

GUIDELINES FOR INTEGRATING  
THE ENVIRONMENTAL DIMENSION INTO  
RURAL ROAD PROGRAMMES

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## TABLE OF CONTENTS

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INTRODUCTION	1
RURAL ROAD PROJECTS AND THE ENVIRONMENT	1
SPECIFIC ENVIRONMENTAL IMPACTS	3
(a) Direct Impacts	3
(b) Indirect Impacts	5
(c) Potential Beneficial Impacts	7
PROJECT ORGANISATION AND MANAGEMENT	8
(a) Project Development	8
(b) Incorporating Environmental Aspects	9
(c) Data Collection and Interpretation	12
(d) The Benefits of an Integrated Approach	16
(e) Local Participation	17
CHOICE OF TECHNOLOGY	18
(a) Two Approaches	18
(b) An Environmental Comparison of Rural Access Projects	19
CHECKLIST	22

## INTRODUCTION

Roads, by facilitating movement of people, commodities, services and information, affect society in a multitude of ways. A single road may initiate a rural settlement's transition from a subsistence to a trade economy. A road penetrating a previously inaccessible wilderness area may provide opportunities for land development and small industry, but may simultaneously promote massive depletion of valuable natural ecosystems. Road networks exercise a direct and profound influence on patterns of population clustering and dispersal.

A road can be pictured as a line superimposed on the landscape, along which movement is enhanced. Movement across this line, however, may be impeded - not only by the physical presence of the road itself, but also by the traffic that moves along it, the settlers and settlements it attracts, and the influence it exerts on the use of adjacent land.

These guidelines are concerned with environmental impacts of rural access road building, upgrading, and maintenance. The term "environment" is here taken to mean natural and human-made physical environments. Rural access roads can roughly be defined as small roads with low traffic volumes, whose main objective is to promote the interchange of people, goods, services, and information within rural areas or between rural and urban markets.

Emphasis is placed on choice of technology. The guidelines contain a comparison of labour-based and equipment-based methods. The objective is to define the major possibilities and limitations of the technologies with respect to rural road programmes and the environment in developing countries.

Although economic considerations are not treated independently, they cannot be completely ignored. This is partly because of the frequent, or frequently perceived, trade-offs between economic and environmental goals, but also because an inexpensive road, all other things being equal, will leave more resources to cater for environmental concerns.

Finally, a survey of environmental impacts of road projects also supports the general maxim that prevention is superior to restoration. These guidelines should ultimately be seen as a manual, to be used by planners, designers, and supervisors, on how to incorporate the environmental dimension into rural road programmes before the damage becomes too costly to abate.

## RURAL ROAD PROJECTS AND THE ENVIRONMENT

Unlike trunk roads and primary roads, rural access roads are characterised by relatively low volumes of traffic. Some of the environmental impacts directly related to the traffic itself, such as noise and pollution from exhaust fumes, are thus of lesser importance. Issues related to safety, however, may remain crucial, particularly in rural centres where population density is high.

Rural access roads typically penetrate rural agricultural landscapes or wilderness areas. Environmental issues related to agriculture, natural resource use, and ecosystem preservation thus acquire added significance.

Construction of rural access roads is undertaken to meet a variety of objectives. In developing countries, a frequent goal of rural road projects is to improve access to markets for agricultural commodities. Road projects are also often an initial and integral part of more extensive rural development programmes, aiming to facilitate future development of infrastructure and social services such as health and education, local markets for exchange of goods, and even industry. Rural road construction may also satisfy more specific needs, such as providing access to areas of mature timber forest, transportation of mining equipment and extracted ore, resettlement of densely populated areas, or creating a link between two previously unconnected rural settlements.

One may distinguish between construction of new roads in formerly inaccessible regions, and the upgrading or rehabilitation of already existing roads and paths. The road surface is usually gravel or earth; the relatively low traffic volume associated with rural roads will rarely justify the costs that attend the building of a fully paved road.

The type and severity of environmental impacts will clearly depend on both the objectives that the road is supposed to meet and methods employed to fulfil these objectives. Long-term environmental effects of a rural access road will for example be influenced by the degree to which continued assistance in the form of industrial or infrastructure development is provided. The probable consequences of building a new road through a virgin rainforest are vastly different from upgrading an existing gravel road in an intensely cultivated area.

In addition to parameters associated with the planning and construction of the road itself, environmental effects are connected to a number of natural conditions such as topography, vegetation, soils and climate, as well as existing social parameters related to economy, demography, culture, and organisation.

Most tropical countries regularly experience periods of heavy and intensive rainfall. In conjunction with the frequently unstable soils, the tropical climate poses particular problems related to soil erosion in many developing countries. Tropical regions also contain most of the world's plant and animal species. Ecosystems are generally diverse but fragile.

The majority of people in developing countries are farmers, depending on the productivity of the land for their daily sustenance, and are thus particularly vulnerable to adverse environmental effects. Lack of formal land ownership and political infirmity may leave them powerless to remedy damage already done.

#### SPECIFIC ENVIRONMENTAL IMPACTS

Environmental impacts may be divided into (a) direct impacts - those impacts that

are a direct result of construction, maintenance, and use of the road, and (b) indirect impacts - impacts that arise because of changes in primary environmental, economic, cultural, demographic, or institutional parameters. Direct impacts are usually immediate or short-term, and relatively easy to gauge; indirect impacts take longer to appear, and are more difficult to predict.

