WORLD BANK TECHNICAL PAPER NO. 376

Roads and the Environment

A Handbook

Edited by
Koji Tsunokawa
Christopher Hoban

The World Bank
Washington, D.C.

First printing November 1997

Technical Papers are published to communicate the results of the Bank's work to the development community with the least possible delay. The typescript of this paper therefore has not been prepared in accordance with the procedures appropriate to formal printed texts, and the World Bank accepts no responsibility for errors. Some sources cited in this paper may be informal documents that are not readily available.

The findings, interpretations, and conclusions expressed in this paper are entirely those of the author(s) and should not be attributed in any manner to the World Bank, to its affiliated organizations, or to members of its Board of Executive Directors or the countries they represent. The World Bank does not guarantee the accuracy of the data included in this publication and accepts no responsibility whatsoever for any consequence of their use. The boundaries, colors, denominations, and other information shown on any map in this volume do not imply on the part of the World Bank Group any judgment on the legal status of any territory or the endorsement or acceptance of such boundaries.

The complete backlist of publications from the World Bank is shown in the annual *Index of Publications*, which contains an alphabetical title list with full ordering information. The latest edition is available free of charge from the Distribution Unit, Office of the Publisher, The World Bank, 1818 H Street, N.W., Washington, D.C. 20433, U.S.A., or from Publications, The World Bank, 66, avenue d'Iena, 75116 Paris, France.

ISSN: 0253-7494

Koji Tsunokawa is senior transport specialist in the Infrastructure Development Group in the World Bank's Middle East and Nort Africa Regional Office. Christopher Hoban is a senior highway engineer in the World Bank's South Asia Infrastructure Sector Unit.

Library of Congress Cataloging-in-Publication Data

Roads and the environment : a handbook / edited by Christopher Hoban and Koji Tsunokawa.
p. cm. — (World Bank technical paper ; no. 376)
Includes bibliographical references and index.
ISBN 0-8213-4031-X
1. Roads—Environmental aspects. 2. Environmental impact analysis. I. Hoban, Christopher J., 1952- . II. Tsunokawa, Koji, 1947- . III. Series.
TD195.R63R63 1997
333.77—DC21 97-28971
CIP

Table of Contents

List of Boxes

List of Figures

List of Tables

Foreword

Roads often bring significant economic and social benefits, but they can also have substantial negative impacts on communities and the natural environment. As we become more aware of these impacts, there is a growing demand for the techniques and skills needed to incorporate environmental considerations into road planning and management.

This, the second edition of the handbook, is an updated version of a World Bank report (TWU 13) released in September 1994. It has been substantially revised and modified based on user feedback, field experience and intensive review of recent international literature while maintaining its balance between conciseness and comprehensive coverage of the issues.

This handbook is intended primarily for:

- *Road agency managers,* who need to broaden the skills and capabilities of their organizations to deal with evolving issues such as the natural environment, social impact analysis, public involvement, landscape design and environmental law.
- *Road engineers, planners and contractors,* who need to increase their awareness of environmental issues at all stages of their work.
- *Environmental specialists, community groups, academics, development organizations* and others with an interest in the relationship between roads and the environment.

A key objective of the handbook is to integrate environmental thinking into road planning and management, and to improve communication among different disciplines and interest groups, which often use different concepts and terminology. Engineers, for example, sometimes need to call in environmental experts; this handbook tells them how best to use their services, how to integrate their advice into various road management activities, and how to implement and follow up on proposed environmental strategies.

This handbook is the result of a joint effort by the World Bank and SETRA (*Service d'Etudes Techniques des Routes et Autoroutes*), the technical arm of the French Ministry of Infrastructure and Transport. It has been used in studies and training in several countries and translated into French; other translations of this new edition are planned. The handbook was financed partly by the Japanese Consultant Trust Fund; Chodai Company, Ltd., Tokyo, was engaged to help prepare this edition under the World Bank's supervision.

The guidelines in this handbook are not necessarily official standards for World Bank projects, but rather should be regarded as general indications of good practice to assist road agencies in dealing with environmental issues.

Anthony Pellegrini
Director
Transport, Water & Urban Development Department
Financial & Private Sector Vice-Presidency
The World Bank

Acknowledgments

The revised edition of this handbook was prepared on the initiative of Zmarak Shalizi and John Flora of the World Bank, who decided that the time was ripe to incorporate user feedback based on field tests of the first edition. The revision was based on intensive surveys and interviews with users within the World Bank, conducted by an interdepartmental team consisting of Aidan Davy, Chris Hoban, and Koji Tsunokawa.

The contribution of Chodai Company. Ltd., Tokyo, was based on these surveys and interviews. The company produced several draft versions of this document in consultation with the World Bank. The Chodai project team was led by Kozo Kaneyasu, and comprised Kimio Kaneko, Geza Teleki, Yoshihiro Miyamoto, and others. Their contribution is greatly appreciated. The revision was managed by Koji Tsunokawa. Overall supervision was provided by Anthony Pellegrini, Director of the Transport, Water and Urban Development Department, and John Flora, Transport Advisor, Transport Division.

Comments and advice were received from numerous other staff of the World Bank. Ken Gwilliam undertook the final revision of Chapter 19. Other contributors include Dan Aronson, Mohammed Bekhechi, Ken Chomitz, Shelton Davis, Ed Dotson, Katrinka Ebbe, Junko Funahashi, Colin Gannon, Ian Heggie, Olav Kjorven, Reider Kvam, George Ledec, Maria-Clara Mejia, Jean-Roger Mercier, Juan Quintero, Ellen Schaengold, Anil Somani, Gus Tillman, Tony Whitten, and others. Technical and administrative support from Barbara Gregory, Delphine Hamilton, Norma Silvera, and Violeta Wagner is gratefully acknowledged.

The first edition of the handbook (Report TWU 13) was prepared by the World Bank in collaboration with SETRA. That document was based on earlier work by Asif Faiz and Michel Ray of the World Bank. The first edition was prepared by the World Bank's Interdepartmental Working Group, comprising Chris Hoban, Michel Ray and Phil Paradine. Additional primary contributors to the first edition were Alan Spake of SETRA, Jean-Marc Pages of BCEOM, and Jaques Grelot of Organization and Environment (all in France). Individual sections in the first edition were contributed by Gordon Appleby and Jane Taboroff.

Abstract

The objective of this handbook is to provide a description of practical methods which are useful in designing and executing effective environmental assessments (EAs) to those who are involved in various aspects of road projects, from planning to construction to maintenance. This handbook is primarily concerned with specific road projects, ranging from major works on new alignments to minor rehabilitation and maintenance activities on existing roads. The techniques discussed can be applied to in-depth environmental assessment studies, or to modest action plans for dealing with environmental aspects of small projects. As EA practitioners are by no means the only set of participants in the EA process, this handbook is not limited to their exclusive use. People representing the project proponents, government agencies, NGOs, research groups, and community organizations, as well as any others whose input is desired in both the project development and EA processes, are all intended handbook users.

This handbook consists of two parts. Part I provides an overview of the EA process in the context of road planning and construction and also describes the detailed methodological steps of the EA process, as they apply to specific projects being planned. Part II provides a more detailed, in-depth discussion of each of the major factors involved in environmental assessment, including impact mitigation, of road projects. Each chapter covers one component of the environment and provide a description of possible impacts, the nature and scale of the impacts, and some practical information on common mitigation options. This is followed in each chapter by a checklist which suggests common ways of minimizing the impacts on the component. Each chapter ends with a list of information sources which users may want to refer to for more details.

Executive summary

Road projects are generally intended to improve the economic and social welfare of people. Increased road capacity and improved pavements can reduce travel times and lower the costs of vehicle use, while increasing access to markets, jobs, education, and health services and reducing transport costs for both freight and passengers.

For all the positive aspects of road projects, they may also have significant negative impacts on nearby communities and the natural environment. People and properties may be in the direct path of road works and affected in a major way. People may also be indirectly affected by projects, through the disruption of livelihood, loss of accustomed travel paths and community linkages, increases in respiratory problems due to air pollution, and injury from road accidents. Disturbances to the natural environment may include soil erosion, changes to streams and underground water, and interference with animal and plant life. Roads bring people, and people bring development. New roads may induce development in previously undeveloped areas, sometimes significantly affecting sensitive environments and the lifestyles of indigenous people. Roads are agents of change, and can be responsible for both benefits and damage to the existing balance between people and their environment.

All of these concerns will rarely arise in relation to a single project, but it is common to find at least some even in relatively minor road works. Much can be done to avoid, mitigate, or compensate for the negative environmental impacts of a road project, but it is important to identify potential impacts early in the road planning process and to make provisions for avoiding or mitigating these effects wherever possible. Failure to identify potential impacts may result in delays and cost increases later on in the project's development. Neglecting to account for impacts may also cause the road agency to adopt solutions that compromise the environment. Poor environmental management has been shown to produce negative public perception of road projects, creating additional problems for those yet to come.

A truly sustainable approach to road transport development calls for a substantial change in attitude towards the environment as it relates to the preparation and management of road projects. Costs of the indirect effects of pollution and disruption must be examined. Changes to the health and social and cultural well-being of communities, and impacts on the biophysical environment and biodiversity, must be considered. The needs of the poor, and of future generations, need to be taken into account.

The change in attitude towards the environment has three elements. First, the full range of impacts on the natural and social environment needs to be identified. Second, these impacts need to be quantified. The techniques for this analysis are often substantially different from those used in road engineering, and often less well developed. In some cases, like that of the health effects of motor vehicle noise pollution, scientific consensus is still only gradually emerging. Third, procedures need to be established for avoiding, mitigating and compensating for these impacts. These should include provisions for consulting affected communities, and following up with implementation plans and training.

The process which systematically deals with these elements is generally called environmental assessment (EA). The objective of this handbook is to provide a description of practical methods for designing and executing effective EAs to those who are involved in various aspects of road projects, from planning to construction to maintenance. However, this handbook should not be viewed as a cookbook full of recipes which can be

Roads can harmonize with the surrounding environment and serve multiple users

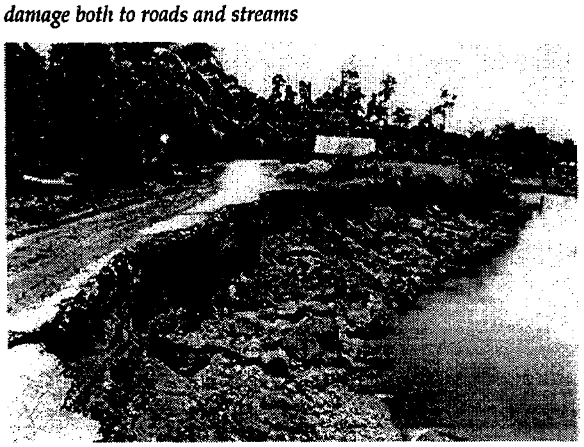
applied systematically in all situations. It should instead be thought of as a kind of template for designing and executing effective EAs. Methods and approaches will need to be adapted to the specific needs of each project, environment, country, and community.

The EA approach is not aimed solely at identifying the negative effects of a project in the context of the area it is being planned in, but also should optimize the positive effects of the project. Project management should be organized so that environmental matters are considered, gathered, analyzed, and weighed, and have a timely influence on the planning, budget, and design of the road project.

This handbook is primarily concerned with specific road projects, ranging from major works on new alignments to minor rehabilitation and maintenance activities on existing roads. The techniques discussed can be applied to in-depth environmental assessment studies, or to modest action plans for dealing with environmental aspects of small projects.

The discussion does not deal in any detail with alternatives to motorized transportation, including measures to restrict demand for motor vehicle use, expansion of public transport services, support for non-motorized modes of travel, and long-term changes in urban form and travel patterns. These issues are critically important for the establishment of sustainable transport services, and should be fully considered in the analysis of transport strategies and large urban road projects. While they are discussed briefly in various chapters of this handbook, they are largely outside of its scope, and need to be more fully dealt with elsewhere.

Uncontrolled erosion can cause substantial damage both to roads and streams



Just as good road project planning, management and execution requires well-trained professional transportation engineers, technically credible and environmentally sensitive, road EAs require experienced environmental professionals supporting the engineering team. These personnel should be brought into the project development process at a very early stage.

As EA practitioners are by no means the only set of participants in the EA process, this handbook is not limited to their exclusive use. Representatives of the project proponents, government agencies, NGOs, research groups, and community organizations, as well as any others whose input is desired in both the project development and EA processes, are all intended handbook users. The title page of each chapter contains a schematic diagram that outlines which readers, in addition to EA team members, will benefit the most from reading the chapter.

Part I The Environmental Assessment Process

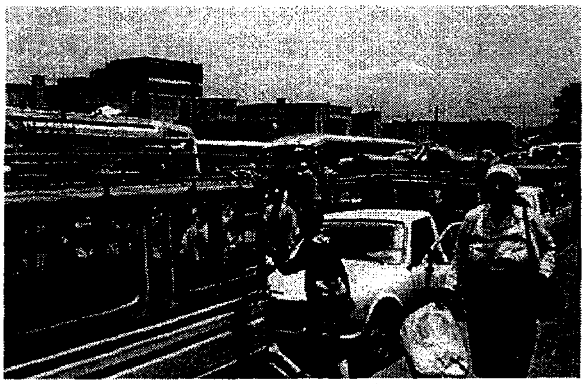
Part I of this handbook provides an overview of the EA process in the context of road planning and construction and also describes the detailed methodological steps of the EA process, as they apply to specific projects being planned principally in a rural and inter-urban setting. The urban setting is more complex and issues pertaining to urban road projects warrant treatment in a separate handbook.

Chapter 1 introduces the environmental assessment process as a planning tool, underscores the importance of knowing something about roads and their impacts in different land-use settings, i.e. urban versus rural and new versus rehabilitation projects. Five types of EAs applied to road projects are defined in this chapter.

Chapter 2 makes clear the fact that without administrative support for EA and without adequate technical capacity or regulatory and monitoring functions, an EA is merely a paper exercise. Secondly, a case is made for early and careful planning; although this may seem too time consuming, it will pay large dividends once the EA gets underway since the work will have been well thought out and optimized.

Chapters 3 and 4 provide details on the EA steps, with Chapter 3 addressing early screening and scoping while Chapter 4 defines each EA step in some detail. The two provide a comprehensive step-by-step methodology for project-

Roads support economic development, but growing road use adds congestion and pollution to the urban environment



specific EA. In Chapter 3 the notion and use of the Valued Ecosystem Component (VEC) is introduced; a number of examples are provided.

Of considerable importance in Chapter 4 is the discussion of the Environmental Management Plan (EMP), a standard and key output of well-prepared full EAs. An example of such a plan is also provided.

Chapter 5 highlights the close relationship between a well-planned and collaborative-style public consultation and a successful environmental assessment. The importance of identifying who should be involved, knowing how the information needs to be solicited from stakeholders, and how it should be presented, is emphasized.

Chapter 6, the last one in Part I, defines the different types of impacts practitioners need to be aware of when planning and undertaking EAs.

The box that follows contains eight recommendations which summarize the message that Part I of this handbook seeks to send to road agencies and their EA practitioners.

Part II Environmental Impacts, Their Mitigation and Their Economic Valuation

Part II provides a more detailed, in-depth discussion of each of the major factors involved in environmental assessment, including impact mitigation, of road projects. Chapters 7-17 each cover one component of the environment and provide a description of possible impacts, the nature and scale of the impacts, and some practical information on common mitigation options. This is followed in each chapter by a checklist which suggests common ways of minimizing the impacts on the component. Each chapter ends with a list of information sources to which users may refer for more details.

Chapters 7-17 are designed for quick reference and should help the reader to:

- identify and review legislation and regulations affecting environmental issues;
- identify opportunities for positive environmental actions;
- consult with interested and affected people and incorporate their knowledge and preferences into environmental decisions;
- develop environmental management plans with clear responsibilities, resources and follow-up procedures;
- include environmental responsibilities in contracts and contract management; and access more information.

The topics or themes discussed in this manner are:

Biophysical environment
- Soil
- Water
- Air quality
- Flora and fauna.

Socioeconomic environment
- Community life and economic activity
- Land acquisition and resettlement
- Indigenous or traditional populations
- Cultural heritage
- Aesthetics and landscapes
- Noise
- Human health and safety.

Chapter 18 addresses the important issues of impact management during construction, selection of contractors with environmental sensitivity, and the inclusion of environmental clauses within

A road and stream come together in Kenya

contracts. A listing of the more general impacts commonly found with new (or "green-field"), rehabilitation and upgrading works projects is presented. In addition, useful mitigation measures are described.

Chapter 19, the final chapter, presents a preliminary guide to the economic valuation of environmental impacts, and describes the most common economic valuation techniques and the circumstances under which they are most usefully applied.

KEY RECOMMENDATIONS FOR ROAD DIRECTORS AND EA PRACTITIONERS

1. Road agencies should have a clearly designated staff member with overall responsibility for environmental matters and knowledge of environmental laws and regulations.
2. The environmental coordinator should have access to senior management, and have their support in coordinating environmental actions throughout the organization.
3. Identification and assessment of potential environmental impacts should be an integral part of the project cycle. It should commence early in the planning process to enable a full consideration of alternatives, and to avoid later delays and complications.
4. Assessments should be followed up with action plans, monitoring and remedial measures to ensure the effectiveness of environmental recommendations and decisions.
5. Road agencies should develop global policies, procedures and standard contract clauses for the consideration of environmental factors; these should apply to road strategies, planning, management, and operation.
6. Road agencies should review environmental aspects of laws and regulations related to road planning, road works, and road use, and should make recommendations to other government agencies and departments on the need for improvements to the legal framework.
7. Community involvement is an essential element of environmental management of roads. Procedures and skills should be developed for informing the public and interested parties about road proposals, and using consultation and participation to include the community in the decision-making process. This process recognizes the importance of non-technical factors in assessment of environmental issues, and the problems experienced in many road projects through a lack of timely consultation.
8. Training is required for road agency staff, consultants, and contractors responsible for assessment of environmental impacts and mitigation measures, and for implementation and monitoring of action plans.

Part I

The Environmental Assessment Process

1. Assessing the environmental impact of road projects

HOW TO USE THIS CHAPTER IN THE CONTEXT OF EA AND ROAD PLANNING

Stage in road planning (A)	EA activity (B)	Involvement in addition to EA team (C)
	Screening	
	Scoping	Proponent
Concept	Consultation	Key regulatory
Pre-feasibility	Determining baseline conditions	Other government agencies
Feasibility	Selection of preferred solution	NGOs
Engineering design	Assessment of alternative designs/methods	Research groups
Construction	Development of environmental management plan	Public/community organizations
Operation & maintenance	Effects and compliance monitoring	Advisory experts
	Evaluation	
	Reporting	

Shaded area = (A) Stages of EA covered in this chapter; (B) focus of this chapter; and (C) primary target readers.

KEY QUESTIONS ADDRESSED:

? What is environmental assessment?

? What role does EA play in the planning of a road project?

? Why should road managers and planners examine road-environment issues at both project and program levels?

? What is the difference between project-specific and strategic environmental assessment?

? How are biophysical, social, and economic impacts linked, and why is it important to consider them together?

? What factors determine the amounts of time and money allotted to environmental assessments?

1.1 THE ENVIRONMENT AND ITS ECOSYSTEMS

The word "environment" refers to our surroundings—the context within which we exist. All things, living or non-living, exist surrounded by other things, and therefore all have an environment. For humankind, the environment means, on a broad scale, the biosphere.

The biosphere is that portion of the earth-atmosphere system which supports life, and is characterized by its existence. It includes the oceans, the continental landmasses, and the lower atmosphere. The basic structural unit of the biosphere is the ecosystem. Each ecosystem occupies a space in which homogeneous conditions prevail, regardless of scale. Area can be defined in terms of a few hundred square meters or thousands of square kilometers, and depth can vary from a few centimeters (desert soil) or dozens of meters (tropical rain forest) to kilometers (oceans).

The components of the environment are inextricably linked—no component exists in total isolation, and nothing can be changed without affecting something else. Consequently, the environment cannot be assessed simply by examining its components in isolation; instead, they must be considered as parts of the whole. This concept is crucial in understanding the role which humans play in affecting their environment.

People are an integral part of the environment, and are active participants in many ecosystems. Indeed, every aspect of human interaction, be it social, economic, or physical, can be considered to affect the ecosystems of which we are a part. In other words, we affect the functioning of our environment through our daily actions.[1] As we change the nature or intensity of our activities, the natural equilibrium of our environment must shift to accommodate these changes. Likewise, as systems change around us, and in response to us, we must accommodate them. Our actions have consequences not only for our immediate environment, but for us as well; anything we do to degrade our environment will generally affect our well-being later on.

A key characteristic of the environment is its compromise between evolution and balance. This dynamic equilibrium is a reflection of the interactions between and within ecosystems. As disturbances arise, a system is thrown off temporarily. It then begins the process of establishing a new balance, which may or may not be the same as before. The amount of time required to re-establish a dynamic equilibrium may range from minutes to tens of thousands of years, depending on the scale of the disruption and the relative fragility of the ecosystem.

Road construction and traffic operations, if undertaken without a proper understanding of the relationships inherent in environmental function, can be accompanied by serious disruptions to the environment, from which it may take a long time to regain equilibrium. In human terms, this may mean that generations must function in a debilitated environment and suffer many possible associated socio-economic hardships and financial losses.

1.2 ROADS, THE ENVIRONMENT, AND THE NEED FOR ENVIRONMENTAL ASSESSMENT

There is a growing awareness that road development has major environmental impacts.[2] Some of the major environmental impacts of road projects include damage to sensitive ecosystems, loss of productive agricultural lands, resettlement of large numbers of people, permanent disruption of local economic activities, demographic change, accelerated urbanization, and introduction of disease.

Since environmental impacts from road development are quite common, such projects usually call for comprehensive environmental assessment studies, carried out by EA professionals (both specialists and generalists) who support the main engineering team. Substantial time and effort is often required to identify potential impacts and options for minimizing them (Sections 3.1 and 3.2), to consult with various groups who have an interest in the project (Chapter 5), and to develop and implement mitigation plans (Sections 4.5 and 4.6). In addition, contract clauses (see Section 18.3) covering work procedures and staff training need to be prepared, and work processes in

[1] Here and throughout this handbook, the term environment shall be assumed to encompass both bio-physical and socio-economic components, unless specified otherwise.

[2] Based on the 1995 World Bank survey of large development projects funded by the Bank.

relation to roadside communities, flora, and fauna given considerable attention.

In order to conduct EAs successfully, road agency staff need to understand the assessment process and must coordinate it with road planning, design, and construction activities, allowing sufficient lead time and funds for the necessary additional steps (see Chapters 3 and 4).

It is essential that road agency staff be able to

- recognize potential environmental concerns;
- know when to call in specialist experts;
- know how to specify and manage their work; and
- know how to implement mitigation plans and environmental contract clauses.

New skills may have to be developed to meet the demands of the EA process. This is especially true in the area of consultation with affected residents, interested members of the public, government departments, and other organizations (known collectively as the stakeholders). While road agencies are generally quite responsive to the concerns of these stakeholders on engineering issues, the dialogue on environmental matters often needs to be expanded to include a broader range of topics. Agency staff involved in the consultation process must be equipped to address varying institutional and cultural needs and differences (see Chapters 2, 13 and 14).

Projects limited to road rehabilitation, maintenance, minor construction, as well as to traffic management and regulation, generally involve lesser environmental concerns. These situations do not call for full-scale EAs (see Section 3.5), but do require impact identification, mitigation, and a certain amount of compliance monitoring and documentation.

1.3 NEW, EXISTING, RURAL, AND URBAN PROJECT SETTINGS

In relation to the impacts they generate, road projects are commonly placed into one of five categories:[3]

i) new;
ii) existing (rehabilitation/upgrade);
iii) rural;
iv) urban; and
v) mixed.

1.3.1 New versus existing project types

When planning and executing EAs for new road and road rehabilitation projects, proponents need to be aware that the impacts associated with these two project types are significantly different. Box 1.1 presents these differences in terms of a set of generalized EA steps, defined according to the two project types. The key difference is that, for new projects, the focus is on preventing impacts, whereas for existing or upgrade projects, the focus is on rehabilitating and mitigating further impacts.

1.3.2 Rural versus urban project types

It is also important to distinguish between projects proposed for mainly rural settings versus those planned for predominantly urbanized areas. Road developments in these two environments present significantly different problems.

In the rural setting, the key impacts usually revolve around removal of productive agricultural lands and the opening up of previously inaccessible, or marginally accessible, territory to in-migration and large-scale resource harvesting. Introduction of new sources of noise is often an issue in rural settings where ambient noise levels are typically low. Furthermore, because rural life is so closely integrated with the biophysical aspects of the environment, issues such as water quality and biodiversity conservation deserve special consideration.

In the urban setting, where population densities are higher and the connection to the biophysical environment is less significant, the dominant impacts have to do with displacement of people and their homes, general neighborhood disruption, local airshed contamination, and noise. In those urban areas where the mode of travel is dominated by the non-motorized vehicle, access and movement restrictions become major factors to consider when planning facilities for motorized vehicles.

[3] This is not road planning terminology, but is included here to help identify the likely general magnitude of impacts.

BOX 1.1
COMPARISON OF KEY EA CONSIDERATIONS FOR NEW VERSUS UPGRADE OR REHABILITATION TYPE PROJECTS

For a new facility the focus is on the proper technology and siting. The proponent should:

- justify the need and the use of a preferred technology;
- describe the actions taking place during each of the main phases of a project (construction, operation, and maintenance) which could lead to environmental damage;
- prepare alignment drawings which show the location of the facility relative to the local bio-physical and socio-cultural environmental features;
- identify the potential impacts of the facility relative to surrounding land use within a 5 km radius/corridor[4] of the facility; and
- formulate a plan to prevent anticipated undesirable impacts from being actualized.

For existing facilities, which generally undergo enlargement or upgrading, the focus should be on any necessary repair or rehabilitation of prior environmental damage. For example, a bridge from a previous road project that restricts water flow—thus causing annual flooding, preventing upstream fish migration, and resulting in a severe depletion of the local food source—should be examined with special regard to widening the water channel. For existing projects the analyst would:

- define the nature of the proposed work and how it would change the existing facility;
- identify which, if any, aspects of the existing facility have caused unacceptable negative impacts;
- analyze the combined effect of the rehabilitation action with that of the existing facility operations; and
- prepare an action plan for the repair of the damage done and for the prevention of any negative effects resulting from the new work. **This requirement does not suggest that the state of the environment in the study area must be brought back to the pre-development state but rather that, at the very least, the degradation be halted and the environment not be subjected to significant new negative impacts.**

Consultation is important for both urban and rural locations. It enables road project proponents to identify potential impacts as well as local sources of information and knowledge, to highlight community concerns about the effects of road changes on lifestyles and welfare, and to encourage participation in the development of workable solutions (see Sections 4.2.3 and 4.4.2).

Although the methods discussed here may be applicable to urban projects as well , the major focus of this handbook is on rural and inter-urban road projects. The more complex urban issues deserve a separate volume and will not be dealt with extensively here.

1.3.3 The "mixed" rural-urban project

In reality, most rural projects are actually a mixture of rural and urban sections, since rural roads do not simply stop in the countryside but traverse, or end in, urban areas. If the urban areas at the ends of the road, as well as any urban areas traversed by the road, are in fact an integral part of the project, they should be included in any EA. For various practical reasons, however, urban areas are often excluded from projects. This applies particularly to the terminus. Later, they may find that those traffic problems which result from a larger capacity road feeding into a lower capacity urban arterial (congestion, safety, restricted access, etc.) are forcing remedial actions that are far costlier than early preventive measures would have been, provided they had been based on a thorough examination of these urban nodes. There are many cases where it is desirable to include all urban sections in a road project through which a road passes and in which it ends.

1.4 THE ENVIRONMENTAL ASSESSMENT (EA)

In this handbook, a full environmental assessment (which normally yields an environmental impact statement or "EIS") consists of a rigorous study that involves a thorough documentation of existing conditions, an identification of impacts, and a comparative examination of impacts arising from the road project alternatives. A growing number of development planners and managers now recognize that EA is an ex-

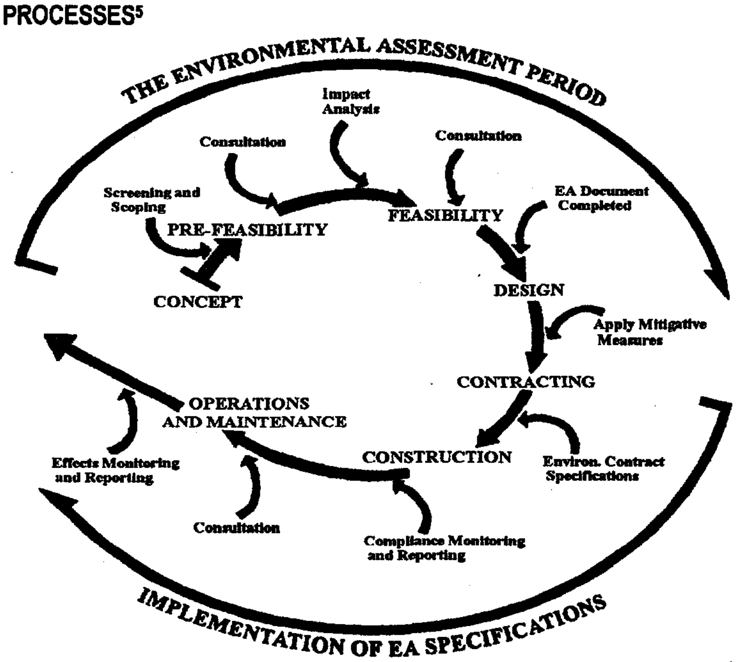
[4] Width of a corridor to be studied depends on the legal requirements plus the predicted extent of the impacts—identified during the project scoping. Corridor widths range from 100m to 10km (for green-field roads).

cellent preventive planning tool, provided that it is implemented early in the project development sequence (Figure 1.1).

EAs generally have three objectives:

i) to present to managers and decision-makers a clear assessment of potential impacts which a project (or a strategic level initiative) may have on overall environmental quality;
ii) to apply to a project (or a strategic level initiative) a methodology which assesses and predicts impacts and provides a) the means for impact prevention and mitigation, b) the enhancement of project benefits, and c) the minimization of long-term impacts; and
iii) to provide a specific forum in which consultation is systematically undertaken in a manner that allows stakeholders to have direct input to the environmental management process.

FIGURE 1.1
SYNCHRONIZATION OF THE EA AND PROJECT DEVELOPMENT PROCESSES[5]



Three of the most important steps in EA are *screening, scoping,* and *analysis of alternatives.* The screening stage provides a preliminary evaluation of the magnitude of potential impacts and determines whether further study—such as a full EA—is needed. The scoping stage should indicate clear spatial and temporal boundaries for the EA. The analysis of alternatives should yield a well-informed decision on the transport solution (see Section 3.2.4) and the optimal project design, based on consultation with stakeholders and experts, as well as a careful technical examination of each alternative (see Chapter 4).

These three steps must integrate biophysical, social, and economic considerations in order to set the stage for an EA which weaves together actual cause-and-effect interactions between the natural and the social environment, thus leading to a more holistic outcome. Unfortunately, this is not always the case, since regulations and practitioners offer conflicting messages on how EAs should be approached (see Box 1.2).

1.4.1 EA and road project development

From an engineering or planning perspective, project development generally follows a well-defined process which includes pre-feasibility and feasibility studies, preliminary design, detailed design, and construction. This is followed by operation and maintenance of the completed project. Depending on the nature of the project, consultation with various government agencies, the public, or both, may be an essential component during several of the early stages of the process. It is important to synchronize environmental studies with the project development process. Ideally, the EA and project development processes should be conducted in tandem. The EA document should be completed by the feasibility stage of the engineering work, and the implementation of the mitigation plan should be tied

[5] This diagram is presented here to illustrate that project development is not really cyclical, but rather has a well-defined beginning and end. New projects enter the process at the concept stage and leave after effects and monitoring have been completed.

BOX 1.2
ENVIRONMENTAL VERSUS SOCIAL ASSESSMENT

EAs continue to suffer from the practice whereby managers and practitioners segregate the biophysical and social environment in actuality, even though regulations and legislation proclaim that the two are integral to one and the same environment. Consequently, the correct legal definitions exist, but they are applied incorrectly. Analysis of EA guidelines for many jurisdictions reveals that while their EA tables of contents include sections on the social components, these social components are treated separately from the EA; sometimes they even appear in a totally separate document under the Social Impact Assessment (SIA) heading. Moreover, terms of reference for EA projects are frequently prepared separately as "environmental TORs" and "social impact TORs." As long as this dichotomy is maintained, a true ecosystem approach to EA will not be possible.

in closely with the design, construction, and operation phases (Figure 1.1).

Increasingly, environmental assessments are required by national and international law as well as other regulations. An environmental assessment should therefore be considered and provided for from the outset in the budget of all road projects.

1.4.2 Types of EA

There are at least five types of EAs now being undertaken around the world. They can be grouped as follows:

Traditional project-specific EAs
i) project specific EA;
ii) programmatic EA;
iii) summary environmental evaluation; and
iv) regional EA.

Strategic EAs
v) sectoral EA.

While the majority of EAs completed are project-specific, the past few years have seen EAs extended to address sector-level planning, programs, and policies (such as the ones dealing with development and environment in a strategic way). An example of a sectoral EA would be the assessment of the effects resulting from a province-wide road rehabilitation program. The project-specific EA, the regional EA, and the sectoral EA are the focus of this handbook, since they are most pertinent to road projects.

1.5 ENVIRONMENTAL ASSESSMENT AT THE INDIVIDUAL PROJECT LEVEL[6]

1.5.1 The project-specific environmental assessment (EA)

The project-specific environmental assessment (EA) is the most common form of EA, and there is considerable experience with its execution.[7] Ideally, EAs should focus on identifying potential impacts on the local and immediate environment within the context of a region or sector. However, they are nearly always carried out in isolation, with little regard for what is happening beyond the project site and without considering existing future plans for the region. Clearly, there is room for improvement in this area. As part of the project scoping exercise, measures such as assessing the cumulative impact of multiple activities, and reviewing existing and planned developments in the region, are both desirable and necessary.

Project-specific EA allows road agencies to

- familiarize themselves with the environmental status of the proposed site and anticipate any environmental impacts that may arise from the road project;
- highlight likely design problems, thus permitting the agency to make early changes and avoid costly delays at a later stage; and
- integrate the project into the existing environment.

1.5.2 The programmatic or class EAs

Another project-level assessment type is variously known as the programmatic,[8] categorical,

[6] For an in-depth discussion of these types of EAs and an extensive bibliography, see World Bank, 1996(b).
[7] While the experience base is extensive, practitioners continue to make the same mistakes; lessons learned are rarely recorded and "effects monitoring" is not undertaken. The International EIA Network is now being established. One of its objectives is to build a library of EIA case studies and make it available to all practitioners. Contacts are listed in the section entitled "Other sources of information" at the end of this handbook.
[8] As used by the United States Environmental Protection Agency.

or class[9] EA. Class EAs have been developed for consideration of groups of projects which are similar in type, scope, and scale, and whose impacts are generally well understood. Examples include sewage treatment facilities, road maintenance and rehabilitation projects, and small bridge construction. The class EA steps applied to a project within a given group consist of a prescribed methodology which includes specific criteria, standards, and mitigation options known to be useful for the group or class of similar projects. For a class EA, mitigative measures are selected from a predefined list of measures that are proven to be effective, and then tailored to the specific project. As long as the projects fall within the definition of the class,[10] the methodology can be undertaken with little involvement on the part of the regulatory agency (e.g. a Ministry of Environment and Planning). The reason for this is that the guidelines used to specify the EA steps for the class undergo their own full EA and become a methodology sanctioned by the regulators and other stakeholders (through consultation sessions). Class EAs can save considerable time and money but, at the same time, are self-policing, thus placing the onus on the proponent to adhere to the specifications. The document arising from a class EA is often referred to as an Environmental Study Report, as opposed to an EIS.

1.5.3 Summary or initial environmental evaluation (SEE/IEE)

In many cases, a more limited environmental analysis is appropriate. This type of study, referred to either as an SEE or IEE, focuses on specific impacts and their mitigation.[11] The results of this type of study can take a variety of forms, but they are sometimes presented as a self-standing mitigation plan or an environmental management plan. The screening, scoping, and consultation tasks are normally used to decide if an SEE or IEE is appropriate for a given project.

1.5.4 The regional EA (REA)

Regional EAs[12] are used to assess environmental effects relating to the broad spatial context of a proposed project. The main objective of the REA is to assess the cumulative and other potential effects that all projects (present and future) proposed for a geographic area or administrative region might have on the environment (see Box 1.3 for a definition of "region"). Examples of these areas might include a coastal zone, a forest region, a watershed, a municipality, a county or a province.

BOX 1.3
DEFINITION OF A "REGION"

The Organization of American States defines a region as "any sub-national area that a country calls a region for purposes of planning or development" (OAS, 1984). Such an area is usually demarcated along administrative boundaries and may be composed of one or more municipalities, provinces, or states. Elsewhere, a region is defined as the locus of a specific problem (for example, poverty, social tension, and population pressure) or according to ethnic makeup. Socio-economic characteristics may also define regions, such as a generally poor rural area or a major industrial area.

For purposes of integrated regional planning and REA, the ideal approach is normally to define the region in natural-spatial terms. Common geographically defined units are river basins, mountain plateaus, forested areas, coastal zones, airsheds, and island configurations. An urban area can also be a very useful unit of analysis, often providing a degree of consistency across natural-spatial, socio-economic, and administrative boundaries.

Therefore, the decision on the study area boundary for an REA will require broad scoping and consultation and will be specific to the situation being assessed.

Source: World Bank, 1996(a).

Therefore, the REA can cover one project or several (multi-sectoral), with the unifying characteristic being common geographic situation. REAs do not eliminate the need for full EAs, but place each specific project into a better-

[9] As applied by the Canadian Environmental Protection Agency.

[10] The definition of a class includes a description of a set of criteria which qualify a project for inclusion in the class. These criteria generally deal with capacity, volume output, area coverage, or type of activity.

[11] While SEEs and IEEs are often the only EA analyses applied, their function is also to determine what additional EA work needs to be done. SEEs and IEEs can be the initial work preceding a more detailed EA.

[12] See also World Bank, 1996a.

understood regional context, emphasizing the interrelated nature of the environment.

1.6 ENVIRONMENTAL ASSESSMENT AT THE STRATEGIC LEVEL

Strategic EAs are formalized and systematic procedures for establishing environmental impacts, which may arise from broad actions such as new policies, national and regional development plans, or major program initiatives. They help to inject environmental considerations and actions into decision-making, above and beyond the project level.

Goodland and Tillman (1996) identify six types of strategic EAs:

i) Sectoral EAs (SEA);
ii) EAs of programs and policies;
iii) EAs of structural adjustment projects;
iv) EAs of privatization initiatives;
v) EAs of international treaties; and
vi) EAs of national budgets.

1.6.1 The Sectoral EA (SEA)

Of the six strategic EA types, only the SEA is addressed in this handbook. It is the most relevant in the context of road development. The main objective of the SEA[13] is to assess macro-scale development alternatives and, through this process, formulate sound environmentally-based advice on appropriate and sustainable development goals. The SEA highlights the benefits and costs of undertaking sector-wide action by comparing one strategy with another.

In the context of roads, an SEA might address a sector-wide investment in a relatively large geographic area, such as a province or state, integrating environmental concepts and strategies into the transportation planning process. This would require an analysis not only of infrastructure but also of land use (see Box 1.4), road user charges, land development and emissions legislation, as well as other policies that can influence transport choices.

SEAs are also useful in identifying macro-level information gaps that need to be filled if informed and environmentally acceptable decisions about sector-wide development are to be made.

SEAs rank projects within the sector in terms of their environmental strengths (including the biophysical, social, and economic components), and likely assessment, mitigation and monitoring needs. SEAs should rely heavily on consultation with stakeholders to build ownership in any proposed mitigation strategy.

SEAs should have four key outputs:

i) an assessment of policy, legal and administrative conditions in terms of completeness and appropriateness with regard to the sectoral initiatives proposed;
ii) an institutional strengthening plan based on the examination of the capacity of key regulatory agencies" ability to set guidelines, enforce standards, manage an EA, review EA results, and act as environmental opinion-shapers for senior decision-makers;
iii) an analysis of alternative investment options, as opposed to project designs (alignments); and
iv) recommendations for sector-wide regulatory changes as possible mitigative measures; one example of this would be requiring the use of unleaded gasoline to reduce lead contamination.

In the transportation sector (and not only there), SEA is sometimes applied in situations where a transportation mode is fixed but various road sub-projects need to be assessed. In this situation, the SEA is used to prioritize the sub-projects in terms of impacts, benefits, and EA requirements. This "modified" SEA pro-

BOX 1.4
COORDINATION OF TRANSPORT AND LAND USE PLANNING

Land use planning issues are usually considered an element of project planning and included in project environmental assessments. However, only a few countries have developed land use plans and policies for use at national and regional levels, that is to say, outside urban areas. Regional comprehensive land use plans, where they exist, provide an important information base for road environmental studies. Conversely, a road or transport planning issue can sometimes be a catalyst for initiating a comprehensive land use plan for the region concerned.

Source: OECD, 1994.

[13] See also World Bank, 1995.

BOX 1.5
SUGGESTED APPROACH TO SECTORAL EA: WORLD BANK ASIA REGION

Experience in the road sector, particularly in rural areas, has spurred development of informal procedures for sectoral EA in the Bank's Asia region to ensure consideration of all possible impacts on the environment. According to the informal procedures, this form of sectoral EA should contain:

- a screening process designed to identify sub-projects having potentially significant issues that would need to be addressed in a sub-project EA;
- a general assessment of the kinds of impact that might be associated with the different types of rural road sub-projects; and
- a sectoral environmental action plan to eliminate, minimize or mitigate the impacts resulting from sub-projects identified as not requiring full EAs and provide general guidelines for long-term monitoring.

Two categories are used in environmental screening of sub-projects:

i) sub-projects that may create a few minor and easily recognizable environmental problems, but no significant ones; and
ii) sub-projects with potentially adverse impacts on environmentally sensitive areas, defined as zones of significant human habitation; ecologically important areas such as wetlands and primary forests; archeological, historical, and cultural sites; and terrain with slope greater than 50%.

The second category of sub-projects usually requires project-specific EAs, while the first category is addressed primarily through the sectoral EA in the form of general impact assessments, sectoral action plans, and codes of engineering practice for environmentally sustainable road developments. These codes apply to both categories of sub-projects and cover such issues as construction practices, site selection, resettlement and compensation, as well as public consultation or participation.

Source: World Bank, 1995.

vides not only a process with which to identify the magnitude of the impact and the EA method to be applied, but it can also be used to prepare all environmental "clearances" for those sub-projects which do not require a full EA. Box 1.5 presents a generalized SEA procedure that clarifies the differences between this and other EA methods.

1.7 EA DURATION AND BUDGET

Among the factors to be considered before beginning an environmental assessment are the time to be devoted to the study (see Section 2.5) and the budget for preparing the study. Broadly speaking, the duration of an environmental assessment is usually between six and eighteen months, and expenses range between five and ten percent of project preparation costs.[14] An EA begun late in the project (at the design stage, for instance) may cause delays and exceed the suggested time range. The budget and timeline expenditures for less extensive environmental analyses are well below these levels; studies lasting as little as six weeks have been reported.

The costs of mitigative actions are better documented; an allocation of two to five percent of project construction costs is often required, yet could be higher in urban areas or sensitive locations.

Questions that should be considered when estimating an EA's duration and budget are

- Is information available in existing databases or is a field study necessary?
- Is seasonality an issue?
- Should the study be conducted by an external project team because of the environmental expertise required or can it be done in-house by a generalist?
- Is the study to be undertaken parallel to technical and economic investigations, or is a report requested only after such planning work has been completed? (The latter is often more expensive, has tighter time constraints, and can lead to project delays.)

[14] In the World Bank (1996b) review of EAs, completed between 1992 and 1995, it was concluded that EAs accounted for 0.06% to 0.45% of the total project cost (as opposed to project preparation cost). Examples: Bombay STP: $310,000 (0.11%); Yemen Road Project: $250,000 (0.27%).

1.8 REFERENCES AND BIBLIOGRAPHY

Canadian International Development Agency and Consultants. 1996. *Project Feasibility Study Report.* Mombassa Urban Transportation Strategy, Project documentation. Hull, Canada: Industrial Cooperation Division, CIDA.

Davies, K. 1992. *An Advisory Guide on Addressing Cumulative Environmental Effects under the Canadian Environmental Assessment Act.* Hull, Canada: FEARO.

Goodland, Robert and Robert Tillman. 1996. "Strategic Environmental Assessment", in J.R. Mercier and S. Muntemba (eds.), *Environmental Assessment in Africa: A World Bank Commitment. Proceedings of the Durban World Bank Workshop.* Washington, DC: World Bank.

Lee, N. and Walsh, F. 1992. *Strategic Environmental Assessment: An Overview.* Project Appraisal 7(3): 126-136.

Leibowitz, S.G. 1992. *A Synoptic Approach to Cumulative Impact Assessment: Proposed Methodology.* Corvallis, OR: Environmental Research Laboratory, US EPA.

Mercier, J.R. and S. Muntemba (eds.). 1996. *Environmental Assessment in Africa, A World Bank Commitment. Proceedings of the Durban World Bank Workshop.* Washington, DC: World Bank.

Organization of American States (OAS). 1984. *Integrated Regional Development Planning: Guidelines and Case Studies from OAS Experience.* Washington, DC: OAS.

Organization for Economic Cooperation and Development (OECD). 1994. *Environmental Impact Assessment of Roads* (Chapter II, Strategic Environmental Impact Assessment). Scientific Expert Group E1. Paris: OECD.

Rabinovitch, J. 1992. *Curitiba, Brazil: Environmental Management Case Study.* Urban Management Programme. Washington, DC: World Bank.

Sheate, W.R. 1992. *Strategic EA in the Transport Sector.* Project Appraisal 7(1): 170-174.

United Nations Environment Program. 1995. *Environmental Impact Assessment "Good Practice Guide".* Nairobi, Kenya: UNEP.

Vanclay, F. and D.A Bronstein (eds.). 1995. *Environmental and Social Impact Assessment.* New York, NY: Wiley.

World Bank. 1996a. "Regional Environmental Assessment," in *Environmental Assessment Sourcebook Update,* no. 15. Washington, DC: World Bank, Environment Department.

World Bank. 1996b. *The Impact of Environmental Assessment: Second Environmental Assessment Review of Projects Financed by the World Bank (July 1992 - June 1995).* Washington, DC: World Bank, Environment Department.

World Bank. 1995. "Sectoral Environmental Assessment," in *Environmental Assessment Sourcebook Update,* no. 4. Washington, DC: World Bank, Environment Department.

2. Environmental assessment management and institutional issues

HOW TO USE THIS CHAPTER IN THE CONTEXT OF EA AND ROAD PLANNING

Stage in road planning (A)	EA activity (B)	Involvement in addition to EA team (C)
Concept	Screening	Proponent
Pre-feasibility	Scoping	Key regulatory agency
Feasibility	Consultation	Other government agencies
Engineering design	Determining baseline conditions	NGOs
Construction	Selection of preferred solution	Research groups
Operation & maintenance	Assessment of alternative designs/methods	Public/community organizations
	Development of environmental management plan	Advisory experts
	Effects and compliance monitoring	
	Evaluation	
	Reporting	

Shaded area = (A) Stages of EA covered in this chapter; (B) focus of this chapter; and (C) primary target readers.

KEY QUESTIONS ADDRESSED:

- ? Who does what in the EA process?
- ? Where, when and why are environmental skills particularly important?
- ? What types of training programs are needed?
- ? What are the key features sought when strengthening governmental institutions?

2.1 EA AND INSTITUTIONAL DEVELOPMENT

Every country has to develop its own capacity to conduct EAs. This is required for a host of public and private sector initiatives, in addition to roads. The EA process is a continuous planning exercise that aims to harmonize developments such as roads with sustainable societal development. The key steps involved in the EA process, as it pertains to road projects, are summarized in Figure 1.1 (page 7) and elaborated in Chapters 3 and 4. Together, these steps require that many distinct functions be performed. While these functions fall into three broad categories—policy-oriented, technical, and managerial—each function calls for specific skills on the part of different players. Environmental skills feature prominently in these requirements.

The full complement of people required to conduct an EA should be drawn from a broad mix of generalists and specialists. Ensuring that these people are well-trained, informed, coordinated, and supported calls for competent management and other institutional support. The development of this institutional capacity to perform EAs on roads is, in turn, closely aligned with the broader exercise of the development of capacities to incorporate environmental considerations into other activities arising from public policy.

International funding institutions are very supportive of national efforts to enhance institutional capacities associated with policy reform, country management of technical assistance, and areas of special operational emphasis including, among others, environmental management.

This chapter examines what is involved in developing the capacity to conduct EAs on road projects.

2.2 FUNCTIONS TO BE PERFORMED AND THE NEED FOR ENVIRONMENTAL SKILLS

The EA process, summarized in Figure 1.1 (page 7), takes place within a larger context of ongoing initiatives on the part of the public and private sectors to promote environmentally sustainable development. Thus the management of a road agency should be able to receive institutional support from other agencies—most notably the environmental agencies—in its efforts to incorporate environ-mental considerations into road development.

Looking at EA in the context of this larger system of environmental management, there are four broad sets of functions that have to be performed and that are particularly significant in ensuring that environmental considerations be incorporated into road planning, construction and maintenance. In performing all four, persons with environmental skills are required. The functions are:

i) developing policy and legal directives;
ii) conducting EA studies;
iii) implementing the environmental management plan; and
iv) managing the overall EA process.

It is for the central executive (the office of the prime minister or president) of a government to assign responsibilities for the effective performance of the first of these sets of functions and thus, indirectly, the latter three. Each function is summarized below.

2.2.1 Developing the policy and legal directives

The development of policy directives will normally be assigned to the environment ministry or its equivalent. The ministry should be mandated with the responsibility for introducing EA into the planning process of public sector agencies. Most frequently, the initial follow-up will take the form of a ministerial decree. It is desirable that an environmental assessment act should follow. This often results in the creation of an environmental assessment agency, reporting to the minister of the environment, and responsible for overseeing the conduct of EAs by line agencies, such as the transportation agency.

The EA Act or similar legislation will most likely assign responsibility to the road agency for conducting, or at least coordinating, EAs on road projects and, more generally, managing the road EA process.

The environmental agency is usually responsible for drafting all environmental policy statements, laws, regulations, decrees, and circulars, and is sometimes responsible for policy guidelines and contributions to international conventions. Inter-agency coordination is necessary both in drafting these instruments and applying them to such activities as road development. In this regard, environmental specialists have a major role to play within a road agency, in keeping abreast of the requirements of regulatory agencies, and in developing an effective dialogue with them during the preparation of new regulations.

The environmental assessment or environmental management plan should note the various national requirements that apply. Financial, physical, or other criteria should be clearly identified. This is especially important in the case of sectoral environmental assessments, where several different procedures may be used. Failure to follow regulations such as the following can block the progress of a whole project.

- Regulations concerning procedures—for example, with respect to supervision of the study, certain regulations specify the conditions under which the authorities responsible for the environment will intervene in the environmental assessment and the extent of their prerogatives.
- Regulations concerning methodology—for example, certain regulations require that studies be carried out in a particular manner and be presented in a specific format.
- Regulations concerning environmental standards (important for management plans).

Regulations are extremely important because they usually specify standards to be used by environmental specialists, and others, when evaluating the acceptability of the project, as well as the measures to be taken in order to protect the environment. Often measures are not specified, but the standard will imply a certain method and level of effort. Requirements of national, regional, and local governments, and any financing institutions, should also be taken into account.

Standards are developed for a diverse range of environmental components, which include air, noise, quality of the water and the soil, protection of natural surroundings or archaeological sites, and public health. An environmental assessment may simply reference the appropriate standards, without providing all the details, except where they are particularly relevant. Mitigative measures are often based on the degree to which impacts change the environment, relative to standards. During the monitoring stage, the particulars of regulatory standards may be of great importance, and should be referenced in project documentation or be readily available.

Although it is not possible, in this handbook, to deal with regulations for all of the above-mentioned environmental components, useful references can be found in Part II.

2.2.2 Conducting the EA studies

While all road-related EAs are likely to be the responsibility of the transportation agency, the scale of the project will likely dictate the organizational arrangements for the conduct of the EA, and who is best suited to carry out the required tasks. Some of the most important of these tasks are the assessment of alternative solutions, the analysis of baseline conditions, the analysis of potential environmental impacts, the evaluation of alternative designs, the development of mitigative measures the valuation of environmental costs and benefits, and the development of the environmental management plan.

Environmental specialists are generally needed within a road agency to undertake all of the above-mentioned types of tasks; indeed, it is highly desirable that environmental specialists be assigned to lead such work. To complement the planning, engineering, and economic skills available within a road agency, environmental specialists should possess a knowledge of the social sciences, natural sciences, and public consultation methods.

For small projects with limited environmental problems, in-house environmental specialists should be able to carry out the entire study independently, perhaps with advice and assistance from other specialists. This experience is important for in-house specialists, as it develops skills which may be helpful when carrying out larger projects.

For larger projects, environmental studies may be carried out by consultants on contract, or by way of a combination of in-house analysis, coordination with other specialized agencies, and subcontracts to consultants or universities for specific components. Where a full environmental assessment is required, the work can be executed by engineering consultants with an environmental division, or by consultants specializing in environmental studies. In-house environmental specialists are needed to establish terms of reference for such studies, to evaluate and supervise consultants, to assist with public consultation processes, and to coordinate with project planners and other environmental experts.

Since consultation is such an important element in the completion of environmental studies (see Chapter 5), the environmental specialist, as well as other team members, should be skilled in consultative techniques and in handling difficult situations that may require considerable tact and diplomacy, often with larger audiences.

2.2.3 Implementing the environmental management plan (EMP)

One of the key products of the EA studies is an environmental management plan, also known as an environmental action plan (see Section 4.8). Its implementation involves managerial and technical level personnel from both within, and external to, the road agency. Environmental skills will be required by many of these persons at the various stages of implementing project actions related to the environment. These stages include route choice, land acquisition and preliminary design, detailed design and contract specifications, construction supervision, and maintenance and follow-up of mitigation plans related to both the social and natural environment.

The environmental specialist's contribution in each of these stages warrants further comment.

Route choice, land acquisition and preliminary design

By working with road engineers and planners at this stage, environmental specialists should ensure that community and environmental issues are incorporated into project formulation early on in the road planning process, and also increase awareness of environmental factors throughout that process (see Figure 1.1, page 7). The environmental specialist should identify potential needs for liaison with outside experts, for example in landscape, wildlife protection, or the design of improved water retention schemes.

Drafting of contract specifications

Road engineers need to work closely with environmental specialists in completing this exercise. Contract specifications are required for the implementation of mitigative measures as part of the overall construction work, such as tree removal, revegetation, construction traffic management, and cleanup of work sites. Certain measures, such as the relocation of animals (temporary or permanent), reforestation, or resettlement, may require the services of specialist subcontractors. Specifications are also required to ensure environmentally acceptable facility operation and maintenance. These would become part of the requirements of the proponent, as opposed to the constructor. This very important matter of contract specifications is discussed further in Chapter 18 of this handbook.

Supervision of construction

Most construction work requires the presence of an inspector, representing either a government road agency, the contractor, or a consultant's office, in order to ensure that the technical clauses of the contract are respected, and that the reasons behind them are fully understood. This latter consideration suggests that these supervisors should have some environmental training (see Chapter 4).

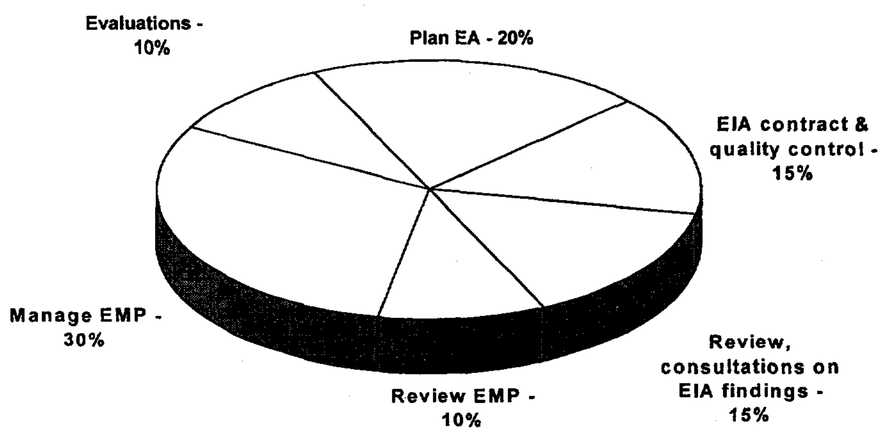
Supervision of maintenance and follow-up of mitigation plans

At this stage, supervisors take responsibility for operating and maintaining the installations once construction is completed. Again, as in the case of construction supervisors, some environmental training is required for inspectors.

Timely action can be critical for the protection of the environment. For example, maintaining drainage ditches and structures will prevent large-scale erosion during major storms. Monitoring mitigative measures during operations helps to ensure that maximum benefit is obtained from their sometimes costly implementation.

Apart from the maintenance of physical infrastructure, attention must also be given to social mitigative measures (ongoing support for affected residents and businesses), natural habitats (success of re-establishment of plant or

FIGURE 2.1
EA PROCESS: APPROXIMATE DISTRIBUTION OF MANAGEMENT EFFORT



Source: Inter-American Development Bank, 1996.

animal species), and traffic management (accidents and impacts on adjacent properties).

Contract managers sometimes add environmental pre-qualification (see Chapter 18) to contracting terms, thereby ensuring that the contractors possess an adequate base level of environmental technical capacity.

2.2.4 Managing the EA process

The overall effectiveness of the EA process is heavily dependent on the capacity of the road agency's management personnel to take appropriate action throughout the process. Environmental specialists can be helpful in ensuring that the performance of the following functions, by a road agency, does indeed reflect appropriate choices such as

- defining policy directions for the road agency in light of policy directives from the environmental agency;
- drafting terms of reference;
- assembling teams for conducting environmental assessments (where the leadership of a generalist with an environmental background is highly desirable);
- ensuring internal coordination within the road agency (for example to integrate the results of studies with action plans);
- negotiating with other administrations (for example environment, agriculture, planning) and clearly establishing supervisory authority where responsibilities are shared;
- staying abreast of, developing, and enforcing regulations;
- defining priorities;
- organizing public consultations and participatory processes;
- implementing mitigation plans;
- developing methods and operational tools for environmental awareness at policy, program, project, and operations levels; and
- organizing training and information campaigns.

