1. INTRODUCTION

Three billion people in developing countries, or about two-thirds of their population, live in rural areas. The majority of them survive on less than two dollars a day, and about 1.2 billion live on less than a dollar a day.[7] Their lives are characterized by isolation, exclusion, and unreliable access to even the most basic economic opportunities and social services. For the majority of their transport needs, they rely on non-motorized means and on rugged paths, tracks and roads which are typically in poor condition and often only passable in dry weather.

For purposes of this paper, rural roads, tracks, paths and footbridges are referred to as rural transport infrastructure (RTI). The RTI network in developing countries consists of an estimated 5-6 million kilometers of designated[8] rural roads and an additional expansive network of undesignated roads, tracks, and paths. While the length of the undesignated network is unknown, it is estimated to be several times the extent of the designated network.[9] The vast majority of trips that take place over RTI (more than 80 percent) are short distances (less than five kilometers) and made by non-motorized means, including walking, animals, bicycle, and porterage.[10]

The Rationale for Action

Rural transport networks in most developing countries are still underdeveloped and of poor quality. Rural households, and particularly women, spend much time and effort on transport activities to fulfill their basic needs. Too many communities still do not have reliable access to main road networks or motorized access,[11] while at the same time resources are being spent upgrading roads to economically unjustified standards for populations that already have a sufficient level of access.

In recent years, renewed emphasis on assisting very poor populations through sustained rural development[12] has led governments and donors to accelerate resource flows to rural infrastructure, with a large proportion being directed at improving transport infrastructure. While these projects are sometimes sector-focused, they are increasingly taking the shape of multi-component rural development projects or social funds with an emphasis on local government and community-based program management. While a cross-sector orientation in such projects is desirable, there is a need for sound technical advice on the design of sub-components and, in particular, on appropriate design and appraisal methods for RTI.

Ensuring an effective RTI system is an essential requirement for rural development, although by itself, it is not sufficient to guarantee success. Without adequate RTI, communities lack the necessary physical access for basic domestic chores, agricultural activities, social and economic services and job opportunities. Without reliable access to markets and productive resources, economic development stagnates, and poverty reduction cannot be sustained. Improvements of the intra- and near-village path and track network, and the provision of all-season basic motorized access—if affordable and appropriate—are therefore essential conditions for rural development.

There is clear evidence that poverty is more pervasive in areas with no or unreliable (motorized access) as compared to more accessible areas. For example, in Nepal, where the percentage of people below the poverty line is as high as 42 percent, in unconnected areas 70 percent of people are living below the poverty line.[13] In Bhutan, the enrollment of girls in primary schools is three times as high in connected villages compared to unconnected ones.[14] In Andhra Pradesh, India, the female literacy rate is 60 percent higher in villages with all-season road access compared to those with unreliable access.[15] Plenty of further evidence of the socioeconomic impact of rural roads exists.[16]

Worldwide experience from past rural development programs and policies suggests that improving the poverty impact of RTI interventions requires attention to three guiding principles:[17]

- An emphasis on reliable, cost-effective access to as many of the rural population as possible, rather than high access standards for a few;

- Cost-effective and innovative techniques such as spot improvement, labor-based approaches, and low-cost structures, and;

- A decentralized and participatory approach with strong local government and community involvement in decision making on local transport investment and maintenance.

Consistent with this experience, this paper proposes approaches to the design and appraisal of rural transport infrastructure that emphasize innovative least-cost solutions for providing locally affordable basic access, as well as appropriate analytical tools and participatory methods for the selection of interventions.

Structure and Context

The paper is presented in four chapters. Chapter One introduces the topic. Chapter Two defines the terminology and concepts that will be used throughout the paper. Chapter Three explains the key elements of design for basic access transport infrastructure. Chapter Four gives guidance for selecting and prioritizing basic access-oriented interventions. Appendix A compares road network, mobility and accessibility indicators of selected countries. In Appendixes B and C, good practice examples are shown for basic access solutions to both motorized and non-motorized transport in a variety of geographic conditions. Appendix D presents low-cost traffic survey methods. Appendix E provides samples of innovative economic appraisals of RTI investments, and Appendix F describes the low volume Roads Economic Decision Model.

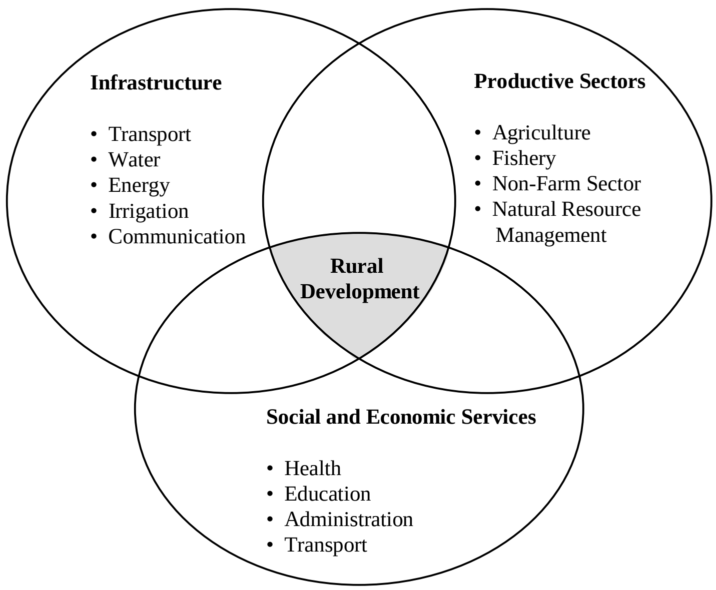
This paper is part of a four-volume series of publications on rural transport promoted by the World Bank's Rural Transport Thematic Group under the aegis of its knowledge management activities. The four volumes are: *Options for Managing and Financing Rural Transport Infrastructure*, *Improving Rural Mobility*, *Developing Rural Transport Policies and Strategies*, and this paper on *Design and Appraisal of Rural Transport Infrastructure*.[18]

2. CONCEPTS AND DEFINITIONS

Rural Transport and Poverty Reduction Strategies

Poverty reduction strategies require a comprehensive framework for implementation.[19] The simultaneous development of adequate rural infrastructure, productive sectors, social and economic services, an appropriate macroeconomic framework, and good governance and local ownership, is required for rural poverty alleviation (Figure 2.1 below). Effective transport, as a complementary input to nearly every aspect of rural activity, is an essential element of rural poverty reduction.

Figure 2.1. ***The Elements of Rural Development***

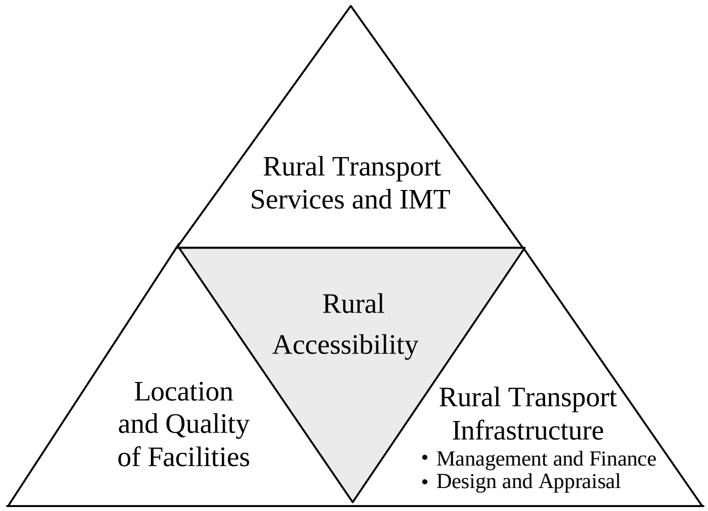


Source: Authors.

A Holistic Approach to Rural Transport

A new approach to rural transport interventions is emerging. It requires a more holistic understanding of the mobility and access needs of the rural communities than has traditionally been the case in rural road sub-sector investments. It is a demand-led, or people-centered, approach with an emphasis on the needs expressed by affected communities. In this context, rural transport is more broadly seen as an input into successful rural livelihood strategies, within which access consists of three complementary elements: (a) means of transport, (b) location and quality of facilities, and (c) transport infrastructure. The approach acknowledges that intervention may be required in all three categories, not simply the latter (Figure 2.2).[20]

Figure 2.2. ***Elements of Rural Transport***



Source: Authors.

Promoting Rural Transport Services (RTS) and Intermediate Means of Transport (IMT):[21] The availability and affordability of rural transport services and intermediate means of transport are crucial to rural development. The single pick-up truck that arrives once a week with essential supplies for the health center and school, as well as agricultural inputs, can be of immeasurable importance to a local community. Any investment program for improving RTI needs to carefully examine the constraints to effective RTS provision and to the ownership of IMT. Such constraints include excessive taxation, regulatory restrictions, inadequate markets, and the absence of credit facilities. Successful approaches to improving transport services must deal with issues related to low population density and transport demand in rural areas, should be cost-effective and use flexible technology.

Few poor rural dwellers own IMT such as bicycles and animal-drawn carts, let alone motorized means of transport. Most of the rural population walk and carry their loads, while the slightly better-off make use of IMT and RTS for the transportation of their products and themselves. For distances up to five kilometers, and even as far as 20 kilometers in some circumstances, walking is by far the most common mode of transportation in rural areas of developing countries.[22] Where RTS are provided, they usually consist of (a) privately provided transport services, often by pick-up trucks for both passengers and freight; and (b) for-hire non-motorized services such as bicycles, rickshaws, donkey carts, and so forth. Government extension services in the agriculture, health and education sectors may also provide informal transport services.

Location and Quality of Facilities: The second element of a comprehensive rural transport framework is the location and quality of facilities. The distance from households to facilities such as wells, forests, grinding mills, schools, and health centers determines the amount of time rural dwellers spend on transport activities. Numerous studies on rural transport have shown that rural households, and particularly women, spend a substantial amount of time and effort on transport activities.[23] The bulk of these efforts is required for domestic subsistence activities, particularly the collection of water and firewood, and trips to grinding mills. In the view of planners, this time is unproductive and wasted, and a drain on potentially productive labor—the principal economic resource for most rural households.[24] Therefore, improved quality and better locations of facilities are important to consider when examining alternative access improvements.[25]

Since the majority of time rural households spend on transport is for domestic activities, the most effective transport-reducing interventions are usually related to better provision of water (such as well construction) and energy-supply facilities and the provision of grinding mills near households. Most countries have policies of providing primary social services (for example, primary schools and dispensaries) at the village level, while secondary level units are provided at more central places. For social services, improving *quality* is often a more serious concern than improving *location*.[26]

Rural Transport Infrastructure (RTI): Complementing means of transport and the location and quality of facilities is the third element of rural transport—RTI. The main requirement for the sustainable delivery of RTI is a conducive framework for management and finance. The framework should include effective resource allocation and a logical system for setting priorities. This, in turn, requires sound advice on design and appraisal. Few developing countries, however, have managed to establish a favorable paradigm for managing and financing RTI. In the cases of these countries, the focus should first be on the development of such a framework in collaboration with all key stakeholders.