(a) Direct Impacts

1. Soil Erosion and Siltation of Waterways

Many developing countries endure periods of high, intensive rainfall, which often cause problems of soil erosion. Heavy rains are also the major cause of road deterioration, and a good road will be characterised by its ability to collect, redirect, and jettison water from the carriageway onto adjacent land. The link between soil erosion and roads springs partly from this need to divert water away from the road, and partly from exposure of soils and removal of vegetation during construction. The threat of soil erosion will increase with amount and intensity of rainfall, size of catchment, steepness of terrain, instability of soils, and lack of vegetative cover.

Cross culverts that collect water from the side drains and discharge it onto below-lying land represent a major erosion hazard under unfavourable conditions. On steep slopes during rains, unless immediate remedial steps are taken, large gullies may form within the space of a few days.

Mitre drains, diverting water directly from the side drains onto adjacent land, are unlikely to cause gully erosion unless they are spaced too far apart. Small furrows will often appear, and may ultimately develop into gullies if control measures are neglected. Water discharges from mitre drains may cause mechanical crop damage during very heavy rains.

Land slides are a hazard on very steep slopes, i.e. slopes equal to or steeper than the natural angle of repose of the soil. In connection with road construction, land slides may occur when water is allowed to remain in the side drain for extended periods of time, saturating the top layer of soil on the downhill side of the drain. The same effect may be seen when cut-off drains parallel to the road are constructed to intercept culvert discharges.

In large catchment areas, during extremely heavy rains, the entire road may in some cases act as a water carrier, leading to formation of immense gullies at the points of outlet, as well as destruction of the road itself.

Quarries and borrow pits, unless care is taken when the site is chosen and the pit is replanted after construction, may induce gully erosion.

Erosion of soils will lead to siltation of waterways, with associated consequences such as change or destruction of aquatic ecosystems, deteriorating water quality, and reduced supply of drinking water. Siltation of waterways may also be caused by runoff from unprotected gravel and earth heaps during rains, and from the exposed

soils of major road cuts and fills.

## 2. Water Pollution

During road construction, oil, grease, and fuel spills from machinery may join water runoff and eventually contaminate drinking water reservoirs. Road accidents involving vehicles transporting toxic chemicals and fuel may pose a real threat on roads supporting such traffic. In the case of tarmac roads, chemical compounds may lead to minor water contamination.

## 3. Air Pollution

Pollution from exhaust fumes is generally not a serious problem on rural access roads. Dust raised by traffic on earth roads, and to a lesser degree gravel roads, during dry periods may damage crops on adjacent land and represent a serious health hazard; many people are allergic to dust, and very high concentrations may lead to lung diseases. Dust will also reduce visibility, increasing the risk of road accidents. The severity of the problems associated with dust will increase with traffic volume and exposure (number of people, and proximity to road).

## 4. Ecosystem Disturbance

A road, by its very existence, will necessarily be a disturbing influence on any natural ecosystem in the vicinity of the carriageway. The degree of disturbance and the scope for remedial measures will depend on the ecosystem through which the road passes, the dimensions of the road and its traffic, and social impacts such as settlement along the road and changes in land use.

A road bisecting a wilderness area, e.g. a primary rainforest, may cut off migratory routes of roaming wildlife populations, lead to fragmentation of sensitive wildlife habitats, destroy habitat heterogeneity, and create undesired edge effects.

Roads cutting through swamps, moors, and other wetlands, may cause flooding or prevent movement of water, and thereby severely alter the balance of aquatic ecosystems.

## 5. Aesthetics

A new road may in itself be regarded as a blemish on the landscape, where beautiful, pristine scenery is concerned. Scars from extensive road cuts, landslides and gullies will exacerbate the problem. Quarries may create large indentures in the natural landscape. A construction camp can be an eyesore, and road workers may leave behind piles of garbage and junk.

## 6. Cultural Sites

Religious sites or other sites of cultural importance may be destroyed by the right-of-way, or rendered useless for their intended purpose because of proximity to the road

and its associated impacts. The primary requirement of many such sites is that they are remote. A road that passes several hundred metres away may thus still exert a disturbing influence through the settlers and activity it attracts. Some cultural sites contain edifices and objects of high cultural or monetary value. A nearby road may increase the risk of theft or vandalism.

## 7. Other Hazards

Roads may facilitate the spreading of contagious diseases and pests through the enhanced movement of people, animals and plants. Abandoned quarries and borrow pits may end up as dead-water reservoirs, promoting the breeding of vectors of malaria, bilharzia and other water-related diseases.

### (b) Indirect Impacts

#### 1. Demographic Shifts

By linking together formerly unconnected areas or opening up new territory for settlement, roads may induce considerable demographic shifts. Environmental impacts of migration are difficult to predict. A road penetrating an isolated region will commonly lead to increased settlement in the area, and rising pressure on natural resources. Where such a road connects isolated settlements to regional and national road networks, urban migration may induce the opposite effect. A road linking two settlements together may lead to migration of people from one to the other, but the end result may also be reduced population and land pressure in both places through settlement of areas in between.

Environmental degradation commences when population density exceeds the carrying capacity of the land. In general, resource pressure and the likelihood of adverse environmental impacts will increase in areas which receive an influx of migrants and decrease in those which experience an exodus. There are, however, important exceptions to this rule: decreased pressure on land may prompt remaining farmers to revert to more expansive land use systems, e.g. traditional slash-and-burn cultivation, nullifying the effects of reduced population density; population dispersal may lead to land ownership conflicts, and associated environmental impacts (see point 3. below).

