

## AFRICA COMMUNITY ACCESS PROGRAMME

**5th Africa Transportation Technology Transfer (T2) Conference  
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**AFCAP Workshop on Rural Accessibility and Mobility**

### Summary Report

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# AFCAP Workshop on Rural Accessibility and Mobility

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# **1 INTRODUCTION**

## **1.1 Background**

The Africa Community Access Programme (AFCAP), a DFID (UK) funded research initiative, is designed to address the challenges of providing reliable access for poor communities. AFCAP provides advice and undertakes research to facilitate the delivery of safe and sustainable rural access. AFCAP is based around a portfolio of research, demonstration, advisory and training projects, which identify and support the uptake of low cost, proven solutions for rural access that maximise the use of local resources. The outputs from these projects are expected to feed directly into regional and national rural transport policies and strategies for poverty reduction. AFCAP is currently active in Ethiopia, Malawi, Mozambique, Tanzania, Kenya and South Sudan.

AFCAP was invited by the organisers of the 5th Africa Transportation Technology Transfer (T2) Conference to conduct a workshop during the conference on theme of Rural Access and Mobility.

## **1.2 Workshop Objective**

The objective of the workshop was to facilitate discussion, knowledge exchange and learning on a range of factors affecting rural access and mobility. These factors include social and economic impacts, road condition and road management, and engineering design standards. The workshop was attended by about 50 practitioners from governments and the private sector, including delegates invited from the six participating AFCAP countries.

The list of participants is included in Annex I.

## **2 APPROACH**

### **2.1 Field Work on the Lawate to Kibongoto Road**

The workshop approach was based around data collected on site on the Lawate to Kibongoto Road in Siha District on the slopes of Mount Kilimanjaro. The site is approximately one hour drive from Arusha. This district road is being upgraded to all-weather standard under AFCAP using the Environmentally Optimised Design Approach. The works are being financed by the Govt of Tanzania. AFCAP is providing technical assistance for the design of the road, supervision during construction, and longer term technical monitoring.

The road is 13.5km long and is characterised by steep gradients and red volcanic soils which are firm but slippery when wet. The road is passable in dry weather but immediately becomes impassable when wet. The traffic is reasonably high for a district road in Tanzania, but still less than 50 motorised vehicles per day. The road serves a highly productive agricultural area.

The workshop participants were divided into three separate groups. Each group was responsible for the collection of data on the road, which was analysed and discussed back at the workshop venue. The three groups were as follows:

1. Social and economic impacts of rural access and mobility (facilitated by Gina Porter and John Hine)
2. Road management - condition monitoring using the GPS method (facilitated by David Geilinger)
3. The design of low volume road pavements and surfacing, with particular reference to the DCP design method (facilitated by Mike Pinard).

### **2.2 Workshop Programme**

Day 1 of the workshop (Day 2 of the Conference) was spent at the workshop venue. There were introductory presentations by each of the facilitators on their respective subjects<sup>1</sup>. There was also an introductory presentation on the upgrading project for the Lawate to Kibongoto Road. The participants were divided into groups for the field work and received their instructions for the following day.

The afternoon of Day 2 of the workshop was spent on site. Participants were transported to site by minibus from the conference venue. Each fieldwork group had separate transport, which enabled the groups to work independently and to return to Arusha at different times if necessary. The groups were provided with packed lunches and refreshments.

On the Day 3 of the workshop presentations were delivered on regional research projects being implemented under AFCAP. Following these presentations there was a live analysis of the condition monitoring data collected on site by the GPS team and a detailed explanation of the DCP design method. After lunch the group that collected socio/economic data reported back on their findings, followed by a discussion on the engineering aspects of the design of the road and analysis of the DCP data collected on site.

The workshop programme is included in Annex II. The activities of each of the three groups and their findings and recommendations are summarised below.

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<sup>1</sup> Copies of all PowerPoint presentations are available from the AFCAP website [www.afcap.org](http://www.afcap.org).

### **3 GROUP 1: SOCIAL AND ECONOMIC IMPACTS OF RURAL ACCESS AND MOBILITY**

#### **3.1 Data Collection (Group 1)**

Reviews of potential social and economic factors affecting rural access and mobility were presented to all AFCAP workshop participants on Day 1 of the workshop, together with a brief introduction to check list interviews as a research method for exploring rural access and mobility. [Further briefing about working with checklists took place on the bus en-route for the road.]

On Day 2 of the workshop a group of 12 participated in field interviews with key informants using the check list approach. Draft check sheets and associated guidelines were provided to each member of the group [see Annex III and IV]. These had been prepared in draft form by Gina Porter on the basis of two pre-meeting visits to the road and similar work in other regions: interviewers were encouraged to use the checksheet flexibly i.e. only as a guide to potential themes. Interviewers were only provided with the checksheet(s) relevant to their interviewee(s).

Possible key informants had also been identified in the pre-workshop visits to the road and arrangements made with a woman district councillor to recruit a small number for interview by workshop participants. A local funeral on the afternoon of the field study prevented planned interviews with members of a women's group [where we had planned to interview on market access issues], but interviews were conducted with 3 primary school teachers and two village heads from the two main settlements on the new road [Kangiya and Manio], two local political leaders, the district councillor herself and a small group of boda-boda drivers. Unfortunately interviewees were mostly male, except for the district councillor and one woman local resident, because of the funeral.

All interviews [with the exception of the boda-boda operators, who were interviewed at their station on the paved road in Lawate] took place near the site office where key informants had been gathered by the district councillor. The workshop group had to combine into pairs to conduct the interviews in some cases, so that each non-Swahili speaker could work with someone fluent in Swahili.

Most of those who undertook the socio-economic interviews were also able to participate in the GPS road condition survey while in the field. The whole group then travelled by bus along the loop road, so that all had an opportunity to reflect on their interview findings in conjunction with direct observation.

#### **3.2 Data Analysis and Reporting (Group 1)**

Opportunity for detailed analysis of the socio-economic data was severely limited by time restrictions [i.e. other conference activities]. In any case, the principal focus of the data collection exercise was to raise awareness of how important it is to take socio-economic issues into account in planning and executing rural access projects and to introduce participants to the concept of exploring socio-economic issues through informal check list interviews, rather than using a pre-designed, highly structured questionnaire.

We reviewed the interviews in a discussion group the following day at the conference centre, jointly identifying key themes for each category [village leaders, political leaders, teachers including road safety issues, boda-boda operators]. Three people were then selected to present findings from each of three important perspectives: 1) village heads and political leaders; 2) teachers and local residents, including their road safety observations; 3) boda-boda operators. These three short presentations were made in the formal [30 minute] feed-back session allocated to the socio-economic group, and moderated by John Hine.

### **3.3 Findings and Recommendations (Group 1)**

The principal areas of discussion, findings and recommendations of the group working on socio-economic issues are noted below. However, it is important to stress that these findings are based on a very limited sample of key informants, interviewed in less than ideal conditions by inexperienced interviewers, and that the interview sample was selected by a district councillor who is very keen to promote the road: responses may well have been shaped to some degree by political interests.

#### **1. Village heads and associated political leaders living in settlements on the road: observations on markets and health**

These key informants identified market and health access as of greatest importance to the roadside villages. The village heads and political leader all expressed a strong view that the road will improve market access, in particular. In Kangiya, for example, access to the village has been limited by a very steep hill which is impassable [extremely slippery] in wet conditions. Villagers produce maize, beans, bananas and milk for home consumption and local markets and coffee [via the cooperative union in each village] for international markets. Much of the agricultural produce has had to be head-loaded to the paved road where there are twice-weekly markets. Women do the majority of trading and it is women who, culturally, are designated the load carriers, since there is no tradition of animal transport in this area [by contrast with the surrounding plains]. Women travel to market with produce twice weekly and purchase cooking ingredients there for use back in the village. However, bananas and, above all, milk, are highly perishable products. Those villagers with dairy cattle have tended to sell sour milk in local village markets because, given milk's high perishability and the uncertain road access [especially in the rains when milk production is at its height], regular reliable market access to the urban milk processing plants cannot be guaranteed. Reportedly an agent occasionally collects milk by truck. It was suggested that the more lucrative fresh milk sales will rise substantially once the road is finished.

Boda-boda operators have been travelling along the road since their first introduction in this area about 4 years ago [see below]. This has already improved the potential for moving small loads [including agricultural produce], especially since the road was graded by the contractor; but fares are high at 2-3,000 shillings, compared to 1,000 shillings for travel by pick-up. Moreover, motorbike-taxis can only operate in dry conditions; they have to cease operations when the road is wet. Nonetheless, at Kangiya about 5% of village households are reported to own motorbikes [piki-pikis] and there are 2 minibuses [daladals] which improves mobility and access to markets and services. The political leader suggested that with further improved access when the road is completed, there will be increasing competition among transport providers and fare prices could consequently reduce.

Health services are located 8kms from Kangiya and very sick inhabitants have often been taken out by stretcher in the past. There is a hospital at the start of the paved road at Kibongoto. We were unable to interview health workers or members of the women's group who might have provided clearer information about transport-related health access issues and how these rank alongside other constraints on health service access. [One teacher interviewed suggested that boda-bodas are used to evacuate people if they are unwell, but for serious illness the taxi or pick-up at Lawate have to be called – he keeps the mobile phone numbers for both. In heavy rain it is still necessary to use the stretcher because no motorised vehicles can negotiate the road].

#### **2. Teachers and local residents: observations on access to school and road safety**

Three primary school teachers based in schools along the Lawate-Kibongoto road were interviewed, all male. Their responses indicate that all pupils travel to primary school on foot, mostly from within 2 kms of the road. Girls walk to school in groups. Bicycles are not popular because of the terrain. The maximum distance of c. 2km to school reflects the fact that the area is unusually well provided with schools [a total of 5 primary and one secondary school along this rural road reportedly serve around 2,000 children]. Consequently, improvements to the road are unlikely to have an impact on children's travel to school.