Developing a Rural Transport Policy and Strategy: To address the issues mentioned above, to ensure that rural transport is an effective facilitator of rural development, and to coordinate the activities of the various actors in the sub-sector, it is essential that rural transport policies and strategies are formulated and implemented. This process must address a broad range of issues, including physical, financial, economic, social, and environmental aspects of rural transport, and must relate to existing rural development and general transport policies and strategies.[27] Without such a comprehensive policy and strategy framework, the management and financing of RTI, especially maintenance, often fails. It is therefore highly recommended that countries formulate and enact an explicit rural transport strategy prior to undertaking an RTI investment program.

What is Rural Transport Infrastructure?

RTI is the rural road, track, and path network on which the rural population performs its transport activities, which includes walking, transport by non-motorized and motorized vehicles, and haulage and transport of people by animals. RTI includes the intra- and near-village transport network, as well as the infrastructure that provides access to higher levels of the road network. Following are the key features of RTI (see also Figure 2.3.).

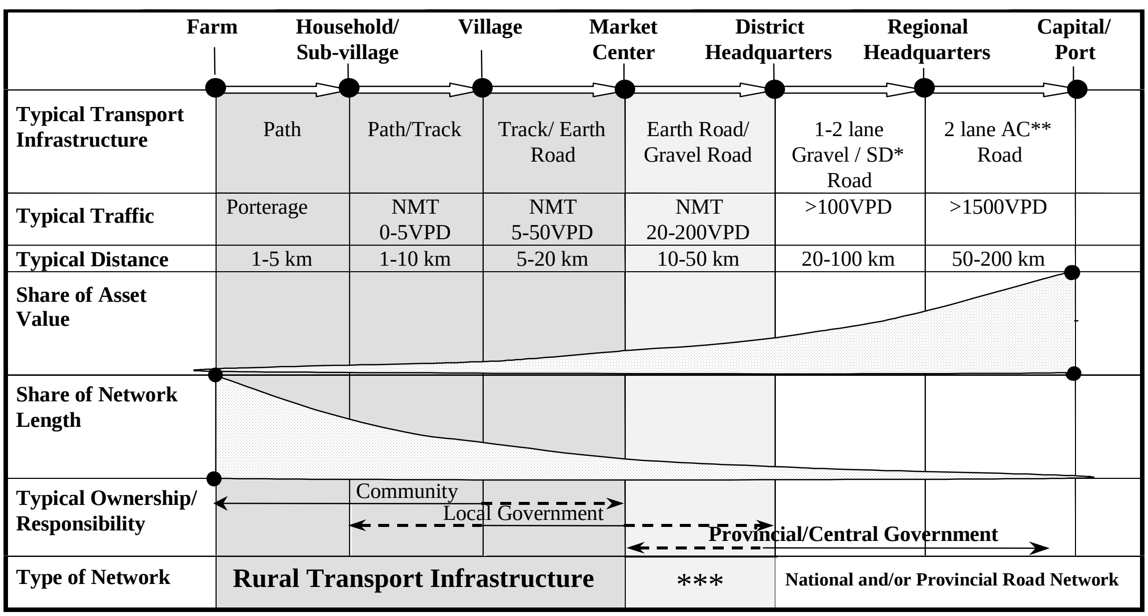
Ownership: By definition, RTI is the local access infrastructure that is normally owned by local governments and communities. Local government roads (LGR) usually have formally defined ownership arrangements, i.e., they are designated. Community RTI is usually undesignated, or not part of the formally recognized transport network. In the absence of a respective legal framework, community RTI belongs to communities. Even designated roads are sometimes informally adopted by the local communities, who take responsibility for their maintenance. However, the capacity of communities to own and take care of RTI is limited usually to the intra- and near-village network and to short links to the main road network.[28]

Managing and Financing: Many different arrangements exist for managing and financing RTI.[29] LGR are often better managed by more central agencies on behalf of local governments,[30] or through joint-services arrangements (such as in Guatemala). Financial resources available for RTI include transfers from central government (from the Treasury, dedicated road funds, or through donor financing), which should be leveraged to generate local resources in cash or in kind. In most cases, financial resources are extremely scarce, particularly for maintenance.

Physical Features: LGR are sometimes at least partly engineered, which means they have an elevated, above-water-level riding surface, side drains and cross-drainage structures, including bridges. The majority of them are single-lane gravel or earth roads. They connect villages to the higher classified road network but are usually relatively short—less than 20 kilometers. Community RTI consists mainly of tracks, paths and footbridges, and sometimes (partly) engineered roads. They should normally not exceed five kilometers in length to ensure that the community has the capacity to maintain it.[31]

Traffic Characteristics: Transport activities on RTI are performed to a large extent on foot, sometimes by intermediate means of transport (IMT),[32] such as bicycles and animal drawn carts, and sometimes by using the services of motorized transport. Average daily motorized four-wheeled traffic on the majority of the RTI network is below 50 vehicles per day (VPD), while non-motorized traffic (NMT) can be a multiple of this number. Although the network of LGR, on average, constitutes about 70 percent of the designated network, it carries only a small portion of the total traffic (10 to 20 percent of total vehicle-kilometers).

Figure 2.3. ***The Farm to Market Transport Chain and Rural Transport Infrastructure***



* Surface
** Asphalt Concrete
*** Part of either RTI or the Provincial Network

Source: Authors.

A Basic Access Approach to RTI Investments

The RTI network is the lowest level of the physical transport chain that connects the rural population, and therefore the majority of the poor, to their farms, local markets, and social services, such as schools and health centers, potentially increasing their real income and improving their quality of life. A minimum level of service of the RTI network, referred to as *basic access*, is therefore one of the necessary building blocks of poverty reduction. In this context, the provision of basic access should be considered a basic human right, similar to the provision of basic health and basic education.[33]

In line with the poverty focus of RTI investments, a *basic access approach* is proposed which gives *priority to the provision of reliable, all-season access to as many villages as possible* over upgrading individual links to higher than necessary standards, thereby giving priority to network *equity*. The optimal distribution of available resources between such *equity*- and *growth*-oriented investments needs to be defined in each particular case. However, there is ample of evidence of "over-investment" on parts of the RTI and main road networks, and the potential for the transfer of resources to more equity-oriented investments is substantial.[34] A key indicator of network equity is the coverage of all-season access within one to two kilometers of rural households (see Appendix A).

A *basic access intervention* is defined as the least-cost intervention (in terms of total life-cycle cost) for providing reliable, all-season passability by the prevailing means of transport. If affordable (see next paragraph), this may mean all-season passability for a pick-up truck, a small bus, or a truck, even if these present only a small fraction of total traffic. However, it should be recognized that appropriate RTI is also required for the efficient and economical use of non-motorized (or intermediate) transport.[35]

The provision of motorable basic access roads is constrained by available resources, especially maintenance and capital budgets. What is affordable depends on the local population's capacity to maintain their own basic access infrastructure over the long-term.[36] Determining what is affordable depends on the complex relationship between this local capacity, available skills, income levels, population density, geographic conditions, and political will.[37] Appraising these factors will shed light on RTI sustainability, and should be undertaken as part of the investment appraisal process. Another broad indicator of the long-term affordability of RTI investments is whether or not a country has the capacity and resources to maintain its main road network.[38] Below a certain per capita income, and particularly in situations of difficult terrain and low population density, even least-cost basic access roads will not be affordable (notwithstanding existing suitable management arrangements and political will). In these cases, basic access provision may need to be focused on improving existing paths and constructing footbridges.

The road infrastructure of a particular country will generally grow in proportion to its level of development. Gradually, the originally existing path and track network will develop into a road network until finally all the households are served with road access, as is the case in developed countries.[39] To assist the understanding of network affordability, it is therefore recommended to compare road network indicators of a particular country with those of countries of a similar level of development. Appendix A provides the rural transport planner with some basic road network, mobility and accessibility data from selected low-, middle-, and high-income countries. The data demonstrate the relatively high burden of infrastructure cost and high existing inaccessibility in low-income countries. Moreover, the table shows that almost universally, motorized mobility grows proportionally to GDP.

3. DESIGNING RTI FOR BASIC ACCESS

This chapter discusses engineering design requirements for RTI. A differentiation is made between four categories of access: no, partial, full, and basic access, with a subsequent focus on the specific requirements of basic access. Design requirements for full access are ignored here, since they are substantially covered in the existing literature. As discussed in the previous chapter, basic access is defined as the level of service which provides the minimum accessibility required for rural socioeconomic development. In a majority of situations, where traffic is below 50 motorized four-wheeled vehicles per day (VPD), this means (trouble) spot improved, single-lane gravel or earth roads. If these are not affordable, the provision of basic access could involve the improvement of paths and construction of footbridges. Some guidelines for the engineering design of basic-access roads, paths, and low-cost structures for different climates and terrain are discussed in this chapter. More technical guidelines for the design of basic access roads are given in Appendix B, and those for paths and footbridges can be found in Appendix C.

Access and "Level of Service"

It can be useful to think of RTI, and its impact on "accessibility," from the perspective of "level of service." The following four levels of service, or access, need to be considered:

- **No (motorized) access:** defined as no motorized access within one to two kilometers of a household or a village;

- **Partial access:** defined as motorized access with interruptions during substantial periods of the year (the rainy season);

- **Full access:** defined as uninterrupted all-year, high quality (high-speed, low-roughness) access, and

- **Basic access:** defined as reliable all-season access for the prevailing means of transport, with limited periods of inaccessibility.

No Access or Partial Access: A substantial portion of the rural population in developing countries still does not have motorized access to transport networks at all, or only unreliable or partial access.[40] This portion of the population is nearly always less well-off compared to those who have reliable access.[41] Due to the low density of the unconnected population, the path and track network that connects them to the existing road network is vast, and is often several times its length.[42] To upgrade this network to even basic access standard, and maintain it at that level, would require enormous resources which in most cases are not available. Furthermore, in many situations the concerned population, if provided with motorable roads, could not afford motorized transport services, let alone private motor vehicles. Therefore, as the previous chapter has attempted to show, when resources are available to ease the transport burden of the unconnected populations, they should be carefully spent on a variety of access-enhancing measures, which may include basic access RTI.