Negative environmental impacts and destructive land use practices result not only from population increase and rising land pressure. There is also the risk that new settlers are unfamiliar with the natural conditions and restrictions of the area, and the requirements for sustainable land use.

Finally, many developing countries struggle with ethnic and tribal animosity. Rural roads, by providing groups of people with access to new areas, may disturb sensitive ethnic balances, and in exceptional cases promote ethnic clashes. In a broad sense, roads facilitate the movement of weapons and the people who use them. More importantly, perhaps, roads penetrating pristine interiors such as the South-American Amazon may promote massive urban-rural migration and industrial development,

leading to displacement or even systematic eradication of indigenous peoples. Besides the obvious human misery directly related to killings and bloodshed, conflict and war will often be accompanied by massive destruction of property, e.g. through the torching of buildings, fields, and forest.

## 2. Changes in Land Use

Besides increased or decreased pressure on land through population clustering or dispersal, changes in land use may be caused by improved access to agricultural inputs such as seeds and fertilizer, easier access to agricultural output markets, or, in the case of e.g. virgin forests and minerals, by improved access to the resource itself.

Possible negative environmental impacts of changes in land use include: water pollution because of increased nutrient runoff from use of chemical fertilizer; health hazards due to increased use of pesticides; deforestation through increased logging of timber or collection of fuelwood; soil erosion or depletion of soil fertility because of deforestation or intensified cultivation; extensive degradation of land through strip mining.

The key issue is to what extent the changes will be towards or away from sustainable land use. Particularly in the cases where roads open up previously uninhabited areas of virgin land, accompanying measures to reduce negative environmental impacts must be considered carefully.

## 3. Land Tenure Issues

Conflicts of land ownership frequently arise when the right-of-way of the road is determined. Rural roads routed along property boundaries will distribute the loss of land among a larger number of land owners, but may give rise to the question of who should be responsible for alleviating potential negative impacts. Vital remedial measures, such as e.g. water retention through tree planting, contour ploughing, or terracing above the road to prevent erosion below the road, may therefore be neglected.

New or improved roads, when penetrating densely populated rural areas, will generally lead to the accumulation of land on fewer hands. This may be due to urban migration, or increased non-farm labour opportunities in the area as a result of increased trade or industrial activity. It is also an inevitable result of the increased activity in the land market that roads usually provoke.

The environmental effects of larger land holdings are ambiguous. If, however, the transition entails purchase of land for short-term gains, exploitative practices may emerge at the expense of the long-term productivity of the land.

### (c) Potential Beneficial Impacts

On steep slopes, tracks and paths resulting from the movement of livestock and



people will often follow a very direct route up and down the hillside, perpendicular to the contours. Such tracks will increase the speed of water, and may cause severe gully formation and soil erosion. A road must necessarily follow a winding path, more parallel to the contours, and may, if appropriate erosion control measures are implemented, reduce erosion.

The collection and discharge of rainwater associated with rural roads may be put to good use. Many arid areas in the tropics are plagued by shortages of drinking water and soil moisture. It is often feasible to build structures that permit channelling of water discharges from roads to irrigation systems and drinking water tanks. The rain water flowing through road drainage systems is frequently of a higher quality than that of natural waterways.

Wind erosion is also a common problem in arid areas. An elevated carriageway transecting a dry, sandy area may itself act as windbreak. Planting rows of drought-resistant trees along the roadside during project implementation can enhance the effect.

Finally, roads built in accord with the natural terrain through which they flow can be impressive structures to behold, and may enhance and underline the beauty of the landscape.

## PROJECT ORGANISATION AND MANAGEMENT

### (a) Project Development

Roads possess the basic characteristic of public goods, in that one individual's use does not preclude or interfere with that of another, or does so only to a very small degree. Thus, in most countries, public institutions must shoulder the main responsibility of initiating and monitoring road construction and maintenance projects. This fact is significant also in an environmental perspective; it has implications for the difficulties that one may encounter when attempting to engage private individuals in the control and abatement of the adverse environmental impacts that road projects may entail.

Although the planning process of road-building projects in developing countries frequently is muddled and anachronistic, projects roughly conform to a commonly applied sequence of project development: a project identification, or initiation, stage; a design and planning stage; an implementation stage; a monitoring and evaluation stage.

Initiation of a rural road project may come about through the evolution of national or regional development plans, or through the recognition of local needs as projected by rural inhabitants through their preferred channels of communication, e.g. district councils, political groups, or sales cooperatives. Whether the project arises from a locally formulated need, or is carried out without local consent, is likely to be of consequence for environmental considerations as well as socio-economic. An important issue is whether local authorities mainly see themselves as the central

government's extended arm in the area in question, or as the local inhabitants' voice in the government.

Most developing countries have an established governmental framework for the planning of road projects. Planning of rural access roads is usually the responsibility of the regional or local office of the relevant ministry or governmental agency. Government staff decide which road projects to undertake, to which specifications the road should conform, when construction should start, and, if it is a new road, what route the road should follow. Funding may be provided by a foreign donor, multilateral organisations, the central government, or, less frequently, by the region's or district's own funds.

Project implementation, i.e. the construction phase, will sometimes be carried out by private contractors. The contractor will then be responsible for hiring labour, providing machinery, and seeing that the road is built according to the specifications in the contract within the agreed time frame. Government involvement is thus limited to supervision, monitoring, and evaluation. In other instances, local or regional governmental units will use their own machinery and crews, and thus be able to complete the entire project without outside assistance. Various combinations of these two scenarios are also common.