These general management functions will be performed throughout most stages of the EA process.

A critical feature of an EA's management is the appropriateness of the allocation of human resources and time to each stage of the process. Particularly important are

- The distribution of management effort to each of the major stages of the EA process. Figure 2.1 makes clear that managing the planning of the EA—scoping, screening and early consultation—should require about 20 percent of the management effort.
- EA contract administration, which should require about 15 percent of the total EA management effort.

- The distribution of effort on the part of the team conducting the EA study (i.e., prior to project implementation). Figure 2.2 makes it clear that, while the identification and assessment of potential impacts may require 25 percent of the team's time, it does not dominate the process.
- EA planning, which should require about 20 percent of the study team's effort. This is very significant since most EAs are "bottom heavy," in that a very small percentage of effort is expended on planning the EA, leading to poor quality EAs.
- Public involvement effort which, although not separated out in Figure 2.2, should account for at least 20 to 30 percent of the time allocated by the study team to mitigation and monitoring planning, and EMP preparation.

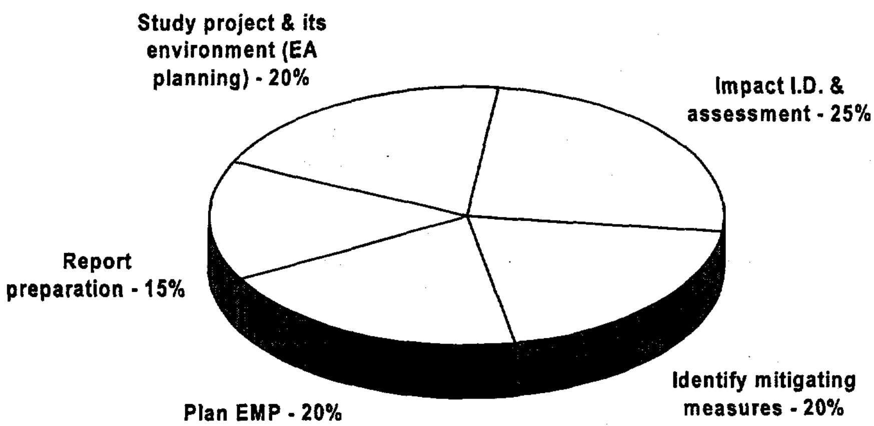
Ultimately, the success of environmental assessment processes depends on the awareness of environmental factors exhibited by all personnel involved at all stages of the project, and on the motivation to deal with problems which may arise.

The training process is used to create or reinforce environmental diagnosis, planning, and management capabilities of the road agency and its environmental assessment team. The environmental assessment field in general needs to overcome a number of serious problems that contribute to major shortages in human resources in many countries, including

- insufficient technically qualified staff, especially at the intermediate level;
- a lack of practical and on-site experience, which may hinder staff productivity as increased attention is expected to be given to environmental issues;
- job turnover, and institutional structures not geared to the needs of environmental assessment and mitigation activities; and
- a shortage, in many countries, of environmental instructors with knowledge of specific fields of importance for road projects.

Road agencies should work towards building environmental units (see Section 2.4)

FIGURE 2.2
EA STUDY: APPROXIMATE DISTRIBUTION OF STUDY TEAM EFFORT PRIOR TO PROJECT IMPLEMENTATION



Source: Inter-American Development Bank, 1996.

2.3 PROVIDING THE REQUISITE ENVIRONMENTAL TRAINING

Environmental skills training is required for environmental specialists working on studies, mitigation plans, and supervision of project implementation. It is also required for the staff of road agencies, contractors, and consultants who are responsible for interpreting environmental policy directives, and for planning, designing, constructing, and managing roads.

that have several persons on staff with a university education in environmental studies, or in closely related disciplines in the natural sciences (for example botany, zoology, geography) and the social sciences (for example sociology, anthropology, land use planning). As emphasized above, it is highly desirable that such people play a leading role in the EA process.

During the transition period when awareness of environmental issues is being developed, a strategic training plan should be prepared, with training activities aimed at the following groups of persons in the road agency who are assumed to have very little or no previous environmental training:

Policy specialists
Although the policy directives on EA will be generated by the environmental agency, it is for the road agency to interpret those directives and to ensure that they are reflected in the policies of the road agency. Policy specialists in that agency should be given the opportunity to work alongside policy specialists in the environmental agency long enough to enable them to fully understand the principles underpinning environmental policy making. Ideally, this on-the-job training should be complemented by some theoretically based training.

Managers
The goal of management training is to convey, as clearly as possible, the general environmental assessment policy of the road agency, which underpins environmental assessment directives and procedures. In this way, managers will be able to mobilize, convince, and guide their co-workers. This type of training can be carried out at seminars of one to two days for groupings of 50 or more participants.

Technical specialists
This type of training is addressed primarily to engineers and their colleagues, who are responsible for planning, designing, and implementing projects.

For those directly responsible for environmental components, training should include case studies and exchanges of actual experiences, as in the preparation of environmental assessment reports. Training can be one to two days in length, but with a smaller group of thirty to forty participants. The objective is to improve understanding of the issues and procedures to be followed in environmental assessment work and to transmit the practical knowledge and tips needed in day-to-day work.

For other engineers and professionals in road agencies, local government, universities, and private practice, training should focus on increasing awareness of environmental issues at various stages of road development and management. It should also highlight the costs associated with ignoring environmental issues.

Site supervisors
This training is intended to provide in-depth methodological, technical, and practical knowledge covering all the activities involved in supervising the construction work and maintenance. Case studies and site visits are indispensable.

Training content should be tailored to meet the needs of each group. It may include relevant technical methods and procedures (for example for erosion protection, noise analysis), guidelines for organization and management (for example for study design and integration with project planning), techniques for communicating with the public, and an introduction to ecological and social analysis. The instructors should consist of scientists or researchers specializing in the natural and social environment, and highway professionals who already have field experience with environmental assessment and road project procedures. The larger the number of instructors with extensive field experience, the better.

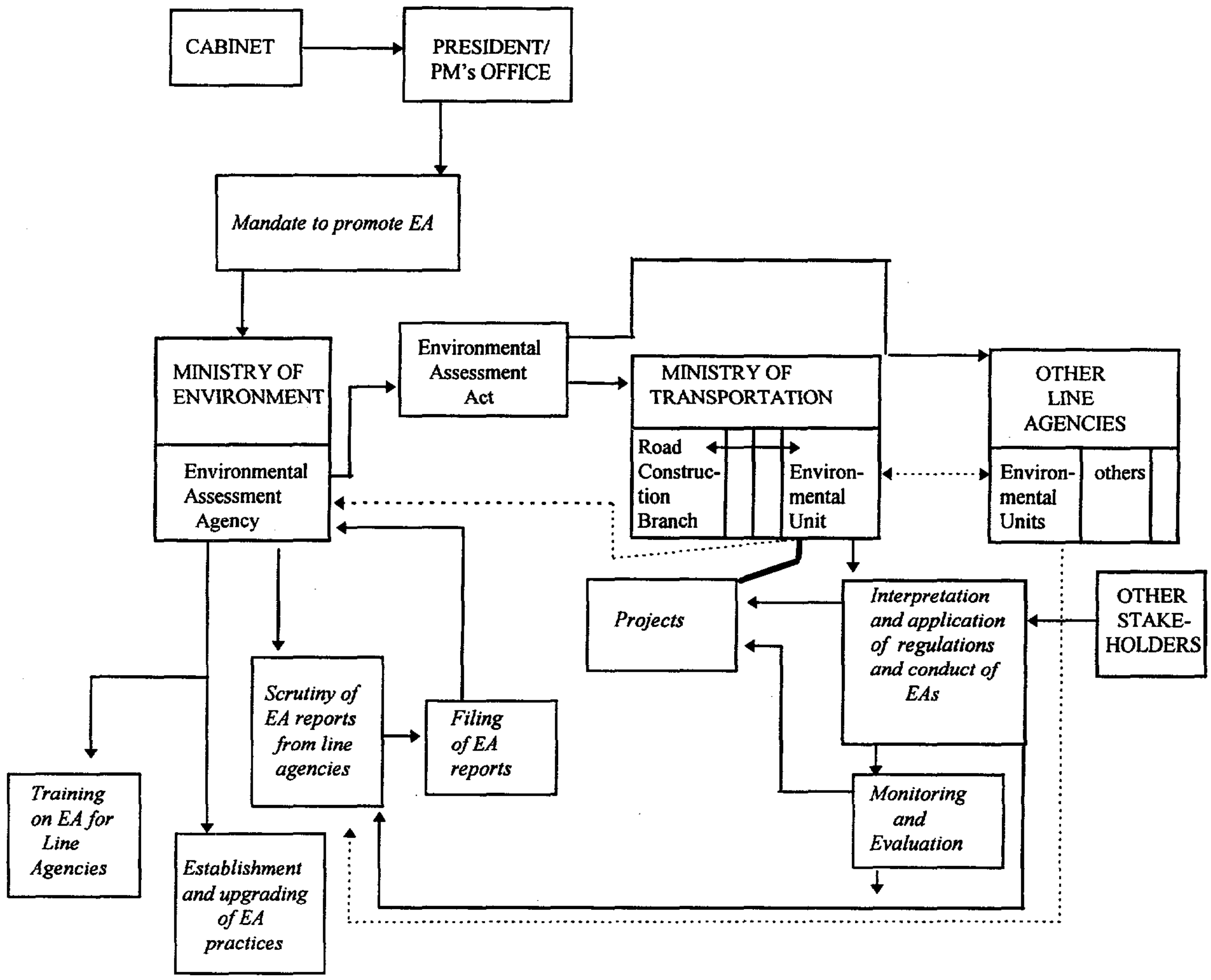
A training program of the type described here can be established and implemented over a period of one or two years. Subsequent training is required to keep abreast of changes in the field of environmental studies and to see that these new procedures are adopted.

2.4 ESTABLISHING THE INSTITUTIONAL STRUCTURES

As indicated in Section 2.2.1, the general policy direction on EAs for road projects should come from the environment ministry, possibly through an environmental assessment agency responsible for overseeing EAs being con-

FIGURE 2.3
TYPICAL INTER-AGENCY RELATIONS FOR A ROAD AGENCY ON ENVIRONMENTAL ASSESSMENT

Note: solid lines indicate flow of activity and dashed lines indicate technical and administrative communication. Italics indicate actions.



ducted by all line agencies. The relationship between the transportation agency and the environmental and other agencies is shown in Figure 2.3. The figure shows the institutional context within which a road agency should expect to carry out environmental assessments. The figure also shows how the initial mandate to promote environmental assessment (emanating from the Cabinet) is transformed into an environmental assessment act that requires the road agency to carry out such assessments of its projects. The follow-up to such assessments is also shown, as are the supportive functions of the environmental assessment agency.

For a road agency that is institutionalizing its approach to EAs on road projects, the following organizational options should be considered:

- appointing a senior advisor to senior management, with limited operational responsibility—something which should be considered as an interim measure;
- establishing a small-scale coordinating unit responsible for defining programs, monitoring, evaluating, and communication (most work would be contracted out to consultants); or
- creating a comprehensive structure that performs most work in-house and uses consultants for specialized topics.

There are two conditions which are essential for success when using any of the above three approaches: a) a senior position in the decision-making hierarchy that enjoys a strong relationship with management; and b) a staff that is prepared to listen to the needs of operation, construction, and management teams within the road agency, and respond to the concerns of other agencies and the public.

Most countries will probably want to proceed by starting with the first of the three options mentioned, and then progress to the second and third. In countries where a unit is being established at the same time as a Ministry of Environment, it may be expedient for the environmental unit in the road agency to assume some responsibility for developing regulations. This is illustrated by the Moroccan example outlined in Box 2.1.

More frequently, the Ministry of Environment will be established first, and will be responsible for developing the regulatory framework within which the environmental units in the various line agencies (including the road agency) will operate. In this more common situation, the prime role of the environmental unit will be to perform the responsibilities assigned to the road agency under the EA Act. This primarily involves

- the interpretation and application of the regulations (see Section 2.2.1);
- conducting EA studies on road projects (see Section 2.2.2 for the prime tasks involved); the implementation of the Environmental Management Plans (see Section 2.2.3 for the prime tasks involved, including monitoring);
- the evaluation of road projects to ensure that EA directives have been observed;
- contributing to the overall management of the EA process (see Section 2.2.4).

It is essential that the mandate of the environmental unit be clearly spelled out, and that it be quite distinct from that of the Ministry of Environment and, if it exists, the Environmental Assessment Agency.

The staffing of the unit, and the training of that staff, has been discussed in Section 2.3. The complement of permanent staff can be expanded as demand grows. Over time, the unit may acquire its own subsections covering, say, land acquisition, social issues, and biophysical issues. However, care should be taken to retain an integrated approach to the assessments.

The unit should be headed by a senior person with an environmental background, good management skills, and an ability to work well with engineers. The head should be a member of the senior management of the road agency.

In addition to forming a headquarters unit, there may be a need to strengthen field environmental capabilities by establishing on-site units. It is good practice to describe the agency's environmental organization in any sectoral or project environmental assessments that are prepared.

BOX 2.1
ESTABLISHING AN ENVIRONMENTAL UNIT IN THE DEPARTMENT OF ROADS AND TRAFFIC, MOROCCO

Morocco has undertaken environmental impact studies of specific projects for some time, especially for freeways and roads in sensitive ecological zones and built-up areas, but the approach has not been systematic or required by legislation. Following the Earth Summit in Rio de Janeiro in 1992, a national Ministry of Environment was established, and a roads and environment unit was created in the Department of Roads and Traffic, with the objectives of:

Short term
- Sensitizing public and private professionals
- Conducting model studies and demonstration projects to involve sector staff
- Conducting research and monitoring environmental impacts of roads
- Developing environmental impact study directives and methodology
- Collaborating with other agencies on development of laws.

Medium term
- Establishing a multidisciplinary environmental audit team
- Preparing regulations regarding environmental assessments for roads.

2.5 REFERENCES AND BIBLIOGRAPHY

Danish Technological Institute. 1989. *Project Related Training in Developing Countries*. Denmark.

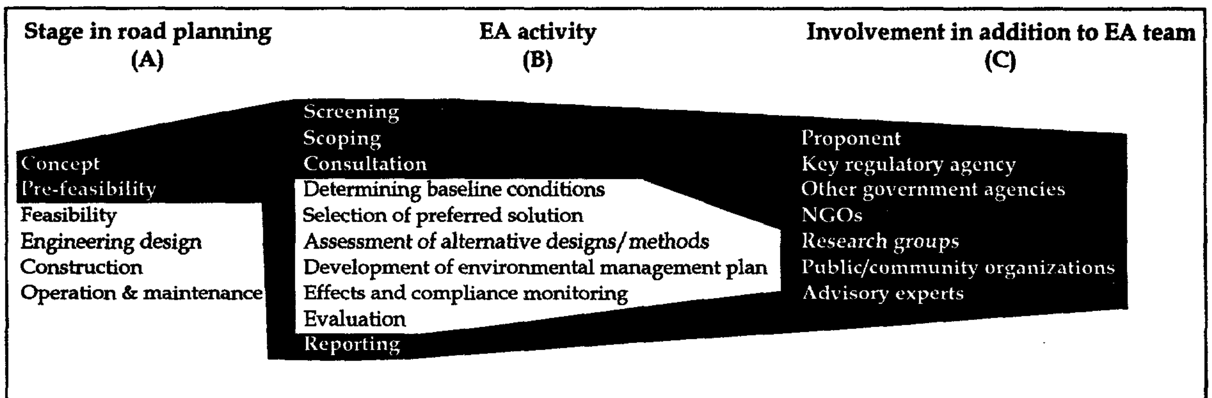
Inter-American Development Bank. 1996. *Environmental Assessment in the Transportation Sector: Guidelines for Managers*. Washington, DC: IDB.

United Nations Environment Programme and International Labour Office. 1990. *Environmental Management Training Course for Employer's Organizations*. Geneva: UNEP and ILO.

World Bank. 1995. *Mainstreaming the Environment: The World Bank Group and the Environment Since the Rio Earth Summit*. Washington, DC: World Bank.

3. An overview of environmental assessment planning and EA reporting

HOW TO USE THIS CHAPTER IN THE CONTEXT OF EA AND ROAD PLANNING



Shaded area = (A) Stages of EA covered in this chapter; (B) focus of this chapter; and (C) primary target readers.

KEY QUESTIONS ADDRESSED:

- ? Why is early planning crucial to successful environmental assessment?
- ? What are screening and scoping?
- ? What are the basic form and content of an EA Terms of Reference?
- ? What is a valued ecosystem component (VEC)?
- ? What comprises an environmental assessment report, and what are some of the presentation options?

3.1 EARLY PLANNING OF EA

A well-planned EA process has two key stages. The first is an early planning period where general environmental impacts from alternative solutions to a road transportation problem are identified and compared, resulting in the selection of an environmentally acceptable project option. The second stage is at the project design level, where the optimal or preferred project design is selected in terms of alignment, grade, pavement treatment, median type, etc. It is this second stage that is generally associated with the EA. Screening and scoping are two key activities at the first stage of the well-planned EA, which are discussed in detail in Section 3.2. Chapter 4 presents key steps involved at the second stage.

The early planning in the road development process is often overlooked, since it is usually the responsibility of people other than those who conduct the EA, or it is considered irrelevant to the overall EA. This is a major factor leading to project difficulties and costly delays later on. Early planning should

- identify the preferred solution to the transportation problem for which the planning activity was initiated;
- establish broad boundaries for the project;
- identify the scope of work required (which leads to the pinpointing of the type of EA to be applied); and
- provide valuable input to the preparation of EA terms of reference.

In properly designed EAs, the early planning is integrated into the project-specific assessment. Its value in flagging serious environmental issues, reducing EA cost, and helping to win early public acceptance of a project needs to be recognized by decision-makers and highlighted whenever possible.

It is recommended that transportation agencies which have not already done so adopt this early planning as an explicit part of their EA process.

3.2 SCREENING AND SCOPING

The planning for an environmental assessment involves two key activities: *screening* and *scoping*[1].

[1] Screening and scoping are most often used on specific projects (as opposed to higher-order solutions) to pinpoint environmentally acceptable designs.

Screening refers to an early determination of the potential magnitude of impacts and hence the depth of study required. This should be the first stage in incorporating environmental considerations into a road development project. Screening should

- provide a definition of the scale and type of project;
- identify a "long list" of valued ecosystem components (VECs) in the study area (see Section 3.2.3);
- establish the general nature and magnitude of the potential impacts; and
- suggest the most appropriate EA process to apply to the project.

Scoping is a process used for defining what can and what cannot be accomplished during a particular environmental study. This would include

- defining the geographic boundary of a study in relation to possible impacts (see Section 3.4.1);
- identifying the time constraints and time horizons of the study (i.e. project time limits and how far into the future one should predict project effects); and
- identifying the skills and human resources needed to undertake the project.

Screening and scoping can be completed by undertaking the following tasks which incorporate the key activities listed above.[2] These seven tasks are

i) describing the need for a project;
ii) describing the proposed project and alternatives (solutions);
iii) identifying valued ecosystem components (VECs);
iv) evaluating the potential impacts of project options on the VECs within the study area;
v) consulting local officials on options and impacts in order to establish institutional capacity and environmental lessons learned in the study area;
vi) selecting a preferred project option (concept); and finally

[2] Exceptions include: projects which are clearly site-specific and can be executed using a programmatic or class EA approach that is initiated without the "front-end" planning; and projects which are clearly beneficial, such as rehabilitation of eroded transportation corridors.

vii) identifying the EA type to be applied to the preferred project option.

It is only after completing these planning tasks that road managers and planners can legitimately say that they understand the proposed project in the context of its environment and in relation to other engineering solutions. Skipping these early planning steps often leads to costly complications and delays later in the project or program development stream.

3.2.1 Description of the need for a project

In order to define what type of project or, alternatively, what solution[3] is most appropriate to relieve the particular road problem, a clear description of the need for the project is necessary. Once this has been achieved, a set of viable alternative solutions can be defined.

3.2.2 Description of the proposed project and alternatives[4]

In describing the project and its alternatives, four key characteristics of each proposed alternative should be determined before a comparative analysis can be undertaken. The four characteristics are

i) spatial requirements (see Box 3.1);
ii) natural resources (including productive land) consumption;
iii) human resources benefits and costs (such as resettlement versus better access to market); and
iv) waste production during the construction and operation/maintenance periods.

BOX 3.1
TYPICAL ROAD RIGHT-OF-WAY REQUIREMENTS

For a 6 to 7 meter wide pavement, the right-of-way (ROW) typically varies between 10 and 40 meters, or 1 to 4 hectares per kilometer of road. Wider ROWs are often used in humid tropical areas where it is necessary to clear a wider strip to allow the pavement to dry.

3.2.3 Identification of valued ecosystem components (VECs)[5]

By combining local knowledge, scientific evidence, and expert opinion, one can identify the social and biophysical components of the environment that are of value in the project area (for whatever reason). These VECs, as they are termed, can be ecological, social, economic, or cultural. Some examples might be a watershed, key species, potable water supply, historical area, population center, or an airshed.

In addition to conducting some basic research, consulting with experts or knowledgeable members of the local community can assist greatly in the compilation of the VEC list and speed up its creation.

Having listed a preliminary set of VECs, the next step is to identify in broad terms how and to what extent the proposed options would affect each VEC. This is best determined by identifying a few environmental indicators for each VEC which would be sensitive to project-induced impacts and could provide indications of potential impact duration, extent, and severity.

Usually, the initial VEC list is long and needs to be reduced. This is best achieved by asking two questions about each VEC:

i) Is there a strong likelihood that the given VEC will be either directly or indirectly affected by the alternatives? If NO, this VEC should no longer be considered.
ii) Can the impact on the VEC be predicted by focusing on indicators of direct or indirect effects?[6] If NO this VEC should be given a low priority, unless it is of very significant value to a majority of stakeholders.

The outcome should be a list of prioritized VECs that provides a good indication of what sorts of impacts might occur with each alternative.

[3] Having more than one alternative solution is not absolutely necessary, but it is highly recommended in order to avoid serious omissions and concerns about project viability.

[4] This refers to alternative solutions or alternative options, as opposed to alternative designs assessed during the later stages of the EA process.

[5] This concept was developed by Beanlands and Duinker (1983).

[6] Direct effects indicators could include area of land disturbed, access restrictions, loss of agricultural land, habitat loss, stream realignment, etc.; indirect effects could include water quality changes, job losses, reduced community cohesion, and increased cost of goods.

3.2.4 Evaluation of potential impacts for alternative solutions

Using the results of the task proposed in Section 3.2.2, as well as the refined VEC list, one can conduct a preliminary matrix screening and quickly identify the project which would be the most environmentally acceptable and provide the best transportation solution. The evaluation takes place on a macro-scale, comparing the management decisions and potential environmental consequences of building a road with other conceptual solutions, such as restricting private vehicle use, supporting public transportation, encouraging non-motorized transport modes, and so forth. This analysis is carried out most beneficially by senior managers who, ideally in the process of undertaking the work, become fully aware of the general benefits and costs they will encounter with each alternative. The application of indicators, such as economic losses and gains, number of people disrupted, and loss of VECs, helps to keep the duration of the analysis short. Finally, the inclusion of the 'no project' alternative is essential if accurate assessment of possible changes is to be achieved.

The analysis of alternative solutions is an essential component of EA. Its completion signifies that the proponent has considered the proposed project in the context of other options and has selected one based on a holistic examination of that alternative's ability to meet transportation objectives.

3.2.5 Early consultation

Prior to selecting a preferred alternative solution, a preliminary consultation should be held (possibly in conjunction with the VEC activity described in Section 3.2.3). The focus should be on introducing the project, outlining possible impacts, indicating the planning timetable, and specifying the guidelines for stakeholder input (including specifications on when input is most desirable).

The consultation session should bring together all stakeholders, including the relevant regulatory agency. A first-order assessment of the institutional and environmental stewardship capacity of the regulators should thus be possible. The results could form a critical basis for deciding what level of EA needs to be undertaken.

3.2.6 Selection of preferred project (solution) and identification of EA type to be applied

Assuming that the preceding tasks have been completed by balancing engineering requirements and environmental considerations with practicality and economics, the 'best' project solution can be identified. The appropriate EA type can then be chosen confidently as the best way of managing the project's environmental requirements.

In general there are five EA types to choose from (see Sections 1.4, 1.5 and 1.6 for definitions):

i) project-specific EA;
ii) programmatic or class EA;
iii) summary environmental evaluation;
iv) regional EA; and
v) sectoral EA.

The choice depends primarily on the size of the area affected, the severity and duration of the possible impacts, and the political and administrative boundaries affected.

The project-specific EA is the most common and serves almost all purposes. The class or programmatic EA would be applied when there is a group of projects that are similar in nature (for example, road resurfacing and shoulder repair projects scattered across a region or a country). It is to these latter projects that a generic set of assessment steps and solutions would be applied. The summary environmental evaluation would be applied to individual projects that had well-known impacts and required only mitigation and monitoring plans. Regional EAs would be applied if the project were one of a series in different sectors within an area, for example, transportation, energy, and agriculture development, all within one watershed. A sectoral EA would be appropriate if the project involved, for instance, the upgrading of the road transportation sector within a large area (a province or a country) and entailed many road corridors and future projects (see Sections 1.5, 1.6 and 1.7 for more details).

The World Bank uses a screening approach that focuses on defining the three characteristics of anticipated impacts: a) their location in relation to sensitive features; b) the project's scale, both in terms of space and time; and c) the sensitivity of the ecosystem component affected. It establishes how severe (or reversible) the impact is and how much significant damage accompanies it. Projects are classified into one of the following categories based on this analysis:

Category A: includes projects which require full EAs; they are likely to have significant adverse impacts that are diverse, irreversible, possibly sector-wide, and unpredictable; they all require a separate EA report;

Category B: includes projects which usually require only a summary environmental evaluation; they are characterized by reversible impacts which are smaller in scope and shorter in duration; they require a chapter in the prefeasibility or feasibility report; and

Category C: includes projects for which no EA is required; however, a brief explanation of why the project does not need any EA may be useful.

Some jurisdictions have developed a more prescriptive screening process. The selection of the type of EA to apply, according to this process, consists of working through a 'decision tree' which matches the project type with the environmental setting and the likely impacts, based on past experience and technical criteria (see Figure 3.1). Such a screening process may be useful for locations in which experienced expertise in EA is not readily available.

This step completes the early planning stage of EAs and provides a solid base for the more detailed EA analysis and decision-making procedures which follow in Chapter 4.

3.3 PREPARATION OF THE PROJECT TERMS OF REFERENCE

Well-prepared EAs are usually based on good terms of reference (TOR); they provide specific guidance on what actions should be taken and in what sequence. TOR are often improved greatly by early screening and scoping of potential impacts. TOR usually contain three categories:

i) definition of the project;
ii) setting and regulatory context; and
iii) scope of work and management issues (requirements for the consulting team, schedule, etc.).

A generic TOR table of contents, which should help to guide users who need to prepare such documents, is presented in Box 3.2. The World Bank's Environmental Sourcebook also includes a section on the preparation of TOR.

3.4 SPACE, TIME AND CONSULTATION

3.4.1 Space

When deciding on the size of the study area, the following physical elements should be considered: the road itself (including possible alternative routes); areas affected indirectly (including feeder roads, maintenance areas, and railways); and locations affected by construction activities (including quarries, borrow pits, dumps, traffic diversions, work camps, and temporary accesses).

The study area should be enlarged if there is a danger that environmental impacts will affect areas beyond the immediate physical surroundings, for instance downstream of a major river crossing. Criteria to be considered here include

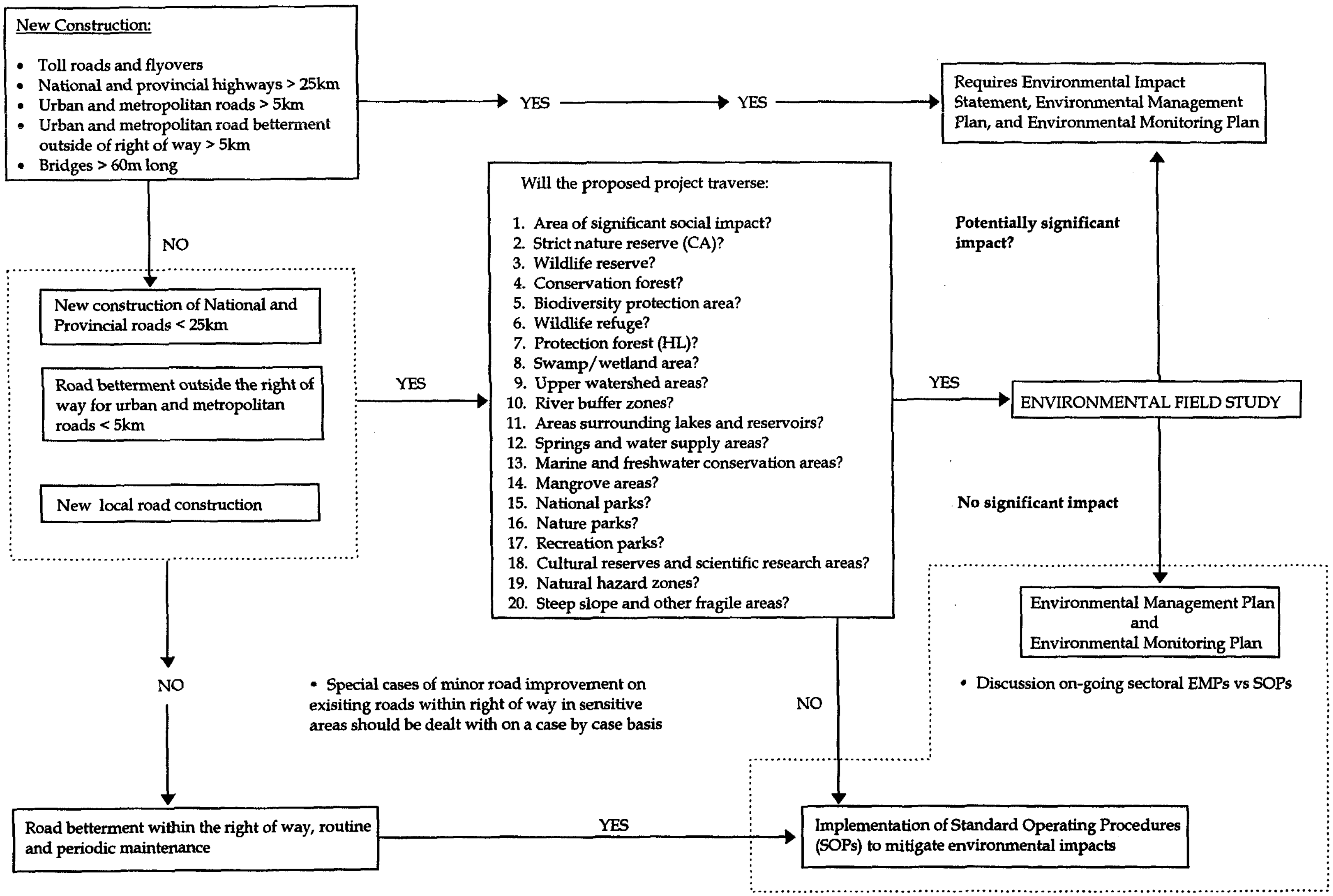
- ecological diversity of the site; as this increases, the study area should be enlarged;
- type and scale of the development scheme; in general, the greater the change from existing conditions, the greater the potential impact;
- VECs; examples might be natural reserves with rare wildlife or fertile farmland.

3.4.2 Time requirements for the environmental study

As stated in Section 1.7, EAs generally take between six and eighteen months to reach the "submission-to-regulator" stage, when they are considered complete. The length of time required depends on whether

- the EA requires investigation during special periods of the year (seasonal aspects of the environmental impacts);

FIGURE 3.1
EXAMPLE OF EA SCREENING PROCEDURE DEVELOPED BY DIRECTORATE GENERAL OF HIGHWAYS, MINISTRY OF PUBLIC WORKS, INDONESIA



Source: World Bank, 1996.

BOX 3.2
GENERIC TABLE OF CONTENTS FOR EA TERMS OF REFERENCE

1.0 Summary
2.0 The Project and Setting
2.1 The Project Objectives and Need
2.2 Review of Parallel Studies
2.3 Relevant Institutional, Legal and Policy Setting
2.4 EA Requirements (including laws)
2.5 The Project Location and Region
2.6 Potential Environmental Impacts
2.7 EA Management and Protocol
3.0 Scope of work
- Description of the Proposed Project
- Description of the Environment (natural and social)
- Legislative and Regulatory Considerations
- Determination of Potential Impacts (natural and social environment)
- Analysis of Alternatives
- Public Consultation Program
- Development of an Environmental Management Plan (including mitigation & monitoring)

4.0 Consultant Team[7]
5.0 Schedule
6.0 Other Information
7.0 Work Plan and Allocation of Resources
8.0 Reporting and Report Production
9.0 Other Deliverables
10.0 Budget

Adapted from: IADB, 1996.

- the environmental components to be studied are numerous and the results must be integrated; and
- the required information involves a lot of site investigation work.

3.4.3 Consultation

In establishing the scope of the study it is highly desirable for all key stakeholders to arrive at a consensus on sensitive features, impacts, and remedial actions (see Chapter 5). Involvement of interested parties such as government ministries, project designers, local officials, associations, community representatives, and local residents at an early stage in the EA process can help to improve the chances that the program will not be subject to last-minute dispute. Meetings and discussions on the scope of environmental studies make use of findings obtained from the initial planning activities described in Section 3.1. The meetings and discussions should

- inform those in attendance of the project objectives and the alternative solutions under consideration;
- identify the natural, economic, and social resources of importance in the area, i.e. VECs;
- explore the possible consequences of the project for the natural and social environment; and
- find agreement on the issues which should take precedence in the study.

3.5 THE ENVIRONMENTAL IMPACT STATEMENT (EIS)

The EIS, or EA report as it is sometimes called, is the most tangible output of the EA process. Its function is to provide decision-makers with information regarding the environmental issues, impacts, and remedial options for a particular project or road program. This information can be used in an integrated evaluation of project options and consequences; taking account of costs (construction and maintenance), access and transport objectives (transport efficiency, safety, economic development), and impacts on the natural and social environment.

As a general rule, the length and level of detail of an EIS should correspond to the potential environmental impacts.

[7] The selection of the consultant team is usually done by the proponent, based on a competitive proposal evaluation process. The team should be led by a person who has extensive professional experience in the environmental field. (see Section 2.2.2).

The following eleven sub-sections outline what should be included in the EIS for a specific project.

3.5.1 Executive summary

This is a concise summary for decision-makers. It provides significant findings and recommended actions, and describes the legal status of the EA report. It also presents any regulatory procedures to which the report will be subject.

3.5.2 The environmental assessment team

This is a list of the names and credentials of the individuals and organizations who prepared the environmental assessment.

3.5.3 Introduction and background

Policy, legal and administrative framework
The policies as well as the legal and administrative framework within which the environmental assessment was prepared are presented here. The environmental requirements of any co-financiers should be identified.

Project description
This is a concise description of the works to be carried out, including any off-site works involving construction camps, access roads, borrow pits, quarries, or asphalt plants.

Related studies
Description of studies concerning relevant land use planning, development, and engineering, as well as any new regulations affecting the project are included in this section. The intent here is to outline a well-defined setting into which the proposed project is to be placed.

3.5.4 Approach and methodology

This section of an EIS is essential and often very poorly prepared. It defines how the information on which EA decisions were and will be made was identified, collected, and analyzed. This section of the document establishes, to a large extent, the level of confidence that managers and decision-makers can reasonably place in the EA findings.

3.5.5 Existing conditions

This section should contain a description of the dimensions of the study area and of relevant physical, biological, and socio-economic conditions, including changes anticipated before the project commences, and courses of action expected in case the project does not materialize. A description of the built and visual environment should also be provided here.

3.5.6 Analysis of alternatives

Analysis of alternative solutions
This section of the report should present the findings of the screening and scoping activity. It is important that the conclusion of this section include a prioritized listing of the alternatives proposed, including their environmental benefits and costs.

The alternative designs
A comparative analysis of the alternative designs and methods being proposed for the selected project should be presented here. It is often useful to present this in a matrix format which shows the potential effects of each alternative on VECs. The negative future effects of the proposed project should be identified, as should possible remedial measures and any residual negative impacts that cannot be mitigated. Positive effects should also be noted (for example, less urban pollution due to a by-pass), and enhancement opportunities should be explored.

The extent and quality of available data, key data gaps, and uncertainties associated with predictions should be identified or estimated. Topics that do not require further attention should be specified and a supporting rationale offered.

A systematic comparison of the proposed project's design, site, and technological and operational alternatives should be conducted in terms of their potential environmental impacts, capital and recurrent costs, as well as suitability under local conditions. The final discussion should provide a presentation of the preferred design to which the remaining EA steps will be applied.

3.5.7 The preferred design

This section should begin with a description of any details not provided earlier in the document, and which are necessary for understanding the project. A discussion of the impact of the project on the VECs in terms of duration, extent, and severity should follow.

3.5.8 The environmental management plan

The EMP (a common albeit not an essential part of an EA report) contains an analysis of the institutional capacity of the existing agency for dealing with the environmental management of the project, a description of proposed remedial measures, and a monitoring plan for the construction and operational period of the project. The EMP often contains construction guidelines that specifically address how the contractors are to incorporate environmental considerations into their work (see Chapter 18).

Mitigation

Feasible and cost-effective measures that may reduce environmental impacts should be identified. They should be prioritized according to their relative importance, their capital and recurrent costs, as well as their institutional, training, and monitoring requirements. The mitigation plan[8] should provide details on proposed work programs and schedules. Such details help ensure that the proposed environmental actions are in phase with engineering and other activities throughout the project's implementation. The plan should consider compensatory measures if mitigative measures are not feasible or cost-effective. This section should conclude with a discussion about the residual impacts, i.e. those that are likely (based on past performance) to remain after the proposed remedial measures have been successfully implemented.

Monitoring

There are two reasons for monitoring:

i) to confirm that mitigative measures agreed to in the EA are implemented ("compliance monitoring"); and
ii) to determine whether the proposed mitigative measures serve their intended function ('effects monitoring').

This section of the EA report (frequently included within the EMP) should define complete monitoring activity, schedule, responsibilities, costs, and supervision.

Environmental construction guidelines

This is an important section of the EA (often incorporated into the EMP), in which aspects of mitigation and monitoring are combined to provide step-by-step instructions on how construction activities, which could affect the sensitive VECs, should be carried out. Usually, this is done in terms of what should be done, by whom, and when.

Resettlement and rehabilitation action plan

If possible, and if required, a resettlement and rehabilitation action plan (RAP) should be a major part of the EMP. It is discussed further in Section 4.7 and Chapter 12.

3.5.9 Consultation

This section should contain a complete record of the consultation undertaken during the EA. Creative tables will often provide a much better summary than long lists of people. The section should specify the means used to obtain the inputs, as well as the input itself, no matter if it is positive or negative.

3.5.10 References

This is the list of materials used in preparation of the study. It is especially important, given the large amount of unpublished documentation commonly used in writing an EIS.

3.5.11 Appendices

Appendices may include maps, plans, special studies, large data sets, evaluation tables, submissions by public groups, etc. Long and detailed EMPs can also be submitted as appendices.

3.6 PRESENTING INFORMATION WITH MAPS IN THE EA REPORT

EA documents are traditionally long, rich in information, and visually uninteresting. This makes their use and comprehension difficult.

[8] The mitigation plan is an important sub-unit of the EMP; it has often been labeled an action plan or environmental management plan.

High-quality EA reports condense text and data into informative graphics and maps. Presentations in these formats do not require specialized equipment, although GIS software does speed up the mapping process.

Well-designed maps are used to describe the project in the context of its total environment, its impact zone in relation to the VECs, its mitigation, its monitoring programs, etc. They are also useful for presenting alternatives and related key issues to the decision-makers, highlighting before and after conditions.

Maps included in the EA report can deal with broad project issues or focus on particular environmental themes and specific geographic locales. They should be designed to enable most readers to visualize the project's effects by using representations which are meaningful to non-specialists.

Finally, selecting one or two standard maps to use during an EA is often a far better idea than having different styles and scales in each EA section, which can actually detract from the presentation (see Section 4.9).

3.7 REFERENCES AND BIBLIOGRAPHY

Beanlands, G. and P.A. Duinker. 1983. *An Ecological Framework for Environmental Impact Assessment in Canada.* Halifax, Canada: Institute for Resource and Environmental Studies, Dalhousie University and Federal Environmental Assessment Review Office.

Canadian International Development Agency. 1991. *Environmental Review Procedures for Transportation Projects Financed by the Canadian International Development Agency.* Transportation Sector, File 1-300-04.001. Hull, Canada: CIDA.

CNRS Paris VI Université. 1978-79. *Cartographie informatisée et géographie humaine.* Paris.

Domingez, Garcia Tejero. 1993. *Topografia general.* Madrid: Mundi Prensa.

Hurault and Lummaux. 1979. *Essai de cartographie de l'environnement d'un milieu tropical d'altitude: l'Adamaoua occidental (Cameroun-Nigéria).* Symposium international sur la cartographie de l'environnement et de sa dynamique, Caen.

Hurault, J. 1985. *Cartography of Tropical Regions.* Paris: Institut Géographique National.

Inter-American Development Bank. 1996. *Environmental Assessment in the Transportation Sector: Guidelines for Managers.* Washington, DC: IDB.

Japan International Cooperation Agency. 1992. *Feasibility Study on the Restoration of Rural Roads.* Manila, Republic of the Philippines: Department of Public Works and Highways.

McHarg, I. 1980. *Design with Nature.* New York: Natural History Press.

Ministère de l'Equipement. 1991. "Environment and Development: Useful Maps" (in French). Paris: Les Editions du Service Technique de l'Urbanisme.

Ministère des Relations Extérieures, Coopération et Développement. 1983. *Cartographie et Développement.* France: Decade.

Organization for Economic Cooperation and Development. 1994. *Environmental Impact Assessment of Roads.* Scientific Expert Group E1. Paris: OECD.

Overseas Development Administration. Undated. *Manual of Environmental Appraisal.* London. ODA.

Permanent International Association of Road Congresses. 1991. *Lexicon of Road and Traffic Engineering.* Paris.

World Bank. 1996. *Strategic Urban Roads Infrastructure Project.* Appraisal Report. Washington, DC: World Bank.

4. Key steps involved in undertaking an environmental assessment

HOW TO USE THIS CHAPTER IN THE CONTEXT OF EA AND ROAD PLANNING

Stage in road planning (A)	EA activity (B)	Involvement in addition to EA team (C)
Concept Pre-feasibility Feasibility Engineering design Construction Operation & maintenance	Screening Scoping Consultation Determining baseline conditions Selection of preferred solution Assessment of alternative designs/methods Development of environmental management plan Effects and compliance monitoring Evaluation Reporting	Proponent Key regulatory agency Other government agencies NGOs Research groups Public/community organizations Advisory experts

Shaded area = (A) Stages of EA covered in this chapter; (B) focus of this chapter; and (C) primary target readers.

KEY QUESTIONS ADDRESSED:

- ? What sequence of steps should be followed when undertaking an EA?
- ? How does one plan a field investigation?
- ? How is the valued ecosystem component (VEC) concept used in EA?
- ? How should mitigation and monitoring be incorporated into EA?
- ? What is the relationship between the technical EA steps and consultation?

4.1 SEVEN KEY STEPS

Assuming that the screening and scoping described in Chapter 3 has been completed, this chapter provides a discussion of seven key steps which are generally required to meet the objectives of EA.[1] These six steps are:

i. description of baseline conditions;
ii. analysis of potential environmental impacts;
iii. consideration of alternatives;[2]
iv. development of mitigative and compensatory measures;
v. design of monitoring and evaluation plans (the environmental management plan); and
vi. documentation (including mapping).

More detailed discussion of methods and sources of information which address these seven steps are provided in other chapters of this handbook. In particular:

- consultation methods and options (Chapter 5);
- assessment of impacts for different components of the environment (Chapters 7-17);
- impacts during different stages of the project, such as construction and operation (Chapter 18); and
- economic valuation of environmental impacts (Chapter 19).

In a properly conducted EA, it is essential that both biophysical and socioeconomic components of the environment be taken into account. The two components can be applied in tandem to the same assessment, where they can work independently; at certain points in the process they need to be brought together to move toward an integrated output.

[1] Details of when each step is to take place within the EA process are shown graphically in Figure 1.1 (page 7).
[2] The consideration of alternatives discussed in Chapter 4 refers to consideration of alternative project designs. Alternative solutions to the transportation problem are dealt with in Section 3.1 and should be completed as the first step in any EA.

4.2 DESCRIPTION OF BASELINE CONDITIONS

Baseline conditions define the characteristics of the existing environment and shape projected future conditions, assuming no project is undertaken. They provide the basis from which project impact comparisons are made.

Baseline analysis consists of more than making a statement on the initial environment of the proposed project. It should permit a comparison of project-induced environmental changes, with other expected environmental changes in the "no-project" scenario. Baseline analysis should take into account

- past trends in environmental quality;
- community preferences or competing demands regarding resource utilization; and
- other current or proposed development programs under study in the project area. The use of the VEC approach as described in Chapter 3 may be very useful in this regard and can greatly reduce the overall data collection effort.

The quality of the analysis of baseline conditions establishes the viability of the impact appraisal, and therefore of the study itself. A more thorough study design brings together more relevant and better-focused data, and vastly improves the overall quality of the study. This stage of the EA process is of prime importance, for it allows the agency and the project proponent to benefit from a thorough study of the proposed site. Hurrying this stage of the EA, or not coordinating with the various organizations affected by the project, will usually be counterproductive and add costs later.

In assembling baseline data, it is important to understand that, in the natural environment, wide variations can occur over long periods of time. For example, forest maturity and natural processes such as fire can dramatically change animal habitats and human use of natural resources from one generation to the next. The VEC method incorporates such considerations, because the local input which contributes to the VEC identification process incorporates past experience and anticipated future values, in addition to present value.

4.2.1 Collecting and analyzing existing basic documents

Existing basic documents may include topographic maps, vegetation maps, aerial photographs, scientific and technical reports, past or current project appraisal reports, other EA documents, and government reports. Information sources and references must always be provided with each set of data.

4.2.2 Assembling information from different sources

Technical, social, demographic, and economic information can be obtained from various government departments at national, regional, or local levels, as well as from other research, business, professional, or non-governmental organizations. Usually, this involves intensive initial communication with officials in order to get a clear picture of the existing database and to inform others that the project has commenced.

4.2.3 Consultation with local residents and professionals

Consultation with local residents and professionals can assist baseline data gathering by validating information from other sources and identifying important local expertise as well as technical gaps. It can often improve an EA's relevance, help to identify real and perceived issues, and even reduce overall EA cost. Consultation is crucial, even if the VEC approach is not used.

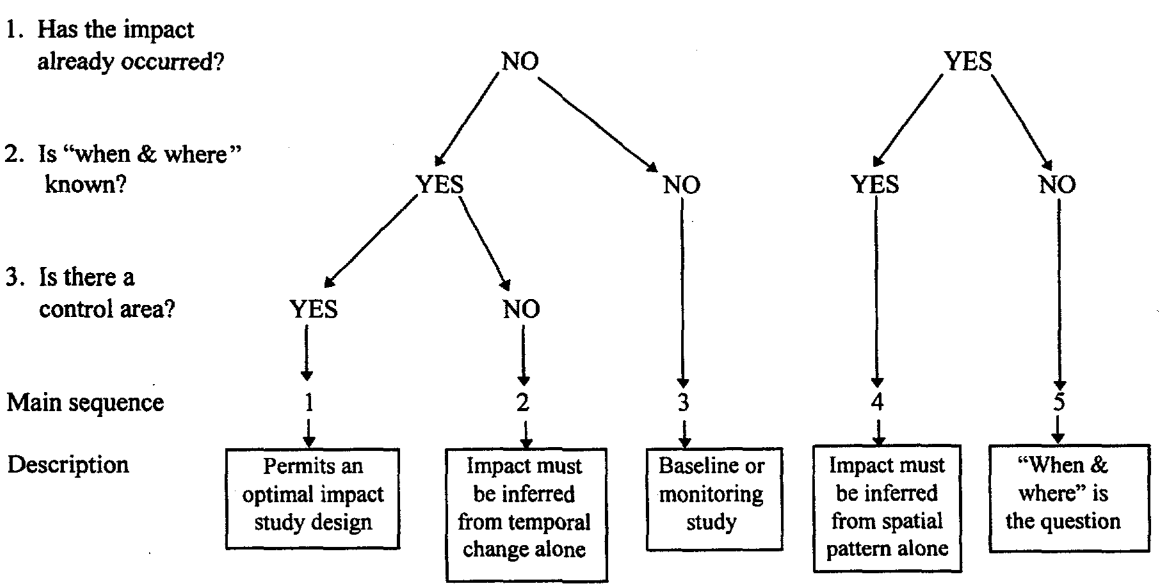
4.2.4 The sampling design

The success of baseline data collection depends, in large measure, on how well the extent of human interference with the environment is understood. It is also critical to understand where and how the data are collected (the sampling design). Proper sampling design will help to distinguish between project-induced impacts and existing background variations. The inclusion of sampling locations that truly reflect conditions outside the influence of existing development may also be important in this regard. A decision-tree for determining, at the macro-level, what sort of sampling program should be undertaken for various project situations is presented in Figure 4.1.

4.2.5 The field investigations

Successful field investigations are based on careful planning and consideration of the environmental context of the project, the available time, and available funding. Field investigations should take note of how seasons of the year and the existing environmental setting

FIGURE 4.1
SAMPLE DESIGN DECISION KEY



Source: Green, 1979.

BOX 4.1
RAPID ENVIRONMENTAL DATA COLLECTION SYSTEM

A consultant working on the World Bank India National Roads Planning Project linked electronic field form software, an electronic notepad (handwriting recognition) and a portable GPS system, and used the combination as a field data collection system. This system automatically converts all field data into computer-ready records that are geo-referenced (latitude–longitude or UTM coordinates) and instantly ready for analysis and graphing, using off-the-shelf software. With this system, the consultant was able to complete the initial environmental evaluation for more than 2,500km of roadway within a four week period and actually use over 2,500 observations in establishing broad-scale estimates of the potential duration and extent of impacts.

may affect results. Experienced environmental specialists, working with experts from the local area, can often design effective and economical field investigations, even with severe time restrictions (see Box 4.1).

Project managers intending to conduct field investigations need to consider explicitly the following factors:

- sample station location;
- number of sampling locations;
- number of replications;
- use of surrogate indicators where use of optimal measures may not be practical; and
- seasonal variations in relation to impacts.

Completion of the VEC exercise greatly reduces the guesswork needed in designing the field program and, in fact, embraces much of the work described in this section.

4.2.6 Tracking project-induced versus natural environmental changes

Understanding the differences between project-induced environmental variations and those that occur naturally in the study area can determine whether the EA produced is valuable or relatively meaningless. Tracking these differences requires structuring the project sampling design in such a way that

- Whatever data are collected reflect the larger context within which the project may take place.
- The design captures the extent of existing human disturbance in the area, recognizing that this change is part of the background conditions and must be factored in when impact predictions are made.

4.3 ANALYSIS OF POTENTIAL ENVIRONMENTAL IMPACTS

Environmental impact analysis consists of comparing the expected changes in the biophysical and socioeconomic environment *with* and *without* the project. For each type of potential impact or environmental concern, the analysis should predict the nature and significance of the expected impacts (some may be quantitative, others qualitative), or explain why no significant impact is anticipated.

4.3.1 Determining significance

Determining the significance of impacts is often left out of EAs because it requires multi-disciplinary, multi-faceted inputs. Significance, if it is expressed properly, addresses the following seven conditions:

i) predicted exceedence of established criteria or standards;
ii) duration of the exceedence in relation to key species' life cycles and requirements for population maintenance;
iii) geographic extent of an effect;
iv) resilience of the environment in which the predicted effect is to take place (i.e. capacity for self-repair – as with tidal flushing);
v) cumulative nature of the impact;
vi) community tolerance of the impacts, and preferences in relation to the costs and benefits of the project; and
vii) need for involuntary resettlement.

Broadly speaking, these seven factors can be considered good indicators of significance when they are blended with competent ecological and sociological appreciation of the affected environmental component. By examining these factors, practitioners should be able to establish the importance of the effect and thus the urgency of the mitigative action.

4.3.2 Impact characteristics

Analysis of potential environmental impacts should include specific discussion of the magnitude and duration of impacts.

Magnitude of impacts

It is relatively easy to quantify the magnitude of impacts for physical effects, such as land cleared, trees removed, and homes affected. It is more difficult to quantify effects on the biological environment (the type of habitat lost, for example); and it is very complex as far as the effects on people are concerned. For the latter, simple indicators could include the number of people affected and estimated economic losses, but wider effects on social and economic welfare should also be analyzed. For some impacts, only a qualitative description of the effect is possible.

Duration of impacts

Allowance should be made for both short- and long-term impacts. The loss of agricultural areas along the alignment of a road is an immediate impact, whereas the retreat of a mangrove swamp following modification to the water flow, or the modification of the saline threshold in an estuary, generally becomes apparent only several years after construction and usually persists from then on. This characteristic is termed the "temporal extent" or duration of an impact. Impacts that are sudden, such as hazardous waste spills, or cumulative, such as contamination build-up in roadside soils and crops, should also be considered.

Part II of this handbook describes a wide range of impacts for consideration, covering the biophysical environment, the socioeconomic environment, and specific issues related to the construction, maintenance, and operation of roads.

4.3.3 Impact types

The predicted impacts of a road project fall into three categories:

i) direct;
ii) indirect; and
iii) cumulative.

A detailed discussion of these and other types of impacts is presented in Chapter 6.

4.4 CONSIDERATION OF ALTERNATIVES

Sound and sustainable road EAs involve the consideration of two types of alternatives (unless special restrictive conditions exist). These are usually referred to as *alternative solutions* to the transportation problem (discussed in Section 3.1) and *alternative designs* for a selected project.[3]

4.4.1 Alternative designs

Alternative designs usually involve options regarding alignment, routing, construction methods, materials used, landscaping, and so forth, while the basic project concept remains constant. Frequently, two to three alternatives are chosen, and within these there may be several other alternative treatments for specific features, for example, options for traversing a wetland or mangrove forest. These may also be considered as separate alternatives. Designs which prevent or avoid negative impacts often require changes to the location of the road or of the off-site activities associated with construction. The VEC consultation activity can help to identify alternatives that are practical and sustainable and that are supported by the various affected interest groups.

4.4.2 Analysis of alternatives

Analysis of alternatives involves comparing impacts that are not easily quantified, not measured against the same criteria, and that vary in time, space, and validity. A number of structured evaluation and comparison methods have been developed for analyzing and presenting environmental data. The most frequently used is a matrix in which socioeconomic and biophysical environmental effects are represented either numerically or visually, using graphic indicators (such as dots or bars, as in a histogram) which vary in size according to the magnitude of the impact. A common way of distinguishing the effects of alternatives is to apply a scaling-weighting and aggregation approach. This involves assigning numerical values to the expected impact on each VEC and combining them all in a single overall measure of impact for each alternative. The greater the total per alternative, the more serious the impact.

Clearly, not all VECs have equal importance; numerical weights are assigned based on informed opinion. This is usually completed by a group of people representing all stakeholders (possibly the members of the workshop team

[3] For more details see World Bank, 1996a.

which identified the VECs). These people vote first on the relative importance of each VEC and then on the relative importance of the factors affected within each VEC. From this, a single numerical value per alternative can be derived. There are a number of drawbacks to this approach, including over-simplification and excessive value judgement. Nevertheless, outputs should be valid, provided they are applied with care (there should be at least one public information session with stakeholders).

Another method for comparing the effects of various project alternatives is the value function method, which is described in Box 4.2.

In practice, there is no technical solution which weights and ranks "correctly" the wide range of issues that need to be addressed. The final outcomes of analyses of alternatives are usually strongly influenced by political and community-based consultative processes; however, these tend to focus on a few main concerns to the exclusion of others. Presentation systems should recognize this and provide information to decision-makers and affected groups, rather than seek to define solutions.[4]

4.5 PLANNING REMEDIAL MEASURES

4.5.1 Avoidance

Avoidance of negative environmental impacts should be a proponent's priority. What can realistically be achieved often depends on the location and scale of road works and related off-site construction and traffic activities. Impacts can be avoided completely by a "no-project" alternative, but it should be recognized that even existing roads have impacts on their surrounding environment; these impacts can increase over time with traffic growth and land development, and may be reduced by maintenance, rehabilitation, and construction actions.

4.5.2 Mitigation

Mitigation is the lessening of negative environmental impacts through: a) changes in the design, construction practices, maintenance, and operation of a road; and b) additional actions taken to protect the biophysical and social environment, as well as individuals who have been impacted adversely by a project. The extent and timing of mitigative actions should be based on the significance of the predicted impacts.

Some aspects of impact mitigation can be incorporated into project design (see Box 4.3), and can largely resolve the threat of impacts before construction commences; examples include roadside drainage, noise barriers, access roads, and footpaths. However, many measures require an ongoing implementation plan to ensure that proposed actions are carried out at the correct times, that environmental measures such as planting and slope protection are maintained, and that prompt remedial actions are taken when the initial measures are not fully successful.

The principle of *no net loss* is a useful guideline for the design of remedial measures, especially those involving people. Adhering to this principle requires planning both immediate measures and long-term actions to ensure that former productivity and quality of life do not suffer as a result of the project.

Two additional factors to be kept in mind in the design of mitigation and compensation plans are that:

i) Some measures may themselves have negative effects. Resettlement, for example, sometimes has significant impacts on residents or the natural environment at the host location. Social issues are the most challenging, since perceptions of "winners" and "losers" can develop quite readily. Design and implementation of equitable and balanced mitigative measures requires considerable care and consultation.[5]
ii) Some measures may not be the exclusive domain of the road agency. Government departments, local authorities, neighbors, nearby businesses, non-governmental organizations, and the legal system may all be involved in their design and implementation (see Sections 2.2-2.4). Clear definition of responsibilities, funding, and reporting requirements can help to ensure the success of such measures.

[4] Well-supported and compelling arguments, presented in as few words as possible, can influence decision-makers. EA practitioners should consider themselves *decision-shapers* whose task it is to provide clear and complete proof of the impacts of a project (positive as well as negative).

[5] Without adequate lead time or warning of impending impacts, remedial measures designed to reduce the effects often fail, since people are not prepared for, or have not planned, the necessary actions.