Full Access: Full access means the provision of a fully engineered road with a consistent cross-section throughout its alignment and water crossings of high standard.[43] Such designs, which are considered the minimal standard for rural roads in many countries, are usually based on "design speed," and are to provide uninterrupted access throughout the year. Costs for a fully engineered rural road will typically be in the range of $20,000 to $100,000 per kilometer. Justification for such standards must be made on economic grounds (see Chapter 4), which is usually not possible on RTI with prevailing traffic levels of less than 50 VPD.[44] Literature on the design of fully engineered rural roads abounds, and this paper will not deal with the issue.[45]

Basic Access

The challenge in meeting basic access needs is deriving standards that can deliver the minimum level of service necessary to promote and sustain the development of rural communities, while providing such access to as many people as possible. Given the practical requirements of rural household socioeconomic activities, basic access RTI should meet the following minimum criteria:

- **Passability or reliability:** One of the most important aspects of basic access is passability or reliability. While it may be technically difficult to define when a road or a path becomes impassable, the impacts on the well-being and livelihood of the population from unreliable access are severe and well-documented.[46] The first priority for transport operators is the safety of their vehicles or animals, and they will often not travel if they consider a road or a path impassable—even if it is a decision based on unreliable information.

- **Adequate access to higher-level networks:** Functioning transport requires integrated systems. Access to main markets, to non-agricultural job opportunities, to higher-level health and educational facilities, and to administrative services requires reliable and affordable access from the community to the higher-level regional or national transport network.

- **Adequate access to local social and economic facilities:** Appropriate access to primary health and education facilities, and to local markets, both by the household and from the outside for the supply of inputs, is a fundamental requirement of basic access.

- **Adequate access to domestic activities:** Improved basic access infrastructure must reduce the time that households, particularly women and their daughters, spend on domestic activities, such as water and firewood collection, trips to the fields and to the grinding mill. It must enhance their productivity, and improve their lives and those of their families.

- **Trafficable by prevailing rural transport vehicle:** Basic access infrastructure must ensure that the prevailing type of rural transport vehicles (motorized or non-motorized) can expect reliable access. Reasonable levels of delays at river crossings or temporary road closings during the rainy season must be tolerated. Accepting such temporary closures can reduce investment costs considerably, as is shown later in this chapter. The maximum time allowed for temporary closures is both a political decision and an affordability issue.[47]

Basic Access "Standards" and Key Design Considerations: RTI standards, in countries where they exist, are often far in excess of what can be economically justified or what is necessary for the provision of basic access. The definition of the standards of basic access is ultimately a political matter and will depend on the development objectives, budget constraints, and social and natural environment of a particular country. In industrial countries, where basic access needs are nearly universally met, the standards of access roads are often defined on the basis of comfort and are not subjected to rigorous economic analysis.[48] On the other hand, in developing countries, where isolation and poverty are key targets of development investments, and resources are usually very limited, least-cost and economic criteria are required for maximizing the impact of interventions.

The removal of surface water is crucial for the success of basic access RTI, since at this traffic level, the weather causes more damage than does the traffic.[49] This means that a good camber of 5 to 8 percent, adequate side drains, and carefully designed cross drainage structures are required. Stone or concrete drifts, or splashes, are acceptable as a substitute for culverts. Major river crossings can be designed to allow traffic passage at low flows, and be closed at high flows. In many situations, peak flows may only last for a short duration (less than three hours). However, where rivers can not to be crossed for long periods, high-level and relatively expensive crossings should be provided to achieve basic access standards. If these are not affordable, providing an all-season footbridge should be considered, to allow pedestrian and IMT crossings during the rainy season.

Although roughness and speed are not important design parameters for basic access RTI, there are certain limits of roughness that should not be exceeded to avoid damage to vehicles. Speeds should normally not exceed 30 km/h, taking into account the varied use of basic access roads, by people, non-motorized, and motorized traffic on the carriage way. The most important criterion for the infrastructure is to be able to withstand the elements and traffic without extensive damage.

The (Trouble) Spot Improvement Approach: Many rural communities are still without road access. Connecting them will be a slow process. Increasingly, however, the situation faced by the rural transport planner is a deteriorating network of roads, tracks, and paths, passable only in the dry season, with difficulty, and not at all in the rainy season. In these situations, the spot improvement approach, focusing interventions only on difficult sections, is an appropriate method to provide basic access at a lower cost.

Spot improvement interventions require considerable judgment on the part of the design engineer. The types of interventions will vary according to the terrain, weather, and vehicle types. However, the construction cost savings can be in the order of 50 to 90 percent when compared to full improvement.

Road failure is most likely to occur on steep hills, at water crossings, and in low-lying areas. Solutions include realignment, paving of steep sections, provision of simple but permanent water crossings, and raising low-lying areas on embankments (see Appendix B). All interventions must be properly designed and engineered, but will only apply to a specific spot. In many situations, upgrading an existing track or earth road to basic access standard will only require interventions on 10 percent of the road length—greatly lowering the costs of providing all-season passability.

It is essential to ensure that untreated sections have sufficient capacity for the prevailing conditions and transport types. If the in-situ soils are incapable of bearing traffic loads when soaked, then it may be necessary to provide camber and drainage throughout. If the soils are not of sufficient strength, even in this condition, then a gravel surface should be provided throughout. During the design process, each section must be carefully analyzed in order to find the least-cost solution.

It is also essential to remember that very limited resources will be available for maintenance. Maintenance should not be confused with rehabilitation. If there is any concern that untreated sections will require more attention than basic vegetation clearing, cleaning drainage facilities, and minor surface reshaping to retain access, then a more substantial intervention should be undertaken. On the other hand, the spot improvement approach also applies to periodic maintenance, where in many situations spot regravelling, instead of full gravelling, is the right approach.

There is generally a great deal of resistance to spot improvement as a technical solution, especially in donor-financed interventions. A number of issues need to be addressed if this approach is to be pursued effectively:

- **Political pressure:** Politicians who are responsible for marshaling funds (including donor financing) for sector investments must answer to their constituencies, and therefore are under pressure to demonstrate effective and visible outcomes. This often leads to a decision to rehabilitate roads to fully engineered standards, rather than to undertake less visible spot improvements.

- **Road agency resistance:** Road engineers and managers want to remove particularly troublesome roads from their work programs. They may also view it as inappropriate to use "borrowed" donor money to produce what could be considered an inferior product. Many engineers are not well-informed about the merits of the spot improvement approach.

- **Private sector incentives:** Contractors and consultants prefer continuous upgrading to spot improvements. Upgrading (which entails higher quantities of earth movements and materials) is often the basis for mark-ups and therefore directly affects profits. Smaller, decentralized, and less visible spot improvements are viewed as unprofitable and are also difficult to define and supervise. Small-scale local contractors, however, may find this type of work very suitable.

- **Donor preferences:** Donor agencies often prefer a fully rehabilitated road to the process of identifying and financing investments in a series of dispersed trouble spots. Individual project financing may favor a quickly executed fully engineered approach because of the short time frame and the requirement to fully disburse funds. However, a long-term program approach is more appropriate for the gradual spot-improvement of a rural access network.[50]

In addition to the above-mentioned problems, spot improvement approaches will not work in areas that have very poor soils or are prone to flooding. Despite these problems, there is a strong case for the spot improvement approach. Without it, most developing countries simply cannot afford to provide basic access to the majority of their rural populations. An example of a successful spot improvement program is given in Box 3.1. Further good examples of successful spot improvement programs exist.[51]

Great potential for furthering the spot improvement approach is also seen in the implementation of performance-based road management and maintenance contracts. Until recently, these contracts have only been applied on major highways, and not on low-volume unpaved roads. A recent World Bank-financed project in Chad is proposing to introduce such types of contracts on approximately 450 kilometers of the unpaved main road network.[52] Performance criteria are: (a) passability at all times; and the assurance of (b) a specified average speed; (c) minimal riding comfort; and (d) road durability and preservation. This type of contract should guarantee an approach whereby the contractor, in his own self-interest, will focus on the critical spots of the network, while assuring a minimal comfort for the road user.

Box 3.1. ***The Roads 2000 Program in Kenya: A Spot Improvement and Labor-Based Approach to Network Rehabilitation and Maintenance***

The Roads 2000 Program is a maintenance implementation strategy that supports a number of policy objectives of the Kenya Road Maintenance Initiative. It was developed as a solution to the deteriorating unpaved road network of 53,000 km. Road condition surveys identified a limited number of trouble spots, rather than general conditions, as the main cause of non-trafficable roads. Furthermore, the surveys found that the traditional equipment-based maintenance approach could not provide the required services with the current funding levels.

Building on the successful experience of the labor-based Rural Access and Minor Roads Programs, Roads 2000 adopted a new approach to rapidly bring the network up to a maintainable standard and place it under effective maintenance with the optimum use of local resources.

The three principal components of the Roads 2000 approach were:

- Rehabilitation Phase: Bring roads back to minimum maintainable standard
- Routine Maintenance: Establish labor-based maintenance system
- Spot Improvement: Plan and carry out a follow-up program of selected spot improvements

During initial preparation work, the road was brought to a passable and maintainable standard by labor units. The role of these work-units was to clear the vegetation and drainage system and re-establish the road camber.

This preparation phase was followed by the establishment of small-scale contractors (group or single person contracts) to carry out routine maintenance on a permanent basis. On the more heavily-trafficked roads (> 50vpd), they were supported by tractor-towed graders.

During the rehabilitation phase, required spot improvements were identified and implemented as funds and resources allowed. Typical works included:

- Installation of new culverts (on average one new line per km);
- Replacement or rehabilitation of existing culverts;
- Spot regravelling (to a maximum of 4 percent of the road network length);
- Provision of alternative surfacing over limited distance (for example, steep sections, approaches to structures);
- Full road reconstruction over a limited distance; and
- Bridge and drift rehabilitation;

The following costs have been established for unpaved roads (adjusted to year 2000 prices):

- Partial rehabilitation and spot improvement $ 2,000 / KM
- Labor-only routine maintenance $240 / KM / Year
- Routine towed grading $280 / KM

Source: Authors.

Staged Construction—Not Recommended for RTI:[53] Staged construction is understood here as investment into structural elements of RTI to accommodate upgrading needs which might be required in the future due to traffic growth. This could mean, for example, the straightening of the vertical or horizontal alignment of an existing basic access road to accommodate a future fully engineered road, the provision of "two-lane" culverts for a single lane road, or the construction of two-lane bridges, where currently single-lane structures would be sufficient. While it might be possible to demonstrate long-term savings through staged construction in the case of trunk or provincial roads, where substantial traffic growth can be expected, the same is normally not possible for RTI, especially when initial traffic levels are very low. Where road agencies insist on such "advance" investments, economic analysis (see Chapter 4) should be carried out to determine their justification. Such analysis must take into account the additional short-term maintenance because of higher-than-necessary investments.