On completion, the road should be evaluated, and procedures for monitoring and maintenance sorted out. Evaluation should preferably be carried out by independent consultants, but is commonly done by the government's own employees. Monitoring is usually also the responsibility of local government staff, whereas maintenance is mainly carried out by contractors or locally hired staff.

#### (b) Incorporating Environmental Aspects

The form and execution of rural road projects hinge on a variety of factors; financial, socio-economic and political factors are often more important than environmental concerns. The presence of potentially negative environmental impacts does not necessarily merit the redesign of a project, let alone its discontinuation. Some environmental factors, however, such as the protection of drinking water reservoirs and conservation of valuable but fragile ecosystems, are so crucial that extensive refashioning or abandonment of a project may be required. Others, such as soil erosion, must be addressed through the implementation of precautionary measures.

Road building is traditionally a technical discipline. The focus of road planning has largely been confined to the road itself. With the exception of urban areas, where road networks are integrated into the wider context of city planning, impacts on land bordering the right-of-way are neglected. Thus, in a general sense, there is a need to extend the responsibility of road planners to the entire area affected by the road.

Incorporating environmental aspects into road-building projects is largely a matter of involving the right people: people who can supply the required information, provide pertinent and balanced advice, and who have the training and competence to carry out necessary precautionary and remedial measures. Most rural roads are

planned by local governmental works units. The offices of e.g. agricultural counterparts are often in the same building or just down the road. Obstacles to closer cooperation are more related to traditional professional boundaries than physical constraints.

It is important that the process of considering the environmental aspects of a road project matches that of the project itself. Planning how to integrate environmental concerns during the road construction phase clearly is not sufficient.

Ideally, procedures that can ensure attention to environmental aspects should already be in place before the projects commence. Engineers and economists have traditionally had to bear the burden of transport planning alone. They may be distinguished professionals and full of good intentions, but only rarely do they have the know-how required to accurately assess the potential environmental consequences of their projects. By involving professionals and local groups with a knowledge of the environment in the framework for development of strategies and selection of projects, obvious pitfalls can be avoided and harmful projects scrapped before resources are squandered on their development.

Incorporating environmental concerns at the project initiation stage could be done in a formal setting, e.g. by way of a committee including members from a variety of local governmental departments and representatives of the local population, or by instigating formal procedures for distributing project proposals to the relevant bodies and inviting their comments. The advantage of formalised procedures is the accountability that it imposes on the planners; the interdisciplinary approach is not an option but a requirement. The drawback is bureaucracy; formal procedures and their enforcement involve legislation, negotiation and often conflict. Human and financial resources are expended, and the planning process is delayed.

The informal approach has the opposite costs and benefits. Many road-building projects will require only a brief review by a few individuals in order to determine its major potential environmental effects. Excessive red tape is avoided, but successful integration of environmental considerations will depend on the willingness of road planners to consult relevant individuals and institutions. Considering the difficulties associated with legislation and enforcement of regulations in developing countries, a less formal approach is usually a more realistic alternative. To successfully promote interdisciplinary practices, however, a concerted effort from donors and central ministerial bodies in terms of building environmental awareness and developing attitudes will be required.

After a brief review of the specifics of a suggested project, it may be decided that no further environmental evaluation is required. This does not mean, however, that environmental concerns may be ignored altogether. Many of the potentially adverse environmental impacts associated with rural access projects have more to do with method and approach than with location; e.g. spills of fuels and oils, creation of stagnant water bodies in borrow pits, or needless destruction of roadside vegetation. It is thus still essential that people with a knowledge of environmental aspects take part in the monitoring and supervision of the project, promoting good environmental

practices among road crews and pointing out mistakes.

A number of environmental concerns must be addressed during the design of a project. Any environmentally ambiguous project should include a scoping exercise, i.e. an initial environmental evaluation, to determine major environmental hazards and how these may be avoided. Again, emphasis should be placed on using information and expertise already in place. Collaboration between public institutions and representatives of the locality is still the most effective way to achieve good results. Where new roads are concerned, proposed alignment of the right-of-way should be shown to e.g. local agricultural and forestry officers. On routine visits to the field, engineers and supervisors should be accompanied by the same officers, and also a local representative. Amongst them, and using a checklist of the type appended to this report, the group should be able to identify all potentially serious environmental impacts, as well as possible ways of avoiding them.

With the exception of extensive regional or national programmes, only projects for which some environmental impacts are unpredictable or likely to be severe, and for which no viable alternative is readily available, will merit a full-scale environmental impact analysis (EIA). Assessment should focus on the major potential impacts identified during the scoping exercise, using independent consultants with experience in EIA. It should be noted that EIA mainly is used to assess completed project proposals. This means, on the one hand, that if environmental considerations have been given due attention in the design of the project, the need for EIA will usually not exist. On the other hand, the scope for changing the project will often, in reality, be very small. EIA is also costly, and must therefore necessarily be applied sparingly.

Macro-scale programmes that encompass road building or rehabilitation on a regional or national basis are in most cases funded by a foreign donor or a multilateral agency. The far-reaching impacts of such programmes, coupled with the availability of funds, may merit detailed EIA. A scoping exercise should reveal the major potential impacts in the various programme areas. Once identified, the dimension and implications of these impacts, including long-term effects, should be determined through full-scale EIA.