BOX 4.2

THE VALUE FUNCTION METHOD AS AN EXAMPLE OF ANALYSIS OF ALTERNATIVES

The value function method is applied to the analysis of the routing alternatives for an expressway. The environment is classified into four types: human environment, community life, natural environment, and cultural environment. As shown in the table below, three to five impact categories are listed for each environmental type, totalling sixteen in all.

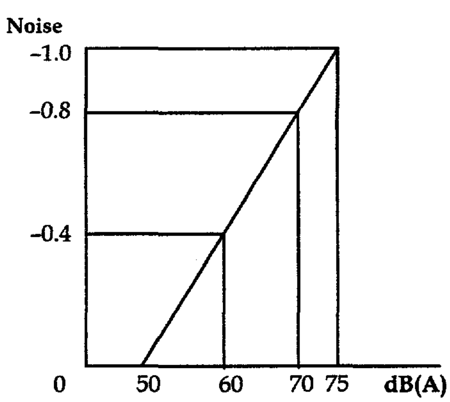
The environmental assessment of routing alternatives takes the following five steps:

i) The analysis begins by estimating the values of sixteen impact categories for each route alternative. For example, the noise level is estimated in dB(A), the air pollution in ppm, and the spatial separation in kilometers of a given route alternative.
ii) The estimated values for the respective impact categories are then converted to non-dimensional environmental quality values that fall in the range from 0 to -1.
iii) The converted non-dimentional quality value of every impact category is then multipled by the assigned weight that indicates the significance of the impact category relative to the others.
iv) The weighted environmental quality values of sixteen impact categories are then totalled to obtain a comprehensive environmental quality value for each route alternative.
v) The route alternative of the largest comprehensive environmental quality value is judged the least environmentally hazardous.

The value function is used to convert the estimated values of an impact category to non-dimensional values. The figure below shows the value function used for the noise level. Zero (0) means no noise hazard, while the value of -1 indicates the marginal level of noise tolerance.

The weights for the respective impact categories can be determined by informed judgment, on the basis of the surveyed opinions from road planners, local inhabitants, and relevant academics. The table below indicates an example of weight assignments.

Noise Level Value Function



Weights for Impact Categories (Xx)

Human Environment	Noise	164
	Vibration	71
	Air quality	108
	Sunshine	60
	Water quality	36
Community Life	Community life	79
	Spatial separation	45
	Radio obstruction	32
Natural Environment	Geospheric	39
	Hydrospheric	44
	Atmospheric	43
	Fauna	50
	Flora	71
Cultural Environment	Landscape	65
	Cultural heritage	53
	Recreation	44
	Total	1,000

Source: Mori, H. and K. Kaneyasu, 1976.

BOX 4.3
EXAMPLES OF MITIGATIVE MEASURES INCORPORATED INTO PROJECT DESIGN

Environmental impact study for the Guinea-Conakry Road Project (96 km road construction in a mangrove swamp and rice-growing area) includes

- traffic management plans for public works vehicles and temporary diversions;
- redevelopment of borrow zones (re-vegetation and stabilization of soils);
- turfing of embankments, drainage of plains, reforestation, and regeneration of plantings; and
- compensation for property taken.

Mitigative measures from transportation EA integrated into regional development programs include

- mangrove swamp development and management plan, covering rice cultivation, fishing, management of firewood, and protection of biodiversity, with provision for training, supervision, and extension services;
- protection of forests and monitoring of hunting;
- creation of a nature reserve as part of the tourism plan;
- water supply program and improvement of sanitary conditions, malaria alleviation; and
- agricultural development program.

4.5.3 Including consultation in mitigation planning

The development and execution of an effective public consultation program is essential to mitigation planning for three reasons:

i) Road projects often require some local input, such as employment, maintenance, or policing functions. In order for the project to be accepted by the local people, and for them to cooperate in its execution, they need to be informed about its arrival. They need to be encouraged to provide input to mitigation design, and made to feel that their contribution will be valued.
ii) There is a very real danger that a project implemented without concerted public involvement will put serious pressures on the quality of life of the local population (and frequently reduce it). There are many examples of this around the world. By generating relevant mitigative measures, proper consultation helps to keep such negative impacts to a minimum and compensation costs low.
iii) In developing countries, large historical databases on background conditions in a potential impact zone are rarely available. If anything, there are usually sporadic clusters of information, collected for very specific reasons, yet generally they are of little use to the EA. However, local and indigenous peoples are literally walking databases of past conditions and can provide some excellent predictive information on future environmental trends and community dynamics. This resource can be tapped through thoughtful (and often inexpensive) community consultation and can add immeasurably to the planning of practical mitigative measures.

The most effective approach to involving local people is the slow building of confidence and trust. However, time constraints in EA often require an alternative, to which Chambers (1983) refers as the "rapid rural appraisal technique."[6]

Rapid rural appraisal involves seeking information from a variety of scientists and knowledgeable community members, and combining the results in a multidisciplinary assessment (see Section 5.5.7). Chambers has described it as a "middle zone" between the anthropological survey and the development cost-benefit matrix analysis, and suggests adhering to two precepts for staying in the middle zone:

i) Optimal ignorance (knowing which facts are not worth knowing); and
ii) Appropriate uncertainty (aiming for the minimum level of accuracy to get the order of magnitude and direction of change).

Through consultation, proposed remedial measures can be tested for acceptance, modified according to local needs, and eventually turned into a solution crafted by the proponent in collaboration with the stakeholders (see Section 5.5.7).

[6] This approach, incidentally, is not limited in any way to rural settings. In urban areas it is just more difficult to identify those individuals who are long-time residents with valuable historical knowledge.

4.5.4 Compensation

Compensation should be considered if steps to reduce impacts are not possible or sufficient. Compensation can be material (reconstruction of homes or natural habitats), financial (compensation for loss of property), or both. Compensatory measures for specific impact areas are discussed in Part II of this handbook.

4.6 MONITORING AND EVALUATION

Implementation of mitigative measures is often the weakest link in the environmental management process and requires special attention from managers. The environmental assessment study should identify plans for works supervision, future environmental monitoring, and evaluation studies (see Chapter 18). This assures continuity between design and construction and helps ensure full implementation of the environmental management plan. It should involve skillful and responsible staff in both environment (biophysical and social) and roads, including those concerned with work supervision during the construction phase.

Responsibility for undertaking monitoring, as well as the reporting procedure, should be specified in the EMP section of the environmental impact statement.

4.6.1 Compliance monitoring

During construction, all mitigative measures designed to reduce the impact of the construction activities should be monitored and enforced by the environmental monitoring authorities. This requires

- defining the proposed mitigative and compensatory measures;
- specifying who is responsible for the monitoring activity;
- including implementation of mitigative measures in contract specifications (see Chapter 18);
- making environmental competence one of the selection criteria for contractors; and
- briefing, educating, and training contractors in environmental protection methods (see Chapter 2).

Compliance monitoring should not be confined to the road right-of-way, but should cover all sites affected by the project, including borrow pits, quarries, disposal sites, waterway diversions, materials treatment areas, access roads, and work camps.

After the construction phase, environmental monitoring must be continued. Some mitigative measures, such as drainage systems and erosion-preventive plantings, require regular maintenance for correct operation, and monitoring is necessary to ensure their continued effectiveness.

4.6.2 Effects monitoring (evaluation)

After mitigative measures are implemented, effects monitoring or evaluation can test the validity of hypotheses formulated in the environmental impact study; they can also determine if the mitigative measures have achieved their expected results.[7] In most countries, such evaluation is not regulated by laws and is therefore often neglected.

Social and financial assistance to affected communities and individuals may also fail to address all problems fully; follow-up monitoring is generally required for a number of years.

Evaluation is necessary not only for individual projects, but also to advance methodology, assist in designing future studies, and—through lessons learned—contribute to the relevance and cost-effectiveness of environmental protection measures. Governmental support is usually weak in this area, but it is necessary for successful evaluation of road projects.

Responsibility for corrective action to be taken in the event of mitigation failure should be defined clearly.

4.7 THE ENVIRONMENTAL MANAGEMENT PLAN (EMP)

The EMP is probably the most important output from the EA process. Variously referred to as the environmental action plan, environmental protection plan or the environmental construction plan, the EMP is the synthesis of all proposed mitigative and monitoring actions, set to a timeline with specific responsibility assigned and follow-up actions defined. It consists of the information one would normally obtain when undertaking the work described in Sections 4.2 to 4.6, and is defined as a set of im-

[7] Effects monitoring presents the primary opportunity for accumulating a "lessons learned" database vis-à-vis mitigation planning.

plementable tasks with specific assignments for the proponent, the contractor, and the regulatory agency—all within a specified time period. A well-designed EMP addresses issues related both to the construction and operation phases of a project; it includes

- a list of all project-related activities and impacts, organized by development stage (planning, construction, and operation);
- a list of regulatory agencies involved and their responsibilities;
- specific remedial and monitoring measures presented for:
  - construction period activities and impacts;
  - operational period activities and impacts;
- a clear reporting schedule, including discussion of what to submit, to whom, and when; and
- cost estimates and sources of funding for both one-time costs and recurring expenses for EMP implementation.

Appendix 1 offers an example of an EMP prepared for a World Bank road project.

Preferably, the EMP should be divided into two broad components, one dealing with the natural environment and the other with the social environment. The social component most often addresses resettlement and economic impacts, and has been prepared, traditionally, as a stand-alone document. It is known as a resettlement action plan or a resettlement and rehabilitation action plan (RAP). It is advisable, unless such is not feasible for practical reasons, that the RAP be incorporated as a major section into the environmental management plan, since this would further the integration of the biophysical and social environmental actions into one project-level action plan. The form and content of RAPs are discussed in Chapter 12.

4.8 DOCUMENTATION

Without clear and complete reporting, an EA can become a vague and confusing set of unverifiable tasks that would be of little use to managers trying to integrate environmental considerations into road planning and development decisions. The environmental impact statement (EIS) is the key document (see Section 3.5), but it needs to be supplemented by construction- and operation-period monitoring reports, which describe how mitigative measures have been implemented and how effective they are. Generally such reports are produced by the monitor or inspector according to a prescribed format, and are submitted to the contract managers and to the key regulatory agency.

In summary, documentation should consist of

- an EIS that includes a complete environmental management plan and resettlement action plan; and
- monitoring reports covering the construction stage and facility operation stage (provided certain measures were specified in the EIS for that period).

4.9 USING MAPS IN EA

Good maps are of great use to EA practitioners and should be employed at all stages of the EA process. They are indispensable in visualizing the spatial relationships between impact sources and recipients, while comparing maps of different dates can be useful in determining changes and trends over time. Maps may be obtained from

- government cartographic departments;
- research departments of universities working in a specific field; or
- development agency project offices.

Given their diverse origin, maps used in EA may vary greatly in scale, range, content, detail, and precision. The year in which a map was produced can be important in assessing how reliable the map is for representing the current situation. Like any source of information, maps are open to interpretation and bias. Attention should be paid to the origin of all maps used in EA.

4.9.1 Dealing with poor availability of maps

Maps may not always be readily available in many developing countries, and this can present problems for EA practitioners. In these situations, the search for materials will have to be extended well past the government mapping office.

Locally-active organizations, such as agencies of the United Nations or NGOs, may produce maps for their own use. Industrial map producers, such as mining companies, may also be good sources of maps. Sometimes, useful maps can be found in reports authored by various organizations on a variety of subjects that overlap with the area of study.

Coverage of the earth's surface by satellite imagery is far more complete and current than is the coverage by maps. Digitized base maps showing major features can be produced from satellite images; however, procuring the necessary computer equipment, software, and images may be prohibitively expensive. Satellite images may be available from commercial suppliers, such as LANDSAT and SPOT, as well as the various international space agencies.

Finally, reasonable maps can often be produced fairly quickly and cheaply in the field by members of the assessment team assigned to that purpose. Maps used in EA are valued more for the general spatial relationships they illustrate than for their precision, and a map drawn carefully by hand will often be as useful as one derived from satellite imagery.

In some countries, the lack of good maps may be related to government restrictions on map distribution for security reasons. Even in such a case, it is sometimes possible to photocopy or photograph existing maps; the copies or prints can then be enlarged for use as base maps.

What follows is a general description of the different types of maps available, and how each type can be used in conducting an environmental assessment. Typical and desirable map scales are provided in Table 4.1.

4.9.2 General maps

General maps are the most widely used and readily available types of maps. They include information on such topics as roads, buildings, vegetation, and topography. Maps that convey topographic information in conjunction with information concerning the built environment and vegetation are especially practical for placing a proposed road in its environment and pinpointing the places where conflicts are most

TABLE 4.1
EXAMPLES OF THE USE OF MAPS AT VARIOUS STAGES OF EA AND SUGGESTED OPTIMAL SCALES

Environmental intervention	Role of information, use and optimal map scale
Screening	Basic maps at scale ≤ 1:100 000
Scoping	Maps presenting the main factors for environmental study. Scale ≤ 1:100 000
Environmental Assessment Report or Environmental Impact Statement	Detailed thematic impacts and synthesis maps showing key issues. Scale ≤1:75 000 - 1:100 000
Environmental Evaluation	Updating of data, confirmation of models, confirmation of impacts. Scale ≤ 1:50 000
Environmental Monitoring	Cartographic comparison of initial state, actual and expected impacts. Scale ≤ 1:50 000
Summary of suggested scales	**Type of data being mapped**
≤ 1:500 000 to 1:100 000	Useful at preliminary study stage for presentation of: • main population centers • important roads and infrastructure • main relief features • main hydrological network
≤ 1:100 000 to 1:10 000	Of interest at feasibility study stage for presentation of: • type of housing (scattered, grouped) • relief symbolized by contour lines • main and secondary hydrographic network with watering places and water supply

obvious. Such maps are useful during the initial scoping process, as well as throughout the remaining EA steps.

4.9.3 Thematic maps

Maps that focus on a specific topic or theme are of particular interest during feasibility studies and the evaluation of a site's sensitivity to various types of environmental impact. A vegetation map can draw attention to fragile ecosystems, such as mangroves or rain forests; a hydrogeology map can reveal the presence of vulnerable groundwater in the vicinity of a proposed road project. Figure 4.2 shows how map overlays can be used to identify environmental constraints, while Figure 4.3 is an example of a map used to highlight environmental sensitivities. In areas where GIS software is not readily available, a mylar overlay process can be effective and does not require a computer system.

4.9.4 Presentation maps

Presentation maps may be prepared for different groups of people, such as

- experts and professionals;
- political representatives at the national, regional, and local levels; or
- affected communities and the general public.

They can be used to disseminate information and stimulate discussion during consultation sessions.

The level of detail and complexity of presentation should be suited to the needs and interests of each group. Impact studies are often illustrated using sensitivity maps, which highlight the environment's sensitivities in its initial state, and constraint maps, which identify impacts on sensitivities caused by the project. VECs can also be mapped and presented in this way.

4.9.5 Synthesis maps

Synthesis maps, which combine key environmental themes (Figure 4.3) are often drawn up for the critical phases of the environmental study; they are used to

- describe the initial state of the local environment;
- describe the impacts and comparison of alternatives; and
- define compensation and resettlement actions.

FIGURE 4.2
THE USE OF OVERLAYS TO SHOW ENVIRONMENTAL CONSTRAINTS

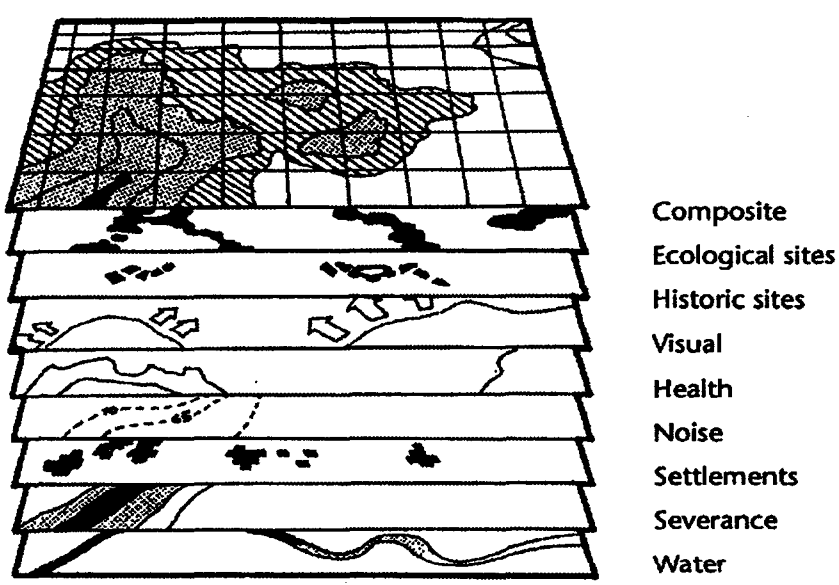
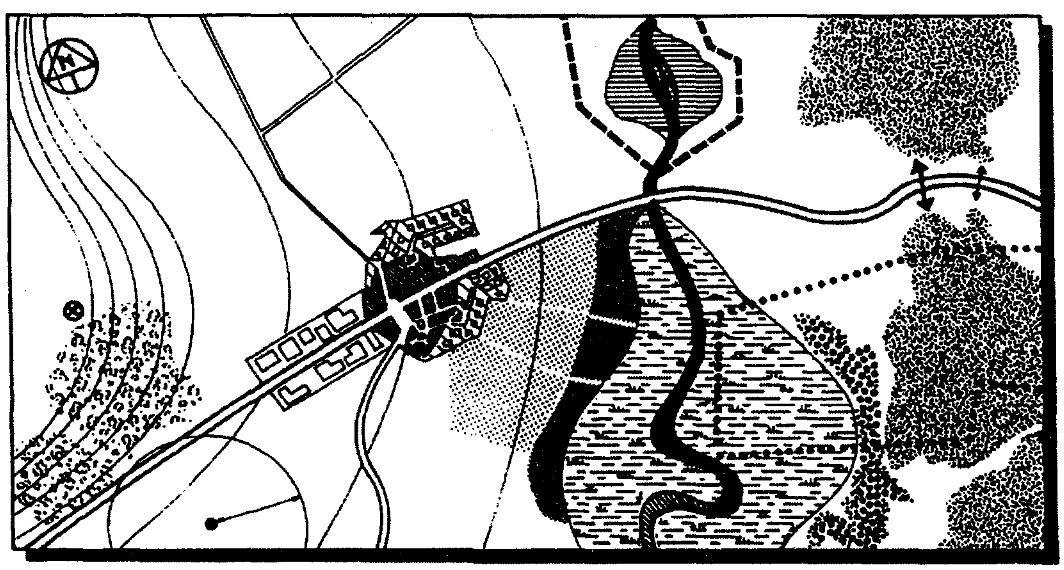


FIGURE 4.3
MAP SHOWING ENVIRONMENTAL SENSITIVITY

- Dense urbanization: strong sensitivity with respect to noise and changes in rights-of-way.
- Sparse urbanization: Strong sensitivity to noise and changes in rights-of way.
- Industrial zone: commercial activity sensitive to changes in access and disruptions of interaction.
- Woodland slope: Susceptible to erosion.
- Undisturbed flood plain: Valuable wildlife habitat. Sensitive to changes in water flow and quality.
- Significant ecosystem: Harbours rare or especially sensitive species, and as such is vulnerable to any modification.
- Valuable wildlife habitat: Sensitive to encroachment and alterations in water flow and quality.
- Good agricultural land: Strong sensitivity to severance of interactions, loss of land, groundwater alterations, and erosion.
- Medium grade agricultural land: Strong sensitivity to severance of interactions, loss of land, groundwater alterations, and erosion.
- Treee plantations: Vulnerable to alterations in groundwater flow.
- Mixed forest: Sensitive to disturbance of wildlife, alterations in grounwater flow, and encroachment.
- Hunting reserve: Sensitive to disturbance of wildlife.
- High-use animal corridor: Threatened by high traffic volume.
- Secondary faunal corridor: Threatened by high traffic volume.
- Valuable spawning grounds: Very sensitive to changes in water quality and flow.
- Good fish habitat: Sensitive to changes in water quality and flow, access important for fishing.
- Drinking water source and protective perimeter: sensitive to contamination and alteration of groundwater flow.
- Cultural heritage site: Sensitive to vibration, uncontrolled access.



4.10 REFERENCES AND BIBLIOGRAPHY

Canter, L.W. 1994. *Environmental Impact Assessment*. McGraw-Hill: New York.

CEC Ltd. 1994. IBRD - *Third National Highway Project; Medium-Term Construction Projects for Expressways in India.* Initial Environmental Evaluation Report, prepared for the World Bank and the Ministry of Surface Transport, Government of India.

Chambers, R. 1983. "Environmental Assessment of Land Transport: Construction and Maintenance." (Draft prepared for World Bank Infrastructure and Urban Development Department), in Sinha, K., et al. 1991.

France, Ministry of Infrastructure. 1993. "Water and Roads Study Report" (in French). Bagneux, France: Roads and Highway Technical Studies Department (SETRA).

Gilpin, Alan. 1986. *Environmental Planning: A Condensed Encyclopedia.* New Jersey: Noyes Publications.

Green, R.H. 1979. *Sampling Design and Statistical Methods for Environmental Biologists.* New York: John Wiley and Sons.

Mori H., and K. Kaneyasu. 1976. *The Value Function Method Applied to the Analysis of Routing Alternatives* (in Japanese). Public Works Research Institute, Ministry of Construction, Japan.

Organization for Economic Cooperation and Development. 1993. *Environmental Impact Assessment of Roads.* Paris: OECD.

Overseas Development Administration. Undated. *Manual of Environmental Appraisal.* London: ODA.

World Bank. 1991. *Environmental Assessment Sourcebook.* Vol. II. Sectoral Guidelines. Washington, DC: World Bank, Environment Department.

World Bank. 1993. *Environmental Screening,* EA Update No. 2. Washington, DC: World Bank.

World Bank. 1996a. *Analysis of Alternatives in Environmental Assessment,* EA Update No. 16. Washington, DC: World Bank.

World Bank. 1996b. *Environmental Assessment(EA) in Africa: A World Bank Commitment: Proceedings of the Durban, World Bank Workshop, June 25, 1995.* R. Goodland, J-R Mercier and S. Muntemba, eds.

World Bank. 1996c. *Environmental Performance Monitoring and Supervisions,* EA Update No. 14. Washington, DC: World Bank.

World Bank. 1996d. *Challenges to Managing the EA Process,* EA Update No. 16, Washington, DC: World Bank.

5. Public involvement in EA

HOW TO USE THIS CHAPTER IN THE CONTEXT OF EA AND ROAD PLANNING

Stage in road planning (A)	EA activity (B)	Involvement in addition to EA team (C)
	Screening	
	Scoping	Proponent
Concept	Consultation	Key regulatory agency
Pre-feasibility	Determining baseline conditions	Other government agencies
Feasibility	Selection of preferred solution	NGOs
Engineering design	Assessment of alternative designs/methods	Research groups
Construction	Development of environmental management plan	Public/community organizations
Operation & maintenance	Effects and compliance monitoring	Advisory experts
	Evaluation	
	Reporting	

Shaded area = (A) Stages of EA covered in this chapter; (B) focus of this chapter; and (C) primary target readers.

KEY QUESTIONS ADDRESSED:

- ? When is public involvement necessary?
- ? Who should participate in a public involvement (PI) program?
- ? How should PI participants be chosen?
- ? What type of consultation or participation is most appropriate for a given situation?
- ? What information should be presented and which medium should be used?

Road projects which affect the surrounding biophysical and socio-economic environment often impinge on the responsibilities, interests, and welfare of many individuals and organizations outside of the road authority in charge of the project.

Throughout this handbook, consultation and communication with various interested groups (known collectively as public involvement) are recommended as an integral part of the EA process. Public involvement (PI) is useful for gathering environmental data, understanding likely impacts, determining community and individual preferences, selecting project alternatives, and designing viable and sustainable mitigation and compensation plans.

Inadequate PI can result in significant information gaps, which could mislead road planners undertaking an environmental assessment. Lack of attention to communication and consultation processes can generate individual, community, or regional opposition to a road project. This can ultimately be a cause of substantial delays, increased costs, and unsatisfactory compromise solutions, which could have been avoided through earlier consultation.

This chapter presents some of the methods which can be used to promote effective public involvement at various stages of the project development cycle.

5.1 GUIDING PRINCIPLES

Effective communication with concerned stakeholders requires information dissemination, information solicitation, and consultation.

5.1.1 Information dissemination

Information regarding proposed road projects quickly reaches the public. That information, unless it has come through a public involvement program, is often general and frequently inaccurate. The organized dissemination of concise and information-rich materials[1] on a project can serve to start the EA on a constructive footing with the public.

5.1.2 Information solicitation

Asking the local community, residents, and interest groups to provide input into the EA is as important as disseminating basic information. Not only will such solicitation generally yield new insights, but it will also initiate constructive dialogue between road proponents and other stakeholders.

5.1.3 Consultation

Consultation involves engaging people in dialogue, in other words, a two-way flow of information and ideas between the proponent and the stakeholders. Members of the public, after hearing and reading about a project, often have no idea how and when they might become involved, and it is the responsibility of the proponent to initiate the dialogue. Consultation programs should provide information which clearly defines

- what is being asked of the public;
- when the public should contribute, i.e. when input is most effective;
- in what form the input should be presented; and
- whom members of the public should contact if they want to participate.

The public's input must be treated seriously in order for its use in the project planning process to become clearly evident. Box 5.1 presents two examples of successful community involvement in EA.

5.1.4 Application

The three components of public involvement listed above can be applied at various times throughout the EA process and may be used either one at a time or simultaneously, depending on the need. While there is no formula for determining when any one phase of PI is best applied, information dissemination and solicitation generally start very early in an EA and are often used in the initial screening of a project. Consultation usually takes place at two strategic stages in an EA process: first, during the analysis of alternative solutions stage, and then during the impact analysis for a preferred

[1] A major mistake in otherwise well-orchestrated public involvement programs is the failure to provide the stakeholders with enough information about the project, so that they can develop informed opinions and provide useful input to the EA process. In some cases, this has been done purposely, thereby totally eliminating the value of the PI process.

BOX 5.1
COMMUNITY PARTICIPATION IN PROJECT DECISION MAKING

In many industrial countries, community representatives are being given a more important role in road project decision-making. The following examples are indicative of a growing trend.

Example 1:
In South Birmingham, UK, road planners were faced with vigorous opposition to new road proposals from a number of community and environmental groups. To resolve the conflict, anti-road groups were invited to come forward with practical alternatives to resolve traffic problems. The cooperative approach led to identification of road modifications which reduced speeds but maintained capacity in built-up urban areas. Perhaps more importantly, the resulting proposals were put forward jointly by road planners and community groups.

Example 2:
In Sydney, Australia, polarized community views of the Botany-West Transport Study led to the formation of a Community Advisory Committee to assist in the preparation of briefs and management of the study. A consensus approach was adopted for decision-making, all committee members had equal status, and information was shared openly. Because the study was considering very expensive infrastructure options, final decisions rested with the state government, but the committee had substantial authority and control over the process—contrary to traditional government agency decision-making procedures. Three workshops and four newsletters (each seeking some feedback) were used to get wider public input from industry, unions, local government, and other interest groups not directly involved in the advisory committee. The study looked first at what sort of future people expected to live in, and then what major transport and land-use options, projects, and policies would be needed.

Source: OECD 1994.

design. In complex and sensitive projects, consultation may occur more frequently.

5.2 WHEN IS PUBLIC INVOLVEMENT NECESSARY?

Not all types of EA require comprehensive public involvement; for example, those which are highly localized or do not interfere with people's lives. However, the general rule should be "when in doubt, consult!"

PI programs are most often triggered by five types of projects:

i) projects affecting indigenous people;
ii) projects requiring resettlement or land expropriation;
iii) projects for specific beneficiary groups such as the poor, indigenous people, women's associations, etc.;
iv) projects that depend on local initiatives to be successful; and
v) projects that trigger economic hardships for neighboring communities, for example by increasing traffic, endangering health, or altering the local resource base.[2]

[2] These types of projects sometimes generate severe hardships for local populations, requiring sensitive consultation to find alternative sources of income.

Thorough project scoping can go a long way toward determining the type and extent of PI program that should be applied.

5.3 DETERMINING WHO SHOULD PARTICIPATE

In developing plans for public involvement, the first priority should be to identify the stakeholders, since their makeup will dictate the size of the study area, as well as the type of program needed.

The first step in stakeholder identification should be an examination of the potential impacts of the project in terms of

- who may be affected directly (project affected people);
- which agencies might have responsibility for the impact management;
- which other organizations might have an interest in monitoring proponent activities or have local knowledge to contribute; and
- which private sector entities might face financial and social hardships if the predicted impacts occur.

During the second step, the EA team needs to determine the enabling environment that will allow for the PI program's success. Political support and official interest in the project should be encouraged, and any regulatory constraints should be removed to ensure that the process succeeds. Usually, the enabling conditions are based on four factors:

i) the existence of an EA regulatory framework, in which some public involvement is specified;
ii) the existence of political will within the lead regulatory agency to undertake a PI process;
iii) institutional capacity (in-country) in terms of PI program planning, sociology and facilitation; and
iv) adequate in-country financial resources (as distinguished from donor funds) to support consultation costs.

Completing these two steps should yield a preliminary "socio-environmental profile" of the project and an initial list of PI participants.

It is suggested that, for the five project types listed in Section 5.2, the first information dissemination step include the entire initial list of stakeholders, however long. For subsequent communications, only those responding to the dissemination should be contacted. For less sensitive projects, a process of stakeholder consolidation may be required, for instance identifying interest group representatives.

5.3.1 Enabling the poor to participate[3]

Generally, it is the poor who are most seriously affected by road projects. Many sociological, cultural, and economic factors have restricted the participation of the poor in public involvement programs. The need for special efforts to involve the poor in PI is often overlooked by government officials. Successful involvement requires an understanding of their needs and aspirations, and of the ways in which decisions are made in their communities. This understanding must be applied when determining which institutions and mechanisms will be most effective in helping the poor to reap the greatest possible benefits from involvement in the planning process.

Since most people will not participate unless they see a clear benefit for themselves or their community, EA teams need to promote the benefits of participation in terms of the following ideals:

- participation may lead to direct improvement of living standards;
- immediate short-term gains for the community are often based on participation; and
- identification of appropriate compensation measures, such as the funding of alternative livelihoods, will benefit the poor only if they participate in such a program's design.

Moreover, one must go a step further and "take participation to the poor" instead of simply calling meetings and waiting for them to show up. This means meeting with them in their living environment or securing for them transportation to and from the meeting. Any information exchange must strive to be non-confrontational and relaxed, permitting ample time for participants to speak or ask questions.

The most compelling action by a proponent to demonstrate that the PI input is being considered seriously is rapid action and response to the comments and needs expressed by the poor.

Women make up a disproportionately large percentage of the poor in the world, yet they are often badly under-represented in the PI process. Therefore it is essential that a pro-active approach be taken to seek their involvement (see Box 5.2).

5.3.2 Local and community participation

At the local level, social science analysis techniques can be used to examine relationships between groups and individuals in order to identify those with the greatest power to influence decisions and outcomes. These techniques can also be used to determine which forms of consultation are most likely to elicit the knowledge and input of people with different interests, such as owners and renters, experts and laymen, beneficiaries and potential losers, men and women, wealthy and poor, farmers and business people, rural and urban dwellers, and different ethnic groups. In order to consult successfully with the full range of people who have an interest in a project, it is often desirable to use several different consul-

[3] The poor are referred to in this handbook as all people living at or below the documented poverty level, those lacking basic life support systems, and those who are particularly disadvantaged (women, minorities, physically challenged people, etc.).

BOX 5.2
WORLD BANK EXPERIENCE WITH THE PARTICIPATION OF WOMEN IN CONSULTATION PROGRAMS

Experience has made it clear that specific steps must be taken to ensure that women participate in (and benefit from) PI programs. A World Bank evaluation of 120 rural water supply projects found that even in a sector in which women carried the greatest share of responsibility, they benefited from only 17 percent of the projects—namely those which had been specifically designed to involve women. There are three key barriers which often stand in the way of good participation by women and for which compensatory mechanisms must be built into the PI. These three barriers are:

i) beliefs and attitudes that confine women to the domestic sphere;
ii) the burden of providing for the family, which leaves little time for PI; and
iii) laws, customs, and other institutional constraints that prevent women from gaining appreciable social and economic independence.

Source: World Bank, 1996.

tation activities; for example, public meetings, expert seminars, interview surveys, neighborhood displays, or small group discussions (see Section 5.5).

5.3.3 Government agencies and research institutions

Various government bodies can provide information on the potential environmental impacts of a project and on future policies and plans that may affect its implementation and operation (see Box 5.3). Some of these organizations also have interests, responsibilities, and jurisdictional authorities that need to be considered in selecting project options and designing implementation plans.

Inclusion in the assessment process at an early stage enables government stakeholders to develop an enduring interest in seeing that mitigative measures are applied.

Apart from road and environment departments, useful information can be obtained from national statistics organizations and departments dealing with demographic, cultural, and economic data, as well as trends that are important in evaluating social impacts. Sectoral agencies can provide information on direct and indirect impacts of road development on agriculture, mining, forestry, or water supply; this might include basic data on supply, production, and distribution constraints. Other departments and research institutes can provide data on the biophysical environment. In many of these areas, local governments have additional information on site-specific conditions.

Government organizations also have a role to play in project decision-making and implementation. Decisions on land use, national parks, and indigenous people, for example, often involve departments outside the road ministry. Implementation of mitigation and compensation plans, as well as enforcement of regulations regarding safety and pollution, may also involve other groups, who should therefore be included through the EA process in the design of these components.

5.3.4 Non-governmental organizations (NGOs)

A wide variety of non-governmental organizations (NGOs) with different capabilities, strengths, and interests in road and environment issues can be found in different countries and regions.

NGOs may be oriented towards communities, ethnic groups, business interests, unions, professions, or issues such as transport, development, poverty, or the environment. In some cases, they have considerable resources and contacts within their interest group and can represent the views of a significant segment of the wider community.

NGOs can bring important information and skills to the environmental consultation process. For example:

- Community and ethnic NGOs can promote awareness of local cultural issues and the socioeconomic context of project options. They may also provide an additional interface with residents and local groups to assist the consultation process.
- Environmental NGOs have the advantage of knowledge about a specific area and the way in which development may affect its status. They can often help identify fragile species and contribute to the design, organization, and implementation of protective measures.
- Development-oriented NGOs may be involved in complementary development op-

BOX 5.3
DEPARTMENTS CONSULTED FOR AN IMPACT STUDY OF A ROAD IN BURUNDI

Ministry of Public Works and Urban Development

Ministry of Planning

Ministry of the Environment, Tourism and Development
Environmental Counsel
Directorate of Forests
Directorate of National Institute of the Environment and Preservation of Nature

Burundi Institute of Agronomic Sciences
General Directorate
Agro-Economic Research Department
Cartographic Department

Directorate of Geology and Energy

Ministry of Agriculture

Burundi Geographic Institute

Office of Coffee

Project offices and financial backers
World Bank Counselor
Project Action Fund
Special Public Works Program
Integrated Breeding Program
National Reforestation Project
European Communities Commission
United Nations Development Program
French Aid and Cooperation Fund

Source: SETRA.

erations, and can assist with implementation issues. Measures to control water runoff, for example, can be designed as part of an NGO's irrigation project. Likewise, road improvements can enable an NGO to launch projects that have run up against obstacles, such as the marketing and distribution of fruit and vegetables.

Therefore, transportation agencies who manage or conduct EAs are urged to seek out and work with NGOs.

5.4 A FRAMEWORK FOR PUBLIC INVOLVEMENT

Public involvement entails a dialogue with interested parties before key project decisions are made. It should cover such issues as the choice of alternate routes, and methods of limiting or compensating for negative environmental impacts. This usually requires a good communicator on the environmental team. While the final decisions on project options generally remain with the road agency, public inputs should be seriously considered and identified if used in reaching road planning decisions. Participation does not imply complete sharing of decision-making power, but recognizes shared responsibility for both negative and positive aspects of the project (as in Box 5.1).

Clear rules and assumptions common to both the proponent and the stakeholders are essential if trust and collaboration are to become the cornerstones of friendly information exchange. A solid PI framework can be ensured by

- defining the breadth of the EA in terms of issues to be addressed and those which should remain outside the process;
- identifying the consultation timetable and duration;
- defining how participants are to be selected, and their relevance to the EA;
- identifying a suitable setting which encourages frank discussion;
- choosing an appropriate consultation method for the community; and
- outlining in advance how information will be disseminated and solicited, and how feedback will be given.

This framework should not be established unilaterally by the proponent but should form an important element of early interaction with stakeholders. Once prepared, the framework constitutes a *public involvement plan.*

5.5 PUBLIC INVOLVEMENT FORMAT

Since nations have varying policies regarding the public's right to speak out, the anonymity of people who participate in the consultation process often must be guaranteed. This can be achieved by not requiring any registration, inviting unsigned written comments, and conducting group discussions, avoiding singling out individuals to speak. This trust, if it can be developed, can be broken for a very long time if just one breach is discovered.

5.5.1 The "open house" (information displays and reports)

Public displays, newsletters and leaflets can be used to disseminate information on initial concepts and proposals for a project, and subsequently on options selected and designs adopted. Displays are usually set up in public buildings, busy roadside areas, shopping areas, or markets, especially those close to the affected areas. Where possible, project staff should be present to answer questions and accept verbal or written comments, which can be incorporated into project planning and environmental assessments.

5.5.2 Interview survey

Surveys are widely used in gathering sociological data and can also quantify opinions, priorities, and concerns of people affected by road projects. A common approach is to interview a representative sample of affected people and ask a pre-defined set of questions, with responses recorded on a standard form. Careful survey design is important to ensure that the sample interviewed is truly representative of the affected groups and that questions are worded so as not to bias responses. Expert assistance is often required in the design of survey procedures, training of interviewers, and interpretation of results.

Because of the time and expertise required, surveys can be expensive and are not used in all cases.

5.5.3 Public meetings

Formal "public hearings" are required for major public projects in some countries, with specific procedures laid down by legislation. The methods vary from case to case and are not discussed further here. EA practitioners should make themselves aware of any legislation pertaining to public hearings in the country in which they are working.

Many other forms of public meeting are used to facilitate public participation in road project evaluations. In general, these should be organized around the following four steps: a) establish "rules of the game," b) provide information, c) seek input, and d) discuss implementation.

An understanding of social and community structures is most important in the conduct of meetings. Organizers should take account of leadership structures, decision-making processes, and the presence of powerful or especially vocal groups within a meeting. Meeting arrangements should allow for different cultural approaches to collective decision-making or public disagreement. The existence of subgroups with substantially different interests, or groups who are unlikely to speak up in public forums, should also be recognized.

The choice of time and location of meetings can have a big effect on attendance and participation. In general, meetings which are held closer to affected communities, and in familiar buildings, are more likely to encourage local participation.

In some cases, formal notes or minutes may be recorded for public meetings, along with the names and affiliations of participants. This can be particularly important for participatory decision-making processes.

Public meetings do not always result in improved communications. Sometimes powerful minorities "hijack" the consultation process, vocal groups express strong opinions to the exclusion of other viewpoints, or tensions arise between different interest groups or within communities. In some cases the meeting can end with uncertainties about project objectives, scope, impacts, or options. Many of these outcomes can be avoided by thorough preparation and a sound understanding of the participants involved.

An experienced and respected moderator or facilitator, independent of the agency proposing the project, can help to ensure the effectiveness of such discussions. It is important, for example, to make sure that participants have the opportunity to express their views, that these are properly understood, and that commitments for future action are clearly distinguished from opinions and examples.

Good communication skills are important for the conduct of public meetings; they can help in probing areas of uncertainty and objectively restating information and opinions.

5.5.4 Individual or group discussions

In addition to public meetings, separate discussions should be arranged with specific groups or individuals. These meetings should be seen as an opportunity to improve communications with diverse interest groups, but not as a way of giving unbalanced influence over the project outcomes. They have a number of objectives.

In some cases, the views of minority groups or less powerful elements of a community, such as squatters, renters, women, and the poor, may be best discussed in smaller and less formal settings. Arrangements for such meetings should recognize social and cultural norms in the local communities. Participants may prefer comments to be anonymous, in aggregate form, rather than being attributed to individuals.

Some groups and individuals have particular knowledge and interests which might justify a more in-depth discussion that could not be accommodated at a general meeting. Examples include affected residents, technical specialists, councilors or political representatives, non-governmental organizations, specific community groups, and specific businesses or occupational groups. Where appropriate, separate meetings can be arranged in which information is presented for a specific audience, and discussion can focus on clearly defined concerns and issues.

5.5.5 On-site consultation

This approach is especially suited to cases with time or other constraints (such as the absence of meeting facilities), or when on-site discussions will be particularly helpful to either the agency or meeting participants. It is also useful for pre-bid discussions with potential contractors, to make sure that environmental issues and responsibilities are clearly understood.

If a site inspection tour is included, the number of participants may need to be limited, according to the number of road project staff available.

5.5.6 Rapid social appraisal

As it is frequently difficult to allocate the time and resources necessary for detailed community surveys and in-depth studies, there is growing interest in a range of alternative and less-structured methods of social data collection. These are collectively referred to as rapid appraisal techniques and include such methods as key informant interviews, focus group discussions, group interviews, structured observation, and informal surveys. Kumar (1993) describes the underlying rationale and methodology and their relationship to more formal social science methods, and provides numerous examples and case studies to illustrate their practical application. The Overseas Development Administration notes five common characteristics:

i) greater speed compared with conventional methods of analysis;
ii) work done in the field;
iii) emphasis on learning directly from local inhabitants;
iv) semi-structured, multidisciplinary approach with room for flexibility and innovation; and
v) emphasis on timely insights, hypotheses or "best bets" rather than final truths or fixed recommendations.

Sketch maps are often used as part of this approach, along with "transects," or diagrammatic representations of land use accompanied by notes about problems and opportunities. An example is shown in Box 5.4. Institutional structures can also be represented diagramatically, as shown in Box 5.5.

5.5.7 Rapid rural appraisal

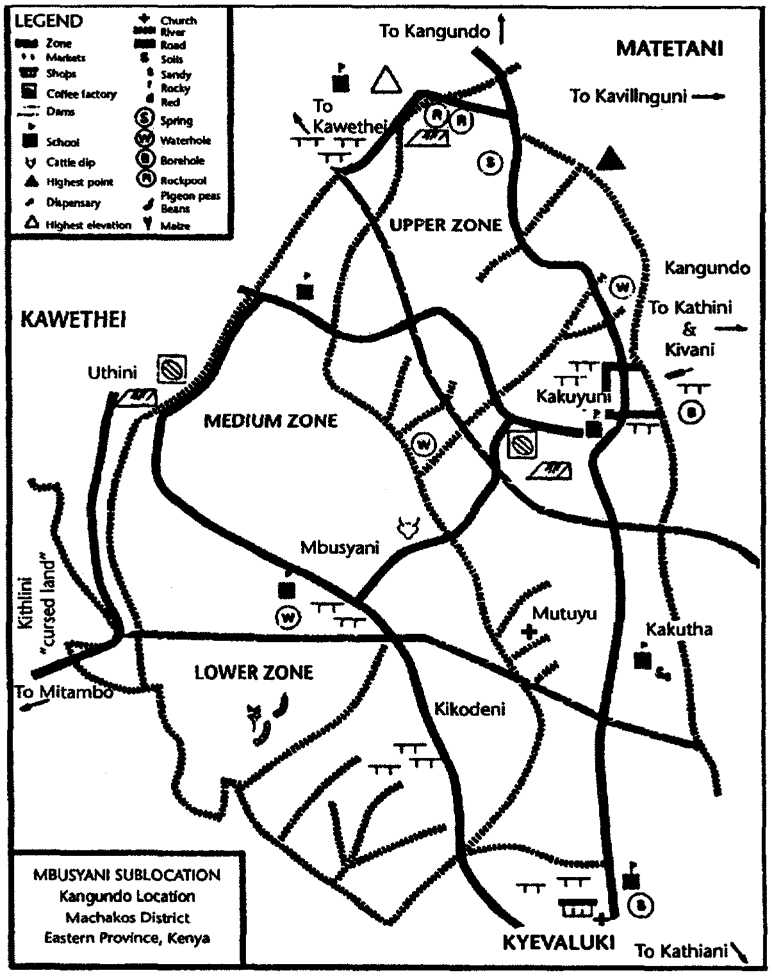
Rapid rural appraisal is normally undertaken by a multi-disciplinary team and lasts from one to four weeks. The use of key informants[4] and strategic questions allows for a compression of data collection time. Combining individual and group interviews is one way of cross-checking information.

The team should include at least one community development specialist and one technical specialist (often an ecologist) with an understanding of the systems likely to be affected by the project. The involvement of local experts and relevant organizations is crucial since they normally would have earned the trust of the local people already, and would possess knowledge and skills valuable to the EA (Yap, 1990).

All practitioners should give very careful consideration to public consultation but recognize that this does not eliminate the need for well-informed data collection and analysis.

[4] Informant is an anthropological term referring to local people who are willing to and do provide information on historical conditions of the study area to the EA team.

BOX 5.4
RAPID APPRAISAL TECHNIQUES:
THE VILLAGE SKETCH MAP



The village sketch map is a spatial representation of the community.

Process: The assistant chief already had a 1:50,000 topographical map. The team traced a base map, then the team, two village elders, and the assistant chief drove all roads and lanes in the entire subdistrict—a trip of about two hours—recording information and talking with people, as appropriate.

Result: The map exercise identified three micro-zones, defined largely by elevation, soils, and rainfall. The upper zone had somewhat higher rainfall, generally fertile soils, and potential for growing coffee. The lower zone was generally drier, had few water sources, and generally lower agricultural potential.

Usefulness: Knowing about micro-zones, disparities in wealth, differences in land use, and variations in resource access provided an opportunity for the assistant chief, women's group leaders, and the appraisal team to locate areas where local leaders thought there were particular problems. Having this initial visual reference provided common ground for the team and local leaders to exchange information.

Assessment: Preparing sketch maps as a first step has proven to be a dramatic and visually important way to announce to the community that something is going on. Several teams have had excellent responses in having the communities prepare their own sketch maps. The exercise is one of the most important rapid appraisal data-gathering tools.

Source: Kumar, 1993.

5.6 GUIDE TO INFORMATION PRESENTATION

Information about the environmental aspects of road development often covers a wide range of technical issues, which may vary in space, time, and degree of uncertainty about likely outcomes. For effective public involvement, key points need to be summarized and presented in ways which are easily understood by various audiences, and provide an objective description of the main factors of interest. The presentation needs to allow comparison of impacts which are not readily quantified in common terms, and may provide different levels of detail when used for residents, experts, and decision-makers. As a general rule, information used in public consultation should be relevant, sufficient, and credible.

5.6.1 Written reports, newsletters, and leaflets

Written documents for informing general audiences should be clear and concise, avoiding long sentences and technical terms or jargon. Illustrative material such as diagrams, photographs, and maps can be very useful. Summaries can highlight important points, and graphs or charts can simplify the communication of some numerical comparisons or trends.

5.6.2 Graphic material

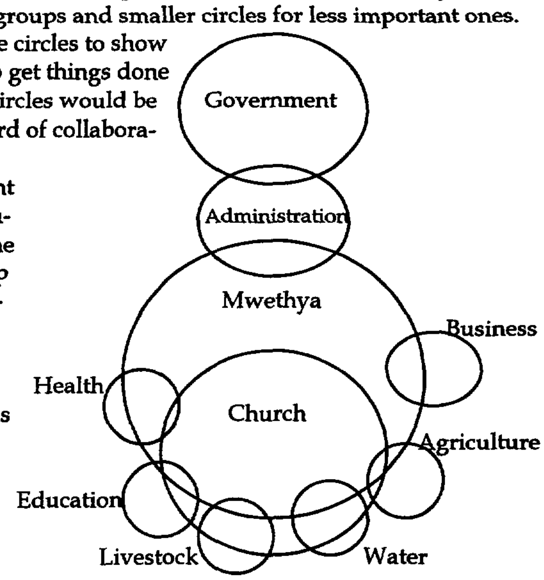
Graphic materials should aim for simplicity and clarity of message in order to be meaningful to non-technical audiences. This often means leaving out some information so that important issues are highlighted. Tables and matrices, for example, should avoid fine print

BOX 5.5
RAPID APPRAISAL TECHNIQUES: INFORMATION ABOUT VILLAGE INSTITUTIONS

While the sketch map and seasonal calendar reveal important physical information, the institutional diagram has become an essential device for gathering social and institutional data. The team first compiled a list of all institutions (church groups, women's organizations, cooperatives, etc.) in the subdistrict. Meeting with clusters of men and women in four different sites of the subdistrict, the team asked residents to rank the importance and cooperation of village institutions. To facilitate this process, the team leader brought 30 to 40 circles, cut from paper. The team leader asked group members to place names of the community's institutions on the labels, using large circles for the influential groups and smaller circles for less important ones.

Next, the group leader asked villagers to arrange the circles to show how different institutions in the community cooperate to get things done (see figure). If two groups worked closely together, the circles would be placed to overlap one another. If the groups had no record of collaboration, circles would be placed separately from each other.

While details varied, they all identified the important role of women's groups, as well as of government institutions in Mbusyani. For Mbusyani, they confirmed that the women's groups were the best bet to supervise follow-up work, raise and manage funds to do the work, and to co-operate with the assistant chief to plan new activities. In another community (not Mbusyani), the institutional analysis revealed that no village group trusted the assistant chief or would work with him. Many other examples of such insights could be cited. The point of the village social analysis is the depth of understanding and the action imperatives that can be derived from a half-day discussion of the village's social and political profile, as perceived by representatives from the community.



Source: Kumar, 1993.

and excessive detail where possible; posters should emphasize only a few messages; and maps should limit the detail presented on options or background (see Section 4.10). Aerial maps and satellite images, if available, are also valuable in describing a site and its environmental components. The application of GIS mapping has led to significant improvement in graphic material presentations.

5.6.3 Audio-visual aids

Aids such as slides and videos can be used to describe the site and surrounding environment, give an impression of the improved road and traffic situation, or present examples of impacts experienced elsewhere and mitigative measures used. Text slides or transparencies should use large fonts and present only very simple messages. In meetings where dialogue is important, visual presentations requiring darkening of the room should be used sparingly.

5.7 REFERENCES AND BIBLIOGRAPHY

European Bank of Reconstruction and Development. 1995. *Manual on Public Participation*. London: EBRD.

Federal Highway Administration. 1982. *Guidance Material for Preparation of Environmental Documents*. Washington, DC: FHWA.

Ministry for Urban Housing and Transport, Directorate of Roads, Ministry of the Environment. 1984. *Voies pour la communication*. Paris.

Kumar, K., ed. 1993. *Rapid Appraisal Methods*. World Bank Regional and Sectoral Studies Series. Washington, DC: World Bank.

Leitmann, J. 1993. *Rapid Urban Environmental Assessment: Issues from Cities in the Developing World*. (2 volumes).

Organization for Economic Cooperation and Development (OECD). 1994. *Environmental Impact Assessment of Roads, Communication Needs and Public Involvement*. Paris: OECD

Overseas Development Administration. Undated. *Manual of Environmental Appraisal*. London: HMSO.

Sinha, K. et al. 1991. "Environmental Assessment of Land Transport: Construction and Maintenance." Draft document prepared for the Infrastructure and Urban Development Department, World Bank.

Urban Management Program, Discussion Papers 14 & 15. Washington, DC: World Bank.

World Bank. 1991. *How the World Bank Works with Non-governmental Organizations*. Washington, DC: World Bank.

World Bank, Africa Region. 1991. *Local participation in environmental assessments of projects*. Washington, DC: World Bank.

World Bank. 1993. "Public involvement in EA: requirements opportunities and issues", in *EA Sourcebook Update*, No. 5. Washington, DC: World Bank.

World Bank. 1996. *The World Bank Participation Sourcebook*. Environmentally sustainable development publication. Washington, DC: World Bank.

Yap, Nonita T., 1990. "Round the Peg or Square the Hole? Populists, Technocrats, and Environmental Assessment in Third World Countries" in R.E. Rickson, R.J. Burge and A. Armour (eds.), "Integrating Impact Assessment into the Planning Process: International Perspectives and Experience". *Bulletin of the International Association for Impact Assessment*. 1&2:8:69-84.

6. Types of environmental impact

HOW TO USE THIS CHAPTER IN THE CONTEXT OF EA AND ROAD PLANNING

Stage in road planning (A)	EA activity (B)	Involvement in addition to EA team (C)
	Screening	
	Scoping	Proponent
Concept	Consultation	Key regulatory agency
Pre-feasibility	Determining baseline conditions	Other government agencies
Feasibility	Selection of preferred solution	NGOs
Engineering design	Assessment of alternative designs/methods	Research groups
Construction	Development of environmental management plan	Public/community organizations
Operation & maintenance	Effects and compliance monitoring	Advisory experts
	Evaluation	
	Reporting	

Shaded area = (A) Stages of EA covered in this chapter; (B) focus of this chapter; and (C) primary target readers.

KEY QUESTIONS ADDRESSED:

? How are environmental impacts classified?

? What are the basic criteria for defining the severity of environmental impacts?

? What is an indirect impact?

? What is a cumulative effect?

6.1 IMPACT TYPES

Environmental impacts arising from road development projects fall into three categories:

i) direct impacts;
ii) indirect impacts; and
iii) cumulative impacts.

These three groups can be further broken down according to their nature, into

- positive and negative impacts;
- random and predictable impacts;
- local and widespread impacts;
- temporary and permanent impacts; and
- short- and long-term impacts.

6.1.1 Direct impacts

Direct impacts are caused by the road itself—that is to say, by road building processes such as land consumption, removal of vegetation, and severance of farmland. For example, the removal of gravel material from a borrow pit, for use in surfacing the road, is an obvious direct impact of road construction. In this case, the land area in which the pit site is located has been directly affected by activities associated with the road project.

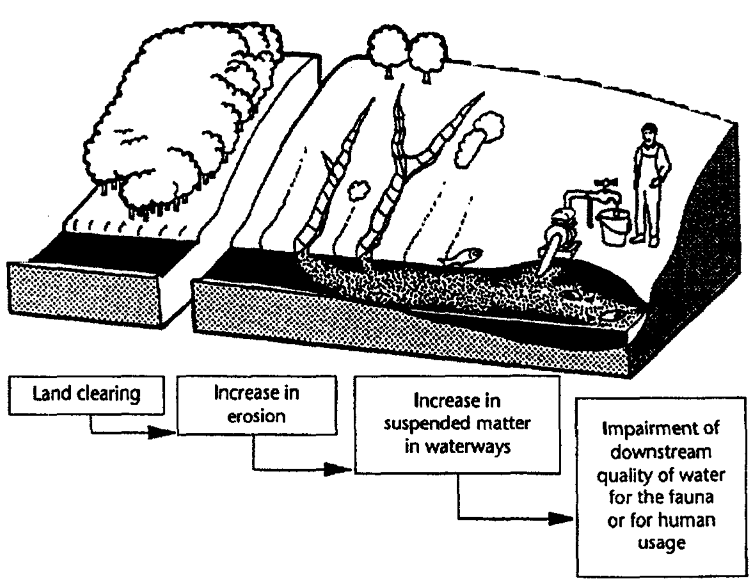
Direct impacts are generally easier to inventory, assess, and control than indirect impacts, since the cause-effect relationship is usually obvious.

6.1.2 Indirect impacts

Indirect impacts (also known as secondary, tertiary, and chain impacts) are usually linked closely with the project, and may have more profound consequences on the environment than direct impacts. Indirect impacts are more difficult to measure, but can ultimately be more important. Over time they can affect larger geographical areas of the environment than anticipated. Examples include degradation of surface water quality by the erosion of land cleared as a result of a new road (Figure 6.1), and urban growth near a new road. Another common indirect impact associated with new roads is increased deforestation of an area, stemming from easier (more profitable) transportation of logs to market, or the influx of settlers. In areas where wild game is plentiful, such as Africa, new roads often lead to the rapid depletion of animals due to poaching.

Environmental impacts should be considered not only as they pertain to road rights-of-way, but also to sites associated with the road project, which include deposit and borrow sites, materials treatment areas, quarries, access roads, and facilities provided for project work-

FIGURE 6.1
INDIRECT IMPACTS: THE EXAMPLE OF LAND CLEARING



ers. These "off-ROW" areas are often where indirect impacts appear (see Box 6.1).

EA practitioners should predict and evaluate the significance of possible indirect effects by

BOX 6.1
EXAMPLE OF POTENTIAL DIRECT AND INDIRECT ENVIRONMENTAL IMPACTS

Environmental impact study for the Guinea-Conakry Road Project (96 km road construction in a mangrove swamp and rice-growing area). NOTE: Direct Impact (D); Indirect Impact (I).

Soils
Compaction of alluvial soils by earth moving equipment (D)
Erosion and modification of surface relief of borrow zones (275,000 square meters) (D)
Loss of topsoil (165 hectares) in the borrow areas (D)
Over-exploitation of agricultural soils due to future development in a zone sensitive to erosion (I)
Irreversible salinization and acidification of mangrove swamp soils (I)

Water
Modification of flowing surface water in borrow areas, causing erosion and siltation (I)
Modification of water flows during construction (stream diversion, modification of water table recharging) (D)
Sedimentation near crossings of presently cultivated flood plain (D)
Modification of surface and subterranean water flows and resulting drying or flooding (I)
Pollution of water tables by equipment lubricants, fuels, and detergents (D)
Displacement of salinity threshold into the mangrove swamp zone: effects on fauna and flora, impregnation of soils with tannin, erosion of coastline (I)

Flora
260 hectares of deforestation and undergrowth clearance (D)
Destruction of plantings (2,800 oil palms, 1,600 various trees) (D)
Reduction of cornice forests around swamps, from modified water flow and increased agricultural use (I)
Disappearance of reproduction and food zones for species of fish, aquatic and migratory birds (I)
Reduction of mangrove plant population (habitat for fauna, purifying microfauna, firewood) (D)
Erosion of the coastline (I)
Increase in farming activity, reduction of fallow times, impoverishment of the soils (I)

Fauna
Reduction in mangrove fauna (crabs, shrimps, egrets, herons, kingfishers, spoonbills, ibises, terns, and other species) (I)
Increase in poaching during the works period, and subsequent hunting and fishing (I)
Increase in tourism (Tristao Island, the center for many migratory birds) (I)

People
Loss of farms and homes (1,300 square meters) (D)
Reduction in agricultural production per surface unit (over-exploitation, impregnation of soils with tannin) (I)
Increase in consumption of wood, particularly from the mangrove swamps: erosion (I)
Reduction in fishing potential (I)
Increase in land tenure conflicts, and conflicts between farmers and nomad cattle breeders (I)
Increase in speed of propagation of endemic disease (I)

Positive Impacts
Providing all weather road link for coastal population with major urban markets, institutions and goods
Sale of dried fish products (90 percent of national production) increased through quicker transport and access
More effective sale of rice from industrial growers (3,500 hectares) and small-scale growers
Creation of jobs
Improved access to medical help

Source: SETRA

taking a holistic approach to impact assessment. It is especially important that any synergetic relationships between impacts be closely examined, since indirect effects frequently lead to synergetic impacts.

