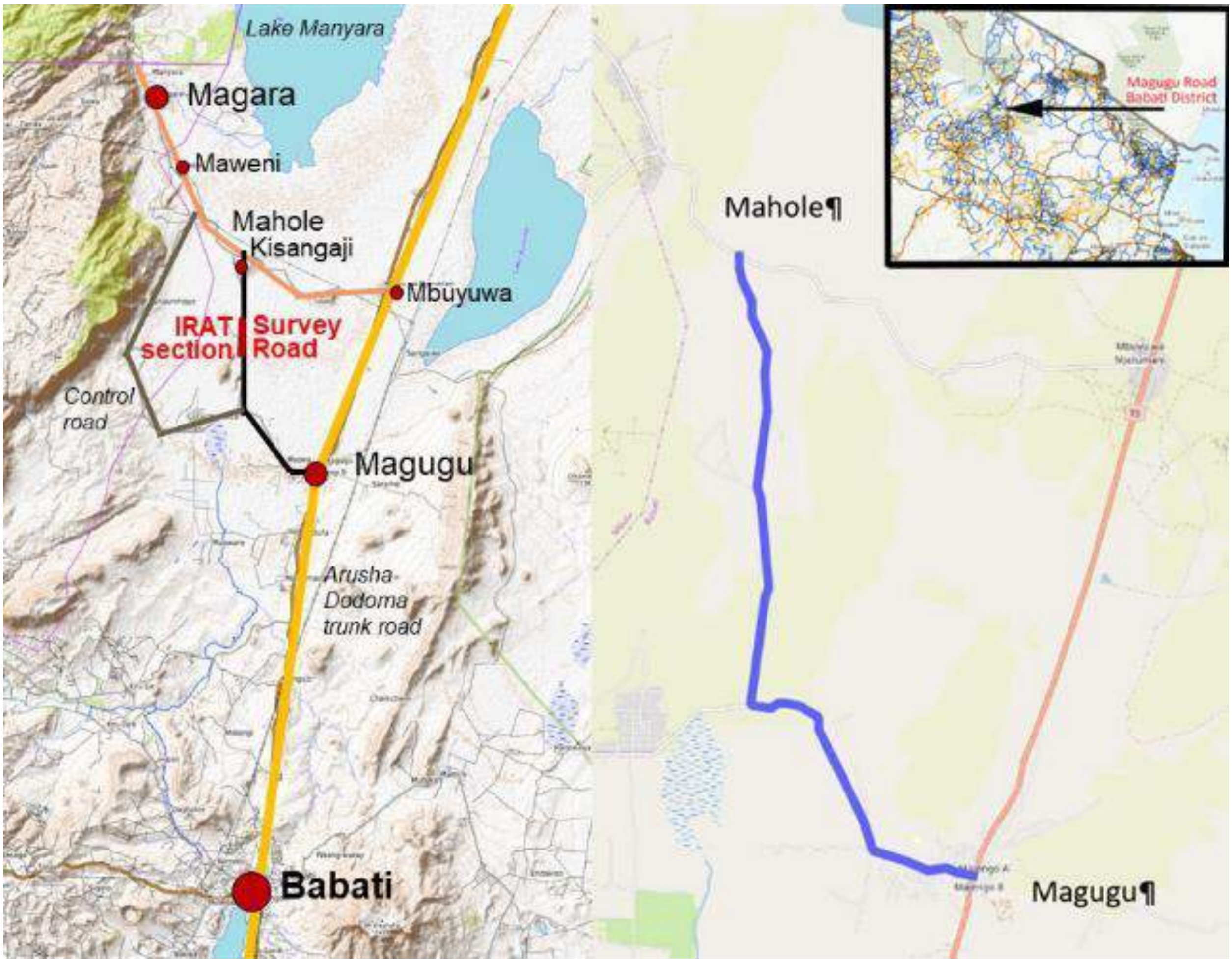
4 Magugu-Mahole Road, Babati District

4.1 Road geography, history and condition

4.1.1 History and context

The road is a 16.1 km collector road (road number 211016 on the DROMAS2 database). Originally it was an important rural road linking Magugu (and the district town of Babati) with the village of Kisangaji (end of this road and site of the large Mahole weekly market) and on to Maweni and Magara. Magara is near the southern end of Lake Manyara and close to one access gate for the Lake Manyara National Park. This is shown in Figure 31.

Figure 31 Diagrammatic map of road showing nearby towns (left) and GPS trace of road (right)



By 2014, one low-lying section of the road passing through a swampy area had become so bad that it was very difficult to pass in the rainy season. The ‘bottleneck’ area in 2015 is show in Figure 32.

Figure 32 Site of a critical low-lying bottleneck section and failed culvert in 2015 before IRAT investments

Source: unpublished IRAT reports

The IRAT interventions were implemented between in 2015-2016 and involved the construction of one 4 m x 1.2 m box culvert and three 2 m x 2 m culverts complemented by a 800 m long raised embankment that crossed the low-lying area that had been a major blackspot. The result was an all-season road. One of the culverts constructed and the slightly raised area is illustrated in Figure 33.

Figure 33 IRAT box culvert immediately after completion in 2016 (left) and in 2019 (right)

2016 source: unpublished IRAT report

4.1.2 Road alignment

This road starts at the junction with the main bituminous sealed road from Dodoma to Arusha within the small town of Magugu. It continues through mainly flat agricultural land to meet the road from Mbuyuwa (on the Dodoma–Arusha highway) to Maweni and Magara. A GPS trace of the road is shown in Figure 31.

4.1.3 Road sections and condition

On the DROMAS2 database, this road is shown as being in good condition in 2018/19 (the most recent data that is available).

The first part of the road up to 1 km is peri-urban (as shown in Figure 34) and has a good camber and earthen side drains. There is a small narrow bridge at 0.7 km with some erosion at the abutment, within the urban area. The road is approximately 5 m wide on average, but the width is variable and can be up to 6 or 7 m in places.

Figure 34 TARURA maintenance sign (left) and first section of the road close to Magugu (right)

There is a drift at 1.57 km and several small culverts, most of which are raised because the road is not on an embankment and as such is not much higher than the surrounding agricultural land. There is another bridge at 5.5 km. From 6 km there is less shape on the road surface with little camber and the land is lower lying. At 6.6 km there is a junction, with the road continuing to the right towards Mahole. The road to the left was designated the control road for the IRAT traffic count studies. At this point the road also narrows, down to 4 or 5 m wide.

From 6.6 km there is little to no camber on the road surface, but there are several culverts and damage to the surface seems limited.

On the first section from Magugu there is a lot of oversize stone in the wearing course, making the surface uneven and quite rough, as shown in Figure 35. This can lead to motorcycles trying to avoid the roughest part of the road and using the shoulder, as pictured. There is also standing water in drains, from 3 - 3.5 km.

Figure 35 The first section of the road, showing oversize stone causing a rough surface that motorcycles avoid

The road is in fair to poor condition in the agricultural area up to the junction at 6.6 km. Culverts are raised above road level because of the low-lying surrounding land, and some culverts are in poor repair, as shown in Figure 36.

Figure 36 A broken culvert showing a two-wheel tractor negotiating the problem

Some large potholes are evident, the drains are overgrown and there is obvious variation in width due to deterioration of the carriageway, forcing drivers to use the shoulder to avoid rough areas, as shown in Figure 37. The general area is low lying, up to approximately 8.45 km.

Figure 37 Low-lying section in 2015 at the time of IRAT investments (left) and potholed in 2019 (right)

From 8.45 km to 9.22 km there is an improvement in condition. The first IRAT culvert is at 8.69 km, the second is at 8.70 km (as shown in Figure 38) and the box culvert is at 9 km (Figure 33). The IRAT investment was limited to removing the bottleneck at this point of the road.

Figure 38 IRAT-funded culverts, showing vegetation growing in the silt

From approximately 10 km the road has been recently graded and is in better shape. The drains are clear and have been maintained more thoroughly. There is another subtle change from about 11.3 km, where the road has good shape with adequate camber and deeper side drains, but the road is not elevated above the surrounding land. For this reason, there are few culverts and the side drains have been constructed fairly deep, with turnouts established. These turnouts do not have a positive drainage outlet but do provide a soakaway function in the surrounding land, which seems to be effective in keeping water away from the road. Standing water can be seen in the turnouts and occasionally in the side drains as shown in Figure 39. The carriageway width is approximately 5 m and the surface is in good condition, with low roughness.

Figure 39 Recently maintained end section showing turnouts, a new culvert and side drains

The road ends at 16.04 km, at the junction with the regional gravel road from Mbuyuwa to Magara. This regional road is in good condition, with good shape, deep side drains and several culverts. The surface is showing evidence of slight corrugations.

4.1.4 Road maintenance

A contract has been awarded for road maintenance (see Figure 34). There is evidence of routine maintenance on the first section, with drains kept clear and the vegetation controlled. There has been obvious recent periodic maintenance with grading work on the last section and a new culvert. There are several problematic structures and the section immediately before the IRAT-funded culverts is likely to become a bottleneck, if it is allowed to deteriorate further.

4.1.5 Key informant interviews on engineering issues

An engineer from the TARURA Babati District Office was interviewed about this road and confirmed that the road is passable all year in its current condition. Before the IRAT works the road was not passable in the wet season but the construction of the culverts and the rehabilitated surface have made a big difference. There are only minor issues remaining, around repair and formation. The condition is consistent through the dry and wet seasons, and the Roads Fund provides a regular budget; TSh 23 million in 2017/18 and TSh 93 million in 2018/19.

Local communities are involved through labour works, for example desilting of drains and bush clearing. The contractors are also actively encouraged to employ people from the local community. Since the IRAT intervention there has been periodic maintenance on 7 km of road (the last section to Mahole), along with some drainage work including the construction of drifts and a new culvert. At present the road is passable all year and transport services have increased.

There is however a perceived issue with the characteristics of the current transport services (predominantly motorcycle taxis) from a local community perspective. The engineer noted three problems: there are more animals using the road, some larger vehicles are overloading and there is cultivation of crops on part of the road reserve (even though there are demarcation posts in place).

4.2 Socio-economic and transport context

The busy first section of the road (Figure 34) on the outskirts of Magugu is peri-urban in nature, with housing, shops and much economic activity. Magugu has a large monthly market held on the 20th day of each month. This market brings in many external itinerant traders, and large numbers of people from the nearby villages visit it. The small, extensive village of Mapea, about 2 km from the start of the road seems to be gradually merging with Magugu in this peri-urban zone. From Mapea there are few villages alongside the road, and the road passes through mixed farmland, with a variety of annual and perennial crops, including maize.

At 6.6 km the road divides and to the left goes to Gichameda, a further 2 km from the junction, which is the headquarters of a long-standing small scale, sugar cane irrigation scheme operating in the Manyara valley. This has some processing facilities, dwellings for employees and a secondary school. This other road continues around the valley, past various sugarcane fields, and meets up with the Mbuyuwa-Magara road near Maweni. It therefore provides an alternative, but longer route between Magagu and Maweni and on to Magara. This can be seen in Figure 31 and Figure 46.

The IRAT intervention was across a low-lying area with no villages used for sugar cane production and some rice farming. Beyond the intervention are a few small villages. The ecology changes to drier, sandier, acacia scrub, with less arable farming and more livestock keeping. The population is quite low. The last village is the small but extensive village of Kisangaji which extends to the road junction with the regional Mbuyuwa-Maweni road. This road also leads to a gate of Lake Manyara National Park resulting in some tourist traffic. Across the road from the junction is the site of the Mahole weekly market (held every Wednesday) that is shown in Figure 40. This attracts numerous people, with perhaps 200 pack donkeys, and many vehicles. Besides a few trucks there may be about 300 motorcycles (taxis and private), about 40 minivans and pickups, and a smaller number of minibuses and bajajis. Most vehicles access the market using the Mbuyuwa-Magara road, and only a few vehicles access the market using the surveyed road, despite it providing a 5 km shorter journey distance between Magugu and Mahole.

Figure 40 Mahole weekly market in Babati District

Most traffic along the studied road comprises motorcycles (see Figure 41) and the main transport services operating along the road are motorcycle taxis. As on other roads in Tanzania, there are increasing numbers of private motorcycles in use, including some that are used occasionally as motorcycle taxis (e.g. on market days or after the harvest).

Figure 41 Motorcycle taxis and motorcycles on the surveyed road

The road is rough, and motorcycles are generally better at coping with rough roads than four wheeled vehicles as they can change their trajectories and weave around difficult obstacles on the road. However, they prefer to use smooth trails, and often create them on the road shoulder or on a side trail, by repeatedly travelling along the same trajectory that gradually becomes worn smooth. On the middle section of the road there are several side trails, which can be seen in Figure 42.

Figure 42 Motorcycle on-road and off-road side trails to avoid the rough road surface

This road has a traditional footpath running from Mapea (near Magagu) to a small village just after the IRAT culverts (around 9.5 km). Motorcycles have started to use this as a motorcycle trail, as it is smoother than the road, and shorter too (it cuts a corner). The section near the IRAT culverts becomes difficult to pass in the rainy season, and so this motorcycle trail is mainly used in the dry season. The start/end of the trail at 9.5 km is shown in Figure 43.

Figure 43 A motorcycle trail used in the dry season to bypass several kilometres of rough road

Informal freight services are provided by two-wheel tractors with trailers. These carry agricultural produce, building and other materials and sometimes people (unofficially). Some of these two-wheel tractors are shown in Figure 44. There are also a few 'toyo' freight three-wheelers (as shown in Figure 9) operating along this road, carrying small-scale freight.

Figure 44 Two-wheel tractors carrying freight and passengers

The use of bicycles is common on the road, particularly by men. Indeed, after motorcycles, bicycles are the second most common means of travel for men. Their use is illustrated in Figure 45.

Figure 45 Bicycles ridden by men on the survey road

4.3 Survey findings

4.3.1 Traffic and trip making

Traffic counts were carried out at two locations on the survey road and at one point on the control road. The traffic count locations were the same as those used in the earlier IRAT traffic counts and their approximate positions are included in the diagrammatic map shown in Figure 46. One location on the survey road was close to the IRAT interventions, and this would measure through traffic as well as local movements. Another location on the survey road was in Mapea, close to Magugu, which might include through traffic using either the survey road or the control road, as well as the local movements of people to the facilities at Magugu town. The third traffic count measured traffic on the initial section of the control road, close to the junction.

The earlier IRAT traffic counts were implemented over three days (including a market day if possible) and results standardised to get a daily average. The count in 2019 did not include a market day, but the results were standardised in a similar way to those of the IRAT counts to make them comparable. The results are presented in Table 21 (near IRAT section),

Table 22 (near Magugu) and Table 23 (control road).

Table 21 Traffic volumes near IRAT intervention on Magugu-Mahole road, Babati District

	Average day-time traffic volumes by vehicle type			
Month and year	*Aug 2015*	*Sep 2016*	*Aug 2017*	*Nov 2019*
Survey days	*Fr,Sa,Su*	*Fr,Sa,Su,M*	*Fr,Sa,Su*	*Th,Fr*
Cars	17.7	9.3	9.0	3.0
Pickups and utility vehicles	17.7	25.0	12.7	1.3
Minivans, minibuses	0.3	8.3	3.0	5.0
Large buses	0.0	0.0	0.0	0.0
Trucks	1.7	4.3	13.0	6.0
Tractors	10.0	17.3	11.3	23.3
Animal transport	0.0	4.0	5.0	0.0
Motorcycles and bajajis	105	112	652	355
Motorcycles				353
Bajajis				1.7
Bicycles	60	138	465	158
Pedestrians	39	81	416	217
All motorised, excluding motorcycles	47.4	64.2	49.0	38.6

Source of 2015-2017 data: Cardno (2017)

Clearly motorcycles are the main means of transport. However, it is difficult to interpret the differences in motorcycle volumes between the years in Table 21. The high figure for motorcycles in 2017 on the middle section of the road, was not consistent with the much lower figure recorded at Mapea close to Magugu (

Table 22) on the same days in the busiest section of the road. There is a growth in the use of two-wheel tractors as freight vehicles. Few four-wheel vehicles are using the road. Most of the minivans recorded (5 a day in 2019) were probably not public transport services but private vehicles (such as Toyota Noahs) or commercial minivans chartered for special events. Some minivans and minibuses occasionally ply the road, notably on market days, but this is neither consistent nor predictable.

Table 22 Traffic volumes on the first section of the **Magugu-Mahole road,** Babati District

	Average day-time traffic volumes by vehicle type			
	Average day-time traffic volumes by vehicle type			
Month and year	*Aug 2015*	*Sep 2016*	*Aug 2017*	*Nov 2019*
Survey days	*Fr,Sa,Su*	*Fr,Sa,Su,M*	*Fr,Sa,Su*	*Th,Fr*
Cars	23.7	47.6	9.0	11.0
Pickups and utility vehicles	19.0	41.6	4.3	19.3
Minivans, minibuses	36.7	23.3	28.0	16.3
Large buses	3.0	0.0	1.7	8.0
Trucks	9.0	5.6	18.7	20.3
Tractors	58.7	50.8	19.0	53.0
Animal transport	22.0	13.4	5.0	0.7
Motorcycles and bajajis	751	721	412	868
Motorcycles				855
Bajajis				13
Bicycles	418	400	223	418
Pedestrians	457	377	66	762
All motorised, excluding motorcycles	150.1	168.9	80.7	127.9

Source of 2015-2017 data: Cardno (2017)

The counts at Mapea near Magugu (

Table 22) also show considerable variation between years, but they generally show higher volumes of most forms of transport in most years, compared to the middle section traffic count (Table 21) and the traffic count on the control road (Table 23). This is consistent with the peri-urban nature of this section of the road. There appears to have been a gradual, steady increase in the numbers of trucks and a decrease in animal-powered transport. Taking away motorcycles, bicycles and pedestrians, the vehicle counts are quite modest.

Table 23 Traffic volumes on Gichameda 'control' road, branching from Magugu-Mahole road, Babati District

	Average day-time traffic volumes by vehicle type			
Month and year	*Aug 2015*	*Sep 2016*	*Aug 2017*	*Nov 2019*
Survey days	*Fr,Sa,Su*	*Fr,Sa,Su,M*	*Fr,Sa,Su*	*Th,Fr*
Cars	14.7	16.5	32.0	0.7
Pickups and utility vehicles	7.7	4.5	19.0	18.0
Minivans, minibuses	11.0	9.9	14.0	4.0
Large buses	0.0	0.0	1.0	0.0
Trucks	11.0	14.7	16.0	14.3
Tractors	5.0	25.4	28.0	22.3
Animal transport	0.7	64.1	3.7	0.7
Motorcycles and bajajis	447	532	426	342
Motorcycles				339
Bajajis				2.7
Bicycles	443	263	365	216
Pedestrians	305	181	390	320
All motorised, excluding motorcycles	49.4	71.0	110.0	59.3

Source of 2015-2017 data: Cardno (2017)

The control road (Table 23) shows similar overall patterns of traffic flow to the other sites, although as would be expected the traffic volumes are much smaller than the road section close to Magugu. The higher number of pickups and trucks (compared to the middle section of the survey road) can probably be explained by the Gichameda cane sugar scheme.

Table 24 provides an analysis of people's movements, disaggregated by gender/age at the three traffic count points, with some overall summaries of the types of vehicle people use to travel. Motorcycles account for the majority of movements of both men and women, with men travelling most and using motorcycles the most. Gender differences are clear, with men comprising 78% of people travelling by motorised vehicles or bicycles. Bicycles are the second most important means of travel for men but fewer women use bicycles. Men's use of bicycles for travel is nearly five times more than that of women. Just over half (55%) of women's trips in wheeled transport are on motorcycles. Children walk along the road in the first peri-urban section, but much less so in the two rural sections. Bajajis are present, mainly in the busy peri-urban section, but they have not yet made much of an impact on the transport market. The proportion of people travelling in other vehicles (pickups, cars, minivans, etc) was low, but was greatest in the busy first section of the road.

Table 24 Analysis of people's movements at two points on the Magagu-Mahole road and on the control road

	Analysis of people's movements based on 12-hour traffic counts, Nov 2019						
	Men	**Women**	**Children**	**Total travellers**	**% of movements**	**Loads**	**% with loads**
On section near IRAT work							
Motorcycles	448	73	22	543	49%	76	22%
Cyclists	147	23	13	183	17%	25	16%
Bajajis	4	0	0	4	0%	0	0%
Other transport	106	54	2	163	15%		
Pedestrians	105	59	53	217	20%	13	6%
Total	**810**	**209**	**90**	**1109**		**114**	
On first section							
Motorcycles	963	230	53	1246	40%	138	16%
Cyclists	394	64	32	489	16%	42	10%

Bajajis	20	14	3	36	1%	3	25%
Other transport	361	115	124	600	19%		
Pedestrians	213	108	441	762	24%	3	0%
Total	**1951**	**531**	**653**	**3135**		**186**	
On control road							
Motorcycles	468	67	6	541	42%	71	21%
Cyclists	220	11	2	233	18%	61	28%
Bajajis	5	4	0	9	1%	0	0%
Other transport	150	21	1	172	13%		
Pedestrians	183	108	29	320	25%	22	7%
Total	**1026**	**211**	**38**	**1275**		**154**	
Combined counts (all roads)							
Motorcycles	1879	371	81	2330			
Cyclists	761	98	47	905			
Bajajis	28	18	3	49			
Other transport	617	191	127	935			
All wheeled transport	**3285**	**677**	**257**	**4219**			
Percent by gender/age	78%	16%	6%				
Percent using motorcycles	57%	55%	31%				
All pedestrians	**501**	**275**	**523**	**1299**			
Percent by gender/age	39%	21%	40%				
All travellers	**3786**	**952**	**781**	**5518**			
Percent by gender/age	69%	17%	14%				

The main reasons for the people's recent journeys are shown in

Table 25. Most respondents said they travelled to go to local shops and markets, to visit friends and relatives and to travel to town. Surprising none mentioned travel to visit health facilities. There were no clear gender-related patterns of reasons for using transport services, although Table 24 shows that most people travelling (as recorded in the traffic counts) were men.