Engineering Design of Basic Access RTI

Basic access RTI has to be properly designed if it is to resist the weather and traffic, and produce a maintainable and sustainable asset. Unfortunately, even where the private sector is well developed, local consultants may have limited experience in the design of this type of rural project. It is necessary to produce designs, specifications, and quantities so they can be packaged out to small-scale contractors and supervised in a cost-effective manner. In addition, the designs themselves must be cost-effective, considering the low cost of the planned infrastructure (design costs should not exceed 6 percent of investment costs). There is limited experience in using local consultants for these services, and design tends to be carried out by technical assistance consultants recruited by projects and programs as part of a technical support package. For long-term sustainability, there is a need to stimulate the involvement of the local consulting industry. For assistance to communities, local NGOs are often the right partners and should be given the opportunity to acquire the necessary engineering skills.

With appropriate terms of reference that clearly specify the required approach, and specially designed training programs for local consulting firms, it is possible to secure local professional services. The absence of the time-consuming tasks involved in a fully surveyed design, detailed bill of quantities, and re-measurement serves to reduce costs. However, there is a much greater need for exercising engineering judgment in the design (and the supervision) of project work. The essential requirements for engineering services for basic access RTI are summarized in Appendix B.

Design Considerations—Traffic, Safety, Environment, and Social Impact: The engineering design needs to take into account a few key design considerations. These are related to the type of traffic use expected on the RTI, road safety considerations, the expected impact on the environment, and the social impact of RTI interventions. These requirements are explained in the paragraphs below.

Traffic: A wide variety of motorized and non-motorized traffic should be expected on RTI. However, roads and structures need to be designed to allow the largest and heaviest users to pass safely without damaging the structures. Often these largest users are seven-ton trucks, and, in other cases, pick-up trucks or motorcycles, and power tillers. In some cases, a design for non-motorized means of transport might suffice. Design to a low standard suitable only for 4WD-drive vehicles should normally be avoided, since these vehicles are rarely used by local transporters or the local population.

One potential problem is the possibility of large trucks using the road to evacuate heavy natural products and resources, such as crops, timber, minerals, etc. One excessively heavy truck can destroy the running surface of a basic access road. The likelihood of such traffic must be confirmed at project appraisal. Ideally, such traffic should be excluded by barriers (width and height restrictions at the start of the road), at the very least during the rainy season. If it is considered impossible to exclude such traffic, then the road must be designed for it, and systems put in place to ensure that the operators contribute their disproportionate share of maintenance costs.[54]

Because traffic levels will determine the type of intervention necessary (for example, basic versus full access), a thorough traffic survey is a prerequisite for all RTI interventions. In order to keep costs down to acceptable levels, it is necessary to select a few strategically correct locations (between villages). If resources are scarce, traffic counts can be correlated with population figures along different alignments in order to establish traffic estimates for links where traffic counts were not possible. Seven-day, 12-hour counts at selected locations are recommended to capture weekly variations. If possible, these can be complemented by counts during various times of the year to capture seasonal variations, as well as origin-destination and trip-purpose surveys. Both motorized and non-motorized traffic should be counted. Special consideration should be given to traffic-generating facilities such as hospitals, natural resource exploiting activities, or others. In Appendix D, low-cost traffic survey methodologies are presented.

Road Safety: Road safety is of primary importance for all road users. However, the safety concerns of basic access RTI are different than those for higher-level infrastructure. Typical problems are single-vehicle accidents and accidents between motorized and non-motorized vehicles, pedestrians and animals. Economic considerations will normally not allow separation of different modes of transport, and it must be accepted that foot and wheeled traffic of different speeds will intermingle in the traffic stream (exceptions see last paragraph of this sub-chapter).

The challenge for the rural transport planner is, therefore, to ensure that the speed of motorized traffic is low, say, not more than 30 km/h, particularly within villages. Spot improved, winding, single-lane roads with a relatively rough surface will, to an extent, automatically achieve this. However, it might be necessary to slow down traffic even more by narrowing the roads on straight sections (similar to urban traffic-calming designs). In such cases, it is essential for sight distances to remain in proportion to vehicle speeds.

On long, straight sections of flat terrain, the provision of trees adjacent to (but set back slightly from) the edge of the road (as is a common practice in Bangladesh) will have the effect of visually narrowing the road and slowing traffic, while providing shade and refuge to foot traffic. Where there is a sharp bend on such roads, painting middle sections of the tree trunks on the approaches to such bends can provide delineation and advance warning of the bend at night or in conditions of poor visibility.

All bridges, drifts, and culvert headwalls should be clearly marked with paint. Road widths must be consistent (even if consistently narrow, except for designated passing, vehicle loading or parking places), and weak road edges next to dangerous drops should be fenced (local bush fencing is acceptable, if maintained. However, metal road furniture such as signs and barriers often have limited life spans in resource-starved rural areas). The objective is to alert unfamiliar road users to obstacles and hazards ahead, so they can pass them safely.

It is often argued that since single-lane roads with passing places are inherently dangerous, wider roads should be built for safety reasons even when the traffic levels are low. However, the risk of vehicle-to-vehicle collision only increases slightly,[55] even if the volumes increase from 10 vehicles per day to 50 vehicles per day, and this level of traffic can be accommodated by passing places. However, where the road is expected to carry large volumes of pedestrian, or NMT, consideration needs to be given to their safety and a wider road shoulder or separate pedestrian and NMT-ways should be constructed (particularly within villages).

Environmental and Social Impact Mitigation: Basic access RTI interventions have both direct and indirect environmental and social impacts. Improved access might require the acquisition of productive agricultural land and housing, which might necessitate resettlement. Such resettlement will likely be minimal in the case of improvements to existing roads.[56] Other major direct environmental impacts are dust from vehicles and erosion of RTI surfaces, drainage structures, and outlets. Indirect impacts are the opening up of previously inaccessible, or marginally accessible, territory to immigration and resource harvesting.

The processes that help to identify and mitigate the potentially adverse impacts of RTI projects, while enhancing their positive effects, are the environmental assessment (EA) and social assessment (SA). Both EA and SA processes must be initiated at the beginning of the project cycle and continued throughout. To make them sustainable, they need to involve local experience and must be done with the participation of the local communities. Particularly in the case of new RTI, the SA might be extended to include studies encompassing baseline, mid-term and ex-post socioeconomic data collection, contrasting these with appropriately selected control areas to enable the monitoring and evaluation of the planned poverty-alleviating impact of the project. For this purpose, data will need to be collected at both the household and the community level from appropriate sample populations in the influence area.

The EA process involves six primary elements: a study of the baseline conditions in the region to establish benchmarks; an analysis of the existing institutional, legal, and administrative frameworks with respect to implementation; identification of potential environmental impacts; mitigation measures; an analysis of alternatives; and an environmental management action plan (EMAP). The EMAP is the output of the EA process and reflects the main impacts at major stages of the project, the relevant mitigation measures, the time-frame of their implementation, the institutional responsibilities, the costs, and the appropriate references to the contract documents.[57] The result of the SA might be a Resettlement Action Plan (RAP). Since the RAP is demand-driven, its implementation needs to be participatory and locally based. Involving experienced NGOs in the implementation is strongly recommended.

The need for EA and SA processes will vary greatly with the type of RTI intervention. In the case of small-scale improvement on existing networks, EA and SA might not be required at all, while in the case of new roads and particularly in mountainous areas, these processes might be extremely demanding. Relevant information on EA and SA can be found in the World Bank's Operational Manual and other relevant literature.[58]

Implementation Methods

Labor-Based Technology: The application of labor-based approaches to basic access RTI interventions contributes to their poverty-alleviating impact. Constructing RTI with labor-based methods requires between 2,000 and 12,000 person-days per kilometer for construction and 200 to 400 person-days per kilometer for maintenance. Utilizing local labor allows the local community to earn wages, as does procuring materials and tools from local sources. Furthermore, labor-based methods contribute to local empowerment through skills-transfer and creation of ownership. Also, if correctly designed, labor-based methods can have a substantial gender-specific impact.[59]

The type of work associated with basic access is ideal for labor-based methods. Spot improvement interventions are small-scale and varied, requiring attention to detail, and often do not require heavy construction equipment. In the case of community RTI, the full involvement of the community gives them the opportunity to acquire the skills for the eventual infrastructure maintenance by labor-based methods. It is important to note that equipment (for example, graders) are seldom available for subsequent maintenance activity for RTI, a fact that should be planned for at design.

There are certain prerequisites for effective labor-based contract execution, including labor availability in sufficient numbers, supervision experience, and the availability of qualified contractors. These contractors must be small-scale and have experience in labor-based project execution. They should possess, or have access to the appropriate equipment. If they have no direct experience in labor-based execution of works, they must at least be willing to undergo respective training.[60] Box 3.2 elaborates on the relevance of labor-based approaches.

Box 3.2. ***Relevance of Labor-Based Execution***

Road construction and maintenance works are often described as equipment-based or labor-based, depending on the relative intensity of productive factor use. The term “labor-based” is used to describe projects where labor is substituted for equipment when it is cost-effective. This covers most road-related activities apart from compaction and heavy earthworks. The term also includes the use of appropriate light equipment (mostly tractor-trailer) which supports the utilization of labor in specific essential activities such as compaction and gravel haulage for surfacing.

In most developing countries, especially in rural areas, unemployment is high, jobs are scarce, and the average daily wage rate for workers in the agricultural sector is somewhere between less than $1 and $5 per day. Equipment is usually owned by a few large-scale contractors or government departments. Maintenance and back-up services can be problematic and expensive, and real equipment costs are prohibitively high. The lower unit-cost of labor relative to capital therefore makes labor-based road works both economical and socially desirable.

In their recent publication *Employment-Intensive Infrastructure Programs: Labor Policies and Practices, 1998*, the International Labor Organization concludes that* labor-based construction and maintenance: (a) was about 10 percent to 30 percent less costly, in financial terms, than more equipment-intensive works; (b) reduced foreign exchange requirements by 50 percent to 60 percent; and (c) created, for the same amount of investment, two to five times more employment.

Several important factors contribute to the viability of labor-based construction techniques, such as government attitude, economic conditions (especially labor and capital markets), the location of the project, road agency administrative and financial procedures, capacity for management and human resource development, and the provision of adequate training.

