



Good Policies and
Practices on Rural Transport in Africa

Planning Infrastructure & Services

John Hine



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Acronyms and abbreviations

| | |
|-------|---|
| AADT | Average Annual Daily Traffic |
| AFCAP | Africa Community Access Programme |
| AICD | Africa Infrastructure Country Diagnostic |
| CBA | Cost-benefit analysis |
| DfID | Department for International Development (UK) |
| DRRP | District Rural Roads Plan (India) |
| EIA | Environmental Impact Assessment |
| EIRR | Economic Internal Rate of Return |
| ERTTP | Ethiopian Rural Travel and Transport Programme |
| FYRR | First Year Rate of Return |
| GPRTU | Ghana Private Road Transport Union |
| GPS | Global Positioning System |
| GIS | Geographical Information Systems |
| HDM-4 | Highway Development and Management Model |
| IDA | International Development Association |
| IFPRI | International Food Policy Research Institute |
| IFRTD | International Forum for Rural Transport Development |
| ILO | International Labor Organisation |
| IMT | Intermediate Means of Transport |
| IRAP | Integrated Rural Accessibility Planning |
| IRI | International Roughness Index |
| IRR | Internal Rate of Return |
| LSMS | Living Standards Measurement Survey |
| LVSR | Low Volume Sealed Road |
| MCA | Multi-Criteria Analysis |
| MIRR | Modified Internal Rate of Return |
| MIRTP | Makete Integrated Rural Transport Project |
| MDG | Millennium Development Goal |
| NGO | Non-Governmental Organization |
| NMT | Non-Motorized Transport |
| NPV | Net Present Value |
| NPV/C | Net Present Value over Cost ratio |
| NRDA | National Rural Road Development Agency (India) |

| | |
|---------|---|
| OMMS | Online Management & Monitoring System (India) |
| PA | Participatory Appraisal |
| PAM | Performance Assessment Marco |
| PCI | Pavement Condition Index |
| PIARC | World Road Association |
| PIRTP | Pilot Integrated Rural Transport Project (Malawi) |
| PIU | Programme Implementation Unit |
| PLA | Participatory Learning in Action |
| PMORALG | Prime Minister's Office Regional Administration and Local Government (Tanzania) |
| PPP | Public-Private Partnership |
| PRA | Participatory Rural Appraisal |
| PMGSY | Pradhan Mantri Gram Sadak Yojana (India) |
| PRSP | Poverty Reduction Strategy Paper |
| RAI | Rural Access Index |
| RAMPA | Rural Accessibility and Mobility Pilot Activity (Malawi) |
| RED | Roads Economic Decision Model |
| RONET | Road Network Evaluation Tools |
| RP | Revealed Preference |
| RRA | Rapid Rural Appraisal |
| RTTP | Rural Travel & Transport Program (formerly a component of SSATP) |
| RTIM | Road Transport Investment Model |
| SSATP | Africa Transport Policy Program |
| STA | State Technical Agency (India) |
| SUMATRA | Surface and Marine Transport Regulatory Authority (Tanzania) |
| TRL | Transport Research Laboratory (UK) |
| TRRL | Transport and Road Research Laboratory (UK) |
| VOC | Vehicle operating cost |
| VTTP | Village Travel and Transport Programme (Tanzania) |
| WHO | World Health Organisation |
| WIDP | Woreda Integrated Development Plans (for Ethiopia) |

Executive Summary

Background

Sub-Saharan Africa is at a major disadvantage compared with other continents on the availability of rural transport infrastructure, intermediate means of transport and transport services, the efficiency of agricultural transport and marketing, and on costs of transport. There is clearly scope for major improvements. Better rural transport is crucial to reducing poverty and isolation and in promoting economic growth. An inefficient and unsafe transport system has key adverse knock-on effects on livelihoods, the delivery of health and education, social interaction and the development of agriculture and the service sector.

The problems of rural transport are largely the manifestation of a wider vicious circle of rural poverty. Low incomes, a weak tax base and a deficient institutional structure lead to a poor quality of infrastructure, a lack of investment and maintenance. Despite its importance, outside of donor-driven programs, rural road planning is poorly carried out, with little analysis of alternatives, and based on very limited data. Low density of transport demand coupled with poor infrastructure lead to low transport productivity with infrequent and high cost transport services. This in turn leads to low mobility rates and poor interaction with markets and services as well as low goods movement and development of resources. These factors, in turn, lead to poor health and education outcomes and poverty—and so the circle is completed. The challenge is how to break the vicious circle of low demand and incomes, poor infrastructure and weak institutions.

This paper provides an overall framework for identifying, planning and prioritizing rural transport infrastructure and services interventions. A key element is to encourage a holistic understanding of rural transport. Although services and infrastructure can be planned in isolation of each other, the best long-term results are likely to be achieved if they are improved in conjunction with each other.

Planning and Prioritization

Within the context of managing rural transport infrastructure and services, interventions planning is a process that involves a number of steps or components:

- ♦ objectives are identified
- ♦ relevant data is collected and analyzed
- ♦ resources and constraints are identified
- ♦ alternative scenarios, (or investment choices or plans) are prepared
- ♦ different scenarios are compared to see how objectives can be best achieved with available resources, taking into account constraints
- ♦ once a final choice made, the plan is put in place with committed resources
- ♦ monitoring of outputs, outcomes and final impacts is then undertaken

Alternatives may be compared using an economic cost-benefit analysis, whereby the objective is usually to maximize the Net Present Value (NPV) of a project or program of interventions.

Prioritization is the process by which different scenarios, options or plans are compared and ranked. This may be carried out within the framework of an economic cost-benefit analysis or via some form of cost effectiveness or ranking process, or a procedure such as Integrated Rural Accessibility Planning (iRAP). The prioritization process may involve multiple stages and include the participation of local stakeholders.

As part of the planning process, road feasibility studies, network plans, and master plans are prepared to indicate the viability and priority of investments. These plans cannot be implemented at once. As a result, a **programming** process needs to be undertaken whereby the different investments are phased in year by year.

A range of planning and prioritization procedures are outlined here, but keeping in mind there is no magic formula. What will work well in one country, or context, may be inappropriate in another. A traffic-based transport cost savings approach to road planning will be easy to apply in a densely populated country where all year round access is in place and traffic levels are moderate to high, but

much more difficult to apply in sparsely populated rural areas where basic vehicle access is the main problem.

It is only by undertaking a comparative analysis of plausible alternative solutions that we can be sure that financial resources are not going to be wasted. Limited funding for implementation is often a major constraint. Too often, no comparative analysis is undertaken and unnecessarily expensive solutions are chosen for rural road investment, which means that there may be far fewer beneficiaries, for the available funds, than may be achieved by using more appropriate alternatives.

Fundamental to all rural transport planning is a need for adequate data and properly trained staff. However, they are both too often lacking, particularly at the district level. In this case, extra resources are needed to collect traffic and other data as well as to provide training for planning and engineering staff in the techniques of transport planning. It is essential that they must be able to identify realistic alternatives and subject them to analysis to determine the best options. It is only when this has been achieved that proper planning processes can be undertaken for both locally funded and donor funded programs.

This paper outlines a range of measures and procedures to plan and improve rural transport infrastructure and services (Cost Effectiveness and Ranking Criteria, iRAP, HDM-4, and the Roads Economic Decision model (RED)). A new planning procedure, the *Rural Transport Prioritization Framework* is introduced, primarily to assist with planning transport service initiatives. All approaches have strengths and weaknesses, and no solution will be ideal in all circumstances.

For rural road planning, the most important first objective is to achieve basic vehicle access. This has important economic and social benefits. A spot improvement approach, whereby the main objective is to achieve all season access is likely to provide the best value for money where traffic volumes are low. However, a transport cost-benefit analysis approach is unlikely to work well due to the difficulties of assessing the social and long-term developmental benefits of establishing basic vehicle access. So where communities are completely cut off, or all season access is not provided, then road investments may be prioritized by a form of a cost-effectiveness criterion that takes into account both adjacent population and traffic. It is important that the initial local screening, within a district, involves strong community participation. The Taylor and Airey (1999) approach or the Ghana Feeder Road Prioritization approach are useful examples.

Once all year round access has been achieved then road investment priorities for improving earth and gravel roads with low traffic volumes (under 200 AADT) can be accessed via a transport cost savings approach. The RED model is well suited for this purpose. If a detailed assessment of road maintenance policies is required, if higher traffic volumes are to be examined, or paved road solutions are to be investigated then the HDM-4 model is better suited because of its capacity to examine road deterioration, alternative structural designs and a wide road works effects. For both approaches, an initial screening may be undertaken that identifies traffic volumes and current road condition. Once the RED or HDM-4 analysis has been undertaken, the final choice of links to improve with available funds should rely on the NPV/C¹ ranking. If there are very significant environmental, social or other issues that differentially affect the identified choices (particularly when these issues have not been taken into account through mitigation measures) then additional multi-criteria analysis may be used to assess the final choice.

If a program is designed to meet a specific wider objective, such as reducing poverty, promote an agricultural target or deal with the consequences of natural disasters or conflicts, then it is best to initially choose regions or districts for investigation that best meet these criteria. Once the selection made, then more conventional transport planning criteria can be taken into account.

Village-based infrastructure, such as pedestrian footpaths, trails, bridges, as well as non-transport infrastructure (schools, well clinics etc.) should be planned using the iRAP tool. Here the key measure of access benefits is likely to be the expected personal travel time savings. Similar projects may be ranked and selected by the expected time savings divided by costs. The iRAP approach has a number of drawbacks and it is essential that significant community participation be involved in establishing priorities.

For transport service solutions, the Framework for Prioritizing Rural Transport Service Interventions presented in this paper could be used, accompanied, where appropriate, with a financial analysis of the costs and revenues to users. Government sponsored transport service initiatives are likely to involve a very high degree of uncertainty, that are not easily amenable to conventional analysis. Hence it is

¹ Net Present Value over Cost ratio

suggested that a range of experts and local stakeholders are involved, using Delphi techniques, to assess the key benefits and viability of proposed measures.

The Table below summarizes the suitability of different planning methodologies.

Suitability of planning methodologies for different interventions

| <i>Rural Transport Prioritization Framework</i> | <i>iRAP</i> | <i>HDM-4</i> | <i>RED</i> | <i>RONET</i> | <i>Producers' surplus</i> | <i>Cost effectiveness, Ranking and MCA</i> |
|---|-------------|--------------|------------|------------------|-------------------------------|--|
| 1. Policy Initiatives | | | | | | |
| Possible | No | No | No | No | No | Possible |
| 2. Village Infrastructure | | | | | | |
| Possible | Yes | No | No | No | No | Possible |
| 3. Intermediate means of Transport | | | | | | |
| Yes | Yes | No | No | No | No | Possible |
| 4. Transport Services | | | | | | |
| Yes | Possible | No | No | No | No | Possible |
| 5. Road Investment without Closure | | | | | | |
| Possible | No | Yes | Yes | Yes for networks | Possible | Yes |
| 6. Road Investment with Closure | | | | | | |
| Possible | No | Possible | Possible | No | No | Possible |
| 7. Road Maintenance | | | | | | |
| No | No | Yes | Possible | Yes for networks | No | No |

1. Introduction

1.1 Objectives

The purpose of this paper is to provide detailed advice and an overall framework, for identifying, planning and prioritizing rural transport infrastructure and services. The intended audience is officials, planners, economists and engineers who are concerned with improving the livelihoods of the rural population in Africa.

This work is designed to complement another SSATP publication on rural transport and its important role for agriculture development in Africa². That paper provides a strategic overview of rural transport to help guide government policy at the highest level, including the interaction of transport with agriculture and other sectors. In contrast, this paper is more ‘micro’ in scope. It focuses more on how rural transport interacts with people’s lives and how different types of interventions may be identified, planned and prioritized.

A key element of the paper is to encourage a holistic understanding of rural transport. There are no precise boundaries as to what constitutes ‘rural transport’ as opposed to ‘national transport’, ‘urban transport’ or ‘inter-urban transport’. In this paper, the term covers both transport at the village and farm level as well as the transport services and infrastructure involved with the movement of people and goods within the village area and between villages, rural markets and urban areas. Although services and infrastructure can be planned in isolation of each other, the best long-term results are likely to be achieved if they are improved in conjunction with each other.

² SSATP Working Paper No. 93. Rural Transport – Improving its Contribution to Growth and Poverty Reduction in Sub-Saharan Africa, Banjo et al, 2012.

Chapter 1 provides a background to planning rural transport. Chapter 2 looks at the policy context, the connections between poverty and transport together with a range of issues affecting transport users. Chapter 3 considers how planning data can be collected through surveys and consultation. Chapter 4 considers and describes the planning and cost-benefit tools and procedures for rural road investment. Chapter 5 identifies transport service interventions and provides a framework for their prioritization. Chapter 6 provides conclusions, recommendations and the need for further research.

1.2 The Role and Importance of Planning and Prioritization

Clearly, the purpose of a systematic planning and prioritization process is to achieve the best outcome with the resources available. If the process is based on reliable data, is easy to understand and transparent, then there is less likelihood for unwarranted political interference. Better transport planning is one of the key components in getting the most from resources, to provide year round access, lower transport costs and lift the rural population out of poverty.

Within the context of **planning** rural transport infrastructure and service interventions, network plans and master plans are prepared to indicate the viability and priority of different investment strategies. These plans gradually become out-of-date but usually have a useful lifetime of five to seven years. Planning is a process that involves a number of steps, or components:

- ♦ objectives are identified
- ♦ relevant data is collected and analyzed
- ♦ resources and constraints are identified
- ♦ alternative scenarios (or investment choices or plans) are prepared
- ♦ various scenarios are compared to see how the objectives can be achieved with the available resources, taking into account identified constraints
- ♦ once a final choice made, the plan is put into action and resources are committed
- ♦ monitoring of outputs, outcomes and final impacts is then undertaken

Because of funding, capacity and management constraints, plans cannot be implemented at once. As a result, a **programming** process needs to be undertaken

whereby the different investments are phased in year by year. **Prioritization** is the process by which investments are compared and ranked to define a program. This may be carried out within the framework of an *economic cost-benefit analysis* or via some form of cost effectiveness or ranking process, or a procedure such as integrated Rural Accessibility Planning (iRAP). The prioritization process may involve multiple stages and may also include the participation of local stakeholders. Comprehensively improved rural transport requires the successful interaction of a wide range of institutions, actors and procedures. There is no magic formula. What will work well in one country, or context, may be inappropriate in another. For example, an ambitious *physical target-based approach*, such as that adopted in India, may work well where there is very ample funding for rural roads but be unsuitable in countries where funding is very scarce. Similarly, a *traffic-based transport cost savings approach* to road planning will be easy to apply in a densely populated country where all year round access is in place and traffic levels are moderate to high, but much more difficult to apply in sparsely populated rural areas where basic vehicle access is the main problem.

A range of planning and prioritization procedures had therefore to be outlined.

To get the best results, comprehensive data collection and systematic planning is required. Where there is ample funding for planning, a wide range of data may be collected and analyzed, and detailed cost-benefit analysis may be possible. However, where funding is limited and planning resources remain scarce it may be necessary to rely more on secondary data, and estimates, and a more limited analysis may have to be carried out. In both cases, the overall objective should still be the same, to get the best results from limited resources that are available. Undertaking a comparative analysis of plausible alternative solutions is the mean to ensure that resources are not going to be wasted. Unfortunately, too often, no comparative analysis is undertaken, and too often (for rural road investment) unnecessarily expensive solutions are chosen with may be far fewer beneficiaries, for the available funds, than may be achieved by using more appropriate alternatives.

2. The Rural Transport System in Africa: Setting the Context for Planning

Inadequate rural transport is a major factor contributing to the poverty of the rural population of most developing countries. It is estimated that over 900 million people worldwide do not have access to a all-season road and about 300 million do not have motorized access at all. For large parts of rural Africa walking and head-loading are by far the most important means of transport, most of this effort being undertaken by women. There is often very limited choice in both motorized and non-motorized transport such as bicycles, carts, camels and donkeys and where motorized transport services are provided these tend to be infrequent, expensive, unreliable, crowded and unsafe.

The main components of rural transport considered here are:

- ♦ Movement of goods and people, in and around the village
- ♦ Village-based infrastructure
- ♦ Location of local facilities
- ♦ Intermediate means of transport – including non-motorized transport
- ♦ Commercial transport services to markets and towns
- ♦ Emergency and health transport services
- ♦ Rural roads

The overwhelming majority of external funding that goes into rural transport initiatives is for rural roads. For example, over 98 percent of World Bank lending in rural transport is for road building and maintenance (Tsumagari, 2007). However it has been argued by many (e.g. “Roads are not Enough”, Dawson & Barwell, 1993) that much greater attention needs to be given to the other components of rural transport systems. Substantial coverage will be given here to the planning and prioritization of both roads and the other components.

2.1 The Role of Transport Policy

It is relatively rare for a government to prepare a separate rural transport policy or strategy document. The topic is usually covered within national transport policy and strategy documents. A good example is the Rural Transport Strategy prepared for South Africa (Republic of South Africa, Department of Transport, 2007) and rural transport policy and strategy statements have also been recently prepared for Nigeria (Federal Ministry of Agriculture and Rural Development, 2013), Uganda (Republic of Uganda, Ministry of Works and Transport, 2013) and Tanzania (See below). Advice on the preparation of a rural transport policy is given by Banjo and Robinson (1999). Important government policy statements may also be found in other documents, particularly in Poverty Reduction Strategy Papers (PRSP).

An Example of National Transport Policy Statements

The Vision:

“To have an efficient and cost effective domestic and international transport services to all segments of the population and sectors of the national economy with maximum safety and minimum environmental degradations.”

The Mission:

“To develop safe, reliable, effective, efficient and fully integrated transport infrastructure and operations which will best meet the needs of travel and transport at improving levels of service at lower costs in a manner, which supports government strategies for socio-economic development, whilst being economically sustainable”.

Source: Ministry of Transport and communications, United Republic of Tanzania, National Transport Policy 2002.

Within many government papers, the terms ‘transport policy’ and ‘transport strategy’ are often used interchangeably to cover the same material. When distinction is made, the term *policy* covers goals and objectives as well as overall guiding principles while the term *strategy* provides details on specific measures, can also cover an action timetable and may outline which institutions and departments are responsible for implementation. General advice on the preparation of a National Transport Strategy is given by Lee and Hine (2008).

Although it may be possible to plan very common interventions (like rural roads) without a policy or strategy, this is extremely difficult for other types of interven-

tions. It is important to understand the detailed objectives of the government, as well as the institutional structure and the legal framework. Many interventions (e.g. those relating to commercial transport services) may require changes in legislation to implement.

Over the last thirty years, common major changes in transport policy in the road sector have been along the following lines: Delegation of day-to-day management away from central ministries to legally constituted authorities and agencies/bodies like Road Funds and Road Agencies, while ministries retain policy and oversight responsibility; commercialization of the road sector; decentralization; and provisions covering public-private partnerships. These changes have been met with varying degrees of success. Where a strong institution has been set up with a strong revenue stream (e.g. road funds and some road authorities) there has been a record of success. However, where the revenue stream or the administration has proved weak, as for example for some local authorities, then the changes have not been so successful. In fact, very often there has been very considerable delays in implementing some aspects of policy, such as with decentralization (e.g. Feeder Roads in Ghana).

2.2 Connections between Rural Transport and Poverty Reduction

Before further developing an approach to planning, it is necessary to understand the nature of the problem. A systematic problem diagnosis can help with designing the most appropriate package of interventions that can address the key constraints. Effective rural transport planning, particularly when addressing service issues but also the wider aspects of infrastructure planning, requires a great deal of background data and information to assess priorities but also to provide a measure of the scale of interventions required. To help with the planning process, this section explores the connections between rural transport and poverty reduction, and provides and discusses a range of data and issues relating to the rural population and their use of and interaction with different forms of transport.

Isolation is a strong contributor to poverty (Stifel and Minton, 2008). Good access to markets and basic services is essential for its eradication. Because of the high proportion of the poorest sections of the population living in rural areas, Poverty Reduction Strategy Papers often articulate the need to increase rural livelihoods through a range of measures including improving rural accessibility. They also usually stress the need to meet the Millennium Development Goals (MDGs).

However, none of the MDGs directly mention transport, even if in most instances it would be impossible to achieve the goals without an extensive and relatively efficient rural transport system.

Breaking the Vicious Circle of Rural Transport and Poverty

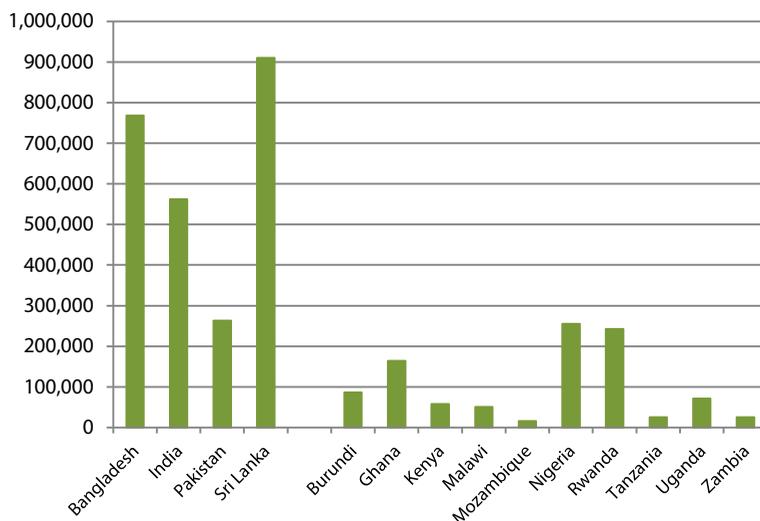
It is useful to think of rural transport as a system in equilibrium with many interacting components. Key outputs are mobility rates, the distance people have to walk to roads and access services, goods traffic levels, transport fares & tariffs and the availability of different modes. The diagram below (Figure 1) is a representation of the complexity of such a system.

Infrequent and high cost transport services lead to low mobility rates and poor interaction with markets and services as well as low goods movement and development of resources. Because of the lack of affordable alternatives a huge personal effort is spent on transport, mostly by women. These factors, in turn, lead to poor health and education outcomes and to poverty; and so the circle is completed.

Individual interventions, such as a rural road investment program, can help to adjust the system of relationships and lead to a new equilibrium with perhaps lower transport costs & tariffs, and lower levels of poverty. However, without long-term secure funding for maintenance the quality of the network will decline and revert to previous levels. If there is poor competition and regulation of transport services then the benefits of improved infrastructure may be limited and not passed on to the rural population.

To a large extent, the problems of rural transport are manifestations of a wider vicious circle of rural poverty. Low incomes, a low tax base and a poor institutional structure lead to a poor quality of infrastructure, low investment, and poor maintenance. A low density of demand coupled with poor infrastructure lead to low transport productivity and infrequent and high cost transport services.

Africa needs strong rural transport to support efforts to reach levels of economic productivity required to alleviate poverty. Figure 2 shows GDP per square km for selected countries in Asia and Africa. The very low density of economic activity for many African countries, compared with those in Asia is apparent.

Figure 2. Comparative GDP (US\$) / sq km for different countries (2012 data)

The relationship between transport and poverty is often expressed through the *Livelihoods Approach* (Davis, 2005) that stresses the importance of assets to sustain livelihoods and reduce vulnerability of the poor to different types of shocks. The physical, financial and social asset value of rural populations will be low when it is difficult to market produce, to access schools and health centers, and to sustain wider family and social networks. A range of indicators are really required to identify the total health of a country's rural transport system, however, in most circumstances, the distance people have to walk to all weather roads, transport fares & tariffs probably represent the most comprehensive measures. Therefore, planning rural transport requires to identify for each intervention, those factors that will either hinder or support long term success.

2.3 The Benefits of Rural Road Investment and Evidence of Impact

Besides the immediate effects improving rural transport can have important long term effects. Private investors, government departments and NGOs will not be eager to place new facilities in an area that suffers poor or intermittent access. Staff working in extension services, schools and clinics will be poorly motivated and unsupervised, and clinics will be badly stocked with drugs. As a result, social and

economic development will be constrained. Improving accessibility, and transport services can break this ‘log-jam’.

Economic theory indicates that road investment is most likely to stimulate rural development if it induces a relatively large change in transport costs, and if there are unused resources of land and labor to exploit, and dynamic urban markets to absorb new production. However, despite a consensus on the importance of rural roads for development, there is surprisingly little hard evidence to validate the theory on the size and nature of their benefits and distributional impacts. Among many studies of the impact of rural road investment, there have been relatively few that have been carried out with proper controls and subject to rigorous analysis and statistical testing (de Walle, 2008). Perhaps the most widely quoted research into the impact of rural roads has been work carried out by the International Food Policy Research Institute (IFPRI) under the leadership of Shenggen Fan³. The approach adopted has been through an analysis of disaggregated national data on household incomes with forms of public expenditure (agricultural research, roads, electricity supply, irrigation, health) which has shown a close relationship between the development of rural roads, and income growth and poverty reduction.

A key result of several IFPRI studies is that rural roads are second to agricultural research in terms of benefit-cost ratio of expenditures (Table 1). Table 1 also shows the capacity of rural road improvements to lift rural people out of poverty. The *Benefit Cost ratios* should be interpreted in terms of returns to expenditure on providing new access rather than total expenditure on roads, because the original analysis was based on differences that increased road length has on measures of regional, or district, household income. Further, it should not be assumed that benefits are exclusively rural in character. There is a good chance that a significant proportion of the benefits will stem from an improvement in urban incomes.

³ Significant studies have been carried out in China (Fan and Chan-Kang, 2004) Vietnam (Fan, Huong and Long), India (Fan, Hazell and Thorat, 1999), Uganda (Fan, Zhang, and Rao, 2004), Tanzania (Fan, Nyange and Rao, 2005), Thailand (Fan, Jitsuchon and Methakunnavut, 2004).