Many decisions are taken during the construction phase that have a bearing on the environment, e.g. positioning of mitre drains and culverts, and removal of vegetation. Again, one option is to involve professionals from other disciplines in these decisions, by allowing them to make regular visits to the site and incorporating their advice. As far as construction is concerned, however, there is also the possibility of providing supervisors and overseers with basic training in how to deal with routine environmental control measures, e.g. how to build and repair soil conservation structures, and generate vegetative cover. Ideally, this training could be integrated in the schools and training centres in which the supervisors and overseers receive their road construction skills, e.g. through the provision of classes in environmental control measures and a small manual where the basic technical aspects are outlined.

The most effective way of maintaining such structures is through a combination of local participation and training of road maintenance crews. How the local population

may contribute is outlined in more detail in a later section. In short, a desirable situation is where local inhabitants and maintenance crews jointly carry out those routine tasks that do not require mechanised equipment, and where the responsible government institution supplies any external materials and machinery that is required.

### (c) Data Collection and Interpretation

Detailed information and baseline data are often hard to come by in developing countries. As far as possible, however, one should avoid the need of separate research to determine the environmental effects of a road project. The key is to gather enough information and knowledge to ascertain whether or not specific environmental impacts are likely to pose serious problems.

The limited resources of most developing countries underline the importance of utilising information and knowledge that are already in place. Many of the third-world governmental agencies responsible for carrying out road works already struggle with excessive bureaucracy; Overloading these organisations with a fresh influx of staff for environmental purposes is not the way to go. Instead, formal or informal procedures should be established to ensure communication with existing sources of knowledge at the various stages of project development. The general idea is not to search for and gather all relevant information in one place, and subsequently assess its implications; rather, road planners should contact individuals and organisations who already have both the information and the knowledge to interpret at their disposal.

The requirements, in terms data collection and precautionary measures, will depend on whether the project involves the building of a new road or the upgrading or rehabilitation of one that already exists. The impact of a new road is usually greater and less predictable than that of upgrading or rehabilitation. When a road already exists, one may draw on visible evidence of environmental impacts already experienced. On the other hand, upgrading and rehabilitation is frequently carried out with very little data to go by; the information gathered before the construction of a new road is usually far more detailed. Because environmental impacts of upgrading also may be severe, and in particular with respect to soil erosion, the tendency to carry out upgrading and rehabilitation without a thorough knowledge of the area is unfortunate.

As far as new roads are concerned, decisions made during the planning phase include: routing of the road (location of the right-of-way in the landscape); mode of operation (private contractor or government); choice of technology (equipment-based or labour-based); time of construction (start and duration); physical specifications (height of carriageway, width of carriageway, borrow or surplus material, road surface material, thickness of surface layer, depth and width of drains, etc.).

Routing of the road will require careful attention to the environment through which the road will pass. Some aspects will be immediately apparent after a brief look at the general conditions of the landscape. For example, a road passing through a gently

sloping, densely forested landscape is unlikely to cause soil erosion, but may disturb sensitive ecosystems and lead to deforestation. Data collection should thus focus on wildlife populations, rare plant species, and experiences from similar road projects in terms of tree cutting and demographic change.

The latter point is particularly important; the most effective way, and frequently the only feasible one, of predicting long-term impacts of a project is to review past experiences of comparable projects, especially in connection with impacts related to deforestation, demographic shifts, changes in land use and land tenure. When such studies are difficult to find, rough analogies can be established through visits to the area of comparison and dialogue with local inhabitants. If the above impacts are deemed to be potentially serious, a formal survey may be required.

Most countries have agencies and organisations responsible for collecting and issuing information on wildlife populations and habitats, rare and endangered plant and animal species etc. These organisations may include ministries of natural resources or the environment, independent research institutions, or even local or domestic environmental pressure groups. A telephone call to such an organisation may be enough to establish to what extent a proposed road is likely to cause any serious ecosystem damage, whether the road passes through rainforest, wetlands, or arid land.

Some of the required information is already available to planners. Geological and topographic maps are standard tools in the planning of a new road. Coupled with knowledge of local vegetation, climate and catchments, a local agricultural or soil conservation officer should, by studying these maps, be able to assess the soil erosion hazard posed by the suggested right-of-way. Although soil erosion is one of the biggest environmental problems associated with rural roads in developing countries, these problems can largely be avoided through sound road-building practices and implementation of erosion control measures. Extensive re-routing or termination of the road will thus rarely be required.

Local agricultural and forestry officers should also be in a position to provide information on the risk of import or export of plant and animal pests. The problem may materialise in connection with penetration of a previously isolated area; are valuable natural ecosystems susceptible to any particular weeds, fungi, or diseases whose spreading may be facilitated through the construction of a road? If pests pose a serious threat, they should be controlled through restrictions on trade of the afflicted agent.

Some information will need to be gathered through visits to the site. Road engineers are capable of assessing the risk of blocking waterways and are familiar with ways of avoiding the problem (drifts or bridges). By contacting local waterworks officials or local inhabitants, the location of drinking water reservoirs, if not already known, may be established. The road should pass as far away from drinking water sources as possible. It may be necessary to ban transportation of toxic materials; siltation can be avoided through erosion control measures.

Talks with representatives of the local inhabitants will establish the location of any sites of cultural importance, and to what extent the proposed route may jeopardise the function and value of the site.