It is with indirect effects that impact linkages between the natural and social environment often take place. For example, the appropriation of land to build a road may displace farmers, and may interfere with their cropping pattern and force them to use another water supply. This change could result in a depletion of a groundwater aquifer, intensification of new land clearing, erosion, water runoff contamination with added fertilizers and pesticides, etc.

Good documentation of the assumptions used in the determination of impacts is critical. Margins of error and the quality of basic information must be indicated when assessing any impacts that are difficult to quantify.

6.1.3 Cumulative impacts

The process of cumulative environmental change can arise from any of the four following types of events:

i) single large events, i.e. a large project;
ii) multiple interrelated events, i.e. road projects within a region;
iii) catastrophic sudden events, i.e. a major landslide into a river system; and
iv) incremental, widespread, slow change, such as a poorly designed culvert or drainage system along a long road extending through a watershed.

These can generate additive, multiplicative or synergetic effects, which can then result in damage to the function of one or several ecosystems (such as the impairment of the water regulation and filtering capacity of a wetland system by construction of a road across it), or the structure of an ecosystem (such as placement of a new road through a forest, leading to in-migration or land clearing which results in severe structural loss to the forest) (see Figure 6.2).

A cumulative impact, in the context of road development, might be the de-vegetation and eventual erosion of a roadside pullout. The scenario might unfold as follows: a road cutting through a mountain range offers some spectacular views, and in the absence of designated rest areas, motorists stop indiscriminately. Roadside vegetation is damaged by vehicle and foot traffic, and the soil is left unprotected. Subsequent rainfall causes erosion and siltation of nearby watercourses. The vegetation never has enough time to recover (because of high traffic volume on the road), and the problem is exacerbated over time.

As this example illustrates, cumulative effects assessment (CEA) is a complex process which requires extensive knowledge of ecological principles and ecosystem response mechanisms.

The success of a CEA relies heavily on the framework that is set up before the assessment is undertaken. The evaluation can begin once

- temporal and spatial boundaries for the assessment have been defined;
- measurable variables have been chosen; and
- the relationships between the chosen variables have been established.

The cumulative effects of the proposed road project on the local environment can then be evaluated by

- compiling a list of activities that are part of the proposed project;
- estimating the changes that will occur in the measurable variables as a result of these activities; and
- estimating the effects that the changes in each of the measurable variables will have within the area defined by the spatial and temporal boundaries.

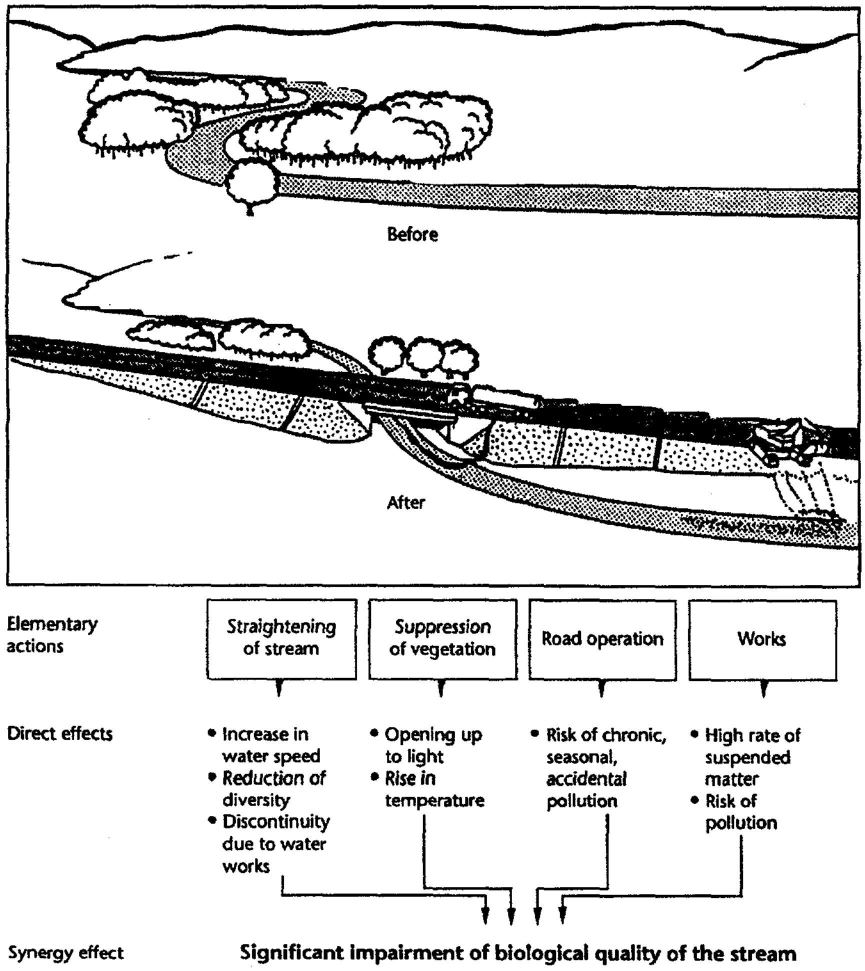
CEA is an effective impact assessment tool, but it must be carried out properly in order to produce reliable results.[1]

6.1.4 Ecosystem function impacts

Technically a subset or variant of cumulative impacts, ecosystem function impacts, which disable or destabilize whole ecosystems, are the most dangerous and often the least likely to manifest themselves over a short period of time. Many road-related examples deal with roads which need to traverse watersheds in

[1] Those planning to undertake CEA as part of an EA are urged to read Preston and Bedford (1988) as well as Spaling and Smit (1994) and (1993).

FIGURE 6.2
CUMULATIVE IMPACTS: THE EXAMPLE OF A STREAM



Each elementary action produces a certain effect or a risk that can be limited, but the combination of such actions and therefore their consequences may be the source of significant effects. In this example, steps can be envisaged with reference to each elementary action, in order to avoid the synergy effect.

which surface and subsurface water movement is complex. One striking example is the highway constructed across a mangrove forest (100 ha in size) along the Caribbean coast. It was not fully understood at the planning stage to what extent the fresh and sea water needed to mix in order for the healthy forest to survive on both sides of the road. As a result, most of the forest has died off;[2] on one side the waters were not saline enough, and on the other there was not enough mixing with fresh water. The effect on the ecosystem was devastating and the impact on the local population which used the mangrove forest area was severe. Almost certainly, no sign of this impact appeared until two to three years after the road was built. A second example could develop in situations where roads bisect wildlife migration routes, which can inflict stress on the migratory population for many generations, or even permanently, and cause instability, increased mortality, and possibly catastrophic decline.

Finally, there is the linkage with the social environment. Having had their traditional grazing areas cut off by new or re-constructed

[2] Once weakened, the mangrove trees, some over 20 m high, were destroyed by disease, etc.

roads with raised-horizontal alignments, cattle farmers may be forced to move their herds onto forest or park lands, which results in a rapid depletion of the understory (grasses, etc.). This destroys the forest edge ecotone and the basic forest ecosystem, as well as threatening the inhabitants with possible invasion from species better adapted to the newly created "grazing-forest" ecosystem. The invaded forest ecosystem is stressed further, users of the ecosystem are affected, and a chain reaction progresses throughout the system, feeding back to the social environment in the form of community disturbances and hardships.

6.1.5 Positive and negative impacts

The emphasis of this handbook is primarily on avoiding and mitigating negative impacts, which should be a high priority in all road projects. Environmental impacts sometimes have both positive and negative effects; some impacts can positively affect some people and negatively affect others in the same environment. For example, rechannelling streams as part of road construction might improve drainage for a roadside farmer, but wreak havoc on the livelihood of others who depend on the aquatic species disturbed by the rechannelling.

Positive outcomes that occur as a result of project completion typically include improved access, reduced travel time and cost, and perhaps reductions in accidents or noise. Other positive outcomes can be designed into a project, for example, improving water retention for local use, flood control, or providing better facilities for pedestrians and bicycles (see Box 6.2). In some cases, positive impacts can appear without having been initially foreseen by the road agency, such as the use of borrow sites to water livestock in dry areas.

6.1.6 Random and predictable impacts

In the preliminary analysis (Chapter 3) of an environmental impact assessment, it is useful to distinguish between assured or highly probable impacts, and more random or unpredictable ones which have a low probability of occurring but which nevertheless may have serious consequences for the environment. For example, in a country with a large, densely settled population, it is reasonable to predict that the construction of a road through unsettled areas will result in population migration, whereas incidents such as accidental pollution, fire, or spillage of toxic products are, by nature, unpredictable. Well understood and predictable impacts can usually be mitigated with remedial measures, and therefore call for minor EA requirements such as an IEE and environmental summary report, as opposed to a full EA.

6.1.7 Local and widespread impacts

Local impacts include effects in the immediate

BOX 6.2
ENHANCING WATER MANAGEMENT THROUGH INNOVATIVE ROAD DESIGN

In dry climates, millions of liters of rainwater are lost through conventional road drainage designs, which treat runoff as a nuisance, not as a resource to be captured. In a survey conducted by the World Bank, it was established that simple small-scale water retention structures along large and small rural roads could make a significant difference to water supplies during the dry periods. The study identified three basic types of structures along roads that, with minor modifications, could become retention areas, with water useable for agricultural purposes. These were:

i) standard stormwater catchbasins—deepened and with controlled drainage added;
ii) various forms of check-dams or fords, to slow drainage, creating ponding; and
iii) various other damming devices, such as sluice gates, raised box culverts and dams.

A study resulted in the preparation of a general design manual to assist engineers in planning for the inclusion of such structural modifications during the design of the roadway.

An important cautionary note: such retention structures should be avoided in high use corridors, since the runoff water may be contaminated with heavy metals and oil. Such waters are not potable by people or animals, can contaminate leafy vegetables, and, if stored in deep basins, can contaminate groundwater aquifers.

Source: Lantran, 1995.

vicinity of a road, such as destruction of a building, or restricted access to a farm. Widespread impacts can occur many kilometers from the project. These impacts are often linked to indirect effects that arise over the medium- or long-term existence of the project and include the influx of settlers, deforestation, and the development of new industries. While the focus of most road EAs has been on relatively narrow corridors measuring 100-500m in width, impacts can extend much further, particularly in new road projects which traverse isolated areas. Major habitat conversion can take place up to 10 km on either side of the cleared ROW. Road planners and EA practitioners should be aware of this possibility and address it explicitly in the project scoping activity (see Section 3.2 and Chapter 10).

6.1.8 Temporary and permanent impacts

Temporary impacts are those whose occurrence is not lasting, and which will eventually reverse themselves, the affected system having returned to its previous state. An example of this type of impact might be the trampling of roadside vegetation during resurfacing; it recovers after a few weeks, to the point where no change from the original state is observable. Permanent impacts are those which are irreversible—the affected system will not return to its previous state on a human timescale. It is important to note that "permanent" from the viewpoint of EA, is defined as "within one's lifetime". Therefore the destruction of a mangrove forest would be permanent.

6.1.9 Short- and long-term impacts

Short-term impacts are those which appear during or shortly after construction; long-term impacts may arise during construction, but many of their consequences appear during the operational phase, and may last for decades.

6.2 IMPACT SEVERITY

To qualify environmental impacts by the type of effect they have on the environment is not sufficient. Impacts must also be categorized according to their seriousness. The most damaging and longest lasting impacts will obviously be the first to be avoided or mitigated (see Section 4.3.2 for further details).

6.3 REFERENCES AND BIBLIOGRAPHY

Gilpin, A. 1986. *Environmental Planning: A Condensed Encyclopedia.* Park Ridge, NJ: Noyes Publications.

Lane, P.A., R.R. Wallace, R.J. Johnson and D. Bernard. 1988. *A Reference Guide to Cumulative Effects Assessment in Canada, Volume 1.* Hull, Canada: Canadian Environmental Assessment Research Council.

Lantran, Jean Marie. 1995. *Water Management and Road Design in the Sahel Region.* World Bank Transportation, Water and Urban Development Department; Infrastructure Note RD-20. Washington, DC: World Bank.

Preston, E.M. and B.L. Bedford. 1988. "Evaluating Cumulative Effects on Wetland Functions: A Conceptual Overview and Generic Framework". *Environmental Management.* 12:5:565-583.

Spaling, H. and B. Smit. 1994. "Classification and Evaluation of Methods for Cumulative Effects Assessment". Paper presented at the Conference on Cumulative Effects in Canada: From Concept to Practice. April 13-14, Calgary, Canada: Canadian Societies of Professional Biologists.

Spaling, H. and B. Smit. 1993. "Cumulative Environmental Change: Conceptual Frameworks, Evaluation Approaches, and Institutional Perspectives." *Environmental Management,* 17:5:587-600.

World Bank. 1991. *EA Sourcebook, Volume II.* "Rural Roads" (pg. 113), and "Roads and Highways" (pg. 168). Washington, DC: World Bank, Environment Department.

Part II

Environmental Impacts, Their Mitigation and Their Economic Valuation

7. Impacts on soils

HOW TO USE THIS CHAPTER IN THE CONTEXT OF EA AND ROAD PLANNING

Stage in road planning (A)	EA activity (B)	Involvement in addition to EA team (C)
	Screening	
	Scoping	Proponent
Concept	Consultation	Key regulatory agency
Pre-feasibility	Determining baseline conditions	Other government agencies
Feasibility	Selection of preferred solution	NGOs
Engineering design	Assessment of alternative designs/methods	Research groups
Construction	Development of environmental management plan	Public/community organizations
Operation & maintenance	Effects and compliance monitoring	Advisory experts
	Evaluation	
	Reporting	

Shaded area = (A) Stages of EA covered in this chapter; (B) focus of this chapter; and (C) primary target readers.

KEY QUESTIONS ADDRESSED:

- ? What is the relationship between the characteristics of a drainage basin and the potential for erosion at a road site?
- ? How is climate linked to soil erosion problems arising from road development?
- ? To what spatial extent should soil impacts be considered?
- ? How are impacts on soil related to other road-related impacts?

7.1 IMPACTS AND SETTING

Soil is an important component of the natural environment, and is a primary medium for many biological and human activities, including agriculture. Its protection in relation to road development deserves considerable attention.

In the road itself, in borrow pits, or around rivers and streams, there are many places where damage might occur. Losses can be considerable for the road agency and others. This includes farmers losing crops and land, fishers losing income because of sedimentation in rivers and lakes, and road users being delayed when road embankments or structures collapse. The costs of correcting these problems are often many times greater than the costs of simple preventive measures.

Soil-related impacts of road development are also discussed in the chapters on water (Chapter 8), flora and fauna (Chapter 10), and construction, rehabilitation, and maintenance (Chapter 18).

7.1.1 Loss of productive soil

The most immediate and obvious effect of road development on soil is the elimination of the productive capacity of the soil covered by roads. Unfortunately, the best sites for road development (flat and stable) also tend to be ideal for agriculture. The narrow, linear character of roads makes the impact of lost land seem minimal, but when the width of the right-of-way is multiplied by its length, the total area of land removed from production becomes much more significant. The removal of productive soil from the local economy can have socioeconomic implications (Chapters 11 and 19), as well as habitat implications for flora and fauna (Chapter 10).

Soil productivity can also be reduced significantly as a result of compaction with heavy machinery during construction.

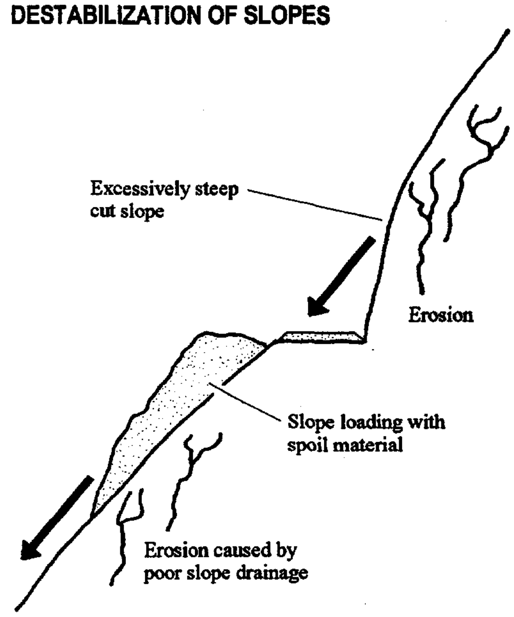
7.1.2 Erosion

When natural conditions are modified by the construction of a road, it marks the start of a race between the appearance of erosion and the growth of vegetation. Disturbance during construction can upset the often delicate balance between stabilizing factors, such as vegetation, and others which seek to destabilize, such as running water. In some cases erosion might result in cumulative impacts far beyond the road itself, affecting slopes, streams, rivers, and dams at some distance from the initial impact.

Destabilization of slopes

Slope stability can be upset by the creation of road cuts or embankments. Excessive steepness of cut slopes, deficiency of drainage, modification of water flows, and excessive slope loading can result in landslides (see Box 7.1 and Figure 7.1). Some sensitive soils, such as shale and "quick clays," are known for being difficult to drain and particularly unstable.

FIGURE 7.1
DESTABILIZATION OF SLOPES



Side-tipping of spoil materials

Spoil material from road cuttings can kill vegetation and add to erosion and slope stability problems (as in Figure 7.1). Large amounts of spoil can be generated during construction in mountainous terrain. Sometimes it is difficult to design for balances between cut and fill volumes of earth at each location, and haulage to disposal sites may be expensive. This creates a need for environmental management of tipped material.

Water flow diversions

Diversion of natural surface water flows is often inevitable in road projects. Diversion results in water flowing where it normally would

BOX 7.1
ROADS AND MASS MOVEMENTS

Mass movements present serious challenges for road development in hilly areas. If not foreseen, mass movements such as flows, slides and falls can lead to frequent need for road reconstruction, and can pose a considerable safety risk for road users.

In many cases, road development in hilly areas is directly or indirectly responsible for the occurrence of mass movements. Road cuts excavated from the base of slopes can lead to collapse, with ramifications for not only the road, but far upslope as well. Building of roadways and spoil tipping at the tops of slopes can result in excessive slope loading, causing failure downslope of the road. Finally, alteration of the drainage regime of slopes, brought about by road building, can induce instability through erosion or increased pore pressure.

Initial reconnaissance surveys of the proposed alignment should identify areas prone to mass movements that should be avoided where possible. When roads are built, care should be taken not to undercut or overload steep slopes, and particular attention should be paid to implementation of adequate drainage measures.

Often roads are not responsible for mass movements, but because of shortsighted or unfortunate alignment choice, may fall prey to them. Alignment choice should reflect caution about possible mass movements.

SOME TYPES OF MASS MOVEMENTS

Movement type	*Materials in motion*	*Moisture content*	*Nature of movement*	*Rate of movement*
Flows				
Dry flow	Sand or silt	very low	Funneled flow down steep slopes of non-cohesive sediments	very rapid
Earthflow	Soil containing sensitive clays	very high	Rapid collapse and lateral spreading of soil following disturbance, often by an initial slide	very rapid
Debris flow	Mixture of fine and coarse debris	high	Flow usually focused into pre-existing drainage lines	very rapid
Debris avalanche	Rock debris, in some cases with ice and snow	low	Catastrophic low friction movement of up to several kilometers, usually precipitated by a major rock fall and capable of overriding significant topographic features	extremely rapid
Slides				
Rock slide	Unfractured rock mass	low	Shallow slide approximately parallel to ground surface of coherent rock mass along single fracture	very slow to extremely rapid
Rock block slide	Fractured rock	low	Slide approximately parallel to ground surface of fractured rock	moderate
Debris/ earth slide	Rock debris or soil	low to moderate	Shallow slide of deformed masses of soil	very slow to rapid
Rock slump	Rock	low	Rotational movement along concave failure plane	extremely slow to moderate
Falls				
Rock fall	Detached rock joint blocks	low	Fall of individual blocks from vertical faces	extremely rapid
Debris/ earth fall (topple)	Detached cohesive units of soil	low	Toppling of cohesive units of soil from near-vertical faces such as river banks or road cuts	very rapid

Source: Adapted from Summerfield, 1991.

not—such as over vulnerable soils—and in concentration of flows; in both cases, the potential for erosion increases. Erosive flows can also arise from blocked ditches and damaged or inadequate water control structures. Water flow diversions are also discussed in Chapter 8.

7.1.3 Contamination of soil

Soil contamination can arise from daily traffic operation on very busy roads (typically over 20,000 vehicles per day). Metals such as chromium, lead, and zinc remain in the soil for hundreds of years. Pollutants settling in roadside soil can impair the growth of vegetation and the success of soil organisms, thus increasing the likelihood of erosion. These effects are usually very localized, affecting only a narrow band on either side of the road.

In colder climates, salting of roads can lead to soil contamination and subsequent decreases in fertility. Pollution risks also arise from transportation of hazardous products during road construction and subsequent traffic operations. These are discussed further in Chapter 18.

7.1.4 Cumulative impacts

Cumulative impacts involving soil damage may affect many aspects of the environment. For example, development of a road could encourage bush fires and deforestation, which, in turn, could lead to erosion of bare slopes, re-channeling of rivers and streams, and possibly minor landslides. This is discussed further in Chapters 4, 6, and 10 (see Section 10.1.2) of this handbook.

7.2 DETERMINING THE NATURE AND SCALE OF IMPACTS

Whenever there are indications of potential soil problems at the outset of the assessment, an initial reconnaissance survey of the site with road engineers and soil scientists should be carried out.

Soil surveys are a valuable tool in assessing soil erodibility, which itself is affected by soil properties such as particle size, structural stability, organic matter content, clay content, and chemical makeup.

Consideration should be given to the watershed as a whole. Runoff dynamics are affected by such factors as degree of paving (or any other "impermeable" development), extent of deforestation, and amount of water stored and used for irrigation. Attempts should be made to foresee any future developments which may affect runoff dynamics.

Potential erosion problems can often be predicted by observing local stream water flow during and immediately after storm events. Very rapid rises in volume and turbidity can suggest poor watershed conditions.

Problems are most likely to arise where a) water flows are more concentrated than before the existence of the road project, b) the road crosses watercourses, c) cut or fill slopes are steeper than previous natural slopes, and d) cleared areas are left unplanted.

Evidence of soil problems on previous or similar works is a useful indicator for anticipating the impacts of the current project. The type and extent of past erosion are important factors to consider in this context. An awareness of previous land use on the road site can pinpoint related problem areas, such as soil contaminated by mine tailings or heavy industry, which, if disturbed, could create pollution problems downstream.

Consultation with the local population is also a vital part of assessing existing and imminent erosion problems. Adapting local erosion control techniques used in agriculture can be helpful to the road agency, as can learning the most suitable plant varieties for controlling erosion in the area.

Much of the information necessary for the identification of potential impacts can be obtained from maps (geological, hydrological, pedological and topographic) as well as aerial photographs. Geographic information systems can be extremely useful in bringing together, and considering spatially, information from a variety of areas. For example, thematic maps of soil type distribution, rainfall, vegetative cover, slope aspect, and drainage basin boundaries could all be overlaid on a representation of the projected road alignment to highlight potential problem areas for soil erosion. The use of maps in conducting EAs is discussed in Section 4.9.

7.3 REMEDIAL MEASURES

7.3.1 Prevention

The likelihood of serious environmental impacts on soil as a result of road projects can be reduced by

- minimizing the area of ground clearance;
- avoiding sensitive alignments, such as those which include steep hillsides;
- balancing filling and cutting requirements through route choice, so as to avoid the production of excess spoil material and reduce the need for borrow pits;
- avoiding previously contaminated sites;
- avoiding the creation of cut slopes and embankments which are of an angle greater than the natural angle of repose for the local soil type; and
- replanting disturbed areas immediately after disturbance has stopped, *not* after construction has been completed.

7.3.2 Mitigation

There is a wide range of techniques designed to reduce the risk of damaging the soil and to fit the project into its environment with minimal adverse effects. Simple techniques such as replanting will be effective in many situations, whereas more sophisticated techniques, such as retaining walls, are used only in the most difficult cases.

Replanting

Replanting cleared areas and slopes is the most effective action to be taken in reducing erosion and stability problems. It should be undertaken as early as possible in the construction process, before erosion becomes too advanced; to be most effective, it should be done immediately after the disturbance takes place. Vegetation should be selected to serve a specific engineering function. In some cases, a short-lived engineering structure, such as a woven wattle fence, is installed, along with vegetation that can take over the function of the structure in time (see Figure 7.2). Engineering functions of vegetation include its abilities to

- catch and retain material moving over the surface (stems);
- armor the surface against erosion and abrasion by intercepting raindrops (leaves);
- support the slope by propping from the base (tree and shrub boles and roots);
- reinforce the soil profile by increasing its shear resistance (roots);
- drain the soil profile by drawing water out through the roots and releasing it to the air by transpiration; and
- facilitate infiltration of water through the soil profile, thereby reducing the proportion of water flowing over the soil surface (roots).

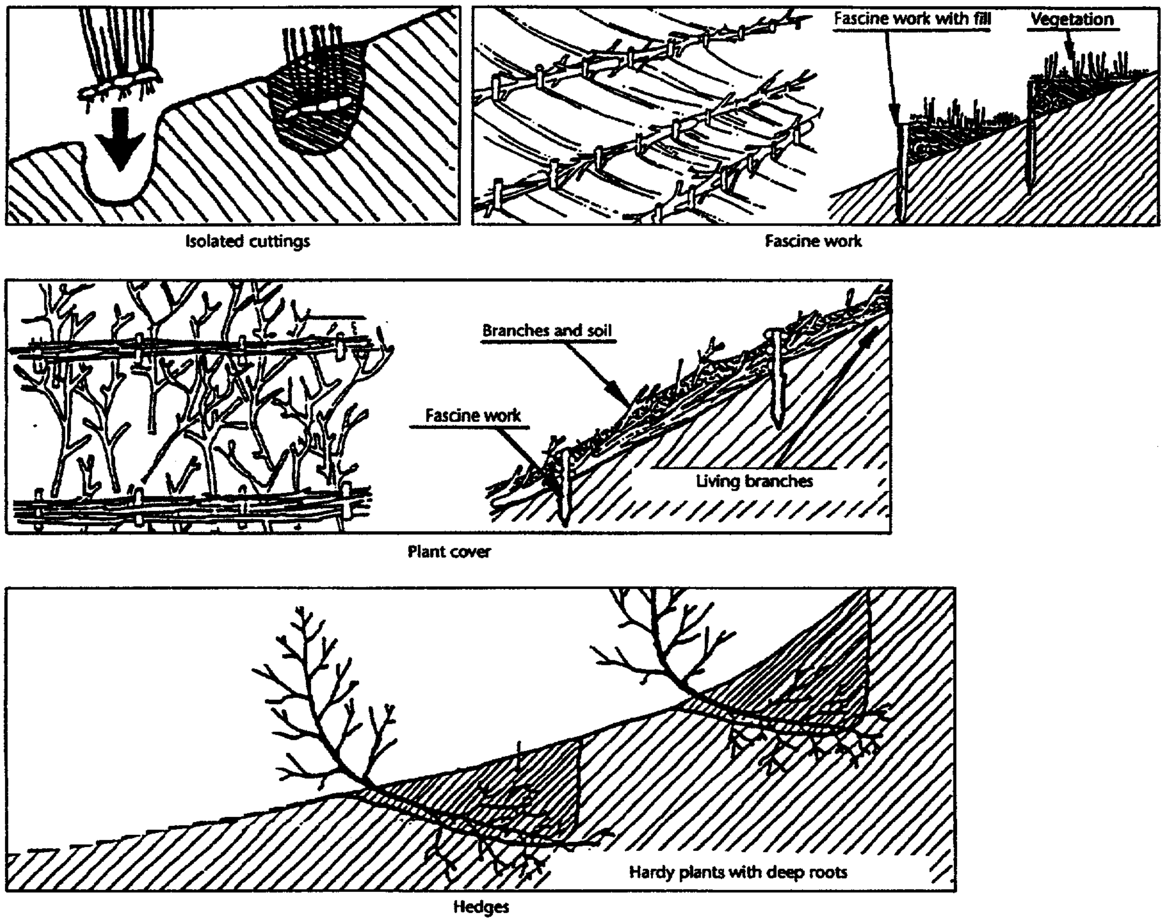
Grasses (herbaceous plants) can effectively limit surface erosion. In order for sowing or transplanting to be successful, it is necessary to

- Store and reuse topsoil. This requires that topsoil be separated from subsoil during the initial excavation. The more fertile topsoil can later be deposited on the slopes to form a superficial layer conducive to seedling establishment.
- Shape the slope surface for maximum seedling survivability (see Figure 7.3).
- Choose the right varieties, according to soil type, climate, ease of maintenance, and desired engineering function. Whenever possible, use local varieties. Vetiver grass (*Vetiveria zizanioides*) is one particularly effective variety for protecting against soil erosion (Box 7.2).
- Choose the right time of the year (for example, take advantage of the rainy season).

Sowing can be performed manually or mechanically, with farm machinery, for instance. Hydroseeders (which use solutions of water, fertilizer, binder, and seeds) are of interest in areas where access is difficult, or as a laborsaving practice where labor costs are high. Other products can also be applied to compensate for sterile soil and to promote seed germination. These may include mulch to protect the seed, covers, binders, and soil stabilizers.

Shrubs and trees (*ligneous* or woody plants) control erosion on slopes that are generally steeper; over 30 to 40 percent, for instance. Examples are shown in Figures 7.2 and 7.4.

FIGURE 7.2
PROTECTION OF SLOPES WITH PLANTS AND PLANT MATERIALS



> **BOX 7.2**
> **VETIVER GRASS (*Vetiveria zizanioides*)**
>
> Vetiver grass is receiving growing international attention for its special properties in stabilizing slopes and resisting soil erosion. Its roots can reach as deep as 3 meters below the surface, probing into rock fissures and tying soil layers firmly to their base, thus resisting slope slippage. The leaves and stems have a remarkable ability to slow water flows and trap sediment, creating a terracing effect on slopes and preventing siltation of creeks and drains.
>
> Vetiver grass is typically planted as a hedge and, under most conditions, will not spread to crowd out other plant life. It can be grown in a wide range of climates, from heavy rainfall to low-rain areas, and can survive fires and long droughts. It is not known for its tolerance of cold extremes, but it has survived considerable cold in a few cases.
>
> Vetiver rootstock is grown in nurseries in several countries. See "Other Sources of Information" at the end of this handbook for a relevant publication.

Engineering Measures

In many cases, vegetation alone may not be enough to prevent erosive damage to slopes, and various engineering measures may be needed to complement or replace it. The use of slope retaining techniques may be necessary when

- slopes are unstable because they are too high and steep;
- climatic conditions are such that establishment of vegetation is slow or impossible;
- there is a risk of internal erosion or localized rupture because of drainage difficulties; and
- it is necessary to decrease the amount of earthwork because the road width is limited.

FIGURE 7.3
SIMPLE TECHNIQUES FOR IMPROVING THE SUCCESS OF SEEDING ON MODERATE SLOPES

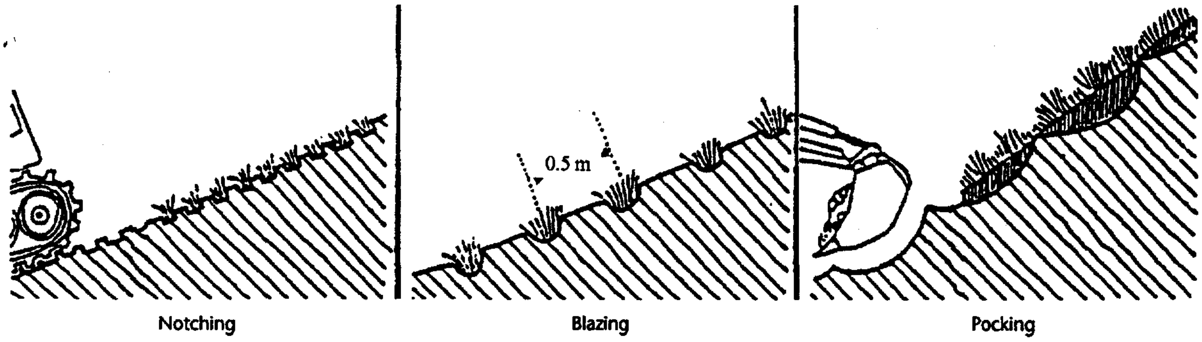
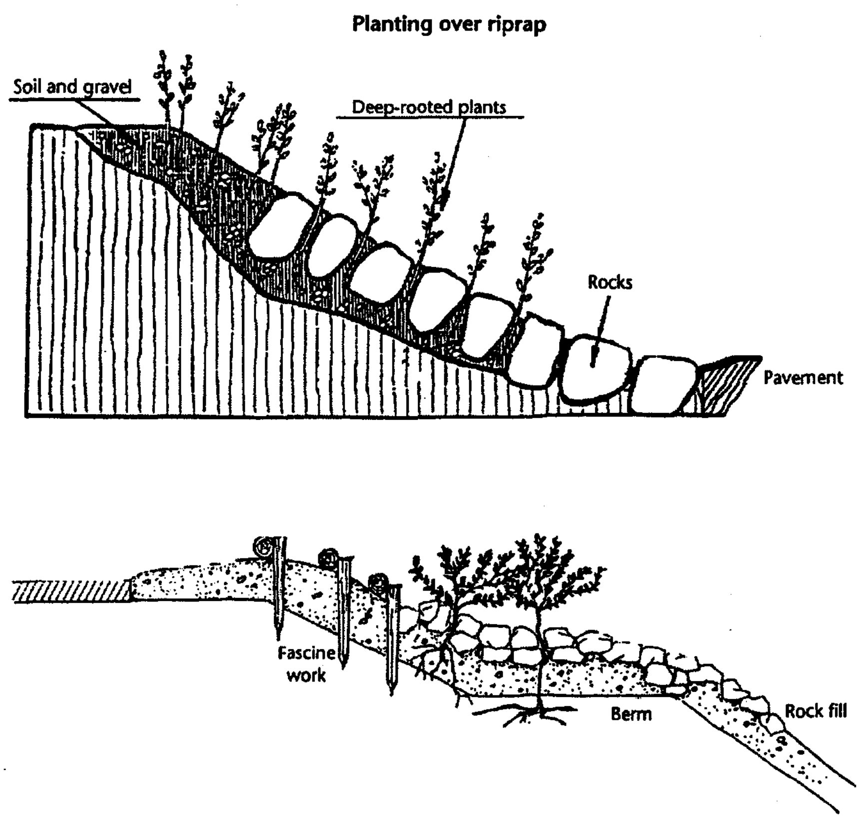


FIGURE 7.4
EXAMPLES OF COMBINED TECHNIQUES FOR SLOPE PROTECTION



Well-established engineering measures for slope protection include:

- intercepting ditches at the tops and bottoms of slopes. Gutters and spillways are used to control the flow of water down a slope;
- terraced or stepped slopes to reduce the steepness of a slope. A berm (or risberm) is the level section between slope faces (Figure 7.4);
- riprap, or rock material embedded in a slope face, sometimes combined with planting (Figures 7.4 and 7.5);
- retaining structures, such as gabions (rectangular wire baskets of rocks), cribs (interlocking grid of wood or concrete beams, filled with earth or rock), or other types of wooden barricades and gridwork, usually battered back against the slope;
- retaining walls, more substantial engineering structures able to resist bending, and with a footing designed to withstand pressures at the base of the slope;
- reinforced earth, embankment walls built up as the earth fill is placed, with anchors compacted into the fill material; and
- shotcreting and geotextiles, generally more expensive options with specific applications (Figure 7.6).

FIGURE 7.5
STANDARD DETAIL FOR ROCK FACING ON A SLOPE

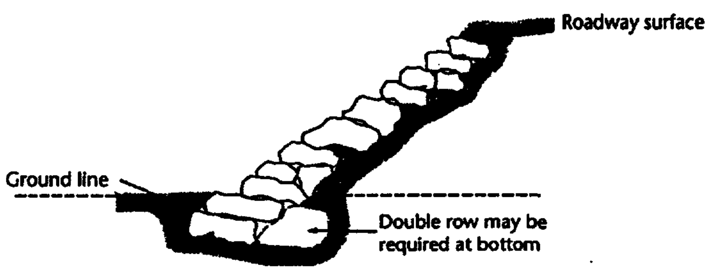


Table 7.1 presents indicative comparisons of some of these alternatives.

For many regions, specific measures and procedures are needed to deal with particularly prevalent environmental concerns. Problems associated with drifting sand in desert and coastal areas are discussed in Box 7.3. (Refer to Box 7.1 for a discussion of mass movements.)

Drainage improvements
A major factor in the prevention of soil erosion and siltation of watercourses is the control of the volume, location, and speed of water flows in the vicinity of exposed soils and slopes. Some important drainage mitigative measures include:

- cutoff drains to catch water before it reaches critical areas, and diverging drains, which avoid excessive concentration of flow (see Figure 7.7);
- concrete dissipation structures designed to slow fast-running storm water in drains, and hence reduce its downstream erosive potential;
- natural materials for energy dissipation in drains, including various combinations of sticks, hay bales, rocks, and plantings. Most of these require ongoing maintenance; and
- settlement basins, which allow silt, pollutants and road rubbish to settle out of runoff water before it flows into downstream watercourses. These are discussed further in Chapter 8 of this handbook.

7.3.3 Compensation

Where it proves impossible to avoid negative impacts on the soil, compensatory measures that aim to make up for losses or damage are considered. Some examples are:

- transformation of quarries into lakes for recreation, aquaculture, or wildlife habitat;
- terracing of nearby marginal farmland to make it more productive on the long term;
- conversion of borrow pits and spoil dump sites into roadside picnic areas and scenic lookouts;
- remediation of soils whose productive capacity has been reduced during the construction phase; for example, using a subsoiler to break up hardpan produced by compaction with heavy equipment; or

FIGURE 7.6
SOME APPLICATIONS OF GEOTEXTILES

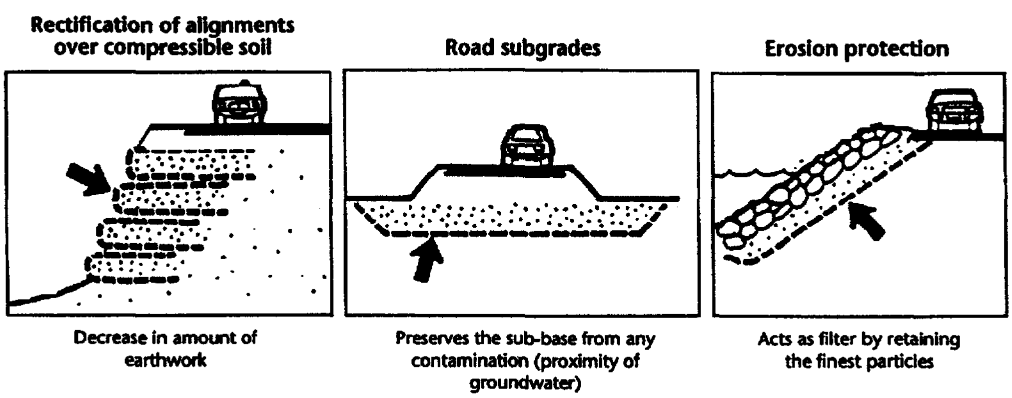
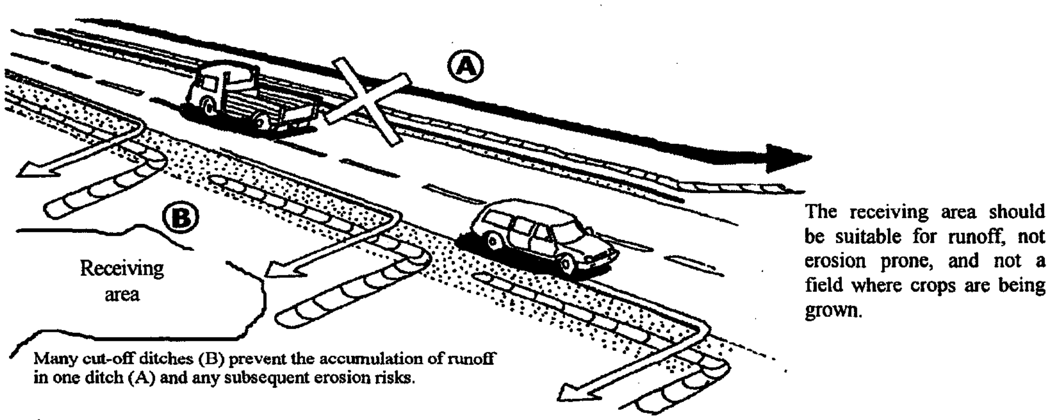


TABLE 7.1
INDICATIVE COMPARISON OF VARIOUS EROSION MITIGATIVE MEASURES

Measures	*Effectiveness*	*Comparative costs*
Grass seeding	Only surface effective, avoids start of erosion	Least expensive
Vetiver grass	Excellent, even at depth	Inexpensive
Shrubs	Excellent	Two to three times cost of grass
Stepped slopes	Excellent	Substantially raise the volume of earthworks – dependent on the distance from quarries
Riprap	Excellent for embankment protection	Depends on distance from source
Crib walls	Good	One-quarter the cost of a retaining wall
Gridwork, wooden barricades, etc.	Fairly good	Five times the cost of vegetation
Geotextiles	Excellent; good mechanical and chemical resistance	Ten to twenty times the cost of vegetation
Retaining wall	Good	Most expensive

FIGURE 7.7
CUTOFF DRAINS



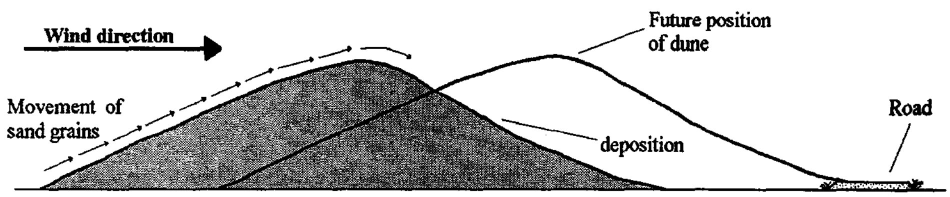
- incorporating phytoremediation into roadside planting strategies to control soil contamination problems. Some plant species render common road-derived contaminants harmless, while other species accumulate them in their tissues, making cutting plants and removing the debris for proper disposal an effective way to get rid of soil contaminants.

7.4 REDUCING IMPACTS ON SOILS: AN ACTION CHECKLIST

The more important steps of the EA process relative to the incorporation of soil considerations into the road development and planning process are as follows:

BOX 7.3
CONTROL OF SAND ENCROACHMENT ON ROADS

In desert regions and coastal zones, where there is little organic matter or vegetation to hold sands in place, the movement of sand can present a problem for road maintenance. An understanding of dune formation and movement is crucial to successful avoidance of sand encroachment problems (see diagram).



Areas where dunes are likely to form or migrate to can be avoided completely through proper choice of alignment. Where this is not possible, mitigation measures may be necessary. These might include:

- encouraging dune development immediately upwind from the road, using structures designed to lower wind velocity; and
- stabilizing existing dunes, with native vegetation where possible.

Source: Adapted from Keller, 1985.

Determine baseline conditions
Collect relevant data to identify the sensitivity of the road and surrounding areas works to erosion, instability and contamination. Soil type, vegetation and land use are particularly important points to consider.

Examine alternative routes
Make informed route choices, thereby avoiding areas with a high risk of erosion or slope instability, or which are particularly sensitive to contamination, where feasible.

Select preferred design
Choose the design which best limits potential for impacts and gives priority to mitigative measures that are easy to implement and require only local materials. Consider form and incline of slopes, design of the drainage network, replanting methods and schedule, as well as ease of future maintenance.

Prepare mitigation plans
Soil-sensitive mitigation plans should include measures to maintain and repair soil-protective plantings, as well as drainage and slope-retaining structures.

Environmental specifications for contractors
Contractors' responsibilities regarding construction and maintenance activities should cover such issues as erosion control, prevention of fuel spills during construction, and planting as well as timely watering of plantings.

Consider legislation
Legislation dealing with soil conservation should be considered. This might include limits on land use along the road (for example, restrictions on grazing and harvesting of vegetation) and requirements for erosion control (especially in mountainous regions).

7.5 REFERENCES AND BIBLIOGRAPHY

Bache, D.H. and I.A. MacAskill. 1984. *Vegetation in Civil and Landscape Engineering*. London: Granada Publishing.

Coppin, N.J. and I.G. Richards, eds. 1990. *Use of Vegetation in Civil Engineering*. London: Construction Industries Research and Information Association.

Environmental Protection Authority, Victoria. 1991. *Construction Techniques for Sediment Pollution Control*. Publication No. 275. Melbourne, Australia.

France, Ministry of Infrastructure. 1944. "Natural Environment Valuation Techniques" (in French). Excerpts from file N 514-515. Antony, France: National Center for Farm Machinery, Rural Engineering, Water and Forests (CEMAGREF).

France, Ministry of Infrastructure. 1980. "Revegetation of Slopes in the Mediterranean Zone" (in French). Road and Highway Technical Studies Department (SETRA). Paris: Mediterranean Technology Research and Development Center, SETRA.

Gray, D.H. and A.T. Leiser. 1982. *Biotechnical Slope Protection and Erosion Control.* New York, NY: Van Nostrand Reinhold Company.

Grimshaw, R.G. and L. Helfer, eds. 1995. *Vetiver Grass for Soil and Water Conservation, Land Rehabilitation, and Embankment Stabilization.* World Bank Technical Paper Number 273. Washington, DC: World Bank.

Japan International Cooperation Agency. 1992. *Feasibility Study on the Restoration of Rural Roads.* Department of Public Works and Highways, Report No. 66, Republic of the Philippines, Manila.

Jensen, Axel Martin, 1993. *Protection of Roads in Mauritania Against Sand Encroachment.* United Nations Development Programme, United Nations Sudano-Sahelian Office.

Keller, Edward A. 1985. *Environmental Geology, 4th edition.* Columbus, OH: Charles E. Merrill Publishing Company.

Lawrance, C.J., P.J. Beaven and R.J. Byard. 1993. *Terrain Evaluation Manual.* Transport Research Laboratory, State of the Art Review 7. London: HMSO.

National Research Council. 1993. *Vetiver Grass: A Thin Green Line Against Erosion.* Board on Science and Technology for International Development. Washington, DC: National Academy Press.

Ruza, F. et al. 1993. *Tratado del medio ambiente.* Madrid: Aglo Ediciones.

República de Colombia, Ministerio de Transporte. 1996. *Politicas y Practicas Ambientales,* Segunda edición.

Summerfield, M.A. 1991. *Global Geomorphology.* New York: Longman Scientific and Technical.

Switzerland, Federal Office of Water Conservation. 1982. "River Flood Protection" (in French). Bern: Directive of the Federal Department of Transportation, Communication and Energy.

United Kingdom, Road Engineering Division. 1993. *Design Manual for Roads and Bridges.* London.

8. Impacts on water resources

HOW TO USE THIS CHAPTER IN THE CONTEXT OF EA AND ROAD PLANNING

Stage in road planning (A)	EA activity (B)	Involvement in addition to EA team (C)
Concept	Screening	Proponent
Pre-feasibility	Scoping	Key regulatory agency
Feasibility	Consultation	Other government agencies
Engineering design	Determining baseline conditions	NGOs
Construction	Selection of preferred solution	Research groups
Operation & maintenance	Assessment of alternative designs/methods	Public/community organizations
	Development of environmental management plan	Advisory experts
	Effects and compliance monitoring	
	Evaluation	
	Reporting	

Shaded area = (A) Stages of EA covered in this chapter; (B) focus of this chapter; and (C) primary target readers.

KEY QUESTIONS ADDRESSED:

? How can road development affect flows of surface and groundwater and why is it important?

? How does road development affect water quality?

? What is the relevance of soil type and geologic structure to the prevention and control of impacts on water resources?

? To what spatial extent should road-related hydrologic impacts be considered?

8.1 IMPACTS AND SETTING

No matter where a proposed road may lie, it must intersect a drainage basin, and where this intersection occurs, alteration of the local hydrology is inevitable. Road development can lead to three types of modification to the natural hydrological environment; these are discussed below.

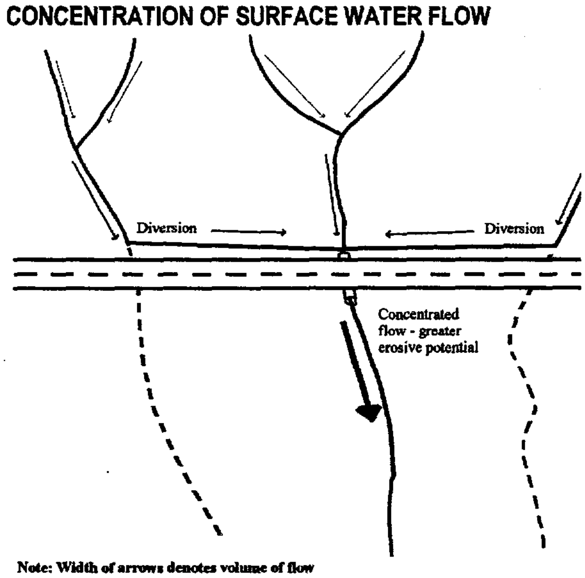
8.1.1 Surface water flow modification

Roads that intersect drainage basins generally modify the natural flow of surface water by concentrating flows at certain points and, in many cases, increasing the speed of flow, as illustrated in Figure 8.1. Depending on local conditions, these changes can contribute to flooding, soil erosion, channel modification, and siltation of streams. These effects are often felt well beyond the immediate vicinity of the road.

8.1.2 Groundwater flow modification

Road drainage and excavation can lower the water table in surrounding areas, while embankments and structures can raise the water table by restricting flow (Figure 8.2). The potential effects include deterioration of vegetation, increased susceptibility to erosion, loss of water for drinking as well as agricultural use, and habitat changes for fish and wildlife.

FIGURE 8.1
CONCENTRATION OF SURFACE WATER FLOW



8.1.3 Water quality degradation (surface and groundwater)

Sedimentation, changes in biological activity in streams and on their banks, uncontrolled construction activities, and spills of chemicals and pollutants can all have adverse effects on roadside water quality. Chronic pollution of surface runoff from exhaust emissions, pavement and tire wear, petroleum product drippage, and corrosion of metals may be issues on some very busy roads. Where oil or lignin is applied to gravel roads to keep dust down, the likelihood of contamination is quite high. Seasonal pollution issues arise during salting of roads for winter maintenance and during periods of low stream flow. Impacts of road works and accidental spills are discussed in Chapter 18.

8.2 DETERMINING THE NATURE AND SCALE OF IMPACTS

8.2.1 Drainage modifications

Significant hydraulic characteristics to be considered include water speed and flow, turbidity, and water level. Where required, further basic data on boundaries of floodable zones and makeup of riverbeds can be obtained from responsible government agencies and local residents. Changes in the volume and speed of flow that deviate significantly from normal conditions should be considered as far downstream as they are observed, taking into account seasonal variations. These factors are considered in drainage design of road pavements but should be checked in an environmental assessment.

The use of the road drainage system to retain more water in dry areas (see Figure 8.3) or to take away unhealthy standing water is a potential environmental benefit of road development.

FIGURE 8.2
MODIFICATIONS IN WATER TABLE AS A RESULT OF ROAD CONSTRUCTION

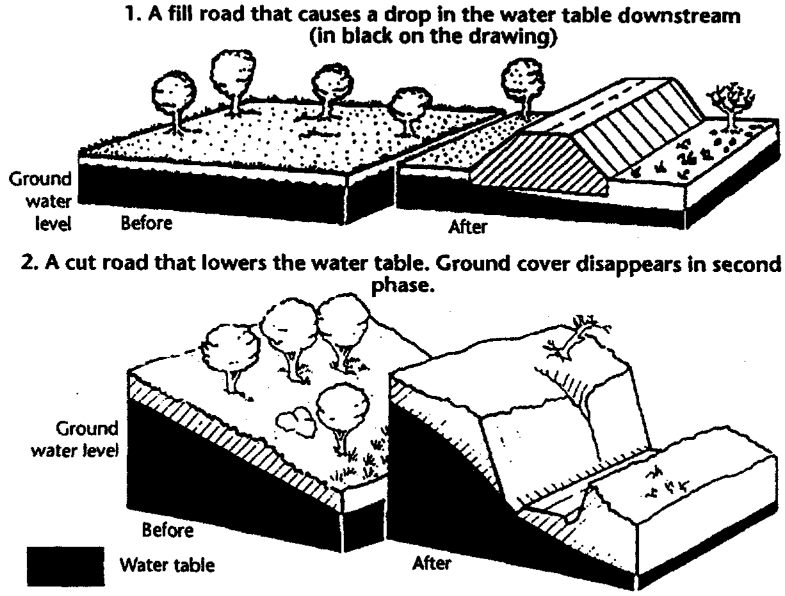
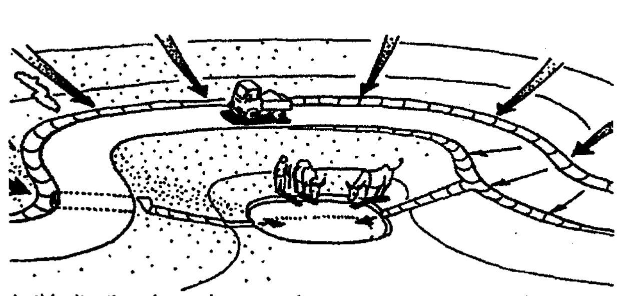


FIGURE 8.3
RECHARGED AQUIFER, RESERVOIR SURFACE



In this site, there is a real opportunity to create a water reservoir:
- cut-off ditches channel runoff
- a former borrow site is put to use
- these reservoirs can be used by inhabitants to water their livestock

In both cases, a check must be made to ascertain that traffic is sufficiently low to cause little or no pollution of drainage water

8.2.2 Water table modification

Changes in the water table should be considered carefully, especially where groundwater is important for human or agricultural uses and in dry regions where groundwater is important to natural flora and fauna. Where substantial changes in groundwater flow are expected, the dynamics of the hydrographic network should be analyzed carefully, since they can be subject to extensive chain reactions (Figure 8.4). Location and extent of aquifers, local geological structure, typical groundwater flow speed, and variations in water levels in local wells are all potentially useful points of reference.

Geographic information systems can be especially useful in relating the spatial extent of groundwater resources to land and water use.

Another tool used to predict impacts on groundwater flow is computer modeling. The application of modeling to water flows is discussed in Box 8.1.

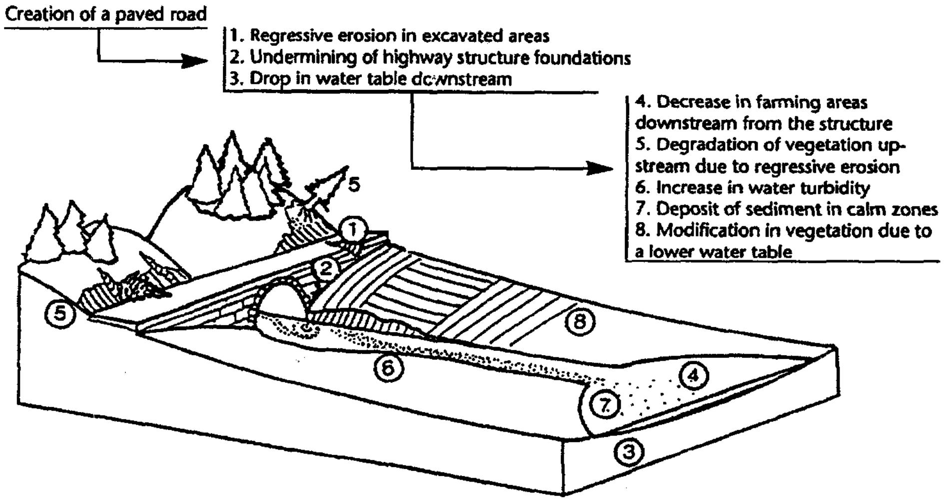
8.2.3 Water quality degradation

Water pollution problems arise most often on roads with high traffic flows, but they should also be considered for projects that are

- near drinking water intake points (Figure 8.5);
- bordering areas of great biological value;
- near rivers with low minimum flows; and
- crossing soils with limited filtering power—limestone and karstic dolomite, for example, have negligible filtering power, while sand and sandstone actively filter suspended matter and clays greatly limit the rate at which pollutants are spread.

Parameters used to measure water quality include: organoleptic conditions such as color and odor; physical and chemical characteristics

FIGURE 8.4
ILLUSTRATION OF A CHAIN REACTION

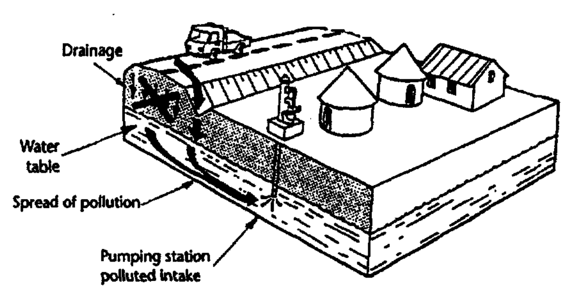


> **BOX 8.1**
> **COMPUTER MODELING IN HYDROLOGY**
>
> Road design usually requires an analysis of rainfall, runoff, the volume and speed of water in drains, and sometimes stream flows and flood levels. This analysis is used to minimize erosion, flooding, and downstream flow impacts. Environmental hydrology models use similar methods, with additional attention to pollutant patterns. The Storm Water Management Model (SWMM)[1] distributed by the US Environmental Protection Agency is a typical example. This model includes three main calculation methods: a) calculation of flows based on rainfall; b) calculation of pollutants conveyed by runoff as a function of deposit time (interval between two rainfalls) and incorporating the characteristics of the catchment basin (land use and slopes); and c) analysis of the impact of buffer volumes on these pollutant flows by simulating the settling and recirculation of the pollutants. The main data to be entered into the model are rainfall, hydraulics (essentially slopes), and land use. The result is a simulation of flow and pollutant concentrations. The impact of these pollutants on the environment is not analyzed by the model and must subsequently be deduced on the basis of flows and pollutants.

such as turbidity, conductivity, sulfate and aluminum content; undesirable substances such as nitrates and hydrocarbons; toxic substances such as chromium, lead, and pesticides; and microbiological contaminants such as total coliforms and streptococci. It is customary for water quality to be classified according to the least favorable parameter measured. Polluted discharge from road surfaces (Table 8.1) can be assessed either by heavy metal content or suspended matter, whichever is the least restrictive to measure.