Table 1. Summary of key findings by different IFPRI studies involving road impact

| <i>Country</i> | <i>Road Type</i> | <i>Benefit/cost ratio of expenditure on increasing length</i> | <i>Road sector ranking</i> | <i>Sector with highest returns</i> | <i>No. of people out of poverty with \$10,000 (2011 prices) road investment</i> |
|----------------|------------------------|---|----------------------------|------------------------------------|---|
| China | Low quality | 6.37 | - | - | 10.5 |
| | High quality | 1.45 | | | 0.1 |
| India | Rural roads | 3.03 | 1 st | Roads | 32.9 |
| Thailand | Rural roads | 0.86 | 3 rd | Ag. Res. | 30.2 |
| Tanzania | Rural roads | 9.13 | 2 nd | Ag. Res. | 170 |
| Uganda | Feeder Murram (gravel) | 7.16 | 2 nd | Ag. Res. | 261 |
| | | - | | | 31.5 |
| | Tarmac | - | | | 20 |
| Vietnam | Rural roads | 3.01 | 2 nd | Ag. Res. | 9.6 |

The results of the IFPRI analysis from China and Uganda indicate that the returns from rural roads appear higher than for more expensive better quality roads. It is also interesting to note the much higher impact of expenditure on new rural road access on poverty reduction in Africa (Uganda and Tanzania), compared with that for Asian countries. However, it should be recognized that the IFPRI research is highly technical and is derived from a complex macro modelling process. Despite the positive results, uncertainties remain regarding other possible explanations, including reverse causality (Raballand et al., 2009).

Micro studies of road impact have identified a wide range of impacts. The Asian Development Bank studies in Indonesia, Philippines and Sri Lanka (Hettige, 2006) found that improved rural roads provide a better mix of transport services, shorter travel times and increased traffic. The impact of the improved roads on transport fare levels was found to be variable depending upon competition in transport markets. More buyers visited the communities with improved roads, which was a major factor in deciding to start a new business. A repeat panel survey in rural Ethiopia from 1994 to 2004, of 1477 households in 15 village areas (kebeles) found that access to an all-weather road was a major factor in reducing rural poverty (6.9%) and increasing consumption growth (16.3%) (Dercon et al., 2008).

Research has shown that there are major differences in the likely effects of opening up first vehicle access compared with the rehabilitation of existing roads. From an agricultural perspective, the first type of intervention is more radical than the second, which tends to be incremental in its effect. Thus, work in Ghana indicates

that the improvement or rehabilitation of an existing rural road has a negligible impact on agricultural prices but the upgrading of a footpath to a road providing vehicle access has a potential beneficial effect that is in the order of a hundred times that of improving the same length of an existing road. This is measured in terms of the change in farm gate prices as farmers and traders shift from head loading to motorized vehicles to buy and sell their crops (Hine, Riverson and Kwakye, 1983).

A study in Peru has found substantial synergies when roads and other infrastructure are provided together (World Bank, 2006). Clearly, there is a case for road investment to be planned and supplied with other forms of infrastructure such as water, sanitation, electricity and telecommunications. However, with limited budgets there are likely to be equity issues if all public investment is restricted to certain favored localities.

The benefits of road investment are not confined to economics. Levy (2004) found that in Morocco improved roads led directly to an improvement in the quality of education. It was easier to recruit and retain teachers and absenteeism of both teachers and students dropped. Similarly, the rural population doubled their use of health care services, the supply of medicine improved and it became easier to implement immunization programs. Women and girls benefited from the provision of all-weather access roads. Girls' enrolment in primary education trebled, very largely because, with the improved roads, butane gas became affordable and the daily collection of firewood for cooking and heating was no longer necessary.

An analysis of data in Pakistan also suggests that the presence of an all-weather road in a village is associated with higher school enrolment rates. The enrolment rate for girls living in villages with all-weather road access was 41 percent compared with 27 percent for those living in villages without. Higher immunization and more births assisted by a skilled attendant were also found to be associated with the presence of all-weather roads (Essakali, 2005).

2.4 The Institutional Structure of Rural Transport

Stakeholders

The main stakeholders involved with rural transport include rural communities, transport operators, farmers, entrepreneurs, health workers, schoolteachers, extension workers, NGOs, road and river transport authorities, road fund organization, police, local and regional and central government administrations, etc. However,

local transport that takes place within vicinity of the village and farm is very largely the sole responsibility of the rural community. Local authorities can have an impact through for example, the assistance to help improve footpaths and pedestrian bridges. However, for out-of-village transport a much wider range of stakeholders and institutions become involved.

Infrastructure

There is a wide range of organizational structures used to cover essential functions for the effective management of the rural road network. The core network ‘ownership’ is usually vested in a central government department, regional or local government, or a roads authority. For lower level village roads, tracks, paths and trails effective control, if not formal legal ‘ownership’, is most often in the hands of the local community. The importance of local sense of ownership in the management of the local network is stressed by Malmberg Calvo (1998).

In some countries (e.g. Ethiopia), one body may be legally responsible for defining the whole road network even though responsibility for management may be split between a range of different bodies. Road finance usually comes from the central government, from local government taxes, donor program, or from a road fund administration. Most planning, work programming, setting standards and central administration is undertaken by publicly employed staff but there are examples (e.g. for local authorities in the UK) where these functions are being fulfilled under management contracts.

The decentralization of the management of the rural road network has been a major trend over the last few years. The identified advantages are that priority setting and planning will be more responsive to the needs of the rural population. The observed difficulties have been that proper authority is often not transferred to lower levels of government, making it difficult to legally administer contracts. Also, local authorities will rarely have sufficient technically qualified staff—particularly with experience of transport planning, and suitable funding arrangements are often not in place.

IMT and Transport Services

Most rural transport services in Africa are supplied by small scale ‘informal’ commercial transport operators often using small minibuses and trucks. The pattern of public transport operations tends to be very different from urban and interurban operations where large-scale companies often predominate. The revenues of rural

public transport operators are almost entirely derived directly from their customers. This is in contrast to rural public transport operations in developed countries that are invariably subsidized through various contractual arrangements with local governments. Although entry into the market is usually fairly cheap (the cost of an old second-hand vehicle) often local associations restrict operational supply through the control of lorry and bus fleets.

The regulation of drivers, transport vehicles and services, is undertaken in most countries either by a national road traffic licensing office or by an office of local government. These authorities will register vehicles, issue driving licenses, road worthiness certificates and collect annual vehicle taxes. Authority to offer commercial services will often be provided by licensing office or regulator. In many countries IMT, particularly bicycles, may be registered and taxed alongside motorized vehicles. The more rural and remote an area is so, the less likely that regulations will be monitored or enforced by the police.

2.5 The Range of Transport Choices

Although the position is changing quickly, it has often been observed that much of rural Africa has traditionally had far fewer different types of transport vehicle, both motorized and non-motorized, than rural Asia. For example in 1985, it was reported that Sub-Saharan Africa had 35 bicycles per 1000 inhabitants, compared to 400 per 1000 in South Asia (Starkey, 2001). At the most extreme, in the forest region of Ghana for example, one used to find little else other than a mummy wagon (typically a three-ton truck) with a wooden body converted for both passenger and freight cargo, and pedestrian transport, where goods, if not transported by mummy wagon, were head loaded.

A number of factors influence the availability of transport. Where there is a stable, high density of demand, as in much of Asia, it is possible for many different forms of transport to coexist—each finding its own niche in the market. Likewise, where population density is lower, it is much more difficult to keep pathways open and level for the easy use of transport aids and IMT. Cultural factors can also play a part. In Southern Ghana, bicycles are often viewed as symbols of ‘low status’, while in Northern part, they have been more popular (Turner et al. 1995).

Women and the Use of Intermediate Means of Transport

A number of studies have looked at how women might benefit from a better use of transport technology (see, for example, Fernando and Porter, 2002). Overwhelmingly, it appears that men (and boys) are able to adopt and make more intensive use of transport technology than women. The reasons for these gender differences relate to a number of interrelated factors, e.g. women spend a great deal of time multi-tasking, which gives them less time during the day to make full commercial use of the technology. Hence, for women that are constrained in this way, the financial returns from using transport technology, are likely to be lower, than for a man. Furthermore, women tend to have far less access to credit and funds for investment than men, and there may be cultural reasons that prevent women using technology, e.g. riding bicycles or motorcycles (Fernando and Porter, 2002).

The Current Position and the Recent Growth of Motorcycle Transport

Undoubtedly, the biggest change in rural transport taking place in Africa is the growth of motorcycles. In December 2005, there were 31,006 motorcycles registered in Tanzania and by December 2010, this number raised to 323,192 (Ministry of Infrastructure Development, 2010). This is equivalent to an annual growth rate of 60 percent per year. Although they are not formally licensed for hire, many motorcycles are used in East Africa in *boda-boda*⁴ taxi use operations. In rural areas, they are mostly used to carry passengers and freight, on journeys between a bus stop and more remote locations away from conventional bus routes. In a study in Tanzania (Starkey et al., 2013) rural motorcycle passenger fares were found to be between 17 US cents and 34 US cents, per km, in comparison rural bus fares were between 3.5 US cents and 4.7 US cents, per km.

Recent surveys of 55 district and regional roads in Tanzania (IT Transport, 2013) illustrate the growing importance of motorcycles and bicycles in rural transport. An example of traffic composition is shown below, motorcycles exceeding bicycles on 20 percent of the roads. The data is grouped in descending order of motorized traffic with Group 1 having the most motorized traffic and Group 6 the least.

⁴ From English border-border.

Table 2. Example Traffic Counts (vehicles per day) on 55 Rural Roads in Tanzania (Groups 1-6)

| <i>Obs.</i> | <i>Car</i> | <i>Pick-up</i> | <i>Minibus</i> | <i>Large bus</i> | <i>truck</i> | <i>Tractor</i> | <i>Motorcycle</i> | <i>Cycle</i> | <i>Animal transport</i> | <i>Pedestrian</i> |
|-------------|------------|----------------|----------------|------------------|--------------|----------------|-------------------|--------------|-------------------------|-------------------|
| 5 | 28 | 127.8 | 22.2 | 4.4 | 40.5 | 2.6 | 259.1 | 146.5 | 0.3 | 438.7 |
| 8 | 8.6 | 44.2 | 8.4 | 6.8 | 29.2 | 3.9 | 180.5 | 146.9 | 4.5 | 256.1 |
| 8 | 9 | 19.5 | 2.9 | 2 | 12.4 | 4.2 | 113 | 163.9 | 3.9 | 326.3 |
| 8 | 3.1 | 12.2 | 2.3 | 0 | 5.4 | 2.4 | 37.6 | 242.6 | 0 | 431.2 |
| 11 | 1.4 | 7.9 | 1.1 | 0.8 | 4.8 | 0.7 | 37.9 | 171.4 | 1.5 | 471.3 |
| 15 | 1.2 | 2.1 | 1.9 | 0 | 1.3 | 0.9 | 14 | 167.9 | 2.1 | 368.1 |

In East Africa, mainly in Uganda and Kenya, the commercial use of bicycles and motorcycles in 'boda-boda' (taxi) operations is very common. In 2001, it was estimated that 200,000 bicycle boda-boda were used in Uganda and 70,000 motorcycle boda boda (Howe and Davis, 2002).

Another important factor promoting the use of motorcycle taxis is the widespread use of mobile phones in rural areas. Today, a customer can call the motorcycle driver directly for a pickup, which represents an enormous improvement in the mobility of the rural population. Yet, there are also many people who find it impossible or very difficult to ride a motorcycle, these include the old, disabled, young children and expectant and nursing mothers. There are also major concerns over the accident risk of motorcycles.

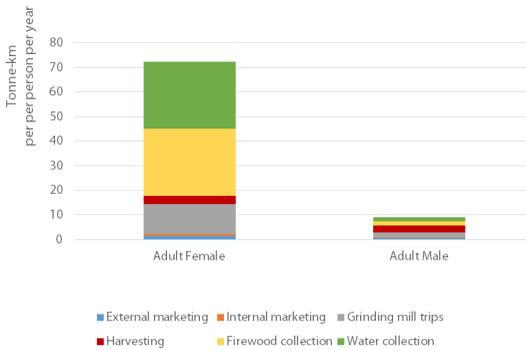
2.6 User Perspectives

Short Distance Trip Making

A number of studies, undertaken by IT Transport and the International Labor Organization (ILO) in the late 1980's, show the huge burden of short distance travel on rural communities. In percentage terms, per number of trips, travel time, load, and ton-km, short distance travel was far more important than external travel. Internal travel was defined as transport within the village, including the collection of water and firewood; trips to the farm and marketing inside the village. External travel was defined as travel outside the village, including journeys to health facilities, grinding mills, and marketing outside the village. (Dawson and Barwell, 1993). A substantial proportion of total travel time and effort relates to the household tasks of farming, collecting water and firewood. Figure 3 shows the transport

burden in terms of tone-km, whereas women share a disproportionate large share amounting to 85 percent of the burden.

Figure 3. The Transport Burden for Men and Women in Makete, Tanzania



The huge amount of time spent on transport tasks particularly by women, represents one of the biggest opportunities to improve rural transport in Africa. Even a small reduction in this burden could significantly affect time available for agriculture and other activities. The SSATP Resource Guide on mainstreaming gender in transport provides further advice on the subject of gender and transport⁵.

Isolation from Transport Services and the Road Network

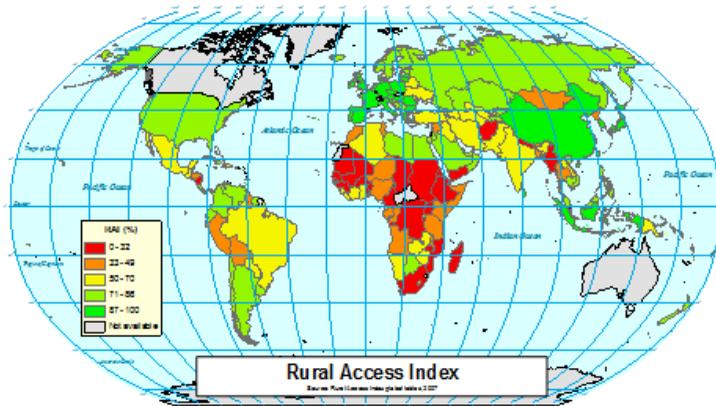
In 2005, a ‘Rural Access Index’ (RAI) was developed to monitor progress in achieving the different MDG targets. The RAI measures the proportion of the rural population who live within 2 km (equivalent to 20 minutes’ walk) of an “all-season” road motorable all year round by the prevailing means of rural transport. As shown in Figure 4, Sub-Saharan Africa is believed to have the worst accessibility of any populated region of the world.

The RAI is important, as it is the only transport indicator required in the IDA /World Bank reporting process. It can be measured by household surveys or via mapping and engineering surveys. The definition of ‘all season’ remains subject to interpretation. It is sometimes accepted to be a paved road, while other surveys may accept good quality gravel roads. It appears that the RAI, as currently inter-

⁵ www.ssatp.org/sites/ssatp/files/publications/HTML/Gender-RG/index.html

preted, will not cover an ungraveled “basic access” road that may in fact provide “all-season” passability, because of the higher roughness values and poorer quality.

Figure 4. The Rural Access Index Estimated for 2007



The RAI was primarily developed as a measure of social access. However, based on research in Burkina Faso, Cameroon and Uganda, Raballand et al (2010) have cautioned that the RAI may not be used as a major economic tool for planning. It is argued that the 2 km index is not a real economic threshold and may result in overinvestment and waste of funds, and maybe should be increased to 5 km.

A further point to bear in mind is that even if a village is located on a reasonable quality road, this is no guarantee that the residents will have easy access to motorized transport services. Surveys in Ghana and Malawi found that 30-40 percent of the rural population have to walk more than 4 km and sometimes up to 20 km to a vehicle pick up point, often located at a road junction, to be guaranteed a reasonable chance of getting onto a bus or truck (Hine and Rutter, 2000).

Transport Services for Health

The greatest concerns of rural women are how to get to a health center or hospital in an emergency, particularly relating to childbirth. This was particularly apparent in consultative work carried out for the development of the Ghana Feeder Road Prioritization Procedure (Hine et al, 2002). Emergency transport has ramifications for road planning, particularly in the case of seasonal impassability, as well as for transport services.

Improving maternal health is one of a key MDG targets. Sub-Saharan Africa has a lifetime maternal death rate of 1:39 compared with 1:4,700 in industrialized countries. In 2010, in Sub-Saharan Africa there were 500 maternal deaths per 100,000 live births, a total of 162,000 deaths (World Health Organisation, 2012). A major problem is the delay in getting to hospital and receiving proper medical attention. It is estimated that 75 percent of maternal deaths could be prevented through timely access to childbirth-related care, facilitated by transport (World Bank, 2008). Another health-related issue of concern (particularly for women and girls) that needs further research is the effect of carrying heavy loads on long-term health and physical development (Porter, 2013).

A number of initiatives and schemes have been set up to deal with health and transport issues. In Malawi and Zambia, TRANSAID for instance has been working with local communities to provide bicycle and motorcycle ambulances. Riders for Health which works in seven African countries provides specialized training in the maintenance of vehicles for health staff. Likewise, the Partnership for Reviving Routine Immunization in Northern Nigeria, Maternal, Newborn and Child Health Initiative in association with TRANSAID, has been working with the National Union of Road Transport workers to train (elementary) drivers for emergency transportation of women in labor to the closest hospital. Compensation is paid to the driver for the cost of fuel only. Between January 2010 and May 2012, 5,515 emergency transfers were recorded. (Adamu et al., 2012).

Transport Services for Education

For primary schools in remote rural areas, school enrolment and attendance will be affected by travel distance. There is evidence to suggest that travel distance to school is an important factor on attendance (Porter et al., 2011). Long journey distances are likely to have a differential impact on girls' education. Once girls reach puberty they may be considered at greater risk when traveling to school (Porter, 2013).

Data from South Africa found 76 percent of 'learners' walked to their destination and that 3 million out of 16 million spent more than an hour per day walking to and from school. A multi-sectoral approach may be required to improve the situation with measures to enhance transport for children and sensitize teaching staff to this issue (Porter, 2013).

Transport for People with Disabilities and the Elderly

The burden of lack of access to mobility aids and rehabilitation services is compounded for disabled people and the elderly. Disability and poverty are closely linked in many developing countries. Typically, the incidence of disability is more than twice as high among the lowest income groups than among the others. Disability leads to exclusion from education and employment opportunities, causing further hardship. Social and cultural attitudes can also exclude people with disabilities from mainstream society. In India, it was estimated that only 5 percent of the estimated 10 million people who have difficulty moving about receive wheelchairs or other devices and the additional services they require (TRL Ltd, 2004a).

Both disabled people and the elderly face particular severe challenges when trying to access rural transport services. Both groups will face difficulties in getting to transport stops and into vehicles (Porter, 2013). Overall, there is very little data on the travelling patterns of the elderly and people with disabilities in rural Africa.

2.7 Transport Costs and Prices

Key definitions are important for transport costs and prices.

- ♦ **Vehicle Operating Costs (VOCs):** These include the various variable and fixed costs paid by a transport operator to operate a vehicle.
- ♦ **Transport Costs:** These are the costs a transport operator incurs when transporting a cargo, including VOCs and other costs such as value of time for passengers and freight or payments at checkpoints.
- ♦ **Transport Prices / Fares & Tariffs:** These are the rates charged by a transport /freight company to the final customer. They include transport costs, operator's overheads and profit margin. They will exclude subsidies paid to the company.

A number of parameters affect transport costs and prices, namely:

- ♦ **Load and Distance:** The greater the load and the longer the distance, the lower the possible average costs measured on a ton/km basis.
- ♦ **Mode of Transport:** Small modes of transport (head loading, IMT) have a comparative advantage, and lower costs for small loads and short distance

transport. Large buses and big trucks have the advantage for heavy loads and long distance transport and provide the lowest costs per ton/km.

- ♦ **Road Characteristics:** The alignment, type and quality of the road surface will affect transport costs, through the effects on speed, fuel consumption and vehicle maintenance costs.
- ♦ **Geographical Dimension:** A number of studies have shown, for the same type of transport, that African freight transport costs are many times higher than in Asia.

Clearly, transport tariffs will be dependent on road characteristics, consignment size and the overall density of demand, including the probability of return loads. Transport tariffs on main roads are likely to be lower than on minor roads, because the density of traffic will mean less waiting time to find a load. It is also common to find passenger fares increasing in the wet season for poor quality roads. For example, a study in Tanzania found fares increasing by between 40 per cent and 67 percent (Ellis and Hine, 1997).

Modelling VOCs of Rural Vehicles

To compare different types of rural transport vehicles, Crossley and Ellis (1996) developed a model to estimate vehicle operating costs. Results show that a bicycle has the lowest operating costs (for short distances) only where demand is 10 tons, per year, and below. For a 10 km trip, the ox cart has an advantage between 10 and 250 tons, while the farm vehicle (the Itaen built in Thailand) has the lowest costs between 250 and 1,500 tons, per year. Trucks have an advantage at higher levels of demand and longer trip distances.

Road Appraisal Models such as HDM-4 and RED calculate vehicle operating costs as a function of road alignment, road width, traffic volume and road roughness. For low volume rural roads, road roughness is the most important factor governing the variation in VOC. However, not all road characteristics are modelled, so the probability of getting stuck in mud, or the probability of road closure because of flooding are not covered.

Perceived Values of Time and the Costs of Head Loading

Despite its importance, there is remarkably little research or documented evidence on the personal value of time (for walking, riding in a vehicle, or load carrying) in Africa. An exception is work carried out by IT Transport in 2005 that undertook a

detailed study of rural values of time in Yendi District (a relatively poor district) in Ghana and the Moshi District (a relatively prosperous one) in Tanzania. The results of stated preference surveys show the average in vehicle values of time were equivalent to 64 percent of the wage rate in Ghana and 49 percent in Tanzania.

Although there is little documentary evidence on the cost of head loading in Africa, it could be 10 to 30 times the cost of transport by truck. From studies carried out in Ghana and elsewhere it was estimated that it takes two person-days to move one ton-km; using a minimum wage rate this amounted to some \$2 to \$2.5 per ton-km. In comparison, it was estimated that on rural roads trucking would cost \$0.2 per ton-km (1991 prices) (Lebo and Schelling 2001). Thus moving goods by head loading was estimated to cost 10 to 12 times as much per ton-km than by truck. An earlier analysis found that head loading charges of moving a bag of maize in rural Ghana were about 30 times more expensive, per ton-km than typical distance movement by a full, medium truck. (Hine, Riverson and Kwakye, (1983b). Starkey et. al. (2002) indicate a cost of \$1.5 per ton-km for head loading.

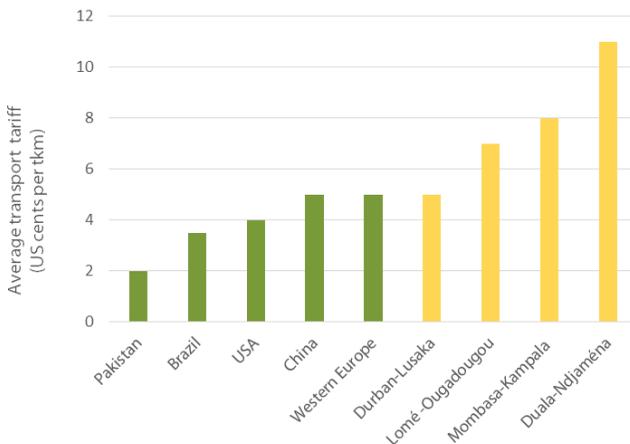
Differences between Africa and Asia

Studies confirm that freight transport tariffs, for comparable journeys, are up to six times higher in Africa than in Asia. Over the past 25 years, there have been at least five such comparative studies of freight transport costs between Africa and Asia. Earlier studies emphasized a range of reasons for the differences (Rizet and Hine, 1993) while the latest study (Teravaninthorn and Raballand, 2009) emphasized very high profits for transporters in Africa. No comparable study has been undertaken for passenger transport; however, it seems likely that the same differences exist. For example, it was reported that in 2008-2009, passenger fares for State Road Transport Services in India averaged 48.37 paise per km, equivalent to \$ 0.01 per km (Economic Times of India, April 22nd 2011). In contrast, an analysis of long distance passenger fares in Tanzania for 2009, averaged 31.92 T Shillings per km or US\$ 0.025 per km (Ministry of Infrastructure Development, 2010).

In 1994, a study that collected transport costs and utilization data relating to rural transport and agricultural vehicles in Asia and Africa. (Ellis, 1996, Ellis and Hine, 1998) confirmed a similar difference. For example, a pickup truck in Africa had operating costs 4.5 times that of Thailand, while a medium truck had costs that were nearly 10 times that of Pakistan. A range of factors had been identified for differences in costs including the prices of fuel, tyres, vehicles and differences in utilization. Lower levels of utilization are shown for African vehicles. The pattern

follows earlier studies, which showed much higher utilization in Asia. For example, tractor units and semi-trailers were found to average 123,000 km in Pakistan compared with 50,000 km in Francophone Africa. Data on transport tariffs from the latest major comparative study is presented in Figure 5. In this study, the same pattern of high transport charges for Africa compared with other parts of the world remains.

Figure 5. Comparison of Long Distance Transport Tariffs (\$ cents per ton-km) 2007



The Role of Transport Operator Associations in Africa

Major factors in keeping transport prices high in Africa relate to transport associations (such as the Ghana Private Road transport Union or GPRTU). These organizations very common, particularly in West Africa, help determine transport fares and the organization of the commercial transport industry. Competition is restricted in various ways, but particularly by the queuing system that operates at the truck and bus terminals. Guards may be employed to restrict non-members from taking loads (Lyon, 2006). As a result, a driver can be waiting in a queue for a week or more to find a load. Prices are thus kept high, and fleet utilization remains low through this system that favors an over-supply of vehicles. This is also an encouragement to keep very old vehicles working well beyond their normal economic life. Operators of newer vehicles need to by-pass the queuing system to recover their capital costs and remain in business.