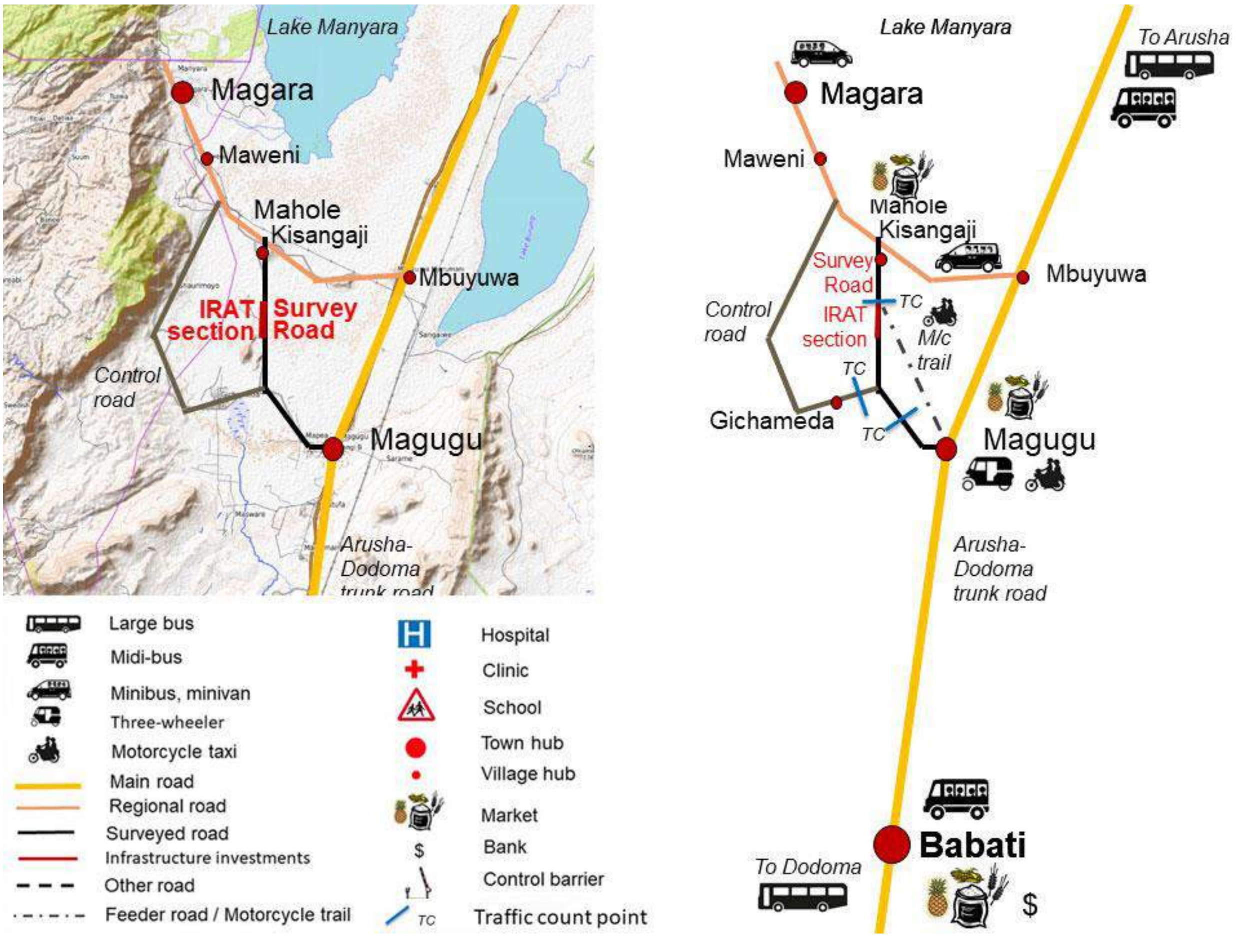
Table 25 Reasons for taking transport services reported on the Magagu-Mahole road, Babati District

Journey purpose	Women	Men	All
Local market or shops	11	9	20
Visiting friends or relations	2	6	8
Visit to town shops, banks, offices	3	2	5
Farming	1	3	4
Business	0	1	1
Sell produce	0	1	1
Funeral/wedding	0	1	1
Total	**17**	**23**	**40**

4.4 Changes and possible explanations

The survey road used to be the main means of access between Magugu and the town of Magara, and various transport services passed along the road. In 2009, a new regional road was built from Mbuyuwa on the Dodoma-Arusha highway to Magara and beyond, including access to the Lake Manyara National Park. This created an approximate triangle of roads, with the survey road (16 km) being the hypotenuse, with the national highway (11 km) and the regional road (10 km) being the opposing sides (see Figure 46). To travel from Magugu to Mahole is 16 km on the survey road and 21 km taking the main road. However, the highway has a high quality, smooth, bituminous surface, allowing cruising at 80 km/h (except though the roadside villages). The regional road is graded gravel and allows travel speeds of up to 80 km/h, depending of the traffic and prevailing conditions. Much of the survey road is rough and slow, making journey times longer and more uncomfortable than the longer, highway route. Therefore, all the regular transport services to between Babati and Magara currently operate on the national and regional road, and not the survey road. Some of the operators occasionally take that road but reported that transport demand is very low, and with fewer passengers boarding than are generally found at the Mbuyuwa junction on the main road.

Figure 46 Diagrammatic maps showing roads and indicating transport services patterns



Minivans provide regular, short distance services between Babati and Magugu. The transport services that share the Babati-Magugu-Magara route are two Hiace minibuses and three Coaster midibuses. They operate from the new bus station that is about 4 km outside Babati, as shown in Figure 47.

Figure 47 Babati-Magugu minivans and a Babati-Magara midibus at the Babati bus station

These transport services charge Tsh 1000 between Babati and Magugu, and Tsh 1,500 between Magugu and Magara. On the longer route to Magara, each vehicle generally makes one return trip a day on normal days, but 5-6 trips each on the day of the Mahole market or the monthly market at Magugu. They all generally use the better road from Magagu to Mahole, via Mbuyuwa. The Mbuyuwa junction with the highway (with passenger pickup point) and transport services operating along the road from Mbuyuwa to Mahole and Magara are shown in Figure 48.

Figure 48 Transport services operating on the Mbuyuwa-Magara road

The IRAT intervention on the survey road removed one bottleneck and allowed all-season access, but it did not address the other road problems, notably the rough surfaces that make it uncomfortable for drivers and passengers. Motorcycles have found various ways to mitigate the problem of roughness, using smoother side trails. In the dry season, they also use a one off-road trail that provides a smooth bypass and shortcut avoiding a long, rough section of the road (Figure 43). Apart from a few sections with wide side trails (as seen in Figure 42), three-wheelers and four-wheeled vehicles cannot use side trails and so bump along uncomfortably. There has been recent work on the last few kilometres, and this is now smooth (but dusty when dry and potentially slippery when wet). As long as the middle section of the road remains rough, transport services and private vehicles travelling to the Magara or the Mahole market have no real incentive to use the road studied: the savings in distance are outweighed by the longer travel time, the higher fuel costs in low gears, potential vehicle damage and the discomfort of those travelling.

However, it is not just roughness that discourages transport services. The road studied in Hai District was connected to two very rough roads (Boma Ng’ombe to Rundugai, and Longoi to Kikavu) that were served by minibuses, minivans and bajajis. This indicates that transport services will use rough roads if they consider the transport demand justifies the operation. On the survey road, there are no large villages after the Mapea-Magugu peri-urban section. The small existing transport demand is mainly being met by motorcycle taxis. The transport operators with larger vehicles are not convinced there are many people who would travel regularly if there were minivans, minibuses or bajajis serving the road. Near the Magugu end, a few bajajis operate on a point-to-point basis. At the Mahole end on market days only, a few bajajis look for market-related custom in the small villages in the last six kilometres of the road. However, rural residents wishing to travel, generally have to use motorcycle taxis to reach the end of the road that is closest to them, from where they can take a minibus or other form of public transport.

5 Chigongwe-Chipanga Road, Bahi District

5.1 Road geography, history and condition

5.1.1 History and context

This 37 km collector road (road number 14011 in the DROMAS2 database) runs between the Dodoma-Mayoni-Singida highway (T3) road which passes to the east of Lake Sulunga and the regional road (R433) that also links Dodoma with Mayoni, but to the west of Lake Sulunga. This is shown in Figure 49.

Figure 49 GPS trace of Chigongwe-Chipanga road showing road network context

The road benefited from various improvements under the IRAT programme from 2016 to 2018, designed to reduce bottleneck constraints. IRAT investments included 8.6 km of road rehabilitation, some culverts and two bridges. The road improvements were at 7.8-10.8 km (between Kigwe and Bridge 1) and at 22.3-27.6 km (just before Bridge 2).

The first 'bridge' was technically a 6-cell box culvert, but it is locally referred to as a bridge, and this document uses the word 'bridge' as well, as it is a significant water crossing (see Figure 51 and Figure 60) and referring to the two 'bridges' aids the description of the traffic and transport services issues. Figure 50 shows the state of a drift before the first bottleneck investment and Figure 51 shows the Bridge 1 (technically a multi-celled box culvert) that replaced it, shortly after its construction in 2017.

Figure 50 Chigongwe-Chipanga river crossing bottleneck prior IRAT intervention in 2016

Source: unpublished IRAT report

Figure 51 Chigongwe-Chipanga Road Bridge 1 (6-cell box culvert) after construction

Source: unpublished IRAT report

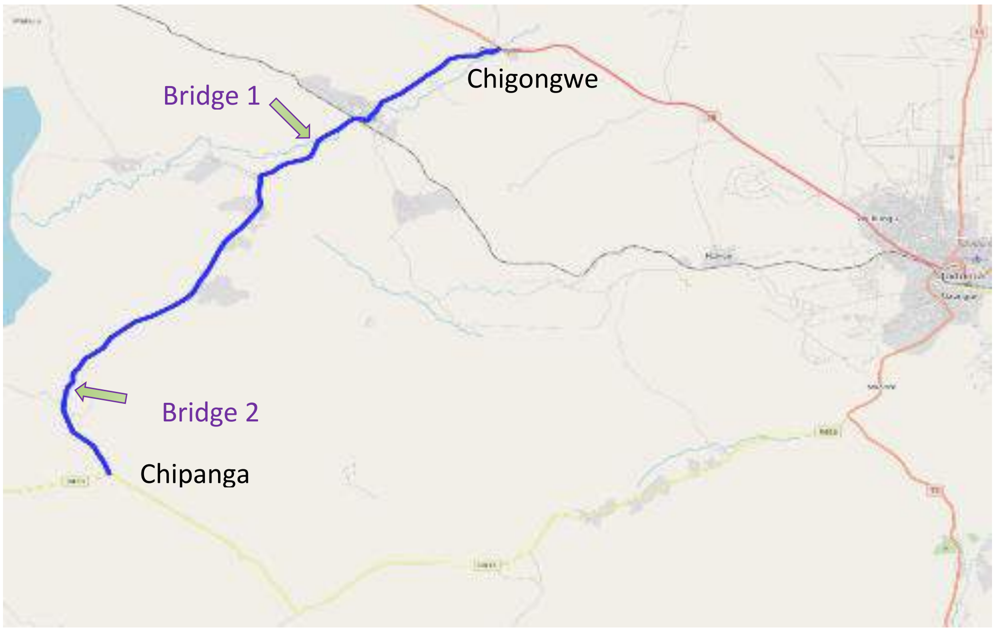
Figure 52 shows the site of the second bridge during its construction in 2018.

Figure 52 Chigongwe-Chipanga Road Bridge 2 during construction

Source: unpublished IRAT reports

5.1.2 Road alignment

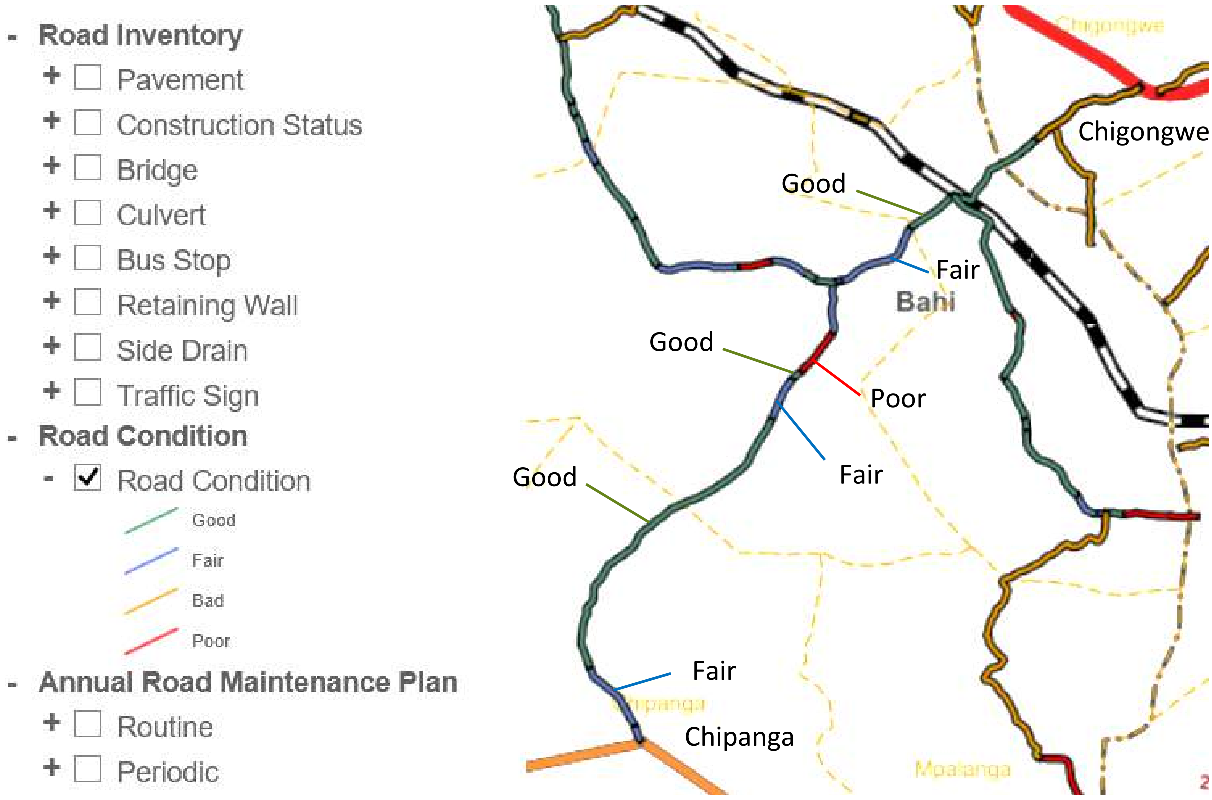
Figure 53 Map showing GPS trace of the Chigongwe-Chipanga Road



5.1.3 Road sections and condition

The nature of this road is broadly similar throughout and so this overview of the engineering situation will not use sections. The two bridges constructed under IRAT are located at approximately 14 km and 30.5 km from Chigongwe. According to the DROMAS2 database for 2018/19 (the latest data available), the road was in good, fair, poor and bad condition for various parts of the road. A copy of the condition assessment can be seen in **Error! Reference source not found.**

Figure 54 Extract from the DROMAS2 database (2018/19) showing road condition



In DROMAS2, the first part of the road is shown as bad condition (amber colour) in 2018, but this was not the observation from the project survey (although there were some rough and rocky outcrops and a broken culvert). It appears that this part of the road has been maintained quite recently and the 2019/20 condition surveys should now show that most of this part of the road is in fair condition. The other assessments along the road are consistent with the surveys undertaken by the team in November 2019. The parts of the road adjacent to the IRAT bridges are in good condition.

The road is gravel throughout, with some areas where the gravel has eroded to leave a largely earthen surface, as shown in Figure 55. The condition varies between fair and poor.

Figure 55 Chigongwe-Chipanga road showing parts that have lost their gravel and shape

The road is between 6 m and 7 m wide. This is a low rainfall area and no soft spots or muddy areas were noticed, but the road surface is quite sandy in places, as shown in Figure 56.

Figure 56 Chigongwe-Chipanga road showing some sandy patches

The road starts with reasonable shape and camber for the first 5 km (Figure 57), but after that the shape deteriorates and is generally flat for the majority of the road.

Figure 57 Chigongwe-Chipanga road showing a well-maintained shape

The road is not raised and in places is lower than the surrounding land, with little drainage apart from side drains. This is possible in a dry area but can still pose problems during heavy rains. Some large side drains have been constructed to the south side of parts of the road, and appear to be designed to capture surface water running off from the gently sloping land during a rain storm, and direct this run-off to culverts passing under the road, as shown in Figure 58.

Figure 58 Chigongwe-Chipanga road showing side drains to catch run-off from the land

Intermittent areas of spot patching or rehabilitation are evident, which suggests that the road is maintained on a regular basis. In some areas there are no obvious side drains and the driven road surface tends to meander where drivers have followed the smoothest route.

There are also several concrete drifts along the road. These are appropriate for dry areas where there is not constant flow along a watercourse. The drifts were constructed with markers at the entrances and exits so that drivers can see the carriageway when the drift is submerged. Some of these bollards have been damaged.

Figure 59 Chigongwe-Chipanga road showing some of the drifts

The first 'bridge' constructed under IRAT at 14 km is a double lane 6-cell box culvert with a span of 28 m, as shown in Figure 60. It is across a river that is constantly flowing, although the flow is minimal in the dry season. It is of concrete construction with a concrete deck, with kerbs and handrails, but no pedestrian walkways.

Figure 60 Chigongwe-Chipanga road Bridge 1 (6-cell box culvert)

The second bridge (Figure 61) constructed under IRAT at 31.7 km. It is a double lane bridge with a span of 48 m. It is of concrete construction with a concrete deck and kerbs (that can act as pedestrian walkways) and steel handrails.

Figure 61 Chigongwe-Chipanga road Bridge 2

Both bridges are 5 m wide and in good condition and provide reliable access throughout the year. There have been no issues with accessibility at these water crossings since the bridges were constructed between 2016 and 2018 and they do not have any signs of deterioration.

5.1.4 Road maintenance

There is evidence of recent maintenance on the road surface, mainly spot patching and short sections of rehabilitation. There is little vegetation, so it is assumed that the routine maintenance comprises mainly clearing drains and culverts. The surface quality varies, presumably due to different levels of maintenance. With a long road such as this it would be difficult to apply consistent levels of maintenance throughout, so it is not surprising that the maintenance providers are forced to spread their resources where they are most needed.

5.1.5 Key informant interviews on engineering issues

An engineer was interviewed from the TARURA Road/Works department. Before the IRAT works in 2016-2018, there were frequent road closures during the wet season, especially between December and April. As soon as the bridges were completed the road became all-season, which has improved the economic and social activities in the local community. At present there are no road closures and transportation has improved. There can be water crossing the road, but drainage structures such as culverts and drifts are provided to ensure that the road embankments are not damaged.

There are no significant changes from season to season and the road is regularly maintained. Traffic has increased over the past two years. A regular budget is provided for maintenance, but it is insufficient to cover all the works backlog. It is used for routine maintenance, periodic maintenance and spot patching. Routine work includes grass cutting, pothole filling and grading. Periodic maintenance includes regravelling, reshaping and re-compaction, which is rarely carried out. Local communities are not involved in the road maintenance.

Transport services overall appear to have increased and a greater variety of vehicles are using the road. Although this road is all-season and is receiving basic maintenance, there are many other roads in the area that have similar problems to those encountered on this road before the IRAT intervention. The annual budget allocated is insufficient to bring them all up to the same standard.

5.2 Socio-economic and transport context

The road passes to the southwest of Lake Sulunga through a semi-arid landscape dotted with baobab trees. There is a sparse population of farmers and pastoralists engaged with the cultivation of rainfed food crops (maize, millet) and livestock rearing, with herded cattle, sheep and goats. About 8 km from the start of the road is the large village of Kigwe, which is within commuting distance of Dodoma. This is served by regular transport services operating out of the Dodoma north-western local bus stand (Mnada Mpya) adjacent to the T3 Singida trunk road and 7 km from the centre of Dodoma. This bus stand is shown in Figure 62.

Figure 62 The Dodoma Mnada Mpya bus stand on the north-west periphery of the city

The Kigwe-Dodoma route is shared by six minivans (Noahs) and three minibuses (Hiaces) that operate a queuing system. Each vehicle has 1-3 trips a day, depending on demand, with the greatest demand (3 trips) on Fridays, the day of the Kigwe weekly market. One midibus (a Coaster) also operates on that route but further up the road to Chikola. This leaves Chikola each day at 6 am and returns from the Mnada Mpya bus stand at 2 pm. The transport services do not generally venture further along the road, due to low transport demand from the small population. One minibus shares the route but starts in the village of Chimendeli (on the 'control' road that goes towards Bahi) and returns there in the evening. The normal fares from the Dodoma Mnada Mpya stand, according to the operators, are Tsh 1300 to Kigwe (USDc 2 per passenger-km) and Tsh 3000 to Chikola (USDc 3.4 per passenger-km). For the Kigwe operators, most of their journey is on the good surface of the T3 trunk road where there is competition. The sole operator who serves Chikola has only about half of his journeys on the good bituminised road. On the day of the Kigwe market (Fridays), all the vehicles do multiple 'shuttle' trips between Chikola and Kigwe, in addition to their Kigwe-Dodoma runs.

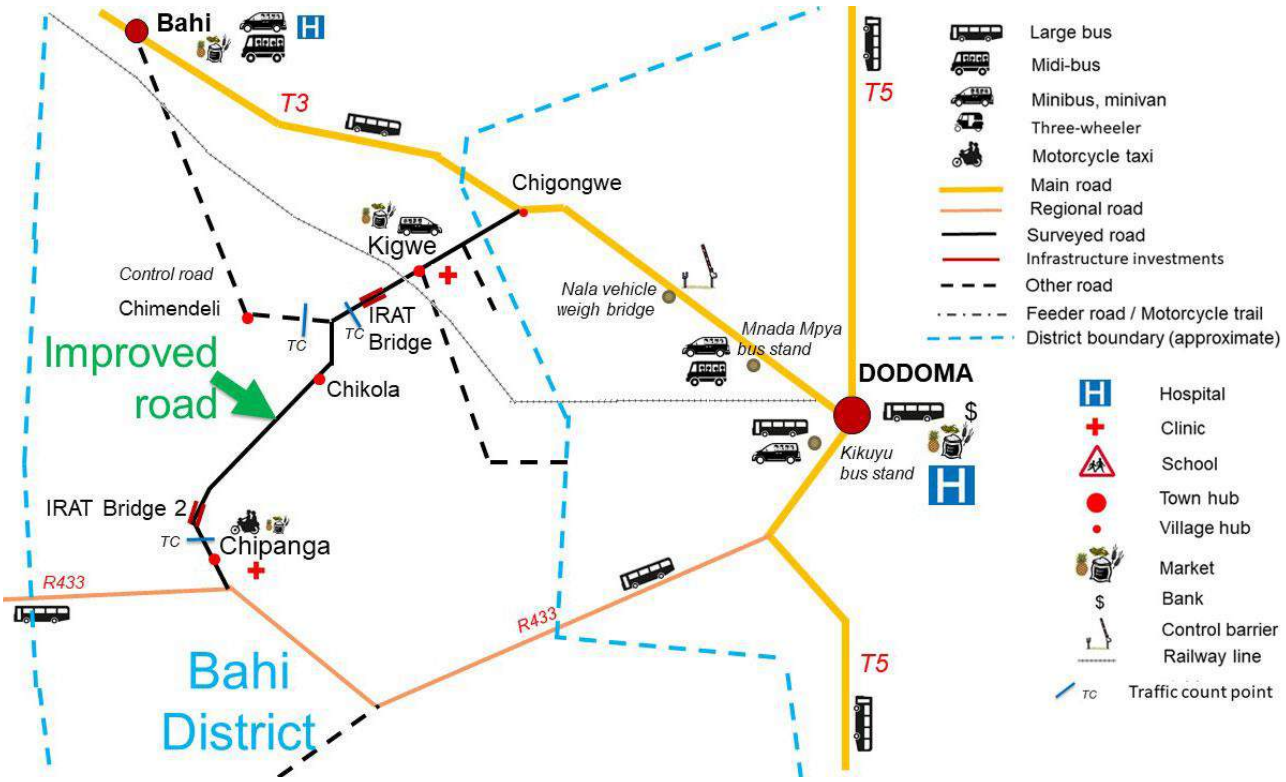
Figure 63 Chigongwe-Chipanga road with minivan approaching Kigwe (left) and the Kigwe market bus stand (right)

Motorcycle taxis operate throughout the road corridor, with stands of several operators available at Kigwe and Chipanga (see Figure 64). Bajajis are not yet widely used on this road. They are important for point-to-point services within Dodoma, notably for taking people from the peripheral bus stands to the main markets, shops and destinations within Dodoma City. Small numbers operate in the small towns (and some large villages) close to Dodoma, but unlike north-eastern Tanzania, they have not (yet) become important for rural transport services.

Figure 64 Kigwe motorcycle repair workshop (left) and motorcycle taxi operators at Chipanga (right)

Transport policy (implemented by LATRA) is promoting decentralised bus stands outside town centres. Dodoma has an express inter-regional bus stand in the city centre, but the regional buses and minibuses, serving local towns and villages have to operate from bus stands several kilometres from the centre of Dodoma, adjacent to each of the arterial trunk roads. Routes to the south of Dodoma operate from the Kikuyu bus stand, about 3 km from central Dodoma, close to the T5 Iringa road. Some large 65-seater buses operate from this stand and travel along the R433 regional road, past Chipanga and onto several destinations including Sansa in Manyoni District. The approximate locations of the transport stands and the routes taken by these buses are shown in Figure 65. This also shows the route used by the Kigwe transport services. The route of the bus services beyond Chipanga along the R433 can be seen in Figure 49.

Figure 65 Schematic map of the Chigongwe-Chipanga road showing road network and transport terminals



Chipanga is not actually on the R433, but the bus services turn off the regional road to pick up and drop off passengers and their goods in Chipanga village, about 4 km from the junction. Four 65-seater buses a day operate on the route. The bus fare from Chipanga to Dodoma (Kikuyu stand) is Tsh 3,000 (USDc 2.3 per passenger-km). Some buses using the R433 route go all the way to Dar es Salaam.