Sediment problems are particularly prevalent during the construction stage, when the largest amount of soil is disturbed and exposed to erosive forces. Particular problem areas include water-crossing sites, such as bridges and culverts, and tunnel drilling sites. Sediment

FIGURE 8.5
GROUNDWATER CONTAMINATION FROM ROADS



[1] See "Other Sources of Information" at the end of this handbook for a relevant address.

loading of surface water can create problems well downstream of the original erosion source.

8.2.4 Sensitive habitat intrusion

Sensitivity to changes in water flows may be physical (effects on hydrology), biological (habitat of flora and fauna), and human (water for recreational, economic, and domestic uses). Wherever possible, sensitive areas should be avoided by the use of alternative routes, and where this is not feasible, priority should be given to route alternatives which interfere the least with VECs. Mitigative measures that might be considered unfeasible under normal circumstances may be justified for use in sensitive areas.

TABLE 8.1
POLLUTANT DEPOSITS FROM ROAD TRAFFIC

	1,000 vehicles per day	*1,000 vehicles per day*
Dust: kg/day/km	5-10	50-100
Lead: gm/day/km	8-14	80-140
Zinc: gm/day/km	4	40
Hydrocarbons: kg/day/km	0.1-0.5	1-5

Note: Typical quantities deposited on the pavement in Western European countries. Actual values vary with vehicle maintenance, road conditions, and loads carried.

8.3 REMEDIAL MEASURES

8.3.1 Prevention

Measures used to avoid severe impacts on local hydrological environment may include:

- avoiding alignments which are susceptible to erosion, such as those crossing steep slopes;
- minimizing the number of water crossings wherever possible;
- using only "clean" fill materials around watercourses, such as quarried rock containing no fine soil; and
- leaving buffer zones of undisturbed vegetation (width increased in proportion to slope) between road sites and bodies of water.

8.3.2 Mitigation

Some common mitigative measures are discussed below.

Flow speed control

Water speed reduction measures can substantially reduce potential impacts. Examples include grasses, riprap, and other devices in water channels, as well as dispersal structures in main drains (see Chapter 7).

Settling basins

Settling basins are sometimes used to remove silt, pollutants, and debris from road runoff water before it is discharged to adjacent streams or rivers. They are most appropriate where the downstream environment is particularly sensitive or where the levels of silt or pollutants are particularly high (see Figure 8.6). Ongoing maintenance may be required where large amounts of silt are deposited.

Paving

Sections of dirt and gravel roads prone to erosion and likely to be a source of sediment can be paved to reduce the amount of sediment produced. This is especially relevant near water crossings.

Infiltration ditches

Infiltration ditches (Figure 8.7) can be used to reduce overland flow by encouraging the movement of runoff down through the soil profile. The volume of flow in downstream drainage structures is reduced, the flow of pollutants is localized, and groundwater is recharged.

Oxidating macrophytes (wetland treatment facilities)

Oxidating macrophytes, such as cattails in temperate climates, can be used to remove some pollutants naturally from settling basins (see Hammer, 1988).

Water collection, control, and treatment

This is a relatively expensive option for polluted runoff from pavements and slopes, but may be called for in particularly sensitive areas.

Selected mitigative measures are compared in Table 8.2.

FIGURE 8.6
PROGRESSION IN RUNOFF TREATMENT

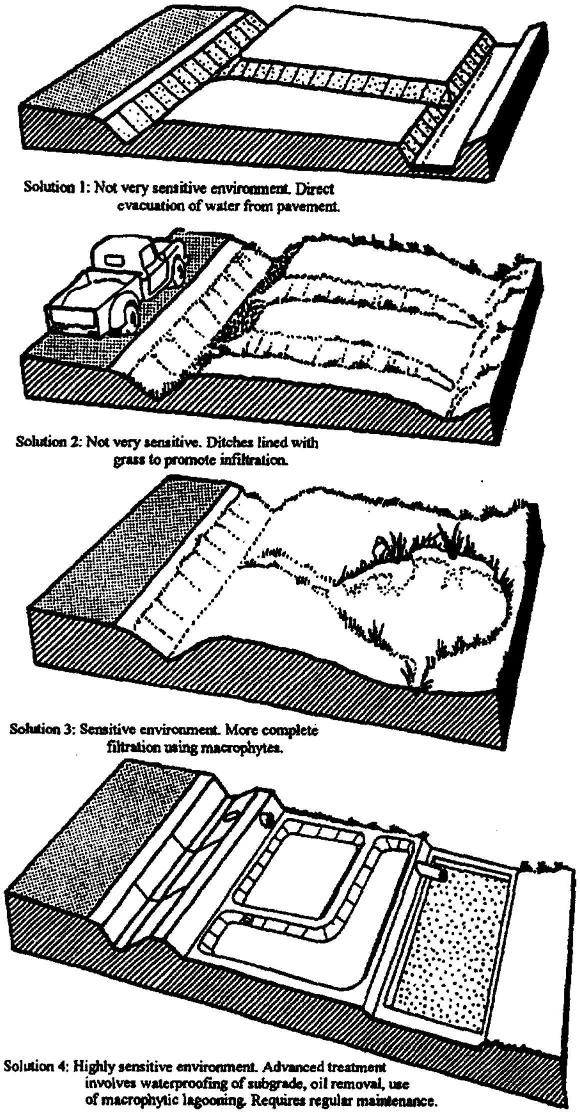
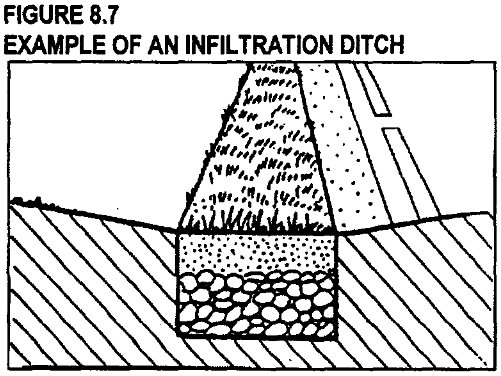


FIGURE 8.7
EXAMPLE OF AN INFILTRATION DITCH



Infiltration ditch

8.3.3 Compensation

Compensatory measures should be considered if they prove more cost-effective than mitigation, or if mitigation proves impossible. Examples are:

- moving a bore hole away from an adversely affected site, provided the local ground water distribution permits this;
- drilling wells for local residents who previously relied on surface water for drinking;
- creating a replacement habitat for wildlife; and
- incorporating environmental enhancements in the project (see below).

8.3.4 Enhancement

Road projects often provide an opportunity to improve some aspects of the hydrological environment (Box 8.2).

In very dry areas, road drainage can be designed to retain water in small dams or maintain a high water table—for example, by raising the inlets to drainage culverts—which increases the availability of drinking water and the viability of many species of flora and fauna, and recharges local aquifers (see Figures 8.3 and 8.8).

In areas prone to flooding, road works can either incorporate retarding basins that reduce runoff peaks (and potentially save on drainage structures), or they can improve drainage in residential or farming areas that are excessively sensitive to flood damage. In some cases, a section of the road itself can be constructed as a dam, perhaps designed to operate as a spillway during peak floods.

8.4 MINIMIZING IMPACTS ON WATER RESOURCES: AN ACTION CHECKLIST

The more important steps in the EA process relative to the incorporation of hydrological considerations into the road planning and development process are highlighted below.

Collect relevant data

Determine the sensitivity of the study zone and identify the main potential impacts, working from basic data on the drainage basin, nature and frequency of flooding, water quality, water use, fauna species and habitats. Assess likely modification of baseline conditions arising from the project.

TABLE 8.2
INDICATIVE COMPARISON OF WATER IMPACT MITIGATIVE MEASURES

Measure	*Effectiveness*	*Comparative costs*
Flow limitation		
Intercepting ditch	Highly effective if properly maintained	Economical; cost of an earthen ditch
Cascade flow slowdown unit (dissipator)	Good but perpetuates flow linearity	Negligible for a concreted ditch
Flood basin	Very good if properly situated	100 times the cost of an outfall
Pollution limitation		
Direct drainage	For very limited volumes, proportional to total discharge	Equivalent to cost of an earthen ditch
Grass	For limited volumes	Equivalent to fascine work combined with grass seeding
Oxidating macrophytes	For long retention periods	20 times the cost of an outfall
Settling basin	Highly effective if maintained; requires space	200 times the cost of an outfall

BOX 8.2
ENVIRONMENTAL ENHANCEMENTS IN ROAD PROJECTS IN AFRICA

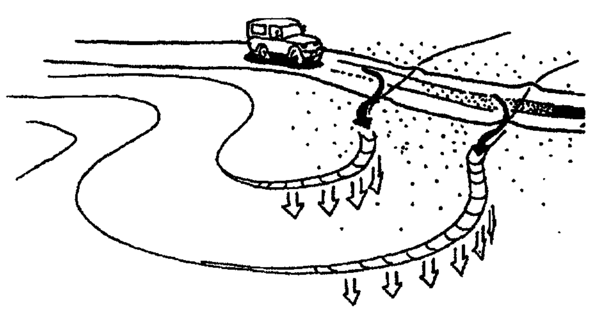
Sahelian Region
Many small dams storing seasonal rainfall are built in the Sahel to fight drought. Additional water storage can be created through the replacement of a bridge or box culvert with a spillway or a raised structure to accumulate water upstream from the road. This makes it possible to reduce construction costs for the road and, at the same time, to store water for the local population.

Where standing water is unhealthy or attracts mosquitoes, water management techniques can improve drainage and absorption. Lantran et al (1994) describes a number of specific design alternatives (also see Box 6.2, page 64).

Burkina Faso
The rehabilitation of 275 km of rural road in southwest Burkina Faso included provision of 20 percent of the $40 million budget for construction wells to be retained for permanent village use, along with dam construction, land drainage, terracing for rice fields, and tree planting set back from the road. Water retention along road embankments was achieved by high placement of cross-culverts, and borrow pits were landscaped for running-water ponds and other uses. Villagers began working on the improved roadside fields and positive impacts on local agriculture were experienced even before roadwork was completed.

Source: Baillon et al., 1994.

FIGURE 8.8
REDUCED EROSION, RECHARGED AQUIFER



The creation of cut-off ditches along contour lines recharges the aquifer in this location and eliminates ditches with excessive flow and risks of erosion

Make informed alignment choices
Minimize water crossings and avoid sensitive areas wherever possible.

Select preferred design which limits erosion
Take account of design changes which concentrate or speed up water flows, lower the water table, or increase flood risks. Factors to be considered include horizontal and vertical alignment, cross section, slopes, drainage of subgrade and surrounding area, as well as restoration of natural surface and underground flow.

Undertake careful planning and design at water crossings
Planning and construction of water crossings needs to be coordinated with local aquatic conditions such as flow regimes, fish movement, and human use. Lack of planning can have severe long-term effects; for example, an improperly sized bridge culvert could cause flooding, leading, in turn, to interruption of fish migration, erosion, and siltation.

Water resources-sensitive mitigation plans
Mitigation plans should include proposals for specific technical measures, such as planting of cleared areas, installation of flow-speed dissipaters in drains, and recommendations for subsequent maintenance.

Water resources management specifications in contract documents
Environmental specifications for contractors should cover road design, bridge and tunnel construction, drainage installation, and any work-site plans which may affect water flows and quality.

Invoke laws, regulations and guidelines on water quantity and quality
Legislation and regulations should be considered as they affect drinking water intakes, irrigation water supply, and wildlife habitat, possibly with the definition of protection perimeters; constructions in floodable zones; and discharge capable of changing the quality of surface water or ground water.

8.5 REFERENCES AND BIBLIOGRAPHY

AMV and Associates. 1979. "Guidelines for Assessing the Environmental Impact of Public Mass Transportation Projects." Washington, DC.

Baillon, J., J.M. Lantran and J.M. Pagès. 1994. "Road Maintenance and the Environment," in *Contracting Out Road Maintenance Activities*, Vol. V. Sub-Saharan Africa Transport Program, Africa Technical Department. Washington, DC: World Bank.

Bernard, J.M. 1987. "Roads and water pollution: Memorandum" (in French). Bagneux, France: Ministry of Infrastructure, Road and Highway Technical Studies Department (SETRA).

France, Ministry of Infrastructure. 1993. "Water and Roads: Study Report" (in French). Bagneux, France: Road and Highway Technical Studies Department (SETRA).

Hamilton, H.R. 1988. *Identification and Ranking of Environmental Impacts Associated with the United States Interstate Highway Systems*. Washington, DC: Transportation Research Board.

Hammer, D.A., ed. 1988. *Construction of Wetlands for Wastewater Treatment; Municipal, Industrial and Agricultural*. Chelsea, MI: Lewis Publication Co.

Kramme, A.D. et al. 1985. *Reference Manual for Assessing Water Quality Impacts from Highway Maintenance Practices*. Washington, DC: US Department of Transportation, Federal Highway Administration.

Lantran, J.M., J.L.Fréjacques and J. Perrin. 1994. *Water Management and Road Design in Sahelian Countries*. Information note. World Bank, Africa Region, Sahel Department.

Ontario, Ministry of Natural Resources. 1990. *Environmental Guidelines for Access Roads and Water Crossings*. Toronto, Canada: Queens Printer.

Rexnord Inc, 1985. *Effects of Highway Runoff on Receiving Water Volume III. A Resource Document for Environmental Assessments*. Washington, DC: US Department of Transportation, Federal Highway Administration.

Spain, Ministry of Public Works. 1988. "Erosion" (in Spanish). Madrid: Directorate General of the Environment.

United Nations, Food and Agricultural Organization. *Systems of Farming Which Conserve Soil and Water*.

9. Impacts on air quality

HOW TO USE THIS CHAPTER IN THE CONTEXT OF EA AND ROAD PLANNING

Stage in road planning (A)	EA activity (B)	Involvement in addition to EA team (C)
	Screening	
	Scoping	Proponent
Concept	Consultation	Key regulatory agency
Pre-feasibility	Determining baseline conditions	Other government agencies
Feasibility	Selection of preferred solution	NGOs
Engineering design	Assessment of alternative designs/methods	Research groups
Construction	Development of environmental management plan	Public/community organizations
Operation & maintenance	Effects and compliance monitoring	Advisory experts
	Evaluation	
	Reporting	

Shaded area = (A) Stages targeted by this chapter; (B) focus of this chapter; and (C) which users benefit the most from reading this chapter.

KEY QUESTIONS ADDRESSED:

? What are the factors influencing the propagation of airborne vehicular pollutants?

? How are regional industrial pollution issues and project-level consideration of vehicle emissions linked?

? To what spatial extent should vehicular air pollution impacts be considered?

? What is the relevance of national and regional air quality standards to project-level impact assessment?

9.1 IMPACTS AND SETTING

The emission of pollutants by vehicles has worldwide impacts and contributes greatly to the total atmospheric pollution generated by people. The use of passenger cars alone is responsible for 60 percent of carbon monoxide emissions, 60 percent of hydrocarbon emissions, and more than one-third of the nitrogen released into the atmosphere. Clearly, pollution by motor vehicles plays a significant role in a serious global problem.

Reduction of air pollution on a global scale requires national policy initiatives and international cooperation, subjects which are well beyond the scope of this chapter; they are addressed more appropriately in a discussion of sectoral assessments. In this chapter, atmospheric pollution produced by motor vehicles is considered primarily on a local level and for specific road projects.

Air pollution from road traffic should be considered for all projects in which a new road, or a change in capacity of an existing road, is proposed. As well, construction-related air pollution needs to be evaluated for every project undertaken. The level of effort and degree of urgency for air quality assessment should be related to host-country standards[1] and local conditions. Where motor vehicles are a major source of the problem, or are likely to be one, air quality assessment is essential.

Emissions stem not only from the use of internal combustion engines, but also from

- industrial plant operation;
- power generation;
- heating; and
- natural events, such as volcanic eruptions.

These emittors must all be accounted for in a road emissions assessment; the significance of the total pollutant load associated with road traffic cannot be determined, nor can cumulative impacts be assessed, without full awareness of them.

Project-level assessment should identify the pollutants of greatest concern as well as the locations where pollutants might exceed acceptable levels.

[1] In those cases where national air quality standards have not been developed, international standards, such as those developed by the World Health Organization, should be used.

The causes of pollution within the traffic stream should be clearly identified, since these have a large effect, especially at the regional level, on the choice of mitigation strategy. It is important to determine whether pollution arises mainly from gasoline or diesel vehicles, whether it can be traced largely to a specific vehicle type, and whether it is produced by all vehicles of a given type or disproportionately from a small percentage of badly maintained vehicles.

9.1.1 Airmass Contaminants

The main products of the combustion of motor fuels are carbon dioxide and water, but inefficiencies and high temperatures inherent in engine operation encourage the production of many other pollutants of varying effect. The major pollutants of significance to roadside air quality in vehicle emissions are discussed below.

- *Nitrogen oxides* (NO_X). Most of the NO_X in vehicle emissions are in the form of NO (nitric oxide), which is a by-product of fuel combustion under conditions of extreme heat and pressure, typical of combustion chambers. Once released from the tailpipe, NO is oxidized to NO_2. In conjunction with SO_2, NO_X play a major role in the formation of acids in the atmosphere. NO_X also react with hydrocarbons in the presence of sunlight to produce photochemical smog.
- *Hydrocarbons* (HC). These are produced by the incomplete combustion of fuel and by its evaporation. Their production is strongly influenced by fuel composition. Hydrocarbons include hundreds of organic chemical substances, the most notorious of which are benzene and ethylene. Hydrocarbons combine with NO_X to produce photochemical smog.
- *Carbon monoxide* (CO). Carbon monoxide is one result of incomplete combustion. Diesel engines produce far lower emissions of both CO and HC than do gasoline engines.
- *Sulfur dioxide* (SO_2). The emission rate of SO_2 is directly linked to the sulfur content of the fuel. Diesel engines produce more SO_2 than do gasoline engines. In conjunction with NO_X, SO_2 is involved in the formation of acids in the atmosphere.

- *Particulates.* This diverse group consists of carbon nuclei onto which various compounds are adsorbed. Typical particulates include suspended airborne particles from diesel fuel combustion, materials produced by tire, brake and road wear, and dust.
- *Lead* (Pb). Added to gasoline to raise the octane rate and help lubricate engine components, lead enters the atmosphere as a fine dust which is easily dispersed and settles on any available surface.
- *Aldehydes.* The aldehydes, including formaldehyde, are a major pollutant group associated especially with engines burning alcohol. They are also produced by diesel engines and, to a lesser degree, by gasoline combustion.
- *Secondary pollutants.* Many primary pollutants are transformed into secondary and tertiary pollutants (Figure 9.1) through various chemical reactions linked to meteorological factors, air temperature, humidity, and the topography of the site. One example of this is the reaction of NO_X and HC in the presence of sunlight to produce ozone (O_3) which, although beneficial in the stratosphere, is a well-documented nuisance at ground level.

In addition to emissions from vehicle exhaust, dust can also have major impacts on roadside air quality. This is especially true in the case of unpaved roads, which make up a large proportion of roads in less-developed regions.

9.1.2 Movement of pollutants

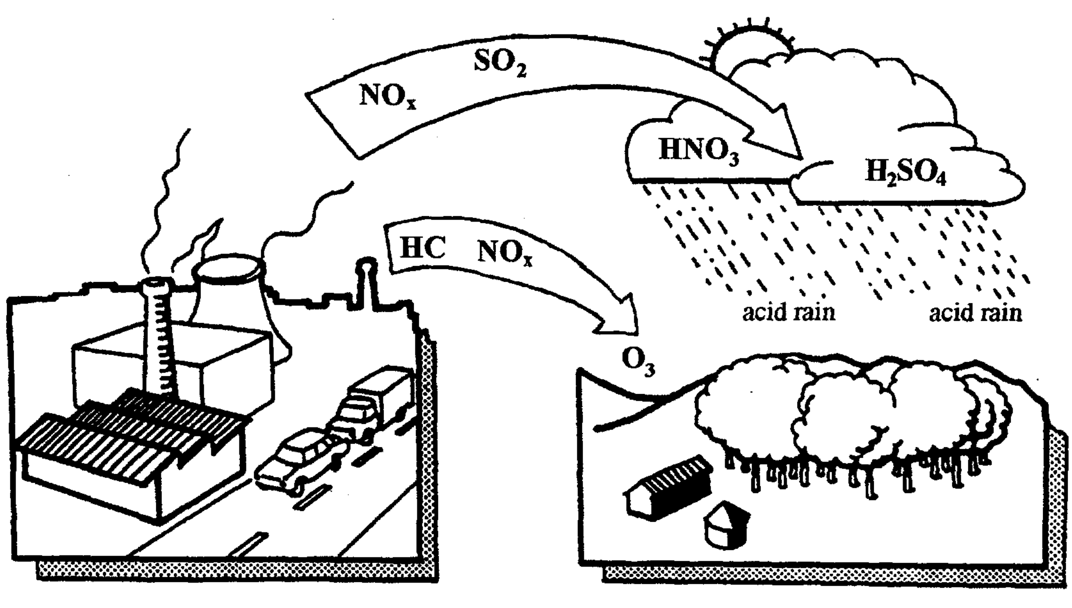
A three-part process describes the mechanism by which the use of motor vehicles affects the lives of humans through the air (see Figure 9.2). The three steps in the process are a) *emission,* b) *dispersion,* and c) *reception.*

Emission

The volume and composition of individual vehicle emissions are determined by the following factors:

- *Fuel composition.* Sulfur content of diesel fuel, as well as lead content and benzene levels in gasoline, has a significant influence on the concentration of those pollutants in the emissions.
- *Level of engine maintenance.* Poorly adjusted timing, dirty and malfunctioning fuel systems, dirty air cleaners, and tampering with pollution control devices are just a few of the maintenance factors which can increase emissions, primarily through incomplete combustion.
- *Vehicle age.* Emissions control technology has improved over the years, and there is a

FIGURE 9.1
SIMPLIFIED DIAGRAM OF INTERACTIONS BETWEEN VARIOUS AIR POLLUTANTS



close relationship between the age of engine and exhaust technology in a vehicle fleet and the total air emissions produced. Fleets with predominantly older vehicles produce much higher levels of emissions than do newer fleets of the same size.

- *Engine temperature.* Cold engines run inefficiently, and catalytic converters on gasoline engines do not function at all until normal operating temperatures are attained.
- *Road geometry.* Engines produce higher emissions while decelerating, accelerating, and climbing grades, so any road features which encourage these actions also encourage higher emissions.
- *Type of vehicle.* Heavy vehicles with large engines emit more pollutants than do lighter, less powerful ones. Diesel engines produce large amounts of SO_X, NO_X, and particulates, while gasoline engines are

FIGURE 9.2
THE EMISSION PROPAGATION PROCESS

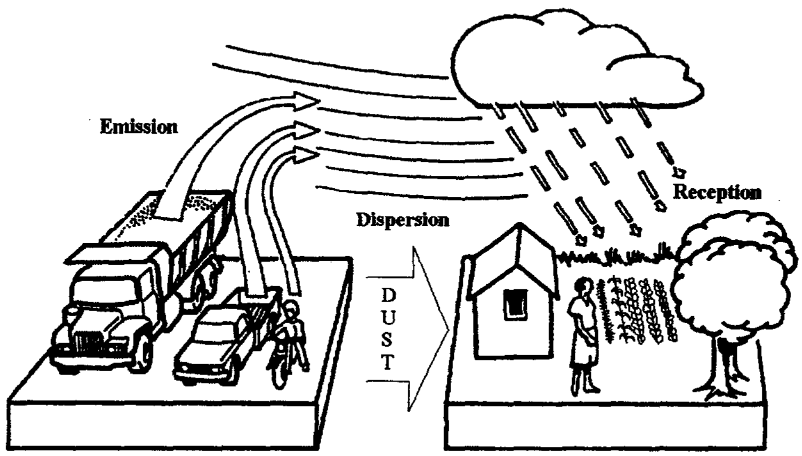
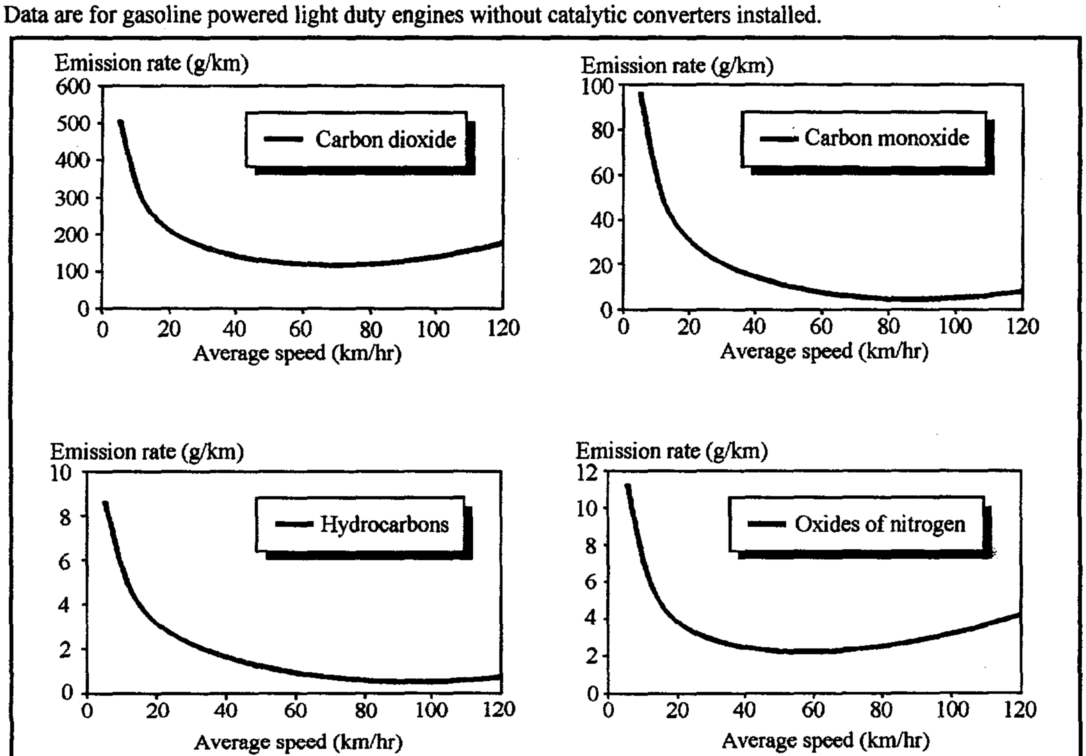


FIGURE 9.3
RELATIONSHIP BETWEEN VEHICLE SPEED AND EMISSIONS

Data are for gasoline powered light duty engines without catalytic converters installed.



Source: United Kingdom Highway Agency, 1993.

larger producers of CO and hydrocarbons.

- *Speed and congestion*. The majority of vehicles operate most efficiently at constant cruising speeds of between 80 and 100 km/hr (see Figure 9.3).

Dispersion

Dispersion of pollutants is dictated by the following factors:

- *Prevailing wind direction*. Concentration of pollutants is greatest downwind of the road. Pollution sources upwind of a road should be considered in an assessment of pollutants for the road site.
- *Weather conditions*. Wind speed, rainfall, humidity and temperature all have an effect on rates of pollutant dispersion.
- *Roadside vegetation*. The height and density of roadside plants determines their ability to filter pollutants from the air.
- *Topography*. Roadside landforms can affect dispersal in any number of ways, from being physical barriers to modifying wind speed and direction.
- *Distance from road*. All other factors being equal, pollutant concentration decreases with increasing distance from the road.

Reception

Pollutants in the airshed of a road are

- intercepted by buildings, monuments, and cultural heritage sites, which are generally stained and dirtied as a result;
- inhaled directly from the air;
- ingested when humans eat food crops grown near busy roads and which have had particulates settle on them;
- ingested when humans touch surfaces in their environment and then make contact with their mouths while eating or playing. Lead commonly finds its way into children's bodies in this way; and
- washed out of the air by falling raindrops and deposited as acid precipitation.

9.1.3 Impacts

Human health

The health impacts of motor vehicle air pollution are difficult to quantify and, hence, difficult to value in economic terms. In many cases, establishment of direct cause-and-effect linkages between localized automotive air pollution and specific illnesses is problematic. However, evidence does strongly suggest that exposure to several of the major emission constituents is responsible for certain health conditions (see Table 17.1, page 167).

Flora

Plants, domesticated and wild alike, are affected both physically and chemically by air pollutants. Dust settles on leaves and can interfere with pollination and photosynthetic function if the accumulation is significant. Acidification of surface water can interfere with nutrient uptake by roots, thus affecting growth. Ethylene, a hydrocarbon, has a detrimental hormonal influence on plant growth, while NO_x, SO_2 and ozone can all cause localized death of leaf tissue (leaf necrosis). Finally, plants can absorb toxic pollutants such as lead from the air, making the consumption of these plants hazardous.

Fauna

Although most of the research efforts concerning pollutants' effects on animals have focused on human health, some faunal health problems have been connected to air pollution. As in humans, the problems are mostly respiratory in nature. Acidification of aquatic ecosystems has definite implications for the health of aquatic species.

Built environment

Objects in use by humans are vulnerable to air pollution on two fronts: staining and corrosion. Particulates are responsible for dirtying all manner of structures, including modern buildings, monuments, and cultural heritage sites. Acid deposition associated with NO_X and SO_2 is especially destructive of limestone, marble, or lime mortar structures. Acidity originating in vehicle emissions is also blamed for deterioration of paints and accelerated corrosion of metals.

9.2 DETERMINING THE NATURE AND SCALE OF IMPACTS

9.2.1 Assessment at the project level

Assessment of the potential air pollution impacts of a proposed road development requires the determination of pollution levels: a) before the proposed development, i.e. for the existing conditions; b) in the future, assuming the project does not go ahead; and c) in the future, assuming the project does go ahead. In all three cases, the assessment relies on the following information, current or projected:

- *Traffic volume.* The key factor in air emissions is the traffic volume (measured as vehicle-kilometers per hour by vehicle type). Often an understanding of traffic peaks and their duration will be required in order to make meaningful projections of emissions levels.
- *Traffic composition.* A percentage breakdown of the number of vehicles by type. Heavy trucks and buses are distinguished from light passenger vehicles, newer vehicles from older ones, and diesel-powered vehicles from those that are gasoline-powered.
- *Speed of traffic.* Average speed of vehicles, with some indication of the consistency of speed (degree of traffic congestion).
- *Dispersion dynamics.* These are described in Section 9.1.1.
- *Vehicle emission levels, by major pollutan.* Useful indicators might be mean annual emissions; hourly concentration peaks, and daily value exceeded once a year.
- *Road surface.* Whether the road is paved or not makes a difference to the amount of dust generated.

Once the current and projected pollution levels have been determined, comparisons can be made with industrial, regional, and national standards for air quality.[2]

9.2.2 Measurement of roadside pollutants

Actual measurement of current emission levels is accomplished at the roadside with the help of exhaust gas analyzers; these measure

- CO by infrared absorption units or ecolyzers;
- hydrocarbons by flame photoionization units;
- NO_X by chemiluminescence; and
- dust and particulate matter by beta gauge (passage through ß-ray), by aspiration (deposit on filter, weighing), and by gravity (deposit on lubricated panel).

9.2.3 Computer modeling of pollutants

Air pollution models can be used at several levels of detail. Some predict emissions based on detailed vehicle parameters and second-by-second speed data (drive cycles) which show the frequency of acceleration, deceleration, braking, and idling. These can be used to evaluate changes in vehicle technology, vehicle maintenance, traffic management, or fuel quality. Other models operate with aggregate traffic statistics and consider the dispersion of pollutants. Examples of this type include Caline 4 and Mobile 5, available from the U.S. Environmental Protection Agency (EPA.). These models determine the air pollution produced by road projects and calculate the propagation (direction and speed, transport and deposit, etc.) of atmospheric pollutants. The data to be entered are traffic statistics (percentage of heavy vehicles), road geometry and topography, general climatology, and the initial concentration of pollutants in the air. Mobile 5 has the added advantage of being able to test air emission mitigation strategies, such as modifying fuel mixtures, fleet servicing, and installation of certain pollution control devices.

9.3 REMEDIAL MEASURES

9.3.1 Prevention

Impacts of motor vehicle air pollution can be prevented by routing traffic away from populated areas and reducing traffic congestion. Bypass roads can keep long-distance traffic out of settlements, preserving the commercial and social integrity of thoroughfares while still allowing access to the highway. As a general rule, avoiding densely populated sites means fewer potential impacts and reduced need for traffic management measures.

---

[2] Air quality standards for several countries are included in Sinha et al., 1989.

9.3.2 Mitigation

Project-specific design improvements to limit motor vehicle air pollution impacts include

- selecting road alignments which avoid passing close to housing, schools, and workplaces;
- providing sufficient capacity to avoid traffic congestion, even with projected increases in traffic flow. Traffic management provisions should ensure that vehicles operate at peak efficiency in populated areas;
- avoiding placement of busy intersections, and tunnel vents and openings near housing, schools or workplaces;
- taking account of prevailing wind direction when siting roads and road features, including refueling stations, near population centers;
- avoiding steep grades and sharp curves which would promote deceleration, acceleration and shifting wherever possible;
- sealing high-use dirt roads, where they pass through populated areas, to control dust; and
- planting tall, leafy, and dense vegetation between roads and human settlements to filter pollutants (Figure 9.4).

National and regional strategic and regulatory measures related to air pollution may form part of an environmental action plan or an air quality strategy for a major city. They can have some influence on the baseline conditions at the project level, and so are relevant to individual projects. Measures could include policies, regulations, charges, and enforcement programs covering

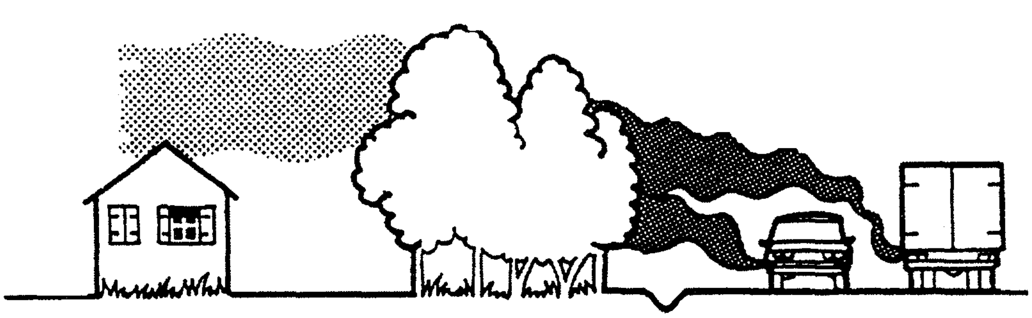
- vehicle emissions standards as well as inspection and maintenance requirements;
- retirement or retrofitting of high-consumption and high-polluting vehicles;
- fuel technology and quality;
- pricing of motor vehicle purchase and use;
- management of demand for motor vehicle travel;
- management of traffic efficiency; and
- investment in better mass transport, such as buses and trains.

9.3.3 Compensation

Where impacts are inevitable, compensation measures are called for. These might include

- provision of local access roads where access to main arteries has been restricted for the purpose of promoting traffic efficiency and safety;
- replacement of land expropriated for bypass roads, interchanges, and route widening;
- provision of replacement market space for roadside vendors for whom access has been restricted in order to facilitate more efficient traffic flow;
- provision of farmland improvements or more economic space for farmers whose crop options have been restricted, or whose soil has been contaminated, by increased traffic volume and consequent emissions;
- supply of funds to be used in additional cleaning and maintenance of buildings and monuments; or
- improvement of local health care facilities which will aid in treatment of pollution-related ailments.

FIGURE 9.4
FILTERING ROLE OF VEGETATION



9.4 MINIMIZING IMPACTS ON AIR QUALITY: AN ACTION CHECKLIST

Road development has tremendous potential for degrading the quality of nearby airsheds if proper planning is not implemented. The more important steps in the EA process, relative to considering and incorporating air quality concerns into road planning and development, are highlighted below.

Establish baseline conditions
Five key steps are recommended:

i) define study area according to the size of the airshed;
ii) determine existing air quality levels;
iii) identify the contributors (and their nature) to air quality degradation;
iv) identify the characteristics of the existing traffic streams; and
v) describe the sensitive VECs and the most applicable indicators of emissions impacts.

Predict future air quality conditions
Predict future air quality conditions for both no-project and project-completion scenarios, considering a number of alternative designs.

Select preferred alignment and design
Select a preferred alignment and design by assessing air emissions for the no-project option in relation to the net emissions (i.e. emissions with mitigative measures factored in) for each proposed alignment and design alternative. Such a process should help to avoid serious impacts to sensitive VECs and should preclude the need for elaborate and costly mitigative and compensatory measures, while still retaining a project that fully addresses the original need.

Define mitigative measures
Define air quality mitigative measures for inclusion in the EMP (see Chapter 4) if the project requires a full EA, or as part of a mitigation plan if the project's impacts are well understood and a good body of knowledge exists on the effectiveness of standard mitigative measures.

Prepare environmental specifications for contractors and operators
Prepare environmental specifications for contractors and operators which incorporate the proposed mitigative measures into the project as distinct tasks linked to a timetable. These clauses should address how environmentally sensitive construction work should be undertaken, and which follow-up measures will be required. A similar format should be used for the operators or proponents, but with a focus on maintenance, enforcement, and reporting to the regulatory agency.

Invoke legislation
Invoke existing laws, regulations and guidelines on vehicle emissions or propose some to fill identified gaps. Legislation and regulations are an important component of an integrated air quality strategy and should, in time, become the principal means used to control air pollution.

9.5 REFERENCES AND BIBLIOGRAPHY

Bellomo, S.J. and S.D. Liff. 1984. *Fundamentals of Air Quality for Highway Planning and Project Development.* Training manual, US Department of Transportation. Washington, DC: Federal Highway Administration

Clapham, W.B., Jr. 1981. *Human Ecosystems.* New York: MacMillan.

Committee of European Ministers of Transport (CEMT). 1990. "Policy on Transport and the Environment" (in French). Paris: OECD.

Economopolous, A.P. 1993. *Assessment of Sources of Air, Water and Land Pollution: A guide to rapid source inventory techniques and their use in formulating environmental control strategies.* Part 1 and 2. Geneva: World Health Organization.

Faiz, A. 1991. "A Look at Atmospheric Pollution Caused by Automobiles," *Roads,* No. 274. Paris: Permanent International Association of Road Congresses (PIARC).

Faiz, A. et al. 1990. *Automobile Air Pollution: Issues and Options for Developing Countries.,* Washington, DC: Infrastructure Department, World Bank

Faiz, A., C.S. Weaver and M.P. Walsh. 1996. *Air Pollution from Motor Vehicles: Standards and Technologies for Controlling Emissions*. Washington, DC: World Bank.

Faiz, A. and J. Carbajo. 1991. *Automotive Air Pollution – An Overview*. Washington, DC: World Bank, Infrastructure Department.

France, Ministry of Equipment. 1991. "Air Pollution Created by Automobile Traffic—Transportation Nuisance" (in French). Les dossiers du CETUR, No. 29. Paris: Urban Transport Study Center (CETUR),

Lee, James A. 1985. *The Environment, Public Health, and Human Ecology: Considerations for Economic Development*. Baltimore: Johns Hopkins University Press, for The World Bank

Maunell, R., P. Callen, K. Bentley, S. McPhail and T. Smith. 1993. "International Workshop on Human Health and Environmental Effects of Motor Vehicle Fuels and their Exhaust Emissions". Proceedings of a Conference 1992. New York, NY: United Nations Environment Program.

Sinha, K., A. Varma, J. Souba and A. Faiz. 1989. *Environmental and Ecological Considerations in Land Transport: A Resource Guide*. World Bank Technical Report INU 41. Washington, DC: World Bank.

Sinha, K. et al. 1991. "Environmental Assessment of Land Transport: Construction and Maintenance." (Draft prepared for World Bank Infrastructure and Urban Development Department).

Spain, Ministry of Public Works. 1985. "Air Pollution" (in Spanish). Madrid: Directorate General of the Environment.

Szwarc, A. and G.M. Branco. 1987. *Automotive Emissions: The Brazilian Control Program*. Brazil: CETESB, Companhia de Tecnologia de Saneamiento Ambiental.

United Kingdom Highway Agency, Road Engineering Division. 1993. *Design Manual for Roads and Bridges, Volume 11: Environmental Assessment*. London, England: UK Highway Agency.

Watkins, L.H. 1991. *Air Pollution from Road Vehicles*. Transport Research Laboratory, State of the Art Review 1. London: HMSO.

10. Impacts on flora and fauna

HOW TO USE THIS CHAPTER IN THE CONTEXT OF EA AND ROAD PLANNING

Stage in road planning (A)	EA activity (B)	Involvement in addition to EA team (C)
	Screening	
	Scoping	Proponent
Concept	Consultation	Key regulatory agency
Pre-feasibility	Determining baseline conditions	Other government agencies
Feasibility	Selection of preferred solution	NGOs
Engineering design	Assessment of alternative designs/methods	Research groups
Construction	Development of environmental management plan	Public/community organizations
Operation & maintenance	Effects and compliance monitoring	Advisory experts
	Evaluation	
	Reporting	

Shaded area = (A) Stages of EA covered in this chapter; (B) focus of this chapter; and (C) primary target readers.

KEY QUESTIONS ADDRESSED:

- ? How are road projects related to global concern for biodiversity?
- ? What are the common ecosystem types and their sensitivity to perturbations?
- ? What are the common direct and indirect impacts affecting these ecosystems?
- ? What methods can be used for ecosystem evaluation in situations where time and data are limited?
- ? How are indicators, VECs, and rapid appraisal applied to EA?
- ? What role can local expertise play in assessing potential impacts on flora and fauna?

10.1 IMPACTS AND SETTING

Previous chapters have examined the relationship between road development and various abiotic components of the environment, such as soil, water, and air. This chapter will look at the effects on some of the biotic inhabitants of the physical environment, namely flora and fauna.

The issue of impacts on flora and fauna is much broader than a concern for individual specimens, and any useful discussion in this area must be considered in the larger context of biodiversity conservation.

Biodiversity refers to the wealth of species and ecosystems in a given area and of genetic information within populations. It is of great importance at global and local levels. Areas of high biodiversity are prized as storehouses of genetic material which form the basis of untold numbers and quantities of foods, drugs, and other useful products. The more species there are, the greater the resource available for adaptation and use by humankind. Species which are pushed to extinction are gone forever; they are never again available for use.

At the ecosystem level, biodiversity provides flexibility for adaptation to changing conditions, such as those induced by human activity. Diverse systems are better able to adapt because their high degree of species redundancy allows for substitutions, thus facilitating the return to a state of equilibrium. Populations which are genetically highly diverse are better able to cope with induced reductions in population size and are therefore not as vulnerable to extinction as are less diverse populations.

Preservation of biodiversity is of global concern, but the causes of loss and their solutions are very often local in scale. Road development continues to be a major player in the overall reduction of biodiversity, and proper planning at the project level can go a long way in limiting the loss, while still serving the transport need.

10.1.1 Direct impacts

Habitat loss

The consumption of land, and the consequent loss of natural habitat, is inherent in road development. Where new roads intersect habitat, the area occupied by the road itself, borrow pits, and quarries is subtracted from the total habitat area available to flora and fauna.

Habitat fragmentation

When a road cuts through an ecosystem, the sum of the two parts created by the cut is less than the value of the initial whole, even when the habitat loss is ignored. Ecosystems are characterized by complex, interdependent relations between component species and their physical environment, and the integrity of the ecosystem relies on the maintenance of those interactions. By slicing through habitat, roads affect an ecosystem's stability and health. Roads tend to fragment an area into weaker ecological sub-units, thus making the whole more vulnerable to invasions and degradation. Nevertheless, roads and natural ecosystems can co-exist if the relationship is built on careful planning.[1]

Corridor restrictions

Most animal species tend to follow established patterns in their daily and seasonal movements. The areas through which they travel on their way to and from feeding, breeding and birthing grounds, and between their seasonal ranges, are known as corridors. When a road intersects or blocks a wildlife corridor, the result is either cessation of use of the corridor because animals are reluctant to cross the road (see Box 10.1), an increase in mortality because of collisions with vehicles, or a delay in migration which may result in the weakening or disappearance of an entire generation of the population. Unfortunately, some animals are attracted to roads for various reasons, including protection from predators, good food supplies, better travel conditions, and so forth. This often leads to accidental death and poaching. On busy roads, the death rate for the local amphibian or other slow-moving animal populations can be as high as one in ten.

Aquatic habitat damage

Road development has perhaps its most serious effects on aquatic ecosystems. Erosion from poorly constructed and rehabilitated sites can lead to downstream siltation, ruining spawning beds for fish. Constriction of flows at water

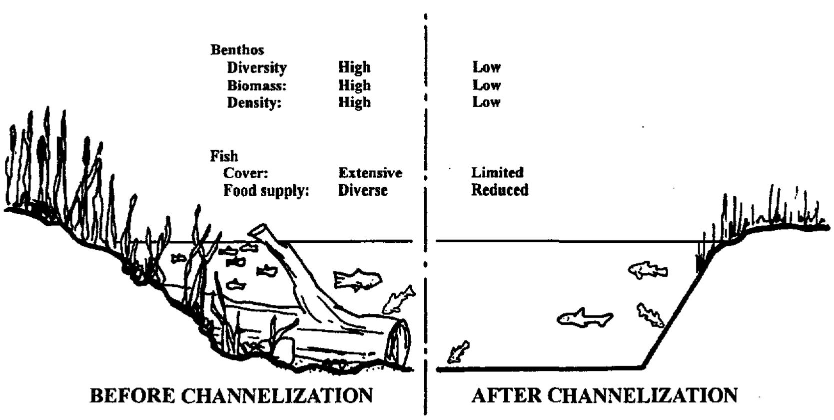
[1] This is demonstrated in the Government of Queensland's (Australia) Manual for Planning Roads in the Wet Tropics.

crossings can make the current too fast for some species. Alterations of flood cycles, tidal flows, and water levels can upset trophic dynamics by affecting the life cycle of plankton, and have corresponding effects on the rest of the food chain.

Rechanneling of waterways is often undertaken as part of road construction to avoid flooding and make crossing structures simpler. In the process, natural streambeds are dug up and useful obstructions, including large boulders, are removed. The same applies to shade trees on the banks. Frequently, the result is a straight, featureless channel, which may be an efficient evacuator of water, but has little in the way of the eddies, shaded areas, sheltering ledges, and turbulence essential to the health and existence of so many aquatic species (see Figure 10.1).

Roads may serve as barriers to movement of some aquatic species, especially where culverts are used. The issue of blockage or restriction of fish migration is extremely important and needs to be assessed for each relevant project. This is critical in areas of the world where streams are dry for part of the year, but during the monsoon season are active fish spawning waters, for example the Tonle Sap Lake watershed in Cambodia.

FIGURE 10.1
EFFECTS OF STREAM RECHANNELIZATION



Source: Simpson et al, 1982

Interruption of biogeochemical cycle
The flow of nutrients and materials is a major determinant in ecosystem structure and function, and road development can easily disrupt it through alteration of flows of surface and groundwater, removal of biomass, and relocation of topsoil. Also, human activity can be a major source of nutrients (sewage, animal dung, and eroded topsoil) which, provided they are allowed to get into the surface water, can raise turbidity and biological oxygen demand (BOD) of the water to the point where certain aquatic species simply cannot survive.

The potential impacts that alteration of the biogeochemical cycle may have on an ecosystem can be very roughly estimated once the nature of the alteration has been established, based on data on soil erodibility, soil fertility, and anticipated human activity, among other things. An understanding of the nutrient regime and energy flow of the affected ecosystem is essential.

10.1.2 Indirect impacts

In many cases, indirect impacts are more damaging than direct ones, and their effects can be felt farther, sometimes several dozen kilometers, from the road (see also Section 6.1.2). Where the road provides access to areas which were previously relatively untouched by human activities, the environmental assessment should take account of these frequently far-reaching effects. Some indirect impacts encountered commonly are:

Accessibility
Roads increase contact between humans and the natural environment, which in most cases leads to ecosystem modification. Penetration of previously unmodified areas makes them available for a host of human activities of varying effect, from recreation, forest and mineral exploitation to colonization and urbanization. Upgrading of existing roads generally facilitates an increase in the number of people having access and is accompanied by an increase in the likelihood of impacts. A classic example of the accessibility impact is the widespread land degradation occurring in Brazilian Amazonia, which has been

induced in large part by road-building initiatives (see also Box 10.1).

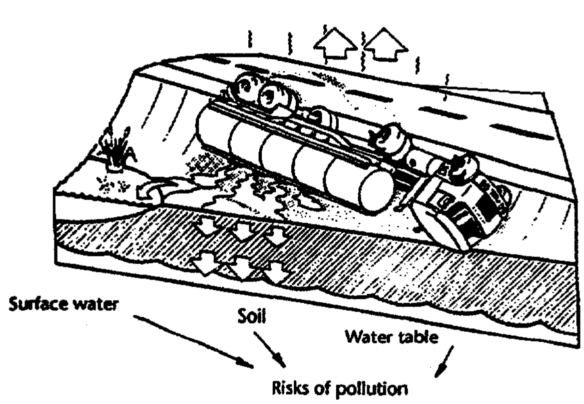
Ecological disequilibrium
The importation of new plant and animal species along the right-of-way can upset the dynamic balance which exists in ecosystems. Native species face competition for resources from new arrivals, and predator-prey relationships can be altered, often to the detriment of the native species. Non-native species can gain a competitive advantage because of a lack of natural controls and become dominant. The result is usually a simplified ecosystem which is more vulnerable to further impacts.

In some cases, road development may actually alter the ecological equilibrium in a positive way by providing for the creation of new ecotones, which tend to be relatively biodiverse. This will only apply if the total area of the existing system is relatively large compared to the newly created ecotone. Also, the potentially positive effect will often be negated by the impacts discussed above.

Contamination of the biota
The presence of motor vehicles introduces the potential for contamination of the soil, air, and water adjacent to the road (see Figure 10.2), and in the case of surface water, well beyond the immediate surroundings. Chronic contamination can become a serious problem for animal species, especially those at the top of the food chain, because of bioaccumulation of pollutants.

Water contamination risks are discussed in Chapter 8, air pollution in Chapter 9, and soil contamination in Chapter 7. Contamination issues associated with the operation and maintenance of roads are dealt with in Chapter 18.

FIGURE 10.2
RISK OF CONTAMINATION FROM ACCIDENTS



BOX 10.1
ACCESSIBILITY AND HABITAT FRAGMENTATION: A CASE STUDY

Mount Leuser National Park on Sumatra, Indonesia, has experienced serious encroachment and deforestation problems as a result of improved road access. The Kutacane to Blangkejeren road, which crosses the park, underwent improvements in the late 1970s, and the greater ease of access which resulted has attracted many new settlers, especially to the areas along the northern section of the road. Subsistence agriculture and illegal logging are producing a widening strip of deforested land along the road corridor. The road has become a barrier to many species of wildlife, and what was once one park is now essentially two.

Source: Republic of Indonesia, 1992.

Fires
Increases in human activity are often associated with more frequent incidents of fires, which can obviously have sudden, severe, and wide-ranging impacts.

Transmission of disease
Roads are effective vectors for the spread of diseases, which can have marked impacts on populations of plant and animal species. Carriers of diseases, both floral and faunal, can gain easy access to wilderness areas along new road corridors. Transportation of livestock and plant products, such as firewood, animal feed, and fruit, may also aid in spreading disease.

10.1.3 Ecosystem types and sensitivity

The biophysical environment is made up of a myriad of ecosystems of different types. Different ecosystem types experience impacts in different ways and display variable levels of resilience in the face of change, depending on factors such as biodiversity, climate, soil type, the similarity of adjacent ecosystems, and size. Some of the major ecosystem types are described briefly below:

Forest ecosystems are highly variable. The variability is determined mostly by climate and altitude. Tropical rain forests, at one end of the spectrum, are extremely biodiverse and productive, and are characterized by intense nutrient cycling. Boreal forests, at the other end, are subject to long winters, have relatively few species, and are neither especially dynamic nor particularly productive. The boreal forests exhibit slow nutrient cycling and represent massive stores of carbon. Deforestation is a frequent consequence of road development, and poses a threat to forest ecosystems worldwide.

Aquatic ecosystems, such as swamps, ponds, marshes, lakes, rivers, and streams, are habitats for important food sources and are characterized by a great wealth of flora and fauna, and high productivity. In general, these ecosystems are important because of their role in regulating the flow in waterways, in filtering water, and in serving as habitats for migratory birds and fish. These environments have regressed sharply over the last few decades and now merit significant protective measures.

Island ecosystems, depending on their size and distance from the mainland, tend not to be especially biodiverse,[2] and generally have a high incidence of endemic species. Interaction between island ecosystems and other terrestrial systems is very limited, or even non-existent, because of the expanse of open water between them. Forces tending to encourage species extinction have greater influence than do those encouraging colonization. The result is that the number of species is usually lower than it would be for a terrestrial ecosystem of the same area on a continental landmass. Island ecosystems are particularly vulnerable to changes that reduce habitat area and population size, because these populations have few choices once their habitat is degraded or lost, or their food sources have become extinct. They are also vulnerable to the introduction of non-native species, which normally do not have any local predators, and quickly get out of control.

Mountain and alpine ecosystems, because of their relatively high altitudes and extreme weather conditions, tend not to be especially rich in species (often highly endemic). They are characterized by steep slopes and are therefore prone to erosion when disturbed. Alpine vegetation, in particular, tends to be very fragile, and recovery of damaged areas can take decades.

Desert ecosystems are characterized by extreme temperature fluctuations, low annual rainfall, and high evaporation. As a result, their species diversity tends to be low (also endemic) and vegetation is usually sparse. What rainfall they do receive often comes in brief but very intense episodes; these have tremendous erosive potential, given that the soils are generally sparsely covered and low in organic matter. For climatic reasons, recovery or recolonization of damaged areas tend to be slow.

Coastal and riparian ecosystems are found at the boundaries between aquatic and terrestrial ecosystems. They tend to be dynamic, diverse, and productive. This applies more to wet climates than it does to dry ones. These systems usually exhibit a large number of species because they contain species from both bordering systems. Many species which inhabit these systems are living at the extremes of their ranges and are therefore especially vulnerable to changes in environmental conditions. Coastal ecosystems include mangrove swamps, salt marshes, dunes, beaches, and nearshore islands, while riparian zones are found at the intersection of terrestrial and freshwater systems such as swamps, rivers, lakes, and estuaries. Coastal and riparian ecosystems are important habitat areas for migrating waterfowl. Unfortunately, these systems are also preferred human settlement areas and are being lost rapidly to development.

Savannah ecosystems occur at a variety of latitudes and are characterized by semi-arid climatic conditions. Their vegetation consists mainly of widely spaced drought-resistant tree species, interspersed with herbaceous plants. Seasonal fluctuations in rainfall are very great, and erosion of disturbed soil can be a serious threat during the wet season.

[2] Exceptions would be the larger Indonesian islands, Sri Lanka, Madagascar, and New Zealand.

Grassland ecosystems are dominated by herbaceous species and generally occur in areas experiencing relatively low rainfall, large amounts of sunshine, and plentiful winds. Grasslands are major carbon dioxide processors, and are thus important to global climate regulation. The sod layer operates as a highly effective protector of the soil against the elements, and its removal during road construction introduces an erosion risk.

Cave, limestone, and karst ecosystems often harbor rare species and display a high degree of endemism. Because of their relative inaccessibility, cave ecosystems have not been explored very extensively, and it is thought that they may contain many unknown species; this is especially true of water-filled cave systems. The systems provide habitat for highly specialized species which often have very limited distributions (some species have population sizes of less than one-hundred individuals, and are confined to single caves).[3] In some areas, cave bats are essential pollinators of economically important tree crops, while other species consume enormous quantities of pest insects. Cave ecosystems are particularly vulnerable to interruptions in groundwater flow, which can result from deep road cuts. Karst features are often the sources of limestone for cement production and are therefore constantly being depleted. Each time a karst formation or cave is mined or otherwise disturbed, biodiversity may be permanently reduced.

Tundra ecosystems occur at high latitudes and are characterized by permafrost (permanently frozen ground) and highly adapted, very fragile plant species. Although annual precipitation is low, the frozen subsurface means that surface water tends to accumulate. Road building in tundra areas invites a host of problems related to the melting of the permafrost and sinking of the roadbed. Most roads are only negotiable during the lengthy winters. As with desert ecosystems, climatic extremes make recovery from disturbances very slow.

10.2 DETERMINING THE NATURE AND SCALE OF IMPACTS

Assessment of potential environmental impacts should take into account a) the extent of the proposed road development, b) the duration of the construction period, and c) the characteristics of the local natural environment through which the road will pass. The use of VECs as a starting point can be very useful in focusing this activity (see Section 3.2.3).

10.2.1 Extent of the project

The design specifications for the proposed road project can furnish details as to the width of the road and right-of-way, amount of cutting and filling, number and location of water crossings, type of water crossing structures, and degree of expected groundwater flow disturbance, as well as any expected raising or lowering of surface water levels. Generally, the larger the area affected, the more significant the impact.

10.2.2 Duration of the construction period

Intense, focused construction activities lasting for a short period of time generally have far less effect than those which may be less intense but are spread over long periods. As a general rule, construction periods which do not exceed the annual reproduction cycle of key organisms (a fish species, for example) usually have less impact than projects which stretch over generations.

10.2.3 Evaluation of the affected systems

An evaluation of the ecosystem or ecosystems to be intersected by a road should have two objectives: a) to take stock of the existing organisms in relation to how their function might be changed by a road, and b) to determine the area's sensitivity to the magnitude and types of change that are expected. Whenever possible, these evaluations should be completed in the context of the local watershed or drainage basin in which the project is to be located.

[3] See Culver, 1986.

Characterization
The descriptive component of the evaluation should comprise[4]

- an inventory of biotic and abiotic resources, as well as their geographic distribution. This can be aided by working with local natural scientists and scientific institutions,[5] and by making use of computer databases and biological inventories that may be available from national and international agencies;
- an estimation of productivity (soil fertility for terrestrial ecosystems, density for aquatic ones);
- a description of species associations, relationships, keystone species, biodiversity, and the food chain;
- a listing of rare or vulnerable species;
- an estimation of ecological significance, which implies importance in the workings of nature on a grander scale—an ecologically significant species, population, or ecosystem may not in itself be rare or extremely sensitive, but its impairment or removal could have effects on other species, populations, or ecosystems; and
- a description of the resource needs of species—biogeochemical cycling and the food chain should be considered.