The question of routing is of importance also in connection with rural towns and centres. A common objective of rural roads is to improve market access and interaction between rural and urban centres. A rural centre will rarely be without road connections of some kind; the key issue in terms of routing will frequently be whether to upgrade an already existing road passing through the rural centre, or construct a new one that goes around it. Pollution and safety considerations would seem to favour the latter option. On the other hand, conservation of the surrounding environment may tilt the scales in the other direction. A road routed around a rural centre will also attract settlement and activity, particularly around junctions where two or more roads intersect. The end result of having the right-of-way pass outside the centre might thus be a shift or expansion of the town itself.

Safety consideration in connection with roads transecting rural centres can be accommodated by constructing speed bumps or, in exceptional cases, inserting traffic lights. Economic considerations, both in terms of costs of construction and socio-economic benefits, will often support a road that passes through the rural centre rather than around it. It is, however, difficult to generalise; each case must be considered separately. Where, for example, the road is expected to support heavy vehicles with potentially dangerous cargo, the environment surrounding the rural centre is robust, and lateral movement inside the centre would be severely impeded by the upgrading of a main road, the best solution may be to locate the road outside the town.

The question of whether construction of the road should be left to contractors or carried out by a government agency would primarily seem to be one of resource availability and finance. It is, however, not trivial from an environmental perspective. Contractors are under no obligation to do more than what is specified in the contract. Thus, for projects that involve the implementation of environmental control measures during construction, extremely detailed specifications will need to be included in the contract, e.g. specifying age, species, spacing and lateral location of seedlings to be planted along the roadside, or indicating the precise location and methods to be used when extracting gravel from a quarry. The end result is a loss of flexibility: many decisions which would best be delayed until the implementation stage, when more detailed knowledge of local requirements and availability of resources had been attained, must be taken during the planning stage. Using different petty contractors for a variety of tasks related to road-building and environmental control could possibly reduce rigidity.

The matter of choosing technology is discussed in a later section.

The timing of construction can generally be reduced to a question of whether or not to carry out road works during the rainy season. Where soil erosion is a potentially serious problem, and rains frequently heavy, this should be avoided.

Physical road specifications relate partly to the amount and type of traffic one may expect to see on the road, partly to the type and amount of materials that must be extracted. Roads that support heavy vehicles and traffic volumes will increase the probability of traffic-related impacts such as air pollution, accidents and noise. Although rural access roads are generally built for relatively low traffic volumes, it may be necessary to scale down road dimensions in order to encourage heavy traffic to use alternative routes. In arid, windy areas, use of very fine surface materials should be avoided, particularly in and around rural centres where exposure to dust is high.

Soil erosion from quarries can usually be avoided through precautionary measures, such as avoiding excavation on steep slopes, and grass and tree planting after abandonment. These measures will also alleviate the aesthetic blemishes which often accompany large quarries. Locating quarries is generally a matter of minimising the distance between quarry and road under construction. Because quarries usually will be located close to existing roads, environmental impacts will commonly be modest. Where large quarries are concerned, however, one should, as with the road itself, investigate the existence of any sensitive ecosystems nearby.

Decisions taken during the construction phase may include positioning of drains, types and number of structures to combat negative environmental impacts - in particular soil erosion, and sorting out chains of command and areas of responsibility with respect to the day-to-day procedure of constructing a road.

Where erosion control is necessary, information will need to be gathered on land ownership, catchments, existing waterways, vegetation, and availability of local materials for the construction of check-dams and safe channels of water discharge. Local agricultural authorities will generally be able to supply the information without difficulty.

Roads require regular maintenance and monitoring, and so does the surrounding environment. Supervisors and overseers who conduct routine monitoring of the road network must also monitor relevant environmental parameters such as soil erosion, water retention or ecosystem diversity, in order to spot new problems as they emerge. Information on the development of problems encountered during construction should also be gathered, along with the status of the measures taken to combat them: e.g. changes in the development of gullies or the concentration of dust particles in the air.

#### (d) The Benefits of an Integrated Approach

Some advantages related to interdisciplinarity have already been discussed: foolish mistakes can be avoided; potentially disastrous developments may be nipped in the bud.

The benefits of bringing people with experience of environmental issues into road building projects will appear throughout the project cycle. During the construction stage, project supervisors and workers will need advice on where vegetation is



essential and where it is not, which grass and tree species to plant in abandoned borrow pits, where culvert outlets may be located without causing damage, and so on.

The general merits of prevention as opposed to restoration are almost universally accepted. The benefits of an integrated approach owe just as much to the fact that two different minds generally are more productive than two identical ones.

By insisting on an interdisciplinary approach, one may run the risk of creating vast bureaucracies incapable of agreeing on the simplest issue, halting the decision-making process in its tracks and the project along with it. Environmental experts, however, should only be asked to perform necessary functions, and improve decisions that would have to be taken anyway.

It has been noted before that the majority of people in developing countries are farmers. Certainly as far as rural access roads are concerned, effects on land and cultivation are of the greatest importance. Local agricultural extension officers are usually well equipped to consider environmental impacts, and offer an additional advantage: they have regular contact with the farmers - the people most likely to suffer from any adverse effects of the project. Agricultural extension officers advise the farmers, and in turn listen to their requests and complaints. Thus, extension officers may provide a crucial link between local inhabitants and project officials where local participation is otherwise impracticable.