The Ngoundere District in Northern Cameroon provides an example where a local mayor decided to address the issue of poor transport services and high fares. In Cameroon, transport syndicates determine fares and routes; they negotiate with

the authorities for access, fees, and for the use of terminals. In Ngoundere, the mayor licensed various transport agencies to operate from different terminals in competition with one another. Within two years, passenger fares dropped by 50 percent with a reported greater frequency of service using cleaner and better maintained vehicles. Fares in the South were found to be 53 percent higher, (for 10 km) and 370 percent (for 200 km) than in Ngoundere (Lisinge, 2001).

Besides the rather negative effects on society of restricting transport supply and keeping transport prices high, transport associations have nevertheless some benefits (Lyon, 2006). They play an important social support role for members, and they often try to maintain standards of honesty and behavior. For example, taxi associations in Nigeria have been very cooperative in the initiative to support the emergency transfer of women in labor to hospital (Adamu, et al., 2012).

2.8 Rural Transport and Agriculture

Agriculture is the major source of livelihood and the most important economic activity that takes place in rural areas of Africa. To properly understand the role of transport in supporting agriculture, it needs to be considered as an integral part of the whole distribution system. The overall efficiency of agriculture is affected by:

- ♦ The nature of the marketing chain
- ♦ Poor quality roads that are rough and seasonally impassable
- ♦ Access to farm inputs, extension advice and credit
- ♦ Monopolistic practices in both marketing and transport
- ♦ Economies of scale
- ♦ Availability and choice of the means of transport
- ♦ The development of modern supply chain management

Transport over the First Mile and the Effects of Impassability and Rough Roads

The first stage of crop movement, from field to roadside, house, village, or to the local market is the most expensive per kilometer, and can represent a major constraint to the development of agriculture. Terrain can be difficult, load sizes are small and there may not be a motorable road. Head loading is in Africa the main form of transport for crop movement. Yet, this type of transport is per ton-mile very expensive – 10 to 30 times more expensive than by truck. If difficult pathways can be improved or converted to a track or road then IMT such as bicycles, mo-

torcycles, animal carts or tractors and other forms of less costly motorized transport can be used.

The Benefits of Road Investment to Agriculture

Improved roads facilitate access to extension services and credit. Remotely located farmers are at a disadvantage in accessing such services. This was particularly noted in a study of Ashanti Region of Ghana. The reason for this problem was the need for multiple trips between a village and the extension services (Hine, River-son and Kwakye, 1983a).



Grace Wahome

During the wet season many unpaved roads become impassable or very hard going, so transport costs rise, and this can have a negative impact on agriculture. Availability of farm inputs can be seriously affected by wet season accessibility as they are needed for the next growing season. Crops and products such as vegetables or milk can deteriorate easily once collected, and can entail serious losses if they are delayed in getting to the market or processing factory. Other

crops such as tomatoes, mangos, bananas and soft fruit can bruise easily and hence be damaged by travelling on rough roads. Thus, road investment is clearly an important tool in promoting agricultural development.

The Efficiency of Transport and Marketing System

The rural transport system is often closely integrated into the agricultural marketing system. The availability of agricultural storage can provide flexibility to supply markets when roads become impassable in wet weather. However, this symbiosis can be detrimental in terms of restricting competition in both transport and agricultural marketing. This will tend to keep farm-gate prices low and retail prices high to the urban consumers thus preventing the effective development of agriculture and rural welfare.

The transport and marketing systems in much of rural Africa are expensive, inefficient and unresponsive. This can be explained by the low density of economic activity where economies of scale cannot be achieved, competition is weak and information flows poor—although this latter factor is undoubtedly changing with the rise of mobile phone in rural areas. It has been shown that agricultural market-

ing associations can keep agricultural prices high by both enforcing retail price control and restricting the supply of particular commodities into certain markets (Gore, 1978). Further, traders in Africa often travel together to a village and are able to prevent competition through allocating farmers to different wholesalers, and credit relationship. Farmers can improve the prices they get by selling directly in the urban markets. However, they often pay a very high price for the transport of their small volume of produce. Marketing is most efficient where there are large concentrations of population and concentrated flow of goods, unlike much of rural Africa. There is also evidence to suggest that, as a proportion of the final price, transport and marketing margins are much higher in Africa compared with Asia. For example, it was found that for food grains 45 percent of the final price was received by producers in Kenya and Malawi, as against 80 percent in Bangladesh and India (Ahmed and Rustagi, 1987).

2.9 Rural Transport Safety and Security

Although there is a shortage of reliable data for all aspects of rural transport, this is particularly acute for safety and security. It is well known that underreporting is a major issue for road safety in Africa. However, there are good grounds to believe that better data exist and consequently much more is known on the incidence and causes of road crashes in urban areas and along interurban routes than for rural areas. Similarly, there are very few specific studies of rural transport safety and security in Africa.

In 2007, it was estimated that 235,000 people died from road traffic injuries in Africa, (an incidence rate of 32.2 per hundred thousand inhabitants) with most deaths occurring for people between the ages of 5 and 44 years old. The risks are particularly high for African pedestrians, those travelling in two and three wheeled vehicles, or in public transport (WHO, 2010). Most rural roads have no separate provision for pedestrians who tend to use the road along with the mix of vehicle types. Unsafe vehicles, poor traffic awareness and safety knowledge will also be issues alongside a lack of enforcement. However, an enforcement regime that interprets the regulations too strictly would involve a significant decrease in services or an increase in prices. A balanced approach is therefore recommended. Starkey (2007) identified the following safety issues in rural areas: inadequate infrastructure, including potholes, lack of safety barriers and signs; unsafe vehicles; unsafe loads and mixed passengers and freight; and unsafe behavior of drivers.

3. Transport Surveys and Consultation

A wide range of consultation and survey techniques are available for rural transport planning. The decision on the survey to undertake will naturally depend on its purpose, the quality and extent of existing sources of information, and the resources available. The approaches described here are qualitative and quantitative. For a large scale specialized survey, it is beneficial to try out, test, modify and refine the questionnaire with several rounds of interviews. To get the most reliable information, it is important to ‘triangulate’ approaches whereby different techniques are applied with different groups to see whether information is confirmed.

Tables 3 and 4 list a range of different types of surveys that can be used. They are derived from the Rural Transport Knowledge Base (Fouracre, 2001). Table 3 covers the supply-side of road transport while Table 4 covers the demand-side. More specific information of these tools can be found in the SSATP document – *A user guide to road management tools*⁶.

3.1 Common Types of Surveys and Consultation

Road Inventory

Increasingly road inventory information is now collected using Geographical Information Systems (GIS) and for some countries, the data is available on the web. GIS enables mapping to be much more accurate and helps road professionals to know exactly where key facilities and infrastructure are located. An instrumented vehicle may collect GIS data as well as a range of road condition data.

While main and secondary road networks are usually mapped using GIS, the mapping of rural road networks has been much more partial. GIS planning proce-

⁶ <http://www.ssatp.org/en/node/290>

dures are currently being used in India and Bangladesh for rural roads; Vajjhala and Walker (2009) provides an example for Lesotho. An instrumented vehicle that can also provide road condition data together with GIS information could be very useful for planning. With GIS data, it is possible to match up at a finer level, where people live in relation to the road network and the characteristic of the population, for example relating to poverty from the Living Standards Measurement Survey. However, using GIS data in this way is still relatively rare, particularly in Africa, but it obviously has considerable potential.

Table 3. Road and Road User Surveys

ROADS

| <i>Survey</i> | <i>Purpose</i> |
|------------------------------|---|
| Inventory | To confirm agency network data. Includes surface types, width, structures, road furniture, etc. |
| Traffic Counts | To establish daily traffic volumes, seasonal and weekly patterns, as well traffic composition. |
| Traffic Speeds | To establish average speeds along different routes |
| Road condition & maintenance | To determine road roughness, gravel thickness, pavement defects, state of drains, structures, etc. and need for maintenance. |
| Axle Load | To determine vehicle overloading and damage to road pavements, these surveys are common on main roads but rare for low traffic rural roads. |
| Safety Surveys | To determine location and nature of safety hazards, as well as accident reporting procedures and trends. |

ROADS USERS

| <i>Survey</i> | <i>Purpose</i> |
|------------------------|--|
| Passenger Loading | To determine load factors, vehicle productivity can also be used to find journeys, distances, journey time and vehicle speeds. |
| Passenger Waiting Time | To determine level of service and passenger waiting times |
| Passenger Interview | To determine journeys distances, journey times, fares paid and passenger satisfaction. |
| Shipper Surveys | To determine freight journey distances, times, tariffs, customer satisfaction. |

Table 4. Demand-Side and Background Surveys

| <i>Surveys</i> | <i>Purpose</i> |
|--|---|
| Origin-Destination surveys | To identify current travel patterns of population, including non-motorized trips. Particularly useful when new road links are planned. |
| Cordon/screen line survey | Similar to OD surveys (Origin-Destination) but carried out on smaller scale across an imaginary line or cordon around an area of enquiry. |
| Stated and Revealed Preference surveys | To try to establish how respondents might respond to proposed transport changes (for example a new service or different fares). Also used to determine traveler 'values of time.' |
| Household Surveys & Travel Diaries | To establish travel patterns and relationship with household characteristics (including income and assets) to help model future transport demand. May also include surveys of farming and economic activity for road impact studies. |
| Market surveys | Surveys of markets and market prices are often undertaken as part of road impact studies and help with demand modelling. |
| Surveys of economic & social facilities and establishments | Markets, hospitals, clinics, schools, churches, factories, warehouses, shops, government offices, water sources, etc. are key journey destinations. Their location and future development are important in demand modelling. |
| Semi-structured interviews and discussions | Semi-structured interviews and discussions with village leaders are important to help understand the background to an area and introduce the researchers to the village. These interviews will take place before more detailed surveys are undertaken. |
| Participatory Appraisal | There are many forms of Participatory Appraisal, however in all participatory surveys, the aim is to understand the context and problems as perceived by local people (i.e. stakeholders) and it can help in getting them involved in developing solutions. |

Traffic Counts

The main objective of a traffic count is usually to obtain an accurate estimate of the Average Annual Daily Traffic (AADT), which can then be used, for example, for an economic road appraisal. In general, the lower the traffic volume the greater the daily variability. Hence, because of the low traffic volumes in rural areas, it is important that the traffic count be conducted over sufficient time to smooth out factors such as market days, peak harvest time, public holidays, religious festivals and weekends. It is often recommended that a seven day count be carried out, covering market and non-market days for the 12 daylight hours, with two days covering 24 hours to help estimate night time movements. Motorized traffic usually falls in the wet season and so, if possible, the counts should be taken twice per year to

cover wet and dry seasons. Ellis and Hine (1997) found that for rural roads in Iringa and Kilimanjaro regions of Tanzania traffic volumes in the wet season for cars, 4-wheel drive vehicles, trucks, and large buses fell, on average, to around 60 to 70 percent of the dry season totals, with non-motorized traffic increasing to over 100 percent of the dry season totals.

Road Condition Surveys

Overall road condition data is often supplied by regional and district engineers on a regular basis using simple classifications of “very good, good, fair, poor, very poor” categories. However, it is well recognized that these subjective evaluations are very inconsistent, and may be influenced by the road agency’s need to meet internationally set targets.

Road roughness is the key driver of vehicle operating costs and, overall it is critical for the assessment of overall road condition. Roughness data is useful for assessing the quality of different components of the rural network, for indicating when maintenance or investment should take place and to assist with road impact evaluations. However, roughness can change very quickly on unpaved roads with traffic, rainfall, and maintenance treatment. Nevertheless, it is recommended that objective roughness measurements be taken of the unpaved road network. It is very useful to know the frequency of grading and regravelling.

As with all surveys, there is an inevitable trade-off between costs, quantity and quality of the data collected. The costs of vehicle instrumentation to record and log roughness data together with GPS position will be in the range of \$8,000 to \$12,000. However, a separate roughness calibration device will also be required. One of the cheapest methods of calibrating is to construct a MERLIN⁷ using a metal frame and bicycle wheel (Cundill, 1996), alternatively commercially made profiler will cost around \$8,000.

Travelling Time and Level of Service Surveys

SSATP developed the SOURCE methodology⁸ for standardized measurement of speed of light vehicles and actual level of services provided by roads. The measure

⁷ Machine for evaluating roughness using low-cost instrumentation.

⁸ Standard Overall Ultra-lite Road Care Estimate (SOURCE). www.ssatp.org/en/node/290

of the speed can be used to calibrate planning models such as HDM-4. It also provides the estimate of traveling time on roads used in conjunction with the value of time in the economic analysis of road projects. Lastly, data collected for an entire network can be used as a proxy of road conditions in the planning process.

Operator and Driver Surveys

Surveys of operators and drivers can provide a great deal of information on the operation and utilization of vehicles, transport fares and tariffs, vehicle operating costs, etc. These surveys can be carried out at truck and bus terminals or by the roadside (origin-destination surveys). Often the surveys will be carried out in the market towns in the areas of interest. For major surveys, particularly involving long distance movement, it is possible to collect data on larger vehicle fleets from the offices of owners and companies in the larger cities.

Household Interview Surveys

Information collected in household interviews may cover household composition, sources of income, levels of expenditure, consumption patterns, education, health, employment, household assets, travel patterns, as well as information on farming. Because household surveys are much more likely to cover the whole population (e.g. The Living Standard Measurement Study, LSMS⁹) they will provide a less biased result than micro surveys such as passenger surveys when investigating travel patterns. Baker and Denning (2005) provide advice on developing a country specific transport module to be included in nationwide 'multi-topic' household surveys. Babinard and Scott (2009) review transport data (with a focus on gender) collected by a range of national household surveys carried out in developing countries. Household surveys may be repeated to establish long-term trends as with a panel survey. Airey and Cundill (1998) provide an example of a rural panel survey.

The costs of household surveys vary considerably. An (unspecified) OECD internet source suggests that in South Asia the survey costs could be \$25 per household while in Africa (and Latin America) it might be as much as \$100 per household. The overall costs of a national road impact study could well be in the region of

⁹ The Living Standards Measurement Study (LSMS) was established by the World Bank to improve the type and quality of data collected by Government statistics offices. Currently a wide range of advice on household surveys is available from the LSMS website at the World Bank. (<http://go.worldbank.org/ZAWINK6M10>).

\$500,000 to \$1,200,000 depending on the extent and frequency of surveys and the quality of the consultants and enumerators. Ideally three rounds of surveys should be undertaken, a before survey, and two after surveys. Grootaert (2002) quotes a range from \$ 238,000 (Trinidad) to \$878,000 (Bolivia) for previous national (non-road) impact evaluations.

Semi-Structured Interviews

Semi-structured interviews are carried out in a variety of ways. Key questions are formulated beforehand but the interviewer is free to explore different avenues as they come up. The interviewer will tend to write answers down in a notebook rather than on a preformatted questionnaire. The approach is often very useful when talking to key informants (village leaders, local administrators, etc.) to understand the background to an area and so is often one of the first types of information gathering administered in an area.

Participatory Appraisal

Participatory Appraisal (PA) is a powerful technique often used to consult a local community over transport issues. The methods are described as “...a growing family of approaches and methods, to enable local people to share, enhance and analyze their knowledge of life and conditions, to plan and to act.” (Chambers, 1994). The term Participatory Appraisal is often used interchangeably with Participatory Learning in Action (PLA), Participatory Rural Appraisal (PRA), and Rapid Rural Appraisal (RRA). A prerequisite of a participatory appraisal is that data collection and analysis are undertaken by local people, with outsiders facilitating rather than controlling. Outcomes of the participatory process are referred back to the community in a process of learning and reflection. Advice on the forms PA for rural transport is provided in the TRL Overseas Road Note 22 (2004b).

A PA is most likely to be employed when dealing with transport issues at the village level. The approach often involves drawing different types of diagram such as Venn diagrams to depict key institutions, individuals and their interaction with the community, and social and resource mapping to identify the location and importance of different resources within the area. Vajjhala and Walker (2009) provide a useful example of how Participatory Mapping combined with GIS was undertaken in Lesotho.

Delphi Technique

This is a structured communication technique, traditionally used by experts, that was developed for forecasting¹⁰. Questions are answered in several rounds, and after each round a facilitator provides anonymous feedback. After the feedback, the experts are encouraged to revise their previous answers. Over time, it is expected that the group will converge towards one answer. Chapter 5 below proposes to use the approach for prioritizing transport service interventions, whereby the maximum desirable benefits of different interventions are made together with estimates of probability support and likely success.

Other Forms of Stakeholder Consultation

There are a very wide range of methods that can be used to consult stakeholders including public meetings, workshops and seminars, focus groups, user panels and representative groups. As an example a range of consultation approaches were adopted in Ghana Feeder Road Prioritization Procedure (See Annex 1). These included press advertisements, preparation of handouts, in-depth interviews with officials, workshops for nomination of candidate roads and for prioritization, and finally a public hearing.

In order to assess the adequacy of rural transport services, Starkey (2007) developed a rapid appraisal procedure based on the hub and spoke system in which participative interviews are held with transport regulators, operators, users and support services. The procedure is stratified to ensure coverage of women (at least 40%), people in remote areas (15%) and people disadvantaged in various ways. Traffic counts are undertaken on selected representative spokes, chosen by hub type and remoteness. Data is collected on passenger and freight tariffs and the operating cost of motor vehicles and IMT.

Road Impact Studies

Road impact studies are a major source of information for rural transport planning. Impact is usually identified through one of the following methods:

- ♦ a cross-sectional analysis (i.e. comparing different locations with different degrees of accessibility at the same time, sometimes referred to as a “with and without” study)

¹⁰ http://en.wikipedia.org/wiki/Delphi_method

- ♦ by some form of historical analysis (through a "before and after" study)
- ♦ by combination of both approaches (often referred to as the “double-difference” or “difference-in-difference” approach)

Impact studies can be undertaken either through an analysis of specific local survey data or through a macro analysis using existing regional or national data. In order to determine the impact of the road investment in ‘before and after studies’, observed differences need to be compared to controls which are very similar in all key aspects and where no change in road investment has taken place. In this way, general changes in national or regional market price trends or the effects of local weather can be screened out. For many road impact studies control locations are identified at the start of the project. However it is in fact very difficult to ensure some years ahead that the planned investment will take place on the proposed road within the specified time period and that for the control location road ‘no investment’ will occur. As a result, many studies have found that a control road was improved and that sometimes the project road investment was postponed.

There are clear advantages in the ‘double-difference’ approach as it can help deal with the weaknesses of the other two approaches, even though biases can still be present. One approach to help reduce the element of bias is to adopt ‘propensity score matching’ whereby elements (e.g. households, areas or roads) are selected to match observations ‘with the investment’ as closely as possible to observations ‘without the investment’ to ensure that the presence or absence of the road investment is the key factor influencing the difference in impact. The double-difference approach, that combines historical ‘before and after’ analysis with a cross-sectional ‘with and without’ analysis, involving control areas (or roads) will obviously provide the most convincing results. Very simply, with the double-difference approach impact is equal to the improvement in welfare and income of households on the roads that are improved, less the improvement in condition that occurs in the designated control households where no road improvement has taken place. Examples of undertaking the double-difference approach to evaluate rural road programs include *The Poverty Impact of Rural Roads: Evidence from Bangladesh* by Khandker, Bakht, Koolwal, (2006), and *Rural Roads and Poor Area Development in Vietnam*, Mu and De Walle, (2007).

Advice on rural road impact evaluation methodology is provided by De Walle (2008) while Grootaert (2002) provides practical advice on procedures and questionnaires. Baker (2000) provides general advice on impact surveys, and Bamberg-

er (2006) discusses the risks and implications of adopting less-than-perfect survey procedures and possible ways of reducing survey costs. Roberts, Khattri and Wesel (2011) provide advice on how to write Terms of Reference for an Evaluation. More information on impact evaluation is also available in the SSATP Working Paper *Good Policies and Practices on Rural Transport in Africa – Monitoring and Evaluation*, (Airey, 2014).

4. Rural Infrastructure Planning

This chapter covers both rural road planning and the planning of village-based infrastructure. Most of the chapter is devoted to rural road planning, whereas section 4.20 considers village infrastructure and the use of the integrated Rural Accessibility Planning (iRAP) tool.

4.1 The Planning Context

Rural roads are managed and financed by a variety of institutions. Management may be by central ministry departments, road authorities, and by local government bodies, while finance may be from central and local government funding, road fund administrations or donors. The nature of the planning that is undertaken with regard to an intervention will depend on its scale, funding source and institutions involved. Rural road planning covers a wide range of interventions from new investments to maintenance and spot improvements on rural access tracks that may be managed by a district council or village committee. Clearly the larger the investment involved the greater the need for formal planning. Cost-benefit analysis and cost-effectiveness criteria are frequently used to plan and prioritize both major road investments and major maintenance interventions; however, they are less used to plan routine maintenance.

A range of policy documents will influence rural road investment and maintenance planning. These include mainly Transport Policy and Strategy, Poverty Reduction and Growth Strategy, Agricultural Policy, Regional and District Plans, National Transport Investment Plans. At the national level, the documents will outline the direction of government policy and guiding principles for the development of the transport sector, the responsibilities of national and local government for the sector, the desired regulatory framework, sources of funding, and general principles for prioritizing investment. National Transport Investment Plans and Regional and District Plans will identify key road investments that it is felt will contribute to national, regional and district development. Ideally, these plans will be backed up by formal planning or prioritization procedures.

In recent years, there has been a trend to separate key functions of the organization and management of the network. Typically, a ministry takes the role of ‘owner’ and is responsible for policy development, defining the network, setting standards, and higher level planning. For main roads, a roads authority takes the role of administrator and commissions maintenance and development works to contractors. For rural roads, a local government body or the regional or local office of the road ministry takes on the role of administrator and either undertakes physical works in house or contracts out the work.

Although examples of efficient in-house works by force account, do exist in Africa, (Zimbabwe is an example, see Gongera and Petts, 2003) most published evidence points to substantial savings if road maintenance and construction are undertaken by competitive contract.

4.2 Key Challenges and Solutions for Better Rural Road Planning

For most countries in Africa, the rural road network is very extensive and largely underfunded. Because the condition of gravel and earth roads can change very quickly, it is difficult for engineers and planners to keep up-to-date with monitoring the network. The move towards decentralization (involving local government), and to a lesser extent deconcentration (of central ministries), has been seen, by many, as a way of increasing the involvement of the local population in decision-making and improving transparency. However, the formal planning process for government funded programs in most of Africa, remains very weak and decisions are largely taken on an ad-hoc basis, by local engineering staff in consultation with the District works committee. For rural roads, formal cost-benefit or cost effectiveness analysis tends to be confined to donor programs. Very little accurate traffic data is collected for the rural road network on a systematic basis. For the most part traffic volumes are assigned to roads based on very broad categories.

While in recent years, there appears to be an improvement in the numbers of professionally qualified engineers and technicians working at the district level, for the most part the focus of their work, and their training, has been on achieving physical work progress and procuring contracts rather than on better planning to get the best results for limited resources. District planning officers can, and do, assist with providing planning information about the district however, their responsibilities cover all sectors and they often have little time to devote to assisting with the intensive collection of

traffic data or other data. They too will usually have little or no training in transport planning matters.

Political interference in road planning is most likely to happen if there is little relevant data and weak planning procedures. However, a formal planning process for rural road investments can be established and sustained by centrally organized bodies that have oversight of the rural road network such as the ministry of local government, department of feeder roads or the road funds. These bodies can demand evidence of some formal planning process when deciding on funds allocation to the districts. However, they will not usually have the capacity to check traffic or other data. Occasionally, local and donor funded consultants are appointed to prepare rural road investment programs using transport planning procedures.

In order to improve planning, there clearly needs to be a recognition that extra resources need to be found for:

1. Collecting key planning data (traffic, adjacent population) as well as road condition data, including the degree of seasonal vehicle passability.
2. Training of district engineering and planning staff, as well as central staff in ministries and road funds on the need and techniques of planning.
3. Additional planning staff and consultants to assist with the transport planning process.

There is no reason why district staff should not be familiar with and capable of using road-planning models such as the Roads Economic Decision Model (RED)¹¹ or simple cost effectiveness models. Because of the cost and intensive training required, the capacity to use models such as HDM-4 and the Road Network Evaluation Tool (RONET)⁶ is likely to remain the preserve of central government staff, the Road Fund and consultants.

Central government bodies and the road fund have a key role to organize and offer training, ensure that planning is carried out according to agreed procedures, monitor performance, assist with providing technical advice on planning and maintenance management procedures and to allocate and distribute funds. They can also coordinate between districts, regions, the central government, donors and consultants. If

¹¹ <http://www.ssatp.org/en/node/290>

local governments do not have the funds for the extra resources identified above, these will have to come from the central government and the road fund.

4.3 General Goals and Objectives

Rural infrastructure is designed, built and maintained to fulfil a wide range of possible goals and objectives:

- ♦ Maximize welfare
- ♦ Promote economic growth and regional balance
- ♦ Increase agricultural output
- ♦ Reduce crop losses and improve food marketing and distribution
- ♦ Provide access to basic facilities, taking into account the needs of the poor, isolated and marginalized groups
- ♦ Minimize the time, costs and effort of the community in accessing facilities
- ♦ Improve health and educational outcomes
- ♦ Promote mobility and social interaction
- ♦ Increase employment and develop local skills
- ♦ Minimize environment damage
- ♦ Improve security and promote national integration
- ♦ Promote maximum value for money from limited budgets

Many of the objectives listed can be partially taken into account by a Transport Cost-benefit analysis during planning. For example, crop losses incurred during travel can be taken into account by adjusting the value of freight when calculating transport costs. The benefits of increased employment can be accounted for by using the opportunity cost of labor rather than market wage rates. Environmental issues may be partially dealt with by ensuring that the main costs of mitigation measures are included in the analysis. A range of tools and procedures used to evaluate rural road projects are discussed below.