5.3 Survey findings

5.3.1 Traffic and trip making

Traffic counts were carried out at two locations on the Chigongwe-Chipanga road and at one point on the control road (the road branching northwards towards Bahi). The traffic count locations were the same as those used in the earlier IRAT traffic counts and their approximate positions are included in the diagrammatic map shown in Figure 65. One location on the survey road was after the first IRAT bridge and this measured all, or most, of the traffic using the bridge. The other traffic count point on the survey road was just after the second IRAT bridge which measured all, or most, of the traffic that used that bridge. The traffic count point on the control road was close to its junction with the Chigongwe-Chipanga road. The majority of vehicles passing this point would probably have already travelled over, or be about to travel over, the IRAT Bridge 1.

The earlier IRAT traffic counts were implemented over three days (including a market day if possible) and the results standardised to get a daily average. The count in 2019 also included the Kigwe market day. The results were standardised in a similar way to those of the IRAT counts to make them comparable. The results are presented in Table 26 (after Bridge 1) and Table 27 (after Bridge 2). The results for the control road for 2017 and 2019 have been included in Table 26 (there was no IRAT control count in 2016).

Table 26 Traffic volumes on Chigongwe-Chipanga road after IRAT Bridge 1 and on control road

	Average daily traffic volumes *(12 hr)*				
Month and year **Survey days**	*Sep 2016* *Tu, W, Th*	*Aug 2017* *Th, Fr, Sa*		*Nov 2019* *Th, Fr*	
	Survey Rd	*Survey Rd*	*Control Rd*	*Survey Rd*	*Control Rd*
Cars	26	5.0	2.3	11	0.7
Pickups and utility vehicles	21	16	2.7	1.0	4.7
Minivans, minibuses	42*	55*	33*	14	10
Midibuses	0	0	0.0	17	10
Large buses	0	0	0.0	0.0	0.0
Trucks	23	4.3	3.0	2.3	1.0
Tractors	14	0.7	2.3	1.0	1.3
Animal transport	44	2.3	2.3	1.3	1.0
Motorcycles	176	123	146	164	127
Bajajis	0	0	0.0	0.0	0.0
Bicycles	70	101	134	83	162
Pedestrians	102	142	494	131	250
All motorised, excluding motorcycles	126	81	43	46	28
** Some of the 'minibuses' may have been midibuses*					

Source of 2015-2017 data: Cardno (2017)

The survey road columns in Table 26 show a gradual decline in most types of vehicle traffic over the years, with variations between vehicles and years as can be expected from low-volume traffic counts carried out over a few days in different months. Motorcycles, bicycles and pedestrians seem to be the transport types that are the most constant and have not declined significantly. The decline does not seem to be related to road issues, since the road access has been improving over the years with the IRAT Bridge 1 and the IRAT road investments improving all-season access. Possible reasons for the changes are discussed in Section 5.4.

Table 26 also shows changes on the control road, which also experienced declines in most vehicle types, with motorcycles, bicycles and pedestrians appearing quite resilient. Given the proximity of the two traffic count locations included in Table 26, it is reasonable to assume that the traffic going over IRAT Bridge would divide into those going onto the Bahi (control) road and those going on to the surveyed Chipanga road. The equivalent would apply in the other direction. So, we can assume that, of the 14 minivans and minibuses crossing the bridge, 10 travelled on the control road (as traffic count) and so 4 went to or from Chikola on the Chipanga road. There would be a small amount of local traffic going from the Bahi road to and from Chikola (and even Chipanga) but from focus group discussions (and traffic counts at Chipanga) it is clear that there is little through traffic on the Chikola-Chipanga part of the road.

The relatively high 'average' numbers of minivans/minibuses (10) and midibuses (17) crossing IRAT Bridge 1, do not give a realistic picture of daily transport services. On non-market days, there is one midibus a day that travels over the bridge, from and to Chikola, and one minibus a day that travels over the bridge, from and to Chimendeli (on the Bahi 'control' road). On Kigwe market days (Fridays), mini- and midibuses operate shuttle services between Kigwe and surrounding villages including Chikola and Chimendeli. This leads to 22 more minibus and midibus return trips across the bridge on market days than most 'normal' days.

Table 27 Traffic volumes on Chigongwe-Chipanga road near Chipanga after IRAT Bridge 2

	Average daily traffic volumes *(12 hr)*		
Month and year	*Sep 2016*	*Aug 2017*	*Nov 2019*
Survey days	*Tu, W, Th*	*Th, Fr, Sa*	*Th,Fr*
Cars	0.8	0.3	2.7
Pickups and utility vehicles	6.0	2.3	3.0
Minivans, minibuses	0.4	1.0	6.0
Midibuses	0.0	0.0	0.0
Large buses	0.0	0.0	0.0
Trucks	0.8	6.3	0.7
Tractors	0.8	0.0	1.0
Animal transport	7.6	0.3	0.0
Motorcycles	77	107	145
Bajajis	0.0	0.0	0.0
Bicycles	86	114	76
Pedestrians	90	189	179
All motorised, excluding motorcycles	8.8	9.9	13.4

Source of 2015-2017 data: Cardno (2017)

From Table 27, it is clear that the section of the road near Chipanga has very little traffic, and most movements are motorcycles, pedestrians and cyclists. Only 13 vehicles a day (excluding motorcycles and bicycles) are crossing the new bridge each day. This is slightly up compared with pre-bridge days (almost 50% in percentage terms), but an increase from 9-a-day to 13-a-day is not yet a good return on the investment. Based on discussions with users, and field observations, the six minivans/minibuses recorded were probably privately owned minivans (Toyota Noahs) used by local businesses and professionals. Some of these may have been chartered for specific journeys. Apart from motorcycle taxis, there are no regular transport services that cross over Bridge 2, yet.

Table 28 provides a breakdown of the movements of people, disaggregated by gender and age. Around the first bridge, 48% of people travelling do so in public transport (this statistic is mainly due to the shuttle transport available on the Friday market days). Around the second bridge, 90% of people travel by motorcycle (36%), bicycle (18%) or walking (36%). Only 5% of people travelling did so in minivans, and these were probably private vehicles, not public transport services. Most people recorded as travelling were men (56%), followed by women (26%) and children (18%). Men were a minority of the pedestrians but made up two thirds of the people travelling on wheeled transport. However, when it came to travel by motorcycle, the distribution was less skewed, with 37% of those travelling on motorcycles being men, 32% women and 22% children. Given that personal motorcycles and motorcycle taxis are generally driven by men, the importance to women of motorcycle taxis is apparent.

Table 28 Analysis of people's movements at two points on the Chigongwe-Chipanga road and on the control road

	Men	Women	Children	Total travellers	% of movements	Loads	% with loads
After first bridge							
Motorcycles	244	37	2	283	25%	13.7	8%
Cyclists	79	4	20	103	9%	14	17%
Minivans, minibuses	111	57	18	186	17%		
Midibuses	184	114	42	340	31%		
Other transport	42	3	0	45	4%		
Pedestrians	40	30	61	131	12%	3.7	3%
Total	**700**	**245**	**143**	**1088**			
After second bridge							
Motorcycles	194	30	5	229	42%	9.7	7%
Cyclists	66	9	13	88	18%	11	15%
Minivans, minibuses	16	9	2	27	5%		
Midibuses	0	0	0	0	0%		
Other transport	20	4	1	25	5%		
Pedestrians	57	64	57	178	36%	13.7	8%
Total	**353**	**116**	**78**	**547**			
Control road							
Motorcycles	182	35	3	220	23%	20	16%
Cyclists	140	31	78	249	26%	38.3	24%
Minivans, minibuses	52	40	14	106	10%		
Midibuses	80	52	29	161	16%		
Other transport	25	2	3	30	3%		
Pedestrians	64	119	67	250	26%	26.3	11%
Total	**543**	**279**	**194**	**1016**			
Combined counts							
Motorcycles	483	137	62	682			
Cyclists	286	45	111	441			
Minivans, minibuses	180	106	35	320			
Midibuses	263	167	71	501			
Other transport	86	9	4	100			
All wheeled transport	**1300**	**450**	**283**	2034			
% by gender/age	64%	22%	14%				
% using motorcycles	37%	30%	22%				
All pedestrians	**162**	**213**	**185**	**559**			
% by gender/age	29%	38%	33%				
All travellers	**1462**	**662**	**468**	**2593**			
% by gender/age	56%	26%	18%				

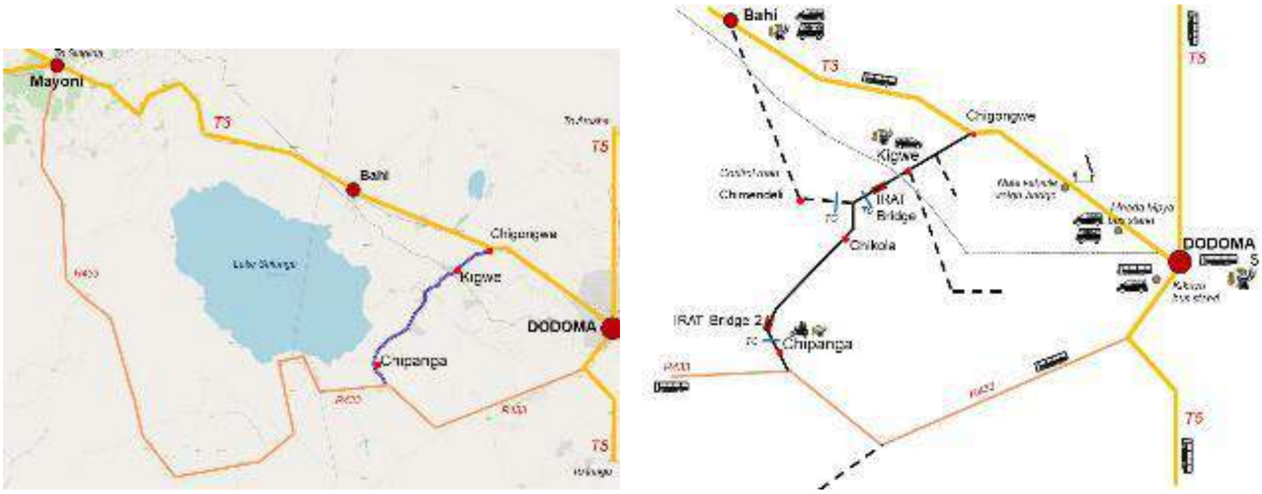
5.4 Changes and possible explanations

The road has improved greatly since 2016, with two bridges, several culverts and work on drainage and the road surface. This has mainly affected travel in the rainy season, although the improved condition will also improve dry season travel. Operators talked of the problem of thick sand that accumulated around the drifts that made it difficult to use some vehicles including large buses. This problem was not observed during the surveys, and so may have been an historical issue.

Transport services do not yet seem to have reacted to the road and bridge improvements, and there has been a gradual reduction in traffic over recent years. This suggests there has been a slight reduction in the economic demand for transport services. The movement of people is still primarily by motorcycles, bicycles and walking.

There are no transport services that operate along all the road, and this can best be understood by viewing the two schematic maps, shown again in Figure 66, for convenience.

Figure 66 Schematic maps of the Chigongwe-Chipanga road showing road context and transport terminals



The main destination for all transport services in the locality is Dodoma. In addition, there are periodic markets in villages (notably the Kigwe market on Fridays), that lead to local surges of movements. These are catered for by short distance shuttle services on market days, provided by the local transport services, notably motorcycle taxis, minivans, minibuses and midibuses.

From Kigwe, there are regular transport services to the Dodoma north-western bus stand. Only two return regular services a day pass over IRAT Bridge 1. There is a daily midibus return service from Chikola to Dodoma, and a daily minibus return service from Chimendeli (on the control road) to Dodoma. However, on Kigwe market days, there is a surge of local demand, and all the public transport operators on the Kigwe route run multiple trips to and from these villages and the Kigwe markets. Instead of the normal two return trips a day crossing Bridge 1, on market days there are 24 return trips, in addition to the services of motorcycle taxis. This shows that transport service operators can and will respond to increasing demand. So, the reason why transport services have not grown on this part of the road is due to low transport demand, irrespective of road condition. The population is small and mainly agricultural, with little economic diversity. For most people, there are no patterns of regular travel away from the villages, except on market days.

At the other end of the road, Chipanga is served by large buses that operate out of the south-western bus stand at Dodoma. These provide relatively low cost transport (per passenger kilometre) to and from Dodoma every day but they are quite slow. They also carry people’s goods. Those wanting to travel faster can hire a motorcycle taxi, which is more expensive but saves much time. The distance from Chipanga to a Dodoma bus stand is approximately the same (57 km) whether one passes via the R433 or via Chigongwe and the T3. The R433 regional road is wider with a smoother surface and so there is little incentive for operators to take the Chigongwe route, given the low population along the way, with little transport demand.

There is also the issue of Dodoma bus stands: the official stand for incoming transport services on the T3 Singida road is the north-western Mnada Mpya stand (7 km from the centre). The official stand for the R433 route is the south-western Kikuyu stand (3 km from the centre). The buses operating from the south-western Kikuyu stand do not pass a weighbridge station. However, all buses on the Singida road using the north-western Mnada Mpya stand must stop on outward and return trips at the Nala weighbridge (see Figure 67). This is a problem for the old buses currently used on the rural routes as these are heavy with much reinforcement steel and large numbers of passengers and many goods. The express buses on the Singida road are more modern, lighter vehicles with smaller overall loads, and these do not need to fear the weighbridge. However, should a rural bus operate on the Chigongwe-Chipanga route, it would have to be weighed on each trip, and so the operator could not use their existing old buses and their current loading systems.

Figure 67 Nala weighbridge on T3 Singida trunk road

Based on existing roads and traffic patterns, it is difficult to see why a large, expensive bridge at Chipanga should be prioritised. There does not currently seem to be much reason for traffic to travel along the Chipanga half of the Chipanga-Chigonwe road (or on the currently rough Chipanga-Bahi control road). However, considering these roads from the perspective of Bahi District, there may be an explanation, based on long-term aspirations. Bahi is the District Town and Bahi District extends southwards beyond Lake Sulunga and as far as Mwitikira (a village on the Mpunguzi-Mwitikira road, described in Section 0 with a map in Figure 74). The approximate boundaries of Bahi District were shown in Figure 65. Some people from Chipanga (and many villages beyond) will need to travel to the Bahi, the district town, occasionally. District officials will have to make visits from Bahi to the south of the district. To make such trips at present, it is easiest to travel via Dodoma, for although this is much longer than a more direct route, the roads and transport services are much better. With the bridges, if the condition of the connecting roads were improved, the surveyed road could provide a more direct and quicker route to the south of Bahi District. This could be part of a north-south link through the middle of the district. Therefore, in the long term, as the roads improve, and the economy diversifies, this may become an important route within Bahi District. However, at the moment, since people's main travel destination is Dodoma, not Bahi, there is not sufficient transport demand to justify transport services on the Chipanga-Chikola part of the road. There is currently very little transport demand for travel over the Chipanga bridge, and this is limiting the development of transport services and is keeping traffic levels very low.

6 Mpunguzi-Mwitikira Road, Bahi District

6.1 Road geography, history and condition

6.1.1 History and context

This road is No. 14018 in the DROMAS2 database. The whole of the 19 km road was rehabilitated under the IRAT programme. The road passes through quite flat land with vertisols (black cotton soils) prone to waterlogging in the rainy season. The work raised the level of the road with an embankment (with several culverts) on the low-lying and potentially waterlogged area that characterises most of the road. Before rehabilitation, the surface was poor (as shown in Figure 68), with delays and disruption during the rainy season, with reports that the road could be impassable to most vehicles for two weeks a year.

Figure 68 Mpunguzi-Mwitikira road in 2015 prior to IRAT rehabilitation

Source: unpublished IRAT report

Construction was completed in 2016, consisting mainly of new culverts and a rehabilitated and raised road surface. Figure 69 shows photos taken during the investment works in 2016.

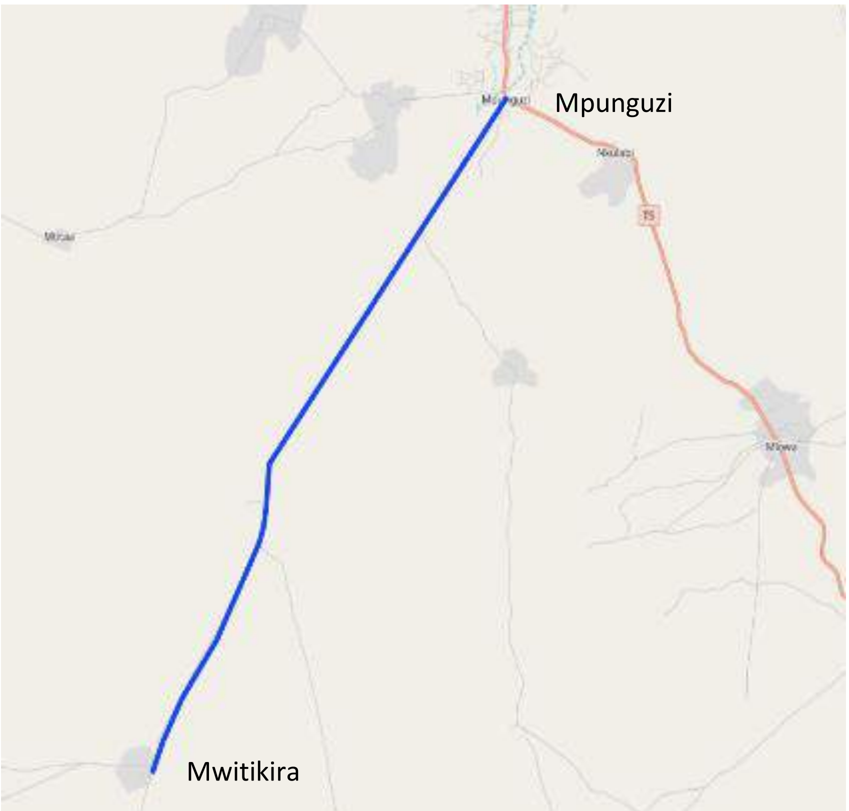
Figure 69 IRAT rehabilitation interventions (embankment and culverts) at the time of construction in 2015-16

Source: unpublished IRAT reports

6.1.2 Road alignment

Figure 70 shows a GPS trace of the alignment, showing the rehabilitated road runs straight for the first twelve kilometres.

Figure 70 Map showing GPS trace of the Mpunguzi-Mwitikira road



6.1.3 Road sections and condition

This road is of similar construction throughout and so in this report it can be considered as one homogenous section. In the DROMAS2 database, the road is shown as being in fair condition throughout based on the latest data available (from 2018/19).

The road is gravel construction and has good shape and camber for much of its length. It starts at approximately 6 m wide in a populated area at Mpunguzi, continues at 6 m to 7 m wide for the first 15 km. It narrows towards the end of the road at Nagulo to about 5 m. The first 15 km is constructed on a low embankment up to 1 m high, to raise the road above the low-lying land and avoid the risk of flooding, which was an issue for this road before the IRAT works were undertaken, as shown in Figure 68. The surface is motorable all year, but the gravel has a lot of oversize stones that are now on the surface, following erosion of the smaller gravel particles and can be seen in Figure 71. The oversize stones make the surface uneven and consequently the ride is less smooth, leading to reduced travel speeds. Some corrugations are also evident.

Figure 71 Mpunguzi-Mwitikira road showing the shape and surface in 2019

Three box culverts each of one cell of 2.5 m x 1.5 m, as well as a 277 m run of ring culverts of 900 mm diameter that have been installed by the IRAT programme (as shown in Figure 72). These seem to act as balancing culverts as there are no main watercourses and no significant side drainage. These culverts have maintained the all-season nature of the road by allowing water to flow freely from one side of the road to the other and preventing the road structure from becoming saturated and consequently weakened.

Figure 72 Mpunguzi-Mwitikira road showing ring culverts included in the IRAT investments

As the road has become rough due to the oversize stones, motorcycles and bicycles have started to use smoother side trails, either on the shoulder of the road or off the embankment along parallel trails. These are shown in Figure 73.

Figure 73 Mpunguzi-Mwitikira road showing smoother motorcycle trails developed alongside the roads

6.1.4 Road maintenance

Maintenance has been applied to this road since the rehabilitation, but the surface is gradually deteriorating as the funds are inadequate to maintain the surface to its original condition. At present routine maintenance and spot patching are the main activities, which retain the structural integrity of the road but are insufficient to maintain the riding quality to the levels of the original construction.

6.1.5 Key informant interviews on engineering issues

An engineer was interviewed from the TARURA office in Bahi. Before the IRAT work in 2016 the road was in poor condition and was often closed for days during the rainy season. Since then there have been no road closures along this section. Traffic increased in the second year and to date the road is still in good condition and transport services have improved. There are currently no issues with the road and social and economic activities in the area are increasing.

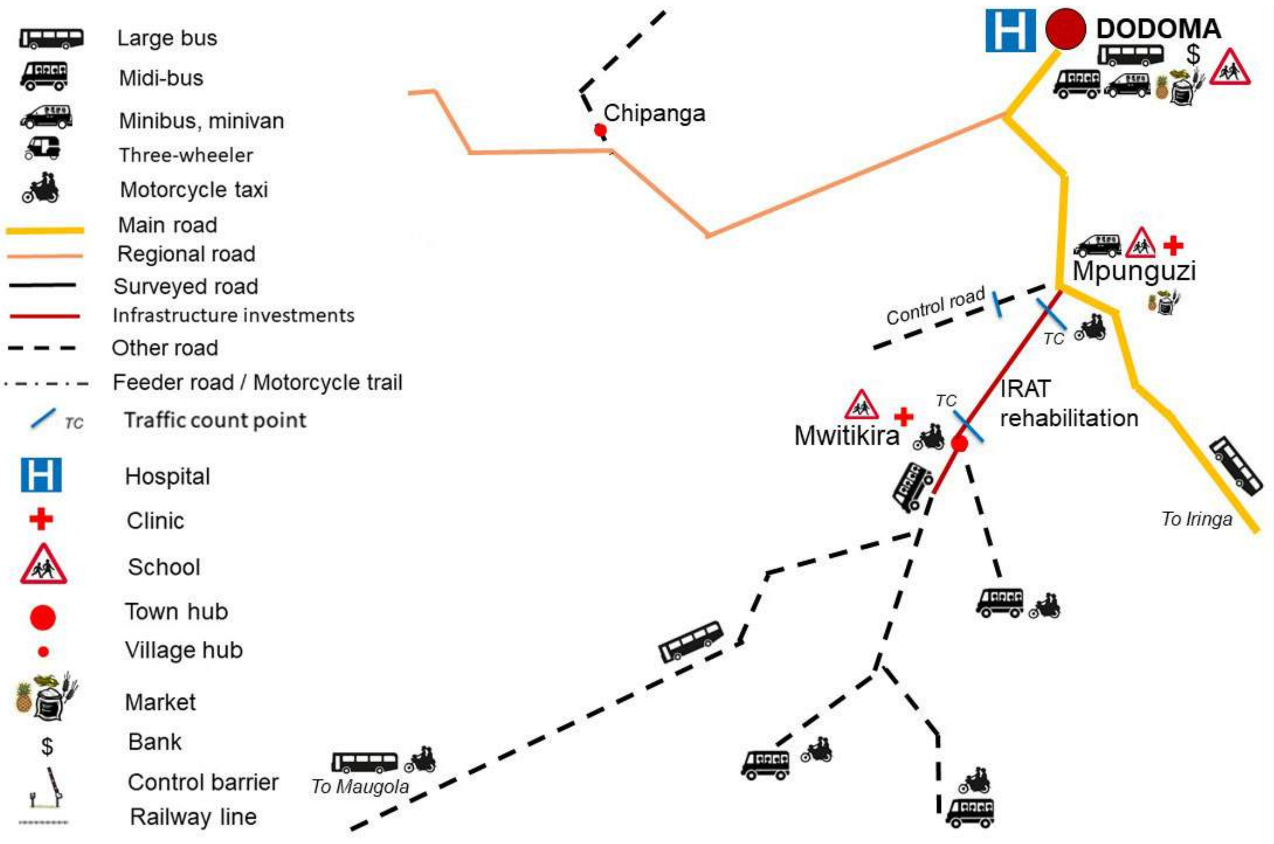
The annual maintenance budget is insufficient for the needs of the road, and this year the funds have been spent on routine maintenance, spot patching and periodic maintenance. Local communities are not involved in this work.

Travelling times have improved on this road. There is a perceived problem with cattle using the road, which is said to cause rapid deterioration of the surface.