#### (e) Local Participation

The notion of bringing local inhabitants into the planning and execution of infrastructure projects is an admirable concept, which often involves considerable practical difficulties. Projects have deadlines, established channels of communication, rules and regulations with which to comply. The distance between planners and local inhabitants is frequently vast, both culturally and physically.

From an environmental viewpoint, the advantages of local participation are immediately apparent. Local people know the local conditions: the natural waterways, the vegetation, the range and frequency of pests and diseases. They are the ones who suffer if something goes wrong. Their perception of environmental hazard is often far more acute than that of planners and experts, holed up in their offices, hovering over maps.

The voices of scattered individuals will not be heard. Local participation demands organisation and pooling of resources. Where established local institutions already exist, these may be used to great advantage. In their absence, it will be necessary to provide a concerted effort in terms of local institution building ahead of the project.

If properly organised, local participation may be utilised throughout the entire project. Beginning with the selection of projects, local institutions can review options and state their preferences. During the planning stage, they may supply vital information on availability of local resources and routes to be shunned because of

potentially damaging environmental impacts. Finally, local institutions may exert pressure on their own members to ensure participation in the implementation and maintenance of environmental control measures.

## CHOICE OF TECHNOLOGY

### (a) Two Approaches

The concept of using labour-intensive technology in infrastructure projects emerged during the past decades in an effort to address problems associated with poverty, unemployment, underemployment and equipment shortages in developing countries. Typical of labour-based projects, besides the favouring of manual rather than mechanical labour, is the emphasis on application of elementary working procedures, use of rudimentary tools and equipment, and an endorsement of local resources in general, such as e.g. local know-how and materials. Assumed socio-economic benefits include growth in employment, increased money supply with associated multiplier effects, and provision of infrastructure that would otherwise be unattainable. A commonly applied definition of a labour-based project is that at least 50% of the tasks are carried out by hand. Equipment-intensive technology denotes, quite plainly, methods that rely more on the use of motorised machinery than manual labour.

The contrast between reliance on heavy machinery and local resources has obvious economic ramifications. Heavy machinery must usually be imported, often depleting meagre reserves of foreign exchange. Local labour, local materials, and locally manufactured tools and equipment are relatively cheap and usually easily accessible. On the other hand, local equipment may be of poor quality, and labour-based technology leads to sluggish, time-consuming project execution. And just as machinery may break down, labour-based projects frequently experience difficulties in securing a regular supply of workers, mainly because of inadequate planning.

It is, naturally, possible to combine features of the two approaches and arrive at what may be termed intermediate technology; extensive use of manual labour, supplemented by light to moderately heavy equipment where manual solutions are considered too laborious. For the purpose of comparison, however, it is practical to look at the two approaches in their undiluted forms.

### (b) An Environmental Comparison of Rural Access Projects

Many of the mitigating measures needed to avoid or reduce negative environmental impacts, e.g. building soil conservation structures or planting trees, must be carried out by hand. Labour-based road projects, having already incorporated manual labour into project implementation, may permit the road workers to also assume the responsibility of carrying out mitigating measures, thus internalising some of the negative environmental externalities of road building.

This arrangement can be practised in the maintenance phase as well as in the construction phase. Labour-based road projects commonly apply the concept of lengthmen, whereby individuals are given the responsibility of routine maintenance

of a given section of the road. Routine maintenance for traditional rural road projects is often limited to the occasional run with a grader.

The benefits of local participation have already been advertised: the direct incentive to avoid or abate negative environmental impacts; anticipation or quick detection of emerging problems. Labour-based projects which rely on local labour automatically facilitate local participation. A possible but unlikely scenario is that the workers themselves will suffer directly the consequences of environmental neglect. Local labourers are, nevertheless, part of the local community, and will be under pressure to take local environmental concerns into account when carrying out their work.

Labour-based technology, in the context of rural access programmes in developing countries, is relatively young: many project contractors, supervisors and overseers have relatively little experience with the approach. Labour-based technology thus does not carry with it a legacy of environmentally damaging practices, as may be the case with more traditional technology. Damaging conventions and routines will not have to be unlearned, and it is possible to promote environmental awareness at an early stage.

The bulky and rough nature of heavy machinery often leads to excessive removal of vegetation and unnecessary exposure of unstable soils. Large cuts and fills are simply not feasible when using labour-intensive technology. The limitations of the human physique will force the road to follow the natural topography rather than cut through it. Manual labour is more adaptable and less severe, allowing more attention to detail and consideration of subtle changes in local conditions.

Consistent use of local resources may also benefit the environment. The erosion of a road carriageway may entail siltation of local waterways, as well as induce further erosion at points below the road. If a road is built using local materials and know-how, such problems may be addressed immediately without having to wait for materials and expertise from outside.

Then there is the matter of economy. A Kenyan study comparing labour-based and equipment-based rural access projects with roads of similar standard, found the economic cost of the latter to be roughly 35% higher than that of the former. Theoretically at least, some of these surplus funds could be used to environmental ends, although relative cost figures will depend on location.

Some tasks, such as the pounding of large blocks of stone into gravel, are extremely laborious when done by hand. The heavy nature of many of the labour tasks connected to road building may lead to physical strains and injuries among the workers. It is also a question of time.

If readily available, heavy machinery is superior when large repairs need to be completed in a hurry, e.g. when a carriageway has been eradicated and must be reestablished before the onset of new rains. In some instances, road sections must be constructed fast, e.g. to transport urgently needed water-drilling equipment into a drought-stricken area.