4.4 Planning Rural Roads to Meet Agricultural and Other Objectives

A large proportion of rural road programs in Africa are initiated by donors specifically to support agriculture or to support community development objectives. These programs may be part of larger schemes where other investments (e.g. technical advice, irrigation, farm mechanization, community resettlement, community funding, etc.) are also provided. In the first instance, these programs will tend to define in broad terms, where the rural road investments will be located. In general, specific districts will be identified that meet certain agricultural, poverty or geographic characteristics. Once the area choice has been made, it will then be necessary to determine the selection of specific roads and tracks to be improved and their standards of construction. The standards of construction are best determined by conventional engineering and economic criteria. Major weaknesses of rural development programs that include rural roads are the lack of consideration about sustainability when rural road maintenance is not funded, the lack of local ownership if local populations are not involved in the planning process, the lack of attention to setting up the proper institutional framework by focusing on the physical part of the investment and the lack of consistency with transport sector policies.

4.5 Planning Rural Road Density and Connectivity

Before considering the economics of road investment, it would be advisable to consider targets of road density and connectivity, which translate into measurable indicators. The Rural Access Index (RAI) is currently used as a measure of how effective the road network is for serving the rural population (See Chapter 2).

Road access and density targets have been particularly important in India. Since the Nagpur Plan (1943-1961), India has put forward long-term targets for the rural road connectivity. These targets have taken different forms based on desirable road densities or maximum distance to a road with variations based on the development of agriculture and the size of village populations. For example, the 1981 target envisaged a road density of 0.7 miles per sq. mile with the maximum distance from a metaled road of 4 miles, for developed agricultural areas. For undeveloped areas, a target density of 0.19 miles per sq. mile was set with a maximum distance of 12 miles to a metaled road. The current Indian government plan, the Pradhan Mantri Gram Sadak Yojana (PMGSY), envisaged all settlements with population above 1,000 (500 in case of hill, NE States, deserts and tribal areas) to be connected by 2009-2010. The thresholds are progressively reduced so that settlements above 500 (250 in case of hill, NE states, de-

serts and tribal areas) will be connected by 2014-2015 and all settlements above 250 will be connected by 2021-2022. The PMGSY target approach is very ambitious and only feasible with a very well-funded budget. In 2010, it was estimated that a further \$40 billion was required to complete the program, in addition to the \$14.6 billion already spent (World Bank, 2010). Although the approach does not use cost-benefit analysis to select roads for improvement, the cost-benefit analysis together with impact studies have been used to validate the program. Details of the planning approach of the PMGSY are given in Appendix 1.

Howe (1971) suggests that road density in different areas of a country tends to be a function of the population density. Clearly, population is not the only factor to influence road building. Alternative models based on employment density or agricultural output value density may also need to be tested to identify areas most in need of road building, and how much is required to meet the given norm.

4.6 Key Engineering and Planning Decisions

In order to meet the wider policy objectives, planners and engineers need to take decisions relating to specific investments:

- ♦ Is the investment worthwhile? Are the benefits greater than the costs?
- ♦ If there is a range of alternative investments, which option gives the best return?
- ♦ Is the proposed project timing optimal?
- ♦ Should components of the project be phased in over a period of time?
- ♦ Would it be better to combine the project with other investments?
- ♦ How should risk affect the choice of projects?
- ♦ If funds are limited, and there are many worthwhile investments, which should be built first?

One of the strengths of an economic analysis is that it can address these issues. Different economic decision criteria such as NPV¹², EIRR¹³, FYRR¹⁴, NPV/C¹⁵, etc. can help provide answers to all these questions.

¹² Net Present Value

¹³ Economic Internal Rate of Return

4.7 The Planning Cycle

In broad terms, the objectives of the planning cycle are that:

- ♦ the highest priority links are identified for improvement and construction
- ♦ the engineering design chosen is the most appropriate
- ♦ the specific investment is economically viable
- ♦ all environmental, social, gender and safety criteria are met
- ♦ there is a minimum risk of major errors
- ♦ there is a feedback mechanism in place

For main and secondary roads, the sequence of activities may be as follows:

- ♦ Network Analysis or Master Plan Study to establish priorities
- ♦ Definition of a program based on priorities and available budget
- ♦ Prefeasibility study
- ♦ Feasibility study/ preliminary engineering design
- ♦ Final decision
- ♦ Final engineering design
- ♦ Procurement
- ♦ Construction
- ♦ Operation and maintenance
- ♦ Monitoring and Evaluation

The process should help ensure that the best road projects are chosen, that there is minimum risk of major errors and the other criteria are met. The monitoring and evaluation will provide feedback. At each of the first three stages, various aspects of road projects will be considered including transport demand, environmental, social, and safety. A ‘broad brush’ approach will be taken at the first stage, and more detailed analyses undertaken at the second and third stages.

¹⁴ First Year rate of return

¹⁵ Net Present Value over cost ratio

Local rural road investment can vary enormously in cost and, particularly for the cheaper interventions; it will not be practical to adhere to the same detail of evaluation given for planning main roads. Nevertheless, many of the same principles will apply. Planning interventions at the district level will usually involve, and take account of, some kind of ‘funds allocation’ process whereby road investment and maintenance budgets are set according to a specified formula (based on population, area, existing road length, etc.). At a minimum there needs to be an initial screening of possible road interventions, after this the best candidate roads need to be assessed from a cost benefit or cost effectiveness point of view. Conceivably, this might be done as part of one study that may also cover social and environmental issues. An example of a screening procedure for rural roads is given for Sri Lanka in Appendix 1.

Lebo and Schelling (2001), suggest:

- a) Initial screening to target disadvantaged areas, or communities, based on poverty indices and to eliminate low priority links.
- b) Ranking the remaining investment choices based on cost-benefit analysis, cost-effectiveness analysis or multi-criteria analysis.

However, because of the common lack of transparency relating to multi-criteria analysis, it is suggested this is ‘kept simple, transparent, and participatory’. Consultation with local communities and representatives of local government is essential at many stages during the planning process of rural roads (see Chapter 3).

4.8 Engineering Design Choices and Standards

Engineering interventions need to be appropriate to the budget available and the traffic type and volume that will use the road. There should be a realistic expectation that the intervention can be properly used soon after its completion. It does not make economic sense, that for example, roads are built without associated structures, or structures without connecting roads, or roads are built “leading nowhere”, in the vain hope that sometime in the distant future further funds will be found to complete the job.

From a planning perspective, it is extremely important to try to ensure that vehicle access is spread as widely as possible, the quality of road access (i.e. road roughness) is a secondary consideration. Hence, assuming funds are limited, it makes sense to ensure that most communities, with the same broad levels of demand, have basic vehicle access before funds are allocated to upgrading a selection of roads to a higher gravel or

paved standard. Planning for Basic Access is discussed in more detail by Lebo and Schelling (2001). The main investment options are:

- ♦ Access, improvements (or spot improvements) on an existing earth road or track for passage of motorized and non-motorized vehicles, particularly in wet seasons
- ♦ Construction and improvement of paths, trails and bridges for pedestrians, animal transport and other forms of intermediate transport
- ♦ Construction of an earth road. Here the road will be built from in situ materials, or from materials that are outside engineering standard
- ♦ Construction or rehabilitation of a gravel road, where imported materials of a specific engineering standard are used
- ♦ Construction or rehabilitation of a paved road
- ♦ Resurfacing of a gravel or paved road
- ♦ Construction of major structures, such as a bridge or culvert

Typically, a *track* will have less than 5 vehicles per day; an *earth road*, 5 to 50 vehicles; a *gravel road* 50 to 250 vehicles per day; and a *paved road* above 150 vehicles per day. The economics of the optimum choice will depend upon construction costs, maintenance operations, traffic volumes, vehicle operating costs, terrain, and climate. Examples of unpaved access roads are shown in Figures 6 and 7.

Partly in response to growing dissatisfaction with the increasing scarcity and cost of good quality gravel for resurfacing, engineers have taken a growing interest in either trying to improve the performance of earth roads, (through the basic access approach and the use of low cost maintenance methods, for example using the towed grader) or in reducing the cost of paving roads, (the Low Volume Sealed Roads (LVSR) approach)¹⁶. These have tended to reduce the effective “window for gravel” between earth and paved roads.

¹⁶ Guidelines for low volume sealed roads. SADC. www.ssatp.org/en/node/292

Figure 6. An example of rural roads in poor condition



Figure 7. An example of rural roads in poor condition

Road Design Standards

Most countries have specified road standards for geometric and pavement design. These standards are based on traffic volumes, vehicle axle loads, terrain and road function. In Ethiopia for instance, the 2011 Design Manual specifies nine geometric standards, four standards for the high volume traffic, ranging from 300 to over 10,000 AADT and five geometric standards for lower traffic volumes, i.e. DC4 for 150-300 AADT, DC3 for 75-150 AADT, DC2 for 25-75 AADT, DC1 for below 25 AADT. There is also a standard for a ‘track’. In general most modern design standards are based on a combination of economic viability and road safety. With the development of road engineering/economic models (HDM-4) there has been an important movement away from basing design on what was often administrative function.

If there is insufficient traffic the latter approach can lead to ‘over design’ and a very significant waste of resources. An example of overdesign is given in Figure 8. In driving on this very wide road for well over an hour, only three other vehicles were encountered.



Figure 8. An oversized road

Labor-Based and Tractor-Based Technology

Rural road construction and maintenance are particularly suited to the use of labor-based and tractor-based technology where more labor and simple equipment (tractors, trailers and towed graders) are used. Labor and small-scale equipment is much more flexible and therefore often ideally suited to the construction of basic access.

The big advantage of using labor-based solutions is that far more people, including women, can be employed and trained to work, so there are much greater benefits to the community. In the 1980s and 1990s, ILO helped in setting up labor-based projects, in a number of countries in Africa. This also involved the training of district engineers, technicians and contractors, in the use of labor-based roadwork.

Tractor-based technology, using tractors, trailers and towed graders has successfully operated in Zimbabwe for many years (Gongera and Petts, 2003). This approach has also spread to a number of other African countries, often in association with labor-based work. The Roads 2000 approach, adopted in Kenya, used the same technology. The general consensus is that labor and tractor based technology can carry out road work to the same standards as capital intensive work, in the most part for similar or less cost. The relative advantage of labor or machine based work will depend on the cost of labor.

4.9 Road Maintenance and Road Deterioration

Road maintenance is critical to the long-term performance and design of roads. In maintaining a given quality of riding surface there is a trade-off between construction standards and maintenance. An expensive concrete pavement surface can last a long time with little, or no maintenance. Conversely, with low traffic, reasonable standards can be achieved on an earth road with intensive maintenance.

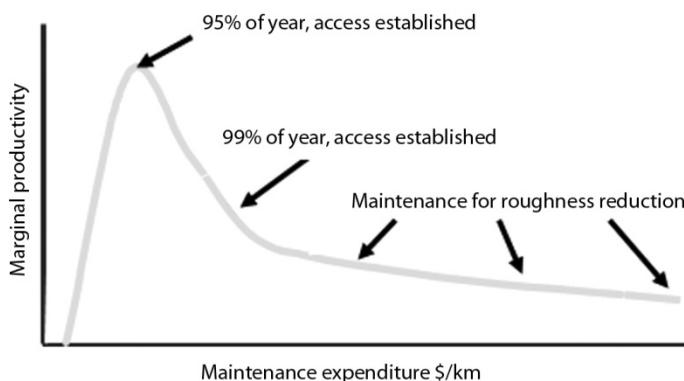
Maintenance Priorities

There is general broad agreement over which maintenance activities should take priority. The Transport Research Laboratory's Overseas Road Note 1 (TRL Ltd, 2003) presents priorities based on a combination of treatment type and traffic volume. The heaviest trafficked roads have priority over lower trafficked roads. In terms of treatment, the highest priority task is emergency work, designed to keep the road open to traffic. Following this is routine drainage work, routine pavement work and the periodic work such as regravelling and surface dressing.

It is interesting to note under this approach that recurrent pavement work has a higher priority than periodic work. This reinforces the results of an analysis using the road-planning model HDM-4. In general, the results suggest that unpaved road grading is extremely cost effective with high economic returns. In contrast regravelling, because of its high expense generally provides much lower economic returns and is often uneconomic for lower traffic volumes, if the alternative is to maintain a high grading frequency of an “earth” surface because the gravel is lost.

The importance of keeping roads open for traffic on very low traffic roads is graphically shown in Figure 9. The curved line, showing the Marginal Productivity of Maintenance Expenditure, for earth or gravel roads initially in very bad condition, demonstrates that starting with very little expenditure the value of each dollar spent on maintenance rises quickly as access is established for around 95 percent of the year. It then falls as further access is established and flattens out as further maintenance is spent to achieve roughness reduction. The graph is useful in helping road organizations determine priorities if maintenance funding is limited.

Figure 9. Marginal Productivity of Maintenance Expenditure on Low Traffic Roads



Road Roughness and Optimal Maintenance Policy

From the point of view of the user, passability and road roughness are the most important characteristics of a road. Road roughness is important because it is a key factor influencing vehicle operating costs (VOCs) and hence transport fares and tariffs.

The International Roughness Index (IRI) measures road roughness on a scale from 0 IRI typically rising up to say 30 IRI where the road is so rough that it is barely drivable. A new asphalt concrete road can have roughness value of 1 to 2 IRI. A newly con-

structed gravel road of good materials can have a roughness value of under 5 IRI. Over time, an increase in roughness can be expected resulting from the effects of weather and traffic.

For paved roads, routine road maintenance will have the effect of delaying the rate of road deterioration and the eventual rise in roughness levels but there will usually be no immediate effect on reducing road roughness. Resealing will only have a marginal effect on reducing road roughness, but again it will help to delay the rate of road deterioration. Reconstruction, rehabilitation or an overlay can substantially reduce road roughness below previous levels.

For earth and gravel road surface routine maintenance can have a substantial immediate effect in reducing road roughness, although the beneficial results may only last a few weeks or months. Regravelling will also reduce the rate of earth and gravel road deterioration. In order to achieve the target of having a substantial proportion of the gravel road network in good condition (i.e. below 10 IRI) there needs to be at least 3 or 4 gradings per year.

Allocation of Maintenance Funds Between Different Road Networks

Governments and Road Fund organisations tend to have a formula for allocating maintenance funding between different road networks. So regional and rural roads may be allocated, say, 30 percent of the total. Funds allocation procedures are also used to allocate funds for road rehabilitation and maintenance to different regions and districts. The allocation may be based on previous performance and subject to bidding and negotiation between national and local authorities. They may also be based on a formula including factors such as population, road length, area and income per head in each district.

Although a rational funds allocation procedure is essential to an effective road maintenance policy, the area has not been researched, or widely discussed in any detail. In part because of funding shortfalls and delays in releasing funds, the process may not be as straightforward as indicated in published budgets: "Allocating the funds among various levels of the network is a murky business." (Malmberg Calvo, 1998).

There is obviously a strong economic case for keeping a high level of maintenance funding for roads carrying the highest traffic volumes. It is argued that if funds are limited it is difficult to justify taking funding away from roads carrying 1000 vehicles per day to reduce roughness on roads carrying 20 vehicles per day. This argument is

true, up to a point. However, as is argued elsewhere in this report, the social and economic consequences of road closure are very high, even for relatively low traffic roads. So a balance clearly needs to be struck, in allocating funds, to ensure that both the high traffic roads are kept in reasonable condition and, at the same time, low traffic rural roads are also open to traffic.

4.10 Taking into Account Social and Environment Issues

Social and environmental issues are taken into account at many stages in the project cycle. At the screening stage (which might be a network analysis study or a master plan study), an assessment will be made to see whether a full EIA is required or not. If not, some form of environmental analysis will be necessary, proportional to the scale of the project and its likely environmental impact. An initial environmental scoping study should identify the most important environmental issues associated with the project. For rural roads, these may be resettlement issues, ecological issues affecting flora and fauna, impact on water courses, etc. Assessing the social and environmental impact is critical to compare and decide on options of design and alignments. After consultation, a workplan for the proposed EIA should be prepared. The EIA will then be undertaken and baseline data will be collected. This will then be followed by an Impact Prediction & Assessment. The significance of any impact should be evaluated and mitigation measures identified. An Environmental Management Plan should be prepared for when the project is to be physically implemented. Finally, a monitoring and evaluation procedure is implemented.

Detailed advice on environmental issues can be found in Tsunokawa and Hoban, (1997). Advice on social issues, in *Social Analysis in Transport Projects: Guidelines for Incorporating Social Dimensions into Bank Supported Projects*, The World Bank, (2006b), and the World Bank's Transport and Social Responsibility Website.

4.11 Income Distribution Issues

Although procedures exist, income distribution weighting is not commonly applied to the cost-benefit analysis (CBA) of road projects. An economic analysis considers the project from a national point of view. In a CBA, the total costs and total benefits arising from a project are identified and measured, irrespective of who incurs the costs or who benefits from the project. Within the conventional CBA, it is usual to treat each monetary unit of benefits as being of equal value to each individual in society, irre-

spective of his or her income level. It is more usual to take account of poverty issues, in the prior screening of projects, either before the CBA is undertaken, or as part of a final multi-criteria analysis, before the final decision is made. Examples from Vietnam and Sri Lanka are given in Appendix 1.

More advice on incorporating the benefits within road appraisal can be found in World Bank Transport Note TRN-26 (2005) and in Gajewski et al. (2004).

4.12 Identifying the Best Projects

Before substantial resources are committed to carry out a detailed feasibility study, it is first essential to ensure that the most promising projects are selected for analysis. In Section 4.7 on the planning cycle, it is suggested that some form of screening study is carried out to identify a wide range of links for initial analysis. The screening may involve identifying projects meeting a poverty criteria and an economic efficiency measure such as ranking projects by a ratio of demand (expressed as traffic or population served) divided by an estimate of construction cost per kilometer. For low traffic rural roads and tracks roads community participation can also be invaluable in this process.

4.13 Transport Cost-Benefit Analysis

Conventional Cost-Benefit Analysis (CBA) is the most widely used procedure for planning road investment. The approach is adopted in the road planning models HDM-4 and RED. The main focus is to maximize economic welfare and perhaps its biggest strength is that it can discriminate between different projects and engineering designs on a rational basis. The main economic components of a Cost-Benefit Analysis (also common to other forms of CBA) are as follows:

- ◆ First round effects and secondary benefits
- ◆ Project and alternative case
- ◆ Planning time horizon, discounting and residual values
- ◆ Use of economic prices and inflation
- ◆ Road investment and maintenance costs
- ◆ Estimating traffic benefits (normal, diverted and generated traffic)
- ◆ Forecasting traffic
- ◆ Estimating generated traffic

- ♦ Vehicle Operating Costs
- ♦ Value of passenger time
- ♦ Accident rates and costs
- ♦ Economic decision criteria
- ♦ Strengths and weaknesses of transport – Cost-benefit analysis

First Round Effects and Secondary Benefits

Any procedure to analyze benefits should be designed to provide *maximum coverage of the costs and benefits* without *double-counting*. Transport Cost-benefit analysis focuses on the direct '*first round*' effects of road investment on traffic and transport costs. The assumption is that these will broadly capture the costs and benefits of road investment without double counting. Because the approach measures benefits to the consumers of transport, it is sometimes referred to as the Consumers Surplus approach. In contrast, road impact studies also include the wider '*secondary benefits*' of road investment on the total economy. These are much more difficult to estimate, particularly 'ex ante', in advance of the investment. It would clearly be double-counting to crudely add the primary traffic based benefits to an estimate of the overall secondary benefits. As an example, one approach of measuring secondary benefits is to estimate the rise in land values, or land rents, following a road investment. Because these arise as direct result of reduced transport costs, it would be double-counting to add transport cost savings to the rise in land values.

The Project and Alternative Case

To carry out an economic evaluation it is necessary to identify a "*base*" or "*without investment*" case in order to make a comparison with different "*project*" or "*with investment*" cases. Different forecasts are prepared of both traffic volumes and transport costs and road maintenance costs to estimate net benefits.

In order for the economic analysis to be as realistic as possible the base case should include a level of road maintenance that is appropriate to the expected traffic volumes. It is sometimes easy to artificially inflate the value of a project case by assuming an unrealistically poor base case with little or no maintenance. Such practices should of course be avoided. Whatever base case is used it is important to include a "minimum do something" case, in other words, a case where the minimum of new investment or other measures are assumed, such as increased maintenance, to address the problem.

The Planning Time Horizon, Discounting and Residual Values

The Planning Time Horizon is the period over which the economic analysis is to be carried out. The choice of time horizon should reflect the economic lifetime of major assets in the investment. In general, main roads are evaluated over a 20 to 30 year period, while rural roads are more commonly evaluated over a 10 to 20-year period.

Because of the nature of the way that costs and benefits are valued in the future (using an economic discount rate) those that occur in the distant future are valued less than those that occur in the near future. Using a 12 percent discount rate a dollar's worth of benefits occurring in the 25th year will only be valued at 0.066 percent, although for traffic benefits, this will be substantially mitigated by a high traffic growth rate.

Traditionally, the economic discount rate has been viewed as the opportunity cost of capital, which vary from country to country. The World Bank has used a 12 percent discount rate for most of its work, primarily to ration its funds. A lower rate can be used for projects particularly focused on the poorest sections of society.

Residual values of major investments are sometimes used in an economic analysis. These should reflect the remaining economic life of an investment. In most instances because of discounting these values will usually have little impact on the outcome of the analysis.

The Use of Economic Prices and Inflation

To carry out an economic evaluation all costs and benefits need to be expressed in economic price terms (shadow prices). Prices should reflect the value that society places on the use of the resource excluding distortions resulting from taxation, subsidies, license fees, and legislation and other market imperfections.

Taxation and license fees do not represent a demand on real resources but transfer of spending power to the Government and hence in determining the economic price the taxation component should be subtracted from the market price. In contrast, an item that is subsidized is under-valued and hence the subsidy element should be added back in.

Depending on economic conditions, it is sometimes appropriate to make other adjustments to determine economic prices. When there is very substantial unemployment in the economy it is argued that the market price for unskilled labor does not properly reflect the true economic cost and hence the value should be adjusted downwards. Other distortions can arise if the exchange rate between local and foreign cur-

rency is kept at an artificial level; hence, there may be a need to adjust the relative prices of imports and exports. Sometimes in feasibility studies, a very detailed *shadow pricing analysis* is carried out in which a range of adjustment factors are calculated and applied.

For most feasibility studies appropriate economic prices can be determined from adjusting market prices for taxation and subsidies. For many countries, *Standard Conversion Factors* are published to convert market prices to economic prices.

In an economic analysis, all prices used throughout the analysis should be in *constant price* terms and refer to a given date. Hence, there is no reason to adjust future costs and benefits for forecast price inflation.

Road Investment and Maintenance Costs

Investment and maintenance costs should be incorporated into the economic analysis using economic rather than market prices. The Standard Conversion Factors are particularly useful for converting construction and maintenance costs to market prices in road appraisals. This will avoid a separate detailed study to achieve the same result.

The new investment and maintenance costs that are to be incurred in a project should be phased into the economic analysis at the time of their main economic consequences. The environmental appraisal will often identify measures that should be taken to minimize the effects of environmental disruption (e.g. sound barriers or tree planting). These costs should also be included within the investment costs of the project.

Estimating Traffic Benefits

In order to evaluate traffic benefits, it is useful to separate traffic into the following categories:

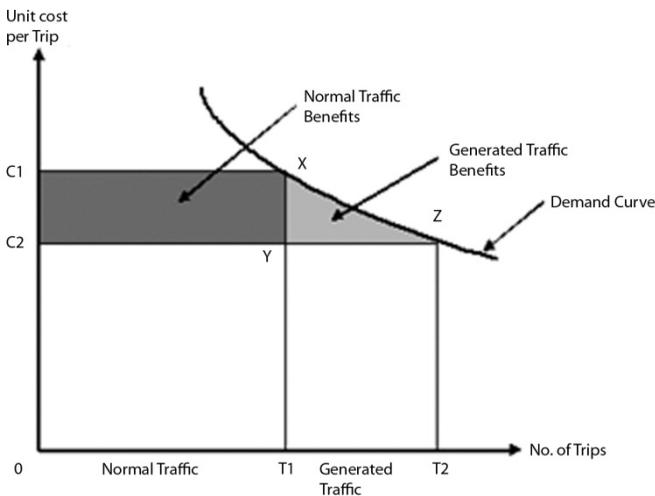
- a) **Normal traffic.** The traffic volume that is forecast to travel on the same route in both the base and project cases.
- b) **Diverted traffic.** Traffic, travelling between the same origin and destination that is forecast to switch routes as a result of the investment.
- c) **Generated traffic.** An increase in traffic volume that is forecast to arise, because of lower operating costs, directly as a result of the road investment.

Normal (and diverted) traffic benefits are valued in terms of the forecast traffic volume multiplied by the forecast change in transport costs. In Figure 10, as transport

costs reduce from C1 to C2, normal traffic benefits are shown to be equivalent to the area C1, X, Y, C2.

Generated Traffic is valued as the forecast traffic volume multiplied by *half the difference in operating costs*. This “rule of half” is based on the assumption that whilst some users would value the improved travel at virtually the full difference in transport costs for many other users the trip is only just worth making at the new lower cost. The assumption is that half the difference in operating costs represents a reasonable approximation for all generated traffic. Generated Traffic benefits are assumed to be half the difference in transport costs between the ‘with’ and ‘without’ cases, i.e. the triangular area X,Y,Z.

Figure 10. A Normal and Generated Traffic Benefits Using the Consumers’ Surplus Approach



Forecasting Traffic

Traffic counting procedures for rural roads should ensure that pedestrians and other non-motorized traffic are covered alongside motorized traffic. Traffic forecasts are required in both the project case, and the alternative, or do nothing, case. For most rural roads, when a change in modal split is not envisaged, a simple extrapolation of current growth trends (typically between 2 and 8 percent per year) will be sufficient for forecasting normal traffic. Particular care needs to be taken with estimating motorcycle traffic because of the very high growth in ownership recorded in recent years.