However, impact on *teacher* travel to school has already occurred with better road grading and the introduction of boda-bodas, thus reportedly improving teacher attendance levels. Many of the teachers are resident on the paved road and walk each day to schools located on the Lawate-Kibongoto road. According to a teacher resident in Lawate, now that boda-boda services are available he travels to his school in Manio [c. 6 kms distant] about 10 days per month by boda-boda, but walks most days because of the cost; moreover, when it rains the boda-boda cannot use the road. It costs him 1,000 shillings to travel to school by boda-boda [compared to 500 for the same journey by pick-up, but the pick-up is used for moving produce on market day and is not a regular service]. He owns a cell phone and keeps more than three boda-boda operators' numbers on it so that he can call a boda-boda if he is tired at the end of the school day. [He also keeps the phone number of the taxi and pick-up based at Lawate in case of health emergencies].

The teacher hopes to buy a motorbike [piki- piki] through the bank where his salary is paid [as do the other teachers interviewed; however, the teachers interviewed were all male – research elsewhere suggests that women are much less likely to purchase motorcycles for personal use]. Three people in Manio village reportedly already own boda-boda and three own piki-piki [but none own four-wheel vehicles]. This teacher also suggested that the road would encourage more interaction with relatives living elsewhere who at present rarely visit because of the road condition.

A particularly strong focus on *road safety issues* by one interviewer raised some important points. Since the road was graded there have been some accidents involving children, but it is unclear whether accidents were actually more numerous before the grading [associated with riding at speed over corrugations in the dry season]: we heard conflicting views. Unfortunately, children at the primary school close to Lawate [at c. 0.5 km, i.e. before the bridge] have devised a game of taunting motorcyclists by running across the road as the motorcycle draws near [observed during our visit]. Since road safety is reportedly not taught to children in primary school, clearly this needs to be rectified. One teacher suggested the need for speed bumps not only to reduce traffic speed but also to reduce road dust entering school classrooms [as this is associated with children's respiratory problems].

### **3. Boda-boda operators: observations on transport services and local employment**

Boda-boda is a relatively new phenomenon in the Kilimanjaro region. According to the operators interviewed they started up in business here in 2007 and have expanded rapidly because of the employment opportunity they offer to young men [which one associated with a decline in criminal activity!] Boda-boda operators charge rates substantially above other motorised transporters [see above] but are able to take passengers [and a small load] direct to the door, a considerable advantage. Their services are used by women as well as men [though from observation, men were far more common as passengers than women, and most women passengers were in their 20s or 30s]. Girl children, in particular, reportedly have difficulty holding on to the driver [possibly associated with cultural issues, as has been observed in

Uganda], which may encourage accidents. Some passengers are also reportedly reluctant to use helmets: a foot rest is considered the most important feature.

The expansion of cell phone use in the area has substantially improved boda-boda business. Use of cell phones reduces waiting times for customers, and brings rapid assistance to the drivers themselves in the case of emergencies such as accidents and breakdown.

In the wet season it is often difficult for boda-boda to operate on the Lawate-Kibongoto road because the road surface becomes too slippery: higher fares are charged at this time [reportedly up to 10,000 shillings]. Other problems reported by boda-boda drivers include fuel cost and scarcity, harassment by corrupt police, lack of professional driver training, and disputes with passengers. They do not have a formal union.

One driver raised the problem of water draining off the road, leading to large stagnant pools of water just beyond the road edge [a hazard not only for pedestrians but also for residents since they are mosquito breeding grounds]. Good drainage of the road is clearly of importance beyond road maintenance.

#### **4. General conclusions: benefits and costs**

- *Benefits for people living or working in settlements along the road are already being reported as a consequence of the initial road grading and associated expansion of boda-boda services and non-commercial motorcycle ownership. These advantages are substantially enhanced by the level of cell phone usage in this area which enables more efficient use of transport services.*
- *Access to health services has already improved to some degree: more improvement is anticipated as wet season access improves and transport services increase in frequency.*
- *Education may already be improving, due to improved access and attendance of non-resident teachers at schools on the road [i.e. rather than to increased attendance of pupils].*
- *Because the area is already densely populated and intensively cultivated, the road is unlikely to lead to substantial increases in agricultural production. However, it may enable:*
  - *a switch from sour milk sales to more profitable fresh milk production*
  - *higher profits from current patterns of agricultural production, associated with a) lower transport costs [more competition among operators] and b) less spoilage e.g. in crops such as bananas.*
- *Social networks may be strengthened as relatives from outside the region are encouraged by better roads and transport to visit more regularly than before.*
- *Elderly and infirm residents who have been limited by their ability to walk may benefit as more passenger vehicles utilise the road. However, they are unlikely to use boda-boda services unless they can be sure of a careful driver.*
- *Transport along the road may improve in terms of both quantity and range of vehicle types with improvement in road surface, bringing benefits for both passenger and freight movements. [The councillor is keen to see introduction of buses to ease passenger movements rather than just depending on pick-ups.]*
- *Although the benefits of the road appear very substantial for a wide sector of the resident population, some potentially negative developments are already appearing and will need careful attention; more may emerge. In particular:*
  - *Road safety issues for pedestrians as traffic speeds increase on the improved all-season road, especially [but not only] at points where visibility is poor. Children, the elderly and pedestrians carrying large/wide loads are likely to face increased danger.*



- *Road safety issues for motorists [notably boda-boda operators and piki-piki drivers] and their passengers, as traffic speeds increase: helmet wear practice, for instance, is poor.*
- *Environmental issues such as dust blowing from the road and standing water at the roadside are emerging.*
- *It is possible that some women currently employed as porters to headload farm produce may lose work [though it is unclear to what extent paid portering as opposed to unpaid household labour obligations prevail in load carrying in the region].*

## **5. Some tentative recommendations based on our check-list interviews and associated observation**

The following recommendations are highly provisional, because of the inevitably superficial nature of our small socio-economic study.

- Road safety improvements for pedestrians need urgent attention. Along the road there are numerous locations where pedestrians are likely to be endangered as traffic volumes grow and motorised traffic speed increases e.g the two very narrow bridges. Engineering solutions need to be supported by intensive road safety training in communities and schools. Active women's groups appear to be widespread in the area and may be an appropriate place to train women who currently conduct so much pedestrian transport of loads. The ministry of education may have relevant manuals for schools; road safety training for women's groups and communities is likely to need specialist NGO support.
- Road safety issues for motorcyclists and their passengers will also increase as traffic speeds increase and traffic volumes expand. Boda-boda operators offer an important service for many [especially poorer] rural inhabitants but accident rates are notoriously high in this transport sector and are likely to increase unless drivers are better trained. While driver training supposedly takes place before road licences are issued, the training provided is clearly inadequate. Helmets, for instance, should be worn by both riders and passengers. Design of an *advanced* safety training course for boda-boda drivers to take after receiving their standard driving licence might avoid excessive emphasis on regulatory aspects associated with driver licensing by government.
- Given increasing accident risks for pedestrians and motorists as vehicle speeds increase with the improved road surface, the local council should be asked to consider traffic management solutions such as introducing one-way vehicle movements.
- Environmental issues such as increased road dust and standing water need attention.
- In many remoter rural areas, support to transport services through subsidy may worthy of consideration given that 'roads are not (always) enough'. However, subsidy is probably unnecessary in the catchment area of this road, since observation [admittedly only from the road] suggests this rural area is atypical in terms of prevailing wealth patterns, with a substantial number of productive farms and well-constructed farmsteads. A review of poverty patterns in settlements beyond the road would be useful prior to reviewing this conclusion about subsidy.
- Some work to explore changes in socio-economic conditions along the road as they occur over and following the construction period would be valuable. A true base-line study to explore subsequent impact of the road improvements is arguably no longer feasible because some initial improvements to road condition have already been made. However, it has been proposed that since grading has occurred at intervals in the past on this road it can be considered part of its normal life cycle,

whereas the road construction work about to be undertaken marks a distinct new development phase.

- Traffic volumes and accident rates need to be monitored carefully.
- A *traffic survey* has already been undertaken: information on data collection points, date and mode of collection etc. was not available for our field visit, but the survey reportedly did include pedestrians. The importance of gender-disaggregated data on mobility and transport is now widely recognised: it would be valuable if *gender and age [child/adult/elderly] disaggregated data* could be collected in both wet season and dry seasons at this point and after completion of the new road to help assess how the road has impacted on transport and mobility patterns. Ideally, this would be collected not only for pedestrians, but also for motor vehicle drivers and their passengers. For pedestrians, data collection on load-carrying quantities/load content could add substantially to the survey. Qualitative research using check lists, possibly followed by a larger survey, undertaken in both roadside and off-road settlements within the road catchment, would add considerably to detailed understanding of the traffic changes observed, since this would allow us to examine key issues such as the extent and ways in which cell phone usage is helping to support more efficient transport services.
- Detailed information on *traffic accidents* along the road should be collected at regular intervals and used to inform ongoing road safety measures.

## 4 GROUP 2: ROAD CONDITION MONITORING USING THE GPS METHOD

### 4.1 Data Collection (Group 2)

An introduction to the techniques used in the GPS Survey method was given at the start of the fieldwork and an opportunity to ask questions was provided. Two GPS devices were used for the survey of the road and two circuits were undertaken such that all ten participants could be closely involved. A logging sheet was provided to each participant so that experience of recording significant events could be gained along the way.

The settings for the GPS were adjusted to record automatically and at set distance intervals so that the output using these varied tracking settings could be compared.

The first circuit was performed with the participants only recording the slow sections that were caused by non-condition related obstacles. These turned out to be very few and hence the second group included the logging of all instances where the vehicle slowed significantly whether road related or traffic related.

A further opportunity for questions was made at the end of each survey circuit.

### 4.2 Data Analysis and Reporting (Group 2)

Downloading of the GPS data was carried out by the consultants who had provided the GPS units although an explanation of how this is achieved was provided to the participants. Analysis of the GPS logs was then demonstrated to the participants taking them carefully through the steps in the process. The data sheets that recorded the obstacles that were encountered in the field survey were used to demonstrate the potential of the approach in identifying fluctuations in the vehicle's velocity due to the various obstacles along the road.

Values for the three Road Transitability Indices were then calculated using a spreadsheet approach in a step by step demonstration. Some discussion was then provided of the significance of each value and an explanation provided regarding the objectives of the GPS Transitability Survey technique.

The three indices proposed for the monitoring process are referred to as the Speed Efficiency Coefficient (SEC), the Time Efficiency Coefficient (TEC) and the Road Accessibility Coefficient (RAC). These broadly indicate the *Extent* of problem areas, the *Intensity* of the problems and the *Reach* of the accessible network.