6.2 Socio-economic and transport context

The Mpunguzi-Mwitikira starts at the junction market town of Mpunguzi (population 24,560), about 30 km south of Dodoma on the T5 trunk road to Iringa. Its position and context are shown in a diagrammatic map in Figure 74. The Mpunguzi-Mwitikira road serves at least 18 villages with a combined population of over 100,000 people. It connects with Mtitaa (population 8,604), Maugola and Manda.

Figure 74 Diagrammatic map of Mpunguzi-Mwitikira road showing context and traffic count locations



Mpunguzi benefits from its junction position with bus stops, a minibus and minivan stand and many small stores. It hosts two large markets a month, on the first and third Wednesdays, as shown in Figure 75.

Figure 75 Mpunguzi twice-monthly market at start of the Mpunguzi-Mwitikira road

The road passes through an agricultural and pastoral landscape, with a low population of farmers and livestock herders. The main crops are maize and millet with some sunflowers. There are areas of acacia trees and scrubby vegetation that are grazed and browsed by herds of cattle, sheep and goats. Near Mpunguzi, there has been some investment in small vineyards, including boreholes drilled to allow irrigation to these cash crops. The agricultural context is illustrated in Figure 76.

Figure 76 Agricultural context of the Mpunguzi-Mwitikira road showing maize, sunflowers, vines and cattle

Along the T5 highway there are frequent transport services, including minibuses that provide regular shuttle services between the Dodoma southwestern Kikuyu bus stand (see Figure 77) and Mpunguzi. The fare charged is Tsh 1000 which is USDc 1.4 per passenger-km, a low tariff since it is an excellent bituminous road with much competition.

Figure 77 Dodoma southwest bus stand at Kikuyu, three kilometres from central Dodoma

The Mpunguzi-Mwitikira road is used by several midibuses and large buses that start at the Dodoma southwest Kikuyu bus stand. They travel on the T5 highway to Mpunguzi, then turn off to Mwitikira (population 7,235) and on to various distant destinations including Maugola, 160 km from Dodoma. Other destinations, on the various rural roads that branch off towards the southwest include Mpayundue (with a monthly market), Manda and Chinugulu. Two large buses share the Maugola route, each doing one single trip each day. Two midibuses operate on the Manda route, with one serving Chinugulu. The bus fare from Mpunguzi to Mwitikira is Tsh 1000 or USDc 2.4 per passenger-km. The fare from Dodoma to Maugola is

Tsh 10,000 or USDc 2.7 per passenger-km. The prices are higher than the shuttle fares to Dodoma, reflecting long-distance bus travel on rough roads, with little competition.

Figure 78 Large bus and a midi-bus on the Mpunguzi-Mwitikira road

Only one Hiace minibus is based in Mwitikira, and this operates an early morning service into Dodoma, returning in the afternoon. However, on Mpunguzi market days, this minibus may make several trips and other minibuses and minivans generally come into Mwitikira to assist with the market surge.

Motorcycle taxis have hubs in Mpunguzi, Mwitikira and most other large villages, and are widely used, but much more expensive than the buses (Mwitikira-Mpunguzi fares may be Tsh 8,000 or USDc 19 per passenger-km).

Figure 79 Motorcycles using the Mpunguzi-Mwitikira road

6.3 Survey findings

Traffic counts were carried out at two locations on the Mpunguzi-Mwitikira road and at one point on the control road (a road to the north that also has a junction with the T5 highway). The traffic count locations were the same as those used in the earlier IRAT traffic counts and their approximate positions are included in the diagrammatic map shown in Figure 74. One location was close to Mpunguzi and the other was close to Mwitikira. The earlier IRAT traffic counts were implemented over three days (including a market day if possible) and the results were standardised to get a daily average. The 2019 counts were carried out over two days, without a market day. The results are presented in

Table 29 (near the start of road) and Table 30 (near Mwitikira close to the end of the rehabilitated section). The results for the control road have been included in Table 30. The IRAT counts put motorcycles and three-wheelers into one category and also did not distinguish between midibuses and large buses. The 2019 counts disaggregated these combined categories, but include the combined totals to allow comparison with, and possible interpretation of, the IRAT counts.

Table 29 Traffic volumes on Mpunguzi-Mwitikira road outside Mpunguzi

	Average daily traffic volumes *(12 hr)*					
Month and year	*Jul 2015*	*Mar 2016*	*Sep 2016*	*Mar 2017*	*Aug 2017*	*Nov 2019*
Survey days	*Tu, W, Th*	*Tu, W, Th*	*W, Th, Fr*	*Fr, Sa, Su*	*Fr, Sa, Su*	*Th, Fr*
Cars	18.5	3.0	32.0	33.7	13.7	6.5
Pickups and utility vehicles	15.2	9.3	19.0	19.0	9.7	18.5
Minivans, minibuses	8.1	6.7	28.5	6.7	8.3	9.5
Midibuses/Large buses	12.6	8.7	15.8	4.3	6.0	10
Midibuses						5
Large buses						5
Trucks	5.5	2.3	19.0	5.0	11.7	3.5
Tractors	1.3	2.0	10.4	21.0	1.3	1.5
Animal transport	5.5	41.0	51.0	5.3	1.0	1.5
Motorcycles and Bajajis	60.3	72.0	137.0	136.0	150.0	271
Motorcycles						270
Bajajis						1
Bicycles	52.2	64.0	115.0	136.0	69.3	36.5
Pedestrians	80.1	154.3	193.0	297.0	50.3	112.5
All motorised, excluding motorcycles	61.2	32.0	124.7	89.7	50.7	49.5

Source of 2015-2017 data: Cardno (2017)

Table 30 Traffic volumes on Mpunguzi-Mwitikira road outside Mwitikira

	Average daily traffic volumes *(12 hr)*					
Month and year	*Jul 2015*	*Mar 2016*	*Sep 2016*	*Mar 2017*	*Aug 2017*	*Nov 2019*
Survey days	*Tu, W, Th*	*Tu, W, Th*	*W, Th, Fr*	*Fr, Sa, Su*	*Fr, Sa, Su*	*Th, Fr*
Cars	25.0	5.3	14.2	18.0	4.7	12.5
Pickups and utility vehicles	17.3	3.7	14.1	17.3	8.3	7.0
Minivans, minibuses	22.7	2.7	10.8	6.7	3.7	6.5
Midibuses/Large buses	8.7	4.7	7.1	4.3	5.7	8.5
Midibuses						5.5
Large buses						3.0
Trucks	9.7	2.0	12.5	5.3	13.7	3.5
Tractors	3.0	2.0	2.7	2.3	0.7	1.0
Animal transport	1.3	2.0	4.1	2.0	0.7	0.5
Motorcycles and Bajajis	73.7	44.7	70.9	98.0	105.0	140.5
Motorcycles						139
Bajajis						1.5
Bicycles	36.3	33.7	133.5	118.7	77.7	15.0
Pedestrians	36.3	54.3	196.6	170.0	125.3	16.5
All motorised, excluding motorcycles	86.4	20.4	61.4	53.9	36.8	39.0

Source of 2015-2017 data: Cardno (2017)

Table 31 Traffic volumes near the start of the control road

	Average daily traffic volumes *(12 hr)*					
Month and year	*Jul 2015*	*Mar 2016*	*Sep 2016*	*Mar 2017*	*Aug 2017*	*Nov 2019*
Survey days	*Tu, W, Th*	*Tu, W, Th*	*W, Th, Fr*	*Fr, Sa, Su*	*Fr, Sa, Su*	*Th, Fr*
Cars	19.1	10.0	11.6	14.0	15.0	8
Pickups and utility vehicles	5.2	6.8	5.5	5.3	8.7	7
Minivans, minibuses	13.9	12.0	9.1	9.0	12.0	12.5
Midibuses/Large buses	0.0	1.7	0.0	0.0	0.0	0
Trucks	0.6	1.8	0.7	0.7	3.7	3
Tractors	2.6	2.4	4.0	2.7	2.3	3.5
Animal transport	11.7	0.6	46.4	17.7	1.0	3.5
Motorcycles and Bajajis	166.1	174.5	243.4	301.0	359.0	257.5
Motorcycles						257.0
Bajajis						0.5
Bicycles	113.8	85.3	113.6	152.3	119.0	39
Pedestrians	128.8	114.8	107.2	156.7	92.0	65
All motorised, excluding motorcycles	41.4	34.7	30.9	31.7	41.7	34.0

Source of 2015-2017 data: Cardno (2017)

As would be expected, the traffic volumes are larger close to the start of the road, and decline by Mwitikira, due to traffic associated with the intervening villages and farmlands. The midibuses and large buses are all long-distance vehicles and would be expected to be similar at both locations. Any variations are likely to be due to vehicles passing one of the counting points before or after the standard traffic counting hours.

The main change to the traffic volumes has been a steady increase in the number of motorcycles in use. This is a consistent trend seen on other roads in Tanzania and was also observed on the control road. Some of these will be motorcycle taxis and others will be only for private use. Bajajis have not yet become widely used in the area, and very few were counted in 2019.

While there have been variations in the number of minivans, minibuses, midibuses and large buses (that had not been fully disaggregated in earlier counts), the numbers have been relatively steady. The higher figures in July 2015 and September 2016 may have been due to market day surges, rather than long-term trends. The road improvements do not appear to have increased the numbers of public transport vehicles. This is consistent with the reports of users and operators. There were also no consistent trends in the number of pedestrians, bicycles or other means of transport.

Table 32 presents an analysis of the numbers of all the travelling people counted, disaggregated for gender and age. Most travellers counted used motorised transport, with low proportions of pedestrians (3-9%) and bicyclists (3%). The numbers of pedestrians and bicyclists recorded in 2019 were lower than the counts of previous years, but these numbers have varied markedly over time. The low proportion of pedestrians and cyclists was also found on the nearby control road and suggests a different travel environment to that seen in several of the other roads studied.

Table 32 Analysis of people's movements at two points on the Mpunguzi-Mwitikira road and on the control road

Analysis of people's movements based on 12-hour traffic counts, Nov 2019							
	Men	Women	Children	Total travellers	% of movements	Loads	% with loads
On section near Mpunguzi							
Motorcycles	360	38	8	406	32%	75	28%
Cyclists	39	1	1	41	3%	4	10%
Minivans, Minibuses	85	28	4	117	9%		
Midibuses, Large buses	304	166	21	491	38%		
Other transport	92	17	2	111	9%		
Pedestrians	67	36	11	114	9%	11	10%
Total	**947**	**286**	**47**	**1280**			
On section near Mwitikira							
Motorcycles	164	15	5	184	28%	40	29%
Cyclists	11	3	4	18	3%	4	23%
Minivans, Minibuses	62	44	0	106	16%		
Midibuses, Large buses	130	105	29	264	40%		
Other transport	57	16	1	74	11%		
Pedestrians	10	4	3	17	3%	2	9%
Total	**434**	**187**	**42**	**663**			
On control road							
Motorcycles	369	63	24	456	62%	90	35%
Cyclists	36	7	6	49	7%	21	53%
Minivans, Minibuses	42	46	17	105	14%		
Midibuses, Large buses	0	0	0	0	0%		
Other transport	55	4	3	62	8%		
Pedestrians	15	36	14	65	9%	24	36%
Total	**517**	**156**	**64**	**737**			
Combined counts (all roads)							
Motorcycles	893	116	36	1045			
Cyclists	85	10	11	105			
Minivans, Minibuses	188	118	20	326			
Midibuses, Large buses	434	270	49	753			
Other transport	204	37	5	245			
All wheeled transport	**1803**	**550**	**121**	**2473**			
Percent by gender/age	73%	22%	5%				
Percent using motorcycles	50%	21%	30%				
All pedestrians	**91**	**76**	**28**	**194**			
Percent by gender/age	47%	39%	14%				
All travellers	**1894**	**625**	**148**	**2667**			
Percent by gender/age	71%	23%	6%				

As on the other roads studied in Tanzania, most (71%) of the travelling people were men, followed by women (23%) and children (6%). This was the only road of the six studied where more people travelled in minibuses, midibuses and large buses than travelled on motorcycles. This seems to be because it was the only road studied that was a through route, with buses passing along the length of the road. It is likely that the majority of the bus passengers would have been in transit to and from the many villages in the hinterland, whereas the taffic counts on the other five roads would not have included many passengers in transit. The other roads studied did not have through routes operating along them. There was also less 'through traffic' on the Bahi-Mpunguzi control road (with no midibuses or large buses), and on this road, 62% of journeys were made on motorcycles. This compares to only 30% of journeys being made by motorcycles on the Mpunguzi-Mwitikira road. While the relative use of motorcycles was much lower than on other roads, they were still an important means of travel, and accounted for half the non-walking journeys made by men, 21% of women's and 30% of children's travel by vehicle.

6.4 Changes and possible explanations

There is widespread agreement that the road improvements reduced travel times significantly. Before the investments, the journey from Mpunguzi-Mwitikira on a slow-moving bus, repeatedly changing to low gears to go through potholes, could take one hour, or more. With the road improvements, that time halved, allowing a bus to travel the distance in half an hour. Motorcycles and cars could travel even more quickly, and this is reported to have led to several crashes. Anecdotal reports suggested that seven people were killed in the first two years following the road improvements. The causes of the crashes were said to be loss of control due to high speeds. In one car, two people were killed when the car went off the road and turned over. Several motorcyclists were also killed when they lost control. With the eroded surface and over-sized stone, traffic speeds are reported to have gradually decreased, but they are still much greater than before rehabilitation. During the survey work in November 2019, a large bus lost control and toppled over, as seen in Figure 80. In this case there were no fatalities.

Figure 80 Large bus that lost control on the Mpunguzi-Mwitikira road in November 2019

Road improvements can lead to increases in crashes, despite the good intentions of the agencies involved. Good straight roads tend to encourage drivers to speed, and at high speeds it is more difficult to control vehicles, when there are issues such as undulations and road surface imperfections. On gravel roads, traffic calming measures such as speed bumps tend to erode quickly and can become hazards as well.

The operators of buses, midibuses and minibuses have been pleased with the road improvements that have saved them travel time, and possibly reduced operating costs. However, all the buses and midibuses are serving distant villages and the roads beyond Mwitikira are sometimes impassable due to poor road condition. From the traffic counts is seems that there are more people travelling, but the number of daily services has not really changed. The operators do not think there is enough demand to warrant extra vehicles operating along the route. Similarly, the number of freight vehicles has not increased. It appears that the key determinant of passenger and freight transport on this route is market demand (which may be gradually growing) and that the reasonable road condition allows the market demand to be met. Had the improvements not been made, the road would have probably deteriorated further, potentially reducing or stopping services. The current road, if maintained, will have the capacity to cope with transport demand as it gradually increases with time in Mwitikira and the many villages beyond.

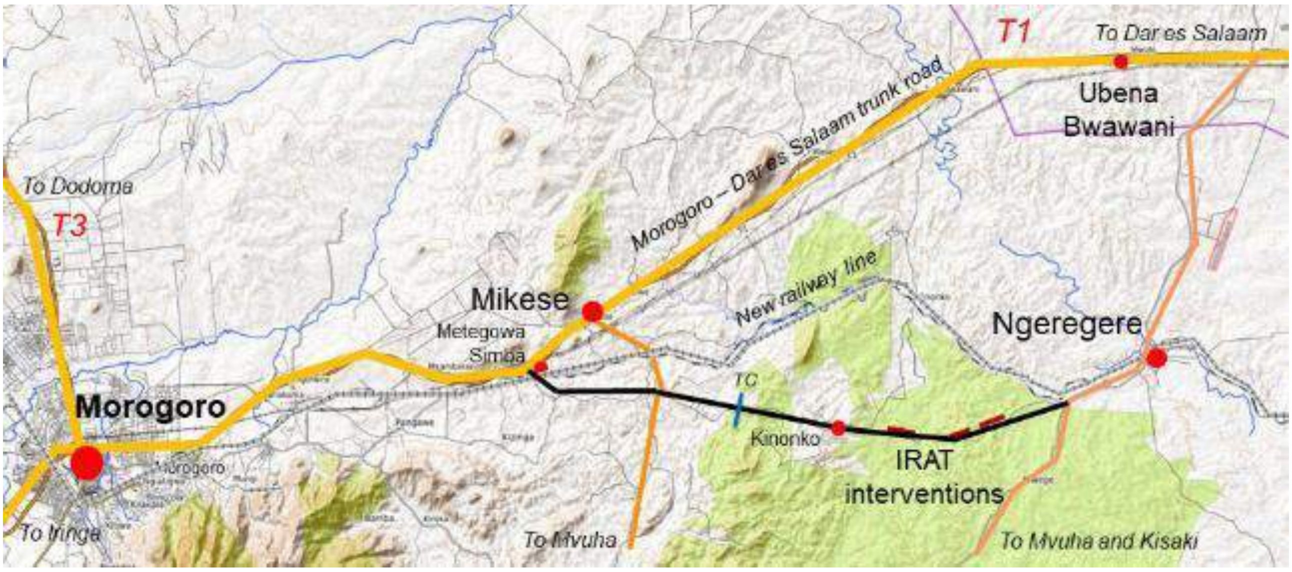
7 Metegowa Simba/Mikese-Ngeregere Road, Morogoro District

7.1 Road geography, history and condition

7.1.1 History and context

Metegowa Simba-Ngeregere road is number 52001 on the DROMAS2 database where it is described as a 32 km collector road. It branches from the main T1 Morogoro-Dar es Salaam highway about 25 km from Morogoro. It passes through small villages and gradually climbs into the hills near Ngeregere, where it meets the unpaved TANROADS regional road running from the T1 highway to Ngeregere, Mvuha and Kisaki. The final junction is about 6 km southwest from Ngeregere town. The general context of the road is shown in a diagrammatic map in Figure 81.

Figure 81 Diagrammatic map showing the context of the Metegowa Simba/Mikese-Ngeregere Road



Between 2014 and 2016, IRAT supported six ‘bottleneck’ interventions on the upper sections of the road, at points where the road was vulnerable to damage and traffic disruption. It was hoped that this investment might encourage midibuses to use this route as a shortcut to Ngeregere. Different pavement solutions were applied to the six areas, including concrete on a steep section, concrete strips, a drift/causeway, lined drains and gravel surfacing. In 2015, the investments included one solid drift, one single-cell box culvert, lined ditches, a concrete pavement on a difficult slope, and parallel concrete strips on another difficult slope. Figure 82 shows a section with side drains being constructed in 2014.

Figure 82 Side drains being constructed during IRAT rehabilitation in 2014 (left) and their state later in 2014 (right)

Source: unpublished IRAT reports

Figure 83 shows a badly eroded road section in 2015 that was replaced by a concrete pavement.

Figure 83 Eroded slope before IRAT rehabilitation in 2015 (left) and subsequent intervention (right)

Source: unpublished IRAT reports

Figure 84 shows parallel concrete strips during and after construction in 2015.

Figure 84 Parallel concrete strips constructed under IRAT rehabilitation interventions in 2015

Source: unpublished IRAT reports

Figure 85 shows photos taken during an inspection in 2016, showing that additional bottleneck problems remained despite the IRAT investments.

Figure 85 Condition of parts of the road in 2016 showing need for further bottleneck interventions

Source: unpublished IRAT reports

In 2018-2019, the TANROADs regional road from Mikese to Mvuha benefited from a major rehabilitation (not funded by IRAT). This road crossed the Metegowa Simba-Ngeregere road and provided an alternative, and better link to the T1 highway. Then, in 2019, the first section of the Metegowa Simba-Ngeregere road was severed as the new standard gauge railway construction progressed towards Morogoro (see Figure 86). This means the road now effectively starts at Mikese, using the regional road to reach it.

Figure 86 Construction of the new railway causing severance of the first section of the survey road

7.1.2 Road alignment

The first section of the road was not accessible in 2019 due to the railway construction ongoing in this area, so the 2019 survey started at the Njia Nne crossroads between the old Metegowa Simba-Ngeregere road and the rehabilitated Mikese-Mvuha regional road.

Figure 87 Map showing GPS trace of the Mikese-Ngeregere Road

7.1.3 Road sections and condition

The sections allocated to the analysis of the road were determined by the surface type. The main surface types were found to be gravel/earth, concrete and concrete strips.

Table 33 Mikese-Ngerengere road sections

No.	Chainage *(km)*	Chainage *(km)*	Length *(km)*	Surface type
1	0:00	8:27	8.27	Gravel/Earth
2	8:27	8:51	0.24	Concrete
3	8:51	17:25	8.74	Gravel/Earth
4	17:25	17:35	0.10	Concrete strips
5	17:35	22:68	5.33	Gravel/Earth

In the DROMAS2 database there is only partial condition data from 2017/18. The first few kilometres show condition which varies from fair to bad, but this is the section that is currently inaccessible due to the railway construction.

The road surface is gravel/earth throughout and starts with good shape and camber, clear and well-shaped drains. The width is approximately 5 m, with some narrower areas through villages and in less well-maintained areas. After the first 3 to 4 km the road starts to lose its shape and the drains become overgrown.

After 8 km the vegetation close to the road increases and the road narrows to about 4 m, with overgrown side drains and some soft spots on the carriageway, as seen in Figure 88. The terrain is generally rolling to hilly. Causeways and culverts are evident.

Figure 88 Soft spots on the Mikese-Ngeregere road in 2019

The concrete section is in good condition, although uneven in places, as evident in Figure 89. There is no sign of cracking or damage, so it is presumed that this was a feature of the construction. Side drains are also good, although there are some sections of drain that are becoming blocked through silting.

Figure 89 Concrete section on the Mikese-Ngeregere road in 2019

On the steeper untreated sections there is evidence of erosion, longitudinally on the carriageway, which has damaged side drains and has caused them to become blocked. This can be seen in Figure 90.

Figure 90 Eroded slopes on the Mikese-Ngeregere road in 2019

The concrete strips section is still in good condition, although there is erosion of the areas outside the concrete which means the concrete is often proud of the gravel base (see Figure 91). This can cause difficulties for bicycles and motorcycles and is a safety hazard. The side drains on the concrete strip section are lined and in good condition.

Figure 91 Parallel concrete strips showing proud concrete that is a safety problem for motorcycles

7.1.4 Road maintenance

Maintenance on this road seems to have been neglected on the remoter parts of the road, especially in the hillier areas where the lower lying parts have muddy areas and soft spots.

7.1.5 Key informant interviews on engineering issues

An engineer from the roads department in TARURA was interviewed for this road. The work carried out on this road had been helpful to the local department and the road is now accessible all year. Some potholes have developed but have been attended to by the responsible authority. Currently the road is in good condition and has benefited those living in the area. In some areas there is water crossing the road, but this is not generally a problem. Following the investments, the road has started to deteriorate, especially during the wet season.