Estimating Generated Traffic

An analysis of 25 main road sections in Ethiopia with significant road improvements, in comparison with 97 sections without improvement, during the period 2000-2003, found that on average traffic was 13.1 percent higher on the ‘with improvement’ sections, than what would have been forecast from the ‘without improvement’ sections. Overall, the average generated traffic for different vehicles, for typical road improvements were calculated to be *cars*: 8 percent, *buses*: 15 percent, *rigid trucks*: 10 percent, *articulated trucks*: 2 percent (Ethiopian Roads Authority, 2005).

In principle, generated traffic can be forecast from an estimate of the transport demand elasticity. The elasticity is the ratio of the percentage change in demand to the percentage change in transport costs faced by the users. It is important to realize that the elasticity relates to the *change in costs for the total journey*, and not just for the change in costs for the link in question. A typical journey may be many times the length of the improved link. There have been many studies of transport elasticities, (mostly related to developed economies, and few, if any, relating to rural Africa) giving varying results. Based on the midpoint values of a survey of transport, elasticities bus traffic would increase 0.6 percent and freight traffic by 0.9 percent for a 1 percent decline in costs (Oum et al., 1990) as the result of elasticities equal respectively to minus 0.6 and minus 0.9 (the minus signs reflects the fact that traffic increases when costs decrease and vice versa).

Vehicle Operating Costs

Changes in vehicle operating costs represent a major component of benefits from road investment. Savings arise from road investment through a reduction in trip distance, trip time, road roughness, and a change in road alignment and in modal split.

The main components of vehicle operating costs are:

- ♦ Capital costs including depreciation and interest
- ♦ Fuel consumption
- ♦ Tyre consumption
- ♦ Maintenance costs including parts and labor charges
- ♦ Driver and conductors labor costs
- ♦ Passenger and freight values of time
- ♦ Oil and lubricants
- ♦ Overhead costs including garaging and insurance

Value of Passenger Time

Savings in passenger time can represent an important component of the economic benefits of road investment. For urban road projects, they often represent the largest proportion of benefits. Passenger time values are usually divided into the following categories:

- ♦ Working time
- ♦ Non-working time

It is commonly accepted that the value of working time is the total cost of employment of an individual expressed per working hour, i.e. it includes salary, bonuses, and any contribution made by an employer to pensions, social security and national insurance. Using a Stated Preference Analysis, IT Transport (2005) undertook a detailed study of the value of time in Ghana and Tanzania, which found that the average values of passenger time were 64 percent and 49 percent of the wage rates in each country respectively.

Accident Rates and Costs

Despite high accident rates and costs to the economy, it is relatively rare to include an accident cost analysis when planning rural roads in Africa. Because accidents are caused by a large range of interacting factors, and are relatively rare along specific road sections, predicting accident rates is difficult at the best of times. Furthermore, it is believed that there is massive under reporting of accidents, particularly in rural areas of Africa. In addition, there has been relatively little research in rural Africa to address these issues.

One exception is work carried out for the use of accident analysis for HDM-4, by Fletcher et al. (2006). The study of Tanzania was carried out over a three-year period on 264 km of roads, and 3,754 accidents were recorded, with most of the data on busy main roads near Dar es Salaam.

Detailed advice on accident costing is provided by Jacobs (1995) and Ross Silcock and TRL (1995). General advice on designing roads to improve road safety is provided by the Transport and Road Research Laboratory (1991). The iRAP method¹⁷ provides a simple and objective measure of the level of road safety on a road network. The results

¹⁷ www.irap.net

associated to estimated costs to reduce the risk can be included in the planning process to take road safety into account in a harmonized manner.

Economic Decision Criteria

A range of decision criteria (such as Net Present Value, NPV and Internal Rate of Return, IRR) are used to help identify the best investment solution. Each has its particular strengths and weaknesses. With a cost-benefit analysis, a number of decision criteria can be established. Assuming an appropriate discount rate and all underlying assumptions are correct, ***a project will be economically worthwhile if the NPV is greater than zero.*** The higher the NPV, the greater the net benefits of the project. If there are no budgetary constraints and there is confidence in all underlying assumptions, then ***the choice between two alternative projects should be based on the NPV.***

Because discounted cost and benefit streams can be easily added or subtracted, the NPV approach is suitable for assessing projects built from separate components, such as when different minor projects are combined together, or when a road project is combined with another form of investment such an agricultural development scheme.

Internal Rate of Return (IRR) and Uncertainty

The Internal Rate of Return (sometimes referred to as the Economic Internal Rate of Return (EIRR) in an economic context) is the discount rate at which the base year value of costs and benefits are equal (i.e. NPV = 0).

The IRR gives no indication of the size of the costs or benefits of a project; it acts as a guide to the ‘profitability’ of the investment - the higher the better. ***The IRR is often used to see how robust a project will be to future uncertainty and possible changes in assumptions.*** For this reason, it is frequently used for initial project screening. The IRR cannot discriminate between mutually exclusive projects, hence the NPV is required to compare alternative solutions of the same project.

Net Present Value over Cost Ratio (NPV/C) and Budget Constraints

The Net Present Value over Cost ratio is simply:

$$\text{NPV/C} = \text{Net Present Value} / \text{Construction Cost}$$

The NPV/C criterion serves to rank projects where there is a budget constraint. This happens when many more worthwhile projects can be accommodated within the available budget—the higher the ratio the more worthwhile the project.

First Year Rate of Return (FYRR) and Optimal Timing

FYRR = Total Net Benefit in First Full Year after Opening/ Construction Costs

For road projects with a smoothly increasing forecast traffic growth, *the First Year Rate of Return (FYRR) gives a rough guide to optimal project timing*. If the FYRR is greater than the discount rate, then the project should go ahead. Otherwise, it should be delayed until it satisfies the criterion.

Strengths and Weaknesses of Transport – Cost-benefit analysis

The biggest strength of a Transport Cost-benefit analysis is that it can discriminate between different transport projects and different engineering designs on a rational basis. However, there are still major problems with valuing many of the components, including vehicle operating cost savings. Its main weaknesses, based on transport costs, are that it is not so good at dealing with:

- ♦ poverty and income inequality issues
- ♦ externalities (environment, national security and integration)
- ♦ social and economic issues relating to major changes in accessibility (e.g. dealing with new vehicle access or seasonally impassable roads)
- ♦ procedure, where there are major uncertainties with forecasting outcomes

4.14 Agricultural Response & Producers' Surplus Approach

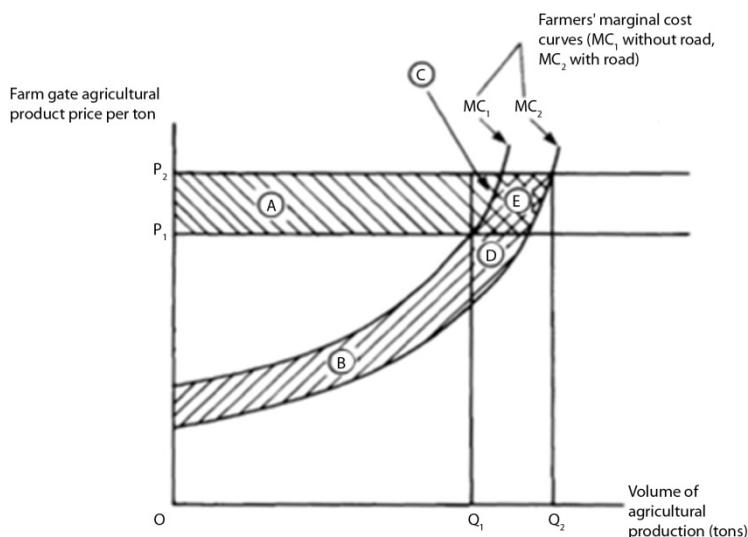
An alternative approach to the (transport cost benefit) consumers' surplus approach to estimating the benefits of road investment is the Producers' Surplus approach. This approach was advocated by Carnemark, et al. (1976). The approach was relatively popular in the 1960's and 1970's, and although it is still used, it fell out of favor with the development of transport cost savings models such as RTIM¹⁸, HDM and RED.

The basic model is diagrammatically described in Figure 11. This shows the benefits from a road investment in terms of the increased profits to farmers who farm in the area of influence of the road. In the without road case agricultural output is Q1 and the farm gate price is P1. Q1 is determined by the marginal cost curve MC1 meeting the price level P1. According to his location each farmer will face a different farm gate

¹⁸ Road Transport Investment Model

price and each will have a different marginal cost curve. The supply curve of an area will be the sum of the individual marginal cost curves.

Figure 11. Producers’ Surplus Benefits Resulting from Lower Transport Costs Giving Higher Farm Gate Prices and Lower Input Costs.



With the road investment two separate effects will occur which will affect agricultural production. Assuming the market price remains fixed, the farm gate price will rise from P1 to P2 as it is now cheaper to transport farm produce to market, and the farming cost curve will fall (from MC1 to MC2) because it costs less to transport farming inputs (labor, fertilizers, tools, etc.) to the farm. This joint effect leads to production increasing to Q2 given by the point of intersection of marginal cost curve MC2 with farm gate price P2. Areas A and C represent benefits from farm gate price rise alone. Areas B and D represent benefits from the lower cost curve alone. Area E is a benefit of the joint effect. Total benefits are given by the shaded area ABCDE.

It is recognized that in practice the exact shape of the marginal cost curve will not be known and so it is suggested that average variable costs are used to determine the incremental producer’s surplus. The total producer’s surplus benefits arising from the road investment are then:

$$= (\text{new farm gate price } P_2 - \text{new average variable cost at } Q_2) \times \text{new output level } Q_2$$

$$- (\text{original farm gate price } P_1 - \text{original average variable cost at } Q_1) \times \text{original output level } Q_1$$

This will give equivalent producer benefits to those shown in Figure 11. However, estimating average variable costs are far from straightforward. Although, in Figure 11 marginal cost curve MC2 lies below MC1, it intersects at a higher point (P2 rather than P1) hence the average of MC2 can be higher than the average of MC1.

The main advantage of the producers' surplus approach is that it focusses directly on the effects of lower transport costs on the main productive activity of rural areas. It may be felt that the alternative transport cost savings approach may miss important benefits because of distortions within rural economies. However, its biggest weakness is in predicting new levels of agricultural production following road investment. Agricultural supply elasticities may provide a way of predicting response to farm gate price changes. Biswanger (1989) and Peterson (1979) quote a wide range of elasticities ranging from 0.07 up to 1.66. However, an examination of many road appraisals using the approach found that increased agricultural production was, in most instances, arbitrarily guessed at, with no supporting evidence (Hine, 1982).

If the producers' surplus approach is used, then it is likely to be in addition to the conventional transport cost savings approach, to ensure that non-agricultural traffic benefits are covered. Care needs to be taken to avoid double counting.

4.15 Social and Economic Case for Basic Vehicle Access

It is sometimes argued that it can be difficult to justify road investment to remote rural communities using conventional Transport Cost-benefit analysis, where traffic volumes are low and seasonal. Although this may be the case in many situations, if a road investment can substantially change vehicle accessibility then there may be a good case on both economic and social grounds for the investment.

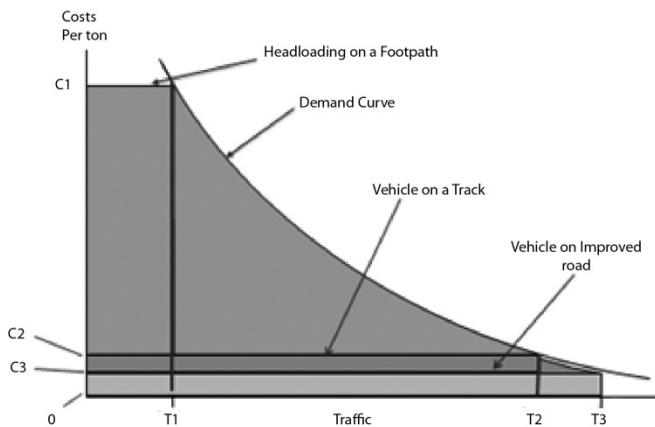
Economic Benefits of Basic Access

On economic grounds if there is currently no vehicle access, or vehicle movements are prevented for many months during the wet season and therefore the alternative is walking or head loading then, there may be a substantial decline in transport costs with the road investment. Because transport costs by vehicle are so much lower than by alternative methods such as head loading the economic case for basic vehicle access can be very strong, provided there is sufficient demand to substantially fill a vehicle at a given time. Moving goods by head load can be as much as 10 to 30 times more expensive than moving by vehicle. In contrast improving basic access to an improved gravel standard may only reduce transport costs by around 20 to 50 percent.

A representation of the benefits of upgrading a footpath to a basic access earth road and upgrading an earth road to an improved gravel road are presented in Figure 12, using the consumers' surplus diagram. In the first case, transport costs are reduced from C1 to C2 and traffic rises from T1 to T2 while the associated benefits are represented by the area in blue. In the second case transport costs fall from C2 to C3 and traffic rises from T2 to T3 while the associated benefits are represented by the area in red. Because of the very large change in transport costs (from footpath to earth road) there is in the first case an associated large increase in traffic and associated generated traffic benefits. In the second case of the change from earth to gravel road, the transport cost savings are much smaller and hence the generated traffic response and associated generated traffic benefits response will be very much smaller. In this example, a key factor is the shape of the demand curve, which represents the underlying economic opportunities.

Clearly, the economic case will depend on the costs of construction, current non-motorized traffic levels, the duration of the season when the road is impassable, the volume of traffic and the proportion of journeys that will switch modes, or divert, and the likely traffic response to the investment. If vehicles carry passengers as well as freight then basic access will be much easier to justify.

Figure 12. Benefits of Providing Basic Access



Social Benefits of Basic Access

Social benefits can be thought of as a function of size of the population to benefit from a road investment multiplied by the decline in transport costs. If there is no decline or no population to benefit, then no social benefits are expected.

On social grounds, basic vehicle access can be extremely important to the community and the conventional transport cost-benefit analysis is unlikely to capture these benefits. For most situations, where there is good vehicle access, and incomes are sufficient, then people will be willing to make a trip (to hospital, market or visits to friends) irrespective of normal fare levels. In this case, the conventional transport cost savings approach represents a reasonable approximation of the benefits of the road investment and there is little pressure to include additional “social” benefits to the analysis.

However, problems arise where income levels are low and communities are inaccessible or roads are cut off for much of the year. In the extreme case where a new road is being introduced to a remote poor community, where in the “without” case people have to walk twenty kilometers and carry sick relatives to hospital but in the “with” case they can travel (perhaps intermittently) by motor vehicle trip purpose does begin to matter. It can be a matter of “life or death” and the conventional valuation of transport cost savings either for normal traffic or for generated traffic, looks completely unrealistic.

The case for a different approach is then strongest where a remotely located large population makes relatively few trips and the only access is via a poor access footpath, road or track that is cut for several months of the year and vehicle movement is prevented. From the point of view of personal security and the need for vehicle access in a medical emergency, there is an important psychological benefit of all year round vehicle access even if emergency trips are rarely made. Similarly, if a road is cut then it is likely that normal marketing activities in the area will either cease or be severely curtailed. Longer, more circuitous walking trips can be expected. Likewise, whilst government services and external agencies remain crucial to the development of an area there are strong arguments for reasonable all year round vehicle access to major centers within each local district. Any external institution planning to locate staff and facilities in a remote location will think twice if vehicle access is very poor and cannot be guaranteed throughout the year.

It is impossible to capture the long-term impact of improving accessibility (through the conventional measurement of traffic benefits) when this has a direct impact on the location of important facilities. Perhaps correctly, new road investment in rural areas of developing countries is seen as the precursor of many other interventions including schools, clinics, water supply, government offices, NGO activity and commercial investment. A way of incorporating social benefits into project appraisal is via a multi-criteria analysis in which social, economic and environmental costs and benefits are

combined together in a single analytical framework and an overall ranking of different alternatives achieved. A way of doing this is provided by Odoki et al. (2008).

4.16 Road Appraisal in a Context of an Integrated Development Project

Roads often form a significant component of integrated agricultural development schemes. If major agricultural inputs and other investments are planned then perhaps the simplest approach would be to plan the scale and quality of the road infrastructure to meet the forecast traffic levels at minimum discounted cost (effectively ignoring any 'generated traffic' benefits). As output and traffic are forecast to grow then the quality of the infrastructure could be upgraded to meet the future increase in demand. In these situations, it may be necessary to provide an economic appraisal of the overall viability of the combined project including the roads. Attention should be paid to assign benefits and costs respectively to each component of the project and not allocate the same benefits several times to each component or allocate all benefits to one single component without considering the costs of the other components.

However as the Peru Case study (World Bank, 2006a) demonstrates there may be significant positive synergies between the provision of different types of infrastructure (such as electricity, water, telecommunication and roads), for same rural communities. Then, care needs to be taken to ensure that the resulting increase in traffic levels and economic activity is properly taken into account. Unfortunately, apart from the Peru study, there is little published guidance on the scale of likely interactions. It would be therefore important to closely monitor the effects and find out what happened with similar interventions elsewhere within the country and wider region.

4.17 Ranking Procedures, Cost Effectiveness & Multi-Criteria Analysis

Cost Effectiveness and Ranking

Whilst conventional economic cost-benefit analysis is commonly used to prioritize main, secondary and urban roads, other methods are often employed to prioritize low volume rural or feeder road investments. These procedures are often referred to as "ranking" or "screening" procedures. Although there are many formulations, the different procedures are not deliberately designed to fit within a conventional economic framework. The procedures often include indicators or measures of social as well as economic demand, need or benefit. Compared with a conventional economic appraisal less attention is given to the precision of coverage of benefits. Sometimes the

procedure will include a method of incorporating consultation in the selection and prioritization of road investments.

The main advantages of ranking procedures are:

- ♦ Speed, simplicity and transparency
- ♦ Ability to incorporate a measure of social benefits
- ♦ Ability to directly incorporate community choice

The main disadvantages are:

- ♦ The procedures may involve summing and weighting totally different characteristics (i.e. adding up "apples and pears")
- ♦ The weightings adopted are unlikely to be stable in the long run
- ♦ It is difficult for the procedure to assist with the range of ancillary planning choices that may be covered by a conventional economic appraisal such as project timing, alternative project designs, combinations with other investment and maintenance options, etc.
- ♦ The solution may be very far from optimal, leading to economically wasteful investment in the sense that the same objectives may be achieved, by an alternative approach, with less resources

Population is used as a key factor together with the costs of upgrading in the following cost-effectiveness criterion identified by Lebo and Schelling (2001):

$$\begin{aligned} & \text{Cost Effectiveness Indicator of link}(j) \\ & = \frac{\text{Cost of Upgrading link}(j) \text{ to basic access standard}}{\text{Population served by link}(j)} \end{aligned}$$

With this method, improvement of links that have the lowest ratio is given the highest priority. The two key drawbacks of this approach is that there is no measure of benefits resulting from the change in road condition and secondly no importance is attached to traffic which is assumed to be represented by the population when it reflects both the population and the specific socio-economic situation of the rural area served by the road. This method assumes that the socio-economic situation in rural areas is the same across the country.

An approach overcoming these difficulties has been suggested by Airey and Taylor (1999) where two indices are derived one for impassable roads, the other for passable

ones. The approach is designed for roads that are less than 25 km in length and have less than 25 vehicles per day. A simplification of the approach is presented below.

For impassable roads (for example where a bridge or culvert is broken) ranking is based upon the minimum cost per head (person), of the population in the catchment area of the road, for establishing access.

$$\text{Cost/head} = \frac{\text{Estimated cost of minimum improvement works}}{\text{Population served by or living in the zone of influence of the improvement}}$$

The lowest cost per head of establishing access would then have the highest priority.

For passable roads the prioritization is based on predicted traffic multiplied by an access change and divided by the cost of the proposed improvement. Simplifying

$$\text{Prioritization Index} = \frac{\text{Traffic} \times \text{Access Change}}{\text{Improvement Cost}}$$

In this case, the highest value has the highest priority. The access change is calculated from an estimate of the change in road condition. Road condition is based on a scale of 0 to 5, where a rating of "0" is for very poor and "5" is good. The access change is then rating for the "after" condition minus the rating of the "before" condition.

In their original paper¹⁹, the authors put forward an approach to estimate 'post improvement traffic' assuming that the road condition was not a constraint on traffic levels based on different rural economic activities (for example based on marketed agricultural output and traffic generated by other activities). Although this refinement may help, the index should work well, to rank alternative projects, based purely on estimates of dry season traffic volumes.

Another cost effectiveness approach was adopted in the Ghana Feeder Road Prioritization procedure where two measures of benefits are used based on both traffic (for both motor vehicles and other users) as well as on the adjacent population. Seasonal accessibility was also identified as a major problem and to address these issues a combined index was developed (see Appendix 1).

¹⁹ The full paper may be obtained from Cardno IT Transport, The Old Power Station, Ardington, Wantage, Oxfordshire, OX12 8QJ, UK, email: ITTransport@cardno.uk.com.

Multi-Criteria Analysis (MCA)

In the form of multi-criteria analysis, ranking procedures may be used to combine economic, social, environmental and other considerations in the final choice of alternatives for major road investment. The procedure has been widely used in this way in Indonesia and other countries. For each characteristic, the different projects are assessed and put into rank order (e.g. 1st, 2nd, 3rd, etc.). This process is then repeated for the other characteristics. Weights are then assigned to each characteristic and an overall score is obtained. The process is demonstrated below in Table 5. In this table, to achieve the desired result, the ranking is presented in reverse order, i.e. the highest number rank refers to the best.

Table 5. Example of Multi-Criteria Analysis

| | Alternative 1 | | | Alternative 2 | | | Alternative 3 | | |
|--------------------------|---------------|--------|-------|---------------|--------|-------|---------------|--------|-------|
| | Rank | Weight | Score | Rank | Weight | score | Rank | weight | score |
| Economic evaluation | 3 | 50 | 150 | 1 | 50 | 50 | 2 | 50 | 100 |
| Environmental evaluation | 2 | 30 | 60 | 3 | 30 | 90 | 3 | 30 | 90 |
| Development | 3 | 10 | 30 | 2 | 10 | 20 | 1 | 10 | 10 |
| Public transport | 3 | 5 | 15 | 2 | 5 | 10 | 2 | 5 | 10 |
| Accessibility/ Severance | 1 | 5 | 5 | 2 | 5 | 10 | 3 | 5 | 15 |
| Overall score | - | - | 260 | - | - | 180 | - | - | 225 |

4.18 Working with Road Planning Models

This section discusses key issues when working with the road planning models, HDM-4, RED and RNET. The main purpose is to highlight how the models may be used for rural road planning, and identify particular strengths and possible weaknesses. Specific guidance on the operation of the model is provided on the websites where the models can be downloaded.

Highway Development and Management, HDM-4

The HDM-4 (World Bank, 2000) is the principal road-planning model used to evaluate major interurban road investments in most developing countries. The World Road Association (PIARC) is now responsible for the model²⁰.

The HDM-4 contains a wide range of modelled relationships relating to paved and unpaved road deterioration, the effects of a wide range of maintenance and road work activities, and vehicle operating costs for different vehicle types. According to the data input the model will predict, year-by-year, the state of a road surface, vehicle speeds, vehicle operating costs, vehicle pollution, and accident rates. It will also predict when different types of road works be triggered. The model undertakes an economic analysis based on the consumers surplus approach and standard decision criteria such as NPV and IRR. A wide range of alternative maintenance and investment treatments can be specified at the same time for a road project to find the best option.

HDM-4 is extremely versatile and can help design appropriate road surfaces, appraise individual projects, act as a maintenance or pavement management tool to analyze networks, predict network condition, identify future network budgets, and guide strategic planning. A wide range of reports are prepared covering traffic, road deterioration, works effects, road user effects (including VOC and accidents), environmental effects, cost streams and economic evaluation, together with results of the multi-criteria analysis. A similar process is undertaken under “Programmes” and “Strategies”. In these cases, budget optimization can also be specified.

HDM-4 contains as a main strength, a very wide range of technical choices that can be analyzed, and ranked according to rational economic criteria. Perhaps its most important drawback is that it is not freely available to potential users, it is expensive in both monetary cost terms and in time and effort to learn how it can be used. Another drawback is the considerable amount of data required to use the model. However, because the model comes with various examples, and a lot of default values, it is possible to explore various design options, and prioritize different investments and maintenance strategies, even if a full set of input data is not immediately available.

There remain a number of technical weaknesses to be addressed. Perhaps the most important one relates to the uncertainty associated with the key roughness and vehicle

²⁰ www.piarc.org/en/knowledge-base/road-assets-management/HDM-4-Software/

maintenance relationships. There is also an unresolved problem for HDM-4, particularly acute in Africa, relating to treatment of second-hand vehicles. HDM-4 relationships are based on conventional lifetime use of new vehicles, and new vehicle prices are required to be input into the model. However, most vehicles used in Africa are imported second-hand, which will tend to have lower capital depreciation and higher maintenance costs, higher fuel consumption, lower service availability, greater frequency and cost of breaking down on the road, than newer vehicles. To help overcome some of the uncertainty in the economic and engineering relationships, users are recommended to calibrate relationships as appropriate with locally collected data.

With regard to engineering relationships, HDM-4 is best for gravel roads. HDM-4 relationships do not work well when the surface is composed of unspecified material, which is by definition the case for earth roads, which do not have standard specifications for their materials. Likewise, HDM-4 principally models the effect of road surface on vehicle speed through changes in road roughness. Similarly, it is not easy to calculate the effects of traffic diversions that occur during the wet season, thus nor modal shift from head loading to motorized transport that may happen with investment, the tool is not particularly useful for dealing with the provision of ‘basic access’ on earth roads.

Roads Economic Decision Model (RED)

The Roads Economic Decision Model was developed by SSATP to assist with the appraisal of the investment and maintenance of low-volume roads (World Bank 2006c). The model is Excel-based and is designed to be relatively easy to use with fewer data input requirements compared with HDM-4. The model is freely available and can be downloaded from the SSATP website under ‘Tools and Toolkits’.