The SEC is calculated as the proportion of the road or network along which the survey vehicle was able to travel at the threshold velocity or above.

The TEC is calculated as the ratio of the theoretical journey time, assuming that the threshold velocity was maintained throughout the journey, to the actual journey time assuming the threshold velocity is not exceeded. The calculation of this second value is derived automatically in the spreadsheet meaning that there is no need to limit the velocity of the survey vehicle artificially.

The RAC reflects the proportion of the road network which is transitable. It needs to be calculated manually based on the length of the sections of the network that are considered intransitable or inaccessible due to intransitable sections (rupture points). As a general rule the full length of a link in the road network is considered to be intransitable if a rupture point is found at any point along its length.

The plot below shows the survey data recorded during the workshop site visit.

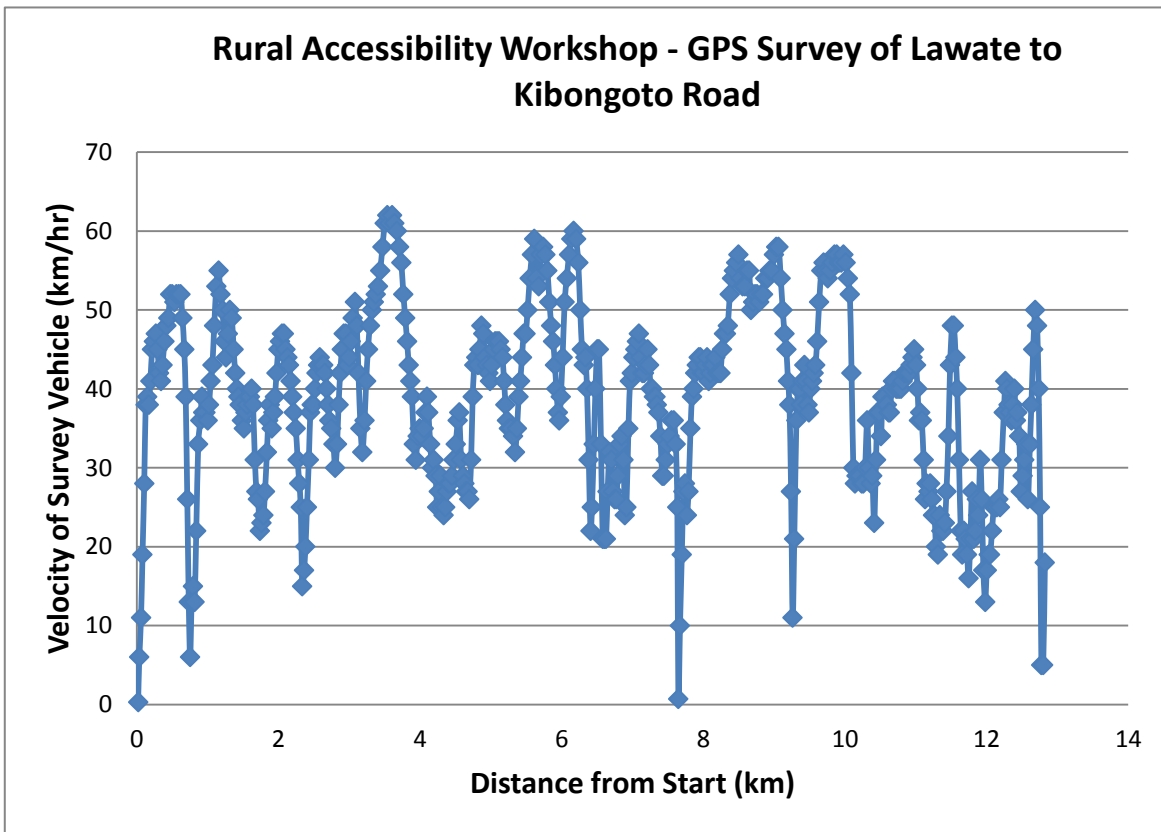


Figure 1: GPS Output

### 4.3 Findings and Recommendations (Group 2)

The mountainous terrain along which the road passes has meant that the geometric alignment of the road is frequently a limiting factor for the vehicle velocity. Thus the adoption of a threshold velocity of 40km/h, as would normally be expected on an unpaved road, requires some re-evaluation. The group felt that a threshold velocity of 25 km/h might be more appropriate. The values derived for the SEC and TEC using these two different threshold velocities are shown in the table below:

Threshold Velocity (km/h)	SEC	TEC
40	52.7%	67.2%
25	90.0%	82.7%

Table 1: SEC and TEC versus Threshold Velocity

On the basis of a threshold velocity of 25 km/h these figures would point to a road in good overall condition. The road has recently been graded in anticipation of further work on providing surfacing for critical sections, thus the figures do suggest appropriate values for the road transitivity. These results might have told a very different story if the weather had not remained dry. This fact highlights the need for the transitivity surveys to be carried out under similar climatic conditions for effective comparison of year on year results.

The general impression gained from the participants was that the GPS Transitivity Survey approach shows clear potential as a cost effective method for monitoring year on year changes in gravel and earth road transitivity. Discussion in the workshop pointed towards the need for further work on the concept in a number of areas. Firstly, the potential to combine the three values into one was suggested. The use of a

threshold velocity was raised as an area where some rationalisation is perhaps needed. Finally, it was suggested that the data provided by the GPS regarding the vertical and horizontal alignment might be utilised in order to determine an appropriate threshold velocity thus improving the potential to create absolute values for the indices, rather than being limited to using relative values.

## **5 GROUP 3: THE DESIGN OF LOW VOLUME ROAD PAVEMENTS, WITH PARTICULAR REFERENCE TO THE DCP DESIGN METHOD:**

### **5.1 Data Collection (Group 3)**

The methodology for data collection was outlined to the Group 3 workshop participants, approximately 40 in all, at the end of the final session on Day 1 of the conference, as follows:

(1) The use of a Dynamic Cone Penetrometer (DCP) to undertake measurements at selected points on the road which would enable the in situ strength, thickness and bearing capacity of the pavement to be determined using a DCP analysis programme.

During the field visit the components of the DCP equipment and the procedure for using it were described to the workshop participants who were also given an opportunity to use the equipment and to record the DCP penetration rates through the pavement structure for subsequent analysis using a DCP programme. DCP measurements (two in advance of the site visit and one during the site visit) were taken at the following locations on the road:

- Point 1: Chainage 0+258 (opposite the contractor's materials stockpile area) on a gravel section of the road; DCP measurements were undertaken during site visit (see Photo No. 1);
- Point 2: Chainage 2+580 on an earth/gravel section of the road. DCP measurements were undertaken in advance of the site visit for subsequent illustration purposes (see Photo No. 2);
- Point 3: Chainage 12+ 860 on an earth/gravel section of the road just past the second bridge. DCP measurements were in advance of the site visit for subsequent illustration purposes.

(2) The options for dealing with those road environment factors that impact on the performance of the road were considered bearing in mind the very limited resources available for the project. To this end, a number of stops were made at potentially problematic sections of the road to discuss measures for dealing in a sustainable and cost-effective manner with such challenges as steep gradients and red volcanic soils which are firm but slippery when wet, road safety issues due to very sharp curves, etc.

### **5.2 Data Analysis and Reporting (Group 3)**

#### **5.2.1 DCP Design Method**

On Day 3 of the workshop, the UK DCP 3.1 programme was used to analyse the data obtained from the field visit. The method of inputting the data into the programme and method of analysis were illustrated to participants. It was explained that such information can be used for the design of low volume road pavements by integrating the required design strength profile for a particular design traffic loading with the in situ soil strength profile obtained from the DCP test and adjusted for the anticipated long-term moisture condition. However, because of time constraints, it was not possible to demonstrate this feature of the DCP programme.

The results of the DCP analysis for the three locations tested are summarized in Annex V where a graphical output of a typical DCP Layer Strength Analysis is also presented.

#### **5.2.2 Environmentally Optimised Design**

During the site visit the following issues pertaining to the road environment were deliberated upon by the workshop participants:

- Alignment
- Road safety
- Environmental factors
- Social factors
- Traffic
- Pavement design
- Drainage
- Materials testing and utilization
- Construction issues

### 5.3 Findings and Recommendations (Group 3)

The following findings and recommendations emerged from the field visit, albeit in the absence of a detailed appreciation of the underlying factors that may have influenced the decisions for the various proposals put forward for the design of the road:

#### 5.3.1 Main findings

##### General

- An enhanced appreciation of:
  - the challenges faced by designers in providing all year passability in a very challenging road environment for relatively low volumes of both motorized and non-motorised traffic and with a very limited budget;
  - the importance of considering non-traditional pavement design and surfacing options within an Environmentally Optimised Design and Spot Improvement approach that is responsive to the requirements of the varying road environment along the length of the road.

##### DCP results

- The very limited number of results (3 No.) indicate that the pavement materials are moderately strong in their dry (approx. OMC) state with the following, relatively uniform, DCP CBR values in the various pavement layers:
  - Wearing course: Mean DCP CBR 68%; range 61%-75%
  - Subbase: Mean DCP CBR 40%; range 39% - 41%
  - Subgrade: Mean DCP CBR 28% (excluding outlier at Ch. 0+258); range 25% - 31%.
- In the absence of laboratory CBRs at varying moisture contents, the moisture sensitivity of the materials is not known and should be ascertained for assessing the implications of moisture variation in service as a basis for designing the pavement.

##### Alignment

- Need to consider widening the surfaced width of the road at very tight curves, such as at the sites of the two bridges, to accommodate the increased swept path of vehicles as well as at “blind” vertical curves.

##### Road safety

- Need to consider the safety of vulnerable road users at bridge sites by exploring the possibility of providing a pathway away from the bridge roadway;
- Need to consider the adoption of an appropriate type of cross-section at urban/peri-urban sections as distinct from rural sections to accommodate non-motorised traffic;
- Concerns over the adequacy of the proposed road width (3.0m carriageway with 1.0m gravel shoulders and passing bays at regular intervals);

- Need for appropriate traffic calming measures at strategic locations such as near schools, bridge sites, relatively poor geometry (horizontal and vertical curvature, etc.);
- Need for low cost measures to demarcate the edge of steep embankments. (e.g. use of treated timber poles)

#### **Environmental issues**

- Need to pay appropriate attention to environmental issues such as borrow pit re-instatement.