Sensitivity
Once the extent of the project is known, and the characterization of the affected area's VECs[6] is complete, the sensitivity of the ecosystem to the proposed changes (or, conversely, its resilience) can be evaluated by considering

- environmental variables which are likely to experience changes of a magnitude greater than that of natural variations;
- previous experience with change (evidence of soil erosion, invasion by non-native species, ecosystem simplification); and
- likely effects on species which are instrumental in the formation and maintenance of habitat, offer crucial links in the food chain, are particularly vulnerable (i.e. rare, or dependent on a single resource), whose corridors are intersected by the proposed road, and whose resource use will be affected by the development.

10.2.4 Use of indicator species or groups

Given the variety of plant and animal species present in most ecosystems, as well as the complexity of their relationships, it is almost impossible to evaluate susceptibility to damage from a road development without extensive data gathering. The small species are particularly difficult to itemize. A practical solution is to use indicators.[7] Indicators are physical, chemical, or biological attributes which provide some indication of the health of an ecological system (see Appendix 3). Rather than identify and study every component of an ecosystem or VEC to determine ecosystem function and health quantitatively, the presence, absence, or state of chosen indicators is used to extrapolate a qualitative impression. Indicators fall into four groups:

i) *response indicators*, which provide evidence of the biological condition at the organism, population, community, ecosystem, or landscape level, e.g. biodiversity;
ii) *exposure indicators*, which indicate the presence of a stressor, e.g. algal blooms;
iii) *habitat indicators*, which are used to characterize conditions necessary to support an organism, population, community, or ecosystem; and
iv) *stressor indicators*, which are natural processes, environmental hazards, or management actions that produce changes in exposure and habitat, e.g. water quality.

Proper evaluation of the state of an entire ecosystem relies on the monitoring of indicators from each group. Indicators should also be selected to represent several levels of organization within an ecosystem.

Indicators are of limited use in predicting impacts directly, but can be used to describe

[4] Such detailed information is required only for full EAs. For IEEs, secondary data would be the primary source.
[5] Most freqently this is not the case, and outside technical expertise is needed. In these situations, the work should be turned into a capacity-building activity, with local experts working side-by-side with outside specialists, undertaking studies, preparing field guides, etc.
[6] The VEC concept is effective in focussing the study area more efficiently; the concept is described in Chapters 3 and 4, and should be initiated during the EA scoping stage.

[7] This is a complex topic and users are urged to read other sources such as Knapp et al. (1991), Victor, Kay and Ruitenbeek (1991), and Kelly and Harwell (1990).

conditions as well as show trends and environmental response; they can therefore contribute to baseline studies and monitoring.

10.2.5 Rapid appraisal

Rapid appraisal is a useful tool for assessments in which the complexity of the environment is so great, or the time available so limited, that a full-scale study is not feasible. Rapid appraisal allows a great deal of varied information to be brought together and synthesized in a relatively short period of time. The method blends modern scientific with traditional knowledge instead of relying soley on quantitative research and empirical results.

Beginning with baseline studies, experts in fields such as ecology, geology, and hydrology, as well as traditional users of the local natural environment, who may have extremely valuable first-hand information and knowledge of their surroundings, provide input about species inventory and ecosystem structure, as well as their function and sensitivity. Surveys, interviews, and meetings of varying degrees of formality are common appraisal components. By using VECs, the appraisal can be even more focused.

The wealth of information thus amassed is considered in the context of the road design specifications and the initial impact appraisal is produced. In the final stage, the appraisal is made available for comment from all contributors and adjusted if necessary. The result is a relatively quick and accurate assessment based on multidisciplinary consensus.

10.2.6 Modeling

While ecological systems are not as well understood as those described by the physical sciences, modeling can nevertheless have applications in assessment of potential impacts on them. Modeling of complex ecosystems may involve combining several models from different disciplines. Thus, the impact resulting from the introduction of a pollutant to groundwater on a certain fish species might be assessed using hydrological models to simulate the delivery of the pollutant to the fish, and a biological model to determine the long-term consequences of the resulting mortality on the fish population.

Computers are often used in environmental modeling, and the development of new computer models is ongoing. Some computer modeling applications which may be relevant to the assessment of ecological impacts are discussed in Chapter 8 (hydrological), Chapter 9 (atmospheric), and Chapter 16 (noise).

10.2.7 Useful sources of information

Every assessment should make use of the various documents available, including topographic, pedological (soil), vegetation, and climate maps; scientific and technical studies; research reports; aerial or satellite photographs (Box 10.2); biological inventories and computer databases. This information may be available from research centers, specialized institutions, universities, government departments, and other project offices[8].

Geographic information systems may also be very useful in visualizing the spatial relationships between ecosystems, the distributions of their component species, and a proposed road alignment. They may also have applications in monitoring the effects of road development (Box 10.2).

10.3 REMEDIAL MEASURES

10.3.1 Prevention

When planning new roads or changes in width or alignment, sensitive natural environments should be identified early in the planning process so that alternate routes and designs may be considered. Wherever possible, road developments should be located more than one kilometer away from sensitive areas to avoid severe impacts on flora and fauna. Water crossings should be minimized, and buffer zones of undisturbed vegetation should be left between roads and watercourses. Groundwater recharge areas should be avoided, and major roads should not be constructed through national parks or other protected areas. Advantage should be taken of opportunities to twin new road corridors with previously established transport rights-of-way, such as railway lines.

[8] A few of the many basic sources are: the World Conservation Monitoring Center Web Site and the GEMS database of the World Health Organization.

10.3.2 Mitigation

Re-engineering road cross-section designs

Road cross-section can be modified to reduce the impact on the environment, for example, by using narrower widths, lower vertical alignments, smaller cuts and fills, flatter side slopes, and less clearing of existing vegetation. Narrower rights-of-way and lower vertical alignment may make crossing easier for animals that find roads a physical or psychological barrier. Also, providing longer sight lines for drivers can reduce collisions with animals by allowing more reaction time.

Planting

Planting in road rights-of-way and adjacent areas can help to support local flora and fauna. In some cases, planting may provide additional habitats and migration routes for local animals, while also guarding against erosion. Border plant species may need to be chosen for resistance to wind or fire in some areas. Planting should be done wherever possible with native species, which are likely to require little maintenance and may prove beneficial in maintaining ecosystem integrity.[9] In cases where non-native species are deemed essential, careful monitoring should be planned, to ensure that they do not compete too successfully with native species and spread uncontrollably.

BOX 10.2
MONITORING LONG-TERM CHANGES IN A ROAD'S ENVIRONMENT

In Ethiopia, aerial photographs and satellite images were used to monitor and analyze changes in the environment of a highway between 1980 and 1993. The road under study crossed an area previously untouched by modern development and quite isolated from the outside world. It was anticipated that population and land use changes would begin immediately after construction of the new road, while traffic flows would increase only gradually.

In the study period, the population of the study area increased from 92,000 to 211,000 people, in part for reasons not related to the road. The number and size of smaller villages increased, and major villages doubled in number. Past aerial photographs and more recent Landsat and Spot data were used to establish four situation maps, and the data were stored in a geographic information system (GIS).

A comparison of the land use maps over this period shows the growth of human settlements and land under moderate and intensive cultivation. A large bamboo forest has been cleared, and the remaining forest is threatened. While the area has a high potential for agricultural development, there is a need to take measures to prevent erosion, loss of soil fertility, and further reduction in forest areas.

Source: Asplan Viak, 1994.

In forested areas, especially tropical ones, reducing the width of vegetation clearance in selected areas may allow trees to touch over the roadway, providing a means of crossing for canopy dwellers.

Animal crossings

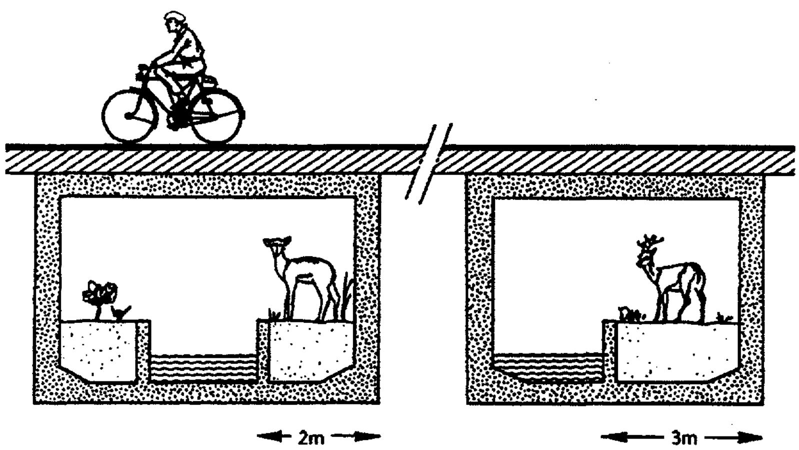
Animal crossings can be used to assist the migration of animals. At important crossing points, animal tunnels or bridges have sometimes been used to reduce collision rates, especially for protected or endangered species. Tunnels are sometimes combined with culverts or other hydraulic structures (Figure 10.3). These measures are expensive and used only at a few locations where they are both justified (by the importance of the animal population and the crossing route) and affordable (relative to the cost of the project and the funds available).

Fencing

Fencing or plant barriers can reduce the risk of collisions between animals and vehicles. In some cases, semi-permeable fencing is used, which excludes species that are more likely to be involved in collisions while letting less problematic species through. Fences may interfere with the migratory patterns of animals, or may simply shift the points where migratory patterns conflict with traffic patterns along the route. Fencing may also, in some cases, interfere in predator-prey relationships, allowing predators to gain significant advantage because prey escape routes are restricted.

[9] Harper-Lore (1996) discusses successful experiences with this approach in the United States.

FIGURE 10.3
WILDLIFE UNDERPASS AND HYDRAULIC STRUCTURE



Water crossings

Aquatic ecosystems are particularly sensitive to road development, and there are a number of ways in which the impacts can be lessened. Standing water can be bridged instead of filled. Stream rechanneling should be avoided as much as possible, but where it must be done, efforts should be made to recreate lost channel diversity. Careful attention should be paid to erosion control techniques near watercourses (see Chapters 7 and 8). Culverted crossings should be designed with the needs of migratory aquatic species in mind. Baffles might be installed to slow the flow enough to allow fish and others to swim against the current, and culvert bottoms should be set below the level of the stream bed. Pre-development streambed gradients should be maintained wherever possible.

Traffic control measures

Reduction of the speed limit may reduce the rate of collisions between vehicles and animals. Some jurisdictions apply lower speed limits, particularly at night and in areas of frequent animal crossings. Signs warning motorists of the presence of animals in places where animal corridors cross the road may also help to reduce collisions. Roadside reflectors may be used to scare animals away from the roadway when vehicles approach at night. Some of these options are compared in Table 10.1.

TABLE 10.1
INDICATIVE COMPARISON OF MITIGATIVE MEASURES FOR PROTECTING FLORA AND FAUNA

Measure	*Effectiveness*	*Compared costs*
Vegetative protection fence	Medium protection, excellent integration into the landscape	Low cost, requires maintenance
Artificial fence	Good protection of animals and drivers, but can inhibit animal movements	Comparable to vegetation fence
Animal overpass	Very effective where warranted	Expensive; same as normal overpass
Animal underpass	Less effective than overpasses for most species, but more common for cost reasons	Same as a culvert
Speed reducing devices	Effective if well enforced	Relatively low cost
Developing of forest borders, planting	Complements the above devices, preferably using local species	Low cost for relatively good results

BOX 10.3
MITIGATIVE MEASURES FOR ROADS WHICH TRAVERSE NATIONAL PARKS

Most national parks are designated as such because of their ecological significance or recreational value, and are set aside for their protection and preservation. **It is always preferable to avoid the construction of a road *for through traffic across a national park or other protected area.*** *In cases where major roads must cross parks* and conflicts between road users and the natural environment are anticipated, various mitigative measures which might not ordinarily be justified may be implemented. These could include

- enactment and enforcement of laws prohibiting hunting, transport of hazardous substances, and removal of plant materials from the park;
- inspection of the contents of vehicles entering the park, in order to discourage importation of potentially hazardous cargoes, such as livestock, when there is reason to believe that disease spread may be an issue; and inspection of vehicles leaving the park, for poached animals and plant materials;
- educational measures aimed at informing the travelling public about the reasons for not feeding wildlife, removing plants, littering, etc., and to instill a general appreciation of the desirability of conservation;
- application of the standard mitigative measures, as discussed in Section 10.3.2, to a greater extent or with greater frequency than in less sensitive situations;
- implementation of traffic control measures such as volume restrictions, lower speed limits (especially at night), and forbidding vehicles to stop while crossing the park;
- provision of rest areas with garbage cans and toilet facilities to discourage indiscriminate stopping along the roadside and littering; and
- use of design features such as deep ditches, narrow shoulders, and barriers to discourage roadside stops and removal of plant materials.

In sensitive areas, such as national parks, additional measures may be needed (Box 10.3).

10.3.3 Compensation

One common compensatory measure is to replace damaged or lost biotopes with others of equal or similar characteristics and ecological significance. Environments damaged by a road project can be restored, and nearby biotopes of the same significance can be protected as parks or reserves. This is only feasible when the affected area is not unique.

Environmental resource 'banking' is a term used to describe the preservation, restoration, enhancement, or even creation of valuable habitat areas to compensate for unavoidable loss of similar resources elsewhere. Reppert (1992) describes the application of this technique to wetland areas in the United States.

10.4 MINIMIZING IMPACTS ON FLORA AND FAUNA: AN ACTION CHECKLIST

The more important steps in the EA process relative to the incorporation of concerns about conserving biodiversity in the road development process are highlighted below.

Collect relevant data
Baseline data should identify areas of ecological interest within the study area. The identification criteria, adapted to the scope of the investigations, will be those commonly used in ecology: biodiversity, rarity and vulnerability of species, wildlife corridors, and so forth.

Make informed alignment choices
Identify potential impacts of road development proposals and carry out a comparative analysis of the various route alternatives in terms of their respective consequences for the natural environment (for details on the analysis of alternatives, see Chapters 3 and 4). Choose routes that avoid sensitive areas and VECs.

Select preferred design
Select the design that interferes the least with wildlife movements and creates the least disturbance to nutrient cycling, especially as related to water movement.

Prepare mitigation plan
Mitigation plans should be suited to the scope of the project, the extent of environmental impacts, and the means available. All measures

proposed should balance cost with effectiveness.

Environmental specifications in contract documents
Environmental specifications for contractors should cover management of work forces (control of poaching and firewood collection), machinery (speed, noise, and traffic), and prevention of erosion and contamination during construction.

Legislation and regulations
Laws pertaining to plant and animal species, protected areas, hunting, fishing, and forestry should be used where available and developed as a more permanent means of impact minimization.

10.5 REFERENCES AND BIBLIOGRAPHY

American Association of State Highway and Transportation Officials. 1976. *A Design Guide for Wildlife Protection and Conservation for Transportation Facilities*. Washington, DC.

Aramburu, P Y. and R. Escribano. 1987. "Ecological Impacts: The Practice of Estimating Impact" (in Spanish). Madrid: Fondacion Conde del Valle de Salazar (ETSIM).

Beanlands, G.E. and P.N. Duinker. 1983. *An Ecological Framework for Environmental Impact Assessment in Canada.* Halifax, Canada: Institute for Resource and Environmental Studies.

Cofiroute. 1990. "Living Together in Sologne." Film. Paris.

Culver, David C. 1986. "Cave Faunas", in *Conservation Biology: The Science of Scarcity and Diversity*, Michael E. Soulé, ed. Summerland, MA: Sinamer Associates, Inc.

Federal Highway Administration. 1986. *Highways and Wetlands: Compensating Wetland Losses.* Washington, DC: US Department of Transportation.

France, Ministry of Infrastructure. 1993. "Road Crossings for Wild Animals" (in French). Bagneux, France: Roads and Highways Technical Studies Department (SETRA).

France, Ministry of Infrastructure. 1987. "Ecological Observations on the Lower Valley of the Doller, Listings and Perspectives" (in French). Mulhouse, France: Roads and Highways Technical Studies Department (SETRA), Eastern Technology Research & Development Center.

France, Ministry of Infrastructure. 1987. "Road Management for Wildlife." Information Note (in French). Bagneux, France: Roads and Highways Technical Studies Department (SETRA).

France, Ministry of Infrastructure. 1986. "Protection of Fauna and Road Traffic" (in French). Bagneux, France: Roads and Highways Technical Studies Department (SETRA).

Gonzales Bernaldez, F. 1981. "Ecology and Landscape" (in Spanish). Madrid: Blume.

GHD Ltd (Guttridge, Haskins & Davey Ltd). 1997. *Roads in Wet Tropics: Planning Design Construction Maintenance and Operation: Best Practice Manual (final draft)*, 4870. Cairns, Queensland Australia: Department of Main Roads.

Harper-Lore, B.L. 1996. "Using Native Plants as Problem-Solvers". *Environmental Management.* 20:6:827-830.

Holdgate, Martin. 1996. "The Ecological Significance of Biodiversity". *Ambio.* 25:6:409-416.

Kelly, John R. and M.A. Harwell. 1991. "Indicators of Ecosystem Recovery". *Environmental Management.* 14(5):527-545

Knapp, C.M. et al. 1991. *The Indicator Development Strategy for the Environmental Monitoring and Assessment Program.* Corvallis, OR: US Environmental Protection Agency.

Kottelat, M. and T. Whitten. 1996. *Freshwater biodiversity in Asia.* Washington, DC: The World Bank.

Krawetz, Natalia. 1991. *Social Impact Assessment; An Introductory Handbook.* Halifax, Canada: EMDI Project Publication, Dalhousie University.

McNeely, J.A. et al. 1990. *Conserving the World's Biological Diversity.* Gland (Switzerland) and Washington, DC: World Bank, World Resources Institute, IUCN, Conservation International, and WWG.

Mahar, D.J. 1989. *Government Policies and Deforestation in Brazil's Amazon Region*. Washington, DC: World Bank.

Misra, P.N. and P.D. Agravals. 1982. *Ecology and Roads in U.P. Hinalays Indian Highways*. New Delhi, India.

New England Research Inc. 1978. *Highways and Ecology: Impact Assessment and Mitigation.* Washington, DC: US Department of Transportation, Federal Highway administration.

Reppert, R. 1992. *Wetlands Mitigation Banking Concepts*. Institute for Water Resources, IWR Report No. 92-WMB-1. Washington, DC: US Army Corps of Engineers.

Republic of Indonesia, Ministry of State for Population and Environment. 1992. *Indonesian Country Study on Biological Diversity*. Jakarta.

Secrett, C. and V.C. Hodges. 1986. *Motorway Madness: Roads and Their Impact on the Natural Environment.* London: Friends of the Earth.

Simpson, et al. 1982. *Manual of Stream Channelization Impacts on Fish and Wildlife.* US Department of Interior.

Urban Wildlife Research Center. 1982. *Wildlife Considerations in Planning and Managing Highway Corridors: User's Manual*. Washington, DC: US Department of Transportation, Federal Highway Administration.

Victor, Peter, J.J. Kay and H.J. Ruitenbeek. 1991. *Indicators of Ecological Sustainable Development.* Canadian Environmental Advisory Council. Ottawa, Canada: Ministry of Supply and Services.

Ward, Janet C. 1990. *Environmental Indicators for State of the Environment Reporting*. Canterbury, New Zealand: Center for Resource Management.

World Bank. 1992. *Guidelines for Monitoring and Evaluation of GEF Biodiversity Projects*. Washington, DC: World Bank.

11. Impacts on communities and their economic activity

HOW TO USE THIS CHAPTER IN THE CONTEXT OF EA AND ROAD PLANNING

Stage in road planning (A)	EA activity (B)	Involvement in addition to EA team (C)
	Screening	
	Scoping	Proponent
Concept	Consultation	Key regulatory agency
Pre-feasibility	Determining baseline conditions	Other government agencies
Feasibility	Selection of preferred solution	NGOs
Engineering design	Assessment of alternative designs/methods	Research groups
Construction	Development of environmental management plan	Public/community organizations
Operation & maintenance	Effects and compliance monitoring	Advisory experts
	Evaluation	
	Reporting	

Shaded area = (A) Stages of EA covered in this chapter; (B) focus of this chapter; and (C) primary target readers.

KEY QUESTIONS ADDRESSED:

? What is it about community life that is so vulnerable to disruption by road projects?

? What are some of the more common manifestations of disrupted community life that arise from poorly planned road projects, and how can they be avoided or minimized?

? What are some of the key features of an approach to the planning of road projects that should ensure that community benefits will outweigh disruptions?

11.1 IMPACTS AND SETTING

Communities owe much of their vitality to the ease with which economic and social interactions take place. Ironically, while roads are central to this continuing interaction, the introduction of a new road, or the widening of an existing road, may well cause disruptions to local interactions which outweigh the benefits. With poor planning, this can be as true of the local road improvement as it is of the new highway. Properly planned, however, both should bring benefits to surrounding communities; for example through lower transport costs, better access to markets, goods, jobs, or services such as health and education. Admittedly, in the case of some major highways and freeways, the benefits may accrue mainly to long-distance travelers and haulage companies and their customers, while benefits to the local community may be minimal. Proper planning calls for recognition that road projects can lead to modifications in the community environment surrounding the road, influencing various aspects of lifestyles, travel patterns, and social as well as economic activities. Recognizing and planning for the management of these impacts is an important aspect of the environmental assessment of roads.

This chapter focuses on the more significant impacts that affect the community as an economic and social entity. Closely related impacts, which may have community-wide effects but tend to acquire their significance from their effects on individuals, are addressed elsewhere in this handbook. Chapter 12 discusses the impacts arising from land acquisition and resettlement, while Chapter 18 addresses impacts associated with construction, rehabilitation, and maintenance work.

11.1.1 The split community

Both new roads and significant widening can split a community. The introduction of faster traffic, access controls, and median barriers generally cuts traditional lines of travel or communication (see Figure 11.1). The alternative routes for local movements are sometimes substantially longer, directly affecting businesses, pedestrians, and users of non-motorized transport. The burden of accommodating the changes is generally greater for the poor.

In rural areas, the normal links between villagers and their farmlands (i.e., their economic space) may be cut by a new road or increased traffic. On the scale of the individual farm, the same phenomenon may disrupt existing farming patterns and connections between fields (see Figure 11.2). The ensuing impact on economic activity could be a loss of agricultural productivity or increased travel costs.

In both urban and rural locations, every effort should be made to facilitate the maintenance of existing patterns of movement and the continued use of existing modes of transportation and communication. Indeed, on those roads which are already difficult to cross, a proposed road improvement has the potential of introducing considerable improvements to community interaction through such simple devices as pedestrian bridges, underpasses,

FIGURE 11.1
CHANGES IN COMMUNITY INTERACTIONS DUE TO WIDENING OR INCREASED USE OF MAJOR ROAD

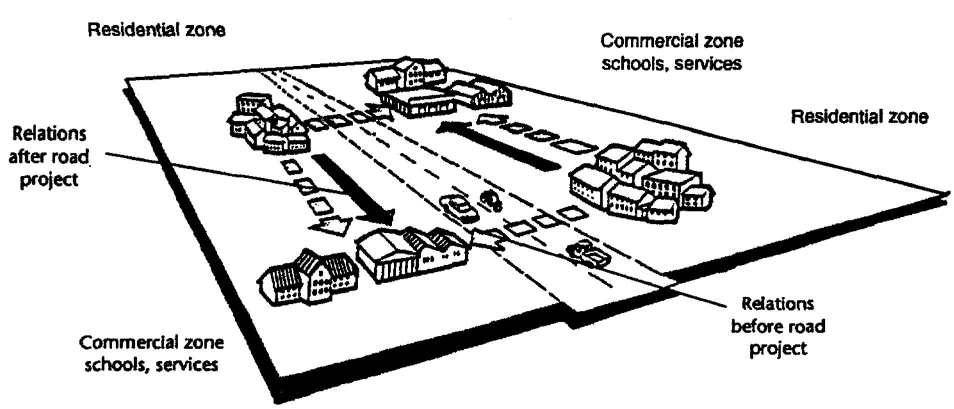
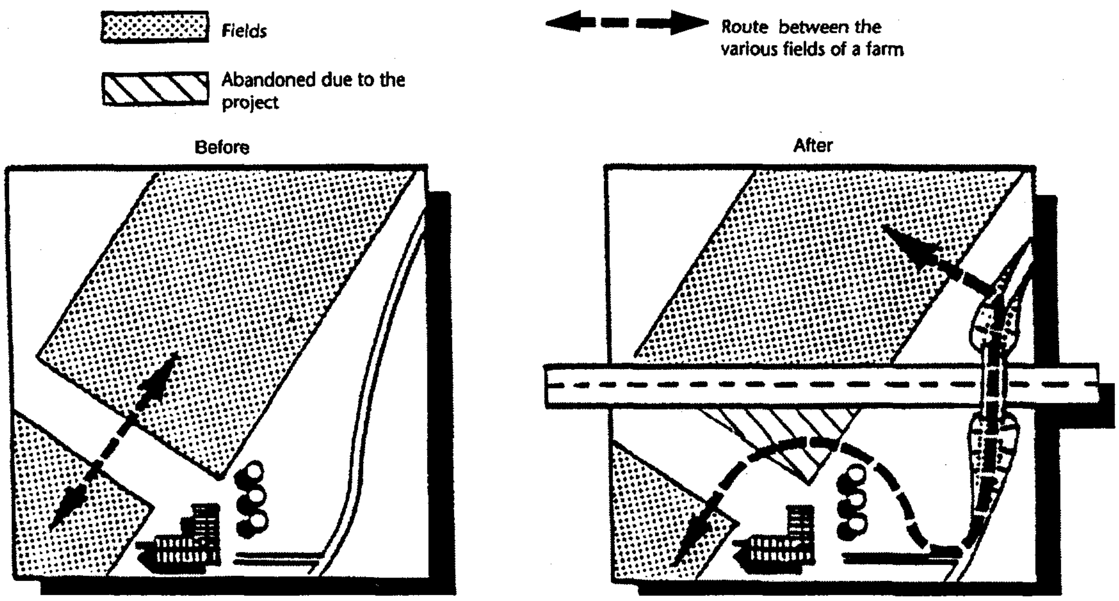


FIGURE 11.2
MODIFICATIONS OF TRAVEL ROUTES DUE TO ROAD CONSTRUCTION



and traffic signals.

11.1.2 The loss of roadside community business and social activity

Permanent occupancy of the open space of a publicly owned right-of-way quite commonly invites encroachment of local community activities onto the roadside, the footpaths, the bus stops, and even the road surface itself. These activities take many forms, including

- the selling of goods, whether from individual kiosks or more expansive markets;
- small businesses such as cafés and vehicle repair shops;
- uncontrolled stops by buses, taxis, and informal public transport;
- unregulated parking, often associated with business activities;
- the production of bricks on the road surface; and
- the growing of crops and the drying of farm produce within the road reserve.

Added to this list of activities are social activities associated with the roadside which are far from illegal. In rural areas, in particular, but also in urban areas and at entrances to towns and villages, the roadside provides a social venue. People congregate along the roads to talk, smoke, drink or watch the traffic go by.

In urban areas, both the business and social activities are often found in built-up areas and near busy intersections, where traffic congestion is already heaviest. As traffic flows increase, conflicts increase between these local activities and the efficiency and safety of traffic functions of the road. Further conflicts and safety concerns arise when road improvement plans call for widening the road and reducing encroachments and accesses. Road planners need to recognize that some of these activities may play an important part in the social and economic life of the community. Economic impacts could include loss of businesses and customers, induced need for capital investment, and high opportunity cost losses. Very understandably, changes which might lead to such impacts may be resisted.

11.1.3 The by-passed community

While by-pass roads can overcome some problems of conflict between road use and community welfare, they may create other problems. On the positive side, by-pass roads reduce the immediate impacts of traffic on the community, and local commercial activities sometimes flourish as a result. On the negative side, communities may fear a loss of business from the diversion of traffic, and some community activities may "migrate" to the new route, potentially changing existing land use patterns and possibly undermining the objective of greater control of access on the new route. Environmental assessments for by-pass routes need to compare the effects of providing the new route with the effects of not providing it, (for instance, by analyzing the effects of increasing traffic on existing roads through built-up areas).

By-passes, like other road projects, can also cause changes in vehicle flow on the secondary network, possibly creating nuisances if traffic should increase at some locations.

11.1.4 The reduced convenience of traditional modes of transport

Traditional modes of transport may be disrupted by changes accompanying a road project. Measures which impede road crossings, control bus stopping points, and restrict parking of informal public transport vehicles near busy markets and intersections may reduce the attractiveness of these modes. The barrier effect of widened or new roads can increase travel time and distances for short local trips, especially affecting access by foot, bicycle, and other non-motorized transport. These potential changes need to be assessed alongside the benefits of improved access and transport services provided by an improved road.

11.1.5 The dilemma for tourism

Tourism can be affected both positively and negatively by road improvements. For example, while improved access may benefit the local tourist industry in the short run, increased activity may damage tourist attractions and lead to a decline in tourists and revenues, if not managed properly.

11.1.6 The "culture shock" effect

The "culture shock" effect can arise when somewhat isolated communities are exposed relatively rapidly to increased communication with the outside world. This is especially relevant to indigenous peoples, as discussed in Chapter 13.

11.1.7 The gentrification effect

Gentrification is a term sometimes applied to situations in which the value of land in a particular area is increased by infra-structural improvements, leading to higher rental values, a turnover in occupancy, and a replacement of lower-income tenants and residents by those who can afford the higher rents. This is a distributional issue, in that, overall, development projects can harm some segments of the community.

All of these factors give rise to justifiable concerns on the part of local communities about the effects of proposed road projects on their lifestyles and welfare. It is always preferable to identify and discuss these concerns at an early stage in the road planning process, so that the magnitude of likely effects can be understood more fully and designs can be modified accordingly.

11.2 DETERMINING THE NATURE AND SCALE OF IMPACTS

In broad terms, the assessment of the potential impacts a road project may have on a community is a two-step process involving:

i) a preliminary assessment; and
ii) a complete social assessment (only if warranted).

11.2.1 The preliminary assessment

The purpose of this is to determine the need for, and the scope of, further investigations. In this sense, it is part of the scoping phase (see Chapters 3 and 4). In essence, it is an examination of the project and the roadside activities.

The initial assessment of project activities

In this assessment, key questions to be asked of the project activities are:

- Do they involve new or modified alignments, road widening or roadside works, substantially increased traffic flows, faster speeds, new traffic patterns, or any other changes which could affect the surrounding social and economic environment and the VECs?

- Will they generate substantial construction traffic or temporary traffic arrangements affecting the interactions within nearby communities?

The initial assessment of existing roadside activities
Here, key questions to be asked of the roadside activities are

- Are there significant social and economic activities within the road corridor?
- What are the main local travel patterns (including walking, cycling, and informal public transport), which may be affected by road changes?

For simple rehabilitation and maintenance projects on roads with little roadside activity, the preliminary assessment may determine that the impacts will be minimal, and no further assessment is required. Where there is a possibility of wider impacts, a complete social assessment is required, as discussed below.

11.2.2 The social assessment[1]

There are three components to the assessment of impacts on community life which warrant attention here

i) the identification of the stakeholders;
ii) the consultation process; and
iii) the social surveys.

Identification of the stakeholders
The intent here is to identify the individuals and groups who should be involved in consultations. Typically, they include

- beneficiaries of the project;
- potential losers, i.e. those at risk of experiencing disadvantages;
- other stakeholders or parties with an interest in the project, such as governments and elected officials, experts, and non-government organizations; and
- others whose local knowledge may assist in identifying potential impacts and assessing the viability of alternatives.

[1] While social assessment is recognized as a distinct activity, it needs to be applied within EA as an integral component.

Urban road space often serves pedestrians and roadside stalls in addition to motorized traffic

Consultation
In Chapter 5, methods of providing information, offering consultation and inviting participation were discussed. These included the holding of public meetings and expert seminars, the use of interview surveys, the organization of neighborhood displays or discussions, on-site consultation, and rapid appraisal techniques. It is often desirable to use several different consultative activities to communicate successfully with the full range of people who have an interest in a project.

Procedures for consultative meetings need to be established through the collaborative effort of both the biophysical and socioeconomic components of the project. The types of information that need to be solicited, and the procedures for making decisions, need to be established. This information can help to focus meetings on issues most relevant to the environmental analysis of a project (see Section 5.1).

Potential pitfalls of community consultation should also be considered carefully. Poorly planned consultations can be dominated by vocal or powerful minorities, they can generate tensions within communities or between interest groups, and they may create uncertainties about project objectives, scope, impacts, or options.

The consultation process may take place on more than one occasion in the development of a project. For larger projects, it is common for initial meetings to provide and solicit information, while later meetings discuss solutions and their implementation, perhaps after more analysis and investigation.

Social surveys
For major projects, extensive interdisciplinary studies may be needed in order to establish baseline data and forecast the likely effects of alternative actions. Depending on the issues identified in preliminary assessment, further study may be required of

- *social factors*; for example: customs, value systems, social classes, hierarchical relationships, and kinship structures; organizations, leadership structures, and decision-making processes; social activities and facilities, such as health, education, and sources of energy;
- *anthropological factors*; for example: the various ethnic groups concerned with the project and their living habits; populations vulnerable to any confrontation with other cultures;
- *economic activities*; for example: their reliance on transport; their potential for growth; and
- *transport factors*; for example: existing roads and communications; travel patterns, including those by foot and non-motorized transport; data on traffic and its daily or seasonal variations.

While maps can be particularly useful for identifying key activities, vulnerable locations, and constraints, the linear nature of road projects unfortunately means that secondary sources of information (such as community surveys) are unlikely to exist. Thus, field surveys are required. This issue is discussed further in Chapter 12.

Rapid appraisal techniques offer a range of methods for obtaining social data with limited resources—and in a shorter time than is usually required for more extensive surveys. These are discussed further in Chapter 5 and in the works referenced at the end of this chapter.

11.3 REMEDIAL MEASURES

11.3.1 Prevention

Disruptions to social and economic interactions that make for community vitality can be avoided if a road project follows a route far from any human settlement or if changes made to existing roads are minimal.

11.3.2 Mitigation

The splitting of a community can be minimized by taking account of local movements at the road design stage and by making provision for improved crossings or alternative access routes. The latter can be achieved through the use of signals, intersections, pedestrian underpasses, overpasses, service roads, and alternate arrangements for local traffic circulation. As discussed in Section 11.3.3 below, the quality of different access arrangements can affect property values and the amount of financial compensation that may be called for.

Minimizing the loss of roadside business activity is best dealt with through on-going collaboration between the road agency and those local agencies responsible for the enforcement of encroachment regulations. The intent should be to ensure that the interests of both the road users and the community are served. In this way, far less disturbance of activities on the publicly owned right-of-way should ensue. Yet, this may require more enforcement personnel than are available.

Where road improvements require removal of some local activities from the right-of-way, a common mitigative measure is to provide alternative space for these activities nearby. The covering of drains or the purchase of additional roadside land, for example, can permit continued operation of roadside stalls, customer parking, or pick-up areas for informal public transport services. An example is shown in Figure 11.3.

The effects of bypassing local businesses can sometimes be mitigated by providing service areas adjacent to the new routes and by encouraging local communities to make use of the new opportunities provided. However, care should be taken to discourage the migration of businesses that are not essential for the passing traveler since such movement can drain the existing roadside community of much of its vitality. In other cases, roads can be designed to encourage long-distance travelers to continue to use local businesses.

Residential and business areas should be identified early in project planning and considered as constraints in the choice of alternative routes, the planning of temporary traffic diversions, and the location of work-site camps.

11.3.3 Compensation

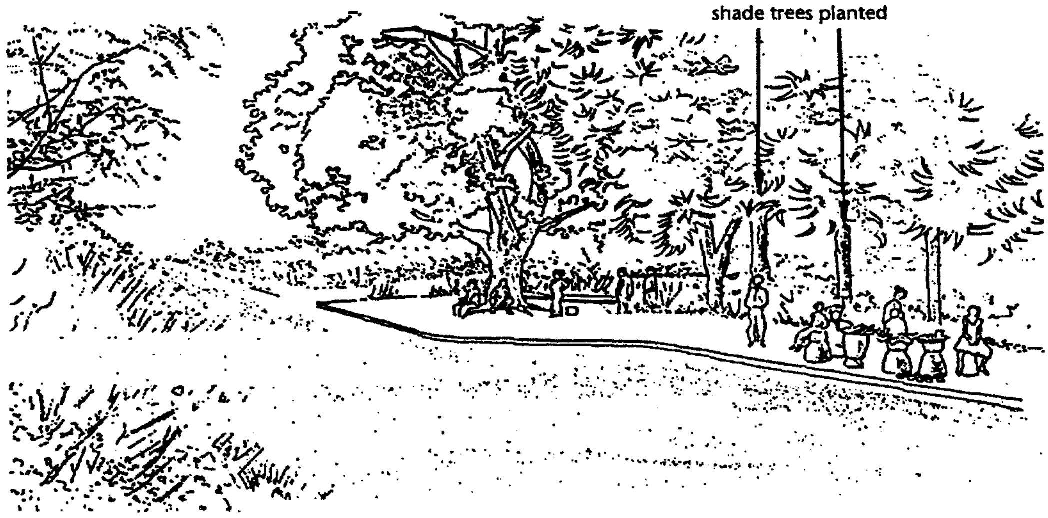
Resettlement and compensation may need to be considered for those whose housing, land, welfare or livelihood is directly affected by a project. This is discussed further in the following chapter on land acquisition and resettlement.

Compensation may also be provided through the restructuring of property layout and access arrangements disturbed by road construction.

More comprehensive compensation for loss of community amenity can often be provided through small landscaping and roadside improvement measures which take advantage of the changes in road layout and operation to provide alternative spaces and facilities. Service roads, roadside markets, and bus parks are examples of facilities frequently included in road projects in order to provide for commercial or social activities that are important to community life.

FIGURE 11.3
CREATION OF REST AREA: IMPROVED FACILITIES FOR ROADSIDE ACTIVITIES

Present: Allowing vehicle to stop on the road is incompatible with the traffic speeds expected of the new road



Future: Providing roadside market area and parking—and preserving the traditional "conference tree"—protects local community activities and incomes and improves safety

11.4 MINIMIZING IMPACTS ON COMMUNITIES AND THEIR ECONOMIC ACTIVITY: AN ACTION CHECKLIST

Road projects should be planned to maintain the social and economic interactions that are vital to community life. This section highlights the more important steps in the EA process relative to the incorporation of this principle into the social development process.

Baseline data and potential environmental impacts

Basic information on the nature of the project and roadside activity will indicate whether potential impacts are significant (see Section 11.2.1). Where a complete social assessment is required, quantitative data may cover land use, demographics, economic activities, traffic counts, and travel patterns (see Section 11.2.2). These may be supplemented with sociological data on community cultures, organization, and social activities. Many details of the current situation can only be obtained through community consultation; this involves surveys, questionnaires, and meetings. The impact assessment may include maps of constraints, sensitivity to changes, and forecasts of changes to baseline conditions, with and without the project.

Analysis of alternatives

Information on each alternative should include socioeconomic as well as biophysical environmental impacts, including possible secondary effects on lifestyles, travel patterns, and land use. Where community impacts are significant, the final choice of alternatives may depend not only on technical criteria, but also on the priorities and perceptions of those affected. Thus consultation is crucial.

Mitigation plan

Many options are available to mitigate the effects of road development on the surrounding communities (see Section 11.3). Technical, financial, and institutional aspects should be considered to ensure that chosen measures are feasible, effective, and sustainable in the particular social environment.

Environmental specifications for contractors

The main requirement relevant to this section is to ensure that work camps, temporary works, and the lifestyles of construction workers do not have any negative impacts on the social and economic welfare of nearby communities.

Legislation

Legislation on property rights, expropriation procedures, and compensation requirements should be considered; this should also involve public participation and include appeal processes.

11.5 REFERENCES AND BIBLIOGRAPHY

Burdge, R.J. and R.A. Robertson. 1990. "Social Impact Assessment and the Public Evaluation Process." *Environmental Impact Assessment Review*, 10. New York.

Cernea, M.M. 1988. *Involuntary Displacement and Resettlement of Populations by Development Projects*. Washington, DC: World Bank.

France, Ministry of Transport. 1982. "Agriculture in Road Projects—Technical Guidelines, Documents and Maps." (in French). Bagneux, France: Roads and Highways Technical Studies Department (SETRA).

Inter-American Development Bank. 1990. *Strategies and Procedures on Sociocultural Issues as Related to the Environment*. Washington, DC: IADB.

Kumar, K., ed. 1993. *Rapid Appraisal Methods*. World Bank Regional and Sectoral Studies. Washington, DC: World Bank

Spain, Ministry of Public Works. 1988. "Agriculture and Environment" (in Spanish). Madrid: Directorate General of the Environment.

Spain, Ministry of Public Works. 1988. *Contaminacion agraria difusa*. Madrid: Directorate General of the Environment.

World Bank. 1991. *Environmental Assessment Sourcebook*. Environment Department. Washington, DC: World Bank.

12. Impacts arising from land acquisition and resettlement

HOW TO USE THIS CHAPTER IN THE CONTEXT OF EA AND ROAD PLANNING

Stage in road planning (A)	EA activity (B)	Involvement in addition to EA team (C)
	Screening	
	Scoping	Proponent
Concept	Consultation	Key regulatory agency
Pre-feasibility	Determining baseline conditions	Other government agencies
Feasibility	Selection of preferred solution	NGOs
Engineering design	Assessment of alternative designs/methods	Research groups
Construction	*Development of environmental management plan*	*Public/community organizations*
Operation & maintenance	Effects and compliance monitoring	Advisory experts
	Evaluation	
	Reporting	

Shaded area = (A) Stages of EA covered in this chapter; (B) focus of this chapter; and (C) primary target readers.

KEY QUESTIONS ADDRESSED:

? What is the measure of a government's success in minimizing adverse social, psychological and economic impacts arising from land acquisition and resettlement?

? Who is affected by land acquisition and resettlement, and how?

? What are the major difficulties facing road planners in ensuring minimal disruption to the lives of persons affected by road projects, and how can they be overcome?

? What is the approach to be taken to squatters occupying the government-owned right-of-way and privately owned lands that are to be expropriated?

12.1 IMPACTS AND SETTING

Road development often requires the procurement of privately owned land. This land has to be acquired by the government from its current owners. While it is sometimes possible to negotiate a price for voluntary sale of a property, governments often have to use their rights to compulsory acquisition (expropriation) of properties for public projects. By its nature, expropriation causes economic loss, and social and psychological disruption for the affected individuals and their families. Naturally, the greater the number of people involved, the greater the disruption and loss.

A government's right to expropriate carries with it a responsibility to ensure that those affected do not bear an unfair share of the costs of a project which will bring benefits to others. In the simplest terms, this responsibility should be to ensure that the standard of living of all affected persons is restored to the level enjoyed before the commencement of the road project. To the extent that a government is successful in restoring those living standards for all affected, the adverse impacts will have been minimized and possibly obviated. The mitigation plan often involves resettlement. Depending on how well the resettlement is planned, it may go a long way in compensating for the loss and disruption, or it may exacerbate the suffering.

The economic impacts of expropriation may include the loss of houses or businesses, or the loss of business income, either temporary or permanent. These can be estimated and costed. However, the actual valuation of these losses often proves to be a difficult and protracted process (see Chapter 19).

The social and psychological impacts and associated costs are more complex, and they are often much more devastating. Neighborhoods can be disrupted and, in the worst instances, broken up completely by large construction projects. People who meet on a daily basis and who constantly do each other small but important favors may be left deprived when separated by physical barriers or long travel distances. There are also social and psychological costs associated with disruptions to businesses. Business people may find their established clientele cut off from their shops or experience changes in business practices they neither anticipate nor like. These kinds of social and economic changes often find personal expression in a variety of physical or psychological disorders.

The manifestation of these impacts is heavily influenced by the linear nature of road projects and, in the case of road upgradings, by the existence of what may be a sizeable, but often well-established, right-of-way. Typically, road projects

- cut across communities (as opposed to affecting the entire community equally);
- run through many governmental jurisdictions; and
- in the case of upgrading projects, tend to displace a disproportionately large number of squatters who have occupied the government-owned right-of-way.

In reality, many road projects consist of some stretches of new highway along with the upgrading of link roads to nearby communities. It is important that such projects be conceived of and planned holistically. If they are not, there is a danger that many people occupying the link roads, for example, may be subjected quite abruptly to a major increase in traffic generated by the new highway to which the link roads connect.

The presence of squatters on the right-of-way poses particular challenges. There are many reasons why the poor, the homeless, those pursuing informal economic activities, and small-scale farmers encroach upon the publicly owned right-of-way and, in many cases, the existing road surface. More often than not, road projects tend to displace these persons whose very presence signifies their need for special attention. National legislation, which determines the categories of land ownership, often recognizes only formal, registered title. However, in many countries there are various forms of informal or unregistered title, including usufruct rights (permanent or temporary use), seasonal use rights, rights of access to commons, and others. In short, lack of legal tenure of land or assets should not be regarded as a criterion for withholding financial compensation or assistance in relocation. However, it is important to distinguish those who were living in the project area prior to project approval from those who have invaded the area simply to benefit from the relocation.

The above-mentioned scenario implies that the teams conducting the assessments and implementing the land acquisition and resettlement programs will have to invest considerable time and effort in

- inter-jurisdictional coordination of studies and mitigation activities;
- establishment and management of field surveys to obtain data (which are not available from censuses or secondary sources) on the strips of affected lands and their all-too-often unregistered occupants;
- prevention of invasions onto the right-of-way; and
- land availability and land use restrictions in the "host" community.

Keeping in mind these broader considerations pertaining to the impacts arising from land acquisition and resettlement, as well as the setting within which they are carried out, the implications for determining the nature and scale of the potential impacts must now be examined.

12.2 DETERMINING THE NATURE AND SCALE OF IMPACTS

In the preliminary planning of a road project, the approximate number of properties, houses, businesses, and roadside activities likely to be affected by land acquisition should be identified for each option under consideration. In addition, it is necessary to identify the number of squatters, their kiosks, and other informal activities affected by road proposals. This provides a first indication of the potential need to investigate land acquisition and resettlement issues more closely.

Where no land acquisition would be required, and where only very minor impacts are likely to be experienced, simple measures to avoid or mitigate these effects should explored.

Where land acquisition or a change of land use is required, a table of project-affected persons should be developed. This table may be somewhat inexact in the early stages of project planning, but the details should become precise as options are defined more clearly and as the land surveys (and ultimately the final design) are completed. At each stage, the table should identify the types of people affected (e.g., as owners, tenants, employees, squatters); the type of impact on land (e.g., farm size reduced, house or shop acquired, access limited); and the type of impact on people (e.g., reduced livelihood, lost house). Table 12.1 provides an example of the categories of project-affected people that could be used. Modifications may be required for specific situations.

Assessing the scale of impacts requires more detailed analysis. For residences, impact assessment requires an inventory of houses affected and the extent of property acquisition from each. It also requires a determination of the type of occupancy for each resident and an indication of length of residence. The potential for local resistance to change often increases in proportion to length of residence. Owners, tenants, and squatters are distinct categories of residents under most national laws. As explained in Section 12.1, however, only the first category—owners—are usually entitled under the law to compensation for expropriated property, even though the latter categories—tenants and squatters—will also have to resettle and may enjoy some rights. It is advisable to plan to compensate or assist all affected persons.

Assessment of impacts on businesses requires a slightly different approach. An estimate of temporary financial loss and of temporary relocation costs, if any, will be required for businesses that will be able to relocate within the immediate area. By contrast, for businesses that will have to move out of the area, or that will suffer a major loss of clientele, it will be necessary to estimate the minimal costs of relocation and re-establishment. Allowance should also be made for technical and financial assistance to modify and adapt businesses to new circumstances. For farmers, economic losses can include the value of crops in the ground and the loss of earnings due to unfamiliarity with the new land (see Chapter 19).

Land acquisition and resettlement actions also have impacts on the remaining residents and businesses, who may be faced with diminished family and community structures and business clientele, and reduced property values.

In addition to site inspection and land surveys, household and business interview surveys are often required to establish the extent of impacts. Because of the lack of secondary

TABLE 12.1
EXAMPLE OF CATEGORIES OF PROJECT-AFFECTED PEOPLE AND PROPOSED ACTIONS

Category of Person by Effect	*Action*
1. Owner: loses house and all land	Replace house and lands in new area
2. Owner: loses house and some land (land left not viable)	Replace house and all lands in new area
3. Owner: loses house and some land (land left is viable)	Replace house, as proprietor wishes; either on remaining land, with compensation for land lost, or on new plot
4. Owner: loses house but no land lost	Replace house either on remaining land or on new plot
5. Landless owner: loses house	Replace house on new plot in original or new area, as proprietor wishes
6. Tenant: loses house	Assist with housing in old or new area, depending upon tenant's wishes
7. Squatter: loses house	Assist with housing in old or new area, depending upon squatter's wishes
8. Owner: loses all land but not house	Either replace lands within a reasonable distance of house, or replace house and lands in new area, as proprietor wishes
9. Owner: loses some land (land left not viable), but not house	As with #8
10. Owner: loses some land (land left is viable), but not house	Compensate for lost lands
11. Owner: loses home-based business income (temporary), but not home	Compensate for lost income
12. Owner: loses home-based business and home	Replace house in original or new area, as proprietor wishes, and compensate for lost income during relocation process
13. Tenant, squatter or street vendor: loses effective use of business site	Provide alternative location with equal or better access, services and business potential
14. All categories: lose neither land nor house	No action
15. Host community/area	Strengthen resource base and social services stressed by influx of resettled people

sources of data, as emphasized in Section 12.1, this type of individual consultation with affected persons and communities should play an important role in identifying potential impacts, possible alternatives, and mitigative measures. This is discussed further in Chapters 5 and 11.

In some informal sectors it is not easy to determine exactly who is affected or what the long-term impacts are likely to be. Many markets and 'squatter businesses', such as roadside kiosks and small workshops, are not formally organized and have few, if any, records of ownership, tenancy, income, or length of occupancy. Tax collectors or unofficial market administrators may have detailed knowledge, which can be supplemented by other forms of local consultation. A related problem is that the benefits of compensatory and mitigative measures may not go to those most affected and in need, especially if alternative facilities are of a higher quality than those lost and thus become attractive to other, more influential, groups in the community. Similarly, the survey team should be looking for signs of recent invaders who may have moved into the area once it has become public that some assistance with improved housing may be available. Community-based organizations and other interested non-governmental agencies can frequently be enlisted to help prevent such invasions.

In some cases, property ownership or development rights are not clearly defined under the law. These should be identified as early as possible, since they can take many years to resolve. Examples of problematic situations include the possible rights of long-term squatters who have established homes and rental arrangements as well as property development rights 'allocated' to individuals or companies without clear legal documentation.

12.2.1 Stresses in the "host" community

While most resettlement planning concentrates on those people who need to be resettled, the community or communities that receive and absorb the resettlers must also be taken into consideration.

In regions where arable land is scarce, or where other basic resources such as fuel wood and water are in short supply, the impacts on the host community from the influx of a new group of "users" can be severe.

EA planners should always investigate the host areas' ability to sustain a resettled population without serious resource depletion. Important factors to consider include

- availability of clean water (in all seasons);
- amount and productivity of agricultural land;
- health services;
- school system;
- sewage disposal and water delivery systems;
- road network; and
- utilities.

Planners should determine which resources will not be able to support the influx of displaced people in a sustainable way. Mitigative measures should then be planned to fill any gaps.

Great care must be taken to avoid resettling people in areas where they will be viewed as trespassers taking up resources in short supply, or in areas which are totally foreign to them. In the former case, the resettlement can become a major source of tension within the community and may end up being the basis for enduring conflict. In the latter case, people who are resettled in unfamiliar environments may have considerable difficulty adjusting, e.g. having to learn new agricultural methods to apply on different soils. Resettlement may condemn these people to lasting poverty.

12.3 REMEDIAL MEASURES

12.3.1 Prevention

Impacts on roadside land users can be avoided by choosing route locations away from built-up areas and by restricting the extent of road works to avoid interference with existing activities. In some cases, the adoption of a reduced-speed design, reduced right-of-way land requirements, or design changes (underground drainage, for instance) can avoid impacts on properties and activities.

It should also be noted that the impacts associated with not acquiring land can also be significant. Many road improvement projects, for example, follow existing alignments and seek to minimize the extent (and cost) of land expropriation. This approach can result in the widening of roads through villages, towns, and major urban centers. In these locations, the existing roads are sometimes so narrow that road widening eliminates sidewalks and pedestrian access—with negative effects on the safety of pedestrians, on informal modes of transport, and on the quality of community life as a whole (see Chapters 11 and 17). As a second example, adoption of a narrow road reserve can substantially limit options for controlling water flows and soil erosion—with potentially negative effects on the environment. In short, serious consideration should also be given to the social and environmental costs of non-displacement of people and business activities.

12.3.2 Mitigation

As with prevention, mitigation of land acquisition impacts is achieved primarily by modifying the route or design of a road to minimize its effects on nearby properties and land uses. The design of alternative access to affected proper-

BOX 12.1
CONSULTATION AND PARTICIPATION IN RESETTLEMENT PLANNING AND IMPLEMENTATION

Local consultation and participation are essential to the success of compensation plans. Family-by-family consultations and, in squatter communities, informal groupings, should often be used in preference to the more formal, larger community meetings in order to ensure satisfactory outcomes. A typical example is the issue of replacement housing provided by a road agency. Dissatisfaction can arise for a variety of reasons, including basic disgruntlement over being moved, discontent over the style of architecture, the construction materials, the number of rooms, or the cost of additional services. Through a process of local consultation and participation, it may be agreed that the agency will install the basic public infrastructure (electricity, water supply, for example) and provide either a choice of house types or a house frame. In this latter approach, the agency allows the resettlers to salvage as much of their former houses as possible, supplies other needed construction materials, and provides funds to enable the prospective resettlers to complete the houses. The agency will have to complete the home for those resettlers who are unable, for whatever reason, to finish the house themselves.

ties and the management of temporary works and traffic diversion can also reduce the magnitude of impacts on property and welfare.

Consultation with affected people and other interested parties (Box 12.1) can assist planners in mitigating the impacts of land acquisition and resettlement actions by providing clear and timely information as well as opportunities for a complete discussion of options, preferences, and likely outcomes. Thus, by taking full account of the needs of those affected, the design of implementation arrangements should be based on more solid information (see Chapter 5).

In the event that displacement is necessary, or that disruptions to livelihoods will occur, a comprehensive assistance strategy is required. This should go beyond financial compensation to include social and commercial rehabilitation or replacement.

12.3.3 Compensation

Many countries have laws and regulations governing property rights, compensation, and appeal procedures for land expropriation. Road planning should make allowances for the considerable time and money which are commonly involved in these processes.

Rehabilitation is a term often used by environmental specialists to describe the process of reestablishing lifestyles and livelihoods following resettlement, recognizing that this process involves more than just replacing lost property or assets. The term is confusing when applied to road projects, since it is also used by transportation engineers and planners to describe construction works that bring a deteriorated road back to its original condition. "Social and commercial rehabilitation" may prove to be a more precise term. Such rehabilitation may require additional financial, technical, and organizational assistance, which is rarely provided for in legislation or administrative arrangements.

Legislated compensation procedures generally provide only for the owners of property and make no allowances for tenants, employees, or squatters. Additional arrangements must be defined to ensure that these affected groups are not substantially disadvantaged by land use changes, and that they are assisted in relocating and re-establishing their homes and sources of incomes. These additional arrangements are provided in a resettlement and rehabilitation action plan (see Box 12.2)

For landowners, assistance provided under existing legal statutes—in addition to provisions laid out in the environmental management plan—will be sufficient to generate appropriate compensatory action. However, for other persons without legal title to land, such additional assistance will be the major means of compensation and mitigation of losses.

Monetary compensation poses a number of concerns in resettlement and rehabilitation programs. Most notable are the following:

Valuation of assets is usually significantly lower than present market value, especially since book (or tax) value of properties is commonly employed in such valuations. Even present market value can leave people less well off than before (see Chapter 19). If, for example, there are many resettled people seeking scarce land, prices may rise, and resettlers may have to pay more than the previous market rate just to replace their former assets. In anticipation of the problems that may arise, the road planners should acquire a clear understanding of expropriation and valuation procedures, and ensure that negotiation and arbitration procedures are in place and operating effectively.

Property markets do not always exist in a form which allows ready replacement of land and livelihoods. In densely populated areas it may be especially difficult to buy property with an agricultural, housing, or community environment similar to that associated with the property expropriated for road development.

Timing of payments can be critical. When properties are valued, but payment is delayed for several years, the ultimate monetary compensation may not reflect market rates at the time of payment. This consideration is especially important when high inflation characterizes the national economy, and delayed payments may result in depreciated compensation. Thus, inflation should be taken into account.

The manner in which compensation is paid can be significant for the long-term welfare of the recipients. People not used to money—or with insufficient resources to meet current expenses—will typically spend the compensation payment on other articles of consumption, thus becoming vulnerable to landlessness or homelessness. Therefore, in many instances it is useful to pay most of the compensation into a blocked bank account, from which the funds are released when the resettler has identified a new home, business or land, and signed all relevant contracts. A small amount—up to 20 percent of the funds—can be paid in cash to the resettler so that he or she can take care of other domestic needs.

Restoration or replacement of any assets expropriated may be preferable to financial compensation; it may prove to be a better way to replace, in full, the source of the owners' livelihoods. However, these assets must be replaced at the new site before displacement and relocation occur. This may require considerable front-end investment. In urban areas, for example, it may be desirable to incorporate commercial arcades and other similar arrangements offering displaced street vendors access to markets. Continuation of their economic activities would thus be ensured under safe conditions for both customers and vendors.

Wherever possible, restoration or replacement should be provided at a minimum distance from the previous location.

The recovery of the costs of resettlement can sometimes be achieved through the use of toll systems. Since such direct systems are not always available, however, the costs of resettlement may have to be incorporated into the project's budget. There should be no reason why the displaced persons should have to bear the costs of their displacement.[1]

BOX 12.2
THE RESETTLEMENT AND REHABILITATION ACTION PLAN (RAP): CHECKLIST OF TYPICAL CONTENTS

1. Objectives and principles
2. Project description
3. Project benefits
4. Project losses and impacts
5. Linkages with existing laws and guidelines
6. Entitlement framework (title holders; squatters and encroachers; loss of land and assets; loss of income; other impacts)
7. Replacement cost for losses
8. Rehabilitation and income restoration
9. Choices and option
10. Consultation and participation
11. Targeting of vulnerable groups
12. Resolution of grievances
13. Development of resettlement sites
14. Integration with host communities
15. Institutional arrangements
16. Guidelines for implementation

12.4 MINIMIZING IMPACTS OF LAND ACQUISITION AND RESETTLEMENT: AN ACTION CHECKLIST

The specifications for land acquisition and resettlement in road projects are guided by the basic notion that the conditions of life, including income, must be restored at least to those levels that existed before the project was undertaken. These specifications must be written

[1] A well prepared resettlement and rehabilitation action plan addresses all the above considerations and is contained within the overall EMP.

down in a resettlement and rehabilitation action plan (RAP). Box 12.2 provides a checklist of the major points to be covered in an RAP.