Like HDM-4, RED is based on the consumer’s surplus approach to calculate benefits. The model uses the VOC relationships of HDM-4 and can predict user benefits from specified changes in road roughness. It is particularly useful for low volume roads where seasonal passability issues are present. The user is able to specify different roughness values, road lengths, for wet and dry seasons, together with the length of the wet season, so it is easily able to cater for situations when vehicles need to seasonally divert to other routes. RED is also able to deal with uncertainty (a major issue for many rural road interventions) through a range of tools including risk analysis, sensitivity testing and automatically calculated switching values.

Perhaps the most challenging aspect of using RED is that, unlike HDM-4, it does not predict changes in road roughness, or other measures of road condition, from road deterioration relationships. For unpaved roads, roughness is critically dependent upon maintenance treatment; increased grading frequency can dramatically alter roughness levels. Where uncertainty is very high, as for example dealing with provision of basic access then there may be no option but to guess a suitable roughness level.

Road Network Evaluation Tools (RONET)

RONET was developed by the SSATP to help assess the performance of a country's road maintenance and rehabilitation policies. It assesses the current network condition and traffic, computes the asset value of the network and road network monitoring indicators. It can be used to assess the performance over time of the network under different road works standards and different budgets. The model can also be used to determine appropriate road user charges to support the maintenance of the network. RONET is freely available and can be downloaded from the SSATP website.

To undertake its analysis, RONET uses simplified road user cost relationships and road deterioration/road works effects relationships from HDM-4. However, the model is relatively user-friendly being Excel-based and requires a far lower volume of data input than HDM-4. RONET was used to provide an overall assessment of Sub-Saharan Africa's road maintenance, investment and funding requirements under the Africa Infrastructure Country Diagnostic (AICD) (Gwilliam et al, 2008).

Overall, RONET provides an extremely useful tool for managing network and allocating funds. A possible weakness of the approach may relate to the broad traffic categories used in the analysis. The default versions of the AADT run for example, from 30-100, 100-300, 300-1000, 1000-3000, 3,000-10,000. While it is unlikely that there would be a gross error in overall budgets, traffic volumes, fuel consumption, etc. it is possible though that a significant error might occur for these data within the individual road surface and traffic categories. Only a detailed investigation would show this up. Hence, it is recommended that the user checks the general reliability of classification used against actual traffic data, and if necessary amends the class intervals.

4.19 Planning Village-Based Infrastructure using the iRAP Tool

There are three main ways of improving accessibility to village-based facilities:

- ♦ Improving and increasing the availability of transport infrastructure

- ♦ Siting facilities more closely (proximity) to the household
- ♦ Introducing and improving transport services and the means of transport

Village-based transport infrastructure includes community roads and tracks, footpaths and walkways, small scale bridges (see Figure 13) and river jetties. Village based facilities might include water sources, woodlots, clinics / health centers, schools, markets, grinding mills, shops, post office, places of worship, sports ground, and community hall.

Figure 13. A Community Footbridge in Kenya



Paul Starkey

iRAP has been an important tool for planning and prioritizing rural infrastructure and siting facilities. It is also used to identify requirements for improving the means of transport. iRAP has been used at the village, district and regional level. However, in this section only its use at the village/district level is discussed. iRAP is designed to be a

simple and user-friendly tool that can be used by local planners and communities. iRAP procedure involves secondary and primary data collection, processing and analysis; preparation of accessibility profiles, indicators and maps; prioritization; data validation and defining targets and objectives, project identification; implementation and monitoring and evaluation (Donnges, 2003). Data is collected on: the general village characteristics; sources of livelihoods, agriculture and marketing; the existing transport system; location and availability and quality of services; travel times, frequencies, costs and modes; perceived problems and priorities. A variety of accessibility indicators will be used within iRAP. For example, for longer distance travel, transport fares may then be the most appropriate accessibility indicator. However, personal travel time from household to different facilities may be regarded as the core indicator for planning village-level infrastructure.

In the iRAP procedure weightings may be used (for example carrying a heavy load would be weighted differently from a journey not carrying a load) and a system of thresholds may be employed, to help ensure for instance that every household was

within a certain maximum travel time to a facility. Community consultations will be involved to decide on weightings and thresholds. From this, composite indicators can be built up and locations mapped to show which communities are in need of what facilities. Projects can then be identified to address the identified need.

In simple terms, the estimated reduction in total personal travel time may be regarded as key benefit of a proposed investment. Priorities may then be assessed in value-for-money terms, by comparing the forecast resulting change in travel time, say over a year, with the investment cost. So similar projects could be ranked by ratios of the change in travel time divided by the investment cost; and to efficiently use an available budget projects with the highest ratios would be chosen first in rank order until the budget is exhausted. Because different sectors will have different budget constraints, the marginal cut-off ratios will vary from sector to sector.

The use of travel time savings as a key indicator of benefit, works best when the investments being compared have similar characteristics, life cycles and maintenance and operating costs. When operating and maintenance costs become more important, for example for non-transport infrastructure such as schools or clinics then a way has to be found of bringing investment costs, maintenance and running costs to a common basis. Annualizing the investment costs is one solution, whereby priorities may be determined by the annual total travel time savings divided by the difference in annual investment and running costs. However, with larger and more complicated investments, a full cost-benefit analysis may be required. In this case, the appropriate values of travel time will need to be used.

Quality issues, particularly for non-transport interventions, will also need to be considered, when planning infrastructure. For example, water quality will vary from source to source. Similarly, education may be better provided in a larger school, where supervision is easier to arrange. A larger clinic may be staffed with higher quality professionals and will be more likely to have a consistent supply of drugs. Larger markets will attract more traders and are likely to provide a wider range of goods and better prices. There is also a case for developing the synergies between different sectors by centrally locating key facilities so that they may in turn be supplied more cheaply by electricity, piped water, roads and commercial transport services.

There is clearly a trade-off between quality and travel time (or quality and travel costs)—difficult to quantify and incorporate all issues into a simple numerical prioritization framework. Nevertheless, it should be possible to sensitize communities to the issues and help them adopt minimum size thresholds which will partially deal with the

problem. These issues will of course be brought up by the different sector representatives and sector ministries.

It has been estimated that survey costs for an iRAP village are around \$30-\$75 per village (Donnges, 2003). In Malawi, iRAP field surveys were carried out in Ntchisi District covering 254 Village Development Committees (VDCs) including 1,659 villages. The overall costs of the Ntchisi study was \$700,000 including consultants, iRAP and GIS surveys. The estimated roll-out costs to the remaining 25 other districts of Malawi is estimated to be \$250,000 per district, assuming a five year life would be \$50,000 per year, per district. (IT Transport Ltd in association with CCE Ltd, 2005).

A number of significant initiatives covering district and village level transport, using iRAP and other approaches, have been set up in different countries with initial support of donor organizations including the SSATP under its rural component. Examples from Malawi and Ethiopia are outlined in Appendix 2.

5. Introducing and Planning Transport Services

Transport Services have been called the “forgotten problem”. There is a persistent widespread assumption that investment in roads will spontaneously lead to the provision of transport services by the private sector (Porter, 2013). Yet as is shown in Chapter 2 for much of the rural population, road services are unavailable, infrequent, dangerous and expensive. Transport services in rural areas are overwhelmingly provided by the private sector, while the institutional capacity of the government to monitor, evaluate and intervene in the provision of rural transport services is very weak. What capacity there is tends to be directed towards urban and to a lesser extent interurban services.

5.1 Introducing Intermediate Means of Transport

The use of intermediate means of transport (IMT) in Africa has been growing, both in volume and in diversity over the past thirty years. The growth in motorcycles, in Tanzania from 2005 to 2010, which was at a compound rate of 60 percent per year, is such an example. Starkey (2001) lists other examples:

- ♦ Kenya imported fewer than 2,000 bicycles in 1985, but as many as 100,000 in 1989.
- ♦ In Mauritania, the number of donkey carts increased from zero to 75,000 in 30 years.
- ♦ Transport donkeys in Sahelian countries increased from one million in 1950 to 2.5 million in 1999.
- ♦ In Senegal, more than 150,000 animal drawn carts have been sold from one factory.

The growth of IMT has been overwhelmingly supplied by the private sector, with relatively little direct government involvement, although changes in taxation and import duties may also have played a part. Donor and government sponsored pro-

grams to introduce IMT have also been tried out, on small scale, in many African countries. However, most of these initiatives have not been successful in the longer term. A number of review papers relating to their adoption and IMT initiatives were carried out from 2001 to 2006 (Starkey, 2001; Porter, 2002; IT Transport Ltd, 2003; IT Transport Ltd, 2006). Their general findings suggested the following:

- ♦ Acceptance and growth in their use is not entirely predictable.
- ♦ Growth in their use tends to occur around existing established clusters of users. Hence, for a new initiative a minimum number of IMT concentrated in an area may be a better strategy for establishing long-term use, by providing a market for spare parts and repair facilities and gaining wider acceptability in their use.
- ♦ Cultural factors can be extremely important in determining the uptake of an IMT. In many countries, negative attitudes against women owning and using an IMT have prevented their use. Likewise, some are perceived to be low status, as for example bicycles in southern Ghana.
- ♦ Access to spare parts or repair and maintenance are very important for more complex ones such as power-tillers.
- ♦ Ability of an IMT to generate time and effort savings in carrying out household chores may not be enough to secure long-term viability. Being able to directly earn cash income from the IMT (for transport services, marketing or hiring it out) may be very important for long-term viability and to ensure that funds are available for maintenance when required.
- ♦ Ability to make good use of an IMT all year round, for passenger transport for instance, may be important in the long-term adoption of an IMT, rather than just being able to use it for moving goods during the harvest period.
- ♦ Availability of loans to secure IMT is also a key element. However, care must be taken to ensure that users have wide options as to which IMT may be purchased. Unsatisfactory results can arise if the loans are tied to particular IMT types.
- ♦ Men may be reluctant to lend out their IMT to their wife or children if they believe they will not be repaid should a repair be necessary.
- ♦ There is evidence that within rural areas of specific countries the richer sections of the population will adopt IMT at a faster rate than the poor

sections of the population. Larger farmers can use the IMT more intensively for marketing. Hence, care needs to be taken if IMT programmes are directed specifically towards the poorest groups.

- ♦ Quality of IMT being provided is important. Many IMT manufactured by local artisans have been of poor quality and have failed to take off because they have not given good service.
- ♦ Environmental and cultural factors are very important with the introduction of animal transport. Humid climates do not suit donkeys and camels. People must have basic understanding of animal health care.
- ♦ Despite the difficulties, programs to introduce animal traction (such as donkey carts), with suitable training have been amongst the most successful initiatives.
- ♦ Government regulations on use of IMT (such as bicycle, motorcycle, taxi or for hire operations) may limit its earning capacity and restrict its use.
- ♦ Roads, tracks or pathways must be suitable for IMT use. For example, bicycles are not suitable for sandy soils of Senegal.

Clearly, a wide range of issues need to be addressed when considering an IMT introduction program. Although there are no guarantees of success, the program is more than likely to fail if just one of the above issues is not satisfactory. The issues need to be researched and the program well-funded. Methods of possible promotion include setting up demonstration projects with training in use and animal care; repair facilities; ensuring that taxation levels on the import of key IMT (bicycles, motorcycles) are not a disincentive; and allowing new forms of IMT based services to be licensed for commercial hire.

5.2 Improving the Policy and Legal Framework of Services

Although there have been a few studies that have looked at the way rural transport services operate, very little has been published on the oversight, management and legal framework of transport services in Africa. In much of Africa, rural transport services are run from bus and lorry or trucks where vehicles queue, and customers are obliged to go to the first vehicle in the queue. By sharing out demand in this way, the operators have formed a cartel that tends to keep prices high, restricts utilization and keeps older vehicles in operation. The role of transport unions and associations that run the trucking terminals is discussed in Section 2.7.

In Ghana, the Ghana Private Road Transport Union (GPRTU), runs truck and bus terminals, and helps enforce transport tariffs and fares. In Tanzania, the Surface and Marine Transport Regulatory Authority (SUMATRA) regulates the frequency and fares of the larger buses operating in rural areas; however, there is much less control over the operations of smaller vehicles. Police enforcement of safety and licensing regulations, together with axle load control, is very common on major routes, but less common on lightly trafficked rural roads in Africa.

Wide differences in the pattern of motorcycle and bicycle taxis have been observed. In some countries such as Ghana for instance, motorcycle and bicycle taxi services are rare, while in other countries (Nigeria, Kenya, Uganda or Tanzania) they are very common. However, it appears that in Tanzania, the services are not legally allowed although there is no enforcement to prevent the operations.

In contrast with urban transport policies, rural transport policies in Africa appear to be relatively silent on services and tend to focus on the provision of infrastructure, planning the location of facilities close to the population, and the provision of IMT. However, concern over poor services and the operation of cartels (in this case for urban transport, but the same issues are also likely to apply to rural transport) is evident from the Kenya Transport White Paper (Republic of Kenya, Ministry of Transport and Communications, 2004).

There are no easy solutions to directly improving existing transport services. Powerful vested interests will resent changes they perceive as threatening. Working in rural areas is doubly difficult given the difficulty of monitoring operators away from the main towns and off main corridors. In order to address key issues, it is first necessary to undertake surveys to collect information on the nature of services that are currently provided. This will provide direct evidence of the case for intervention and which areas of the country are most in need. Furthermore, major new initiatives in rural transport services are likely to require changes in the legal and regulatory framework backed up and guided by a new articulation of (Rural) Transport Policy (see Section 2.1). This in turn will also require studies, discussions with stakeholders, possible pilot interventions and a great deal of consensus building. A possible scenario for moving forward might be as follows:

- ♦ Government and donors are requested to support a new approach and provide initial funding for studies, meetings and pilot interventions.
- ♦ Terms of reference are prepared and consultants recruited to collect local background information, undertake brief rural surveys, interview stake-

holders, identify possible pilot interventions, and map out a framework for moving forward.

- ♦ A senior public official is identified to act as a ‘Champion’ to see reforms through.
- ♦ A stakeholder workshop will then be held to review and refine the framework and make recommendations.
- ♦ Pilot interventions are carried out and monitored by consultants.
- ♦ Results of the pilot studies are reviewed at a stakeholder workshop, followed by a public meeting to review the findings of the workshop.
- ♦ A policy paper is prepared that can be presented to Cabinet and adopted as Government Policy.
- ♦ Changes in legislation are drafted, and presented to Cabinet and Parliament. Any associated changes in public budgets are implemented together with institutional changes in regulatory and service organizations.
- ♦ New policy is then adopted, implemented and monitored.

Before any new transport policy reform measure is considered, it would be useful to review how it might be implemented. A useful checklist is provided in the World Bank Transport Note, ‘Economic Appraisal of Regulatory Reform – Checklist of Issues’ TRN 24, 2005.

5.3 Possible Transport Service Solutions

A number of possible transport service solutions are outlined below. Some solutions may be covered by existing legislation while for others new legislation may be required. In each case, it will be necessary to decide how the changes will be implemented and which bodies will be responsible for monitoring and enforcement. Maybe a new regulatory authority will be the best option (as for example SUMATRA in Tanzania). Obviously, where new resources are required it will be necessary to identify sources of funding.

Operator, Vehicle and Driver Licensing

In most countries, vehicles and drivers are tested and licensed so that they are safe to operate commercial services. Increasingly, commercial operator licensing has

been introduced to ensure that vehicles are properly managed in a safe way; a technically qualified manager is specified as being responsible. However, for many countries it may be too expensive and not practical to insist that a properly qualified manager looks after small buses and trucks on short distance rural operations. The approach should be adopted for high capacity long distance buses and trucks where the dangers of speeding and accidents are considerable.

Controlling Routes and Fares

Route licensing. This helps restrict the number of operators on a route. It is used for bus operations, with a requirement that a certain service frequency is achieved.

Fare control. This helps prevent operators from overcharging fares.

Encouraging Competition through Rival Associations

The example from Northern Cameroon (see Section 2.7) shows how the local mayor tackled the transport associations directly and got them to provide a higher quality service at a lower price. In this case, rival associations were set up so that an element of competition was involved. A key issue is controlling the number of vehicles as this is often a major force promoting high fares if there is oversupply of vehicles for a limited demand. Competition by rival associations may be set up through competition by different forms of operator i.e. large buses, minibuses, motorcycle taxis, pickup trucks, trucks, power tiller transport, etc. Each type of vehicle might be assigned its own terminal in the urban center and be operated by a different association.

A Public-Private Partnership (PPP) Bidding for the Market

In most high-income countries, rural passenger transport is subsidized to ensure that minimum service frequencies are achieved and fares set at a reasonable level. This is mostly achieved through a PPP setting with operators ‘bidding for the market’ whereby different operators put in a competitive bid to be subsidized by a certain amount, assuming a given service frequency and fare levels. The operator that demands the least amount of subsidy is given the exclusive right to operate on the route. The arrangements can vary, sometimes the operator collects and keeps the fares, in other arrangements fare revenues go back to the government agency. To estimate the amount of subsidy required to sustain a transport service, Rabal-land et al. (2011) undertook surveys of both bus operators and passengers in rural Malawi to determine how much the local population were willing to pay.

State-Owned Services

Although national bus companies still operate in many countries, the approach diminished with the worldwide move to commercialization in the 1980s and 1990s. It was felt that States could not operate efficient services and private operators would do better. Although there have been many benefits from commercialization, it has had some serious adverse effects on some rural routes, in Zambia for example, where services were permanently discontinued without private operators filling the gap. At the last resort, it is an option where nothing else will work, although there may be subsidy involved, which will have to be looked at carefully.

Village-Owned Vehicle

One solution would be a cooperatively run and operated vehicle by, prominent members of a village, the village council, or a local religious group. The approach has been adopted from time to time (Millennium Village Initiative) but very little information is available. There is anecdotal evidence of failure (i.e. people in the village run it for their own personal gain or disappear with the assets) and some evidence of success (the Sri Lanka Community Bus Project set up with the help of the local IFRTD in 1997). Some initial external finance was available but the bus generated an income, which kept it going and a replacement bus was purchased, by the funds generated, in 2008. An evaluation of the project was carried out by the Centre for Poverty Analysis, (2009).

Monitoring Prices of New Vehicles and Spare Parts

Major differences have been found between countries in the prices of new vehicles and spare parts. Prices in Africa tend to be extremely high (often in the range of two to three times) compared with those found in Europe and Asia, for virtually identical new vehicles and parts. Because of the high prices for new vehicles, second-hand vehicles tend to be imported which can be very unreliable. It is suggested that governments maintain a database of prices and components to monitor what is happening in the sector. The information may be used to challenge dealers, identify restrictive practices and set taxation policy.

Promotion of Transport Services for Maternal Health and Emergencies

A number of initiatives have been developed to help expectant mothers get to hospital, and more widely assist with medical emergencies. These include provision of specialized motor vehicles and IMT to act as ambulances. There have also been training and vehicle maintenance programs for medical staff. In Northern Nigeria

a program working with the National Union of Road Transport workers has also had a great deal of success in helping to get women in labor to hospital using taxis. (Adamu, et al., 2012).

A study undertaken in Uganda showed a 62 percent improvement in health service access with the bicycle ambulance ("Appropriate Mobility for Improved Access to Health Care Services in Rural Communities. A Case Study of the Bicycle Ambulance Project" Kayemba, Patrick G. and the FABIO Team.) The study shows that women were the greatest users of this concept although Uganda is a male dominated society and women's opinions did not count for as much. Officials did not either put the word out about the availability of this service. The usage rate could have been even higher if there had been a public education program in place to let people know about the bicycle ambulance program. Public education is a critical component that must be part of any program for people to get the maximum benefit from it. Still, the bicycle ambulance program in Uganda has been successful in saving many lives and has provided a faster means of transport to move those who cannot walk and who can't afford motorized transport.

5.4 A Framework for Prioritizing Service Interventions

There is currently very little advice available to help prioritize service interventions. This is clearly a problematic area, as there are no ready-made solutions.

The main focus of the framework proposed in the following section is to assist with planning transport service interventions, although the approach can also conceivably be used to plan transport investments or prioritize between types of measures. The outlined approach is based on a simplified version of cost-benefit analysis whereby the user tries to quantify the likely benefits in monetary terms, compared then with the estimated intervention costs. Although monetary values are used to assess the benefits and costs, the approach should not be thought of as a robust economic analysis—it is more an aid to decision-making to help identify the strengths and weaknesses of interventions and compare them.

The Framework Components

With the framework procedure, a wide range of information needs to be collected. Much of it may be very uncertain and best 'guesstimates' are likely to be required. A range of data is to be collected, particularly involving costs and estimates of monetary values of benefits along with estimates of the strength of support of different

measures and the likelihood of their success. It is suggested that Delphi method be employed to obtain some of the data (See Chapter 3).

The proposed information to collect is as follows:

- ♦ Name and type of intervention
- ♦ Geographic area covered
- ♦ Target beneficiary population
- ♦ Current incidence of use of service or facility
- ♦ Expected growth in use per year
- ♦ Expected increase in use as a direct result of proposed intervention
- ♦ Maximum realistic monetary benefit, or cost reduction, per event or trip
- ♦ Strength of political support to initiate intervention
- ♦ Strength of administrative budgetary and funding support
- ♦ Strength of support by target beneficiary population
- ♦ Strength of support by current service providers
- ♦ Strength of support by regulators
- ♦ Likelihood of strong adverse reaction by key players
- ♦ Probability of implementing intervention within five years
- ♦ Evidence of success of similar interventions elsewhere
- ♦ Expected percentage realization of estimated maximum benefits
- ♦ Initial cost of implementing intervention
- ♦ Annual running costs of intervention
- ♦ Anticipated lifetime of intervention for planning purposes

Name and type of intervention: This is obviously required for future reference and to distinguish between interventions.

Geographic area covered: Interventions can differ enormously in scale depending on the targeted geographic area covered. They may be for a village, a road, a local district, a region or for a whole country.

Target beneficiary population: To estimate total benefits of service interventions it is required to identify the direct population that will benefit from the intervention. It may be appropriate to record total population in the area or just the specific users of the service.

Current incidence of use of service or facility: This is calculated in relation to the chosen beneficiary population. It may be calculated per event or per trip, by individual members of target population per year. For a service or facility that is to be improved then the incidence relates to the existing use of that service or facility. If a new service or facility is to be introduced then incidence of use of the nearest alternative should be recorded.

Expected (normal) growth per year: This relates to the expected growth in use for an existing unimproved service or facility. Annual population growth or annual traffic growth might be appropriate metrics.

Expected increase in use as direct result of the intervention: An increase in use as a result of the proposed intervention is in addition to the expected normal growth given above. It is the same as ‘generated traffic’ in road project appraisal.

Maximum realistic monetary benefit, or cost reduction, per event or per trip: This estimate of benefit directly relates to the measure of incidence of use given above. There are different ways of estimating the monetary benefit. One approach is via a calculated change in transport fares and costs to the user as a result of the intervention. This is, of course, similar to the transport cost savings benefits that is used in road appraisal. However forecasting cost changes will not work, as estimate of benefit, for many transport service interventions. For example major components of the benefits may be social or from controlled fares, via some form of new competition or regulatory control. In these cases, it may be better to estimate the benefit by Delphi techniques using a focus group. The estimate of benefits is specified as a realistic maximum, further information will be used to estimate what proportion of the maximum benefit will actually be achieved.

There are a variety of methods for directly estimating transport cost savings. The approach adopted will depend on the nature of the intervention and the information available. For interventions at the village-level, the iRAP approach that focuses on personal time savings, multiplied by the value of time may be the best to use. If IMT interventions are planned then it will be necessary to compare the value of current travel time, not using the IMT, with the cost of using the IMT,

together with the operators' time. In this case, either current hire costs of the IMT might be employed or its costs may be calculated from the purchase price together with an assumed utilization rate, interest charges, vehicle lifetime and maintenance and running costs. If new patterns of vehicle operation are planned then evidence may be collected from elsewhere to estimate the extent to which fares may be reduced. Obviously, evidence of transport price changes from similar interventions in similar circumstances will carry the most weight. In any event, it will be essential to collect existing fares and freight tariffs. It will also be useful to carry out a full financial analysis of operating costs, including hire charges (or depreciation and interest costs), running and maintenance costs, together with realistic utilization rates to see whether the predicted fare levels are plausible.

If the nature of the intervention is more social in character then a Delphi technique should be employed, whereby a panel is asked to provide an estimate of the monetary value of the benefit resulting from the intervention. For this, it will be essential to prepare a package of information for the panel that they can refer to. This should include information on the current travel patterns and fares, and levels of income and expenditure, as well as information on the proposed intervention and past records of successes and failures. It might be best if the panel is composed of both technical experts as well as representatives of the local community.

Strength of support (or adverse reaction) by different stakeholders: In order to estimate the likelihood of success for different interventions, it is important to gauge what support there is among different stakeholders. Measures of support may be best expressed as a percentage, with 100 percent being maximum support and 0 percent representing no support. The likelihood of adverse reaction would be the reverse with 100 percent representing very strongly against the proposal. It is not usually necessary to consider the support for most rural transport infrastructure because it usually has very substantial support from virtually all stakeholders. However, the situation may be more complicated with transport services. New institutional arrangements and new legislation may be required, which may be problematical with a challenge from vested interests. Clearly, the support for interventions will vary according to what initial groundwork is carried out beforehand to elicit support and to allay fears.

The following stakeholder support and reactions are identified:

- ♦ Strength of political support to initiate intervention
- ♦ Strength of administrative budgetary and funding support for intervention

- ♦ Strength of support by target beneficiary population
- ♦ Strength of support by current service providers
- ♦ Strength of support by regulators
- ♦ Likelihood of strong adverse reaction by key players

This list is not fixed and other stakeholders (police, local government, road authorities) may be identified. If it is not practical to interview or survey different stakeholders then Delphi techniques may be employed to gauge likely support.

Probability of implementing intervention within five years: From an assessment of the stakeholder and budgetary support, an estimate may be made of the likelihood of being able to make the intervention within a reasonable timeframe.