#### **Social issues**

- Need to consider provision of access to adjacent properties to avoid blocking of longitudinal drains by tenants to gain entry to their plots.

#### **Drainage issues**

- Particular need to ensure that adequate drainage is provided along the entire length of the road (attainment of minimum “drainage factor”, cross-fall, appropriately angled mitre drains, etc.) to minimize adverse impact of moisture on the pavement materials.

#### **Pavement design**

- The efficacy of adopting a traditional multi-layered pavement system in relation to the very low volume of traffic to be carried by the road and in light of experience elsewhere with the design of such roads;
- Need for a detailed DCP survey to more fully characterize the in situ strength profile of the existing road as a more cost-effective basis for upgrading some of the unsealed sections of the road to a sealed standard by maximising the use of the in situ materials;
- Need for future traffic surveys to include both non-motorised and motorized traffic to facilitate proper planning and design of the road cross-section, provision of traffic safety measures, etc.

#### **Materials**

- Need to ensure reliable characterization of the pavement and gravel materials properties to facilitate their efficient utilization on the project;
- Need to appreciate the difference in test results obtained from BS and AASHTO test methods in relation to the criteria used for their acceptability;

#### **Construction issues**

- Need to maximize use of natural resources by, where possible, using stone masonry rather than concrete for culvert head and wing walls;
- Need to maximize use of local labour, where possible, not only for employment purposes but also for “ownership” of the project and possible later involvement in the maintenance of the road (e.g. through the use of lengthman method).

#### **Surfacing options**

- Need to consider an armoured gravel road base as an alternative, or in addition, to the other surfacing options;
- Need to consider performance limits of proposed options by incorporating more than one surfacing thickness at a given section.



- Need to consider the transition zone between rigid and flexible pavements to avoid in service deformation at the interface.

### **5.3.2 Main recommendations**

1. The need for more detailed consideration of the road safety aspects of the road;
2. The need for more rigorous characterization of the available materials to facilitate their cost-effective use in the paved and unpaved sections of the road;
3. The need for considering the DCP design method for designing the paved sections of the road;
4. The need to consider widening of the road surfacing from 3.0m to say 4.5m or 5.0m by utilizing the savings likely to accrue from the adoption of a more appropriate approach to the design of what is essentially a very low volume road;
5. The use of other surfacing options, such as armoured gravel, and inclusion of varying surfacing thicknesses to ascertain the performance limits for a particular option.;
6. The inclusion of non-motorised traffic in future traffic surveys;
7. The need for more attention to be paid to the drainage aspects of the road in terms of ascertaining their “drainage rating”.

## **6 OVERALL SUMMARY AND RECOMMENDATIONS**

The AFCAP Workshop on Rural Access and Mobility provided participants with an opportunity to engage in practical aspects of the provision of rural transport in Tanzania. The road that was chosen for the field work serves an agriculturally productive area and will shortly be upgraded to all-weather standard under the AFCAP research programme in Tanzania. At present the road becomes impassable when it rains, due to steep slopes and red volcanic soils.

The surveys carried out by Group 1 highlighted the importance of the road to rural livelihoods and the social and economic development of the communities living along it. More reliable access will result in improved attendance by teachers at the schools along the road, easier access to the health facilities at Kibongoto, and will provide an opportunity to local resident to sell higher value products such as fresh milk in the local markets. Group 1 noted the importance of mobile phone networks in improving access by communities to transport services, and also highlighted the increased road safety risks that the community will face when the road has been improved.

Group 1 recommended routine monitoring of the social and economic impacts of the road during and after improvement. Traffic counts should be carried out regularly, and should ensure that all traffic (including pedestrians and non-motorised vehicles) are counted. The data should be disaggregated by gender. The group recommended road safety awareness training in the community, which could be provided through the schools, and advanced safety training for boda boda drivers. Drivers and passengers on boda bodas should wear helmets.

The GPS surveys carried out by Group 2 enabled the participants to gain hands-on experience with the innovative method of monitoring road condition. Feedback from the workshop will lead to further improvements to the GPS method, such as a mechanism to derive a threshold velocity that is directly responsive to the road alignment and the terrain.

Group 3 participated in the analysis of the existing gravel road pavement using the Dynamic Cone Penetrometer (DCP). The results from the DCP tests were analysed at the workshop venue to demonstrate the computer software that is available for this task. The results from the DCP analysis indicated that savings might be possible on the number of new pavement layers proposed for the upgrading of the road. This will lead to cost savings that could be applied elsewhere such as road widening and alignment improvements.

Group 3 also discussed the wider aspects of the design of the road and the application of the Environmentally Optimised Design approach. The discussion included road width and road alignment; at present there are some tight curves and steep slopes that might become hazardous when the traffic levels on the road increase. The discussion on standards recognised the limitations of the budget available for upgrading the road and that the road is being designed for very low traffic volumes.

Group 3 also recommended increased attention to the safety of road users and consideration of additional surfacing techniques such as armoured gravel.

## **7 THE WAY FORWARD**

The success of the workshop, in particular the field work component and the feedback received from participants, will be used in the following ways under AFCAP:

1. The feedback and discussion will influence the final design of the road, including the road geometry, the pavement design and surfacing options;
2. The traffic count methodology will be revised to incorporate the workshop recommendations;
3. The GPS condition monitoring method will be refined and further disseminated to potential users in the region;
4. Field work exercises will be incorporated into future conferences, in particular the 2<sup>nd</sup> AFCAP Practitioner Conference to be held in June 2012.

## ANNEX I: WORKSHOP PARTICIPANTS<sup>2</sup>

Name	Institution/Organisation	Country
Akram Ahmedi	TRL	UK
Selemani A Selemani	TMA	Tanzania
Mike Pinard	Intra Africa	Botswana
Manqoba Shange	Ken Department of Transport	RSA
Bernado Munaku	ATTI	Tanzania
Loishorwa Likimaitare	Tanzania Buildings Agency	Tanzania
Jacob Ruwa	Roads Board	Kenya
Robert Ayieko	Roughton	UK
Simon Gillett	Roughton	UK
James Mitchell	Roughton	UK
Nkululeko Leta	AFCAP	Zimbabwe
Wilie Botha	Aurecon	RSA
Leopold Runji	PMO-RALG	Tanzania
Khamis M Khamis	Pemba Rural Roads Project	Tanzania
Eufransia Bille	Civil Aviation Authority	Tanzania
John Malisa	Tanroads	Tanzania
Dalesa Hecandjo	Roads Authority	Namibia
Edward Amupadhi	Roads Authority	Namibia
David Geilinger	Road Fund	Mozambique
Elina Kayanda	PMO-RALG	Tanzania
Jennifer Mugulsiye	Road Fund	Uganda
John Hine	Ministry of Transport	Tanzania
Gina Porter	Consultant	UK
Rob Geddes	AFCAP	Zimbabwe
Geoff Fishbourne	AFCAP	UK
Katie McLeod	AFCAP	UK
Nelson Kudenga	Department of Roads	Zimbabwe
Tom Bishop	AMEND	Tanzania
Brienna Rust	Peace Corps	USA
Abdul Awadh	IT Transport	Tanzania
John Mativo	Kenya Rural Roads Authority	Kenya
Fintan Pilowoko	Ministry of Works	Tanzania
Joe Odhiambo	CSIR Agreement	RSA
Samson Kalesi	Bagomoyo District Council	Tanzania
Kingori Zacharia	Kenya National Highways Authority	Kenya
Sophia Tetu	Roads Authority	Namibia
Jasper Lugemarila	Tanzania Buildings Agency	Tanzania
Raya Joshwa	Ministry of Works	Tanzania

<sup>2</sup> Some listed participants did not attend all three days of the workshop. Other participants, who attended only day 2 and/or day 3, might not be on this list.

Per Christiansen	Ministry of Works and Transport	Uganda
Usama Kayima	Ministry of Works and Transport	Uganda
Chala Bowse	Oromia Roads Authority	Ethiopia
Akinyele Moses	Roughton	Kenya
Charles Adrian	PMO-RALG	Tanzania
Hilary Lyimo	PMO-RALG	Tanzania
Furaha SHoo	Siha District Council	Tanzania
Wycliffe Omutiko	Ministry of Works	Kenya
Philip Wai Wai	Ministry of Road and Bridges	South Sudan
Berad Thesseling	Huesker Synthetic	Germany
Peter Assinder	Huesker Synthetic	UK
Simon Oladele	Botswana T2 Centre	Botswana
Kenneth Mukura	TRL	Zimbabwe
Abdi Abdulla	Zanzibar Road Fund	Tanzania
Francis Marimo	Afri-Base Consultants	Tanzania

## ANNEX II: WORKSHOP PROGRAMME

<b>Day 2 (22<sup>nd</sup> November)</b>		
<b>Time</b>	<b>Themes</b>	<b>Facilitators</b>
14:30 to 14:45	Welcome and Introduction to AFCAP Introductions by Participants	AFCAP CMG
14:45 to 16:30	<ol style="list-style-type: none"> <li>1. Rural transport and the MDGs: Defending Investments in Rural Transport.</li> <li>2. Mobility Issues in accessing key services</li> <li>3. Introduction to the GPS Method for Rural Roads Condition Monitoring</li> <li>4. The Design and Construction of the Bago to Talawanda Road in Tanzania and Introduction to the Lawate to Kibongoto Road project.</li> </ol>	John Hine – Technical Assistant in Ministry of Transport in Tanzania Dr Gina Porter – University of Durham, UK David Geilinger – Adviser to Mozambique Road Fund Roughton International
16:30 to 17:00	Tea/coffee	
17:00 to 18:30	The Design of Low Volume Roads: <ol style="list-style-type: none"> <li>1. Engineered Earth Roads and Gravel Roads.</li> <li>2. Low Volume Sealed Roads.</li> <li>3. Performance Review of Malawi Low Volume Sealed Roads and the DCP Design Method.</li> </ol>	Mike Pinard – Consultant
<b>Day 3 (23<sup>rd</sup> November)</b>		
<b>Time</b>	<b>Themes</b>	<b>Facilitator</b>
13:00 to 18:30	Site visit to Lawate to Kibongoto Road project. Practical exercises on: <ol style="list-style-type: none"> <li>1. Social impacts and mobility</li> <li>2. GPS condition monitoring</li> <li>3. DCP design method</li> </ol>	Gina Porter David Geilinger Mike Pinard
<b>Day 4 (24<sup>th</sup> November)</b>		
<b>Time</b>	<b>Themes</b>	<b>Facilitator</b>
09:30 to 12:00	Case Studies (paper presentation followed by discussion): <ol style="list-style-type: none"> <li>1. The Design and Construction of Otta Seals in Mozambique</li> <li>2. The Maintenance of District Roads in Dodoma Region</li> </ol> Analysis of data collected during the field visit and preparation of presentations (in groups).	Kenneth Mukura – TRL(UK)  Abdul Awadh – IT Transport
12:00 to 13:30	Lunch	
13:30 to 15:30	Report back from groups and discussion.	Rob Geddes – AFCAP Technical Services Manager