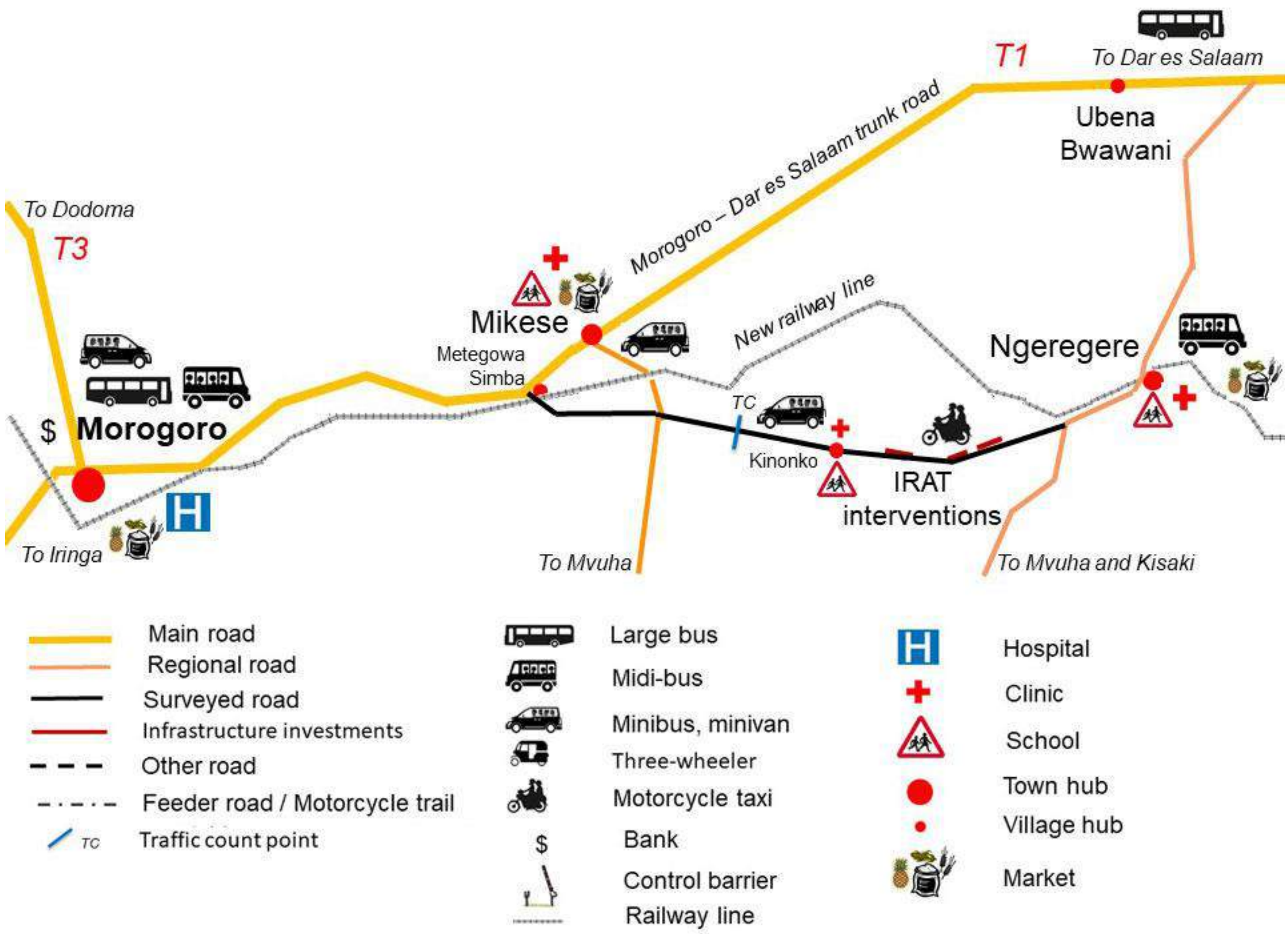
The annual budget for maintenance is between Tsh 0.8 billion and Tsh 1.3 billion per year. Small road gangs have been formed in the district and are registered to perform minor civil works. These gangs are used in maintenance works specifically for actions that do not require heavy plant and equipment. Periodic maintenance has been performed for the past financial year on this road.

Road maintenance develops the community, as well as individuals. People save time and can easily transport their goods to market in a reliable way. More vehicles are using the road because it is passable all year. The engineer did note however that more drainage structures are needed in certain places.

7.2 Socio-economic and transport context

As noted, the first section of the road from Metegowa Simba (population 1200) has been severed by the new railway line. Now, the road can be thought of as starting in Mikese, 33 km from Morogoro. Mikese is a busy small town highly influenced by its location on the Morogoro-Dar es Salaam highway. The Mikese ward has a population of 15,500. The road crosses the line of the new railway (without problems) and also the old, narrow gauge line. After 6 km, there is a crossroads at Njia Nne, with a simple control barrier monitoring forestry outputs. The surveyed road goes to the left and gradually climbs towards Ngeregere. This context is shown in Figure 92. Even before the railway severance, traffic east of Njia Nne had been increasingly using the Mikese road, which was better and quicker than taking the more direct route to Metegowa Simba.

Figure 92 Diagrammatic map of the road and its context showing traffic count locations



The start of the road has many people living close to the road in extensive villages and outlying farms. There are also many informal enterprises, with little retail stores and small workshops (carpentry, blacksmithing, motorcycle repairs). There is mixed crop farming, with maize and cassava and some tree crops. There are few livestock. After Kinkonko, an extensive village about halfway along the road, the population becomes sparse, and the area more wooded, with few villages or houses, and little economic activity other than farming and some charcoal production. The last few kilometres before the junction are in a protected forest, with no houses near the road. The IRAT investments were all made in the second half of the road, where there is a very low population density and low transport demand.

There is a Hiace minibus service that has two or three trips a day from Kikonko to Mikesse and on to Morogoro. Some minivans use the road, but these are generally hired for specific purposes or are private vehicles. There are no midibuses on this route. There is a midibus service from Morogoro (the intra-regional bus stand, located adjacent to the main bus stand) to Ngeregere. This takes the T1 highway and the longer, but better regional road to Ngeregere. This is 20 km longer, but much quicker. It also passes several small towns and large villages where passengers may wish to board. Two of the midibuses that serve this route are shown in Figure 93.

Figure 93 Midi buses on the Morogoro-Ngeregere route at Morogoro (left) and on regional road to Ngeregere

The main means of movement along the road are by walking, cycling and by motorcycles, as illustrated in Figure 94.

Figure 94 Parts of the Mikese-Ngeregere road showing its use by pedestrians, bicycles and motorcycles

Motorcycles are by far the most numerous form of motorised transport, and their use to carry passengers and freight is illustrated in Figure 95. There are motorcycle taxi hubs at the large villages such as Kinongo.

Figure 95 Motorcycles using the Mikese-Ngeregere road

7.3 Survey findings

Traffic counts were carried out at a location close to the midpoint of the Mikese-Ngeregere road. The 2019 traffic count location was comparable with that used in the earlier IRAT traffic counts and its approximate position is included in the diagrammatic map shown in Figure 92. The average daily traffic volumes are presented in Table 34. There was no associated control road.

Table 34 Traffic volumes on the Mikese-Ngeregere road

	Average daily traffic volumes *(12 hr) near the mid-point of the road*					
Month and year	*Aug 2015*	*Apr 2016*	*Oct 2016*	*Mar 2017*	*Oct 2017*	*Dec 2019*
Survey days	*Fr,Sa,Su,Mo*	*Tu,W,Th,Fr*	*Th,Fr,Sa,Su*	*Fr, Sa, Su*	*Tu, W, Th,*	*Sa, Su*
Cars	11.7	17.0	9.0	7.7	4.0	3.7
Pickups and utility vehicles	16.1	8.3	13.7	4.0	13.0	4.3
Minivans, minibuses	4.1	6.0	1.0	0.0	2.7	7.0
Midibuses/Large buses	0.0	0.0	0.3	0.0	0.0	0.0
Trucks	3.5	0.0	2.0	0.0	0.7	0.3
Tractors	2.5	8.3	2.7	2.3	2.3	4.3
Animal transport	0.0	0.0	0.0	0.0	0.0	0.0
Motorcycles and Bajajis	274.4	186.7	275.7	376.7	298.0	395.3
Motorcycles						395.3
Bajajis						0.0
Bicycles	44.5	50.7	37.3	34.0	37.3	61.3
Pedestrians	37.3	93.3	42.0	57.0	48.0	273.3
All motorised, excl. motorcycles	37.9	39.6	28.7	14.0	22.7	19.6

Source of 2015-2017 data: Cardno (2017)

The traffic counts are dominated by motorcycles which have been increasing over the years. There were about 400 motorcycle movements a day and only 20 other vehicles. The minivans and minibuses recorded travel west from Kikonko to Mikesse and on to Morogoro. They only operate (infrequently) on the lower section of the road. The other vehicles are a few cars and pickups related to local businesses, charcoal carrying, local dignitaries and various organisations and services. Bajajis do not yet operate on this road. This road had the lowest proportion of 'conventional' motorised vehicles of all the roads studied in this project, with 97% of the recorded traffic count movements being motorcycles, pedestrians or bicycles. An analysis of the movements of all recorded travellers on the Mikesse-Ngeregere road is shown in Table 35.

Table 35 Analysis of people's movements near the mid-point on the Mikese-Ngeregere road

	Analysis of people's movements based on 12-hour traffic counts, Nov 2019						
	Men	**Women**	**Children**	**Total travellers**	**% of movements**	**Loads**	**% with loads**
Motorcycles	407	70	31	508	53%	109	27%
Cyclists	52	3	6	61	7%	17	
Other transport	62	28	17	107	11%		
Pedestrians	103	88	83	273	29%	31	11%
Total	**625**	**189**	**136**	**950**		**157**	
All wheeled transport	**522**	**101**	**53**	**677**			
Percent by gender/age	77%	15%	8%				
Percent using motorcycles	65%	37%	23%				
All pedestrians	**103**	**88**	**83**	**273**			
Percent by gender/age	38%	32%	30%				
All travellers	**625**	**189**	**136**	**950**			
Percent by gender/age	66%	20%	14%				

Of the people recorded travelling, 53% travelled on motorcycles, 29% were pedestrians and 7% used bicycles. Eleven percent of travellers rode in minibuses and minivans, or private vehicles. Most (66%) of recorded travellers were men, followed by women (20%) and children (14%). Men were the main travellers on motorcycles (77%) followed by women (15%) and children (8%). The fact that men are the main people moving along the road and account for most people using wheeled transport is similar to the other roads studied. The numbers of pedestrians are much more evenly balanced, with 38% men, 32% women and 30% children.

7.4 Changes and possible explanations

The IRAT investments did improve the passability of the upper half of the road, which had been very poor. However, it became evident during the IRAT visits to review the investments soon after they were made that other ‘bottlenecks’ had developed, and even more investments would be required to make the road convenient to use. However, there has been little major investment since that of IRAT.

The main notable change in road use has been the substantial increase in motorcycles. This is in line with similar growth seen on the other surveyed roads (and on control roads) and is unlikely to be associated with the IRAT road improvements. Motorcycle taxis are currently increasing everywhere in rural Tanzania. They are proving to be appropriate to meet the small transport demand on rough rural roads, being highly flexible and generally better at coping with poor quality roads than many ‘conventional’ vehicles.

There does not seem to have been any significant increase in other traffic, and there are no transport services (other than motorcycle taxis) that use the upper half of the road where all the IRAT investments were made.

The IRAT investment proposals had envisaged the road could become an important transport services link between Morogoro and Ngeregere. It would represent a significant shortcut, being 20 km shorter from Morogoro to Ngeregere than travelling along the T1 highway and on the regional road going to Mvuha and Kisaki. However, transport operators and key informants reported at the time of the IRAT investments, and to this day, that the road width was too narrow to allow midi-buses to easily pass. This is particularly true in the rainy season, when vehicles can get stuck at the edges of the road. The road is still very rough, and can become muddy and slippery and it is still subject to localised flooding. More importantly, the transport demand in the upper half of the road is tiny, with only a few houses and no markets. On the lower section of the road, there were more people and some transport demand to go to Morogoro. There was little or no demand along the lower section of the road to go up the road to Ngeregere.

Some people living in Ngeregere want to travel to Morogoro, so that removing 20 km from their travel distance might seem attractive. However, with the condition of the road now (and that immediately after the IRAT investments), their journey time would be much longer, more uncomfortable and with a greater risk of getting stuck. For the operator, the potential to have other people board along the route would be small, and less than the possibilities along the T1 highway. There are suggestions that the regional road to Ngeregere will be bituminised soon, and it will remain an important strategic road serving the Ngeregere airforce base. The continued improvement and maintenance of the regional road will reduce further the likelihood that transport services will operate all the way along the surveyed road.

The area served by the lower one third of the road appears to be economically active, with many enterprises in addition to the dominant occupation of farming. It is close enough to the growing city of Morogoro to become even more active, and have people commuting to the city from rural dwellings. This may mean that the current two or three minibuses a day could increase over the years, with midibuses replacing the minibuses. However, this transport market would not require access to the upper sections of the road for a long time, if at all. Few, if any, of the residents in the lower sections are likely to want to travel to Ngeregere. The communities all ‘face’ Morogoro, with Mikese as a smaller, closer destination for basic shopping, marketing and services.

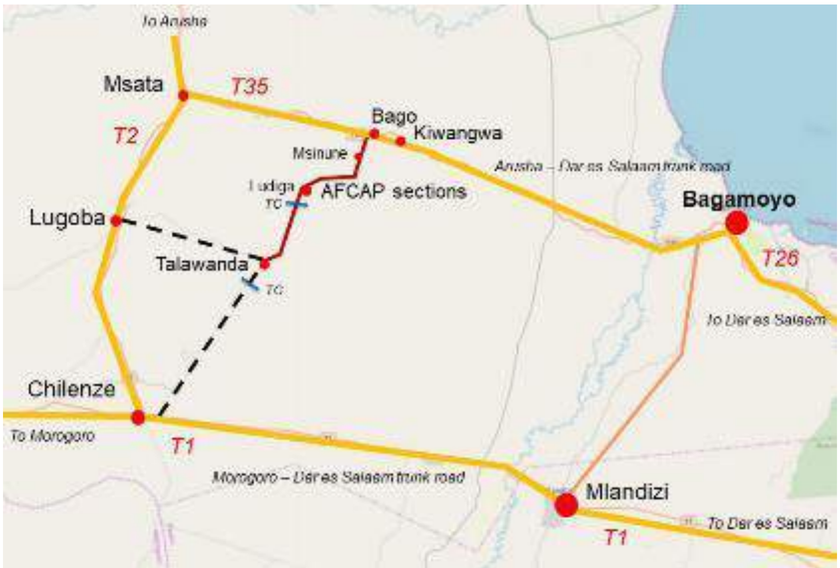
8 Bago-Talawanda Road, Bagamoyo District

8.1 Road geography, history and condition

8.1.1 History and context

The road is located in the coastal region of the Bagamoyo District (road 69018 in the DROMAS2 database) and illustrates typical problems of coastal regions such as sandy subgrades and flat marshy areas of black cotton soils. The road is 20.2 km long and connects the small villages of Bago and Talawanda, passing through a number of other settlements including Msinune and Ludiga, as shown in Figure 96.

Figure 96 Diagrammatic map of the Bago-Talawanda road and its context



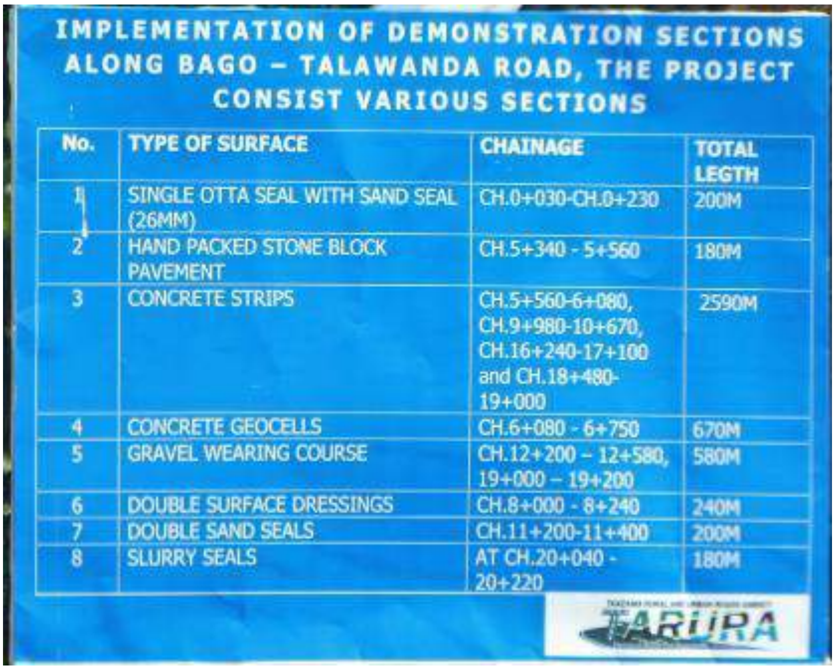
In 2009, the road was difficult to pass in the rainy season, with some eroded and/or slippery sections, as shown in Figure 97.

Figure 97 Examples of road condition in 2009 before AFCAP1 intervention

Source: Roughton, 2013b

In 2010-2011, this road was rehabilitated by Roughton under a contract with AFCAP (Phase 1). The investment was made in the context of a research project designed to provide a trial road to test various surface types. The aim was to identify the strengths and weaknesses of each design, and to establish which engineering measure was best at withstanding the prevailing climatic and traffic conditions. The surfaces included various bituminous seals, gravel, geo-cell blocks, packed stone and concrete strips. Between some of the demonstrations were some gravel and earthen sections. A TARURA sign explaining the different interventions and their lengths is shown in Figure 98.

Figure 98 TARURA sign at Bago explaining the demonstration sections along the road



IMPLEMENTATION OF DEMONSTRATION SECTIONS ALONG BAGO – TALAWANDA ROAD, THE PROJECT CONSIST VARIOUS SECTIONS

No.	TYPE OF SURFACE	CHAINAGE	TOTAL LEGTH
1	SINGLE OTTA SEAL WITH SAND SEAL (26MM)	CH.0+030-CH.0+230	200M
2	HAND PACKED STONE BLOCK PAVEMENT	CH.5+340 - 5+560	180M
3	CONCRETE STRIPS	CH.5+560-6+080, CH.9+980-10+670, CH.16+240-17+100 and CH.18+480-19+000	2590M
4	CONCRETE GEOCELLS	CH.6+080 - 6+750	670M
5	GRAVEL WEARING COURSE	CH.12+200 – 12+580, 19+000 – 19+200	580M
6	DOUBLE SURFACE DRESSINGS	CH.8+000 - 8+240	240M
7	DOUBLE SAND SEALS	CH.11+200-11+400	200M
8	SLURRY SEALS	AT CH.20+040 - 20+220	180M

The area is in gently rolling hills and much of the road has a gradient of about 5%. There are no steep sections and little erosion is present. There are many waterways which cross the road. Small bridges and drifts have been constructed to deal with these and are largely effective in doing so. Several culverts can also be seen.

Most of the trial sections have been effective and still provide a good to fair riding quality with all-season access. The various poor areas along the road are related to drainage and are outside of the surfacing trial sections.

8.1.2 Road alignment

The rehabilitated road followed an existing alignment from Bago, on the T35 Bagamayo–Msata road, to Talawanda, as can be seen in Figure 99.

Figure 99 Map showing GPS trace of the Bago-Talawanda Road

8.1.3 Road sections and condition

The road has been divided into sections in accordance with surface type, as shown in Table 36. The chainages for these sections have been set using a GPS-based odometer and so are approximate.

Table 36 Bago-Talawanda road sections

No.	Chainage (km)	Chainage (km)	Length (km)	Surface type
1	0:00	0:18	0.18	Bituminous seal: single Otta seal with a sand seal
2	0:18	5:30	5.12	Gravel
3	5:30	5:55	0.25	Hand packed stone
4	5:55	6:04	0.49	Concrete strips - reinforced
5	6:04	6:70	0.66	Block paving - geocells
6	6:70	8:00	1.30	Gravel
7	8:00	8:26	0.26	Bituminous: double surface dressing
8	8:26	9:97	1.71	Gravel
9	9:97	10:67	0.70	Concrete strips - unreinforced
10	10:67	11:16	0.49	Gravel/earth
11	11:16	11:39	0.23	Bituminous seal: double sand seal
12	11:39	16:25	4.86	Gravel/earth
13	16:25	17.:1	0.86	Concrete Strips - reinforced
14	17.:1	18:48	1.37	Gravel/earth
15	18:48	18:76	0.28	Concrete Strips - reinforced
16	18:76	19:85	1.09	Gravel
17	19:85	20:05	0.20	Bituminous seal: slurry seal

In the DROMAS2 database, the road is shown as being in fair condition throughout in 2017/18, which is the latest data available.

Single Otta seal with a sand seal

The road starts at the Bago junction with a bituminous paved section which is a single Otta seal with a sand seal above. This section is in fair condition with a few small potholes. There is some bleeding, but this is not uncommon for an Otta seal surface, especially as it has had an additional bituminous layer applied above. The condition of this section in 2011, 2015 and 2019 is illustrated in Figure 97.

Figure 100 Otta seal section near Bago in 2011, 2015 and 2019 (L-R)

Gravel surface

From the initial bituminous paved section to 5.3 km the surface varies between earth and gravel. The road passes through a small village and intersperses between gravel and an earthen surface. The earthen surfaces tend to be quite coarse or sandy. Width is generally 3-3.5m. Through the village the road appears to be maintained, but outside the village there are some areas of bad erosion, which would make the road difficult to pass in the wet season. Drifts, rather than culverts, are mainly used in the valleys. Examples of the condition of gravel sections in 2011, 2015 and 2019 are shown in Figure 101.

Figure 101 Gravel sections in 2011 (left), in 2015 (centre) and 2019 (right)

Hand packed stone

From 5.3 km there is a surface of hand packed stone. This was originally constructed without kerbs as shown in Figure 102 (far left) in a photo taken in 2011, soon after construction. The voids between the stones were filled with sand. However, this system did not survive a year before failing. The sand was washed away, and with vehicle movements, the stones rose up towards the edge and separated from each other as shown in Figure 102 (centre and right).

Figure 102 Hand-packed stone section in 2011 (far left), in 2012 (centre) and 2015 (right)

From 2012, all vehicles using this short section had problems. Motorcycles developed smooth side trails along the shoulder, while other vehicles including light trucks started to use side trails alongside the road to avoid this very rough and uneven surface, as shown in Figure 103.

Figure 103 Transport responses to failed section showing motorcycle shoulder trails and truck on side trail

The failed section had to be repaired, and this time high kerbs were installed to retain the surface. Gaps were left in the kerbs every 5 m to facilitate drainage into side drains, which are wide and flat alongside the road (see Figure 104). This system has survived for several years, although the surface is uneven, mainly due to the nature of the materials and the way the stone was dressed. It is still in good condition with little sign of recent deterioration. However, there is vegetation growing between the stones in the non-trafficked areas, and if left to grow this will eventually damage the surface.

Figure 104 Re-habilitated packed stone section in 2016 (left) and 2019 (right)

Reinforced concrete strips

There are two sections with parallel concrete strips, which are joined by concrete connectors between the strips. The first section is not reinforced, while the second section was constructed with reinforced concrete. On both sections, the concrete is in good condition but there is erosion of the gravel base alongside the strips, which causes a slight vertical edge, as can be seen in Figure 105. This is a risk to motorcycles and bicycles that have to move on and off the strips to avoid other vehicles.

Figure 105 Parallel concrete strip sections in 2011 (left) and in 2015 (right)

Since their construction, the connectors between the parallel strips have been proud of the surrounding gravel, with vertical edges at right angles to the road (creating small kerbs to be crossed by traffic using the centre of the road). This would pose particular problems to three-wheelers since their front wheels would repeatedly have to climb these kerbs. There is also some vegetation growing on the gravel base between and alongside the strips. While there was a construction difference between the reinforced and non-reinforced sections, in 2019 there was no obvious visible difference between the sections that could be attributed to the reinforcement. There was some breakup of both construction types, as can be seen in Figure 106 where the left photo is of the reinforced section and the right photo is of the unreinforced section.

Figure 106 Parallel concrete strips in 2019, showing proud connectors and some sharp edges due to strip damage

Block paving or geocells

There is a section of block paving or geocells, as shown in Figure 107. The blocks have been cemented together at the edges of the road to form a type of kerb, which retains the blocks in place. At the start and end of the section there is damage where vehicles have run over the shoulder to access the carriageway, but apart from that the section is in fair condition and is motorable all year. The surface is uneven due to the slight settlement of some of the blocks, and this shows as slight rutting in some areas. There is vegetation growing between the blocks that are not in the main traffic lines, which will eventually cause damage if left unchecked. Earthen drains are in place and are effective.

Figure 107 The geocell section in 2011 (left), 2015 (centre) and 2019 (right)

Double surface dressing

Another trial section of approximately 250 m constructed with a double surface dressing on a gravel base. This is shown in Figure 108. The surface is generally in good condition, with few cracks or potholes. There is some encroachment by vegetation at the edges of the road, but the camber is maintained and there does not appear to be any deterioration, apart from where the end of the bituminous paved section meets the adjoining gravel section, which is to be expected. The surface still has a good riding quality.

Figure 108 The double surface dressing section in 2011 (left), 2015 (centre) and 2019 (right)

Double sand seal

Another road section has a double sand seal. This surface was laid on a gravel base. This section runs through a village and it is probable that this section was used here to reduce dust for the inhabitants. The surface is still smooth, and is in fair condition, but with some erosion especially at edges and at junctions where vehicles access the main carriageway, as can be seen in Figure 109.