* Based on comparative studies carried out in a number of countries, such as Ghana, Lesotho, Madagascar, Rwanda, Zimbabwe, Cambodia, Lao People’s Democratic Republic (Lao PDR) and Thailand.

Source: Authors.

Despite these advantages, it has been difficult to mainstream labor-based approaches. The difficulties encountered include inflexible labor laws, the availability of cheap second-hand heavy equipment, unsuitable procurement laws, and a lack of capacity to rapidly pay labor-based contractors.[61] To mainstream labor-based approaches, these obstacles need to be overcome at the policy level.

Small-Scale Contractor Development: By their very nature, basic access interventions are small-scale, varied, and scattered. The work is ideal for execution by small-scale labor-based contractors and by community contracts. Such types of contracting require (a) an appropriate policy environment; (b) capacity building programs for designing, managing, and execution of contracts; and (c) appropriate procurement procedures.

Considerable experience is available for the development of small-scale labor-based contractors.[62] An enabling environment must be created. If the contractors are to survive, they require a regular workload, rapid payment of bills, and access to credit facilities and equipment rental opportunities. The key is the management capacity of the contracting agency. To overcome capacity constraints at the local government level, it is often recommended that government entities join together to form joint-services committees or hire consultants to assist in contract management.[63] Contractors’ associations have an important role to play in the capacity building process as well.[64]

The limited capacity of single small-scale contractors may require the employment of numerous contractors if major earthworks are involved (average capacity will be about 1 km of earthworks per month and 0.5 km of gravelling per month). Part of the capacity building process is assistance to the contractors with appropriate equipment, which in most cases is tractor-towed equipment, such as trailers, water bowsers, rollers and towed graders.[65]

Community Contracting: Community contracting has become a major means of channeling grant funding to the rural poor. Community contracting means procurement by, on behalf of, or from communities. Implementing agencies are the communities themselves who take direct responsibility for their own development, and the role of government here is to provide facilitating support (usually through the assistance of NGOs). Participation from the community has to be an overriding consideration in designing the various procedures, including procurement and disbursement. Simplified procurement procedures for community contracting are required.[66] Experience from such community-based investment operations has shown that participation greatly assists accountability. A key feature for successful community contracting is the existence of a legal framework that gives communities legal status, without which they are unable to receive or manage funds.

Maintenance of Basic Access RTI

A common feature of RTI is insufficient or non-existent maintenance. Financial allocations to RTI maintenance are almost always inadequate, both relative to the main road network and compared to general expenditures for construction.[67] Moreover, capacity to execute maintenance is lacking. A good indicator for the lack of maintenance capacity is the need for rehabilitation, which by definition is caused by a lack of maintenance. Earth and gravel roads and paths are very vulnerable to the elements and will often not survive a single season without proper maintenance. A road or path is no better than its weakest link, and one failed drainage structure or section can be sufficient to disrupt access. The principle roots of maintenance neglect are institutional and financial. These must be addressed prior to any consideration of investments in RTI.[68]

Maintaining an earth or gravel road is relatively costly. As a rule of thumb, undiscounted maintenance costs over the typical life of RTI will equal the initial construction costs. For example, a typical $5,000/km basic access road may cost an average of $250 a year per km to maintain over its assumed twenty-year life.

From an engineering point of view, there are important tradeoffs between routine, recurrent, and periodic maintenance, and further investments. Often, enhanced routine maintenance is able to provide the required “passability,” which reduces the need for periodic maintenance or further investments in the form of spot improvements. This is of particular importance with respect to periodic maintenance.[69] In many developing countries, reserves of naturally occurring gravel used for periodic renewal of gravel layers are simply no longer available. The maintenance of a proper camber and the protection of drainage structures will reduce the need for periodic maintenance and rehabilitation. If comparing the costs of increasing the grading frequency on earth roads against gravelling at low traffic levels, the former is usually much more economical.[70]

4. APPRAISING RTI FOR BASIC ACCESS

Appraisal, in the widest sense, includes the analysis and assessment of social, economic, financial, institutional, technical, and environmental issues related to a planned intervention. This chapter discusses appraisal in the context of participatory approaches for the selection and priority setting of RTI interventions and projects, as well as the economic rationale of the planning process. It also describes alternative screening and ranking methods, in particular cost-effectiveness and cost-benefit approaches. For further information on these methodologies, the reader is referred to the relevant literature.[71] For a discussion of technical issues, see the previous chapter. Examples of recent economic appraisals of World Bank financed RTI projects are given in Appendix E.

A Participatory Planning Approach

Local communities are the main stakeholders and users of RTI. In recognition of this, there is now wide acceptance that their participation in the preparation and implementation of investment programs enhances local ownership and commitment, and fosters better accountability, management and sustainability.[72]

Although ongoing decentralization efforts in many developing countries have made local governments and communities responsible for the provision of local facilities, including RTI, a comprehensive planning process for these assets has not usually been put in place. In a first step, at both the local government and community level, priorities must be assessed across sectors. Once the need for a RTI intervention or project has been agreed upon, care must be taken that maintenance of existing RTI is incorporated into the early stages of the planning process.

The planning framework must be built on a participatory and iterative process, simultaneously bottom-up and top-down. A national or state-based agency for RTI should set guidelines. However, the driving force of the process must consist of priority setting and consultations at the local government and community level.[73] For ensuring and building capacity for effective participation, in most cases it is necessary to employ local NGOs or consultants that are professionally trained in participatory methods.[74]

Local consultations are also emphasized in the planning process in industrialized countries that rarely apply strict economic analysis to capital investments for local roads. In developing countries, however, where resources are extremely scarce (and often provided by donors) coherent selection tools that include economic considerations and are understandable to the local planners and communities can usefully support the participatory decision-making process (for example by illustrating opportunity cost and incremental trade-offs).

It has been argued that participatory decision-making can replace the economic selection process. This might be the case if investments are entirely locally financed, but even then the "wish list" will typically be more sizeable than available resources and a rational process (using economic criteria) should be used to help prioritize alternative investments. However, even modest contributions from outside sources can make economic planning tools useful, since the outside funding agencies, be it a road fund, government or a donor agency, will need to be convinced that the proposed investment is a sound and prudent use of its contribution.

Local Transport Plans*—*A Key Tool for the Participatory Process: Key tools for the participatory planning process are local transport plans, in the form of elaborate local government (district) transport "master plans" or simple community transport sketches (Figure 4.1).

Comprehensive coverage of transport infrastructure (including roads, paths, waterways, etc.) and transport producing facilities (villages, schools, health centers markets, etc.) should be contained in these plans. Guidelines for their preparation should be provided by the focal institutional entity responsible for rural roads in the country.[75] The objectives and core design criteria for these plans should ideally be contained in a country's National Rural Transport Policy and Strategy. Furthermore, they should be based on regional development plans which reflect the various sector strategies (such as health, education, infrastructure and agricultural development). They should be prepared in a participatory way in close consultation with the communities. A complementary planning tool for the community level planning process is the Rural Accessibility Planning (RAP) (Box 4.1).

Box 4.1. ***Rural Accessibility Planning (AP)***

To improve rural access effectively, an appropriate planning tool has been developed, with ILO technical assistance, through pilot projects in Asia and Africa. It partners with communities and local organizations to identify their access problems and propose solutions. AP focuses on the household, and measures its access needs in terms of time spent to get access. The underlying principle of AP is to reduce time spent on access which could then be spent on other activities.

Steps 1 and 2: Data Collection and Processing. Trained local enumerators collect data on household time spent and mode used to gain access to services and facilities. Processed data results in a demand-oriented access spread sheet for the target area.

Step 3: Preparation of Accessibility Profiles, Indicators and Maps. Access profiles for target areas cover basic information on location of facilities and services and the difficulties people have accessing them. Accessibly Indicators (AI) are calculated by multiplying the number of households (N) with the subtraction of the average travel time to a facility (T) minus the acceptable/target travel time Tm, times the frequency of travel (F): AI=N*(T-Tm)*F. Finally, maps are established with the available information.

Step 4: Prioritization. The larger the value of the AI, the greater the problem.

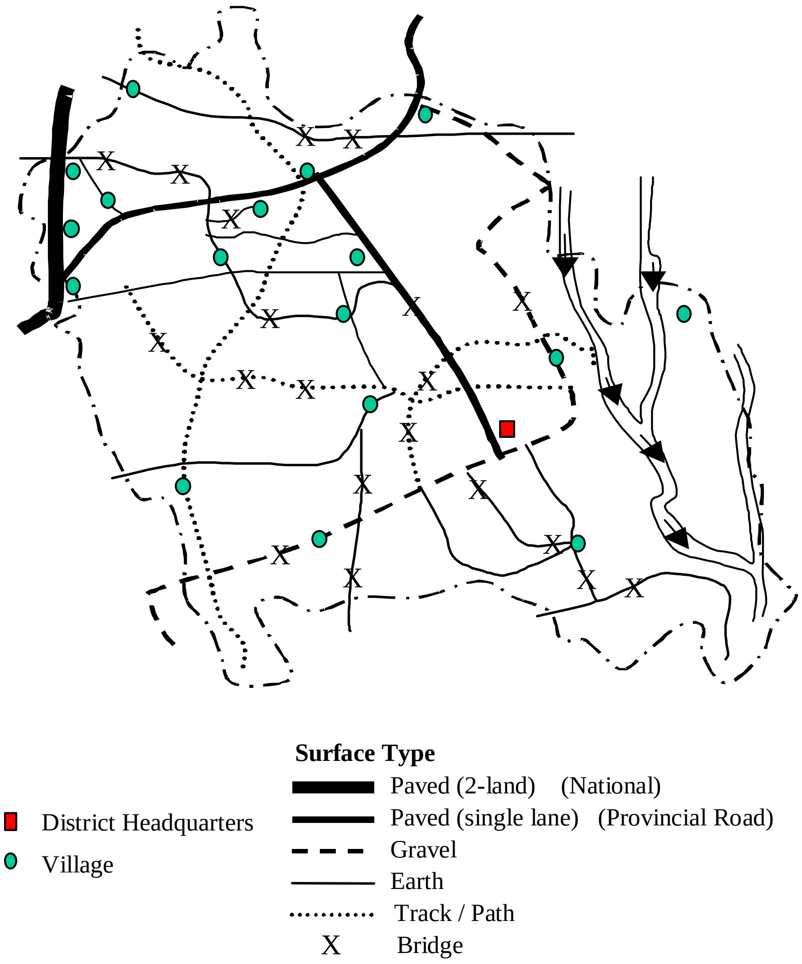
Steps 5, 6 and 7: Data Validation and Defining Targets and Objectives, and Project Identification. Results of the AP are presented and discussed in a participatory decision making workshop where pending on available budgets interventions are identified, which most effectively reduce time and efforts spent in obtaining access (including improved transport infrastructure, provision of means of transport and relocation of facilities).