Labourers working on infrastructure projects must, unless they are unemployed, sacrifice time allotted to other tasks. In the case of farm owners, this may lead to neglect of good farming practices and labour investment in the long-term productivity of the land. Many labour-based projects encourage the participation of female workers, in a commendable effort to allow women to become financially independent and generally promote gender equality. Women, in addition to agricultural productive activities, often carry out domestic chores such as child care, water collection, fuelwood gathering and food preparation. The attention given to these tasks may decrease through participation in off-farm income-earning activities. In the case of road construction, however, these problems can to a large extent be avoided by proper selection and targeting of the work force, i.e. unemployed men and women, and through the provision of rudimentary child-care facilities at the construction site.

In general, the potential for guaranteeing sound environmental practices in road building projects is enhanced through the use of labour-based technology. The use of manual labour, however, is by itself not enough. Steps to ensure local participation, such as making sure workers are hired locally and incorporating local institutions into the planning of the road, are prerequisites. Training of contractors, supervisors, overseers, and maintenance workers is paramount. In case of emergencies, where major intervention is required urgently, a minimum of machinery should be kept in reserve. It is possible that intermediate technology can combine desirable features of both technologies.

## CHECKLIST FOR ENVIRONMENTAL SCREENING OF RURAL ACCESS PROJECTS

## Questions To Ask

## Possible Actions

## DURING THE PLANNING PHASE

Will the road lead to significant demographic shifts?	<input type="checkbox"/> Determine probable shifts and associated environmental impacts
Is the road likely to cause changes in land use?	<input type="checkbox"/> Determine probable changes and associated environmental impacts
Will the road lead to property rights disputes or changes in land tenure?	<input type="checkbox"/> Determine nature of disputes or probable changes and associated environmental impacts
Will the right-of-way transect wilderness areas or other virgin land, leading to probable deforestation and destruction of valuable ecosystems?	<input type="checkbox"/> Choose alternative route <input type="checkbox"/> Abandon project
Will the road lead to fragmentation of wildlife habitats, or impede the movement of wildlife populations?	<input type="checkbox"/> Choose alternative route <input type="checkbox"/> Abandon project
Will the carriageway pass through wetland areas, and (a) obstruct movement of water?	<input type="checkbox"/> Construct bridges or drifts <input type="checkbox"/> Choose alternative route <input type="checkbox"/> Abandon project
(b) disturb wetlands ecosystems?	<input type="checkbox"/> Choose alternative route <input type="checkbox"/> Abandon project
Will the road in any other way disturb the balance of nearby ecosystems?	<input type="checkbox"/> Reduce projected traffic volume by scaling down road dimensions <input type="checkbox"/> Choose alternative route <input type="checkbox"/> Abandon project
Will the road interfere with religious or cultural sites?	<input type="checkbox"/> Choose alternative route <input type="checkbox"/> Abandon project
Will the traffic lead to serious health hazards or crop damage because of air pollution from (a) exhaust fumes?	<input type="checkbox"/> Reduce projected traffic volume by scaling down road dimensions <input type="checkbox"/> Choose alternative route
(b) dust?	<input type="checkbox"/> Select other surface material, e.g. gravel or tarmac instead of earth
May the road seriously diminish the beauty of surrounding landscape?	<input type="checkbox"/> Avoid large road cuts and fills <input type="checkbox"/> Plant trees and bushes along roadside <input type="checkbox"/> Scale down road dimensions <input type="checkbox"/> Choose alternative route
Is the road likely to promote the spreading of pests and diseases to or from the accessed area?	<input type="checkbox"/> Instigate measures to control plant and animal imports or exports <input type="checkbox"/> Abandon project

Will the road pass close to large or vital drinking water reservoirs?

- Prohibit transport of toxic materials
- Implement erosion control measures
- Choose alternative route
- Abandon project

Will the road transect steep areas which regularly experience heavy rainfall?

- Implement erosion control measures
- Choose alternative route

Will quarries disturb surrounding ecosystem?

- Select alternative site

May quarry seriously diminish beauty of surrounding landscape?

- Plant vegetation in and around abandoned quarry
- Select alternative site

#### DURING THE CONSTRUCTION PHASE

Will culvert outlets entail risk of gully formation?

- Locate culvert outlets above natural waterways
- Reduce flow of water through terracing, contour ploughing or tree planting above road
- Reduce flow of water by delaying harvest of crops on land above road until after rains
- Reduce speed of water in side drains by constructing scour checks
- Construct mitre drains at short intervals along road
- Secure waterway below culvert outlet by constructing check dams and planting vegetation

Are quarries likely to lead to soil erosion?

- Careful siting and excavation
- Implement erosion control measures

Are borrow pits likely to lead to stagnant water bodies?

- Replant abandoned borrow pits
- Careful siting

Will labour camps lead to  
(a) social disruption?

- Careful siting, away from existing settlements
- Promote social activity through provision of leisure facilities

(b) accumulation of garbage?

- Instigate garbage collection and disposal

#### DURING THE MAINTENANCE PHASE

Are environmental control measures likely to deteriorate without regular care?

- Choose a maintenance system involving manual road maintenance

Are road maintenance crews unable to carry out adequate maintenance of environmental control measures because

(a) they are unqualified

- Provide training in environmental control
- Hire qualified labour

(b) they are insufficient in number

- Hire more workers
- Higher work intensity, e.g. more days per week

Are permanent structures of inferior quality or insufficient in number?

- Improve structures
- Increase number of structures