Figure 109 The double sand seal section in 2011 (left), 2015 (centre) and 2019 (right)

The villagers appreciated the dust reduction properties of the double sand seal, but not the scope it provided for fast but quiet traffic movements. They therefore, on their own initiative, created three traffic calming humps, before, inside and after the village, as can be seen in Figure 109 (centre) and Figure 110. One of these involved digging a trench across the road.

Figure 110 Village attempts at traffic calming on a double sand section in 2015 (left) and in 2019

Slurry seal

The final section of road as it approaches Talawanda is slurry seal. This is badly deteriorated, where much of the surface is missing and the base is exposed. Figure 111 shows the condition of this section in 2011, 2015 and 2019, showing that much of the surface had eroded by 2015. Despite this, deep potholes have not developed, which suggests that this section had a good foundation. It is also well drained and has low traffic levels. The side drains are overgrown but seem to be functional as the road has maintained its shape. There is no apparent maintenance, judging by the condition of the surface. The section is short, at approximately 200 m, and the road is narrow at the start, approximately 3m wide.

Figure 111 Slurry seal section in 2011, 2015 and 2019

Drainage issues

Side and cross drainage is effective and is in good to fair condition throughout the road. There are several drifts at key water crossing points, constructed in concrete. All are in good to fair condition and serve an important purpose to keep the road open all year. There are signs of erosion on the earthen sections where some culverts appear to be blocked.

8.1.4 Road maintenance

Maintenance is evident on this road, although improvements could be made if more funds could be made available. Maintaining effective drainage is key to keeping this road open all year. Some farmers clear the vegetation growing on the road shoulders adjacent to their fields, as shown in Figure 112.

Figure 112 Farm workers clearing vegetation on road shoulders adjacent to their fields

8.1.5 Key informant interviews on engineering issues

An engineer from TARURA, based at Chalinze, was interviewed for this road. Before the work, the road was impassable for periods in the wet season. Since the work in 2010/11 it has remained as an all-season road. The main issues remaining are with water crossings, depending on the season and the intensity of rainfall. When rainfall is higher there tends to be less traffic. Most maintenance is routine and spot improvement. The recent budgets have been TSh 12.5 million for 2017/18 and TSh 36 million for 2018/19.

The local communities are given employment when maintenance is required. The communities also provide the roads department with information on the condition of the road. Over the past three years routine maintenance has been applied each year, and spot improvements have been implemented twice. Maintenance has made a difference to the road by improving riding quality, making travel more comfortable and reducing travel times.

Local services have increased, specifically dispensaries and growth in the agricultural sector. Different types of vehicles are using the road, including pickups, motorcycles, saloon cars and trucks. The main remaining problem is budget and having enough funds to maintain the road properly. More budget is required to maintain the road surface and drainage.

8.2 Socio-economic and transport context

The Bago–Talawanda road (20 km) starts at Bago junction village, adjacent to Kiwangwa, a small town with shops and bus stops for passing public transport. Kiwangwa ward has a population of 15,000. Bago is 44 km from Bagamoyo town along the Bagamoyo–Msata trunk road (65 km). From Bago, the surveyed road traverses rolling, hilly terrain to Talawanda village (20 km). Villages along the way include Msinune (with a primary and secondary school and clinic) and Ludiga (with a primary school). Talawanda also has a primary school, a secondary school and a small clinic. Its population, including the surrounding ward, is 9,300.

Along the first half of the road are several medium size pineapple plantations, and many banana and plantain plants, as illustrated in Figure 113. The pineapples are an important cash crop, and the number of informal plantations is increasing.

Figure 113 Pineapple plantations on the Bago-Talawanda road and use of motorcycle for pineapple transport

While the first part of the road has many crop fields (maize, cassava, beans, groundnuts), the agriculture becomes more extensive towards Talawanda, with shifting cultivation and secondary bush, grazed by pastoralist's small herds of cattle, sheep and goats, as shown in Figure 114.

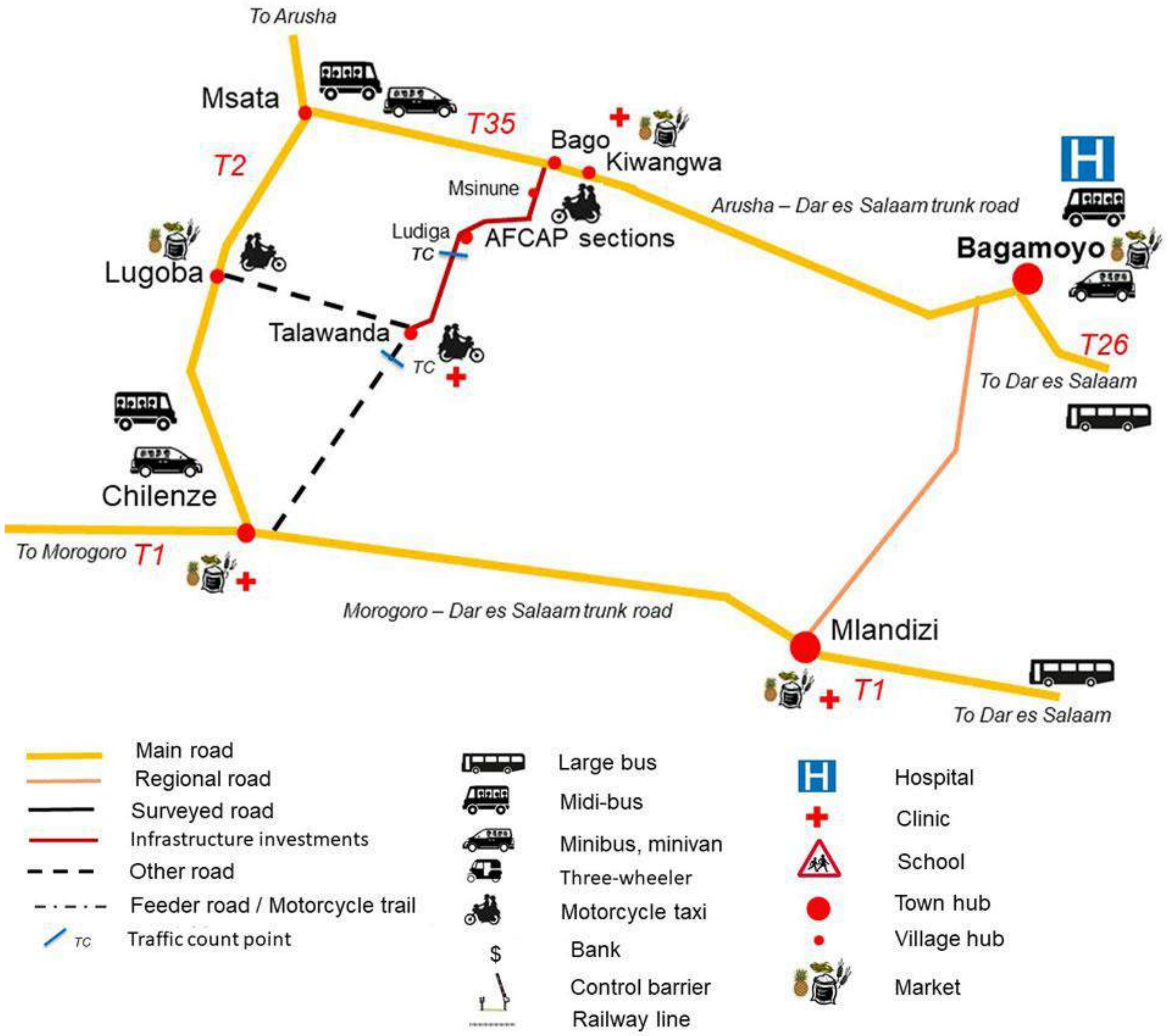
Figure 114 Second part of Bago-Talawanda showing secondary bush and pastoralist herds

The transport services on the surrounding roads include long-distance buses along the trunk roads, including Dar es Salaam to Moshi and Arusha to the north, and Dar es Salaam to Morogoro and Dodoma to the south. Local midibus, minibus and minivan services operate to and from the Bagamoyo bus stand, and go to many destinations including Chilenze, via Bago, Msata and Lugoba. These locations are shown in Figure 115. The various transport services are supervised by their associations, in cooperation with the Bagamoyo bus stand officials, and operate by rota throughout the day.

In past years, there have been some attempts to introduce minibus or minivan services to Talawanda, and possibly onward to Chilenze or Lugoba. The operators reported that prior to 2011, the trial services to Talawanda were abandoned due to the poor road. After the road improvements, road condition was not the main issue, but the problem was the lack of market demand. There are some minivans with route licences between Bagamoyo and Talawanda, but these voluntarily terminate at Kiwangwa and operate shuttle services along the main road.

The only regular transport services along the Bago-Talawanda road are motorcycle taxis, and these have hubs at Bago, Msinune, Ludiga, Talawanda and Lugoba (and other junctions on the highways). A diagrammatic map providing an impression of the various transport services available in the area is shown in Figure 115.

Figure 115 Diagrammatic map of the Bago-Talawanda road showing key transport services hubs



The main means of wheeled transport used on the road are motorcycles and bicycles. The riders of motorcycles and bicycles often carry freight loads, including agricultural produce and charcoal. Examples of people using bicycles are shown in Figure 116.

Figure 116 Bicycle users on the Bago-Talawanda road

8.3 Survey findings

Traffic counts were carried out at Ludiga village, around the mid-point of the Bago-Talawanda road. This traffic count point had also been used in the previous traffic counts undertaken by Roughton as part of their AFCAP project. The Roughton 12-hour counts were continued for a full week, while the 2019 counts were undertaken over two 12-hour-days. The 2019 survey also included a count on the road from Talawanda to Chalize which is the continuation of the Bago-Talawanda road. The approximate positions of the traffic count locations are shown in Figure 115. The traffic count statistics (average daily movements) are presented in Table 37.

Table 37 Traffic volumes on the Bago-Talawanda road

	Average daily traffic volumes *(12 hr)*						
	Near the mid-point of the Bago-Talawanda road						**Chalinze road**
Month and year	*Sep 2010*	*Aug 2011*	*Apr 2012*	*Sep 2012*	*Apr 2013*	*Oct 2019*	*Oct 2019*
Survey days	*1 week*	*1 week*	*1 week*	*1 week*	*1 week*	*W, Th*	*W, Th*
Cars	0.7	1.5	10.5	1.5	5.2	0	0.5
Pickups and utility vehicles	4.6	4.6	14.6	4.6	9.1	10	0.5
Minivans, minibuses	0.0	0.0	0.0	0.0	0.0	2.5	0.0
Midibuses/Large buses	0.0	0.0	0.3	0.0	0.0	0.0	0.0
Trucks	0.0	0.0	12.8	1.8	5.5	0.0	0.5
Tractors	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Animal transport	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Motorcycles	41.5	150	221.7	233	229.3	253.5	151.5
Bajajis						1.5	0.0
Bicycles	174.3	186.7	201.8	259.3	170.8	62	14
Pedestrians	199.5	161.8	308.6	590.9	431.9	426	202
All motorised, excl. motorcycles	5.3	6.1	38.2	7.9	19.8	12.5	1.5

Source of 2010-2013 data: Roughton (2012, 2013a, 2013b).

The traffic counts confirmed that motorcycles are the dominant form of motorised transport, and these have increased greatly over time, although the increases since 2012 have not been as dramatic as on many other roads studied. Apart from motorcycles, there were fewer than 20 motorised vehicles a day. While more vehicles are using the road than before the rehabilitation, there does not seem to be much underlying growth in traffic. The minivans recorded in 2019 were likely to be private vehicles or chartered services and were not public transport services.

Bajajis have not yet started to make an impact on this road. They may start to assist with transport services on the parts of the road close to Bago. It may be difficult for them to operate on the parallel concrete strips as between these are concrete connectors, which may be proud, with vertical surfaces of up to 100 mm above the surrounding gravel. This is where the front wheel would be expected to travel. While bajajis can slowly mount kerbstones, to have long sequences of these would be slow and uncomfortable.

There are few trucks operating along the road. Light trucks are sometimes used to collect charcoal and farm produce and/or to deliver supplies to schools and various utilities (electricity is being brought into Talawanda). It appears that most of the freight movements, such as the transport of charcoal and pineapples are undertaken by motorcycles and pickups.

The ongoing road to Chalinze is mainly operated by motorcycles, with quite large motorcycle volumes (more than half those on the improved Bago-Talawanda road) but very few other vehicles.

An analysis of people's movements is presented in Table 38. Nearly all of the journeys (92%) along the Bago-Talawanda road involve walking (46%), motorcycles (39%) and bicycles (7%). A quarter of people travelling were children, and many of these would be walking to their schools: children accounted for half of the pedestrians counted. Over half (58%) of people travelling were men, three times the proportion of women travellers (17%). Most (78%) of the people travelling on motorcycles were men, and motorcycles accounted for 82% of men's travels along the road. Motorcycles were also important for the travels of women (76% of recorded journeys) and children (61% of journeys counted).

Table 38 Analysis of people's movements at the midpoint on Bago-Talawanda road and on road to Chalinze

Analysis of people's movements based on 12-hour traffic counts, Nov 2019							
	Men	Women	Children	Total travellers	% of movements	Loads	% with loads
Ludiga (mid-point)							
Motorcycles	303	46	7	356	39%	22	8%
Cyclists	50	2	12	64	7%	6	9%
Bajajis	4	3	0	7	1%	1	67%
Other transport	39	28	1	68	7%		
Pedestrians	155	56	216	426	46%	7	2%
Total	**551**	**135**	**236**	**922**		**35**	
On Talawanda-Chalinze road							
Motorcycles	198	57	15	270	38%	35	23%
Cyclists	12	1	1	14	2%	5	36%
Bajajis	0	0	0	0	0%		
Other transport	7	0	0	7	1%		
Pedestrians	52	44	107	203	60%	4	1%
Total	**269**	**102**	**123**	**494**		**44**	
Combined counts (all roads)							
Motorcycles	501	102	22	625			
Cyclists	62	3	13	77			
Bajajis	4	3	0	6			
Other transport	46	28	1	75			
All wheeled transport	**613**	**135**	**36**	783			
Percent by gender/age	78%	17%	5%				
Percent using motorcycles	82%	76%	61%				
All pedestrians	**206**	**100**	**323**	**628**			
Percent by gender/age	33%	16%	51%				
All travellers	**819**	**234**	**358**	**1411**			
Percent by gender/age	58%	17%	25%				

The main reasons for the people's journeys are shown in Table 39. The main reasons for travelling were to go to local shops and markets and to town as well as visiting friends and relatives. As with the other roads surveyed, few people reported using transport services to travel to health services. None mentioned farming, as their farms were reached on foot or by bicycle. There were no significant gender differences in travel destinations, although Table 38 shows that most people travelling (as recorded on the traffic counts) were men.

Table 39 Reasons for taking transport services reported on the Bago-Talawanda road, Bagamoyo District

Journey purpose	Women	Men	All
Local market or shops	5	7	12
Visit to town shops, banks, offices	6	6	12
Visiting friends or relations	3	9	12
Health	2	1	3
Religious meeting	1	0	1
Total	**17**	**23**	**40**

8.4 Changes and possible explanations

The AFCAP investments improved the road which became an all-season route. Traffic has increased, but the only transport services regularly operating are motorcycle taxis. These have increased greatly since the road improvements in 2011-2012, but comparable growth has been seen on most other roads in rural Tanzania. Interestingly, the slight growth since 2013 appears less than the underlying trend throughout Tanzania. This may be due to weak local economic growth and little increase in transport demand.

Figure 117 Motorcycle taxis (left) and motorcyclists carrying charcoal to urban centres (right)

Talawanda has a population of only 9,300, and its population has been decreasing in recent years. Key informants in Talawanda reported that most families concentrate on farming and are not used to travelling much. Perhaps there is a vicious circle with poor transport demand limiting transport services, and poor transport services restricting the growth of transport demand.

Talawanda is far from Bagamoyo (64 km) and most people do not need to go regularly to the district headquarters. The nearest shops and trading facilities are at Bago/Kiwangwa (20-22 km), Lugoba (17 km) and Chalinze (24 km). People often travel to these locations for services and onward connections to other towns such as Mlandizi. The road to Luboba is poor and mainly used by motorcycles. The road to Chalinze is passable all year, but traffic is low due to little transport demand. Given that there are no minibus or similar services from Talawanda, people reported that when they did travel, they tended to take motorcycle taxis to and from Luboba that has the closest facilities and onward transport services. In contrast, people living in Ludiga (the midpoint of the road) travel to facilities and transport services at Bago/Kiwangwa, as this is much closer to them (10-12 km).

According to transport operators based at the Bagamoyo bus stand, on several occasions in the past ten years, midibus, minibus and minivan operators have tried to serve the Talawanda road. This was confirmed by residents in Talawanda who recalled various initiatives that all ceased after a few weeks. Operators found there was insufficient transport demand, so they were not operating to their full capacity. There were not many passengers and/or loads on each trip. One recent attempt involved a minibus that normally operated on the Bagamoyo-Chalinze route (via Msata). The operator wanted to run some services between Bagamoyo and Chalinze via Talawanda. This routing is more direct and would save about 15 km. The road condition was significantly worse than the highway route, but this was not the main issue. The real problem was the low market demand. There were few people wanting to join the services from Talawanda (or along the route). In contrast, along the bituminous trunk roads, there was demand in many of the towns along the road and, despite the competition from the various frequent transport services on the highway, loads were higher than passing via Talawanda. Similarly, a minivan operator currently has a route license from Bagamoyo to Talawanda but keeps to the main roads, running a shuttle service from Bagamoyo to Kiwandwa (adjacent to Bago). The minivan only goes along the road if it is chartered by a person or a group.

9 Discussion of emerging issues

9.1 The study and its limitations

The study investigated changes in transport services on six low volume rural roads, following various investments in the road infrastructure. Through recent and historic traffic count data, and surveys of transport users, operators and key informants, it has been possible to present six case histories involving a range of road investments. These provide details of the infrastructure changes, illustrated by historic and recent photos, and the changes to traffic volumes and the transport services. This has allowed observations to be made and some conclusions drawn.

As their name implies, low-volume rural roads have low traffic volumes. Some components of traffic, such as timetabled bus services, can be quite consistent with, say, two buses a day throughout the year, except when the road is impassable. However, most traffic fluctuates greatly with market day surges. For example, on the Bahi Chipanga bridge road, minibus and midibus services increased twelve-fold on market days. Markets in Tanzania may be weekly, monthly or at other intervals, and so may, or may not, be on the same day of the week each time. There are also seasonal issues, with traffic influenced by the weather and by crop cycles. Major weddings, funerals and political meetings can lead to traffic surges, as can religious celebrations and national holidays. Traffic movements can be suppressed by fuel shortages and disease outbreaks (human or animal). There are also human issues as, despite training, enumerators cannot always be relied upon to correctly distinguish vehicle types and to maintain reliable observations throughout the day. All these uncertainties make it very difficult to compare traffic count data sets from different years, and this study has reported some major fluctuations in traffic, that have not always been easy to interpret. Similarly, despite enumerator training, not all questions to respondents are asked in clear ways that lead to reliable responses. However, despite the limitations of the study, there have been some clear lessons learned, backed up by the survey data.

9.2 Overview of investments and consequences

The investments in six different roads and the resulting changes to traffic and transport services have been presented in the previous report sections. A simplified overview of some of the issues raised is presented in Table 40. These summaries need to be treated with caution and interpreted in the light of the much more detailed information presented in the descriptions and analyses in the previous sections.

It should be stressed that the issues summarised in Table 40 have been identified with the great benefit of hindsight and research. The various prioritisation and investment decisions may have been made in relation to different criteria than those discussed here. However, there are several clear issues emerging: the increased use of motorcycles, the lack of traffic growth, the lack of change or growth of 'conventional' transport services, the importance of road connectivity and the need for maintenance to retain the benefits of the road investments. These and other issues will be explored in the subsequent sections.

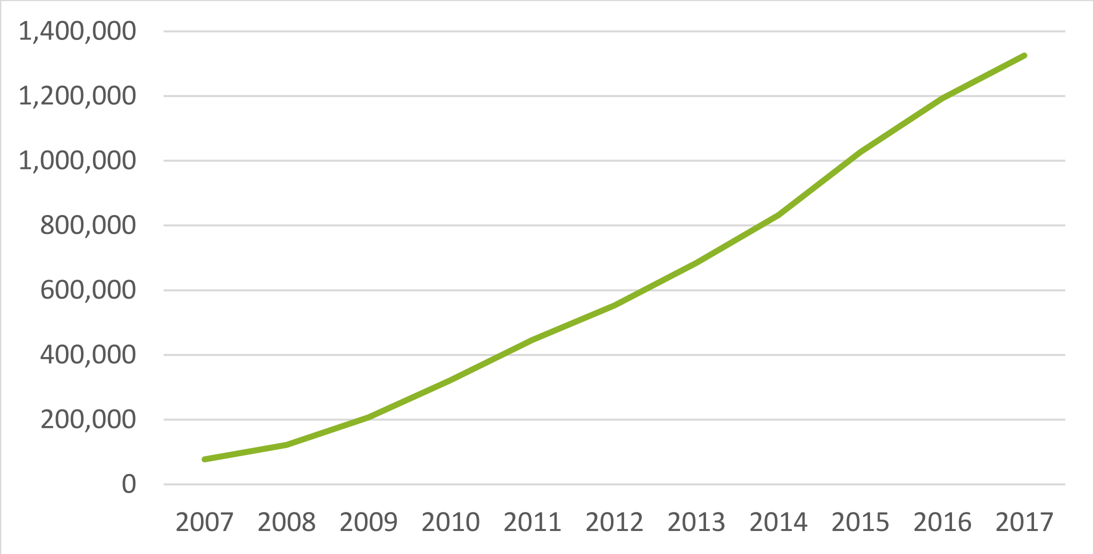
Table 40 Simplified summary of key issues identified on the six roads studied

Road	Hai	Babati	Bahi Chipanga	Bahi Mpunguzi	Morogoro	Bagamoyo
Context	U-shaped 10 km road on flat land with 5 km over a rice growing area. Few villages. Low population.	Old road alignment with new longer alternative route. Low population. Mixed farming, some sugar.	Road between two artery routes to Dodoma. Crosses undulating, semi-arid mixed farming area with low population	First 20 km of a long, branching collector road network serving many villages. Flat agricultural land with sparse population.	Road rises up hills, with decreasing population and a protected forest. Could be a shortcut to Ngeregere, a small market town.	Road traverses undulating land, initially intensive crop farming, then shifting cultivation and herding. Low population.
Intervention	5 km rehabilitation and embankment	Two culverts and short embankment	Two bridges and road works	20 km rehabilitation with embankment	Several bottleneck works with concrete strips and section	Full rehabilitation with different surface treatments
Problems solved	Better access to small agricultural area	Difficult wet season section now all-season	Difficult wet season sections now all-season	Difficult wet season sections now all-season	Some difficult wet season sections now all-season	Difficult wet season sections now all-season
Road problems remaining	Ongoing road difficult	Half of road very rough	Few: but some rough sections	Few: but road getting rough	Narrow road. Remaining bottlenecks	Few: but some earth sections eroded
Transport demand	Little local demand. No through traffic	Little local demand. Through traffic has better alternative	Little local demand particularly over bridge 2 where through traffic has better alternative	Little local demand but overall good demand from through traffic from several feeder roads	Tiny transport demand over improved sections. Through traffic has better alternative	Little local demand. Possible through traffic has better alternative
Motorcycle changes	Large expansion	Large expansion	Large expansion	Large expansion	Large expansion	Large expansion
Traffic changes	Initial growth then no change	Initial growth then little change	Little change over bridges	Little change	Little change	Little change
Transport services	No change. Only motorcycles	No change. Only motorcycles	Bridge 1: some minibuses Bridge 2: No change. Only motorcycles	No change: same minibus, midibus and bus services mainly from other roads	No change. Only motorcycles	No change. Only motorcycles
Planning issues	Some agricultural access but lack of useful network connectivity	Better alternative route available	Better alternative route available for bridge 2	None. Important collector road serving many routes. Safety issues	Better alternative route available	Important rural access but lack of good through route

9.3 Motorcycles and motorcycle taxis

There has been a huge increase in motorcycles in Tanzania in recent years. In 2003, there were only 2,000 registered in the whole country (Bishop and Amos, 2015). By 2014, there were over 800,000. By 2017, there were over 1.3 million motorcycles, with numbers still rising rapidly, as shown in Figure 118.