This section highlights the more important steps in the EA process relative to the incorporation of this basic notion in the road development process and their formulation in an RAP.

Baseline data and potential environmental impacts
Given the linear nature of road projects and their potential for disrupting people's lives, it is important that

- project-affected persons and properties for both the displaced population and the host area should be identified at the earliest stages of the road planning process;
- impacts should be categorized in terms of the types of land, persons, and activities affected, and whether the effects are temporary or permanent; and
- land surveys—as well as household and business interview surveys—should be used to provide detailed information, especially where initial analyses identify possible effects on land use, social interactions and psychological well-being (see Section 12.2).

Analysis of alternatives
Given the social, psychological and economic costs inherent in any option, it is important that

- each alternative under consideration be fully costed (see Section 12.2 and Chapter 19);
- the valuation of each impact recognize the full costs experienced by those faced with relocation of homes and businesses, as well as those affected in the host community;
- tenants, squatters, and employees be included as well as property owners; and
- consultation be used in the comparison of options, since their impacts will depend on the priorities and perceptions of those affected.

Mitigative and compensatory measures
To ensure the effectiveness of these measures, it is important that

- individual entitlements and other rights, whether legally recognized or not, be catalogued and awarded if considerable impoverishment is to be avoided for many, if not most, of those affected (see Section 12.3.2);
- expropriation and valuation procedures be investigated to determine: a) their basis and accuracy; b) the effectiveness and fairness of any existing negotiation and arbitration procedures; and c) the arrangements for the making of payments (see Section 12.3.3);
- relocation assistance arrangements be reviewed, to determine: a) what assistance people will be afforded in the search for new locations; b) what follow-up support will be provided; and c) what help is available to those who, for whatever reason, fail to reestablish their homes or businesses;
- follow-up remedial procedures be introduced to monitor the effectiveness of compensation, relocation, and assistance programs, and to provide additional assistance to those who have not been sufficiently protected by the initial arrangements. Responsibilities, entitlements, and finances for these remedial procedures need to be clearly defined in the action plan, while taking into account the overlapping responsibilities of different governmental agencies;
- institutional capabilities to carry out the relocation and rehabilitation operation be assessed and, if necessary, strengthened. Road construction agencies rarely have the inhouse capacity to manage resettlement operations. Thus, they look either to other government agencies or to private sector agencies. The goals in this context are to define responsibilities clearly and to establish whether the agency or organization selected has the charter to deal with all the affected parties (small shops and enterprises, for example), the legal right to acquire and transfer land title, and the administrative capacity to carry out the operation required. These measures are generally defined in an EMP.

Environmental specifications for contractors
These should ensure, first of all, that temporary works and traffic management do not disrupt unduly nearby land users, and that remedial measures for resettled persons are implemented in ways that take account of their social and economic concerns (defined in the RAP). Secondly, contractors should participate in the preparation of the host areas (in terms of either constructing or upgrading of infrastructure) to accommodate the increased use.

Legislation
Legislation on the following issues should be considered:

- property rights, expropriation procedures, and compensation requirements; and
- public participation and appeal processes.

12.5 REFERENCES AND BIBLIOGRAPHY

Cernea, M. 1988. *Involuntary Resettlement in Development Projects: Policy Guidelines in World Bank-financed Projects.* World Bank Technical Paper No. 80. Washington DC: World Bank.

Cernea, M.M. and S.E. Guggenheim, eds. 1993. *Anthropological Approaches to Resettlement: Policy, Practice and Theory.* Boulder, CO: Westview Press.

Cernea, M.M. 1993. *The Urban Environment and Population Relocation.* World Bank Discussion Paper 152. Washington, DC: World Bank.

World Bank. 1990. "Involuntary Resettlement." Operational Directive No. 4.30, *The World Bank Operational Manual.* Washington, DC: World Bank.

13. Impacts on indigenous peoples

HOW TO USE THIS CHAPTER IN THE CONTEXT OF EA AND ROAD PLANNING

Stage in road planning (A)	EA activity (B)	Involvement in addition to EA team (C)
	Screening	
	Scoping	Proponent
Concept	Consultation	Key regulatory agency
Pre-feasibility	Determining baseline conditions	Other government agencies
Feasibility	Selection of preferred solution	NGOs
Engineering design	Assessment of alternative designs/methods	Research groups
Construction	Development of environmental management plan	Public/community organizations
Operation & maintenance	Effects and compliance monitoring	Advisory experts
	Evaluation	
	Reporting	

Shaded area = (A) Stages of EA covered in this chapter; (B) focus of this chapter; and (C) primary target readers.

KEY QUESTIONS ADDRESSED:

? How can we account for the fact that the lives of indigenous peoples are profoundly vulnerable to disruption by road projects?

? What are some of the more common negative effects that road projects have on indigenous peoples and how can they be avoided or minimized?

? What are some of the key principles which must be observed when planning and executing a road project to ensure that indigenous peoples continue to lead self-directed lives and continue to earn their livelihood from sustainable sources?

? How can road projects assist indigenous peoples to enjoy the potential opportunities to participate in a process of development that they will control?

13.1 IMPACTS AND SETTING

Roads are very crude instruments of economic and social change. Nowhere is this more evident than in areas inhabited by indigenous peoples. The cultural, social, political, and economic integrity that characterizes indigenous peoples renders their lives extremely vulnerable to disruptions from outside. Whether a road is being planned to cross an area inhabited by indigenous peoples or to open up that same area, it will have a marked effect on their lives.

Road planners have to realize that while a road will create some opportunities, it will more likely thrust indigenous people into an artificially accelerated development stream. This situation will affect social cohesion, produce physiological effects on the individual, and have a negative impact on individual perceptions of self-worth. Road planners, working closely with indigenous community representatives and sociologists, must attempt to enable indigenous people to adapt at a pace and in ways that they can manage and control.

The definition of indigenous peoples has been the subject of much debate over the last several decades. Box 13.1 provides a useful summary of one approach to identifying such people. For purposes of this discussion, the five characteristics proposed by the World Bank serve as a useful backdrop against which to identify potential impacts. They suggest that as a result of a poorly planned road project, indigenous people could suffer the following impacts.

13.1.1 Loss of traditional sense of identity

For many traditional peoples, the land is a sacred, inextricable part of themselves, their lifestyle, and their livelihood. Indeed, the flora and fauna are typically considered beings, which are integral parts of the cosmos. Thus the very definition of self is bound up with the land, and its flora and fauna, in a manner wholly alien to most outside economists, planners, developers, and settlers.

Roads can too easily disrupt this sense of identity. By opening up areas settled by indigenous or traditional peoples to development and settlement by other peoples, road developments initiate a process that involves not just a loss of ecological balance between people and the land but the loss of that people's traditional sense of self-identity.

13.1.2 Loss of livelihoods and violation of traditionally-exercised land rights

New and improved roads bring increased contact with outside peoples, who either occupy the land for farming or exploit other re-

BOX 13.1
CHARACTERISTICS OF INDIGENOUS PEOPLES

In 1991, the World Bank produced Operational Directive 4.20 for the guidance of its staff. It describes Bank policies and processing procedures for projects that affect indigenous peoples. The Bank's policy recognizes the many different ways in which national legislation identifies and defines indigenous peoples and the differing social and economic contexts within which they are found. As the Bank notes, "indigenous people are commonly among the poorest segments of a population. They engage in economic activities that range from shifting agriculture in or near forests to wage labor or even small-scale market-oriented activities." The Bank suggests, therefore, that rather than proposing a formal definition of who these groups are, it is more helpful to recognize five characteristics which can be used to identify indigenous peoples within particular geographical areas. These characteristics, which may be present in varying degrees, are

- a close attachment to ancestral territories and to the natural resources in these areas;
- self-identification and identification by others as members of a distinct cultural group;
- an indigenous language, often different from the national language;
- presence of customary social and political institutions; and
- primarily subsistence-oriented production.

Obviously, project managers must exercise judgment in using these characteristics to identify indigenous peoples and should make use of specialized anthropological and sociological experts throughout the project.

Source: World Bank, 1991.

sources such as minerals, forests, or wildlife. The increased competition for existing resources can put the indigenous peoples at a disadvantage, especially when settlers introduce ecologically inappropriate, and unsustainable, production systems.

Often, indigenous peoples have no recognized land ownership, and they are not compensated for the land that is taken from them. Rather than fight for their rights in an alien national legal system, they may withdraw from the new population centers, thus increasing the population pressures on other, already traditionally occupied lands. In extreme instances, physical conflict can break out between settlers and the indigenous peoples, as the latter try to reclaim their heritage.

In response to the many violations of indigenous peoples' traditional land rights and their rights to participate in development, several international legal conventions, declarations, and other legal instruments have spelled out these rights. Box 13.2 summarizes key points from the International Labor Organization's Convention no. 169.

13.1.3 Health and social problems

The new arrivals, as well as the road construction crews, often bring with them serious health and social problems, including disease, alcohol abuse, and unemployment (see Chapter 17). These problems destabilize traditional lifestyles and can take a heavy toll among relatively isolated indigenous peoples.

Malaria is one example of a disease that is known to have been spread to remote areas through the construction of forest roads. However, ill health can also result from the disruption of traditional cultivation patterns, and hence, traditional sources of nutrition.

13.1.4 Violation of rights to participate in development

The physical and cultural stresses placed upon indigenous peoples by road development can lead to major disruptions to their culture, lifestyles, and welfare. While these pressures are not due to the road alone, the road is generally a major instrument of any externally initiated development project. Road planning must therefore take careful account of the delicate situation of many indigenous peoples in isolated areas. Beyond providing the indigenous peoples with the necessary protection for the continuation of their current mode of development, road planners must also be sensitive to their desire to participate in their further development—at a pace and in a way which they control (see Box 13.2).

BOX 13.2

INDIGENOUS PEOPLES' RIGHTS TO LAND AND TO PARTICIPATION IN DEVELOPMENT

The rights of indigenous peoples to land and to participation in development are emphasized in several international legal instruments, declarations, and conventions. These documents establish basic principles for relating to indigenous peoples, and define minimal standards for the relations between them and nation states. One such convention is *ILO Convention no. 169*. The *Convention concerning Indigenous and Tribal Peoples in Independent Countries* (1989) includes the following relevant articles:

"The peoples concerned shall have the right to decide their own priorities for the process of development as it affects their lives, beliefs, institutions and spiritual well-being and the lands they occupy or otherwise use, and to exercise control, to the extent possible, over their own economic, social and cultural development. In addition, they shall participate in the formulation, implementation and evaluation of plans and programs for national and regional development which may affect them directly." (Article 7, item 1)

"The rights of ownership and possession of the peoples concerned over the lands which they traditionally occupy shall be recognized. In addition, measures shall be taken in appropriate cases to safeguard the right of the peoples concerned to use lands not exclusively occupied by them, but to which they have traditionally had access for their subsistence and traditional activities. Particular attention shall be paid to the situation of nomadic peoples and shifting cultivators in this respect." (Article 14, item 1)

"The rights of these peoples concerned to the natural resources pertaining to their lands shall be specially safeguarded. These rights include the right of these peoples to participate in the use, management and conservation of these resources." (Article 15, item 2)

Source: ILO, 1989.

13.2 DETERMINING THE NATURE AND SCALE OF IMPACTS

The assessment of the potential impact of roads on traditional peoples requires an extraordinary sensitivity to the culture and ways of life of these populations. Thus, although the procedure for the preliminary assessment of an area may be similar to that outlined for a more conventional community in Chapter 11, the undertaking of a complete social assessment is likely to be characterized by the need to observe the following general principles:

- use the language of the indigenous peoples;
- identify and work with their leaders from the outset;
- if "culture brokers" have to be used, take care that they are representing the wider community's interests;
- involve local anthropologists, sociologists and other persons who can inspire the trust of the indigenous peoples' leaders;
- give particular attention to ways of involving women in the assessment and the project's planning; and
- integrate the social and biophysical assessments.

Observing these principles, the social assessment should then be guided by the same general observations made in Chapter 11. In addition, however, there are a number of specific observations warranting mention here.

13.2.1 Identifying the population and the affected area

This involves more than a simple exercise in identifying stakeholders. It is particularly important to

- obtain a reasonably accurate estimate of the population living in the affected area;
- understand the social organization of these peoples, including the size of community groups, the basis for their composition and the extent of their traditional territory; and
- assess their systems of production over the course of the year (e.g. hunting and fishing methods, food gathering patterns, and farming techniques).

13.2.2 Consultation and participation

Prior to conducting consultations, it will be necessary to identify spokespersons for the indigenous peoples. These will usually be their community leaders, but they may also be intermediary organizations or individuals.

The manner in which indigenous peoples are consulted will vary. Sometimes, representatives of the agency can contact the population directly. At other times, it may be preferable to go through intermediaries who are familiar with and are known to the affected population, such as non-government organizations or individuals (especially anthropologists and sociologists) who have worked in the area for an extended period of time. Whoever conducts the consultations, the discussions should be held in the indigenous language, illustrative materials should be provided to facilitate clear and complete comprehension, and sufficient time must be allotted to ensure full and thorough discussion among the population.

13.2.3 The surveys

Given the inter-related nature of the potential impacts identified in Section 13.1, each impact, if realized, would be the product of varying combinations of similar phenomena. In light of this consideration, it is particularly important that the social assessment be informed by assessments of

- the biophysical setting;
- the legislative framework; and
- the enforcement mechanisms and the powers of indigenous organizations.

The biophysical setting

Disturbances to the existing ecological balance are potential impacts which must be considered seriously. Traditional peoples usually exploit the land and its resources in a sophisticated and sustainable manner. The loss of resources and the intrusion of settlers can substantially disturb that delicate balance. As the flora and fauna in a given area form an integral part of the indigenous peoples' traditions and identity, what happens to them will substantially affect the viability of those traditional cultures, as well as the natural environment of the region.

The legislative framework

The social assessment will also call for discussions with central government officials on the nature of the legislative framework that exists to recognize the rights of indigenous peoples and the government's observance of international instruments, such as the International Labor Organization's Convention no. 169 (see Box 13.2). Many countries include specific definitions, clauses, and legal frameworks within their national constitutions, statutes, and relevant legislation. These legal definitions, available from the Ministry of Internal Affairs or its equivalent, determine the status of the indigenous peoples, the nature of their tenure, and the manner and means of dealing with these populations. Land tenure law is a specific consideration. National legislation will determine whether and how indigenous peoples are to be compensated for the loss of some of their ancestral area. This is important information for the impact assessment.

Enforcement mechanisms and the power of indigenous organizations

It is also important to recognize that whatever is legislated may not be enforced effectively. If, as is often the case, there are weaknesses in the enforcement of legislation and, as is nearly always the case, the indigenous peoples have very weak access to national and regional political structures, their human rights and traditional land rights may not be enforced. Thus, these capacities also require careful assessment.

Indigenous people often have their own time-honored regulations relating to resource use and waste management. These may prove to be very useful in shaping enforcement mechanisms to better address road impact management.

13.3 REMEDIAL MEASURES

13.3.1 Prevention

Complete prevention is possible only if all new roads can be routed around indigenous areas. If this is not technically or economically feasible, every effort must be made to ensure that any prospective road does not encroach upon the productive resources, sacred sites, and burial grounds of the indigenous peoples.

Control of access may also be considered, for example, through the establishment of an indigenous reserve with restricted entry. However, care should be taken not to create barriers to wildlife movements.

13.3.2 Mitigation

Where impacts are unavoidable, road agencies should, at the very least, act to protect and preserve the traditional rights of these populations in the formal legal arena of the country. Preferably, they should go further. One way to accomplish this is through the formulation of an indigenous peoples development plan (IPDP) for any project that affects them. The essential characteristics of an IPDP are identified in Box 13.3. They are reflected in the content of this chapter and provide a useful foundation on which to develop any approach to mitigation and compensation.

A key feature of an IPDP is that, beyond the minimization of impacts and compensation for negative effects, it maximizes the potential benefits of development interventions. If this same approach is to guide the formulation of other mitigation plans, it is essential that the participation of the affected indigenous peoples be central to that planning process.

Indigenous peoples are very diverse; some may welcome new roads, while others may oppose them. Local consultation and participation can help road planners understand and incorporate local views and opinions. Only such an approach can ensure that the road follows the most mutually acceptable and least destructive route, and that mitigative measures are realistic and culturally compatible with the needs of the indigenous communities.

Local consultation and participation also provide an opportunity to determine whether traditional groups wish to remain in the area (and whether they have the capacity to coexist with increased development), or to relocate to some other area. In the former case, some restriction of access may be considered, and authorities may wish to employ indigenous peoples as scouts and guards in order to ensure that any incoming population does not overexploit the area. In the latter case, the authorities can assist the group in moving. In both instances, consideration should be given to

BOX 13.3
KEY FEATURES OF AN INDIGENOUS PEOPLES DEVELOPMENT PLAN

Given the vulnerability of indigenous peoples to negative effects of externally-initiated development interventions, the planning and implementation of projects, such as road projects, need to be supported by a plan that addresses the specific needs of the indigenous peoples. In recognition of the need for such a plan, the World Bank has stipulated in its policy on indigenous peoples (Operational Directive No. 4.20, September 1991) that Bank-funded projects should include an indigenous peoples development plan (IPDP). The key features of such a plan, as outlined by the World Bank, provide useful guidance for road agencies planning roads that will have some impact on indigenous peoples (whether or not they are funded by the Bank). Although reference should be made to the Bank's OD4.20 for details, the features of such a plan can be summarized as follows:

Key characteristics of the plan's overall design are that the plan

- reflects full consideration of the options preferred by the indigenous peoples;
- is informed by studies that attempt to anticipate trends likely to develop as a result of the project;
- utilizes simple implementation arrangements, yet recognizes the need for specialized skills for interacting with indigenous peoples;
- reflects consideration of relevant patterns of social organization, religious beliefs, and resource use;
- supports sustainable indigenous production systems;
- minimizes indigenous peoples' dependence on the project and enhances their capacity for local control;
- reflects the need for long lead times throughout the project; and
- builds on any relevant existing programs.

The implementation of the plan is likely to involve activities relating to health and nutrition, productive infrastructure, linguistic and cultural preservation, entitlement to natural resources, and education.

Thus the key elements of the content of the plan should be

- an assessment of the legal framework and the capacity of the indigenous peoples to use the legal system to promote their rights;
- baseline data that convey the key dimensions of the indigenous peoples' way of life;
- arrangements for ensuring long-term land tenure rights;
- a strategy for local participation throughout the project;
- the identification of mitigation activities (e.g. relative to education, health, credit, and legal assistance);
- a preliminary assessment of need and subsequent plan to strengthen the capacity of governmental, non-governmental, and indigenous peoples' institutions to play an effective role in both the project itself, and in the on-going development of the indigenous peoples;
- an implementation schedule;
- plans for monitoring and evaluation; and
- cost estimates and a plan for financing the indigenous peoples development plan.

Adapted from: World Bank, 1991.

helping the indigenous peoples to obtain formal legal title to their territory.

When a road goes through an indigenous area that is also a protected area (indigenous reserve, national park, ecological reserve, or protected forest), the local population can be employed not only in the design but also in the implementation of the management plans. Indeed, depending upon the wishes of the local population, locals can be employed on the construction crews.

Finally, the engineering design of the road can assist in the restriction of access to sensitive areas. Construction of a road with narrow shoulders, large drainage ditches, and no stopping places can substantially discourage through traffic from stopping along the route or from entering and exploiting nearby areas.

13.3.3 Compensation

Monetary compensation will likely mean little to indigenous peoples, and it may not be adequate or credible for governments to offer to protect their culture and livelihood. Replacement of lost land and resources is an important and viable element of the total package, but it is generally difficult in practice to match the quantity and quality of what is lost. This suggests that the total package incorporated in an IPDP or its equivalent has to consist of a number of complementary elements (see Box 13.3). Some of the more important additional elements are the provision of alternative facilities (e.g. dams) and resources (e.g. fishing rights, or assistance with small fish-farming activities), royalties from mining and other development activities, increased medical and education services (although great care is required in the design of assistance schemes which are compatible with, and do not undermine, traditional cultures and lifestyles), and the strengthening of indigenous peoples' institutions.

This last element is particularly important. In some instances, indigenous peoples are considered the equivalent of legal minors and are thus ineligible to hold land or passports. When the formal legal system so disadvantages indigenous peoples, project authorities will have to take exceptional measures to ensure the cultural integrity of those populations and to defend them from encroachment by new settlers.

Thorough consultation, participation, and social analysis can assist in the design, implementation, and monitoring of such measures.

The organization of the monitoring is central to the credibility and success of the development plans over the longer term. Monitoring by representatives of indigenous peoples' own organizations can be an efficient way for the project's management to absorb the perspectives of indigenous beneficiaries. Building up the participation of affected indigenous peoples in the monitoring process should be a primary goal. However, given the tendency for most existing institutions for indigenous peoples to exhibit weaknesses in management, these capacities will generally require strengthening. Thus, in the near term, independent monitoring bodies will be required. The governmental monitoring unit should be staffed by experienced social science professionals, and reporting formats and schedules should be appropriate to the project's needs. Monitoring and evaluation reports should be reviewed by the project's management and funding agency personnel. Evaluation reports should be made available to the public.

13.4 MINIMIZING IMPACTS ON INDIGENOUS PEOPLES: AN ACTION CHECKLIST

Road projects should be planned and developed in ways that protect the way of life of indigenous peoples from negative impacts, as well as providing opportunities for participation in development on terms that indigenous peoples welcome. This section highlights the more important steps in the EA process relative to the incorporation of this principle into the road development process.

Baseline data and potential environmental impacts

Basic information on the presence of indigenous peoples and the nature of the project and roadside activities will help to determine whether potential impacts are significant (see Section 13.2). Where there is any evidence of such effects, a complete social and biophysical assessment is required. Experts and knowledgeable locals can provide basic information on community structure, numbers, lifestyles, and use of resources. The consultation and participation process should then be very carefully organized (see Section 13.2.2), and should take into account the leadership structures in affected communities, as well as possible differences in viewpoint within communities; knowledgeable and trusted intermediaries should be utilized where these are available. Sufficient time must be allowed for thorough discussion and consideration of a broad range of road options and their potential impacts. Summary information may include maps of constraints and sensitivities, and forecasts of changes in baseline conditions with and without various project alternatives.

Analysis of alternatives

Priorities and concerns of the affected communities (see Section 13.2.3) should be considered along with the developmental objectives of the road project. Implementation issues will be important in selecting options and mitigative measures which are culturally acceptable and which can be sustained over the long term.

Mitigation plan
Clear responsibilities need to be assigned for the implementation of mitigative and compensatory measures; sustainable financing must be provided and remedial actions taken where the original measures are found to be not entirely successful; and on-going monitoring (see Section 13.3) is required.

Environmental specifications for contractors
The main requirement here is to ensure that work camps, temporary works, and the lifestyles of construction workers do not have negative impacts on the social and economic welfare of nearby communities. Project workers, for example, should be restrained from hunting, fishing, or otherwise using the local resources that are held in common by the indigenous peoples.

Legislation
Given the generally inadequate recognition of the rights of indigenous peoples to control their own lives and the development of their environment, it should be incumbent upon the management of a road project to ensure that those rights are respected and afforded legal recognition. This recognition should be made effective through the strengthening of indigenous peoples' capacities to exercise their rights (see Sections 13.2.3 and 13.3.3).

13.5 REFERENCES AND BIBLIOGRAPHY

Davis, Shelton, ed. 1993. *Indigenous Views of Land and the Environment.* World Bank Discussion Paper No. 188. Washington, DC: World Bank.

Davis, Shelton and Lars Soeftestad. 1995. *Participation and Indigenous Peoples.* World Bank Environment Department Paper No. 021. Washington, DC: World Bank.

Goodland, Robert. 1982. *Tribal Peoples and Economic Development: Human Ecological Considerations.*

United Nations, International Labor Organization. 1989. *ILO Convention No. 169: The Convention Concerning Indigenous and Tribal Peoples in Independent Countries.* Geneva: ILO.

Uquillas, J.E. and J.C. Rivera, eds. 1993. "Indigenous Peoples and Development in Latin America" (in Spanish). Dissemination Note No. 8. Environment Division, Latin America and the Caribbean Technical Department. Washington, DC: World Bank.

World Bank. 1991. "Indigenous Peoples". Operational Directive No. 4.20, *The World Bank Operational Manual.* Washington, DC: World Bank.

14. Impacts on cultural heritage

HOW TO USE THIS CHAPTER IN THE CONTEXT OF EA AND ROAD PLANNING

Stage in road planning (A)	EA activity (B)	Involvement in addition to EA team (C)
	Screening	
	Scoping	Proponent
Concept	Consultation	Key regulatory agency
Pre-feasibility	Determining baseline conditions	Other government agencies
Feasibility	Selection of preferred solution	NGOs
Engineering design	Assessment of alternative designs/methods	Research groups
Construction	Development of environmental management plan	Public/community organizations
Operation & maintenance	Effects and compliance monitoring	Advisory experts
	Evaluation	
	Reporting	

Shaded area = (A) Stages of EA covered in this chapter; (B) focus of this chapter; and (C) primary target readers.

KEY QUESTIONS ADDRESSED:

- **?** What is it that a society may lose when a road project threatens to damage a part of its cultural heritage?
- **?** How are cultural heritage sites identified?
- **?** How is the significance of threatened cultural heritage assessed?
- **?** How does one provide for the best possible long-term protection of cultural heritage threatened by a road project?

14.1 IMPACTS AND SETTING

The term cultural heritage, also termed cultural property, refers to sites, structures, and remains of archaeological, historical, religious, cultural, or aesthetic value. Cultural heritage, often only partially known and studied, is a particular form of expression of human values which serves to record past achievements and discoveries. Its identification and examination by specialists are helpful in understanding the significance of a site, according to its aesthetic, historic, scientific, and social value, in addition to its amenity value.

The process of assessing the cultural significance of a site is outlined in Box 14.1. For purposes of this discussion, the concept of cultural significance, as expressed through the above-mentioned values, serves as a useful backdrop against which to identify potential impacts. These values suggest that a road project may have the following impacts on cultural heritage:

- damage caused by road construction, related works such as quarries and borrow sites, and unregulated access to cultural heritage sites. Such damage could affect the historic, scientific, social, and amenity values;
- aesthetic impacts on cultural monuments and archaeological sites; and
- positive impacts on the amenity value aris-

BOX 14.1
SIGNIFICANCE ASSESSMENT OF CULTURAL HERITAGE

Cultural significance is a concept used in estimating the value of a site. It includes aesthetic, historic, scientific (research), social or economic value, and the concept of *amenity value*. Sites that are likely to be significant are those that help our understanding of the past, or enrich the present, and that will be of value to future generations.

Significance assessment is the basis for determining any action that will protect cultural sites and is an integral part of a site management plan. It requires in-depth knowledge of art and architectural history, social history, and knowledge of materials. There usually are many management alternatives for any site; thus understanding the site's significance is a prerequisite for deciding on a course of action. Adequate detail is also needed to determine the best or most appropriate method of conserving cultural significance, as different elements require different management strategies.

Cultural significance can be assessed in different ways and with varying scope. The process may be informal and rapid or it may be formal and require a complement of specialized expertise (such as archaeologists, legal specialists, anthropologists, and botanists). It may deal with an individual site or be part of a regional or local overview. The appropriate level of detail will vary according to circumstances.

Aesthetic value. Aesthetic judgment is perhaps the most subjective of the criteria used in determining cultural significance. Although such judgment is shaped by cultural background and taste, the design, level of craftsmanship, and choice of materials also play an important role. It can explain why the general public is attracted to some sites more than others.

Historic value. A site can be a typical or well-preserved example of a culture, group, period of time, or type of human activity, or might be associated with a particular individual. Often the place, rather than exemplifying one phase or aspect of history, is the embodiment of a long sequence of history.

Scientific or research value. This value will depend upon the importance of the data which could be obtained from the site; more specifically, its rarity, quality or representativeness. In addition to information on technological change, sites can provide evidence of changes in climate, the environment, and the animal population. The assessment of scientific or research significance is difficult because often potential rather than present scientific significance is being evaluated.

Social value. This concept embraces the qualities by which a place becomes a focus of spiritual, political, national, or other cultural significance to a majority or minority group. To the local, regional, or national community such sites may be a source of pride, education, or celebration, or a symbol of enduring culture. The qualities causing this preference are very important and in many cases are the strongest argument for conserving the place. For example, the site may be accessible and well known rather than particularly well preserved or scientifically important.

Source: Taboroff, 1994.

ing from improved access to sites recognized for their cultural value; and on the scientific, historic, and social values arising from the addition of interesting sites previously unknown or overlooked; and the updating of the region's heritage.

14.2 DETERMINING THE NATURE AND SCALE OF IMPACTS

14.2.1 Preliminary assessment

In some cases, the initial assessments of project activities, as well as the land likely to be physically or visually disturbed by the road, may bring to light potential historical or archaeological issues. Public consultation or knowledge of prior archaeological or cultural finds in the region may suffice to identify the existence of such issues. But, in many areas, the information base is too limited, and field surveys will be necessary. In such instances, the assessment team will have to draw upon the information sources identified in the next section and conduct surveys sufficient to determine whether a full assessment is required.

14.2.2 Cultural heritage

If the preliminary assessment establishes the likelihood that historical and archaeological sites, relevant to the road route and its surrounding area, are present, then a complete assessment will be required of potential impacts on cultural heritage. For this, the services of an archaeologist or historian are usually necessary.

Four components of a cultural heritage impacts assessment warrant attention here:

i) secondary sources of information;
ii) the survey process;
iii) the establishment of cultural significance and priorities; and
iv) the assessment of the scale and cost of the impacts.

Secondary sources of information
The lack of adequate information on cultural heritage is probably the single greatest obstacle to its effective protection. Thus the following sources should be examined thoroughly:

- inventories of sites, classified according to applicable legislation and comprised of specialized publications from the departments of the culture ministry (or its equivalent); or from universities and research centers; descriptions of ruins and sites; and excavation reports. With respect to the applicable legislation, Box 14.2 provides some useful pointers as to the kinds of legislation that are particularly relevant to cultural sites;
- legislation of the kinds identified in Box 14.2 should also be surveyed to identify any restrictions on certain categories of cultural heritage;
- bibliographic sources, including travelers' accounts;
- maps which may reveal such information as field boundaries that conserve traces of ancient roadways, and other cartographic evidence of cultural heritage;
- toponyms (place names) taken from texts of old maps and drawings, which provide considerable useful information that may identify settlements which are no longer readily visible, (for example a location rich in traces of ashes from fires or homes destroyed by fire might bear the significant toponym of

BOX 14.2
CULTURAL HERITAGE IN INTERNATIONAL AND NATIONAL LAW

Cultural heritage is legally protected in almost every country. The Convention for the Protection of the World Cultural and Natural Heritage of 1972 has become the foundation for national and other legislation since it requires signatories to adopt general policies, establish appropriate organizations and service, and develop legal, scientific, and financial measures for the protection and conservation of cultural and natural heritage. The World Heritage List, sponsored by UNESCO, also encourages protection and to date includes more than 360 cultural sites of exceptional interest and universal value.

At the national or state level, there are generally four kinds of legislation relevant to cultural sites: (i) heritage place protection acts that specifically protect particular places (or places as a class) and specify procedures for their protection; (ii) land management, zoning, or planning acts that provide general protection for sites; (iii) notification or listing acts that allow for the recording of important data on cultural sites; and (iv) acts to conserve natural areas in which cultural features are located. In many countries, religious laws also address cultural heritage and, in some cases, assign ownership or oversight responsibilities to various religious authorities.

Source: Taboroff, 1994.

"black lands"); and

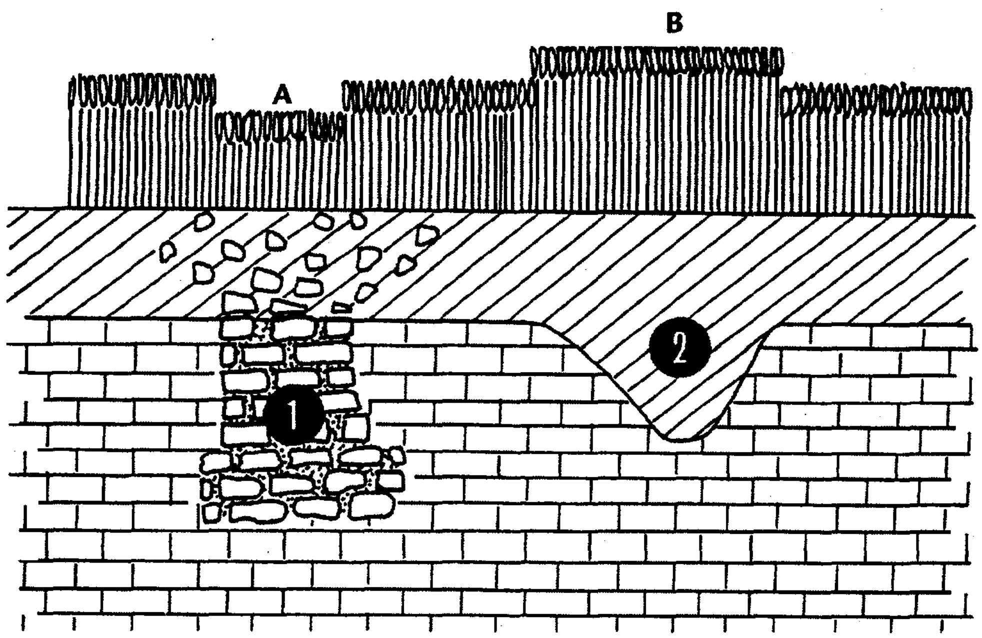
- low altitude aerial photography, which has proven one of the best ways to investigate and detect archaeological ruins (Figure 14.1, Box 14.3).

The survey process

Field surveys for cultural sites generally include the following three steps:

i) carry out a rapid field survey, usually on foot, to identify the pattern of site distribution in the area under examination;
ii) determine the area that includes evidence of remains and the points that present the highest concentration of artifacts; record their location, characteristics, and state of conservation—carrying out sample soundings, if necessary; and

FIGURE 14.1
IDENTIFICATION OF ARCHAEOLOGICAL SITES USING AERIAL PHOTOGRAPHY



The drawing illustrates one phenomenon that can be used in aerial reconnaissance of archeological sites. A buried wall (1) can cause lower humidity prejudicial to the growth of cereals (A). An ancient ditch cutting into the subsoil (2), to the contrary, promotes cereals' growth and makes them greener (B).

BOX 14.3
AERIAL PHOTOGRAPHY FOR ARCHAEOLOGICAL SURVEYS

The discovery of an archaeological site by aerial photography is rarely an accident, but rather the result of a systematic investigation of clues derived from examination of aerial evidence. The following details should be given particular attention:

- *Topographic and vegetation clues:* Their study can reveal anomalies in the structure of the landscape (fossilized ruins; terrain anomalies, such as mounds or tells).
- *Phytological clues:* Anomalies in the growth of crops (Figure 14.1), reflected in differences in height and color, vary according to the nature of the underlying structures (e.g. details of vegetation often corresponding to archaeological structures).
- *Pedological clues:* Anomalies in the surface characteristics of soil are reflected in variations in shading on the photograph. Where building materials are lying just under the surface, this may be revealed by color contrasts with that of the surrounding earth.
- *Hygrometric clues:* Anomalies in soil humidity can be revealed by a color that differs from that of the surrounding superficial layers (e.g. damper soil may lead to a darker color of the soil and that of vegetation).

iii) authenticate and localize the information gathered. For example, identify where the people obtained the stones they used to build their structures.

If the road project is a complex one, involving more than a single road, it may have an effect on the cultural heritage that warrants a more comprehensive regional approach to the impact assessment and to the organization of the management of the heritage features.

The establishment of cultural significance and priorities

There may be several sites of interest that are susceptible to disturbance in any one area. Once the survey information has been gathered, the team can conduct a significance assessment of each site based on an analysis of the remains for their archaeological, historical, scientific, religious, or aesthetic significance (see Box 14.1). At this stage the state of conservation of the remains should also be assessed and recommendations should be made regarding needed protective measures.

Relative to each site, priorities can then be determined, taking into consideration site classification according to legislation, the depth to which archaeological artifacts may be found below the ground surface, and the condition and significance of the site. These priorities might be organized as follows:

- highly important sites and protected sites, to be preserved intact;
- sites of special cultural interest, to be avoided whenever possible; and
- potential sites, requiring surface exploration as well as limited archaeological sounding and recording.

Box 14.4 gives an example of the approach taken for the planning of a road-widening project in the city of Ningbo in China.

The assessment of the scale and cost of the impacts

The assessment of the scale of the impacts will reflect the significance of the heritage, the degree of irreversibility of the anticipated impacts, and the extent of potential damage. Both direct impacts (e.g. destruction) and indirect impacts (e.g. changes to water tables and induced development) should be assessed. Minor as well as major heritage values should be included, since any one value may be subject to several different sources of pressure and thus cumulative impact acquires significance.

BOX 14.4
ROAD WORKS IN HISTORIC URBAN AREAS: CHINA

Under the Zhejiang Multi-Cities Development Project, the World Bank is helping to finance the improvement of urban infrastructure in the city of Ningbo. Due to the rapid growth of the city, the existing road networks are inadequate to carry the present level of traffic. Current growth trends suggest that economic activity and traffic volume will increase in Ningbo. Significantly, the existing roads correspond in large measure to the roads known as early as the 11th century. The original consulting road engineers, when thinking of ways to improve traffic flows, chose to focus efforts on the already established traffic routes. This option, however, involved the widening of roads in the historic core of the city and the destruction of numerous historic structures including temples that are the center of activity for religious communities.

In view of the possible negative impacts of the proposed works on the cultural heritage of Ningbo, specialist architectural conservators were called in to carry out an analysis of the cultural heritage assets. They ranked the buildings and sites adjacent to the proposed road alignment according to architectural and cultural significance, and recommended alterations to the road in order to spare as many of the important structures as possible. The value of a small lake in the center of the city for recreational and visual amenity was also emphasized by the consultants, who urged that the city take steps to conserve the unique character of the lake. They also suggested the creation of conservation areas. In their report they raised the question of creating a ring road rather than routing all traffic through the city.

The suggested road alignments have been adopted by the city. An inventory of cultural property in the project area has been undertaken. In view of the tremendous pace of new building in Ningbo—as in other cities in China—it is urgent to establish zoning and development controls to guide the development of roads and infrastructure while protecting clusters of historic buildings and other areas of interest. Planning for the protection of the cultural resources at an early stage in project identification is the best way to ensure cost-effective and adequate conservation.

The effectiveness of the government in enforcing relevant legislation should also be taken into account, along with the cost of enhancing this effectiveness, if necessary.

Where tourism could be increased to the benefit of the local or national economy, the costs of realizing such benefits should be calculated. Similarly, any anticipated losses in tourism revenues (arising from damage generated by the road project) should be calculated.

14.3 REMEDIAL MEASURES

14.3.1 Prevention

Where possible, road construction should avoid any alignment that cuts through known cultural sites (see Figure 14.2). If an important site is uncovered during road works, possible realignment of the road should be considered.

In some unusual cases it is preferable to leave a cultural site buried beneath the road. This may involve raising the level of the road, as shown in Figure 14.2.

14.3.2 Mitigation

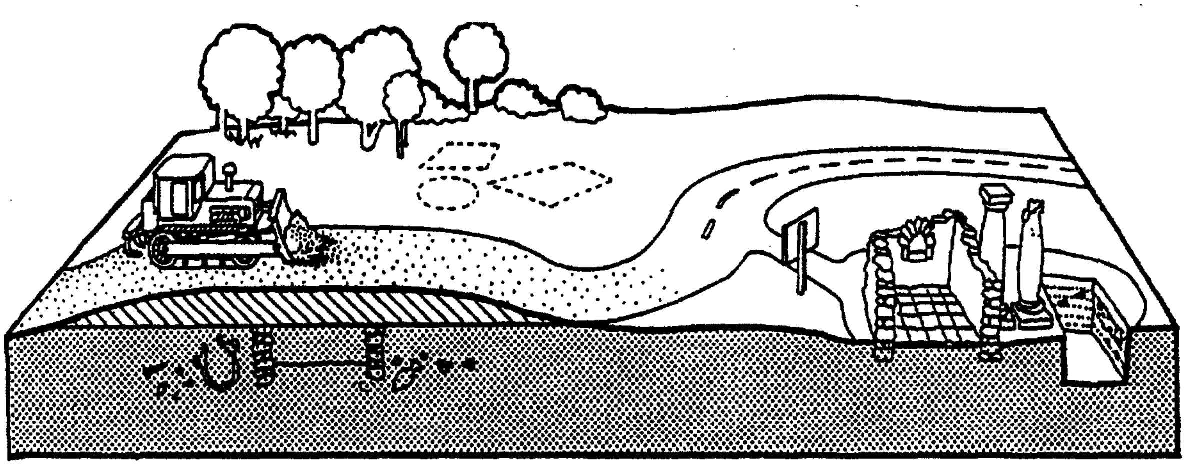
Commonly-utilized mitigative measures include excavation, erosion control, restoration of structural elements, rerouting of traffic, and site mapping. Other measures that may be required on occasion are structural stabilization, soil and rock stabilization, control of groundwater levels, vegetative stabilization, control of flora and fauna, and site surveillance.

In exceptional cases, if it proves impossible for an alignment to avoid a cultural site of value, salvage excavation should be undertaken. Relocating artifacts or ruins from a site is a last alternative and can be expensive.

A site management plan will be required. It should identify conservation actions required and, where necessary, provide guidance on other measures such as salvage or relocation. It should establish monitoring and evaluation procedures and a schedule of operations and budget. Particularly important is the inclusion in the plan of specific contract clauses to define responsibilities of companies and workers who discover new sites or artifacts, or who damage known sites. These chance find procedures, all too often, are given inadequate attention. At the very least, they should identify the authorities to whom the company or individual should report, the format for such reporting, the waiting period required before work can be resumed, and measures for interim care of the found items.

Dialogue between the road department and the ministry in charge of cultural heritage needs to be frequent and continuous to avoid situations which either damage the cultural site

FIGURE 14.2
AVOIDING OR COVERING ARCHAEOLOGICAL SITES



or delay the road project. In some countries, road projects have been delayed for years because of a lack of procedures governing cultural sites, or lack of funding for the protection, study, or restoration of these sites. In practice, a cooperative relationship between road builders and archaeological specialists is essential. If cultural heritage requirements are too rigid, some site discoveries may be hidden or destroyed to avoid compliance. If, however, road workers fail to allow for heritage sites, substantial delays and cost increases can occur.

All this suggests that if the mitigation plan is to be effective, in most countries it will have to include proposals for strengthening the legal framework and the institutional capacities for the on-going management of the cultural heritage in question. Thus, when the legislation is being examined in order to identify relevant information pertaining to the sites in question, an assessment of the effectiveness of that legislation and of supportive institutional capacity should also be conducted.

14.3.3 Compensation

Examples of compensatory actions may be

- tourist development of the site where heritage elements are conserved and showcased, and
- classification of the site as protected under appropriate legislation. For sites of international quality, UNESCO listing as a World Heritage Site may be proposed.

14.4 MINIMIZING IMPACTS ON CULTURAL HERITAGE FEATURES: AN ACTION CHECKLIST

Baseline data and potential environmental impacts
The identification and prioritization of historical and archaeological sites should occur prior to route surveying. It should pinpoint highly sensitive areas, and archaeological soundings (see Section 14.2).

Analysis of alternatives
Options for the avoidance of sensitive areas should be considered seriously (see Section 14.3.1).

Mitigation plan
Any such plan should include rules for the construction phase and archaeological supervision (see Section 14.3.2).

Environmental specifications for contractors
These should specify the actions required and the person responsible, and should define the nature and scope of any additional development work that may be called for (see Section 14.3.2).

Legislation
The analysis should focus on legislation that is in effect in the country or region, and the regulations regarding various classes of protected sites (see Box 14.2 and Section 14.3.2).

14.5 REFERENCES AND BIBLIOGRAPHY

Federal Highway Administration. 1993. "Building Partnerships, Building Bridges: Meeting Transportation and Environmental Goals: The Inside Story about South Carolina's Isle of Palms Connector." Leaflet No. FHWA-PD-93-048, and video. Washington, DC: Office of Environment and Planning, Department of Transportation.

Federal Highway Administration. 1977. "Historic Preservation and the Federal-Aid Highway Program." Information leaflet. Washington, DC: US Department of Transportation.

France, Ministry of Transport. 1978. *Consideration of Archaeological Heritage in Road Studies – Recommendations.* Bagneux, France: Department of Road and Transport Engineering and Research (SETRA).

Goodland, R. and M. Webb. 1987. *Management of Cultural Property in World Bank Assisted Projects: Archeological, Historical, Religious and Natural Unique Sites.* World Bank Technical paper 62. Washington, DC: World Bank.

Low, K.S. 1984. *Effects of Road Constructions on the Environment: Technology, Culture and Development.* Kuala Lumpur: Institute of Advanced Studies.

New York State Department of Parks and Recreation. 1982. *Mitigating the Effects of Heavy Equipment Compaction on Buried Cultural Materials.* Federal Archaeology Report. New York.

Office of Technology Assessment. 1986. *Technologies for Prehistoric and Historic Preservation.* Washington, DC: United States Congress.

Taboroff, J. and C. Cook. 1993. *Cultural Property and Environmental Assessment in Sub-Saharan Africa: A Handbook.* Africa Region, Environmental Assessment Working Paper No. 1. Washington, DC: World Bank.

Taboroff, J. 1994 "Cultural Heritage in Environmental Assessment". *Environmental Assessment Sourcebook Update* No. 8. Washington, DC: World Bank, Environment Department.

15. Impacts on aesthetics and landscape

HOW TO USE THIS CHAPTER IN THE CONTEXT OF EA AND ROAD PLANNING

Stage in road planning (A)	EA activity (B)	Involvement in addition to EA team (C)
	Screening	
	Scoping	Proponent
Concept	Consultation	Key regulatory agency
Pre-feasibility	Determining baseline conditions	Other government agencies
Feasibility	Selection of preferred solution	NGOs
Engineering design	Assessment of alternative designs/methods	Research groups
Construction	Development of environmental management plan	Public/community organizations
Operation & maintenance	Effects and compliance monitoring	Advisory experts
	Evaluation	
	Reporting	

Shaded area = (A) Stages of EA covered in this chapter; (B) focus of this chapter; and (C) primary target readers.

KEY QUESTIONS ADDRESSED:

- How does one translate aesthetic considerations with respect to the landscape into design principles for road planners?
- What are some of the more common mistakes made in road planning that give rise to aesthetic concerns?
- What is involved in identifying the potential impact of a road design on the aesthetic sensibilities of local community residents and road users?
- How can one minimize a road's undesirable impacts on a landscape and make the most of its positive attributes?

15.1 IMPACTS AND SETTING

15.1.1 Links between aesthetic values and regional landscape design

Before examining the potential impact of road developments on aesthetic sensibilities, the challenge of translating aesthetic considerations into design principles that can be used by road planners warrants comment.

It is now becoming more widely accepted that an understanding of ecology is essential for environmental planning in the larger, regional landscape. Stemming from that acceptance is a growing recognition of the fact that human respect for the biophysical determinants of any given physical setting is a major consideration in attaching aesthetic value to a landscape or to any structure, such as a road, that is introduced into that landscape.

A well-designed road fits in well with its surrounding landscape because its design reflects the principles of regional landscape design. These principles can and should be applied whether or not the area being considered is one of special physical beauty. Their observation will serve to minimize not just the visual disturbance to the landscape but also the disturbance to the physical functioning of the natural and human ecosystems. In fact, if applied well, they can contribute to the enhancement of environmental benefits. To the extent that a road's design is successful in reflecting these principles, it should prove to be aesthetically more appealing.

These principles of regional landscape design can be summarized as follows:[1]

- Respect natural and human processes of change. Analyze what nature and people have done to the site. Try to maintain links with the past, allow today's lifestyles to continue, and do not attempt to control the landscape.
- Employ an economy of means. The road design that results in a minimum use of resources and effort should contribute to enhanced environmental, economic and social benefit.
- Respect and make the most of the diversity of the landscape. The biophysical determinants of a site have traditionally constituted constraints on human activity. In this setting the local vernacular landscape arose. Today's technologies free societies of many of those constraints. It is thus easier for developments, such as roads, to be out of keeping with their settings. Today's designers have to make responsible choices.
- Respect the connectedness of natural elements and human uses of nature. The movement of water, of wildlife, and of local people in their community all contribute to the coherence of a region's landscape.
- Recognize the potential for human development activities to contribute to environmental enhancement. The principles of energy and nutrient flows should be applied to the design of such features of the human environment as roads.
- Make visible the processes that sustain life. Opening the view from the road to life along the road, rather than hiding it, maintains interest in the surroundings and extends understanding of that environment and the communities it supports.

It is against the backdrop of these general principles, which are applicable to regional design in general and not just to roads in a regional landscape, that the road designer can more easily appreciate how and why a road can have a negative impact of an aesthetic nature.

15.1.2 Potential negative aesthetic impacts

Negative aesthetic impacts can be expressed as a product of the poor consideration of the above-mentioned design principles and a resulting lack of harmony between the road and various features of the landscape, such as those listed below:

- The natural relief and morphology of the landscape. In this case, such disharmony can occur if the route does not follow the relief as closely as possible and causes the formation of major cut and fill zones, out of character with the terrain in height, length, and incline of slopes; or if the route cuts transversely or diagonally across a system of parallel valleys; or does not avoid landscape with an uneven relief.

[1] This section draws heavily from Hough 1990 and Hough 1995.

- The hydrology—e.g. if road construction results in rerouting and channeling of a waterway.
- Vegetation—e.g. if the road project results in deforestation, destroys or does not bypass isolated trees, avenue trees, or hedges; or if it interrupts the continuity of vegetation in a valley or other setting.
- The structure and pattern of the landscape—e.g. if the road distorts the existing field system by, say, cutting obliquely through a rectangular farm system and creating numerous isolated plots which may be difficult to cultivate, out of place, and thus aesthetically disturbing.
- Urban or village areas—e.g. if the road separates two urban centers or if a strong existing urban pattern has not been taken into consideration in its design. Roads can also modify the way a city or village evolves and expands and can encourage new urban expansion. This may be an objective of road development or an unexpected outcome with undesired visual and community impacts.
- Recreational areas—e.g. if these areas, which will require good access, are not traversed with sensitivity; and finally.
- Architectural or cultural heritage—e.g. if the road crosses through a park of historical interest or blocks or cuts off a view of archaeological or cultural interest. (Related issues are discussed in the previous chapter on cultural heritage.)

15.2 DETERMINING THE NATURE AND SCALE OF IMPACTS

A landscape analysis can help to define features of the landscape, using available cartographic and photographic documents and tours of the site. In order to facilitate comprehension by the public, the tools used are mainly visual. They may include

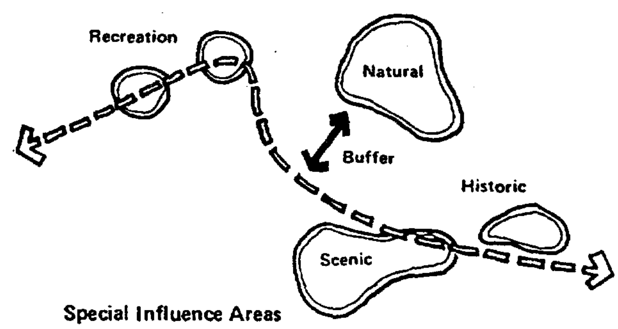
- one or more thematic maps, depending on the dimension of the site and its complexity (e.g. relief maps, maps of urbanization, vegetation, landscape, and main features, as well as maps that provide a synthesis of all major road and landscape design factors. Particularly valuable in terms of regional landscape design are maps of special influence areas located in the travel corridor, see Figure 15.1).
- schematic cross-sections to explain the structure of the landscape and the distribution of its various components in relation to the relief; and
- photographs, usually arranged by landscape unit or theme to support the analysis.

Consultations should be held with local communities to obtain the information suggested by the regional design guidelines. This should assist the road planners in refining the alternative alignments.

The road alignment, or the various alternatives under consideration, can then be integrated into this initial landscape using

- maps with route alternatives superimposed over the current environmental state;
- photomontages that use photographs taken on-site, or oblique aerial photographs, to simulate the road's route and impact; and
- analyses of the vertical alignment and cross-sections where the contour of the natural terrain coincides with that of the road's route. In this way it is possible to visualize the importance of cut and fill zones.

FIGURE 15.1
SPECIAL INFLUENCE AREAS



New roads should not be located within the travel corridor until all special influence areas have been located and defined as far as possible. (These areas, representing unique recreation, scenic, natural aesthetic and historic values, are the most powerful aesthetic influences on road location within the corridor).

Landscape is a subjective concept that cannot be precisely quantified. It includes a large number of parameters. A study of the relief, vegetation, buildings, hydrography (watercourses), and land division system makes it possible to identify several different landscape units on the site. Each unit is defined as a part of the territory with its own special characteristics (relief, forms of land use, vegetation, buildings, color, etc.) which can be perceived by the eye and enjoyed by the senses. Landscape units are homogeneous parts of the landscape which can be defined by such criteria as coherence, readability, hierarchy, harmony, and stability.

Coherence: A landscape is coherent if its various components (e.g. relief, vegetation, buildings) harmonize—if they are aesthetically in keeping with one another. This is a strong feature of truly vernacular landscapes. Contemporary structures, on the other hand, rarely attempt to relate to their natural setting. Their coherence may be created by forms, colors, proportions, etc.

Readability: A landscape is readable if it is easy for the observer to comprehend.

Hierarchy: A landscape with hierarchy is one with a predominant feature.

Harmony: A landscape exhibits harmony if there is a relationship in terms of mass and scale between the various components making up the landscape. It aims for maximum overall coherence compatible with the widest possible diversity (Figure 15.2).

Stability: A stable landscape is one which, although dynamic, retains the same characteristics and qualities through time and space.

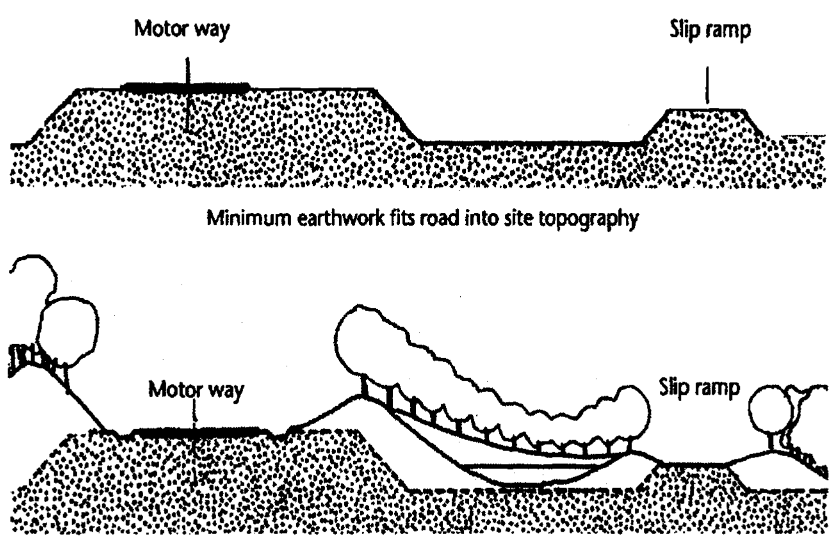
Landscape analysis must consider the overall route, and integrate sections which have been studied separately, in order to avoid creating a project which appears splintered and lacking in cohesion.

15.3 REMEDIAL MEASURES

15.3.1 Prevention

It is not possible to prevent the presence of a road from affecting the surrounding landscape. Even maintenance and rehabilitation works can change the appearance of a road, for example through the use of vegetation and shaping of the roadside.

FIGURE 15.2
USING VEGETATION TO IMPROVE HARMONY BETWEEN A ROAD AND TERRAIN



15.3.2 Mitigation

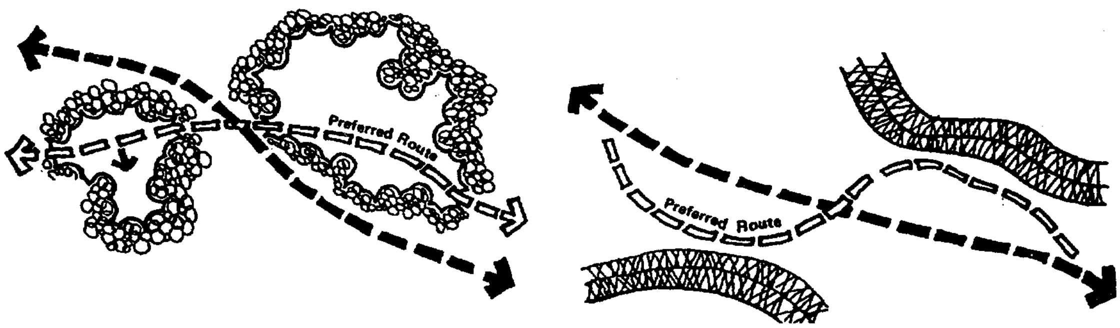
The above-mentioned regional landscape design principles should provide guidance in resolving major issues relating to alignment, landscaping maintenance, and the provision of user services.

Alignment

Alignment characteristics can be selected to best fit the route into the landscape.

- Vertical and horizontal alignment should follow the natural relief as closely as possible within technical constraints such as slopes and radius of curvature.

FIGURE 15.3
MAKING THE MOST OF LANDSCAPE FEATURES



- Curves can accentuate views, while ensuring adequate safety for passing. Coming into close proximity with a natural feature of special interest, such as a rock face, is often better than avoiding it (Figure 15.3).
- Slopes on either side of the road can be varied to match the site's natural topography.
- Bridges, viaducts, and tunnels can be used across steep terrain rather than high cuts and embankments, to preserve the landscape's visual and physical continuity. Computer landscape illustration may help the road agency to visualize the completed road project within the landscape (Figure 15.4).
- Drivers can enjoy the view of a bridge (Figure 15.5). They are often beautiful structures.
- Views from the road can be revealed, composed, or reinforced by road layout and design but should also take road speed into into account (Figure 15.6).