Step 8: Implementation, Monitoring and Evaluation. Identified projects are integrated into the overall local planning system for implementation, monitoring and evaluation with local communities fully involved.

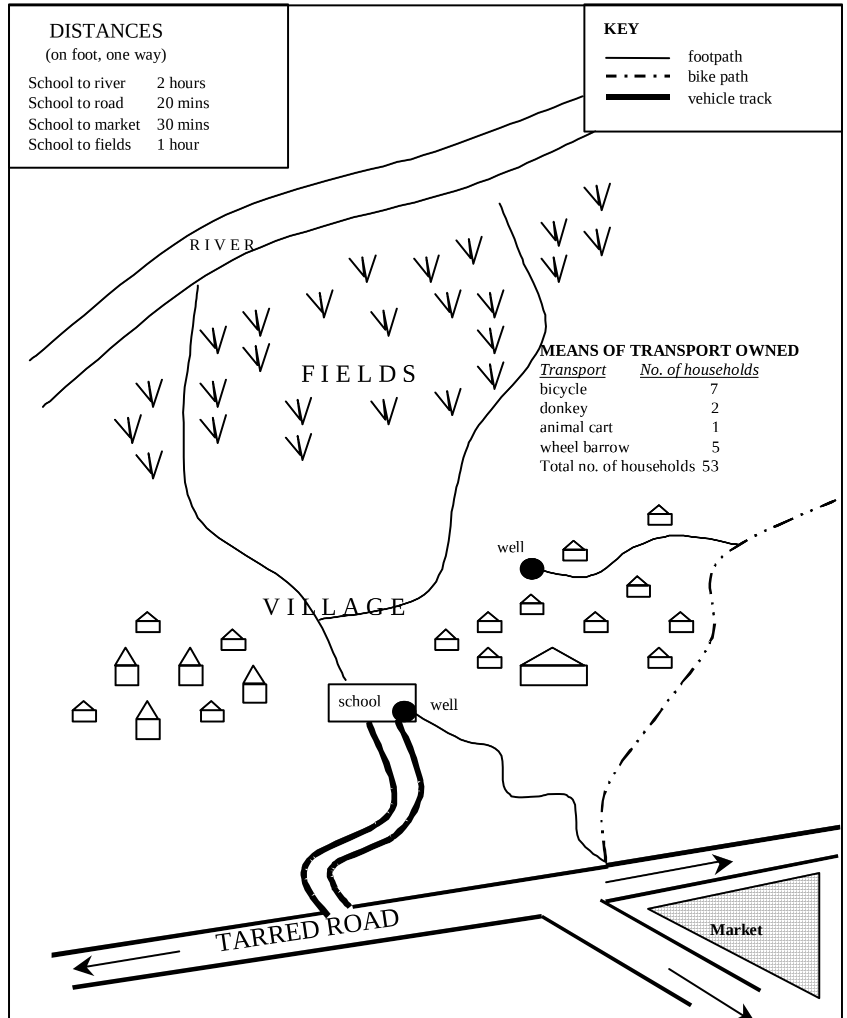
Source: Adapted from Fatemeh Ali-Nejadfard, 2000.

Most of the necessary data for the master plan can be obtained by means of a low-cost road and path inventory and condition survey conducted by local engineers or consultants in consultation with communities.[76] Planners and engineers conducting the survey assess the expenditure and type of works necessary to bring each link to basic access standard.[77] In addition, when existing traffic levels merit, the condition survey should assess the costs of bringing links to fully engineered standard. During the condition survey, traffic data (see Appendix D) and other information such as location of villages, schools, health centers and major traffic-generating facilities such as markets are collected simultaneously. On the basis of the condition survey and socioeconomic data, an "as is" map is established. An example is shown in Figure 4.1.

Figure 4.1. ***Typical Local Government and Community RTI Network "as is" Maps***



Source: Authors.



Source: Adapted from J. Doran, 1996.

Selection and Priority Setting Methods

Screening and Ranking: Selection and priority-setting methods for basic access RTI interventions consist of two broad types of methodologies which are usually applied in succession: (a) screening and (b) ranking. ***Screening*** decreases the number of investment alternatives given budgetary constraints, which may involve: (a) targeting disadvantaged areas or communities based on poverty indexes, or (b) eliminating investments into low-priority sections of the network selected based on agreed criteria.

Targeting Poor and Disadvantaged Communities: One of the purposes of screening is to target investments to disadvantaged regions, local governments and communities. Screening approaches were developed initially for targeting isolated or economically deprived communities and regions. They have since been adapted for the selection of districts, communities, and municipalities on the basis of poverty criteria—measuring economic standing and potential, as well as social development (such as literacy and health statistics). This might also be a useful approach for identifying areas adversely affected by structural adjustment measures or natural disaster. In China, for example, poverty-based pre-screening was used to identify "priority counties," with a second- and third-stage screening process was then used to identify specific road sections and corresponding design standards (Box 4.2).

Box 4.2. ***Selecting Road Improvement Components for Poverty Alleviation***

Two recent Bank-financed highway projects in China (Second Henan Provincial Highway Project, 1996, and Second Shaanxi Provincial Highway Project, 1996) included a poverty-focused component. The component was proposed in line with the provincial government programs of Road Improvement for Poverty Alleviation (RIPA), which aimed to provide all-weather access through rehabilitation, upgrading, and construction of rural roads to a main provincial road axis for every poor county township and the majority of villages.

A three-stage screening procedure was developed to select rural roads to be included in the project's RIPA component. The first stage of screening identified the "priority counties" that were most in need of improved road transport as an element in alleviating their poverty. The criteria used to prioritize included average income per capita, number of the "very poor" per 10,000 population, value of agriculture production, value of mineral production, and other social development indicators (including literacy rate, health workers per thousand population, and access to clean drinking water).

The second stage of screening used a cost-effectiveness criterion to select rural road systems from these priority counties. In this stage, rural roads for improvement in these counties were grouped into the RIPA systems based on three criteria: (1) continuity of the system; (2) maximization of the population served; and (3) connectivity to as many settlements as possible. Then a cost-effectiveness criterion—the proposed investment cost divided by population served in the influence area of the system—was used to screen the RIPA road systems. The very high unit cost systems were dropped. Finally, available financial resources were taken into consideration in deciding the number of systems and size of the RIPA packages that passed this stage of the screening.

The third stage of screening consisted of an analysis of the economic and social benefits of each of the road systems included for consideration at the end of the second stage. The analysis also included a review of motorization trends to guide the selection of proper road class and road engineering design that would meet the future needs of both motorized and non-motorized traffic in these rural areas.

Source: Hajj and Pendakur, 2000.

Eliminating Low-Priority Links of the Network: Another use of screening is to eliminate low priority links from consideration for investments. For example, in the case of the district transport master planning process in Andhra Pradesh, it was decided that for each village only one link, normally the shortest one, would be upgraded to basic access standard. This reduced the road network that was considered for interventions from about 5000 kilometers to 3000 km per district (Figure 4.2 and Appendix E.1). There are many other examples of elimination by screening.[78]

Ranking: After screening methods have been applied to a given set of investment choices, resources are still unlikely to be sufficient to finance the balance of the remaining desirable interventions, and hence a ranking or prioritization exercise is required. The following three main ranking methods for RTI are discussed in the following paragraphs: (a) multi-criteria analysis; (b) cost-effectiveness analysis; and (c) cost-benefit analysis.

Multi-Criteria Analysis

Multi-criteria analysis (MCA) is commonly used to rank RTI investments. Criteria such as traffic level, proximity to health and educational facilities and agricultural assets receive weights (points) relative to their perceived importance. Each road link is then allocated the number of points corresponding to the fulfillment of the particular criteria. The aggregate number of points that each intervention receives is computed by simply adding the points allocated per indicator, or through the application of a more complex formula. The result of this process leads to a ranking of the investment options.

In most examples, indicators used under MCA implicitly reflect economic and subjective evaluations. If the weights and points are decided upon and allocated in a participatory way, MCA has the potential to be a participatory planning method based on implicit socioeconomic valuation. However, it tends to be applied by consultants or planners in isolation without consultation with the concerned users and stakeholders. The outcome of the MCA methodology, is often, unfortunately, non-transparent, especially if too many factors are considered and a complicated formula applied. Therefore, if adopted, this method has to be used with great care and kept simple, transparent, and participatory.

Cost-Effectiveness Analysis

A subset of the MCA is the cost-effectiveness analysis (CEA). CEA compares the cost of interventions with their intended impacts. CEA is widely used to appraise investments in the social sector, however, has rarely been used in the transport sector. This has largely been due to the belief that the impacts of transport interventions are mainly economic in nature and should be measured. With the increased focus on the poverty and social impacts of transport investments, and their justification on these broader grounds, CEA has recently become more prominent.

The operational policies[79] of the World Bank allow the use of CEA in situations where benefits cannot be measured in monetary terms, or where measurement is difficult. There are provisions, however, that (a) the objectives of the intervention are clearly stated and are part of a wider program of objectives (such as poverty alleviation); and (b) the intervention represents the least-cost way of attaining the stated objectives. “Least-cost” in the context of RTI means that “basic access standards” have been applied as elaborated in Chapter 3.