Figure 118 Number of motorcycles registered in Tanzania, 2007 to 2017



Source: MoWTC Tanzania (2016 and 2017)

Motorcycles were by far the most numerous vehicles on all the roads studied, and motorcycles comprised between 83% and 95% of the motorised vehicles counted on the six roads, as shown in Table 41. Of the people counted during the traffic counts on the four roads that did not have any bus or minibus services, between 70% and 89% of people's motorised journeys were on motorcycles. This dropped to 44% on both the roads with minibuses/buses. By including pedestrians and cyclists, the percentage of people's journeys on motorcycles drops to between 42% and 53% on the roads without minibuses/buses and to 28-39% on those roads with minibuses/buses. This is shown in Table 41. Most people travelling were men, with between two and four times more men travelling than women. Men were the main users of motorcycles and 58-71% of their journeys were on motorcycles. Although women travelled less, they used motorcycles for 37-76% of their journeys on the roads without minibuses/buses and 21-24% of their journeys where minibuses and buses were an option.

Table 41 Motorcycles as proportion of motorised traffic and people's trips on motorcycles on the six roads

Road	Hai	Babati	Bahi Chipanga	Bahi Mpunguzi	Morogoro	Bagamoyo
Motorcycle component of motorised traffic	90%	84%	83%	84%	95%	87%
Percentage of people's journeys on motorcycles	45%	42%	28%	39%	53%	44%
Percentage of people's motorised journeys on motorcycles	74%	70%	44%	44%	83%	89%
Percentage of men's journeys on motorcycles	69%	57%	43%	50%	65%	82%
Percentage of women's journeys on motorcycles	58%	55%	24%	21%	37%	76%
Note: the figures in blue are for the two roads near Dodoma that had minibus/bus services						

In the early 2000s, 'boda-bodas' in Tanzania were pedal bicycles with cushioned carriers over their rear wheels for transporting passengers and goods. Some bicycle passenger services still exist, but most have been replaced by motorcycle taxis that are now found almost everywhere in rural Tanzania. This study showed that motorcycles were by far the most numerous vehicles on all the roads surveyed. In Tanzania, and most countries in the global south, this is now true on most, if not all, low volume rural roads. The policy and planning implications of this rapid growth are only starting to be developed in Tanzania and elsewhere. Road investments have been following guidelines prepared before transport planners and engineers had fully understood the implications of such a fundamental change in traffic growth. It is still not clear how road planners and engineers should respond to the fact that most rural roads are mainly used by motorcycles, pedestrians and bicycles.

Although their tariffs can be high, and there are issues of safety and exposure to the elements, motorcycle taxis are proving appropriate and popular in Tanzania and elsewhere. On poor roads, they can generally travel faster than large vehicles, and can avoid many of the potholes and proud stones. Where roads are very rough, they frequently develop smoother trails, on the road shoulders or alongside the road, as was apparent on most of the roads surveyed. This increases the comfort for the drivers and passengers. The fact that motorcycles move to the shoulder of the road, or off the road, highlights that road design or maintenance that does not consider the growth of motorcycles, leads to further degradation of the road and/or the surrounding environment.

The biggest advantage of motorcycle taxis is that they can respond to low-market demand situations. Even a single passenger can represent an economic transport demand. With mobile phones, motorcycle taxis can be called to collect a passenger (sometimes even if they are off the road) and take them to their exact destination. The many advantages of motorcycles for personal use and as motorcycle taxis helps to explain why on five of the six roads, motorcycles were the main means of travel for people, often by a large margin. On the one road (Mpunguzi-Mwitikira) where midi-buses and large buses moved a greater daily number of people, this was due to the through traffic, with many passengers transiting along the road from several distant villages.

One potentially interesting point emerged from the surfacing trials on the Bago-Talawanda road. One of the sections was perceived to have sharp, small stones on the surface that were uncomfortable for the feet of pedestrians, tended to cause punctures in the tyres of bicycles and motorcycles, and were more prone to causing motorcycles to skid than the other surfaces. While the interviewed stakeholders referred to the small stones as ‘gravel’, it seems likely that this surface was actually the double surface dressing that was covered with fine stone chippings. These chippings persisted for several years and would have fitted the description of being sharp and painful on the feet. While such materials are widely used for road construction internationally, they would not be deemed appropriate for pedestrian walkways or cycleways. It can be argued that rural roads in Tanzania are mainly used by motorcyclists, pedestrians and cyclists, and so the materials should be ‘fit-for-purpose’ for these travellers, as well for the ‘conventional’ traffic for which rural roads have been designed in the past.

As has been noted, the policy implications of the great expansion of motorcycle use are only just being raised, with questions about the continued justification for wide rural roads, if most of the traffic comprises motorcycles. There may be logic in retaining current standards for the ‘collector’ rural roads, but beginning to use less costly construction practices for the smaller feeder roads serving a small number of villages. This debate is beyond the scope of this report, but two related issues have emerged from this research: two roads had parallel concrete strips, and most roads had examples of ‘motorcycle trails’.

9.4 Motorcycle trails

On most of the roads there were clear examples of motorcycles creating ‘motorcycle trails’ on road shoulders or on paths parallel to the road. These generally did not require specific initiatives, but evolved after some individual drivers had chosen slightly smoother routes and subsequent motorcycles followed these to gradually create smoother paths that more and more motorcycles followed. These are also used by bicycles. These trails make the journeys more comfortable, and for this reason they allow faster speeds. The trails do not seem to get highly rutted, and so when motorcycles have to pass another vehicle, it is not difficult to move out of the trail and then move back. The trails alongside the road generally cease when it comes to water courses, and motorcycles re-join the road to cross bridges, culverts and drifts. This potentially creates a risk if there is another vehicle travelling straight along the road, and the two drivers do not take sufficient notice of the other vehicle’s trajectory. In the dry season the side trails may continue off the road, across the dry water course.

It is not immediately clear what the road authorities could or should do to assist motorcycles with regard to smooth rides. If there were larger smooth side strips designed for motorcycles, they would probably also be used by other vehicles, creating possible hazards. On the Babati road, one section is so rough with oversize stone that even cars and pickups use the side trail alongside the road for greater comfort and speed.

The motorcycle operators were questioned about paths and trails that link houses and villages off the road to the road network. Most operators were aware of, and used, such trails to reach off-road houses and take people to markets, shops and medical facilities. They were regarded as being important for their businesses. All the trails referred to appear to be informal trails, which evolved from footpaths. However, certain authorities or organisations in several countries in Africa and Asia have developed simple standards for such trails, to allow off-road villages to be connected by all-season trails, which can be earthen, concrete, brick or gravel (SuM4All, 2019). Simple trail bridges can traverse water crossings. Some examples of organised trail provision are shown in Figure 119.

Figure 119 Examples of constructed motorcycle trails in Liberia (left), Bangladesh (centre) and Myanmar (right)

9.5 Parallel concrete strips

Parallel bituminised strips were developed in Zimbabwe as a low-cost solution for low volume rural roads. For most of the time the cars and small trucks (the main vehicles using those roads at that time) could drive on both the strips, only moving onto the surrounding gravel if they met another vehicle or if a vehicle from behind wished to overtake. This was a cost-effective solution for the small number of vehicles driving in rural areas. The concept was developed with the suggestion that parallel concrete strips could be used on potentially difficult slopes to allow cars, pickups and small buses to gain traction, with a construction price much cheaper than a road-width, concrete slab. The concept is entirely valid when designing roads for small numbers of four-wheel vehicles. However, it becomes invalid if most of the wheeled road users are motorcyclists or bicyclists (as is now the case in Tanzania). Concrete strips have vertical edges, and proud vertical edges are a risk to bicycles and motorcycles, as they can cause the cycles to skid and crash when moving on or off the concrete. When most traffic comprises motorcycles and bicyclists, riders have to move off a strip to pass another cyclist. Less frequently they have to move off the strips to allow a four-wheel vehicle to pass. Each time they move on or off the concrete can be a risk, if there is a proud edge. The concrete strips on the Morogoro road seem to have been quite badly constructed from the outset and had vertical sides from the start (see Figure 91). These worsened with erosion and lack of maintenance, as shown in Figure 120.

Figure 120 Parallel concrete strips on Morogoro road showing dangerous proud vertical edges

The quality of construction appears to have been better on the Bagomoyo road, although from the outset there were some proud edges (see Figure 105), that inevitably worsened with erosion. While the contractor had tried to cover the sides with gravel, the design involved proud concrete connectors in the middle of the road. These are a hazard for overtaking motorcycles and bicycles and would make it extremely difficult for a three-wheeler to ride on that section (see Figure 106).

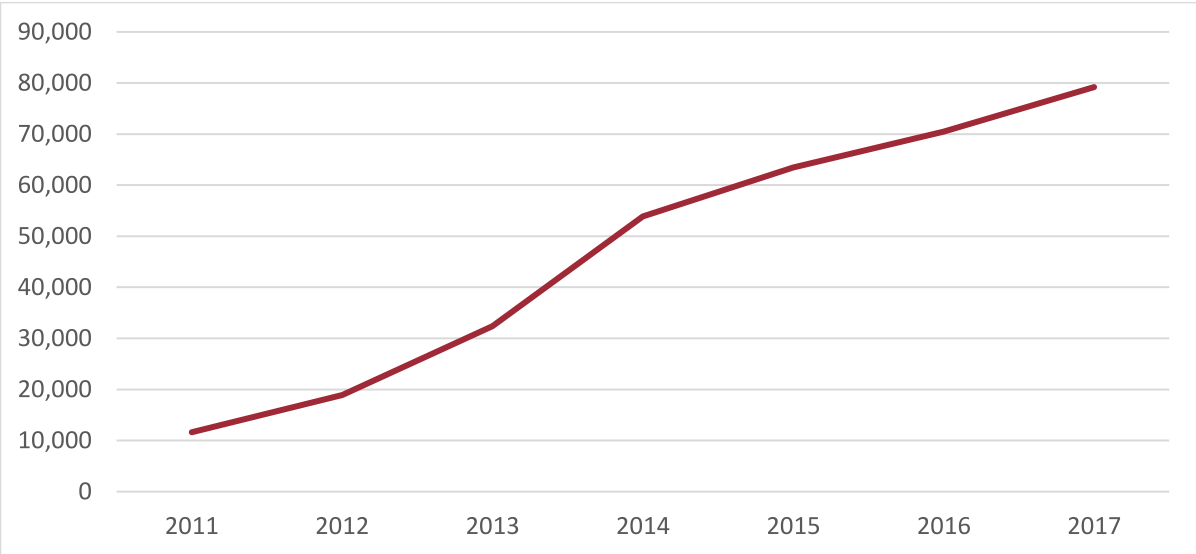
Parallel strips might have a role, if the connectors were lower (they could be below the top surface) and if maintenance was assured. However, erosion will occur every rainy season and roads should be fit-for-purpose under the prevailing maintenance regimes. This suggests parallel strips are not likely to be appropriate in the short-to-medium term, given the pressures on maintenance budgets and the large number of motorcycles and bicycles using rural roads in Tanzania.

It should also be noted that vertical edges can be a problem if concrete is used on motorcycle trails. On motorcycle trails, the risks are diminished as there are only two edges to a trail (four for strips) and trails are normally wide enough for two motorcycles to pass without moving off the trail.

9.6 Motor tricycles

Bajaji passenger three-wheelers and freight three-wheelers are more recent innovations in Tanzania than motorcycles. Their distribution within Tanzania and their uses have expanded greatly in recent years, although their overall numbers are far fewer than motorcycles. In 2017 there were 80,000 three-wheelers (Bajajis and freight) compared to 1.3 million motorcycles (MoWTC, 2017). Figure 121 shows the growth of motor tricycle numbers in recent years.

Figure 121 Number of motor tricycles registered in Tanzania, 2011 to 2017



Source: MoWTC Tanzania (2016 and 2017)

The main use of bajajis is as point-to-point taxis in urban and peri-urban areas. The decision of LATRA to promote out-of-centre bus stands is providing an important niche for bajajis as they provide low cost shuttle services between the bus stands and the town centres. Bajajis are not yet important on any of the roads studied; they were not present on some roads and only carried 3% of travellers on the Hai road, and 1% of travellers on the Bagamoyo road. However, their numbers in Tanzania are increasing and there are some examples of them providing route-based rural transport services. On the collector road that leads to the surveyed road in Hai District, 20 bajajis run regular route-based services between Boma N'gombe and Rundugai throughout the day. Their frequency is a function of their low capacity (three-to-six people) which is appropriate for rural areas. Minibuses charge less, but to charge that low fare they require about 16 people to travel at the same time. On that road, this is only realistic for daily commuter journeys and for market-day shuttle services. On several of the roads studied, there would appear to be a niche for bajajis. Bajajis are slower than motorcycles, but they are more enclosed and may feel more appropriate for women, particularly those travelling with children. Because they have not yet had an impact on the roads studied, little evidence can be presented here. In Hai, transport users rated them the best for journey times, passenger fares, safety and security (above motorcycle taxis and pickups, the only other public transport on that road). However, on that road, the bajajis lost out in the overall rankings as they were rated very poor for aspects related to availability and frequency because they had not started regular services along that road. This suggests that bajajis could become popular services, if they were to start operating as low-volume transport services.

9.7 Engineering issues

Though most of the trial sections have been effective in providing a good to fair riding quality with all-season access, some sections have had drainage related issues since the trials. Some of the surfacings have not performed well, such as the slurry seal which is badly deteriorated.

Some key lessons have been learnt and should be used to inform future selection of appropriate surfacings for low volume roads. For example, experience has shown that hand packed stones can only perform well when high kerbs are installed to retain the surface; without this the sand will be washed away and the stones will rise up and become separated due to the action of vehicles. Furthermore, some of the surfacings such as the hand packed stones and concrete strips were found to be inappropriate for two-wheeled vehicles, due to a very rough and uneven surface. This resulted in motorcycles developing smooth side trails along the shoulder of the road while light trucks left the road altogether and created a temporary side track. This shows that although a motorable road with all-season access is very important for road users, the riding quality of the surface also can have an impact on its appropriateness.

Although maintenance had been undertaken on most of the roads, it was intermittent, with some sections experiencing bad erosion that makes the road difficult to pass in the wet season. Since most LICs have funding challenges for maintenance, spot improvements can be adopted in the short term to eliminate the bottlenecks and keep the roads motorable using limited funds. However, there is a danger of spot improvements becoming the norm rather than the exception, and therefore deliberate long-term planning must be put in place to secure adequate funding. Comprehensive maintenance interventions across the whole network are necessary to provide roads with all-season access.

9.8 Unclassified networks

Tanzania has a large rural road network under TARURA. A review of the network is ongoing, but the estimate for classified and unclassified roads is close to 130,000 km. Of these, less than 60,000 km are classified. Because TARURA is not mandated to maintain unclassified roads, this means that they are unable to maintain more than half of the rural network. This creates an issue whereby even if a road exists, if it is not maintained the transport services can be affected.

9.9 Climate Change

Probably the biggest challenge to rural road networks today is climate change. Tanzania is recognised as an especially vulnerable country, with low lying areas along the coast that often flood and mountainous areas that are exposed to high rainfall. Earthen roads are especially vulnerable and these make up a large proportion of the rural road network. Many earthen roads become unmotorable for 3 or 4 months during the rainy season.

Many of the expected problems related to climate susceptibility can be minimised by good maintenance. However, as in most low-income countries there is a significant maintenance backlog resulting from historical climatic events. The inability to fund routine maintenance results in parts of the rural network being more susceptible to climate-related damage. For example, sections which lose their shape and camber lead to standing water on the road surface which can result in the development of soft areas and ultimately failure if timely maintenance is not undertaken.

There is a need to develop appropriate engineering adaptation procedures that can be used to strengthen the long-term resilience of low volume roads. For example, drainage structures should be designed to cope with extremely high precipitation. It has already been observed that some failed culverts are being replaced by higher capacity ones. Furthermore, narrow drainage structures negatively impact on key engineering aspects, such as erosion of abutments and approaches. When road embankments are not raised high enough to deal with the extreme rainfall, it leaves the road exposed to damage.

There is need to develop and/or review climate adaptation policies in order to incorporate the engineering lessons learnt from past and current studies being conducted. Furthermore, there is a need to create greater awareness of the engineering lessons to the responsible technical personnel at the different levels involved in management of low volume roads.

9.10 Road condition and transport services demand

The study has been identifying key infrastructure issues that affect the provision of rural transport services. Two of the key issues appear to be road passability which is often a seasonal problem associated with inundation, mud and slipperiness. Many of the IRAT bottleneck interventions were designed to overcome such seasonal problems, such as water-logged soils (culverts and raised embankments on the Hai, Babati and Mpunguzi roads), water crossings (bridges on the Chipanga road) and slippery inclines (concrete sections and drainage on the Morogoro road). The AFCAP investments on the Bagamoyo road included improvements to allow all-season access, as well as whole road rehabilitations leading to much smoother roads. The IRAT interventions on the Mpunguzi road also constituted a whole road rehabilitation, producing smoother roads. All the road improvements studied have made the roads all-season, but they have not (yet) led to significant changes in transport services.

One of the issues raised by operators and key informants relates to roughness. As noted, it is difficult to use the RoadLab mobile app to measure the IRI as it does not record below 15 km/h, and so it ignores the roughest sections of the road. One proxy for roughness can be speed. The average speeds for the drive-through video surveys are given in Table 42.

Table 42 Average speeds recorded during the drive-through video surveys

Road	Average speed *(km/h)*
Hai: Chekimaji-Kawaya road	42.5
Babati: Magugu road first half (little maintenance)	28.8
Babati: Magugu road second half (recent rehabilitation)	43.3
Babati: Magugu road overall	34.3
Bahi: Chigongwe-Chipanga bridge road	43.2
Bahi: Mpunguzi-Mwitikira road	36.5
Morogoro: Mikese-Ngeregere road	29.7
Bagamoyo: Bago-Talawanda	33.5

Recent rehabilitation leads to smoother roads, and the smoothest roads were those recently rehabilitated which were Babati second section (2018-2019) and Bahi Chipanga (2017-2019). This was followed by Hai (2016) which has had very little traffic. The Bahi Mpunguzi-Mwitikira road (2015-2016) was rehabilitated about the same time as the Hai road, but it has had higher volumes of heavy traffic (buses and trucks) and is now painfully rough due to over-size stone. The Bagamoyo road was rehabilitated in 2011, but with several sealed sections and these are still quite smooth (and the road has had little traffic to wear it). The first half of the Babati road and most of the Morogoro road have not been rehabilitated for many years and are very rough. As can be seen, there is no simple correlation between roughness and transport services. The Hai road appears the least rough road but has no transport services, other than motorcycle taxis. The roads adjoining the Hai road are very rough but have minibus transport services. The Bagamoyo road is quite good but only has motorcycle taxis. The Bahi-Mpunguzi road with some buses, is now quite rough, but its deterioration has not yet affected transport services.

Findings on all the roads suggest that roughness is not the key limiting factor for the development of transport services on roads that are passable. The Hai road provides a particularly clear example, being the best road on the local network. No transport services operate on this road (other than motorcycle taxis). Yet on the connecting roads, in 2 km in one direction and 6 km in the other direction, there are minivan, minibus and bajaji transport services operating regularly, along roads that are very rough. Their roughness might be comparable with the difficult first section of the Babati road that had the lowest average speed of 28.8 km/h.

Transport services operators are willing to operate on poor roads if there is market demand. They depend on passengers being available so they can earn an income. They prefer smoother roads but will not operate on a smooth road unless they perceive there is a sufficient transport market to be served. The evidence of this study points to market demand being the primary limiting factor for the development of transport services. Road condition is a factor in the decision making and the overall profitability of transport services, and it affects the various vehicle options in different ways. However, whatever the road condition (provided the route is passable), the most crucial factor is the transport demand rather than the road surface. This was illustrated in many different ways during the study, including on the Bahi-Chipanga bridge road. On normal days, only two minibus/midibus vehicles a day cross the first bridge (in each direction) to serve two different villages beyond the bridge. On the day of the nearby market, there are 24 minibus/midibus return trips across the bridge. Transport service operators are only willing to operate on that road when they perceive market demand.

9.11 Road connectivity

The connectivity of road networks is also a factor affecting transport services on the roads studied. The road with the most transport services (buses, midibuses and minibuses) was the Bahi Mpunguzi-Mwitikira collector road that provided a route to a branching network of roads serving many different villages. In contrast, the Hai road does not really connect with any other road. It is a U-shaped road that ends not very far from where it started. Without road connections, it only serves the small number of villages along it (and their agricultural land). Three of the roads studied (Babati, Morogoro and Bagamoyo) were potential short cuts, providing shorter alternative routes as the third side of a triangle to two other roads. The longer routes went on good national or regional roads, but the short-cut went on quite rough rural roads. The shorter, rougher roads would have been acceptable to the transport services operators, provided there were sufficient passengers along the way wanting to travel. In all three cases, the transport demand was not there, and so the transport services stuck to the longer main roads. In these cases, the road connectivity offered route options, and the transport services providers went for the option with the greater market demand.

9.12 Transport services regulation

Transport regulators and enforcers with limited personnel and resources tend to concentrate on regulation on urban and inter-urban roads, where there are much higher concentrations of public transport than on low volume rural roads. Many rural transport services operators ignore some regulatory issues, including compliance with documentation, loading limits and safety equipment.

In general, the smaller and more numerous the vehicles, the less compliance with legislation and the less rigorous the enforcement. The results from this survey suggest the motorcycle taxis have little compliance with regulations (operators ride without licences, insurance or safety helmets but carrying loads greater than those that are allowed). On most roads, there was only a 20% use of crash helmets (combining riders and passengers), with the lowest use on the remoter roads and sections of the roads. Many of the motorcycle taxi operators were not members of associations. Harassment from officials or police was not an important issue on the roads studied.

In contrast, the rural buses are clearly regulated and have to adhere to specific routes and operate out of specific urban bus stands. They also have to enter all weighbridges along their routes, which makes the robust and heavy rural buses avoid trunk roads with weighbridges. Minibuses and midibuses are also regulated in terms of routes and bus stands, but they appear to have more flexibility (and/or less enforcement).

The issues relating to transport services regulation on and around the roads studied, and how they affect transport services provision are discussed in another IMPARTS report on ‘Rural transport services: operational characteristics and options for improvements’ that discusses ways to stimulate appropriate investment in rural transport services (Starkey and Hine, 2020).

9.13 Rural Transport Premium

As noted in Section 1.4.4, the RTP is an indicator of the transport benefits provided by rural roads. The RTP is the ratio between the fare per passenger-km of the available public transport services on low-volume rural roads and the fare per passenger-km of standard-class, long-distance bus services. There will always be a premium on rural transport prices as long-distance buses are likely to cheaper, per passenger-km, as they invariably run on better infrastructure (national trunk roads) and benefit from two economies of scale (larger loads and longer distances). Rural transport services typically use smaller vehicles for shorter distances on poorer roads. As roads improve, vehicle operating costs and fares tend to decrease in real terms, particularly if there is competition. If the roads are good, and transport demand is high, rural transport operators will tend to use larger-capacity vehicles, which also allows prices to fall.

The RTP varies with the prevailing transport types, as smaller vehicles generally have higher tariffs per passenger-km. It may also depend on the road and the road section. Busy roads with more competition tend to have lower fares. To maximise the understanding of how rural communities are affected by transport services, it is best practice to disaggregate the RTP for different vehicle types. It can also be helpful to differentiate between busy and remote road sections, as certain transport types may not serve the remoter villages. If the RTP were entirely or mainly based on the less robust transport services that operate on the more developed sections of the road, this would not take into account the reality for the disadvantaged villagers living around the remoter sections of the road.

Table 43 shows the average fares paid per passenger-km for the different vehicle options and for different sections of the roads, as reported by the users interviewed.

Table 43 Average fares in USDc per passenger-km on the eight study roads in Nepal and Tanzania

Road	Section	Motorcycle taxi *USDc*	Minivan/Minibus *USDc*	Bus/Midibus *USDc*
Bagamoyo	*Remote*	12.2	-	-
Hai	*Remote*	20.7	-	-
Babati	*Remote*	12.8	5.3	-
Bahi-Chipanga	*Remote*	12.1	-	-
Bahi-Chipanga	*Busy*	12.1	5.4	-
Bahi-Mpunguzi	*Remote*			2.9
Bahi-Mpunguzi	*Busy*	12.6		2.4
Morogoro	*Remote*	18.1	-	-

Note: most fares relate to the whole road including the remoter sections.
Some transport types were only available on the busier sections towards the end of the road, and these are presented in separate rows

Table 44 provides examples of some typical bus fares for standard class, long-distances buses collected from the Dar es Salaam bus terminal during the survey. These suggest that the average fare is USDc 1.86 per passenger-km. This figure is used as the denominator to calculate the RTP.