## ANNEX III: PREPARING QUALITATIVE CHECK LISTS FOR INTERVIEWS WITH KEY INFORMANTS ON SOCIO-ECONOMIC IMPACTS OF RURAL ACCESS

### [General notes]

#### Features and benefits of checklist interviews [and related qualitative research approaches]:

- Can be used to explore issues in much greater depth than with survey questionnaires.
- Can be used to explore ‘multiple realities’ – i.e. issues where there is no one right answer, but where different people have different ideas and perspectives.
- More amenable to participatory approaches, since research ideas can be generated from the research process, rather than being set from the outset by external ‘experts’.
- Can be used as a stand-alone technique but also offers a valuable base for subsequent survey questionnaire design i.e. a Mixed Methods approach.  
[Qualitative research is good for uncovering why things happen and understanding people’s own understandings of their situation, so a very useful starting point in research].

Undertaking some preliminary check list interviews with key informants can be very helpful for sorting out the important questions to ask in a subsequent survey – i.e. this may ultimately save time and money.

The checklist interview may offer a good opportunity to introduce a new project, its goals etc. to local residents, and to answer their questions, as well as collecting information for triangulation with other data sources.

**Getting diverse perspectives:** This set of notes focuses principally on key informants: administrators, health workers, teachers, transport operators, traders. However, in a checklist study exploring rural access issues, efforts should be made to include interviews with people of varying ages, both sexes, diverse ethnic background, disability, etc., not just key informants. N.B. Children and young people and older people are often excluded from access surveys but access to key services is extremely important for their lives and well being. It is important to explore perceptions of their needs in direct interviews as well as with key informants.

**Flexibility is key to using checklists:** It is not necessary to discuss every theme on the check sheet with every key informant: if the respondent is only willing to give limited time, obtain the basic information you need, then focus on questions where the person concerned may have key knowledge. If an area of new information/insights opens up that looks promising, then explore this, even if it means omitting some other issues. It is better to make sure that you give the informant enough time to respond fully to your questions, and to make sure you understand the responses fully, rather than try to rush through to fit everything in. *It is NOT necessary to stick to a rigid schedule.* Write two to three sentences after the interview about how this interview takes forward our ideas about rural access and raises new questions. Add any new issues to the checklist.

**Language:** Interviews are best conducted in the language with which the informant seems most comfortable. Responses of informants should be reported as far as possible in full. Please give a direct **English** translation of their words, even if their responses seem self-evident, irrelevant or wrong. For important terms where there is no direct English translation, use the local term but provide an explanation in a note at the end of the interview sheet.

*Note-taking and recording:* Take as full notes as possible during the interview, probing where appropriate to get more detail. However, do not prompt unless it is necessary. If you don't manage to get everything the respondent says written down, leave space for additional detail then review and revise as necessary, immediately after the interview and before you start the next interview. If you wish to tape record qualitative interviews then that can be helpful, but given the time that tape transcription requires [6-8 hours per 1 hour interview] it is generally advisable that tape recording is used principally as a back-up to check on specific points made. Recording the interview can sometimes raise respondent concerns and limit their responses.

- A hardback bound notebook will make interview note-taking easier and looks less formal than a clipboard.

### **Accompanied walks: the mobile check-list interview**

Walking [or travel e.g. on public transport] with your informant can be a particularly effective way to learn about their journeys and mobility and access constraints e.g. walking with a child to school, an elderly person to the clinic, or travelling with a trader to market. Travelling along the route often triggers important thoughts and ideas which may be forgotten in a formal stationary interview. As you travel, let the respondent talk through how they experience the journey, and issues relating to the space you are travelling through. Take notes as and when you can during the journey and add further information at the end of the journey.

### **Map drawing as a base for interview discussions**

If it isn't feasible to travel with the respondent, asking the respondent to draw a rough sketch map of routes that they travel regularly can be helpful for identifying mobility constraints, transport hazards etc. This can also be used as a base for discussions about transport mode, seasonal travel variations etc. Take detailed notes of the discussion during the mapping process.



## **ANNEX IV: SOCIO-ECONOMIC ISSUES IN THE LAWATE-KIBONG'OTO ROAD AREA: DEVELOPING A PRELIMINARY CHECKLIST REVIEW**

- Some possible themes are provided for discussion with different types of key informant and other residents using a checklist. These are based on experience from other regions and may need adaptation to the current context. Their main focus is on ***exploring transport and access issues within the broader local context.***
- Draft checklists were provided for five key informant types:
  1. Settlement leaders
  2. Health workers
  3. Teachers
  4. Market traders
  5. Transport operators
  - + 6. Local residents
- During our short visit to the road it will only be possible to explore a few issues with a few key informants and other residents, especially if access proves difficult because of the rains.
- We hope it will be possible to interview 1 or 2 settlement leaders, a few teachers, members of a women's group, a few boda-boda and matatu drivers [i.e. drawing on checklists 1, 3, 4, 5] and various local residents.
- Interviews are ideally conducted individually on a one-to-one basis. However, since there may be only a few fluent Swahili speakers in the group looking at socio-economic issues, it may be necessary to assign one Swahili speaker to work with each person who was unable to speak Swahili i.e. interviews run by pairs.
- Each individual interviewer/ interviewer-pair will be assigned a key informant type for interview [e.g. teacher, transporter etc.]
- Please look through the checklist of potential themes for the assigned key informant type and select from it [and/or from your own experience, if relevant] a set of issues you would like to explore with the key informant [perhaps 10 key questions].
- Note these issues down so that you can use them as an easy checklist interview guide for the interview[s] you conduct.
- Additionally, each individual interviewer/interviewer-pair should try to find a local resident who is willing to be interviewed.
- In the interview first make notes of the basic information required about the key informant, then proceed to your selected themes. If one theme offers important perspectives you may decide not to proceed to subsequent themes but to develop this one. i.e. ***flexibility is vital.***

## 1. DRAFT CHECKSHEET: SETTLEMENT LEADERS

This check list is primarily focused at settlement political leaders and traditional leaders, but some elements could be adapted for interviews with government staff in the area, women's group leaders, church leaders, NGO staff, transport union officials, police [especially re road safety, road accident data], farmers, extension workers, etc. *It is NOT necessary to stick to a rigid schedule.*

### **Note the following information [from observation] before the interview commences.**

Name of study settlement:

Date of interview:

Name of interviewer:

Road access to settlement:

Condition of main local access road to settlement at time of interview:

Observed transport services to/from settlement [types, volume]:

Presence/absence of transport repair services [including cycle repair] [details]:

Presence/absence of mains electricity in settlement:

### **Basic information to be obtained from settlement leaders**

Name of key informant:

Place of interview:

Sex:

Position/occupation:

Approx age [i.e. estimate]:

Length of residence in settlement:

### **Topics for general discussion with settlement leaders (i.e. providing important contextual information)**

#### **a) Characteristics of settlement**

- Size of settlement [population]
- Socio-economic situation of settlement: key economic factors, key current socio-economic problems [briefly] and impact on settlement life
- Settlement Market condition [size, type, frequency per week] or distance to nearest market; changes in market condition over last 5 years [decline/expansion? If so, why?]
- Gender patterns of marketing [who trades most, men or women, why?]
- Farming patterns and key changes over last 5 years. Are there women's crops, men's crops? [detail]
- Any irrigated production? If so, is this affected by road access? [detail]
- Location of nearest grinding mill
- What development programmes are currently underway in this settlement [e.g NGO activities]?

- Ethnic and religious make-up of population and any impact on settlement life

#### **b) Roads and transport**

- Informant's personal assessment of road access conditions at time of this visit
- Road access conditions in other seasons
- Availability, frequency, reliability, and cost of transport at season of interview
- Availability, frequency, reliability, and cost of transport in other seasons [i.e. any variation]
- Transport services improved/declined in past 5 years? Why?
- Boda-boda impact on rural access? When started?
- Transport availability on market days?
- Impact of transport conditions on local farmers?
- Single fare cost to nearest main market centre [and affordability e.g. as a % of daily minimum wage)?
- Rough % of households owning a working bicycle – who uses bicycles? Why? [detail re attitude to cycling]
- Rough % of households owning an animal-drawn cart- who uses carts? Why?
- Rough % of households owning a working motor vehicle- what type? Commercial? [details]
- Any obligations re road maintenance [community rules? apply to both women and men? details]
- Will the new road change life in your community any way? If so, how?

#### **c) Distance to schools and impacts on children's access**

- Distance to nearest primary school in a) kilometres b) time takes to travel there if walk c) time takes to travel by vehicle d) travel cost by cheapest available mode
- Distance to nearest JSS or equivalent intermediate school in a) kilometres b) time takes to travel there if walk c) time takes to travel by vehicle d) travel cost by cheapest available mode
- Distance to nearest Senior Secondary School in a) kilometres b) time takes to travel there if walk c) time takes to travel by vehicle d) travel cost by cheapest available mode
- % of girl children, % boy children in settlement who attend Senior Secondary School regularly [any comments on gender pattern of attendance?]
- Perceptions of a) girl and b) boy children's current patterns of travel to primary school [means of transport used, accompanied or not, etc.]
- Perceptions of a) girl and b) boy children's current patterns of travel to secondary school [means of transport used, accompanied or not, etc.]
- Perception of travel problems getting to school [e.g. cost, danger, time taken, etc.] Discuss any seasonal differences.
- Importance of travel problems versus other problems of attendance [cost, work demands etc.] Discuss any seasonal differences.
- When the road is finished will schools be easier to get to, will more children go / go more regularly or are other factors more important?