Evidence of success of similar interventions elsewhere: Available evidence of success and failure for different interventions should be supplemented by further information searches.

Expected percentage realization of estimated maximum benefits: From a judgment based on an assessment of evidence of similar interventions elsewhere together with evidence of stakeholder support, an estimate of the expected percentage realization of estimated maximum benefits may be made. Again, Delphi techniques may be employed to review the evidence and make the assessment.

Initial costs of implementing intervention: The costs of implementing an intervention are essential for planning and getting value for money. The costs of providing road infrastructure are well known; however, the costs of implementing new services are less understood. Section 5.1 outlines a number of steps that might be required to implement new transport service interventions. This may include considerable consultation, and legislative changes. However, from an opportunity cost point of view only future costs should be included in an analysis. The costs of earlier work can be regarded as ‘sunk costs’ and may be ignored. Therefore, when a key decision has to be made for moving forward, which may be a choice between different interventions, then the total future costs of the different scenarios need to be calculated. These costs should include future administrative staff time, the costs of preparing legislation, the costs of consultation together with the costs of further surveys, and the costs of any additional pilot studies.

Annual running costs of intervention: The running and maintenance costs of any intervention need to be factored into decision-making. For the purposes of any analysis what is wanted is the net difference in running and maintenance costs between the current situation (the non-intervention case) and the intervention case. So for some interventions where running and maintenance costs are very similar between the intervention and non-intervention cases these costs may be ignored. Similarly if the estimate of net benefits already takes into account reduced running costs, as for example in an estimate of the benefits of IMT or new transport services, then it will be unnecessary to factor them in again. However, where a major change in the regulation of services are planned then the additional costs of ongoing regulation should be included.

Growth in running costs: It may be necessary to accommodate the growth in running costs over the lifetime of a project.

Anticipated lifetime of intervention for planning purposes: In any comparison of costs and benefits, it is necessary to consider the lifetime of the intervention. The average lifetime of motorized vehicles, in normal use, is around ten to fifteen years, although modern vehicles may now last much longer. Of course, individual vehicles can last much longer. The effects of policy changes can last many generations although they can also become dated as the nature of institutions and economic activity changes. So a maximum lifespan of say 20 years is recommended. A cost-benefit analysis usually involves discounting hence increasing planning time horizons beyond 20 years may have little impact on the analysis. It is recommended that discounting is applied for this framework analysis.

Framework Analysis

In order to estimate how worthwhile any intervention will be or to compare different interventions it is suggested that forecast year-by-year stream of costs and benefits are incorporated into a spreadsheet format and the Net Present Value, IRR and NPV/C calculated.

The overall estimated benefits per year will need to be calculated in a number of steps. It is first necessary to calculate the maximum benefits per year for the target population. This is split between normal traffic and generated traffic, as in a conventional road project appraisal.

Maximum normal benefits per year, in any given year, for target population is equal to:

(Target beneficiary population) x (Incidence of use per year) x (Maximum realistic benefit per incidence of use) x (traffic growth factor for year in question)

Maximum generated traffic benefits per year, in any given year, for target population is equal to:

(Target beneficiary population) x (Incidence of use per year) x (Maximum realistic benefit per incidence of use) x (Traffic growth factor for year in question) x (Expected percentage increase in use as a result of the intervention) x 0.5

The 0.5 factor is as for the standard treatment of generated traffic in a normal road appraisal.

The **total maximum benefits per year** (for any given year) is then the sum of:

(Maximum normal benefits) + (Maximum generated traffic benefits)

To estimate the **Total expected benefits per year** this is calculated by:

(Total maximum benefits per year) x (Expected percentage realization of maximum benefits)

There is no precise formula for the **Expected percentage realization of benefits**. It is necessary to make a judgment looking at the strength of support, the evidence of success elsewhere and the probability of implementing the intervention. Again, Delphi techniques may be employed.

To calculate a Net Present Value or Internal Rate of Return from each intervention the Total expected benefits per year should be entered into a spreadsheet, for the planning time horizon of the project, along with the estimated Initial costs and Annual running costs of the intervention. For the NPV the costs and benefits may be discounted at the country's planning discount rate. Section 7.6 outlines the procedures for calculating different decision criteria such as NPVs, IRRs, NPV/C and how they may be interpreted.

Of course it is important to remember that the analysis may only represent a general guide to how worthwhile the different interventions are. The emphasis of the analysis is to see the project's benefits from a social/ economic perspective. A separate financial analysis may also be required, to see whether the service will be self-sustaining or whether subsidies will be necessary. Obviously, the data used have to

be expressed in economic price terms to ensure that the analysis represents a conventional economic analysis.

Examples of the use of the Prioritization Framework. Three hypothetical examples showing the use of the framework are outlined below. These relate to setting up an IMT initiative, encouraging competition between transport service operations, and providing emergency ambulances.

An IMT Initiative

In this example, it is proposed to provide 1,000 IMT to 1,000 families. The IMT are estimated to cost \$150 each giving a total of \$150,000. The costs of initial administration and setting up repair facilities are estimated to cost another \$50,000. Overall running costs of the IMT, together with repairs and ongoing administration is estimated to be \$15,000 per year. This is anticipated to grow at 5 percent per year. It is anticipated that each IMT will be used 200 times per year and that the estimated maximum benefit for an average trip (assuming all goes to plan), calculated on the basis of savings in time in effort, is \$0.6 per trip. The expected growth rate in use is 3 percent per year and expected overall increase in activity (i.e. generated traffic) is 20 percent. The anticipated lifetime of the project is 10 years. The project is planned to be set up in one year with full benefits occurring in the next year. The support from different stakeholders is identified in Table 6. Implementation probability is set at 70 percent, and evidence of previous success was estimated to be 60 percent. An overall judgment is made that realization of maximum benefits will be 40 percent giving overall realistic net benefits of \$37,800 in the first year. (i.e. normal maximum benefits of \$120,000, and generated max benefits, \$12,000; both multiplied by 40 percent less running costs of \$ 15,000).

Table 6 provides key project information together with the calculated NPV, IRR and NPC/C results. In this example no information on financing of the IMT are included. If loans are provided to pay for the IMT then a separate financial analysis would be required.

Table 6. IMT Project Example Data

| | |
|-------------------------------------|--------------------|
| Population to Benefit | 1000 families |
| Use (of IMT) per year per family | 200 times per year |
| Annual growth in use per year | 3% growth |
| Induced increase in activity by IMT | 20% |
| Maximum benefit per trip | \$0.6 |
| Political support | 90% |
| Administrative support | 50% |
| Population support | 80% |
| Regulatory support | 50% |
| Adverse reaction | 10% |
| Implementation probability | 70% |
| Evidence of past success | 60% |
| Realization of maximum benefits | 40% |
| Initial costs | \$200,000 |
| Initial running cost | \$15,000 |
| Growth in running costs | 5% per year |
| Anticipated project lifetime | 10 years |
| NPV @ 12% | \$39,542 |
| IRR | 16.7% |
| NPV/C | 0.2 |

Encouraging Competition between Transport Service Organizations

In this example, it is planned to encourage competition between transport services, and help reduce fares, through getting existing operators to operate from rival transport service organizations. The earlier reported example of Ngoundere District in Northern Cameroon may be used as a model. It is proposed that a region of a million people will benefit from the change, which will involve the setting up of 20 transport terminals. The operators will continue to use their own vehicles; however, some compensation will be paid to those operators who wish to leave the business. This will reduce the oversupply of vehicles and help reduce monopolistic practices. The remaining operators should achieve greater utilization of their vehicles and hence lower costs.

Table 7. Competition in Transport Services Project

| | |
|----------------------------------|-------------------|
| Population to Benefit | 1,000,000 people |
| Service use per person, per year | 10 times per year |
| Annual growth in use per year | 4% growth |
| Induced increase service use | 10% |
| Maximum benefit per trip | \$0.5 |
| Political support | 80% |
| Administrative support | 50% |
| Population support | 90% |
| Service provider support | 10% |
| Regulatory support | 60% |
| Adverse reaction | 40% |
| Implementation probability | 50% |
| Evidence of past success | 40% |
| Realization of maximum benefits | 25% |
| Initial costs | \$2,500,000 |
| Initial running cost | \$250,000 |
| Anticipated project lifetime | 15 years |
| NPV @ 12% | \$6,076,301 |
| IRR | 47% |
| NPV/C | 2.43 |

The expected incidence of use will be 10 trips per person per year. Expected annual growth is 4 percent per year, the expected induced increase in demand for services will be 10 percent as a result, of the changes. The maximum benefit per trip is estimated to be \$ 0.5, based on the anticipated reduction in fares. The support of different stakeholders is identified in Table 7. The implementation probability is set at 50 percent and evidence of past success is set at 40 percent. Based on judgment the overall estimate of realization of maximum benefits is set at 25 percent. The initial costs of the project are \$ 2,500,000 to cover the costs of consultation, additional transport terminals and pay compensation. The annual running costs are estimated to be \$250,000 to pay for increased regulation. The anticipated lifetime of the project is 15 years.

In this example, the first full year of net benefits is calculated to be \$1,062,500.

Setting up Emergency Transport

In this example, an emergency transport service is to be set up for one million people. The service costs \$ 250,000 to set up for some 50 motorcycle ambulances.

The running cost is \$50,000 per year, but estimated to grow at 5 percent per year. The estimated use is 0.005, i.e. a half of one percent per year per person. Annual growth in use will be 3 percent per year. The maximum average benefit per trip is set at \$100 per trip. This value is decided by a focus group considering the availability and quality of service of alternative methods. It is high, because of the potential of saving lives. The implementation probability is set at 80 percent and evidence of success is estimated to be 80 percent. The support for the service is indicated in Table 8. The overall judgment of realizing the maximum benefits is set at 80 percent. The anticipated lifetime of the project is 10 years.

Note: With national and district data it may be possible to calculate, for an area, the expected number of maternal, and other, emergencies that are likely to arise per year, and further estimate the proportion of deaths that could be reduced by improved transport.

In this example, the first year of net benefits is \$350,000.

Table 8. Setting Up an Emergency Transport Service

| | |
|---------------------------------|----------------------|
| Population to Benefit | 1,000,000 people |
| Use per person, per year | 0.005 times per year |
| Annual growth in use per year | 3% growth |
| Induced increase service use | 0 |
| Maximum benefit per trip | \$100 |
| Political support | 95% |
| Administrative support | 70% |
| Population support | 95% |
| Service provider support | 80% |
| Regulatory support | 70% |
| Adverse reaction | 0% |
| Implementation probability | 80% |
| Evidence of past success | 80% |
| Realization of maximum benefits | 80% |
| Initial costs | \$250,000 |
| Initial running cost | \$50,000 |
| Growth in running costs | 5% per year |
| Anticipated project lifetime | 10 years |
| NPV @ 12% | \$1,841,754 |
| IRR | 143% |
| NPV/C | 7.37 |

Observations on the three examples

Clearly, the emergency transport has the highest IRR and NPV/C ratio. This is because of the very high valuation per trip (\$100) and the high realization of benefits (80%) because of the very substantial support for the operation.

The transport services project also has a relatively high IRR and NPC/C ratio despite the low valuation of realization of maximum benefits (25%). This is because the overall investment per trip is relatively low, at around one quarter of that of the IMT project, for the first year.

6. Methods for Planning and Prioritization of Infrastructure & Services

6.1 The State of Rural Transport in Sub-Saharan Africa in a Nutshell

Rural transport comprises a range of interrelated activities from the collection of water and firewood, travel to farms, agricultural transport and marketing, travel to school, health centers and hospitals, markets, shops and work, trips to friends and relations as well as the provision of means of transport and the provision of infrastructure. Although the data are far from being comprehensive, it is clear that Africa is at a major disadvantage compared with Asia in terms of availability of IMT and transport services, efficiency of agricultural transport and marketing, and transport costs. There is clearly scope for major improvements.

Rural road investment has so far dominated government and donor supported rural transport interventions. Despite its importance, rural road planning is poorly carried out, with little analysis of choice or alternatives, based on very limited data. It is also worth noting that road investment may promote growth and raise incomes of the better off. However, until village-level transport and rural transport services are dramatically improved, rural transport in Sub-Saharan Africa will remain a drag on the rest of the rural economy and prevent much of the rural populations from achieving their full potential.

Rural transport in Africa is not static. Over the last twenty years, there has been a major increase in the availability of improved domestic water supply which has obviously reduced the daily household drudgery of collecting water. Secondly, there has been a gradual improvement in availability of bicycles and some other types of IMT. Over the last ten years, there has also been an almost explosive growth in the availability of motorcycles, although their numbers per head of population are still very low. With the recent spread of mobile phone, new forms of door-to-door transport services have become available to the better off sections of the population. Likewise, with the advent of road funds, there have been real im-

provements in the maintenance of parts of the rural road network. Yet, perhaps the majority of rural roads and tracks receive no systematic maintenance and, many isolated areas do not have access to any forms of transport service.

6.2 A Framework for Planning and Prioritization

Fundamental to all rural transport planning is the need for adequate data and properly trained staff. However, too often both of these are lacking, particularly at the district level. In this case, extra resources need to be found to collect traffic and other data as well as provide training for planning and engineering staff in the techniques of transport planning. It is essential that they be able to identify realistic alternatives and subject them to analysis to determine the best options. It is only when this has been achieved that proper planning processes can be undertaken for both locally funded and donor funded programs.

This paper has outlined a range of measures and procedures to help plan and prioritize rural transport infrastructure and services. These include Cost Effectiveness and Ranking Criteria, Integrated Rural Accessibility Planning (IRAP), HDM-4, and the Road Economic Decision model (RED). A new planning procedure, the *Rural Transport Services Prioritization Framework*, is introduced primarily to assist with planning Transport Service Initiatives. It has been pointed out that there are strengths and weaknesses in all approaches, and that there is no one solution or approach that will be ideal in all circumstances.

For rural road planning, the most important objective is to achieve basic vehicle access. This has important economic and social benefits. A spot improvement approach, whereby the main objective is to achieve all season access is likely to provide the best value for money where traffic volumes are low. However, a transport cost-benefit analysis approach is unlikely to work well due to the difficulties of assessing the social and long-term developmental benefits of establishing basic vehicle access. So where communities are completely cut off, or all season access is not provided, then road investments may be prioritized by a form of a cost-effectiveness criterion that takes into account adjacent population and traffic. It is important that the initial local screening, within a district, involves strong community participation. The Airey and Taylor (1999) approach or the Ghana Feeder Road Prioritization approach are useful examples of prioritization methods.

Once all year round access has been achieved then, road investment priorities for improving earth and gravel roads with low traffic volumes (under 200 AADT) can be envisaged via a transport cost savings approach. The RED road appraisal model is well suited for this purpose. If a detailed assessment of road maintenance policies is required, higher traffic volumes are to be examined, or paved road solutions are to be investigated then, the HDM-4 model is better suited because of its capacity to examine road deterioration, alternative structural designs and wide road works effects. For both approaches, an initial screening may be undertaken that identifies traffic volumes and current road condition. Once the RED or HDM-4 analysis has been undertaken the final choice of links to be improved, for the funds available, should be based on the NPV/C ranking. If there are very significant environmental, social or other issues that differentially affect the identified choices (particularly when these issues have not been taken into account through mitigation measures) then a multi-criteria analysis may be used to assess the final choice.

If a program is designed to meet a specific wider objective, such as reducing poverty, promote an agricultural target or deal with the consequences of natural disasters or conflicts, then it is best to initially choose regions or districts for investigation that best meet these criteria. Once the selection has been made, then more conventional transport planning criteria can be taken into account.

Village based infrastructure, such as pedestrian footpaths, trails, bridges, as well as non- transport infrastructure (schools, well clinics etc.) should be planned using the Integrated Rural Accessibility Planning (iRAP) approach. Here the key measure of access benefits is likely to be the expected personal travel time saving. Similar projects may be ranked and selected by the expected time savings divided by costs. The iRAP approach has a number of drawbacks and it is essential that significant community participation is involved in establishing priorities.

For transport service solutions, it is suggested that the Framework for Prioritizing Rural Transport Service Interventions, as outlined in Section 5.4, is used. This should be accompanied, where appropriate, with a financial analysis of costs and revenues to users. State sponsored transport service initiatives are likely to involve a very high degree of uncertainty, not easily amenable to conventional analysis. Hence, it is suggested that a range of experts and local stakeholders are involved, using Delphi techniques, to assess the key benefits and viability of proposed measures. Table 9 summarizes the suitability of different planning processes.

Table 9. Suitability of Different Planning Processes for Different Interventions

| <i>Rural Transport Prioritization Framework</i> | <i>iRAP</i> | <i>HDM-4</i> | <i>RED</i> | <i>RONET</i> | <i>Producers’ surplus</i> | <i>Cost effectiveness, Ranking and MCA</i> |
|---|-------------|--------------|------------|------------------|-------------------------------|--|
| 1. Policy Initiatives | | | | | | |
| Possible | No | No | No | No | No | Possible |
| 2. Village Infrastructure | | | | | | |
| Possible | Yes | No | No | No | No | Possible |
| 3. Intermediate means of Transport | | | | | | |
| Yes | Yes | No | No | No | No | Possible |
| 4. Transport Services | | | | | | |
| Yes | Possible | No | No | No | No | Possible |
| 5. Road Investment without Closure | | | | | | |
| Possible | No | Yes | Yes | Yes for networks | Possible | Yes |
| 6. Road Investment with Closure | | | | | | |
| Possible | No | Possible | Possible | No | No | Possible |
| 7. Road Maintenance | | | | | | |
| No | No | Yes | Possible | Yes for networks | No | No |

6.3 The Need for Further Research

There is a clear need for new research to provide an up-to-date picture of transport conditions in countries to help inform policy. There is also an important need for further background research on the relationship between rural transport and social access and mobility, health, education, agriculture and marketing. Much more needs to be known about the operation of rural transport services.

While road planning is a relatively mature activity, there are many weaknesses and some opportunities that need to be addressed including:

- ♦ Planning the provision of basic access for very low traffic roads, including the prediction of modal split following interventions
- ♦ Planning the incorporation of social benefits

- ♦ The prediction of vehicle maintenance costs, and vehicle service availability (particularly for second-hand vehicles) following interventions
- ♦ Identifying the overall impact of rural road investment including estimating benefits that go beyond transport cost savings (i.e. 'wider benefits') and dealing with the issue of 'reverse causality'
- ♦ The advent GIS mapping provides a unique opportunity to plan road interventions much more precisely and that are aligned to the needs of the rural population and coordinated with other interventions.

In contrast, the planning of rural transport services, and to a lesser extent village level infrastructure, is very much at its infancy. These activities have been left, by default, to the local community and the market to deal with. There is a need to find effective ways of working with and strengthening local communities and local institutions and markets, to improve performance. Pilot projects are urgently needed to help identify how best to implement new transport service interventions. Previous initiatives have generated a great deal of knowledge about the factors that are likely help or hinder the introduction of new IMT. Further work can be built on this research.

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Appendices

Appendix 1. Examples of Road Planning Procedures

The following examples have been selected to show, in broad terms, how road planning procedures in different countries have attempted to meet economic and social objectives through various methods.

Planning Rural Roads in India, the PMGSY²¹ Approach

The Pradhan Mantri Gram Sadak Yojana (PMGSY) is a nationwide plan to provide all weather access to the rural population of India. The plan is centrally funded and was established in 2000. The 2005 version envisaged all habitations with population above 1,000 (500 in case of hill, NE States, deserts and tribal areas) to be connected by 2009-2010. The thresholds are progressive reduced so that habitations above 500 (250 in case of hill, NE states, deserts and tribal areas) will be connected by 2014-15 and all habitations above 250 will be connected by 2021-22.

The PMGSY planning approach is very much based on achieving physical targets rather than on meeting specified economic, cost-effectiveness or other criteria. The first priority is to achieve connection to the road network, improving its quality is a secondary consideration. The Ministry of Rural Development has set up the National Rural Roads Development Agency (NRRDA) to provide operational and management support, including design specification and cost norms, scrutiny of project proposals, quality monitoring, online monitoring of progress, R&D etc. In order for a District to have road investment included in the PMGSY a number of different steps need to be taken. Broadly, they are as follows:

1. Every State in India identifies an Executing Agency for execution of the Program. The Executing Agency then sets up a Program Implementation Unit (PIU) in each District, headed by a Superintending or Executive Engineer of the Public Works Department or Rural Engineering Service. The preparation of plans is the responsibility of the PIU who must ensure that

²¹ Pradhan Mantri Gram Sadak Yojana

approval is given by the District council (District Panchayat) and that the views of members of Parliament are also taken into account.

2. A District Rural Roads Plan (DRRP or District Master Plan) is prepared. The DRRP is prepared first at sub-district (or Block) level and then integrated into the District Plan. Sub-District plans are prepared by:
 - ♦ Constituting a team to carry out the work.
 - ♦ Preparing a database by collecting maps, road inventory, condition & census data. Pavement condition data is entered into an online management & monitoring system (OMMS) involving GIS coordinates.
 - ♦ Preparing detailed maps showing the road network, habitation centers and key facilities. All settlements of at least 100 people, which are more than 500 meters from each other are identified on the map. However, only settlements with more than 250 or 500 people are eligible for connection under the PMGSY.
 - ♦ Preparing two lists of settlements that are either unconnected or just connected by a fair weather road. From this, road links are selected that connect the unconnected settlements with all-weather roads. The most efficient and economic link should be chosen that connects up to key facilities such as markets, health, education and administrative centers.
 - ♦ Consultation, scrutiny and approval of the plans by sub-district and district authorities. The sub-district plans are then incorporated into the DRRP.
3. Having established a DRRP a *core network* is identified that provides a single all weather roads connecting to each eligible settlement. The purpose is to avoid unnecessary duplicate links. If a settlement is less than 500 meters from a road, it is deemed to be already connected and not eligible under the PMGSY. Each road link is identified by a code.
4. To be part of the PMGSY, a priority must be established for each link. First of all, a *comprehensive new connectivity priority list* must be established. The methodology adopted for prioritization must be uniform throughout the State. Priorities are based on the population size being connected. Annual proposals are made and agreed by the District Panchayats. If no new road

connectivities remain to be taken up then the selection of roads for improvement may be submitted. The priority list will be based on:

- ♦ **Priority 1.** Through-routes that are water bound macadam roads.
 - ♦ **Priority 2.** Fair weather through-routes that are gravel, or through-routes with missing links or lacking cross drainage.
 - ♦ **Priority 3.** Other through-routes that are at the end of their design life where the pavement condition is poor or very poor (Pavement Condition Index (PCI) is 2 or less). Pavement Condition Surveys will provide PCI on a scale of 1 to 5.
 - ♦ Within each priority class qualifying roads will be listed in terms of population served as an indication of traffic. However, States are expected to conduct traffic surveys to determine Average Daily Traffic.
5. The priority lists will need to be approved by the District Panchayats. The lists must also be sent to the Members of Parliament for their views and suggestions.
 6. The Program implementation unit (PIU) will finally enter the core network priorities into the online management & monitoring system (OMMS).
 7. The PIU will hold consultations with the local community to determine the most suitable alignment, sort out issues of land availability and deal with any adverse social and environmental impact. A 'transect walk' will be arranged for this purpose and digital photographs taken and attached to the submission.
 8. The choice of design surface will be determined by factors such as traffic, soil type, rainfall, following specifications laid down in the Rural Roads Manual. Where populations are below 1,000 and traffic very low (less than 15 commercial vehicles per day), then in the interests of economy the road will generally be designed for a gravel or other unsealed surface, subject to rainfall. Likewise, with populations below 500, the carriageway width may be restricted to 3.0 meter. Where the road passes a built up area, it may be cement or with paved stones and appropriate side drains and cross drainage will be provided so that rain does not damage road or the adjacent dwellings. Minor bridges, of single lane only, may be included in the project. Bridges over 25 meters are the responsibility of the State Government. Based on the design, the PIUs will cost each proposal. Allowances for five years of maintenance will also be estimated.

9. The State Government will allocate money under PMGSY to each district with the aim of providing at least 80 percent of the road length to provide connectivity to unconnected habitations and up to 20 percent of the length requiring improvement (upgrading). Special allocations will be provided to districts bordering other countries and for tribal and backward districts.
10. After approval by the District Panchayats State Technical Agencies (STA) will vet the core network plans and the annual proposals. Within each district, annual funding of the PMGSY is allocated to each project based on the priority lists for new connectivity and improvement (upgrading). After the agencies have cleared the proposals the State Executing Agency will invite tenders, through competitive bidding. At the district level the program will be implemented through the PIUs.

Reference: Ministry of Rural Development, Government of India (2012) Pradhan Mantri Gram Sadak Yojana – Programme Guidelines April 2012

Planning Feeder Roads in Ghana

Before the year 2000, the main criterion used for planning the improvement of feeder roads in Ghana was based on a combination of transport cost savings and the producer's surplus approach involving predicting changes in agricultural output. The approach was felt to be unsatisfactory as it is extremely difficult to predict agricultural response and secondly when feeder roads are in very poor condition or the road is cut it becomes difficult to estimate transport cost savings based on existing motorized traffic flows.

The UK Department for International Development was interested in assisting the Department of Feeder Roads to establish a feeder road program to rehabilitate existing roads and tracks in nine districts in the North of Ghana that had been relatively neglected in the past, in part, because the area was subject to inter-tribal conflict. In connection with this project a new feeder road prioritization procedure was developed. The general objectives of the procedure were as follows:

- ♦ Ensure economic rationality
- ♦ Be sensitive to social and poverty objectives
- ♦ Include community participation
- ♦ Cover the issues of road impassability and traffickability (i.e. when motorized traffic is impeded by the road but not absolutely prevented)
- ♦ Address issues of non-motorized traffic and gender

- ♦ Be relative simple and transparent
- ♦ To be capable of being operated from Districts and Regions without high-level external support.