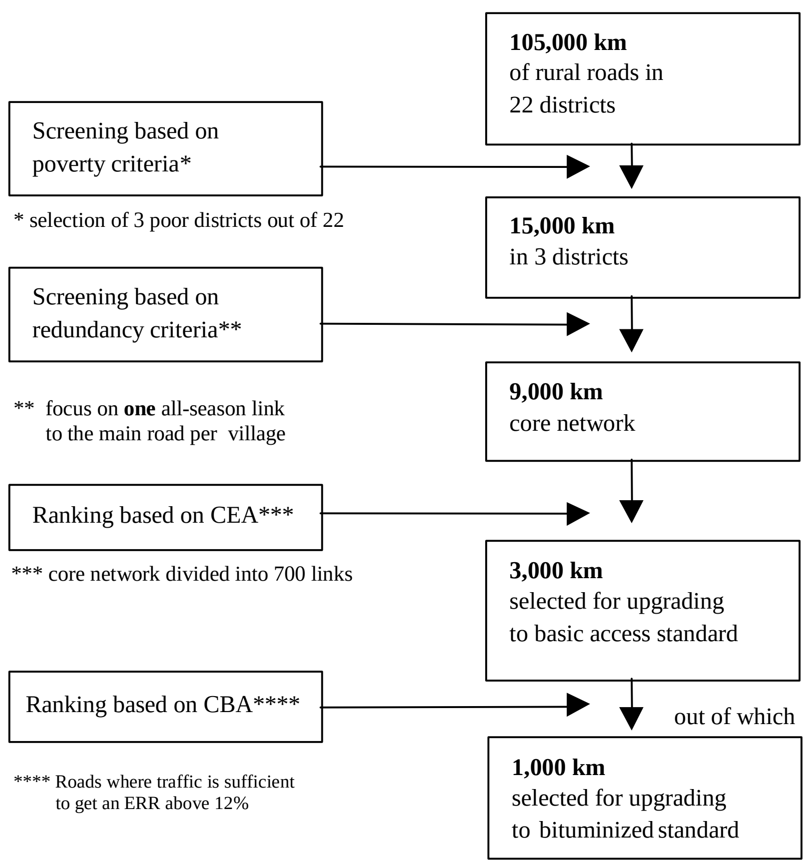
For example, one of the first Bank-financed rural transport projects where CEA was intensively used for the ranking of rural road investments was the Rural Roads Component of the Andhra Pradesh Economic Restructuring Project. The selection process used in this project is described in Figure 4.2. For a description of the economic analysis carried out, see Appendix E.1. The CEA was applied to rank individual links of a "core network" selected on the basis of screening criteria. The cost-effectiveness indicator was defined as the cost of improving a particular link to "basic access standard"[80] divided by the number of people served by the link.

$$\textbf{Cost-effectiveness indicator of link}_{(i)} = \frac{\textbf{Cost of upgrading of link}_{(i)}\textbf{ to basic access standard}}{\textbf{Population served by link}_{(i)}}$$

On this basis, up to 700 individual links were ranked. In view of the available financing, it was then decided that the maximum amount of investment allowed per link would be $50 per person served.[81]

CEA also lends itself to the incorporation of poverty and other factors as is shown in Box 4.3 (for details on the economic analysis of this project see Appendix E.2).

Figure 4.2. ***Applying the Basic Access Approach: Rural Road Component of the Andhra Pradesh Economic Restructuring Project***



Source: Authors.

Box 4.3. ***Applying the Basic Access Approach: Vietnam's Second Rural Transport Project***

The overall goal of this project is to contribute to poverty reduction in rural Vietnam. To meet this objective, the project aims to provide "basic road access" to all communes in participating provinces. For purposes of the project, basic road access is defined as year-round motorized access from the commune center to the closest district center. District centers have many of the higher level facilities —hospitals, upper secondary schools, market centers. Effective year-round road access to the district center can be expected to make significant impacts on living standards in the communes.

A) Basic access roads: Before project implementation, it was not clear whether the budget would be sufficient to provide basic access roads to all communes; (there was also the possibility that it would be too much). A cost-effectiveness methodology that takes poverty, population and project costs into account was thus used to prioritize between eligible roads. Among the different groups in the population, the formula put about three times more weight on the poor than on the non-poor. The choice of three as the relative weight on the poor was discussed and agreed to in focus-group meetings with local non-transport experts and with the Ministry of Transport. The index for ranking alternative basic access roads is then:

$$\mathbf{CE_1 = (\#\ of\ poor + 0.3*\ \#\ of\ non\text{-}poor)/total\ cost\ of\ rehabilitation}$$

B) Selected rehabilitation and spot improvement on other roads: Once basic road access needs are met, remaining funding can be devoted to selected rehabilitation and upgrading of other roads. This budget is allocated to the highest priority road projects as determined by cost-effectiveness rankings based on a formula that takes into account poverty, population served, potential for agricultural development (as measured by unused land with agricultural potential and number of social and other facilities) and costs of the proposed works. The index for ranking roads for rehabilitation/spot improvement is:

$$\mathbf{CE_2 = \{[1 + (unused\ land/per\ person) + (facilities\ /per\ person)]*[\#\ of\ poor + 0.3*\ \#\ of\ non\text{-}poor]\}/\ total\ cost\ of\ rehabilitation}$$

Again, the choice of variables (subject to data availability) were discussed and agreed to in focus group meetings with local non-transport experts and with the ministry of transport.

Source: Dominique Van de Walle, 1999.

Thresholds for Cost-Effectiveness: Unlike CBA, where projects normally are deemed "uneconomic" when their ERR falls below 10-12%, there are no well established criteria for determining "opportunity cost" thresholds when ranking on the basis of cost-effectiveness. Such a determination is then left to policy makers. For example, if access can be provided to two, otherwise similar communities at $100 per person served and $50 per person served, respectively, cost-effectiveness criteria would clearly "rank" the latter community higher. However, the question that remains is whether $50 per capita is a sufficient "return" to justify intervention (could that $50 per person be spent with more impact in another sector, or would it yield an ERR of 10-12% considering the opportunity cost of capital in the country?). In practice, for basic access RTI, such thresholds do not usually become a point of debate, because project budgets are normally pre-set and are exhausted before what most planners agree are reasonable cost-effectiveness limits.

Sample Study to Indicate Economic Viability: To overcome the problem of open-ended thresholds associated with the CEA method, it may be desirable to complement the CEA method with a sample study based on cost-benefit analysis for one or two roads in the project area (see below). If this sample study can establish that a per-capita threshold of investment meets the prescribed economic rate of return for the sample link (such as the $50 used in the Andhra Pradesh appraisal mentioned above), then all links above the threshold are likely to be viable. Such an approach has been shown to provide a good economic basis for applying the CEA method to a broad RTI investment program, especially where socioeconomic characteristics do not vary greatly.

Cost-Benefit Analysis

A more common alternative to CEA is to undertake an economic evaluation of road investments using cost-benefit analysis (CBA). CBA is a comprehensive accounting of all the real costs and benefits associated with a project. In the case of road projects, this includes users and non-users, as well as road agency costs. Where the impact on non-users is negligible, a CBA of road alternatives centers around the trade-offs between total life-cycle costs of infrastructure (capital and maintenance) and user costs and benefits (operating cost of the primarily vehicle and time savings). The outcome of CBA permits ranking of alternative interventions on a particular link based on the net present value (NPV). Where a number of different but independent links are being considered (and there is a fixed capital budget) ranking can be based on the net present value per financial investment outlay ratio (NPV/INV), or net present value per kilometer (NPV/KM) if road infrastructure costs (capital and maintenance) are the same for all links. The benefit from cost savings for transport users can be considered an increase in “consumer surplus”, if such savings accrue to the users as reduction in transport costs or charges. Alternatively, if transport cost reductions lower producers’ input and output costs, and result in higher net income, then the benefits can be considered as an increase in “producers’ surplus.”[82]

Producer Surplus Methods are discussed in detail in the well known works of Carnemark, Beenhakker and others.[83] The method requires assumptions concerning the impact of transport investments on local agricultural productivity and output which are difficult to assess, particularly in a situation where interventions are expected to open up new areas and adequate production data may be difficult to compile. To the extent that RTI investments are increasingly focused on existing networks and often put more emphasis on social rather than economic objectives, the application and relevance of the producer surplus method has decreased in recent years.

Consumer Surplus Methods are well established and applied in road investment models, such as the Highway Development and Management Model, Version 4 (HDM-IV). The methods are reliable to apply to higher-volume roads (>200 VPD). However, its application to low-volume roads encounter problems related to the small magnitude of user benefits and the stronger influence of the environment rather than traffic on infrastructure deterioration. With traffic levels between 50 and 200 VPD, and particularly with regard to unpaved roads, a modified and customized approach can be taken, as is done in the recently developed Roads Economic Decision Model (RED) (see Appendix F). This method attempts to take into account uncertainty related to the input assumptions and an expanded treatment of user benefits (Box 4.4).

For traffic levels below 50 VPD, as is the case on the majority of RTI, the consumer surplus approach is usually not recommended because the main benefits from such projects are not from savings in motor vehicle operating costs, but relate to the provision of access itself. As discussed previously, for various reasons the benefits of access are difficult to quantify. Also, traffic on such very low volume RTI typically consists of a majority of non-motorized vehicles (where part of the costs are human energy needed to pull or push the vehicles, which cannot be easily priced), animal transport such as haulage by mules, walking and head loading (porterage). Therefore, the following section proposes some extensions or special adaptations to the traditional CBA and discusses their appropriate application for RTI.

Box 4.4. ***Roads Economic Decision Model (RED)***

The Roads Economic Decision Model (RED) provides an approach for improving the decision-making process for the development and maintenance of low-volume roads. RED is a consumer surplus model designed to help evaluate investments in roads with traffic volumes between 50 and 200 vehicles per day. The model is implemented in a series of Excel workbooks that estimate vehicle operating costs and speeds, perform economic comparisons of investment and maintenance options, switching values and stochastic risk analysis.

RED simplifies the economic evaluation process but at the same time addresses the following concerns related to low-volume roads: (a) reduces the input requirements; (b) takes into account the higher uncertainty related to the inputs; (c) computes internally generated traffic based on a defined price elasticity of demand to which induced traffic can also be added; (d) quantifies the economic costs associated with the days-per-year when the passage of vehicles is further disrupted by a highly deteriorated road condition; (e) optionally, uses vehicle speeds as a surrogate parameter to road roughness to define the level of service of low-volume roads; (f) includes road safety benefits; (g) includes in the analysis other benefits (or costs) such as those related to non-motorized traffic, social service delivery, and environmental impacts, if they are computed separately; and (h) presents the results with the capacity for sensitivity, switching values and stochastic risk analyses. RED can be downloaded free of charge at http://www.worldbank.org/html/fpd/transport/roads/tools.htm

Source: Archondo-Callao, 1999.