#### **d) Distance to health care services and impacts on residents' access**

- Distance to nearest dispensary/ primary health centre in a) kilometres b) time takes to travel there if walk c) time takes to travel by vehicle d) travel cost by cheapest available mode.
- Distance to nearest hospital in a) kilometres b) time takes to travel there if walk c) time takes to travel by vehicle d) travel cost by cheapest available mode.
- Perceptions of a) women's and b) men's current patterns of travel to health centres and hospitals [modes of transport, distances travelled, etc.].

- Travel problems getting to health services [cost, time, danger, etc.] Discuss any seasonal differences.
- Importance of travel problems versus other problems of health service use [cost, quality, work demands etc.] Discuss any seasonal differences.
- Specific problems faced by elderly in accessing health care?
- If health services were nearer / easier to get to, would more people go / go more regularly or are other factors more important?
- Perception of current vaccination coverage of children in the settlement and reasons for some children not being vaccinated.
- When the road is finished will health services be easier to get to, will more people use them more regularly, or are other factors more important?

#### **e) Distance from and access to key resources**

- Distance to nearest good water supply in kilometres and any issues of access for local people.
- Main source of cooking fuel in the settlement?
- Distance to nearest main supply of cooking fuel [fuel wood or kerosene, whichever most relevant] in kilometres and any issues of access for local people
- When the road is finished will water and cooking fuel be easier to get to? [detail]

#### **f) Views on transport, mobility and movement**

- Personal ownership or availability of bicycles to key informant [detail]:
- Personal ownership or availability of any carts, wheelbarrows, animals used for transport, etc to key informant [detail]:
- Personal ownership or availability of any motorised vehicles to key informant [details including any commercial vehicles]:
- Personal ownership or availability mobile phone by key informant [detail]:
- Perceptions of settlement's main transport and mobility problems: a) for children b) women c) men d) older people
- Views about a) females and b) males riding cycles; reasons for views expressed
- Views about local road accident levels and road safety among children, older people, others
- Will the new road bring any road safety problems?
- Perception of female freedom of movement in the settlement [variation in freedoms given at different ages?] – are any restrictions reported associated with a) vulnerability, b) potential promiscuity?
- Will the new road affect women's travel patterns?

#### **g) New communications impact on transport**

- Percentage of households in settlement with mobile phone ownership?
- Phone charging, phone cards etc. available in settlement?
- Views on impact of mobile phones on settlement life in general? [details]
- Have phones changed people's travel patterns in any ways? [details, re men, women, children, older people impacts]
- Any impact on transport availability/service quality?

## 2. DRAFT CHECKSHEET: HEALTH WORKERS

[i.e. INCLUDING COMMUNITY-BASED HEALTH WORKERS, HSAs, TBAs, TRADITIONAL HEALERS, NGO HEALTH STAFF ETC. ]

**Note:** Efforts should be made to include interviews with a range of women and men health workers [varying ages, length of service, ethnic background etc.] if possible at different types of health centre serving the study settlement. It is not necessary to discuss every issue on the check sheet with every health worker. If an area of new information/insights opens up that looks promising, then explore this, even if it means omitting some other issues. *It is NOT necessary to stick to a rigid schedule.*

### **Note the following information [from observation] before the interview commences:**

Name of study settlement:

Date of interview:

Name of interviewer:

### **Basic information required from all health workers**

Name of key informant:

Place of interview:

Sex:

Name and type of health organisation/centre where works [unless Traditional Healer/TBA in which case state]:

Position:

Approx age [estimate]:

Length of service at this location:

Personal ownership of transport modes [including bicycle, wheelbarrow, carts, car etc.]:

Ownership or availability mobile phone to key informant [details]:

#### **a) Background information on health service provision**

- Main activities of health facility for which you work, including details of any mobile/perapatetic services [e.g. vaccination services] provided  
[if traditional/community worker, ask about own activities]
- Annual treatment figures at this facility/at mobile facilities [any detail for men, women, boy children, girl children?]  
[if traditional/community worker, ask about own activities]
- Broad details of charges [consultation charge, cost of prescription etc.]
- Main problems faced by health facility staff in serving local people  
[if traditional/community worker, ask about own problems of serving local people]
- Main transport problems faced by health facility staff [including operation of mobile services]

[if traditional/community worker, ask about own transport problems re work activities]

- Main problems faced by local residents who might want to use the health facility
- Main problems faced by older people who might want to use the health facility
- Ratio of females to males using the facility [or consulting the individual if traditional/community worker] and explanation of the patterns.
- Will the new road affect usage of the health facility? [detail]

**b) Use of health services [distinguish between people by sex, age, ethnicity etc.]**

- Common reasons for people attending the facility [broad health care, main illness types] [or consulting the individual if traditional/community worker]
- Common reasons for people NOT attending the facility when they are ill [or consulting the individual if traditional/community worker] [ranked]
- Attendance of women and of children on their own? or always with other family member? [details]
- Children accompanying others and accompanied to health services? [details – eg. for any consultation? Only for overnight stay?]

**c) Transport-related health problems [distinguish by sex, age, ethnicity etc.]**

- Any perceived health impacts re load carrying by a) children, b) women, c) men, d) in later life?
- Any perceived health impact from other kinds of work?
- Road accidents dealt with by your facility [or consulting the individual for traditional/community worker]?
- Any statistics for girl and boy children road accidents versus adults? [if so, collect]
- Any likely impacts of the new road on health? [detail]

**d) Vaccination services**

- Local vaccination services - details including how many centres, charges etc.
- Main constraints on vaccination uptake levels in the area served by the health facility? [e.g. Knowledge of immunisation, lack of suitable venues, staff attitudes, long waiting times, cost, transport availability, road access, fear of side effects, timing of sessions? Rank where transport comes among main factors].
- Will the new road affect access to vaccination services?

**e) Travel to health services and views on possible interventions**

- Main mode of travel to this health facility by patients [foot, taxi etc.?)
- Usage of motorised ambulances? [details]
- Usages of non-motorised ambulances – e.g. bicycle ambulances? [details]
- Usage of stretchers and other patient carrying modes? [details]
- Perceptions of transport as a factor affecting access to the health facility [compared to other constraints]
- Which interventions [not just transport] would most improve male attendance at health service and why? *[make it clear that you are not in a position to effect any interventions]*
- Which interventions [not just transport] would most improve women's attendance at health service and why? *[make it clear that you are not in a position to effect any interventions]*
- Which interventions [not just transport] would most improve older people's attendance at health service and why? *[make it clear that you are not in a position to effect any interventions]*
- How big a difference would improved transport / ease of access make to male/ female health service attendance, in the absence of any other interventions? Any specific stories? Why? *[make it clear that you are not in a position to effect any interventions]*

- Would better availability of bicycles make a significant improvement a) for females, b) for males? [details] why? *[make it clear that you are not in a position to effect any interventions]*
- Transport as a factor in referral of patients to higher order health centres [regional hospitals etc. – re availability of emergency transport, ambulance fees etc.]? [any specific stories?]

#### **f) Health worker's personal travel**

- Health worker's own transport to health facility [distance, mode, ease of transport, problems of travel, travel time)
- Health worker's own regular travel to patients in course of work [distance, mode, ease of transport, problems, travel time)
- Will the new road affect your journey to work?

#### **g) Communications**

- Do you have access to a phone [mobile or landline]? If so, how has this affected the way you carry out your health-related work?
- What proportion of people in this community [or the communities you serve] have access to phones?
- Has the use of phones made any differences to people's use of health services? Can you give any example where it helped? [E.g. able to call for help in emergencies]

#### **h) Personal access to/ ownership of transport equipment**

- Ownership or availability of bicycles in household [details]
- Ownership or availability of any carts, wheelbarrows or animals used for transport etc in household [details]
- Ownership or availability of any motorised vehicles in household [details]

#### **i) Attitudes to living in this settlement [or explain why not if doesn't live here]**

- What do you like about living in this place?
- What do you dislike about living in this place?
- Will the new road change your attitude to living in this place?

### 3. DRAFT CHECKSHEET: TEACHERS

**Note:** Efforts should be made to include interviews with women and men teachers [varying ages, length of service, ethnic background etc.] if possible at different types of school [primary, secondary, government, private] serving the study settlement. It is not necessary to discuss every issue on the check sheet with every teacher. If an area of new information/insights opens up that looks promising, then explore this, even if it means omitting some other issues. *It is NOT necessary to stick to a rigid schedule.*

#### **Note the following information before the interview commences:**

Name of study settlement:

Date of interview:

Name of interviewer:

#### **Basic information required from all teachers**

Name of key informant:

Place of interview:

Sex:

Name of school where teaches:

Position at school where teaches:

Approx age [estimate]:

Length of service at this school:

Personal ownership of/access to transport modes [including bicycle, wheelbarrow, carts, animal-drawn cart, car etc.]:

Ownership or availability mobile phone to key informant [details]:

#### **a) Background information about the school**

- Note level [primary, JSS, secondary] and type [government, private etc.]
- School enrolment data [boys, girls separately]
- Age of oldest pupil in school
- Age of youngest pupil in school
- Attendance at school [comparison with enrolment – rough %s]– with daily and seasonal patterns for boys and girls separately
- % of total children of relevant age in school catchment area who are enrolled in school?
- Any boarding at the school?
- Any boarding of children with relatives/ at houses in the neighbourhood so they can attend this school? [details]
- Primary teachers only: does transport [availability, cost] affect transfer to secondary school [a) for boys, b) for girls]? [details]



## **b) Reasons for enrolment / attendance patterns [i.e. re all pupils of the school]**

- Causes of low/high enrolment patterns [girls, boys separately]- ranked
- Causes of low/high attendance patterns [girls, boys separately]- ranked
- Impact of transport on school attendance [boys, girls, age patterns, seasonality?]
- Which interventions would most improve boys' attendance at your school and why *[make it clear that you are not in a position to effect any interventions]*
- Which interventions would most improve girls' attendance at your school and why *[make it clear that you are not in a position to effect any interventions]*

## **c) Child portorage [i.e. load carrying]**

- Incidence/level of child portorage [load carrying] work among pupils [girls, boys separately, age patterns, seasonality?]
- Any impacts of load carrying activities on child performance at school [girls, boys separately, age patterns, seasonality?]
- Will the new road have any effect on children's load carrying?