The development of the procedure was undertaken by engineers and economists at TRL together with the assistance of an externally recruited social development adviser. The procedure took 18 months to develop. It includes both community consultation to nominate roads that are then assessed using a prioritization index. The index was based on developing a benefit cost ratio in which the benefit component comprised transport cost savings of both motorized and non-motorized traffic together with social benefits expressed in money terms. The cost component was the cost of road construction. The highest-ranking roads were nominated for improvement in the program until the allocated budget was spent.

The approach has for main strengths in order to meet the main objectives, to combine economic and social benefits together with community participation. In directly addressing the problems of road passability and traffickability, the main feeder road accessibility constraints are addressed. Value for money is directly incorporated into the procedure, which can help with addressing appropriate engineering design. An innovation in the approach, compared with other feeder road ranking procedures, is that *both* social and economic benefits are calculated to be directly dependent upon the change in road condition and transport costs. If there is little or no change in transport costs, there will be little or no social benefits.

The main weakness of the approach was that the cost of repeated community consultation (in part designed to create a sense of community involvement and hence reduce inter-tribal conflict) which made the process relatively expensive. Additionally are the common problems of all ranking criteria. The social weighting factors, although subject to community consultation and professional debate, are essentially arbitrary. Likewise, some of the cost weighting factors used to estimate the benefits are, at present, not well researched, although, in principle, further research data could be used to improve their validity.

The procedure was successfully trialed in Nanumba District. At the public hearing, the clear advantage of maintaining basic access standards, rather than the more expensive full rehabilitation approach was demonstrated. Initially, district representatives (at a workshop) had given priority to roads involving relatively expensive interventions. It was pointed out that with the planned budget the District Workshop ranking would provide for three roads to be constructed with 55.4 km

of improvements, benefiting approximate 8,400 people and giving annual benefits of \$423,000. If the same budget was spent using the Prioritization Index then five roads would be built, giving 95 km of roads and benefiting approximately 17,650 people with annual index benefits of \$649,000. Although these arguments were accepted at the public hearing, there was still concern that a particular road section might not be built involving people wading and waist deep, through about half a kilometer of water (this issue was not given a high priority at the earlier District Workshop). It was agreed that it would be dealt with separately and addressed by saving money through reducing road widths.

The general approach was as follows:

- ♦ Local consultants were trained and recruited to engage the local communities in the district to identify roads they wanted improving.
- ♦ Identified roads were presented to subcommittee of the area councils to nominate two roads for each area (approximately ten (10) areas in each district).
- ♦ The nominated roads from each area were then investigated by an engineer to identify the current state of the road or track, the measures needed firstly to provide basic access (i.e. all year road accessibility by vehicle) and secondly to bring the road up to a full gravel road standard.
- ♦ For the nominated existing road and the improved alternatives, the engineer estimated road roughness and the period in the year the road suffers from absolute impassability and the period it suffers traffickability problems.
- ♦ Traffic surveys were undertaken on each road to measure both motor vehicle traffic and pedestrian and other non-motorized traffic movement.
- ♦ The adjacent population for each road was estimated from census returns and maps.
- ♦ A prioritization index benefit cost ratio was developed which had a benefit component (including both transport economic benefits and social benefits), modified engineering costs represented the cost component of the index.
- ♦ It was proposed for the DfID funds to the nine districts that half the money be initially allocated evenly to each district and that those roads with the highest benefit cost ratios be selected for inclusion in the program until the available funds are "spent". In a second round, the prioritization index data is pooled together with all remaining funds and those remaining roads with the highest

scores are selected until all the remaining funds are spent. The process ensures that each district gets some road investment.

- ♦ In order to make the selection process as open as possible a district workshop is held for district representatives to make their own prioritization list. This is then discussed together with the results of the technical analysis at an open public forum to agree the final program.

For each road, an index is built from traffic, population and engineering cost data. Costs and benefits are estimated for both full upgrading and spot improvements. To achieve the greatest value for money, it is essential that unnecessarily high standards are avoided and that road widths (formation, carriageway and structures) are kept to a sensible minimum in relation to traffic volumes.

In order to address the issue of appropriate road standards (in this case between basic all year round access and full gravel standard road), it is necessary to compare the incremental benefit cost ratio (difference in benefits divided by the differences in costs) with the established cut off benefit cost ratio of the whole program. If the incremental benefit cost ratio is greater than the program cut off ratio the higher cost intervention (i.e. full rehabilitation) should be undertaken; if it is less than the cut off ratio then the lower cost project (i.e. basic access improvements) should be undertaken.

The selection process is budget limited. However, in order to ensure that completely uneconomic roads are not selected for the program, a sensitivity analysis was carried out in order to define a minimum cut off ratio. This was also reinforced by a community participation exercise to address the same issue, i.e. circumstances in which road improvement were felt to be worthwhile.

The benefits components of the index include:

- ♦ Motorized traffic benefits
- ♦ Non-motorized traffic benefits
- ♦ Social benefits

Total transport benefits are calculated for a calendar year. In order to ensure that longer lasting improvements were valued more highly in the analysis in constructing the benefit cost ratio the costs of structures were divided by a factor of two. The benefits were calculated as follows.

Motorized traffic benefits. The procedure identifies three main areas where motorized transport benefits from improved access.

- ♦ Benefits associated with improved levels of road roughness using the conventional relationships between road roughness and vehicle operating costs (VOC). Table 1 shows the main parameters for different levels of road roughness.
- ♦ Benefits from infrastructure improvements that improve the traffickability of a road. In this context, it is defined that a road has traffickability problems when the percentage of wet season traffic falls below 50 percent of the dry season traffic.
- ♦ Benefits from infrastructure improvements that improve the passability of a road. In this context, it is defined that a road has passability problems when the road is completely closed to motorized traffic for either all or part of a year. This will generally be a problem during the wet season. Table 2 contains the multipliers associated with traffickability and passability. For consistency of definition, if a road has a passability problem at a certain times of the year then it is deemed not to have a traffickability problem at the same time. If there is doubt, passability problems are more severe and take precedence. Hence:

$$\text{Days with no problems} + \text{Days with traffickability problems} + \text{Days with passability problems} = 365$$

Table 1. Benefits for motorized transport from roughness reductions

| <i>Infrastructure quality</i> | <i>Infrastructure code</i> | <i>VOC per km (cents)</i> |
|-------------------------------|----------------------------|---------------------------|
| Good gravel (IRI 6) | G | 45 |
| Average (IRI 9) | A | 52 |
| Poor (basic access) (IRI 12) | P | 57 |
| Extremely poor (IRI 17) | E | 75 |

Table2. Factors associated with seasonal access constraints to motorized transport

| <i>Seasonal access constraint</i> | <i>Factor x VOC</i> |
|-----------------------------------|---------------------|
| Impassability | 7 |
| Traffickability | 2 |

Non-motorized transport benefits. Many prioritization techniques ignore benefits to non-motorized transport but research has shown that a considerable proportion of the transport burden is carried by NMT and that they benefit from improved infrastructure. The parameters shown in Tables 3 to 5 show that there are substantial benefits to NMT where there are no existing transport services reducing to very small benefits where basic access is already established.

The largest benefits are associated with extremely poor quality access where there are no transport services. Infrastructure improvements are then most likely to lead to a change of transport mode (from bicycle to truck). This type of modal change has the potential to deliver large transport cost savings.

The inclusion of NMT, particularly head loading, allows gender inequalities in the transport burden to be addressed. In many parts of Ghana, women carry an overwhelming proportion of head loads. This procedure recognizes this situation and gives benefits to the increased probability of modal shift or to the time savings associated with walking on improved infrastructure.

Table 3. Benefits for NMT where infrastructure is impassable or there is extremely poor access and no useable transport services

| <i>Benefits in cents per km</i> | | | | |
|---------------------------------|------------------|------|--------------|-----------------|
| | Headload (>10kg) | Walk | Cycle (load) | Cycle (no load) |
| Good Gravel | 11.4 | 2 | 5.4 | 0.5 |
| Average Condition | 11.3 | 1.9 | 5.3 | 0.4 |
| Basic access | 11.2 | 1.8 | 5.2 | 0.3 |

Table 4. Benefits for NMT for extremely poor access and weak existing services

| <i>Benefits in cents per km</i> | | | | |
|---------------------------------|------------------|------|--------------|-----------------|
| | Headload (>10kg) | Walk | Cycle (load) | Cycle (no load) |
| Good Gravel & Average Condition | 2.2 | 0.5 | 1.1 | 0.1 |
| Basic access | 2.1 | 0.4 | 1 | 0.1 |

Table 5. Benefits for NMT where infrastructure is improved from basic access

| | Benefits in cents per km | | | |
|-------------------|--------------------------|------|--------------|-----------------|
| | Headload (>10kg) | Walk | Cycle (load) | Cycle (no load) |
| Average condition | 1.0 | 0.2 | 0.5 | 0 |
| Good Gravel | 1.1 | 0.2 | 0.5 | 0 |

Social Benefits. Many low volume roads are impossible to justify on the grounds of transport cost savings to existing traffic. However, many of the roads will provide an essential social and economic service in enabling communities to reach health facilities, markets, education and to visit friends and relatives. Problems with access to services are very often greatest with the poorest communities and where physical access is extremely poor. To build these factors into the prioritization procedure four parameters have been included as shown in Table 6.

A social access benefit component has been included which gives a greater weighting to roads in high population areas. In order to allow for a minimum degree of social movement, it is suggested that a population factor is added to the other benefit components. The factor provides a way of improving the index score of populated areas even if there is little or no motorized traffic. Therefore, if access is poor and trip constrained, a weighting can help redress the balance compared with areas that might have higher traffic volumes but lower population.

Recent research carried out in rural Ghana by TRL has shown that vehicle trips per year range from about three (found in Yendi) to 35 (found in Kwabre) trips per person per year. It is suggested that five return trips per year represents an acceptable minimum estimate of social trip making which may be added to existing traffic levels to ensure the prioritization index can account for a minimum level of trip making for all communities.

For direct estimates of accessibility improvement and full rehabilitation benefits adjacent road population should be multiplied by a factor of "1.0" to estimate vehicle trips per year. This figure is based on five return trips per year, 10 passengers per average vehicle $5 * 2$ (single trips)/10 = 1 vehicle trip per person per year.

- ♦ *The social access benefit* is calculated by multiplying the social access benefit factor (taken as “1”) by the population that depend on the road by the average distance traveled along its length and by the change in transport costs for motorized transport (per km). It is recognized that both the adjacent population to the road section and the population adjacent to other road sections (that also depend on the road) need to be included.
- ♦ *A poverty benefit component* has been included which gives a greater weight to roads running through the poorest one third of districts (as listed by Ghana’s common fund allocation procedure). The poverty benefit component is calculated through the use of a poverty weighting factor that is multiplied by the social access benefit component.
- ♦ *A benefit component for isolation from health facilities* has been included. As with social access and poverty, this benefit component is population dependent. The benefit component is calculated through the use of isolation from health facility weighting factor that is multiplied by the social access benefit component. Communities which have identified isolation from markets as a key factor and where the mean road distance is further than 10 km from a hospital would qualify.
- ♦ *An index for isolation from markets* has been included. Isolation from markets was highlighted through consultation with the communities as being of highest concern. Communities which have identified isolation from markets as a key factor and the mean road distance to an urban market is more than 10 km would qualify. In this case the isolation from markets index will be multiplied by the sum of motorized, and non-motorized transport benefits.

Table 6. Social benefit factors

| Social benefit component | Social benefit factors |
|---|------------------------|
| Social Access (Population) | 1 |
| District Poverty (Yes/No) | 0.5 |
| Isolation from health facilities (Yes/No) | 0.5 |
| Isolation from markets (Yes/No) | 0.1 |

Engineering Data used in the Analysis

Engineering surveys were carried out on the roads nominated for improvement. It was estimated that approximately 50 km could be surveyed and costed in one day. The roads were initially classified into sections: Road Access Condition A (road access is impassable for some period during the year), Road Access Condition B (road access is possible throughout the year but unreliable), and Road Access Condition C (road access is possible and reliable throughout the year). Interventions were then identified to firstly provide basic access throughout the year, and secondly to bring the road up to a good standard of roughness, mostly involving full rehabilitation. For each existing and future condition of the road, roughness was estimated together with an estimate of the period of the year when passability and traffickability problems would occur. For each intervention, the costs of construction would be identified, together with a separate estimate of the cost of structures involved.

Reference: Hine J, S Ellis, S Done, and D Korboe Ghana Feeder Road Prioritisation. (2002), ILO Conference, Maputo.

Vietnam Rural Transport III (RT3) Rural Roads Planning Procedure

The following outlines the planning and prioritization adopted for the Vietnam Rural Transport III (RT3) program supported by a World Bank credit in 2005. RT3 supported the provision of both basic (all weather) access roads and road improvements to gravel and sealed road standard. Following RT2 only a small number of communes lacked basic access, however this was the first priority for RT3. Basic access roads were justified purely on social grounds, while road improvements were initially justified on economic grounds. However, due to limited annual budgets, for both types of road, indices based on the number of poor people served by the road divided by the cost of the road were used to finally prioritize when, and if, the intervention would be included in the program.

²² Full details of the procedure, covering consultation, engineering design and costing and prioritization, together with associated Excel spreadsheet, are available from the author at Johnlhine@gmail.com.

The indices were therefore:

$$\begin{aligned} \text{Basic Access Index} &= (\text{no. poor people}) + 0.2 \times (\text{no. non-poor people}) \\ &\qquad\qquad\qquad \text{Cost of road} \\ \text{Improvement Index} &= \frac{\text{no. poor people}}{\text{Cost of road}} \end{aligned}$$

Given the difficulty and cost of carrying out detailed engineering and economic feasibility studies on a large number of short and widely dispersed roads, a simplified procedure was used to determine pavement type, approximate costs and the economic viability of road improvements. This was based on establishing traffic thresholds for improvements based on calculated economic NPV and IRR for different terrains and pavement types using the HDM-4 model. Road Class which determines the geometric standards to which the road should be built, was identified from Ministry of Transport' Standards, depending on road function and traffic volumes. Assumptions on traffic counts were taken from counts carried out from different studies.

A regression analysis was undertaken to obtain relationships between traffic volumes, population and land use variables. Where traffic volume data was not readily available, these relationships were used to compute traffic volumes.

Each province provided a "long list" of candidate roads for inclusion in the RT3 program, developed in accordance with the provinces general planning procedures. Prioritization was carried out separately for each province. Basic access roads were included in the first year of the program in accordance with the ranking index until either all roads had been included or the budget limit reached. The balance of the budget was then made available for road improvements.

Based on traffic volume, road function and the economic HDM-4 threshold analysis, the road class, and pavement type were determined for road improvements. Road construction costs were estimated from surface type and terrain. The roads were then prioritized according to the index given above and included in the program until the provincial budget had been used up.

The civil works budget allocations, for the program, to provinces are based on 50 percent evenly distributed between them and 50 percent allocated on the basis of

rural population weighted by rural poverty incidence and lack of access. Maintenance funds are allocated based on length of district roads.

Figure 14 provides a diagram of the road selection procedure and Table 7 provides traffic thresholds for different interventions according to road class and terrain.

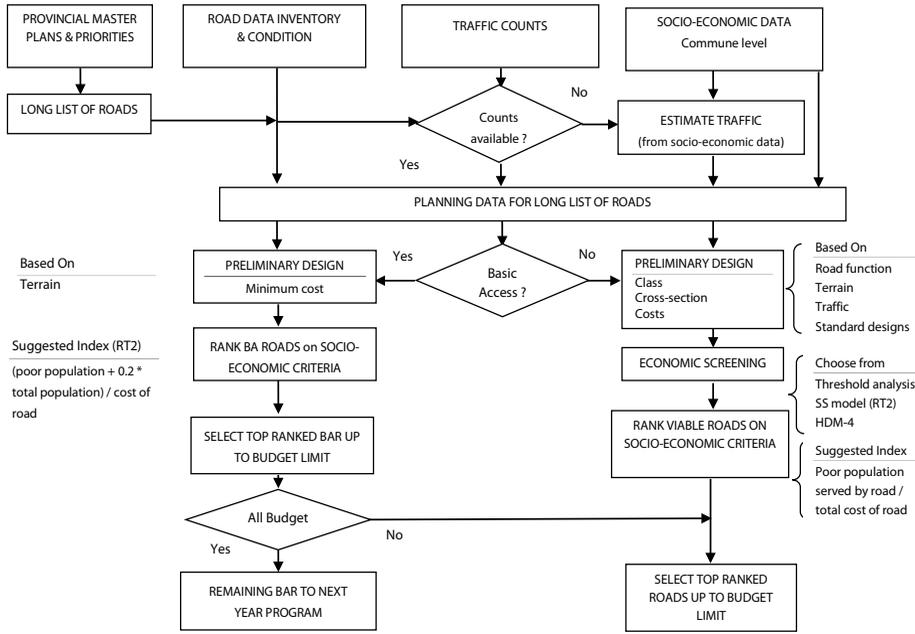
Table 7. Threshold Traffic Volumes for Road Improvements

| <i>Road Class</i> | <i>Flat</i> | | <i>Rolling</i> | | <i>Mountainous</i> | |
|---------------------------------------|-----------------|------------|-----------------|------------|--------------------|------------|
| | vpd (MT) | Pcu | vpd (MT) | Pcu | vpd (MT) | Pcu |
| Gravel Roads Compared to Earth Tracks | | | | | | |
| V | 50 | 35 | 55 | 40 | 60 | 45 |
| VI | 35 | 25 | 40 | 30 | 60 | 45 |
| A | 35 | 25 | 40 | 30 | 40 | 30 |
| B | 30 | 20 | 35 | 25 | 35 | 25 |
| Sealed Roads Compared to Gravel | | | | | | |
| V | 400 | 300 | 350 – 400 | 250 – 300 | 250 – 300 | 175 – 225 |
| VI | 350 – 400 | 250 - 300 | 350 | 250 | 250 – 300 | 175 -225 |
| A | 300 – 350 | 225 - 250 | 250 -300 | 175 – 225 | 250 – 300 | 175 – 225 |
| B | 250 – 300 | 175 - 225 | 250 | 175 | 200 – 250 | 150 -175 |

Notes: vpd – Vehicles per day, pcu –passenger car equivalent units.

Reference: Roughton International, (2005) Third Rural Transport Project (RT3), Consultancy Services for Technical Assistance for Project Preparation. Ministry of Transport, Vietnam.

Figure 14. Rural Road Section Procedure for RT3 in Vietnam



Sri Lanka – Provincial Roads Project

This project to improve the provincial road network was initially supported by the Asian Development Bank, in 2004, and later by the World Bank. This network, estimated at about 15,700 km, constitutes about 14 percent of the total road network. It provides the key connection between the rural and the national networks. Due to the long-running communal conflict and a lack of consistent funding for provincial roads over the past 20 years, little maintenance or rehabilitation has taken place. The roads in the provincial network were mostly in an advanced state of deterioration, with extensive pot holing, breakup of bitumen surfacing, broken and inadequate culverts and pavement failure.

The Feasibility Study outlines a road prioritization procedure involving a number of different stages. Simplifying, the procedure is as follows:

- a) initial nomination of roads by provincial governments
- b) allocation of road length to be considered for each province

- c) short listing selection procedure (based on factors such as connectivity, traffic, road condition etc.) for roads in each province
- d) economic analysis of short listed roads
- e) application of 10 percent EIRR cut off
- f) final ranking (multi-criteria analysis) based on combination of economic analysis and social criteria

After the initial nomination of roads by the provincial governments, an allocation procedure was developed to determine the length of road to be built in the different provinces. The criteria used for this provincial allocation (and the weight assigned to each) were as follows:

- ♦ Land area (20%)
- ♦ Population (20%)
- ♦ Poverty headcount index (35%)
- ♦ Total provincial road length (30%)
- ♦ Registered vehicles per km of provincial road (10%)
- ♦ Length of provincial road already improved under previous projects (15%)

For each province and criterion, a normalized index was computed:

$$NI_{P,C} = DV_{P,C} \div DV_{M,C}$$

Where $NI_{P,C}$ is the normalized index for province P and criterion C;
 $DV_{P,C}$ is the data value for province P and criterion C; and
 $DV_{M,C}$ is the median province-wise data value for criterion C.

A cap was imposed on the number of kilometers that could be shortlisted in the Northern Province, because of uncertainty about the practicality of carrying out feasibility and design work during on-going hostilities. This produced a surplus allocation, which was redistributed to the four border provinces roughly in proportion to the damage they suffered as a result of the conflict in the north and east. In total 2,400 km of road was allocated between the nine provinces.

To provide a short list of roads in each province, totaling the allocation to the province, a screening was carried out on the initial long list of roads provided by

each province. The criteria chosen, and weightings used, varied slightly from province to province. The criteria and weightings for Uva province, are as follows:

- ♦ Connectivity to major roads (25%)
- ♦ Access to communities and economic and social assets (20%)
- ♦ Traffic volume (15%)
- ♦ Road condition (5%)
- ♦ Surface type (5%)
- ♦ Maintenance costs (5%)
- ♦ Potential contribution to poverty reduction (15%)
- ♦ Likely impact of project (high, moderate, low) (10%)

Following the derivation of the short list, an economic analysis was carried out on each short listed road. This comprised a conventional transport cost analysis (including road safety benefits) together with calculated economic benefits associated with reduced impassability (in this case educational benefits from increased school attendance) and benefits associated with reduced crop losses. The results of the calculated IRRs from the economic analysis were scaled whereby an IRR of 50 percent has a rank of 10 and an IRR of 10 percent has a rank of 0.

Two social assessments were made of each shortlisted road. One, from public sources to identify the total population, housing and commercial units benefiting from each road. The other, from field surveys looking at 25 meter belt of land each side of the road to identify the population and facilities to benefit from each road. In each case, a score was obtained by dividing by road length and then by normalizing on a scale of 0 to 10.

Finally, a multi-criteria analysis was undertaken to provide the final ranking whereby the economic analysis was given a weighting of 70 percent and the first social assessment based on published data a weighting of 10 percent and the second social assessment based on field survey was weighted at 20 percent.

Originally, it was planned to include an environmental assessment within the multi-criteria analysis. However, this was dropped because it was felt that the environmental mitigation measures included in the engineering costing used in the economic analysis covered this.

Reference: CARDNO, (2008) Draft Report. Consulting Services for Feasibility Study and Detailed Engineering Design of Provincial Roads. ADB Sri Lanka Road Project Preparatory Facility, Columbo.

Appendix 2. Examples of District Planning Procedures

Malawi District Development Planning using the IRAP Tool

Following an initial work carried out in the Makete project in Tanzania, it was decided, with support of ILO, to develop an Integrated Rural Accessibility Planning (iRAP) tool to improve accessibility to services. As a result, major initiatives in the development of iRAP were carried out in the Philippines, Malawi and elsewhere. Under the Pilot Integrated Rural Transport Project in Malawi, iRAP was introduced, in the late 1990's to Mwanza District, Lobi, Dezda District, and Embangweni, Mzimba District).

It had been observed that previous District Development Plans (DDP) were like 'shopping lists' based on limited secondary data, prepared by different sector representatives, with little buy-in from the local communities, and as a result priorities could be easily changed. It was felt that a more rational approach needed development, with much greater community involvement using iRAP. In 2004, under the Rural Accessibility Mobility Pilot Activity (RAMPA) the iRAP data collection exercise was implemented for Ntchisi District, involving 254 Village Development Committees with 1,659 villages. From this information, a revised high quality DDP was produced. Furthermore, with the new planning tool a much more rational approach could be used to planning the location of roads and new facilities, and possibly to effectively resist irrational pressures by various sections of the population. Although developing the database involved a considerable initial effort, the fact that the information was largely supplied by the local population established its credibility and acceptance. The RAMPA project also covered significant IMT initiatives.

Reference: IT Transport Ltd in association with CCE Ltd, (2005) Road Maintenance and Rehabilitation Project, Management Services for Rural Accessibility and Mobility Pilot Activity, Ardington.

Ethiopian Rural Travel and Transport Programme (ERTTP)

From the outset, the ERTTP was perceived to be a way of preparing comprehensive district (Woreda) development plans using accessibility as a key tool to integrate the various components. The objective went beyond increasing access to services to include increasing employment and income generation. The program was administered by the Ethiopian Roads Authority but with representation of other ministries. Although most of the proposed investments were beyond the village, including rural roads and major investments, the approach was also designed to tackle some of the within village and local transport issues including provision of IMT and village level infrastructure. A series of manuals were prepared outlining how the Woreda Integrated Development Plans should be prepared. These covered:

- ♦ Manual for Formulation and Implementation Framework
- ♦ Manual for Planning, Monitoring and Evaluation
- ♦ Manual for Rural Transport Infrastructure Development
- ♦ Manual for Means of Transport and Service Development
- ♦ Manual for Non-Transport Interventions and Income Generating Schemes
- ♦ Manual for Resource Mobilization and Management

In 2001, consultants were recruited to prepare eight pilot Woreda Integrated Development Plans using a variety of consultation and planning techniques. It was recognized that, in view of the diversity of Woreda characteristics a ‘one-size-fits-all’ approach would not be appropriate. By 2008, 130 such plans had been prepared or were under preparation. The plans produced were very comprehensive covering significant investments in agriculture, health, education, etc. Implementation of each plan was the responsibility of the Woreda officials, with the roads desk responsible for overall coordination. A wide range of planning procedures were adopted by the ERTTP including, iRAP, transport cost-benefit analysis and conventional financial accounting approaches.

An assessment of the implementation of the eight pilot plans, in relation to the transport related components, was carried out in 2008. The assessment found significant improvements in both accessibility and socio-economic conditions resulting from road investments (of varying standards), provision of IMT, and increased

provision of facilities such as health posts and schools. The ERTTP approach has been scale-up nationally under the ongoing Universal Rural Access Program.

Reference: IT Transport Ltd, (2008) Ethiopian Rural Travel and Transport Programme (ERTTP): Assessment of the Pilot Project, DfID/Ethiopian Roads Authority, Ardington.