Extending the CBA Framework for RTI

Because traditional CBA approaches do not account for many of the benefits of RTI investments, extending the framework of CBA holds promise for improved analysis. The proposed enhancements of traditional CBA techniques are aimed at finding broader measures of economic benefits and costs applicable to RTI. That is, while the principles of analysis are the same, the special features of RTI call for special methods of analysis. The methods described here can serve as a useful foundation for "pilot" or "sample" CBA to supplement CEA, or in the case of a low-volume road that presents a major investment, a new access option to a given area, or a proposed upgrading to a higher than basic access level. Possible enhancements of CBA include:

- Better assessment of the costs of interrupted access
- Estimating operating cost savings of NMT
- Savings due to mode changes (from NMT to motorized transport)
- Improved valuation of time savings, and
- Valuation of social benefits from improved access to schools and health centers

Better Assessment of the Cost of Interrupted Access: For cases where passability suffers during the rainy season, an assessment can be made of the extent of interruption. Seasonal changes in transport quality can be assessed on the basis of local socioeconomic impact, such as higher goods prices, lost productivity, or decreased social travel. In such cases, an assessment of the impact on particular activities may be necessary, since losses associated with seasonal interruptions will vary by activity (agriculture, marketing, travel for jobs and related wage earnings, school attendance and consequent decline in quality of education, health visits, etc). It may be difficult to directly observe the impact of seasonal access variations, and such information will usually need to be collected either through a local survey or other participatory processes. In addition, it may be possible to examine the costs associated with alternative (but longer) routes (that increase transport cost and time), or substitutes for transport (migration, storage), or even lost opportunities and income, to better understand the impact.

Estimating Operating Costs Savings of NMT: Methods for calculating the non-motorized transport user cost savings from road improvements have only recently become a part of project evaluation. Studies in Bangladesh and Indonesia have estimated user costs for a set of NMT and the results of these studies has been integrated in the HDM-4 model.[84] In particular circumstances, additional country- or area-specific field work may be necessary to get realistic estimates of NMT costs. Particular information is required regarding operating costs in relation to differing road surface conditions. Box 4.5 gives an example from Bangladesh.

Box 4.5. ***Rickshaw Operating Costs in Bangladesh***

Studies in Bangladesh indicate how to realistically assess (changes in) the cost of transport services by rickshaws and rickshaw-vans that are used as a major form of rural transport The rickshaw-van is the most common NMT used for goods in rural Bangladesh, and it is driven (pedaled) by a van driver. It can carry about 400 kg weight per trip. Since the main cost of its operation is the time and food-energy used by its driver, its operating cost is difficult to estimate. For project analysis, therefore, charges actually made by the rickshaw-van operators on different types of road conditions were collected through surveys. The vehicle operating cost savings used in the study are based on actual differentials in charges between existing poor roads and improved roads, as they substantially reflect the cost variations due to greater exertion, time and additional food for higher level of effort and energy needed for plying on rougher roads. Since NMT transporters operate in a highly competitive market where there are no significant externalities, these financial rate differences are taken to reflect economic cost differences. The surveys showed that the rate per ton-km on moving on a rough (earth) road was more than double the rate for a smooth asphalt road (about $0.50 per ton-km for the rough road, compared to $0.20 per ton-km on smooth roads). An interesting aspect of the case in Bangladesh was the realization that human–pulled vehicles need smooth surfaces even more than motor vehicles, and that road investments in black-topping could be justified when heavy NMT traffic exists, even though the number of motor vehicles in use is less than 50 per day. It was also clear that the people generally had small parcel loads or a few bags at a time to transport over short distances, which was best suited for the efficient form of NMT in Bangladesh (the rickshaw-van). Indeed, with road improvements there was a fast increase in both motor vehicles and NMT traffic. The Bangladesh studies also established that after road development there is dynamic growth in traffic and a change in vehicle composition: buses starting to appear for the first time, and overall traffic growth exceeded 100 percent even in the first year after project completion. The study also found that cost differences between the with- and without-project situations are best estimated through likely changes in the composition of vehicles (decline of bullock carts and head porterage, and increase in both NMT and motor vehicles) and related unit costs.

Source: (1) "Bangladesh Rural Infrastructure Impact Study," with special reference to RDP-7 and other projects, 1999. (2) Bangladesh Rural Infrastructure Strategy Study, 1996.

Savings due to Mode Changes (from NMT to motorized transport): Very significant savings can be made due to road improvement- or construction-induced changes in the modes of transport. Resulting cost reduction can ten fold as shown in Box 4.6 below.

Improved Valuation of Time Savings: A critical aspect of examining alternative RTI interventions is an understanding of the impact of improvements in infrastructure on journey times, and therefore (beyond the impact on vehicle operating costs) on productive time saved, including those associated with non-motorized travel and transit time of freight. The process of valuing time in transport operations is not without controversy (Box 4.7), and while there are currently no universally accepted methods for determining a "value of time," some general guidance is possible.[85] For additional, information on valuing travel time savings, see Gwilliam (1997).

Box 4.6. *Savings due to Mode Changes in Ghana and Elsewhere*

Studies in Ghana (and elsewhere) have established that head porterage takes about two person-days to move one ton-km, using factors of average load size, walking speed per hour, and time for the return trip (without load). Using the minimum wage rate, this amounted to about $2 to 2.50 per ton–km. The minimum wage is taken as a proxy for the resource costs (food, expenses, etc.), and for the time and effort involved.

More recent studies indicate that where transport is not available, the rural poor experience a shortage of productive time in doing various chores in their daily lives and farming, marketing, and transport activities, and therefore their time should be given a higher monetary value. This is indeed a valid consideration, but not reflected in the price noted above (see also next paragraph on the valuation of time savings). The estimated rate of $2 to 2.50 per ton-km mentioned above was also found to reflect the actual market charges for such operations.

This rate range is found valid for head porterage in many developing countries. In Balochistan (Pakistan), Nepal, and Bhutan, where mule transport is a common form of transport in rural areas, the actual cost is found to be about $3 to 4 per ton-km, including the cost of the mules and the persons walking with them. In Bhutan, a similar rate was found through market inquiries of actual charges levied, and also from indicative tariff rates published by the Royal Government of Bhutan. This rate should be compared with about $0.20 per ton-km for trucking operating costs on low-volume roads, which would become applicable after road construction or improvement.

Source: Adapted from Tampil Pankaj, 1991.

Box 4.7. *Valuing "Journey Time Saving" in Developing Countries*

The issue of valuing time, or more specifically journey time savings, has been the subject of extensive theoretical and empirical investigation. However, most of this work has focused on conventional journeys of people by road and reflects the traditional arguments of transport economics. These revolve around the use of resource assessments of value, or inferring resource values from the behavior of travelers. Walking trips and those by other non-motorized means of transport have largely been ignored. Moreover, debate has generally centered around the issue of valuing journeys in *working time or non-working time*. The first of these categories refers to time for which the traveler is paid out of employment remuneration, and the second to all other uses of time such as commuting, shopping or social purposes. These categorizations are appropriate to the economic and social structures of developed countries, yet they are less helpful when the study population comprises rural household members who are: (a) predominantly self-employed; and (b) characteristically engage in multi-purpose, or simultaneous task trips. The latter is especially true of women who in many societies are the dominant transporters at the household level (see Bryceson 1995).

Most transport economics literature assumes that the majority of the rural population in developing countries will be in non-wage employment, and it is therefore considered to be traveling in non-working time which is ascribed a zero value. This clearly does not make sense, either in resource or behavioral terms. Walking journeys consume both energy and time, which are both valuable resources in rural subsistence households. The creation of energy is rarely a free good. Moreover, there are numerous examples where the behavior of such societies indicates that they place a relatively high value on their time.

Source: Howe, 1997.

In collecting data on the value of time, special attention should be given to estimating values which can be applied to particular modes of travel, such as bus versus bicycle travel. In addition, overall journey length may change stated time values, as can income level. Both should be evaluated in survey data. Finally, time required for walking, waiting, or transfer may need to be valued differently than specific travel time (on or in vehicles) and should be reported separately where possible. Where it is not possible to obtain local values for travel time, estimates from household income or shadow wages should be substituted. Table 4.1 offers relevant guidelines:

Table 4.1. ***The Valuation of Time Savings from Transport Improvements in Developing Countries***

Where it is not possible to derive values locally, the following bases should be used:
(W = wage rate per hour; H =household income per hour)

Trip Purpose	Rule	Value
Work trip	Cost to employer	1.33 w
Business	Cost to employer	1.33 w
Commuting and Other non-work	Empirically Observed value	0.3 H (adult) 0.15 H (child)
Walking/waiting	Empirically Observed value	1.5 x value for trip Purpose
Freight/Public Transport	Resource cost Approach	Vehicle time cost + driver age cost + occupants time

Source: Gwilliam, 1997.

Valuation of Social Benefits from Improved Access to Schools and Health Centers: It is often argued that the most important impacts of rural infrastructure improvements take place through changes in the patterns of personal mobility and increased social travel.[86] Improved rural access provides social benefits in promoting education, particularly through increased enrollment of girls, health benefits, increased labor mobility, the spread of information and knowledge, and also improved access to markets. Many studies demonstrate the dynamic changes that improved rural mobility brings to the social and economic life of rural areas. A study in Bangladesh comparing two sets of villages showed that villages with road access, compared with villages without access, fared much better in farm-gate price of produce, fertilizer use, land under irrigation, household income, income per acre of field crops, wage income of landless labor, and percentage of employed women.[87] Another comparative picture of villages from Bhutan, all under the same agro-climatic and cultural environment and also in the same district, not far from each other, demonstrate similarly impressive contrasts in school enrollment levels and other aspects (Table 4.2).

Table 4.2. ***Access, Income, and Education in Bhutan***[88]		
	"Accessible" (0-0.5 days walk to nearest road)	**"Not accessible" (1-3 days walk to nearest road)**
Distance to nearest road (walking time)	0-0.5	1-3
Average annual income/farm household	$176 equivalent	$71 equivalent
Enrollment of boys (age 6-16)	73%	42%
Enrollment of girls (age 6-16)	64%	22%
Source: Project Appraisal Document on a proposed credit to Bhutan for a rural access project, World Bank, November 1999.		

One common approach to quantifying social benefits (particularly benefits from improved access to education and health facilities) is to use a sample case as guidance for assessing similar benefits from other roads improvements in similar areas or regions in the same country. Such estimates can be considered together with the usual transport cost savings estimated separately. However, care must be taken to ensure that there is no double-counting of benefits in the process. In the above study, benefits from education were estimated from increased school enrollment levels (due to improved access), using estimates of the incremental life earnings of the children who would have otherwise remained unskilled. Health benefits were assessed based on reduced sick days away from work, lost net income, and other health savings from better access to health centers. Such an approach may involve considerable field data collection and analysis. The first study along these lines for appraising a rural infrastructure investment was done recently for the Bhutan Rural Access Project which was approved by the Board of the World Bank in December 1999. The Bhutan case also highlights other important approaches for the careful assessment of benefits from rural road access improvements. These benefits include the estimation of mule-haulage costs in the without-project situation, and the use of a 40-year life assumption for the road, which specifically is defined as a well-designed and erosion-protected mountain road with a gravel surface with expected good maintenance (in the case of Bhutan). Sensitivity analysis regarding these assumptions was done (see Appendix E.2).