## **d) Travel to school and related issues**

- Rough % of children who travel on foot to this school [by sex and age]
- Rough % of children who travel by bicycle [breakdown by sex and age]
- Rough % of children who travel by motor vehicles [breakdown by sex and age] Detail re vehicle type – any boda-boda travel to school? [detail]
- Main differences in pattern of travel by age [younger v. older children]
- Maximum distance pupils travel by motorised transport to this school
- Maximum distance pupils travel on foot to this school
- Maximum distance pupils travel by bicycle or other non-motorised transport to this school
- Maximum time pupils take to travel by whatever means to school [i.e. longest regular journey time]
- Any provision of transport services by school? [type, quality, usage, charges]
- Is travel to national examination centres a problem for children from your school? [details]

## **e) Teacher's own travel**

- Teacher's own daily travel to school from home [distance, mode, ease of transport, problems of travel, travel time]
- Teacher's own travel to home [if permanent residence is elsewhere: location, distance, mode, frequency, ease of transport, problems of travel, travel time]
- Will the new road affect your journey to work? [detail]

## **f) Pupil punctuality**

- Main cause of poor punctuality/lateness to school? [by sex, age, season]
- Impact of work activities on punctuality/lateness to school [girls, boys separately, age patterns, seasonality?]
- Impact of transport on punctuality/lateness to school [including seasonality?]
- What is your attitude to pupils' lateness?
- What punishments/sanctions do you apply [if any]?
- Will the new road affect children's punctuality? [detail]

### **g) Attitudes towards transport, traffic and possible interventions**

- Attitudes to bicycle riding in this settlement/school [girls, boys separately]
- Attitudes to any use of boda-boda services by boys? by girls?
- Road safety training [any done? if so, what does it include?]
- Incidence of road accidents among pupils? [younger V older pupils? Boys V girls? Fatalities?]
- How big a difference would improved transport / ease of access make to boys' / girls' school attendance, in the absence of any other interventions?
- Would availability of bicycles make a significant improvement a) for girls, b) for boys? [if not, why not? other details] *[make clear we are not in a position to make provision]*
- Any specific issues for children with disabilities/ special needs?
- Will the new road entail additional road safety training at this school?

### **h) Telecommunications and media**

#### **Own use**

- Do you have any access to a mobile phone? If so, who does it belong to? Mainly used for work purposes, family/social reasons or emergencies?
- Has mobile phone availability changed your travel patterns or work in any way?

#### **Pupils' use**

- What % of pupils have access to mobile phones [details: gender pattern? age of owners?] Any impact of mobiles on travel to school? Can you give a specific example?

### **i) Attitudes to living in this settlement [or explain why not if doesn't live here]**

- What do you like about living in this place?
- What do you dislike about living in this place?
- Will the new road change your attitude to living in this place?

#### 4. DRAFT CHECKSHEET: TRANSPORT OPERATORS

**Note:** This key informant checklist suggests some themes for discussion with transport operators and other transport-related workers serving local settlements. It could be administered to transport workers in their home, at a repair station, while they are visiting the settlement, at the taxi rank or lorry park, or on the road to the settlement etc. Efforts should be made to include interviews with a range of transport operators [e.g. boda-boda, minibus and taxi drivers], owners, repairers etc. of varying ages, scale of business, length of service, ethnic background etc. The interview mostly covers issues with reference to the particular study settlement. It is not necessary to discuss every issue on the check sheet with every transporter. If an area of new information/insights opens up that looks promising, then explore this, even if it means omitting some other issues. ***It is NOT necessary to stick to a rigid schedule.***

#### **Note the following information before the interview commences:**

Name of study settlement:

Date of interview:

Name of interviewer:

#### **Basic information required from all transport operators/owners**

Name of key informant:

Place of interview:

Sex:

Occupation/Position:

Approx age [estimate]:

Length of service at/to this location:

Personal ownership of/access to transport modes [including bicycle, wheelbarrow, carts, animal-drawn cart, car etc.] [details]:

#### **a)Transport**

- Discuss various transport services available from/to this settlement e.g.:
  - modes available
  - fares [including difference in rates between boda-boda, matatu etc]
  - are modes available affected by route quality? [seasonal price changes?]
  - seasonal variation in provision?
  - repair services - availability to operators
  - motorbike-taxi and bicycle-taxi services [approx. date established, perceived advantages, disadvantages]
  - freight patterns [evacuation of large loads, small loads]
- Main challenges in your work? [detail]
- Transport as a factor affecting livelihoods in this place [farming etc.][details]
- Transport as a factor affecting children's attendance at school? [details]

- Any school provision of transport services? [detail]
- Transport as a factor affecting people's use of health services? [detail]
- Views on any health centre transport provision [mobile clinics etc.]?
- Attitudes to women's travel [details e.g as boda-boda passenger]
- Girl children as passengers – problems? safety issues? driver harassment issues?
- Boy children as passengers – problems? safety issues? other issues?
- Children as pedestrian hazard? Views on road safety teaching in school etc.
- Attitudes re cycling – female cyclists (incidence, attitudes), views re impact of cyclists on road safety?
- Older people as passengers– problems? safety issues? other issues?
- Any catering for disabled passengers/special needs? Actual examples?
- Extortion by police, transport workers or road officials? highway robbery? pilfering? need for escort? [details] Biggest of these problems?
- Incidence and role of transport unions? [which modes? Advantages? Disadvantages?
- Fuel access/cost/quality [dilution problems ?] [detail]
- Insurance costs? [detail]
- What would be the best way to improve transport serving this settlement [*Make it clear that we are not in a position to effect any changes*]
- Will the new road have any impact on your work as a transporter? [detail]
- Will the new road have any impact on your life more generally? [detail]
- Any obligations re road maintenance [personal? community rules?]

**b) Phone communication**

- Do you have any access to a mobile phone? If so, who does it belong to? Main purpose [family business, social calls to friends, emergencies]?
- Do you use it in your business?
- Impact on organizing help following breakdown or traffic accident? [stories?]
- Has the expansion of mobile phone ownership affected your work? If so how?
- Any impact on provision of transport services to community? [in general? in emergencies?]

## 5. DRAFT CHECKSHEET: MARKET TRADERS

**Note:** Efforts should be made to include interviews with both women and men traders [varying ages, commodity trade types, retail/wholesale scale of trade, ethnic background etc.]. It is not necessary to discuss every issue on the check sheet with every trader. If an area of new information/insights opens up that looks promising, then explore this, even if it means omitting some other issues. ***It is NOT necessary to stick to a rigid schedule.***

### **Note the following information before the interview commences:**

Name of study settlement:

Date of interview:

Name of interviewer:

### **Basic information required from all traders**

Name of key informant:

Place of interview:

Sex:

Approx age [estimate]:

Main trading commodity:

Trader scale/type [retail, wholesale, broker etc.]:

Years of experience in trading:

Other occupations:

Personal ownership of/access to transport modes [including bicycle, wheelbarrow, carts, animal-drawn cart, car etc.]:

Ownership or availability of mobile phone to key informant [details]:

### **a) Background information about market[s] access and related services**

- Main commodities traded?
- Distance from home to nearest market? Is this main personal trading location? If not, why not?
- Main markets where trades? Distance? Frequency of market visits? Why these markets?
- Has business improved or declined in last 5 years? Why? [detail]

### **b)Transport issues**

- Main transport mode used to market? Advantages? Disadvantages?

- Any constraints on travel to market [transport availability? transport cost? load size? road conditions?]
- Impact of transport problems on trading pattern? [distance, mode of transport, overnight stays]
- Any constraints on personal travel e.g. spouse objects to travel? child care? work load at home? [detail]
- Travel hazards - any harassment during travel by fellow passengers? Pilfering by fellow passengers? [stories]
- Extortion by police, transport workers or road officials? robbery? need for escort? [details] Biggest of these problems? [stories]
- Travel accidents? Cause? Impact on trade? [stories]
- Impact of travel/mobility constraints on trading pattern? [distance, mode of transport, other duties, overnight stays] [detail re each constraint and impact]
- Consequences of late arrival at market? [perishability issues, e.g.in dairy sales, bananas?] [stories]
- Main constraints on personal trading business? Where does transport rank among these constraints? [detail]
- Any purchase of goods from other farmers [i.e. bulking]? If so, what are the main constraints? Where does transport rank among these constraints?
- How big a difference would improved transport / ease of access to farmers and markets make to your trading business, in the absence of any other interventions? Why? [stories?] *[make it clear that you are not in a position to effect any interventions]*
- Which needs more attention, improving transport/access from homestead to market or improving transport/access from fields to homestead? [details]
- Use of financial services eg. Savings bank? If so, how far away, any access problems? [detail]
- Do use boda-boda? If so, for what purposes?
- Will the new road affect your trading pattern in any way? [detail]

#### **b) Communications**

- Impact of mobile phones on personal trading partners and trade patterns? Any specific impact on transport and travel patterns?
- Any negative impact of phones? [robbery?]
- Use mobile phone banking [MPESA]? If so, is it changing personal pattern of travel and trade?

#### **c) Load carrying**

- Any loads *personally* carried [headloaded] regularly to market? If so, distance? Size/nature of loads carried? Why not motor transport?
- Perceived impacts of load carrying on health? Other impacts?
- Any family members regularly headload for you? If so, distance? Size/nature of loads carried? Why not use of motorized transport instead? Impacts re health? [detail]
- Any payment to porters for load carrying of goods to market? [detail re gender, age, any relationship, ethnic group, size of loads, commodity type, distance carried, charges] [detail]
- Any other loads *personally* carried regularly [water, firewood, produce from fields?] If so, distance carried from source to homestead? Size of load? Impacts on health/other impacts? [detail]
- Any family members regularly carry other loads for you [water, firewood, produce from fields?] If so, load type, distance carried from source to homestead? Size of load? Impacts on health/other impacts? [detail]
- Will the new road affect headloading by you? By your family? Employment of porters?