Table 44 Standard bus fares for various routes in Tanzania in December 2019

Tanzania			
Origin	Destination	Distance *km*	Fare *TZS*
Dar es Salaam	Chalinze	101	3,500
Dar es Salaam	Morogoro	186	7,500
Dar es Salaam	Iringa	489	22,000
Dar es Salaam	Mbeya	797	40,000
Dar es Salaam	Dodoma	451	18,000
Dar es Salaam	Moshi	544	27,000
Dar es Salaam	Kahama	988	40,000
Dar es Salaam	Arusha	624	27,000
Dar es Salaam	Mwanza	1134	45,000
Dar es Salaam	Bukoba	1382	60,000
Average fare per passenger-km *(TZS)*			**42.7**
Average fare per passenger-km *(USDc)*			**1.86**
Note in December 2019. USD1 = TZS 2300			

Table 45 shows the calculated RTP values for the various transport services operating along the six roads studied. The two roads close to Dodoma (Bahi-Chipanga and Bahi-Mpunguzi) have two values, one for the busier sections and one for the more remote sections.

Table 45 Rural Transport Premium (RTP) values for transport services on the studied roads in December 2019

Road	Section	Motorcycle taxi	Minivan/Minibus	Bus/Midibus
Bagamoyo	*Remote*	6.6	-	-
Hai	*Remote*	11.1	-	-
Babati	*Remote*	6.9	2.8	-
Bahi-Chipanga	*Remote*	6.5	-	-
Bahi-Chipanga	*Busy*	6.5	2.9	-
Bahi-Mpunguzi	*Remote*			1.6
Bahi-Mpunguzi	*Busy*	6.8		1.3
Morogoro	*Remote*	9.7	-	-
Note: The Rural Transport Premium is calculated from the average fares per passenger-km paid on the rural roads divided by average fares per passenger-km for long-distance buses				

A few observations can be made on the RTP figures. The lowest figures relate to buses on the Bahi-Mpunguzi road. These were large buses travelling over 100 km along the road network. These had economies of scale, but with the rough road sections, there is a small premium compared to long-distance buses on bituminous roads. The bus fares to go beyond the Bahi-Mpunguzi road along the remoter roads give an RTP of 1.6, while the lower fares charged to travel along the Bahi-Mpunguzi road and on to Dodoma (along a bituminous highway) give an RTP of 1.3. This could be because of the road quality and/or because of lack of competition on these remoter sections. This research has suggested that competition is particularly important, with examples from several roads (including the Hai road and its poor quality adjoining roads) where there are lower fares associated with competition on the busy, high-demand sections despite rough roads.

The RTP for medium size vehicles (minivans and minibuses) is generally intermediate between the higher-capacity buses and the small capacity motorcycles and three-wheelers. On two roads, these gave an RTP of 2.8-2.9.

There seems a clear difference between motorcycle and three-wheelers operating on busy sections and remote sections of the road, although there were not enough three-wheelers operating on the surveyed roads to collect sufficient fare and RTP data to analyse. The RTP will always be high for these vehicles due to their low capacity, but it is sometimes much higher on the remoter sections of the road. One reason may be that on the remoter road sections, these vehicles cannot be sure of having passengers on their return trips, so they may charge single trips as if they were return trips. However, the highest RTP of 11.1 was found on the Hai road, and this was associated with short distance journeys on a good quality road with low transport demand. Point-to-point transport services (including taxis) generally charge more per passenger-km for a short journey. In a low demand setting, this can be exacerbated by the higher fares charged due to the risk of only travelling with a load in one direction. On most roads, the motorcycle taxi RTP was around 6-7.

9.14 TARURA planning and understanding of transport services

The various TARURA engineers interviewed generally spoke optimistically about the impact of the IRAT and AFCAP interventions, talking of significant increases in traffic and transport services. However, the results of the traffic counts and the views of transport users, transport operators and key informants suggested that any changes had been small. This could be interpreted as the engineers saying what they thought was expected of them, or it might be due to insufficient understanding of the traffic and transport services issues on the various roads.

At a more senior level, some of the planning assumptions apparently made within TARURA, the District Councils and IRAT can be questioned (with the great benefit of hindsight). The road investments, including expensive embankments and bridges, did not greatly increase transport services, and nor did they encourage traffic and transport services to operate on short-cut routes, where there was a better option available in terms of road condition and, most importantly, transport demand. Some roads, including those in Hai, Bahi-Chipanga and Morogoro seemed to prioritise intra-district connectivity, when the rural people were more interested to travel to larger towns and cities rather than the district town.

At the IMPARTS workshop held in Arusha in November 2018, road engineers from TARURA and from many other ReCAP countries, discussed transport services issues with great interest. There was a strong consensus that road agencies should develop a stronger understanding of transport services issues, through capacity building and greater involvement with transport services operating along rural roads. Output indicators, such as transport services frequencies and tariffs should be included in road management databases (Starkey et al., 2019b).

From the results of these road studies, it does appear that TARURA and its associated projects would benefit from greater understanding of rural transport services to facilitate its planning and prioritisation of investments. Some resources to assist this are provided in the final IMPARTS reports and guidelines (Starkey and Hine, 2020; Starkey, et al., 2020a and 2020b).

10 Conclusions and recommendations

10.1 Research objective and key finding

The research objective was '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'. The key finding was that the provision of rural transport services by the informal private sector depends mainly on the road being passable and there being sufficient transport demand to allow the operator to make a profit. The larger transport services, such as buses and midibuses need a high transport demand to operate on a road, while the smaller transport services can operate with lower levels of demand. While poor road condition may increase operating costs and lead to higher tariffs, provided the road is passable, it is transport demand that primarily determines whether larger transport services can operate along a road. This research has highlighted that good road sections and good bridges will not stimulate transport services unless there is sufficient transport demand.

10.2 Motorcycles

Most traffic on the roads studied comprised motorcycles, and on the four roads without conventional public transport services, a high proportion of men's and women's journeys involved motorcycles. Where there were bus or minibus services, the proportion of people's journeys using motorcycles was lower, but the motorcycles were still an important means of travel. From the traffic counts, it was not possible to distinguish between motorcycle taxis and motorcycles used only for personal and family travel. The number and proportion of personal motorcycles appears to be increasing, and it was estimated by the traffic enumerators that the majority of rural motorcycles were not motorcycle taxis. Nevertheless, motorcycle taxis are extremely important for the rural communities surveyed, and people's responses confirmed that they were highly appreciated.

Two of the roads had parallel concrete strips with proud vertical edges that can be hazardous to motorcycles and bicycles. Given the importance of motorcycles in Tanzania, such parallel strips seem inappropriate. Some of the investments, including the Chipanga bridge and the Hai road appeared to be over-designed for the current traffic, which is mainly composed of motorcycles. There seems scope for providing less-costly road infrastructure on routes that are not likely to have much large traffic (trucks, buses and midibuses). Narrow roads would be cheaper, although two of the narrower roads (Bagamoyo and Morogoro roads) were criticised by some respondents for their small width. Narrow roads might discourage larger public transport vehicles such as buses and midibuses from operating. However, the research suggested that the main determinant of transport services provision was market demand, and not the width or condition of the road.

Motorcycles are used to reach off-road villages, and motorcycle operators stressed the importance of motorcycle trails to allow people in off-road villages to travel to markets and medical facilities. All motorcycle trails to villages have been developed informally, by motorcyclists using footpaths. This research did not study the extent to which off-road villages were connected by motorcycle trails. However, given the importance of such trails, it would seem appropriate to develop a strategy to ensure that all off-road villages are accessible by motorcycle trails. Low-cost motorcycle trails can be constructed by community groups, supported by some engineering advice. TARURA could develop a 'motorcycle trails and a trail bridge' unit to support such a strategy, which should complement and enhance the use of the current rural road network.

Motorcycle users have also developed on-road and alongside-road trails to avoid very rough parts of the rural roads. Since this is a widespread practice that benefits motorcycle and bicycle users, it would seem appropriate to consider the implications of this in TARURA's strategy for road construction and maintenance.

10.3 Transport demand and road condition

The study of the transport services on the six surveyed roads and some adjacent roads clearly points to the conclusion that while road condition is an important consideration for transport services, it is less important than the prevailing transport demand. *A good road or a good bridge does not attract minibus or bus services to use it, unless there are sufficient people wanting to travel. This was shown on the roads in Hai, Bahi-Chipanga and Bagamoyo. An improved road that is a short-cut will not attract minibus or midi-bus services unless there is transport demand along the road, particularly if there are better alternative routes with existing transport demand. Evidence for this came from the Babati, Morogoro and Bagamoyo roads.*

The old rural buses with high clearance can tolerate rough roads, provided they are passable and there are sufficient travellers to justify their costs. Rural buses generally operate on quite long routes terminating in large towns or cities. Buses can tolerate rough roads, provided there are no sections with deep mud, slippery slopes or deep sand. Minivans and minibuses have lower clearance and are less suited to very rough roads. They are more likely to provide shorter shuttle services, particularly in peri-urban rural areas.

Motorcycle taxis can operate where there is little transport demand and can tolerate quite bad road conditions. Bajajis need greater transport demand than motorcycles to ensure they travel with full loads. They mainly operate as point-to-point taxis in urban and peri-urban areas, but in Tanzania and in other countries, they are increasingly operating route-based services in rural areas. While they have small wheels and low clearance, they can operate on rough roads and they are light enough to be assisted through bad patches of mud or sand.

Transport demand is not static and there can be ascending or descending spirals of transport demand and transport services. When transport services are available, rural people are more likely to consider travelling, and the availabillity of transport can facilitate enterprise development and the diversification of local economies. This is most apparent in peri-urban areas, where people in well-connected satellite villages start small businesses and the numbers of small shops, service providers and artisanal production facilities increase. Examples seen during this study were the first part of the Bahi-Chipanga road (with the development seen around Kigwe), the first part of the Morogoro road and the village of Rundugai, close to the road studied in Hai, which all had some regular transport services. Similar economic development and diversification was observed in the first few kilometres of the Babati and Bagamoyo roads, although as distances were small, the transport services on these sections were mainly motorcycle taxis and bajajis.

There is further discussion about transport services demand and ways it might be stimulated or consolidated in another IMPARTS report on 'Rural transport services: operational characteristics and options for improvements' (Starkey and Hine, 2020).

10.4 Planning rural road investments

With hindsight, it is possible to challenge certain assumptions that appear to have justified some of the road investment decisions and learn lessons. The IRAT investments were not specifically designed to stimulate transport services but were expected to lead to increased traffic flows. In general, there was little sustained growth in traffic, although without the investments, the traffic might have declined. For each road, possible explanations for the lack of growth of traffic and transport services have been discussed. Small populations served and low transport demand have been cited for the Hai, Babati, Bahi-Chipanga, Morogoro and Bagamoyo roads. Lack of connectivity was also apparent in Hai. The existence of good alternative routes were important factors for the Babati and Morogoro roads, as well as for Bahi-Chipanga (the alternative route from Chipanga to Dodoma) and Bagamoyo (the alternative Bagomoyo-Chilenze route). The relevant transport demand is not limited to the local villages as there may also be a demand for through traffic. It was observed that there was no reason for through traffic to travel on the Hai road. Similarly, in the short-to-medium term, there is no real through traffic demand on the Bahi-Chipanga road, although as Dodoma grows and connecting roads improve, it could become a useful road for within-district travel. There was little prospect for through traffic on the Morogoro road, due not only to the poor condition of the road, but also because Ngeregere is not a major destination for people, unlike Morogoro.

Many of these observations relating to traffic growth could have been predicted had the planning teams liaised more with local stakeholders (including transport services operators). More effort might have been made to understand the various components of transport demand (local villages and through traffic), and how road investments might affect these.

10.5 Spot improvements

Spot improvement appears to be an appropriate strategy for keeping roads passable when funds are limited. Spot improvements can turn a seasonal road into an all-season road. While the extent of the seasonality of the different roads varied greatly, the various investments allowed all the roads to be considered 'all-season'. However, spot improvements need to be part of a continuous strategy, and not one-off investments. The removal of one bottleneck will not prevent others from developing. This was particularly clear on the Morogoro road that soon needed more investment to relieve other difficult sections. Without these, the original investment had little long-term impact, as the road was still a difficult road to traverse. On the Babati road, one bottleneck was removed, but much of the road remained very rough and uncomfortable for users, and through traffic had a better alternative route to use.

10.6 Recommendations

10.6.1 Plan roads in consultation with local stakeholders and consider economic transport demand

Road planning and prioritisation needs to be carried out in consultation with local stakeholders, including transport services operators. The stakeholders may well have different priorities that need to be discussed and reconciled. All will aspire to high quality roads, but budgetary limitations may force them to prioritise affordable options.

The concept of district level transport plans, as developed in Nepal, is valuable. These can identify the strategic essential roads (national, regional and district) and the roads that offer alternative, but not essential options for within-district connectivity. The aspiration of district councils for within-district connectivity may not coincide with the normal traffic patterns that tend to lead to arterial connectivity with the nearby towns and cities. It is important to consider what are the main destinations to which rural people wish to travel: they may be more attracted to towns and cities that are outside their district than travelling to the district town.

Transport services operators need to be consulted about the prevailing transport demand and travel patterns. It is important to understand their operational and route aspirations, and how investments in specific roads might affect them. This will help to inform the level of economic transport demand, and how it might be affected by road investments.

Additional suggestions for stakeholder participation in local road planning are provided in the IMPARTS Guidelines (Starkey, et al., 2020b).

10.6.2 Increase understanding of rural transport services

Staff of TARURA have not been trained to interact with transport services operators to understand their operational practices and priorities. Rural residents depend on transport services for their mobility, so a greater understanding of these rural transport services could assist in planning more appropriate road investments and maintenance strategies. Such interactions could be undertaken in the context of developing district level transport plans.

At a higher level, closer cooperation between LARA and TARURA is recommended. At present, LARA is mainly involved with regulating bus routes and urban transport services, and a combined LARA-TARURA taskforce to look at rural transport issues could be beneficial.

It is recommended that road-related transport services data be maintained in the DROMAS2 database. This could include the number and types of services operating on particular roads, approximate frequencies and typical tariffs. This could be collected every year and submitted with the road condition data. This would lead to the gradual development of an important database of transport-services related information that could be used in road planning, appraisals and evaluations.

10.6.3 Preserve road investments though maintenance

Road investments need to be preserved though regular routine and periodic maintenance. The study provided some examples of good practice, but TARURA staff and local stakeholders also pointed to insufficient resources to protect the investments.

10.6.4 Provide infrastructure best suited to the prevailing means of transport

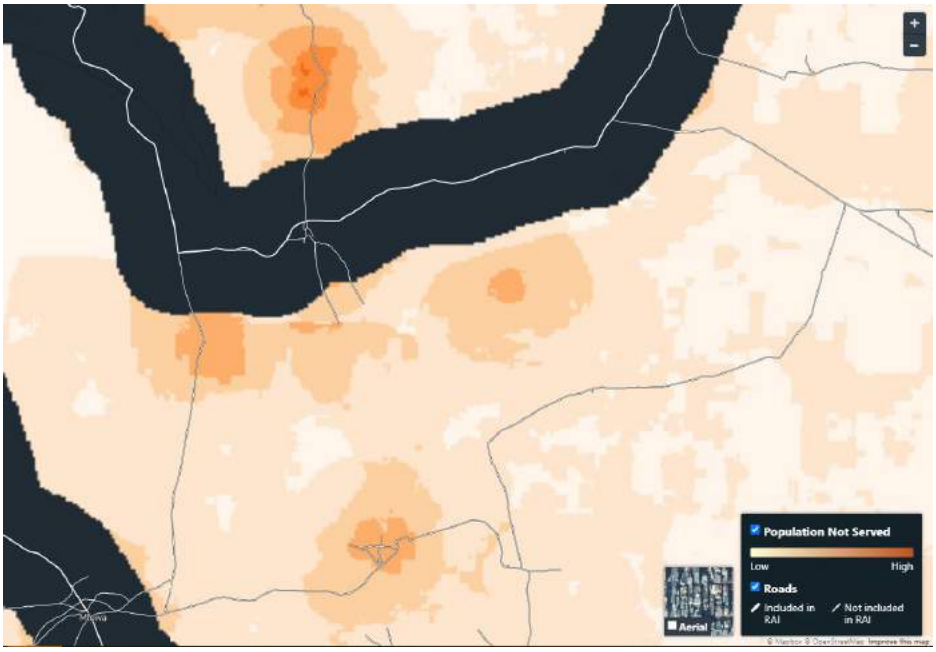
Most traffic on rural roads comprises motorcycles, and rural infrastructure should be appropriate for these vehicles. Parallel concrete strips should be avoided. A strategy should be developed at district level, as part of district transport plans, to ensure all off-road villages can be reached by motorcycles. This would mean that all villages would be connected to the rural road network by simple infrastructure that can be used by motorcycles, the prevailing means of rural transport. In many cases, this would not require significant resources, as simple footpaths can be easily widened through community action. There would be a need for some simple, inexpensive trail bridges, and proven low cost designs are available from Nepal and elsewhere. In hilly areas, engineering advice might be needed to ensure motorcycle trails have appropriate drainage, and steep sections might require some engineering solutions. The motorcycle trails should be considered additional to the road network, and not a substitute for roads. It is recommended that TARURA establish a motorcycle trails and trail bridge unit that can provide specialist advice to districts.

For many rural roads, the prevailing traffic does not require wide carriageways or two-lane bridges. Cheaper design standards could release funds for other investments and for ensuring good maintenance. However, on strategic roads where midi-buses or large buses are anticipated, attention should be paid to the road width, as narrow roads are not considered appropriate, if buses are likely to need to pass each other.

10.6.5 Better understand the geographic need for transport services

The Rural Access Index (RAI) measures the proportion of the rural population who live within 2 km of an all-season road and is Indicator No. 9.1.1. for the Sustainable Development Goals (SDGs). The RAI is prepared geospatially, showing the road network, population distribution at 100 m x 100 m squares and urban/rural boundaries. When viewed geospatially using GIS mapping this can provide a good overview of populations that have lower access to roads and therefore to transport services. Satellite imagery and many open source mapping tools also indicate where tracks and trails complement the official road network, so geospatial tools such as the RAI measurement tool (https://rai.azavea.com/) developed in parallel to the ReCAP RAI project, can be useful as a simple way to identify where connections to remote communities or settlements could be beneficial. The RAI measurement tool is illustrated in Figure 122. This shows how populated areas (shown in orange) are connected to the road network. The roads with the black 2 km buffers are all-season roads, other roads are fair weather roads or tracks.

Figure 122 Screen shot of the RAI measurement tool



Note: The populated areas are shown in orange. The roads with a black 2km buffer are all-season roads. The other roads shown are fair weather roads or tracks.

11 References

Bishop, T. and Amos, P. (2015). Opportunities to improve road safety through 'boda-boda' associations in Tanzania. Final Report. AfCAP project TAN2015G. Africa Community Access Partnership (AfCAP), Thame, UK. 59p. Available at: http://www.research4cap.org/Library/BishopAmos-Amend-Tanzania-2015-BodaAssocs+Final+Report-AFCAPTAN2015G-v150616.pdf

Cardno (2017). IRAT Traffic Count, Draft Final Report. Cardno, Thame, UK for Improving Rural Access in Tanzania (IRAT) Project and President's Office, Regional Administration and Local Government (PO-RALG), Dodoma, Tanzania. 66p. (Unpublished).

Cardno (2018). IRAT Final Report. Cardno, Thame, UK for Improving Rural Access in Tanzania (IRAT) Project and President's Office, Regional Administration and Local Government (PO-RALG), Dodoma, Tanzania. 66p.

Gillespie, T.D., Paterson, W. D. O and Sayers, M. W. (1986). *Guidelines for conducting and calibrating road roughness measurements*. World Bank technical paper 46. Washington D.C.; World Bank. http://documents.worldbank.org/curated/en/851131468160775725/Guidelines-for-conducting-and-calibrating-road-roughness-measurements

MoWTC Tanzania (2016). Tanzania Transport and Meteorology Sector Statistics 2016. Ministry of Works, Transport and Communication, Dodoma, Tanzania. Available at: https://www.mwtc.go.tz/uploads/publications/en1557392998-Statistics Publication for 2017-2018 .pdf

MoWTC Tanzania (2017). Tanzania Transport and Meteorology Sector Statistics 2016. Ministry of Works, Transport and Communication, Dodoma, Tanzania. Available at: https://www.mwtc.go.tz/uploads/publications/en1558531295-Statistics Publication 2016 .pdf

Roughton (2012). Construction report: Bago Talawanda Road: Bagamoyo District, Pwani Region. Africa Community Access Project Project AFCAP/TAN/008. London Crown Agents for DFID. 224p. Available from: https://assets.publishing.service.gov.uk/media/57a08a99e5274a27b200068f/District-Roads-Improvement-Bagomoyo-District-Construction-Report.pdf

Roughton (2013a). Bagamoyo Final Monitoring Report. Africa Community Access Project Project AFCAP/TAN/008. London. Crown Agents for DFID. Available at: http://research4cap.org/Library/Roughton-Tanzania-2013-Bagamoyo+Monitoring+FR-AFCAPtan008-v130709.pdf

Roughton (2013b). Design and construction of demonstration sites for district road improvement in Tanzania. Africa Community Access Project Project AFCAP/TAN/008. London. Crown Agents for DFID. 143p. Available at: http://research4cap.org/Library/Roughton-Tanzania-2013-Demo+Sites+Final+Report-AFCAPtan008-v131024.pdf

Starkey, P. and Hine, J., TRL (2020). Rural transport services: operational characteristics and options for improvements. Report of the 'Phase 3' findings of the Interactions: Maintenance and Provision of Access for Rural Transport Services (IMPARTS) Project. ReCAP GEN2136A. London: ReCAP for DFID.

Starkey, P., Hine J., Workman, R. and Otto A. TRL (2019a). Interactions between improved rural access infrastructure and transport services provision: Phase 1 Scoping Report. ReCAP GEN2136A. London: ReCAP for DFID. 79p.

Starkey, P., Workman, R. and Hine J., TRL (2019b). Interactions between improved rural access infrastructure and transport services provision: Report of an Inter-regional Workshop held 12-13 November 2018, Arusha, Tanzania. ReCAP GEN2136A. London: ReCAP for DFID. 20p + 135p.

Starkey, P., Workman, R. and Hine J., TRL (2019c). Interactions between improved rural access infrastructure and transport services provision: Phase 2-3 Progress Statement. ReCAP GEN2136A. London: ReCAP for DFID. 81p.

Starkey, P., Hine, J. and Workman R., TRL (2020a). Interactions between improved rural access infrastructure and transport services provision: Final Report. ReCAP GEN2136A. London: ReCAP for DFID.

Starkey, P., Workman R. and Hine, J. TRL (2020b). Guidelines on integrating rural access infrastructure and rural transport services provision in the planning, design and implementation of rural transport. ReCAP GEN2136A. London: ReCAP for DFID.

SuM4All (2019). Universal rural access: companion paper to global roadmap of action toward sustainable mobility. Sustainable Mobility for All (Sum4All), Washington DC. 44p

TANROADS, 2020. https://www.tanroads.go.tz/about-us/chief-executive-message. Accessed 5 January 2020.

Willilo S and Starkey P, 2012. Rural Transport Service Indicators: Tanzania Country Report. September 2012. African Community Access Programme (AFCAP) Project GEN/060. International Forum for Rural Transport and Development (IFRTD), London, UK for Crown Agents, Sutton, UK. 57p. Available at: http://www.ruraltransport.info/RTSi/resources/project_outputs.php

World Bank (2020). https://data.worldbank.org/indicator/NY.GDP.PCAP.CD?locations=TZ-ZG Accessed 15 January 2020.

World Population Review (2020). http://worldpopulationreview.com/countries/tanzania-population/ Accessed 15 January 2020.