## 6. DRAFT CHECKSHEET: OTHER LOCAL RESIDENTS

### **Note the following information [from observation] before the interview commences**

Name of study settlement:

Date of interview:

Name of interviewer:

Road access to settlement:

Condition of main local access road to settlement at time of interview:

Observed transport services to/from settlement [types, volume]:

Presence/absence of transport repair services [including cycle repair] [details]:

Presence/absence of mains electricity in settlement:

### **Basic information to be obtained from local resident**

Name [can be just a first name or nick-name]:

Place of interview:

Sex:

Occupation(s):

Approx age [i.e. estimate]:

No. of children resident with you and approx ages:

Length of residence in settlement:

Personal ownership or availability of bicycles to key informant [detail]:

Personal ownership or availability of any carts, wheelbarrows, animals used for transport, etc [detail]:

Personal ownership or availability of any motorised vehicles [details including any commercial vehicles]:

Personal ownership or availability of mobile phone [detail]:

### **Topics for general discussion**

#### **a) Roads and transport**

- Informant's personal assessment of road access conditions at time of this visit
- Perception of road access conditions in other seasons
- Availability, frequency, reliability, and cost of transport at season of interview
- Availability, frequency, reliability, and cost of transport in other seasons [i.e. any variation]
- Transport services to settlement improved/declined in past 5 years? Why?

- Perceptions of settlement's main transport and mobility problems: a) for children b) women c) men d) older people
- Views about cycle riding by girls and women [detail]
- Views about local road accident levels and road safety among children, older people, others [detail]
- Will the new road bring any road safety problems? [detail]
- Perception of women's freedom of movement in the settlement [variation in freedoms given at different ages?]
- Are any restrictions on women's mobility associated with a) vulnerability, b) views about potential promiscuity?
- Will the new road affect the travel patterns of people in this community? [adults, children, older people] [detail]

#### **b) Personal travel**

- Personal use of Boda-boda? [detail: journey purposes? frequency? year first used? Advantages? Disadvantages?]
- Personal use of other transport? [detail]
- Impact of current transport availability and cost on personal livelihood?
- Single fare cost to nearest main market centre [and affordability e.g. as a % of daily minimum wage]?
- Any personal obligations re road maintenance [community rules? ] [detail]
- Will the new road change your travel patterns? [detail]
- Will the new road change your livelihood and life in any way? If so, how?

#### **c) Load carrying**

- Any loads *personally* carried [headloaded] regularly? If so, distance? Size/nature of loads carried? Why not motor transport?
- Perceived impacts of load carrying on health? Other impacts?
- Any family members regularly headload for you? If so, distance? Size/nature of loads carried? Why not use of motorized transport instead? Impacts re health? [detail]
- Any payment to porters for load carrying of goods to market? [detail re gender, age, any relationship, ethnic group, size of loads, commodity type, distance carried, charges]
- Any other loads *personally* carried regularly [water, firewood, produce from fields?] If so, distance carried from source to homestead? Size of load? Impacts on health/other impacts? [detail]
- Any family members regularly carry other loads for you [water, firewood, produce from fields?] If so, load type, distance carried from source to homestead? Size of load? Impacts on health/other impacts? [detail]
- Will the new road affect headloading by you? By your family? Employment of porters?

#### **d) Distance to school and impacts on children's access [if has resident children of school age]**

- Distance travelled by children to primary school [if relevant]
- Distance travelled by children to secondary school [if relevant]
- Details of each child's current patterns of travel to primary school [means of transport used, accompanied or not, etc.]
- Details of each child's current patterns of travel to secondary school [means of transport used, accompanied or not, etc.]
- Do your girl children ever use boda-boda to get to school? [detail] For other purposes?



- Do your boy children ever use boda-boda to get to school? [detail] For other purposes?
- Details of any travel problems experienced by children in getting to school [e.g. cost, danger, time taken, etc.] Discuss any seasonal differences.
- Importance of travel problems versus other problems of attendance [cost, work demands etc.] Discuss any seasonal differences.
- When the road is finished will your children get to school more easily? Will they go more regularly or are other factors more important? [detail]

#### **e) Distance to health care services and impacts on residents' access**

- Distance to your nearest dispensary/ primary health centre in a) kilometres b) time takes to travel there if walk c) time takes to travel by vehicle d) travel cost by cheapest available mode.
- Distance to nearest hospital in a) kilometres b) time takes to travel there if walk c) time takes to travel by vehicle d) travel cost by cheapest available mode.
- Travel problems experienced getting to health services [cost, time, danger, etc.]? Discuss any seasonal differences.
- Importance of travel problems versus your other problems of health service use? [cost, quality, work demands etc.] Discuss any seasonal differences.
- If health services were nearer / easier to get to, would you personally go / go more regularly or are other factors more important?
- When the road is finished will health services be easier for you to get to, will you use them more regularly, or are other factors more important?

#### **f) Distance from and access to key resources**

- Distance to your nearest good water supply in kilometres and any issues of access.
- Main cooking fuel used? Distance to nearest main supply in kilometers? Any issues of access?
- When the road is finished will water and cooking fuel be easier to get to? [detail]

#### **g) New communications impact on transport**

- Does anyone in your household own a mobile phone? [detail]
- What is the network coverage like? [detail]
- Phone charging, phone cards etc. available in settlement?
- Impact of mobile phones on your life ? [details]
- Any impact of mobile phone use on your use of transport? [detail]
- Any impact of mobile phones on transport availability/service quality? [detail]

#### **i) Attitude to living in this settlement**

- What do you like about living in this place?
- What do you dislike about living in this place?
- Will the new road change your attitude to living in this place?

## ANNEX V: THE DESIGN OF LOW VOLUME ROAD PAVEMENTS, WITH PARTICULAR REFERENCE TO THE DCP DESIGN METHOD – OUTPUT OF DCP LAYER STRENGTH ANALYSIS

### (a) Site Visit Photographs



DCP measurement at Ch. 0+258



DCP measurement at Ch. 2+580

### (b) Summary of results of DCP measurements

#### (i) Chainage 0+258 (Gravel wearing course)

Layer No.	Penetration rate (mm)	DCP CBR <sup>2</sup> (%)	Layer thickness (mm)	Position	Pavement strength (SNP)
1	4.55	61	250	Wearing course	4.04
2	6.90	39	207	Subbase	
3	1.55 <sup>1</sup>	190 <sup>1</sup>	62	Subgrade	

1- Low penetration rate due to hard stratum or large rock; 2- At prevailing in situ moisture content (approx. OMC) and density (approx. 95% BS heavy in wearing course, 93% BS Heavy in Subbase and 90% BS heavy in subgrade)

#### (ii) Chainage 2+580

Layer No.	Penetration rate (mm)	DCP CBR <sup>1</sup> (%)	Layer thickness (mm)	Position	Pavement strength (SNP)
1	4.09	68	307	Wearing course	4.22
2	6.67	41	200	Subbase	
3	8.53	31	341	Subgrade	

1- At prevailing in situ moisture content (approx. OMC) and density (approx. 95% BS heavy in wearing course, 93% BS Heavy in Subbase and 90% BS heavy in subgrade)

#### (iii) Chainage 12+860

Layer No.	Penetration rate (mm)	DCP CBR <sup>1</sup> (%)	Layer thickness (mm)	Position	Pavement strength (SNP)
1	3.74	75	337	Wearing course	4.47
2	6.82	40	375	Subbase	
3	10.70	25	107	Subgrade	

1- At prevailing in situ moisture content (approx. OMC) and density (approx. 95% BS heavy in wearing course, 93% BS Heavy in Subbase and 90% BS heavy in subgrade)

(c) Typical DCP Layer Strength Analysis Report

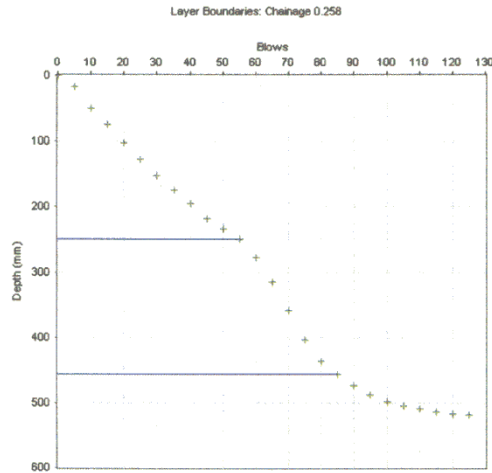
UK DCP V3.1

DCP Layer Strength Analysis Report

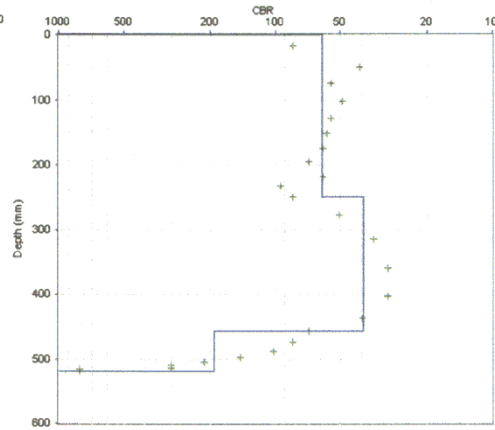
Project Name: T2 Conference

Chainage (km): 0.258  
 Direction: East  
 Location/Offset: Lane 1  
 Cone Angle: 60 degrees  
 Zero Error (mm): 80  
 Test Date: 22/11/2011

Surface Type: Unpaved  
 Thickness (mm): 0  
 Base Type:  
 Thickness (mm):  
 Surface Moisture: Moderate  
 Moisture adjustment factor: Not adjusted



Layer Boundaries Chart



CBR Chart

Layer Properties

No.	Penetration Rate (mm/blow)	CBR (%)	Thickness (mm)	Depth to layer bottom (mm)	Position	Strength Coefficient	SN	SNC	SNP
1	4.55	61	250	250	Base	0.11	1.13	1.13	1.13
2	6.90	39	207	457	Sub-Base	0.11	0.86	0.86	0.90
3	1.55	190	62	519	Subgrade	--	--	--	--

Pavement Strength

Layer	Layer Contribution		
	SN	SNC	SNP
Surface	--	--	--
Base	1.13	1.13	1.13
Sub-Base	0.86	0.86	0.90
Subgrade	--	2.08	2.01
<b>Pavement Strength</b>	<b>1.99</b>	<b>4.07</b>	<b>4.04</b>

CBR Relationship:

TRL equation:  $\log_{10}(\text{CBR}) = 2.48 - 1.057 \times \log_{10}(\text{Strength})$

Report produced by .....