FIGURE 15.4
COMPUTER LANDSCAPE ILLUSTRATION

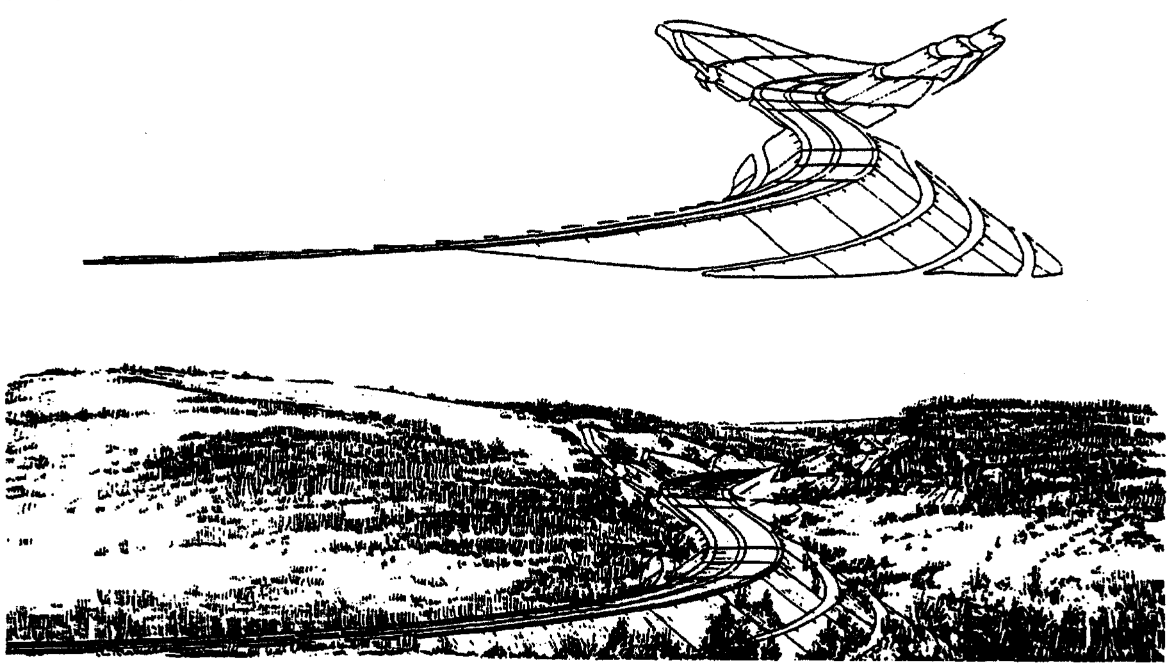
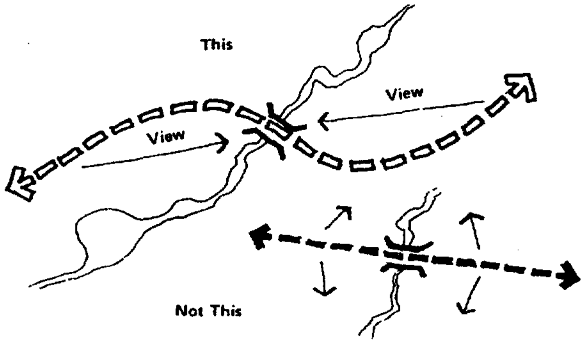


FIGURE 15.5
MAKING THE MOST OF BRIDGES



Some of the best designed bridges go unnoticed by people driving over them. Alignment can be used on occasion to reveal such structures before crossing.

Bridges should maintain a continuous vertical alignment, and long bridges should maintain horizontal alignment.

Landscaping proposed for the route should

- fit in with local vegetation (trees, shrubs, avenue trees, hedges);
- make use of vegetation to harmonize with or improve the existing landscape;
- be representative of the road's category and function;
- respect views and not be planted systematically just to fill in space;
- take advantage of natural openings in the existing vegetation;
- frame and underscore the various landscape units crossed;
- suit and underscore the various engineering structures;
- ensure user safety by using the landscape to signal changes in the route, for example, by decreasing the space between avenue trees before entering a curve or village; and
- pay attention to the aesthetics of engineering structures by selecting materials that adopt local colors and textures and which give the structure a simple shape.

Maintenance

Maintenance of roadside vegetation, slopes, and structures can greatly affect visual appearance and can be enhanced by involving maintenance workers in the planning and management of the roadside environment. Plant indigenous wildflowers and grasses for a low maintenance ("no mow") roadside.

Littering and other eyesores can be reduced to some extent by

- avoiding the use of too many different types of noise barriers;
- establishing regulations or fines for littering; and
- regulating billboard and storefront advertising along roads, especially at the entrance to cities or towns, to prevent unsightly proliferation and protect road user safety.

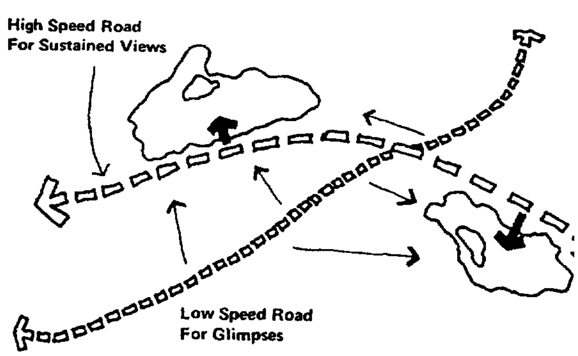
User services

User services made available to motorists along the roadway can help ensure the success of a road project and help avoid concerns such as littering or vehicles making indiscriminate stops along the roadway. They also contribute to road safety by allowing drivers to rest or check vehicles and loads during a trip. Examples include rest areas, scenic lookouts, and shoulder pull-off areas.

15.3.3 Compensation

Negative impacts on the landscape can be compensated for, to some extent, by reforestation of areas to replace those taken up by the construction of the road and rehabilitation of landscape problem areas.

FIGURE 15.6
DESIGNING VIEWS WITH SPEED IN MIND



Not all views have to be sustained, especially at lower speeds. A series of short "glimpses" is sometimes preferable to a continuous view. Integrating glimpses at higher speeds, however, is often dangerous to highway safety.

15.4 MINIMIZING IMPACTS ON AESTHETICS AND LANDSCAPE: AN ACTION CHECKLIST

This section highlights the more important steps in the EA process relative to the incorporation of aesthetic considerations into the road development process.

Baseline data and potential environmental impacts

Useful reference documents include maps of varying kinds, drawings, photographs, and texts (see Section 15.2). Critical features and locations can be identified using thematic maps of topography, vegetation, buildings, major geographic areas, and the main structural components of the site (discussed in Chapter 4 and again in Section 15.2). Public consultations, to capture the views of the local people about their local landscape, are essential here.

Analysis of alternatives

Photographs with legends and drawings are used to visualize and explain the landscape characteristics, in order to identify the best route and areas of environmental sensitivity which require special care in the design process (see Section 15.2).

Mitigation plan

This will include aesthetic considerations, especially in relation to road project structures, and other environmental devices such as noise barriers. Implementation and maintenance plans for seeding and planting should cover areas to be planted, species, and techniques to be used (see Section 15.3).

Environmental specifications for contractors

In addition to modifying certain elements (for instance screens or bridges), the contractor will have to plant vegetation according to the specifications set by the landscape architects. (See Chapter 18 for a more detailed discussion of contractor specifications.)

15.5 REFERENCES AND BIBLIOGRAPHY

Aguilo, M. 1981. "Methodology for the Evaluation of the Visual Fragility of Landscapes" (in Spanish). Madrid: E.T.S. ICCP.

Fernandes Canadas, M. 1982. "Landscape and Physical Planning. Systematic Approximation and Valuation" (in Spanish). Madrid: ETSIM.

France, Ministry of Infrastructure. 1993. "Landscape and Development" (in French). No. 22. Bagneux, France: SETRA.

France, Ministry of Infrastructure. 1989. *Planting on the Roadside*. Technical guide. SETRA - CAUE 77.

France, Ministry of Infrastructure. 1989. "Roads and Landscape: Building Roads and Highlighting Landscapes" (in French). Report of colloquium held June 22, 1989. SETRA and Association des Sociétés Françaises d'Autoroute.

France, Ministry of Infrastructure. 1987. "Roadside Landscapes" (in French). No. 80. Metropolis. Bagneux, France: SETRA.

France, Ministry of Infrastructure. 1984. "The Art of the Highway" (in French). Bagneux, France: SETRA.

Gonzalez Bernaldez, F. 1977. "Ecology and Landscape" (in Spanish). Madrid: Blume.

Hough, Michael. 1995. *Cities and Natural Process*. London: Routledge.

Hough, Michael. 1990. *Out of Place: Restoring Identity to the Regional Landscape*. New Haven, CT: Yale University Press.

Hough, Stansbury Associates Ltd. 1973. *Design Guidelines for Forest Management*. Toronto, Canada: Ministry of Natural Resources.

Trans-European Motorway. 1991. *Aesthetic, Economic and South Motorway*. Document No. TEM/CO/TEC /46, TEM Project Central Office, Warsaw. SETRA.

16. Impacts on the noise environment

HOW TO USE THIS CHAPTER IN THE CONTEXT OF EA AND ROAD PLANNING

Stage in road planning (A)	EA activity (B)	Involvement in addition to EA team (C)
	Screening	
	Scoping	Proponent
Concept	Consultation	Key regulatory agency
Pre-feasibility	Determination of baseline conditions	Other government agencies
Feasibility	Selection of preferred solution	NGOs
Engineering design	Assessment of alternative designs/methods	Research groups
Construction	Development of environmental management plan	Public/community organizations
Operation & maintenance	Effects and compliance monitoring	Advisory experts
	Evaluation	
	Reporting	

Shaded area = (A) Stages of EA covered in this chapter; (B) focus of this chapter; and (C) primary target readers.

KEY QUESTIONS ADDRESSED:

? How can road noise affect human welfare?

? What are the major sources of road noise?

? Can noise pollution be measured? What instruments or methods are used to measure it?

? What can be done to compensate for or mitigate the impacts of road noise?

16.1 IMPACTS AND SETTING

In many areas, noise is one of the most obvious impacts of daily road use. However, its effects are often given lower priority than economic or other environmental impacts, largely because they are rarely visible and are difficult to quantify monetarily. Yet most humans and animals that suffer chronic exposure to severe noise pollution are keenly aware of its presence, and may experience a range of problems as a result of this exposure. It is therefore important to understand how road noise comes to exceed acceptable levels, and what can be done to prevent, mitigate, or compensate for its effects.

16.1.1 Sources of road noise

Noise associated with road development has four main sources: a) vehicles; b) friction between vehicles and the road surface; c) driver behavior; and d) construction and maintenance activity.

Vehicle noise

Vehicle noise comes from the engine, transmission, exhaust, and suspension, and is greatest during acceleration, on upgrades, during engine braking, on rough roads, and in stop-and-go traffic conditions. Poor vehicle maintenance is a contributing factor to this noise source.

Road noise

Frictional noise from the contact between tires and pavement contributes significantly to overall traffic noise. The level depends on the type and condition of tires and pavement. Frictional noise is generally greatest at high speed and during quick braking.

Driver behavior

Drivers contribute to road noise by using their vehicles' horns, by playing loud music, by shouting at each other, and by causing their tires to squeal as a result of sudden braking or acceleration.

Construction and maintenance

Road construction and maintenance generally require the use of heavy machinery, and although these activities may be intermittent and localized, they nevertheless contribute tremendous amounts of sustained noise during equipment operation.

16.1.2 Road noise impacts

Noise associated with road development affects the environment through which roads pass by degrading human welfare, by sonically vibrating structures, and by disrupting wildlife.

Human welfare

Even when it is not perceived consciously, chronic exposure to road noise can affect human welfare in varying degrees, both physiologically and psychologically. Chronic noise exposure can be a source of annoyance, creating communication problems and leading to elevated stress levels as well as associated behavioral and health effects. It can cause auditory fatigue, temporary and permanent lessening of hearing ability, sleep disorders, and can even contribute to learning problems in children.

Vibration

The vibration induced by the resonance of traffic noise can have a detrimental effect on structures standing near the road. This is of particular concern in the case of cultural heritage sites, which may have been standing for many centuries, but which were not designed to withstand such vibration. Makeshift or lightly constructed buildings, common in many developing countries, may be the first to succumb to vibration damage.

Wildlife disturbance

Noise may prevent many animal species from approaching or crossing road corridors because they are afraid. As a result, road corridors become barriers to regular wildlife travel routes, effectively rendering roadside habitat areas inaccessible to some species. Such disturbance reduces the success of these species and contributes to ecological alteration (see Chapter 10).

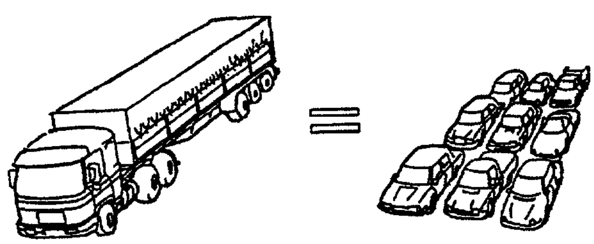
16.2 DETERMINING THE NATURE AND SCALE OF IMPACTS

Motor vehicles are inherently noisy, and noise impacts are inevitable in any road development, regardless of scale or character. The factors contributing to noise impacts are, however, highly variable; consequently, the nature of the noise impacts associated with individual road projects differ greatly. Contributing factors fall into six groups:

Vehicular factors

Different vehicle types produce different levels of noise. In general, heavy vehicles such as transport trucks make more noise than do light cars; they tend to have more wheels in contact with the road (see Figure 16.1), and often use engine brakes while decelerating. Poorly maintained vehicles, such as those with incomplete exhaust systems or badly worn brakes, are noisier than well-maintained ones. Also, certain types of tires, such as off-road or snow tires, are especially noisy.

FIGURE 16.1
ACOUSTIC EQUIVALENCE BETWEEN HEAVY AND LIGHT VEHICLES



Road surfaces

The physical characteristics of the road surface and its surroundings play a large role in determining noise output. Well-maintained, smooth-surfaced roads are less noisy than those with cracked, damaged, and patched surfaces. Expansion joints in bridge decks are especially noisy. Roadside surfaces such as vegetated soil tend to absorb and moderate noise, while reflective surfaces like concrete or asphalt do not have any beneficial function.

Road geometry

The vertical alignment of the road can affect the ease with which noise can be transmitted to roadside receptors. For instance, siting a road in a cut below ground level or on a raised platform may serve to keep receptors out of the impact zone. This concept is illustrated in Figure 16.2. Also, the presence of barriers along the roadside, whether specially installed for noise control or naturally occurring, can lower the impact of road noise.

Vehicles tend to produce the most noise while ascending and descending steep slopes and while rounding sharp corners; this means that roads which incorporate these features will tend to be noisier at those points.

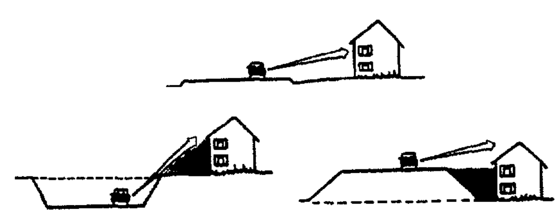
Environmental factors

Weather conditions such as temperature, humidity, wind speed, and prevailing wind direction can play a role in determining how individual sites are affected by road noise. Temperature and humidity determine air density, which in turn affects the propagation of sound waves. Downwind sites are generally exposed to greater noise levels than are sites upwind of roads.

Ambient noise levels, associated with industrial and other human activity, affect the perception of the magnitude of the road noise impact. In areas with low ambient noise levels, the noise from a new road development will generally be more noticeable than a similar noise level would be in an environment with higher ambient noise levels. New roads in quiet areas or noisy trucks at night are often perceived as worse than higher levels of noise in a busy area during the workday. On the other hand, measured noise levels and potential health impacts are highest where traffic noise combines with noise from other sources, possibly producing an unacceptable overall noise level.

Topography can also help determine noise impact. For instance, noise from roads occurring in mountain valleys or canyons tends to be more noticeable than that from a similar road

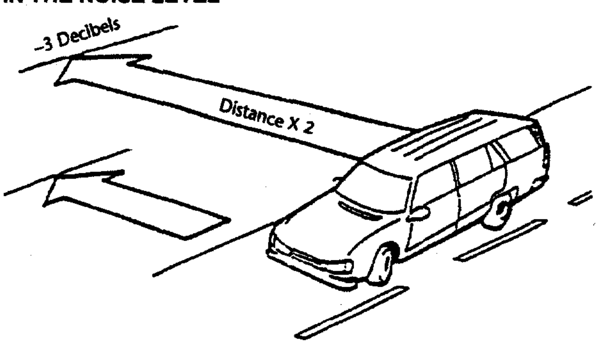
FIGURE 16.2
RELATIVE POSITIONS OF ROADWAY AND RECEPTOR



Audible nuisance is higher when the residence is located at pavement level on a flat plain, because noise is reflected off valley walls. By the same token, hills and knolls can act as natural barriers to noise if they occur between the road and receptors. Above-grade roads, which are often necessary in flood-prone areas, tend to broadcast noise over greater distances.

Spatial relationships
Perhaps the greatest determinant of noise impacts is the spatial relationship of the road to potential noise receptors. The closer the road to receptors, the greater the impact (see Figure 16.3). The higher the population density in roadside areas, the greater the number of people likely to be receptors, and, consequently, the greater the impact.

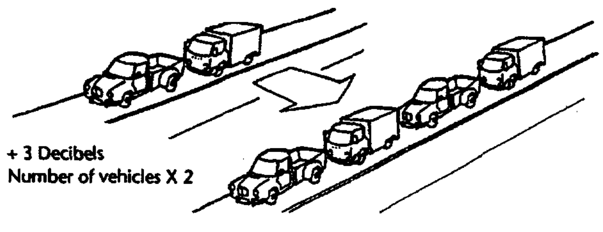
FIGURE 16.3
DOUBLING THE DISTANCE BETWEEN THE ROAD AND THE RECEPTOR RESULTS IN A DECREASE OF 3 dB(A) IN THE NOISE LEVEL



Traffic stream
The noise production of a particular traffic stream is determined by a number of factors: the type of vehicles in the stream and their level of maintenance; the number of vehicles passing per unit time (see Figure 16.4); the constancy of flow—vehicles tend to be noisier in stop-and-go traffic; and the speed of traffic flow—noisiest at high speeds (see Figure 16.5).

The relationship between traffic stream cycles and ambient noise is also important; ambient noise levels are generally lowest at night, and if traffic noise peaks at night, the impact will be great. Conversely, if traffic noise peaks at the same time that ambient noise levels do, the effects will be less noticeable.

FIGURE 16.4
WHEN TRAFFIC ON A ROAD IS DOUBLED, THE NOISE LEVEL INCREASES 3 dB(A), ALL OTHER FACTORS BEING EQUAL



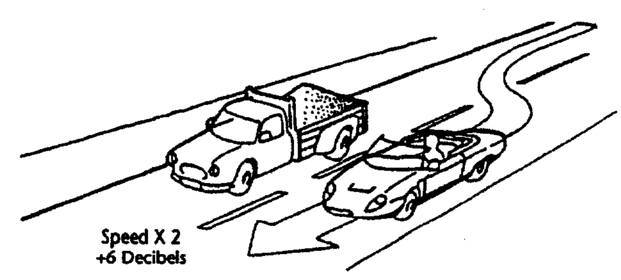
16.2.1 Assessing noise impacts

Assessment of potential road noise impacts relies on an accurate evaluation of the baseline conditions, a thorough knowledge of the characteristics of the proposed road development, and a good understanding of how roadside activity will evolve in the medium and long term.

When assessing the potential noise impact of a road development, it may also be helpful to keep the following in mind.

- Road noise impacts will be greatest where busy roads pass through densely populated areas.
- If, at the outset, there are indications of complex noise impacts, consultation with a noise engineer may prove helpful.
- Some receptors are more sensitive to noise exposure than others. Road noise in industrial zones and uninhabited areas without much wildlife is not likely to be particularly problematic, whereas residential suburbs and particular localities such as schools or hospitals may experience significant impacts.

FIGURE 16.5
DOUBLING THE SPEED RESULTS IN AN INCREASE OF 6 dB(A)



- It should be recognized that there are some locations (such as busy urban intersections) where it is very difficult to implement noise-limiting measures.

16.2.2 Noise measurement

Noise measurement specifications require definition of the period of measurement, the noise parameter to be recorded, and the position of the recording instrument relative to the road and adjacent properties.

Measurement units
The indicator used to measure sound levels is a logarithmic function of acoustic pressure, expressed in decibels (dB). The audible range of acoustic pressures is expressed in dB(A). The human ear perceives a constant increase in sound level whenever the acoustic pressure is multiplied by a constant quantity. The scale of sound levels shows that calm environments correspond to a level of 30 to 50 dB(A), and that beyond 70 dB(A) sound becomes very disruptive (Figure 16.6). Note that, because the decibel is a logarithmic function of acoustic pressure, the noise levels of two or more sounds are not added up as in conventional mathematics, but are multiplied.

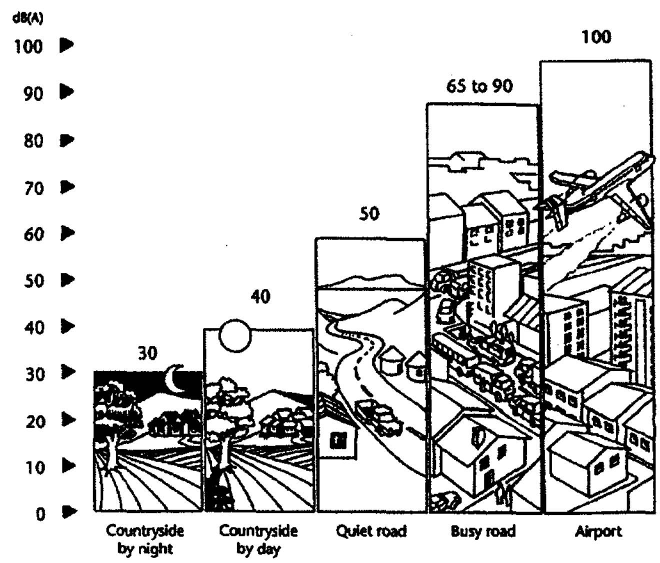
Since noise is variable over time, measurements and forecasts are expressed as mean values or other indicators over a given period of time.

The equivalent acoustic level (Leq) is the sound level of a stable noise which contains the same energy as a variable noise over the same period. It represents the mean of the acoustic energy perceived during the period of observation. The equivalent acoustic level of noise during the period 8 a.m. to 8 p.m. is written as Leq (8 a.m. - 8 p.m.) or Leq (12hr).

L10(12hr) is an alternate measure, indicating the noise level exceeded 10 percent of the time over a twelve-hour period. For the 18-hour period 6 a.m. to 12 midnight, L10(18hr) is typically 3dB(A) higher than Leq for the same period.

Nocturnal noise levels are generally lower than are diurnal levels. For example, the nocturnal Leq (12 a.m. - 6 a.m.) is typically 10 dB below the Leq (8 a.m. - 8 p.m.), except in the case of especially high nocturnal traffic with a high percentage of heavy goods vehicles.

FIGURE 16.6
SCALE OF SOUND LEVELS



The equivalent acoustic level in front of (outside) a building facade facing the traffic determines the building's exposure to noise. This is the best indicator of the discomfort caused to the building occupants.

Measuring instruments
Existing noise levels can be measured using devices called sonometers, which convert sound wave energy into an electrical signal, the magnitude of which is displayed or recorded.

Measurements obtained using these instruments can become valuable baseline data, but their further usefulness is somewhat limited, both in terms of sampling period and as a result of their inability to distinguish separate sources of noise.

Forecasting noise levels
Forecasting methods include equations, computer models, and physical models. The simplest are equations, which estimate noise from information on traffic flow, composition, and speed.

Computer models are perhaps more widely employed and can be used to forecast future changes in baseline conditions and the likely impacts of a project and various mitigation options. A few examples of computer noise models in use are the FHWA model (USA); STAMINA 2.0 (USA); OPTIMA (USA); and Microbruit (France). Up to date information on the availability and use of computer noise models should be available from national transportation agencies.

16.2.3 Noise level standards

National standards may specify one noise level not to be exceeded for all types of zones (such as Leq"12hr" under 70 dB"A") or, more realistically, different noise levels for different zones, such as industrial, urban, residential, or rural areas. Lower limits are sometimes specified for nocturnal noise.

Details of road noise standards are usually available from national transportation agencies.[1] If no national standards exist, objectives can still be established for various types of road projects. Indicative standards used in Western Europe might be not to exceed a Leq (8 a.m. - 6 p.m.) of 65 dB(A) for residences in urban areas, and 60 dB(A) for rural areas. It is important, when considering international standards, to take into account the differences in noise criteria, measurement methods, and applicability to various types of projects.

It should be noted that noise standards are only applicable for a defined measurement method which specifies the location of measurement devices and the duration of measurement. Indeed, one obstacle to consistent compliance with standards is the fact that noise measurement is dependent on so many variables, such as weather and the type, position, and number of sensors. Unless the values of the variables are clearly defined and strictly adhered to, compliance with standards may not be especially meaningful.

16.3 REMEDIAL MEASURES

16.3.1 Prevention

Noise problems can be avoided by moving the road alignment or diverting traffic away from noise-sensitive areas using bypass roads. Choosing alignments which minimize steep slopes and sharp corners, especially at sensitive locations, can also prevent noise problems.

16.3.2 Mitigation

Vehicular measures

Motor vehicle noise can be reduced at source, for example through vehicle construction, selection of tires and exhaust systems, as well as vehicle maintenance. Control of vehicle noise emissions can be attempted using vehicle design rules and in-use noise regulations and enforcement, subjects beyond the project-level scope of this handbook.

Surface design and maintenance

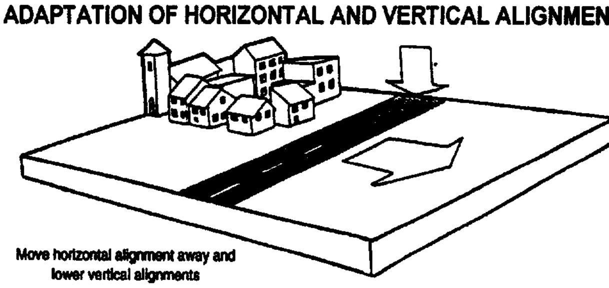
The application of a bituminous surface layer over worn concrete roadways is effective in reducing frictional noise. The use of open-graded asphalt and the avoidance of surface dressings may also be effective in reducing frictional noise in sensitive areas (see Box 16.1). Some jurisdictions are experimenting with asphalt made using discarded tires, which appears to reduce frictional noise as well. Generally, smooth, well-maintained surfaces such as freshly laid asphalt without grooves and cracks will keep noise to a minimum.

Road geometry

Road design should avoid steep grades and sharp corners to reduce noise resulting from acceleration, braking, gear changes, and the use of engine brakes by heavy trucks at critical locations.

Figures 16.2 and 16.7 illustrate how adapting the vertical alignment of a road can decrease noise at nearby buildings.

FIGURE 16.7
ADAPTATION OF HORIZONTAL AND VERTICAL ALIGNMENTS

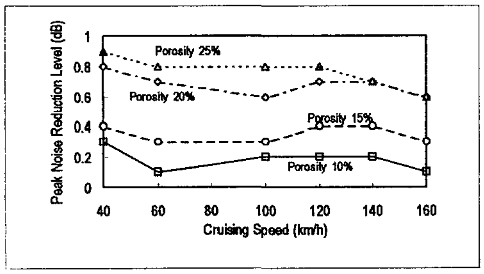


[1] Sinha et al (1989) includes details of noise level standards for several countries.

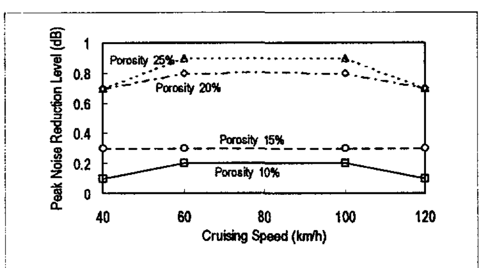
BOX 16.1
REDUCING ROADSIDE NOISE LEVELS BY CHANGING THE PAVEMENT COMPOSITION AND POROSITY

Conventional asphalt pavement usually consists of a mixture of bitumen and a range of graded aggregate materials, yielding *densely graded asphalt pavement.* In contrast, *drainage asphalt pavement* uses an open graded asphalt mixture, which eliminates the aggregates of intermediate grading to obtain a higher porosity mixture.

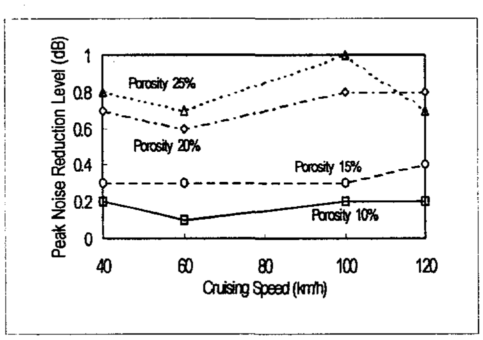
The noise levels from vehicles traveling on the drainage asphalt pavement (DA) are lower than on the densely graded asphalt pavement (DGA). In comparison to the DGA pavement, the peak noise levels at various cruising speeds are reduced on the DA pavement as shown in the line graphs. For example, the peak noise reduction would be in the range of 0.1 and 0.4 decibel with the DA porosity of 10 to 15 percent. With the porosity of 20 to 25 percent, the peak noise levels would decrease by the range of 0.1 to 1.0 decibel. The two bar charts compare the measured noises between the DGA pavement, with a porosity of 5 percent (upper chart), and the DA pavement, with a porosity of 20 percent. The noise reduction by the DA pavement falls in the range of 5 to 6 decibels in the former case, and from 1 to 3 decibels in the latter case. Compared with the DGA pavement, the noise levels of vehicular traffic drop by some 10 decibels on the porous elastic pavement that uses urethane-bonded rubber particles.



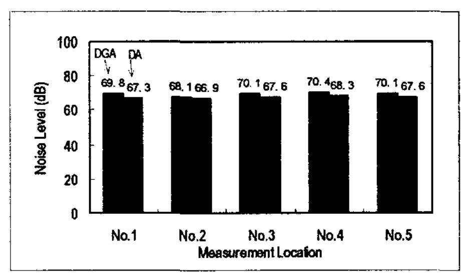
Car



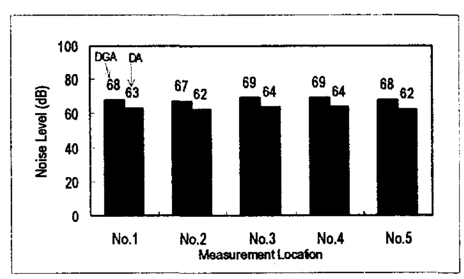
Light Truck



Heavy Truck



DA: porosity 5%



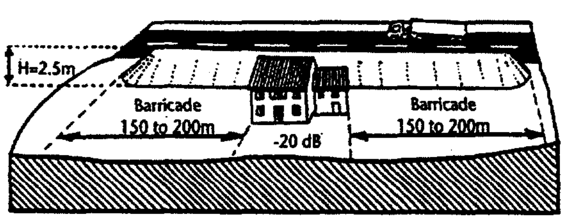
DA: porosity 20%

Source: Meiarashi and Ishida, 1996.

Noise barriers
Noise barriers are among the most common mitigative measures used. They are most effective if they break the line of sight between the noise source and the receptors being protected, and if they are thick enough to absorb or reflect the noise received. Various materials and barrier facade patterns have been extensively tested to provide maximum reflection, absorption, or dispersion of noise without being aesthetically ugly.

The types of noise barriers most commonly employed consist of earth mounds or walls of wood, metal, or concrete which form a solid obstacle between the road and roadside communities (Figure 16.8). Noise mounds require considerable areas of roadside land; for narrow alignments, bridges, and roads on embankments, wall-type barriers may be the only viable option. Two or more barrier types are often combined to maximize effectiveness. Plantations of trees and shrubs, for instance, contribute little to actual noise reduction, but they do confer a psychological benefit in reducing the perceived nuisance of traffic noise, and they are often used to 'soften' the visual appearance of mounds and walls.

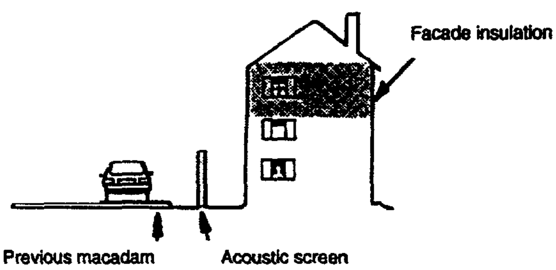
FIGURE 16.8
POSITIONING A BARRIER OR SCREEN



Insulation
Building facade insulation, such as double window glazing, is an option usually adopted as a last resort in order to dampen noise in buildings. It is most likely to be needed in cases where noise impacts result from an unforeseen expansion of traffic volume along existing roads.

The relative costs and effectiveness of some of the measures outlined above are compared in Table 16.1. A successful mitigation plan will often incorporate several of the measures (see Figure 16.9). A busy road passing by a high-rise building, for example, may require specialized surfacing, a barrier or screen to reduce traffic noise at lower levels, and facade insulation for the upper floors of the building.

FIGURE 16.9
COMBINATION OF TECHNIQUES



16.3.3 Compensation

The purchase of roadside properties by governments may, in many cases, be more viable than the implementation of extensive measures to protect only a limited number of people. Monetary compensation for noise impacts is currently offered only in a small number of countries and cases.

16.4 AVOIDING IMPACTS ON THE NOISE ENVIRONMENT: AN ACTION CHECKLIST

Road development has the potential to degrade the quality of life experienced by those who inhabit areas near roads if noise concerns are not dealt with. This section highlights the more important steps in the EA process which incorporate noise considerations into the road planning and development process.

Baseline data and potential impacts
Basic information must be gathered on current properties that may be affected by road noise, and on areas of potential future development, especially for housing. Where sensitive zones or potential problems are identified, measurements should be taken of current noise levels, and models should be used to predict future noise levels, including longer-term (i.e. five- and ten-year) estimates. The analysis should highlight currently quiet locations likely to experience a large change in noise levels, as well

TABLE 16.1
INDICATIVE COMPARISON OF VARIOUS NOISE MITIGATIVE MEASURES

Measure	*Effectiveness*	*Comparative costs*
Earth barrier	Same as that of other types of barriers (e.g. wood or concrete); needs more space	Very cheap when spare fill material is available on site.
Concrete, wood, metal or other barrier fences	Good; requires less space	10 to 100 times the cost of an earth barrier, but may save land cost
Underground road (cut and cover)	An extreme option for very heavy traffic; requires ventilation if over 300m long.	80 to 16,000 times the cost of an earth barrier
Double glazing of windows for facade insulation	Good but only when windows are closed; doesn't protect outside areas	5 to 60 times the cost of an earth barrier

as locations which could experience problems from construction noise.

Analysis of alternatives
Areas of choice include road alignment, barriers, pavement design, and building modifications. In some industrial or urban areas, ambient noise levels are already high, and the noise from new road works may be of the same order. In other cases, there may be tradeoffs between noise protection and increased land consumption, which will prove undesirable for other environmental and community reasons. Consultation with affected communities and individuals can assist in identifying preferred solutions within budgetary and other constraints.

Mitigation plan
Noise protection measures will usually be incorporated into road design and construction. Ongoing maintenance actions are necessary, for example, to ensure effectiveness of open-graded asphalt road surfacing. Long-term noise monitoring may also be appropriate.

Environmental specifications for contractors
Specifications for building noise protection devices should clearly indicate the location, design, and materials and methods of construction, and should account for future road maintenance needs. In carrying out construction, quarrying, or other such activities in noise-sensitive areas, special attention may have to be paid to equipment noise standards, hours of operation, material haulage routes, and other aspects of work-site management.

Legislation
Laws and regulatory measures can assist efforts to reduce noise impacts by, for example, not allowing new residential buildings near major roads; by requiring by-pass routes for the noisiest vehicles, especially at night; and by limiting speed and construction operations near especially sensitive areas such as schools and hospitals, particularly during periods of low ambient noise.

16.5 REFERENCES AND BIBLIOGRAPHY

Alexandre, A.Y. and J.P. Barde. J.P. 1973. "The Time of Noise" (in French), Paris: Flammarion.

Alexandre, A.Y. and J.P. Barde. "The Practical Determinants of a Charge for Noise Pollution," *Journal of Transport Economics and Policy*, 14.

France, Ministry of the Environment, Ministry of Transport. 1980. "Guide to Noise Created by Land Transport—Noise Level Forecasting" (in French). Bagneux, France: Centre d'Etudes des Transports Urbains.

Fribourg, M. 1971. "Automobiles and Noise: An Action Program" (in French). Paris: La documentation française.

Galloway, W.J. and T.J. Schultz. 1980. *Noise Assessment Guidelines*. Washington, DC: US Department of Housing and Urban Development (HUD).

Garcia Senchermes. 1983. "Urban and Interurban Noise" (in Spanish). *Manual for Urban Planning and Architecture*. Madrid: CEOTMA Ministry of Public Works.

Japanese Highway Planning Inc. 1995. *Study on Noise Barriers and Other Noise Protection Measures*. Consultant Report. Washington, DC: World Bank.

Meiarashi, S and M. Ishida. 1996. "Noise Reduction Characteristics of Porous Elastic Road Surface". *Applied Acoustics*, 47:3:239-250.

Ministry of Public Works. 1987. "Noise" (in Spanish). Madrid: Director General of the Environment.

Nelson, P.M. 1987. *Transportation Noise Reference Book*. Crowthorne, Berkshire, London: Transport and Road Research Laboratory.

Organization for Economic Cooperation and Development. 1991. *The State of the Environment*. Paris: OECD.

Organization for Economic Cooperation and Development. 1988. *Transport and the Environment*. Paris: OECD.

Sinha, K. et al. 1991. "Environmental Assessments of Land Transport: Construction and Maintenance." (Draft prepared for World Bank Infrastructure and Urban Development Department).

Sinha, K. et al. 1989. *Environmental and Ecological Considerations in Land Transport: A Resource Guide*. World Bank Technical Paper. Washington, DC: World Bank.

US Department of Transportation. 1990. *Highway Traffic: Noise in the United States; Problem and Response*. Washington, DC: FHWA.

17. Impacts on human health and safety

HOW TO USE THIS CHAPTER IN THE CONTEXT OF EA AND ROAD PLANNING

Stage in road planning (A)	EA activity (B)	Involvement in addition to EA team (C)
	Screening	
	Scoping	Proponent
Concept	Consultation	Key regulatory agency
Pre-feasibility	Determination of baseline conditions	Other government agencies
Feasibility	Selection of preferred solution	NGOs
Engineering design	Assessment of alternative designs/methods	**Research groups**
Construction	Development of environmental management plan	Public/community organizations
Operation & maintenance	Effects and compliance monitoring	Advisory experts
	Evaluation	
	Reporting	

Shaded area =(A) Stages of EA covered in this chapter; (B) focus of this chapter; and (C) primary target readers.

KEY QUESTIONS ADDRESSED:

? In what ways can road development hasten the spread of disease?

? What are the special considerations for non-motorized transport?

? Which sectors of government should be responsible for promoting accident prevention and road safety?

? How can education and thoughtful design reduce the negative impacts of road development on human health and safety?

Improved travel for motorized traffic may come at the expense of other road users, such as these women carrying water in India.

17.1 IMPACTS AND SETTING

Nowhere is impact prevention more important than in the area of road safety and human health. Poor planning can lead to loss of life, which can neither be mitigated nor adequately compensated.

Road projects often have serious negative consequences for the health of local populations. By encouraging direct contact between previously disparate areas, roads provide ideal corridors for the transmission of disease between humans, and from plants and animals to humans. It is also likely that some form of air or water pollution will occur as a result of road development, further endangering the health of people living near the new development.

Safety is an issue that must be addressed as well, since road accidents result in deaths, injuries, and damage to property. They are a major public health problem and a significant cost to the economy in many parts of the world. While accident rates have been falling in many of the more developed countries, they are increasing in other countries where the road systems, travel speeds, and level of motorization are still growing.

Pedestrians and non-motorized vehicles are the most vulnerable users of roads, and are at greater risk of being injured in accidents. In areas where these road users mix with motorized traffic, special measures must be adopted to prevent the increased mobility of motorists from undermining the safety and health of all other road users.

17.2 DETERMINING THE NATURE AND SCALE OF IMPACTS

17.2.1 Human health

Road development may be instrumental in the decline in health of a local population in several ways. It can

- facilitate the transmission of diseases;
- contaminate the local water supply (see Chapter 8);
- pollute the air (Chapter 9); and
- become a source of noise pollution (as discussed in Chapter 16).

Disease transmission

Disease transmission is facilitated by the migration of people, which invariably accompanies road projects. Work crews—as well as the relatives and dependents who usually follow them—may bring with them a multitude of communicable diseases including diphtheria, poliomyelitis, tetanus, and malaria. Their temporary camps, often characterized by standing water and poor waste management practices, provide the ideal conditions for vermin, and other vectors of disease, to multiply and infect the local human population. At the same time, it is possible that a disease endemic to the project area will be contracted by the work crew, and then transmitted to a population near the next work site (see Box 17.1).

BOX 17.1
ROADS AND THE SPREAD OF STDs

Throughout the world, the spread of AIDS and other sexually transmitted diseases (STDs) can be linked to the construction of roads and the resultant opening-up of new regions. Although there are no empirical data to support this theory, it is believed that migrant populations—particularly truck drivers and construction workers—whose mobility is enhanced by new road projects are the most likely vectors for these diseases. The spread of STDs in brothels along some highways, for example, was probably hastened by the migrant population that regularly used that road (and its 'services'). This particular impact of road construction can only be mitigated through education of both the migrant and local populations.

TABLE 17.1
VEHICLE EMISSION COMPONENTS AND THEIR HEALTH EFFECTS

Pollutant	*Health effects*
Carbon monoxide (CO)	Reduces the ability of the blood to carry oxygen. Symptoms of exposure include headaches, vertigo, impaired mental function, aggravated cardiovascular disease, and impaired fetal development. In strong doses, fatal asphyxiation.
Oxides of nitrogen (NO_x)	Aggravate and induce respiratory and cardiovascular afflictions such as asthma, emphysema, tuberculosis and bronchitis.
Hydrocarbons (HC)	Contribute to eye, nose and throat irritation. Benzene is a known carcinogen.
Aldehydes	Eye, throat, and lung irritation. In some cases, allergic reactions.
Particulates	Eye and respiratory irritation, aggravation of asthma. Some are suspected carcinogens.
Lead (Pb)	Nervous disorders, impaired mental function, and behavior problems, especially in children. Also anemia, possibly brain damage.
Sulphur dioxide (SO_2)	Aggravates respiratory ailments such as asthma, bronchitis, and emphysema.

Source: Adapted from Clapham, 1981; Lee, 1985.

It is useful to consult statistics from international agencies, such as the World Health Organization, to determine the geographic distribution of communicable diseases that are most often transmitted by work crews and other highly mobile populations. This information can be combined with reports from local health authorities about the incidence of these diseases, to find out whether the road crews might bring different strains of a disease, or completely new diseases, to an area.

Water supply contamination

Water supply contamination often occurs when an influx of people—associated with the road project—overloads the local sanitation infrastructure, and encourages the spread of waterborne diseases such as amoebic dysentery, typhoid and cholera.

Where the local population uses surface water for drinking, concerns about polluted run-off from the road (Chapter 8), and road accidents involving vehicles carrying hazardous materials (Section 18.4.1) must be addressed.

"Casual" water

In the tropics "casual" standing water, created by road projects, presents a considerable health hazard, since it provides breeding habitat for snails, flies and mosquitos. On a World Bank project in the Sub-Saharan region, it was found that more bilharzia transmission resulted from puddles on road maintenance projects than from irrigation canals (Listori, 1995). Moreover, abandoned tires, old barrels, and cans provided more fly and mosquito breeding habitat than did nearby natural and irrigation water bodies (Listori, 1995).

Air pollution

Air pollution becomes a health problem when the road in question is heavily used by motorized traffic and where there are dense settlements alongside the project. Table 17.1 gives an overview of the health risks associated with chronic exposure to motor vehicle emissions.

In areas where food crops are grown adjacent to a heavily-traveled road, project planners and local residents should be aware that concentrations of heavy metals might be found in roadside plants. This type of contamination is a serious health hazard, since it can taint the entire food chain, and needs to be addressed.

17.2.2 Road safety

There are many features of a road and its surroundings which influence the risk of a road accident or the severity of accidents when they do occur. Examples of these features[1] include

- pavement and shoulder condition;
- the presence of roadside poles, trees, ditches, steep slopes, and barriers;
- signs, markings, intersection layout and control;
- roadside access, parking, and bus stop arrangements; and
- provisions for pedestrians, cyclists, and other non-motorized road users (Box 17.2).

At a national level, accident exposure is often measured by accident rates (fatalities, injuries, and accident numbers), and is related to the number of vehicles registered or vehicle-kilometers traveled. Since the number of fatalities and the number of vehicles comprise the most readily available statistics, the ratio of deaths per 10,000 vehicles on register is often used; accidents per 100,000 population is also a commonly-used statistic.

At the project level, local information on accident history may identify unsafe locations on existing roads. Examination of similar projects could identify potential problems associated with road improvements, such as increased speed through built-up areas, lack of pedestrian crossing facilities, and inadequate allocation of road space for non-motorized vehicles. Examination of the connections between improved and existing roads may highlight possible hazards at new intersections and inconsistencies in road standards which might not be recognized by drivers.

Traditional modes of transport, like these cycle taxis in Indonesia need roadside space at key urban locations

Accident reporting systems are essential for identifying accident "blackspots" where physical improvements are most likely to be successful. Further information can identify

- the types of people affected (i.e. pedestrians, motorcyclists, car occupants);
- the types of accidents (i.e. head-on or right-angle collisions, single vehicles leaving the road); and
- the types of locations (i.e. intersections, curves, or divided roads).

This information is usually recorded by police attending accidents, and its quality and synthesis depend on coordination, management, and training efforts.

Analysis of accident data is essential in ensuring that remedial measures are well targeted and effective. This requires specialized skills and knowledge and should be used both to identify critical problems and to test the results of past safety efforts.

Within the parameters of road safety, the possibility of landslides must also be examined (see Box 7.1). Unstable cuts above a road, or below, if the road collapses, can prove fatal to road users who happen to be in the wrong place at the wrong time.

17.3 REMEDIAL MEASURES

17.3.1 Prevention

Health

The prevention of major outbreaks of disease can be accomplished through a comprehensive health awareness campaign, carried out in conjunction with a road project. Successful awareness programs include preventive measures such as immunizing the vulnerable population, and educating people about diseases

[1] Transport and road research Laboratory *(1991)* contains a useful guide for evaluating and improving road safety, using these types of features as indicators.

BOX 17.2
EXAMPLES OF MITIGATIVE MEASURES FOR PEDESTRIAN AND NON-MOTORIZED VEHICLE ACCIDENT BLACKSPOTS

Activities
- walking or traveling along the road in the direction of, or toward traffic
- crossing the road
- standing on or by the road

Accident "blackspot" associated with
- negligent crossing or walking
- undefined crossing sites
- narrow road
- low quality shoulder surface
- poor visibility
- high speed
- rushing into the roadway
- lack of non-motorized lanes/paths
- disjointed bicycle network

Mitigative measures
Improvement of pedestrian and cyclist facilities
- widening or construction of shoulders
- construction of separate lanes and paths
- provision of non-motorized-only streets
- painting of edgelines in order to separate shoulders
- construction of exclusive bridges for non-motorized road users
- provision of traffic signals with phases for bicyclists
- establishment of non-motorized vehicle waiting area
- temporal separation by limiting the entry of motorized or non-motorized vehicles

Speed-limiting measures
- provision of speed limit signs for non-motorized vehicles
- construction of humps to reduce speed of motorized vehicles in narrow streets
- active police enforcement of speed limits

Improvement of visibility
- parking prohibition
- removal of sight limiting obstacles, plants, etc.
- construction of cycle-rickshaw waiting area within street parking
- installation of lighting (especially of crossing sites)
- use of liths and non-motorized vehicle reflectors

Limiting of non-motorized vehicle movements by fences or guardrails

Improvement of crossing sites
- (re)painting of zebra crossing and provide signs
- provision of line of reflective studs on both sides of zebra crossing
- construction of raised zebra crossing (with warning signs)
- construction of level-separated crossing

Regulations, education, and safety awareness training

(including STDs); how they are contracted, and how to avoid them by using treated water, practicing "safe sex," and keeping living areas cleaner. Spraying incoming and outgoing vehicles, as well as screening and treating affected local and migrant populations are two measures which may also be effective in controlling the movement of disease vectors (through contaminated water and between people).

The negative impacts of localized air pollution on human health can be prevented by choosing road alignments which avoid human settlements. The prevention of air pollution itself is discussed in Chapter 9.

Casual water
There is a startlingly high correlation between increases in endemic tropical diseases such as malaria and bilharzia and casual waters at construction sites (Listori, 1995). The best preventive measure is to prepare a site management plan which explicitly focuses on the elimination of casual water through "good housekeeping" practices.

Safety

There is no doubt that accident prevention is more valuable than any mitigative or compensatory measure. Its effectiveness will depend on cooperation amongst, and actions taken by, the various groups which are directly and indirectly involved with the road project.

Proper design of road safety features is a very effective way to prevent accidents. Planners and contractors involved with the design of the road should

- examine road design standards, safety equipment specifications and training to ensure that design details take account of safety concerns and that specific safety features are correctly designed and installed;
- require that road design audits be done, at preliminary and final design stages, by specialists in road safety and traffic operations; and
- draft traffic management plans, including details of signs, markings, intersection layouts, channelization of flows, access restrictions, footpaths, bus stops, and provisions for non-motorized vehicles.[2]

Road safety and accident prevention are also the responsibility of the ministries and agencies which regulate the transportation network. Effecting national policy changes is beyond the scope of the project-level environmental assessment, but it may be a feasible goal when doing sectoral EAs for national or regional road development schemes. In some jurisdictions, road safety councils have already been established to evaluate and recommend the adoption of road safety policies such as

- mandatory use of seat belts;
- compulsory driver training and testing;
- prohibition and punishment of driving while impaired by drugs or alcohol;
- traffic safety education for children; and
- testing and inspection of all vehicles according to national vehicle safety standards.

If this type of centralized institution does not exist, then it is the responsibility of the road project proponents to advocate the creation of a road safety council or at least to promote similar safety standards on each project.

Road councils, with the help of their member agencies and ministries, are also obligated to develop national or regional road safety plans, which might include

- ensuring that post-accident emergency assistance and medical care are available to all accident victims;
- developing an accurate accident data recording system;
- conducting research and regularly monitoring the state of road safety;
- determining the need for further road improvements (based on accident data); and
- encouraging research and development of new, safety-oriented road technologies.

The development of a safety council requires a long-term commitment to institution building, training, and funding, but it is an option that should not be overlooked. The data and statistical information assembled by a centralized body can be very useful for devising successful mitigation programs in the future (see Chapter 2 for further discussion of institution building).

Safety and non-motorized vehicles (NMVs)

It is particularly important at this stage to look at impact prevention for the more vulnerable road users—pedestrians, cyclists, animals, rickshaws, etc.—since they can become a major source of traffic congestion and are involved in a higher number of accidents. For every road improvement that allows more motorists to travel faster, there should be a parallel improvement in road safety features for non-motorized vehicles, such as

- NMV lanes physically separated from motorized traffic by barriers or designated by pavement markings;
- shoulder improvements;
- NMV paths within an independent right-of-way;
- streets on which motorized vehicles are banned;
- bicycle parking lots; and
- waiting areas (for example for cycle-rickshaws).

[2] These should be incorporated into road designs, while separate traffic plans for managment of traffic during construction and maintenance should be the responsibility of the construction contractors (see Chapter 18).

The construction of exclusive facilities is the most effective approach in the minimization of safety impacts on non-motorized vehicles. Physical separation with barriers usually provides better protection than pavement markings, but in many cases the roadway is too narrow for constructing exclusive lanes or paths. If this is the case, a shoulder of at least 1.5 to 2.0 meters should be provided so that NMVs can travel safely, without slowing the motorized traffic flow. If the shoulder is used for non-motorized vehicle travel, adequate pavement strength must be maintained. If the pavement used for shoulders is not strong enough, it quickly deteriorates with use, and easily develops potholes—a condition that makes travel difficult and dangerous for slow-moving vehicles such as bicycles or rickshaws. Such shoulder conditions may cause non-motorized users to use the main roadway instead, thereby negating any positive effect that may have resulted from the separation of motorized and non-motorized vehicles.

Pedestrian facilities such as sidewalks, zebra crossings, and pedestrian bridges improve the flow and safety of vehicular traffic, particularly in urban and near-urban areas. However, if they are improperly designed or congested by street vendors or illegal settlements, these safety features can be so inconvenient that people will choose a more dangerous route just to shorten their journey. (See Chapter 11 for a discussion on roads and community severance.)

Where there is a high concentration of bicycles and rickshaws, off-street parking and special waiting areas can reduce traffic congestion and accidents between motorized and non-motorized vehicles.

It is important to emphasize that improvements benefiting motorized road users are not always positive for non-motorized users, and any roadwork should be carefully assessed for its impact on the safety of pedestrians and NMVs.

17.3.2 Mitigation

Health

Measures to mitigate negative impacts on water quality and disease transmission are similar to the preventive measures discussed earlier in this chapter. For example, if the spread of disease among the local people and road crews is not prevented, an epidemic can be avoided by encouraging 'good health' practices through education. If the work-site is identified as the source of the problem, the contractors should be obliged to keep it clean and provide adequate sanitation facilities for the workers and their families. Potable water should also be supplied to all households in the short term to prevent further infection of the population. (Section 8.3 discusses remedial measures for water contaminated as a result of road run-off.)

Health impacts from severe air pollution are difficult to mitigate in the short-term; however, in the long-term, action should be taken to prevent inhalation of airborne contaminants. Such action might include planting dense stands of vegetation along the road to filter dust and other pollutants, or increasing the distance between the road and the people, either by moving the road or resettling the people. These mitigative measures are discussed further in Chapter 9.

Safety

If accident prevention is not a priority on a road project, then mitigative measures will almost certainly be necessary. Road safety councils are useful sources of information at this stage if they have been properly set up for data collection. The development of 'blackspot' programs, which set aside funds for low cost improvements targeting known high-accident locations, is a common mitigative measure (Box 17.2). To undertake this type of program, it is important that there be evidence of actual accident history at the proposed site. Furthermore, any mitigative measures should have a history of effectiveness, be based on a rigorous analysis of expected benefits, and include a follow-up program for monitoring the accident blackspot after the improvements have been made. All of this data is more reliable if it has been assembled by a centralized and standardized body such as a road safety council.

The provision of rest areas on heavily traveled highways is also important for ensuring the safety of all road users. These allow drivers to leave the busy road safely, rest, and use toilet facilities. Rest areas are also an excellent place for drivers to check the condition of their vehicles. Frequent checks are especially important for trucks, since a brake failure or tire blowout on a large truck can be extremely dangerous, and potentially fatal, for other users of the road.

Road users who are involved in a disproportionate number of accidents, such as pedestrians and non-motorized vehicles, should be included in special safety programs which teach people proper traffic safety, and funds should be provided for new physical road safety features to protect them.

17.3.3 Compensation

Individuals who have contracted a disease, been injured, or died as a result of contact with a road project cannot receive adequate compensation. Instead, compensation should benefit the entire community. For example, the provision or improvement of community health services could compensate for the increased risks associated with living on or near a road.

17.4 AVOIDING IMPACTS ON HUMAN HEALTH AND SAFETY: AN ACTION CHECKLIST

Road projects have the potential to drastically degrade the health and safety of local residents if developed or managed incorrectly. This section highlights the more important steps in the EA process which consider and incorporate health and safety concerns in road planning and development.

Baseline data and potential impacts
Accident data and geographic distribution of communicable diseases should be reviewed and analyzed to predict and identify trends, hazardous locations, and groups at greatest risk. Health and safety problems are not the same in all countries, and particular attention should be given to local accident experience, and incidence of certain diseases.

Analysis of alternatives
Consider safety and health consequences, and whether a parallel awareness program would be necessary with each alternative alignment. Consider using accident blackspot remedial measures as an element of road improvement projects.

Mitigation plan
Review design standards and the need for training in safety-conscious design principles. Take adequate precautions to prevent the spread of disease and promote health awareness.

Environmental specifications for contractors
These should cover correct practices for installation of safety features such as guardrails, culvert end-walls, and road signs, as well as traffic safety requirements for the operation of work zones and construction traffic. Enforce 'good housekeeping' practices on work sites and in crew camps.

Legislation, policies and national programs
Laws, regulations, and enforcement related to speed, alcohol, and vehicle safety should be reviewed, beginning with those aspects under the direct control of the road agency directly responsible for the road project (for example speed zoning, road signs). In the long term, road safety programs, policies, regulations, and priorities need to be coordinated with other agencies in the framework of comprehensive safety action plans. Nation-wide awareness campaigns about the threat of communicable and vector-borne diseases associated with a more mobile population should be implemented. Legislation can be used to control air and water contamination by contractors in particular. Hygiene and health education could become part of local school curricula.

17.5 REFERENCES AND BIBLIOGRAPHY

Carlson, G. and K.O. Hedman. 1990. *A Systematic Approach to Road Safety in Developing Countries.* INU63 Report. Washington, DC: The World Bank.

Clapham, Wentworth B, Jr. 1981. *Human Ecosystems.* New York, NY: Macmillan Publishing Co., Inc.

Department of Transport (UK). 1986. *Accident Investigation Manual.* London: Department of Transport.

Department of Transport (UK). *Traffic Signs Manual.* (Published Chapter by Chapter). London: HMSO.

Economic Commission for Africa. 1991. *Proceedings of the Second African Road Safety Congress in Addis Ababa, 16-20 October, 1989.* Oslo: Institute of Transport Economics.

Federal Highway Administration (FHWA). 1982. *Synthesis of Safety Research Related to Traffic Control and Roadway Elements. Two volumes.* Report No. FHWA TS-82-833. Washington, DC: DOT/FHWA.

Heggie, Ian G. 1987. *Transport and Environment: A Review of Current Policies and Procedures.* Discussion paper, Transportation Issue Series, Report No. TRP6. Washington, DC: World Bank.

The Institute of Highways and Transportation. 1991. *Urban Safety Management.* London: The Institute of Highways and Transportation.

The Institute of Highways and Transportation. 1990. *Guidelines for: The Safety Audit of Highways.* London: The Institute of Highways and Transportation.

The Institute of Highways and Transportation. 1990. *Highway Safety Guidelines: Accident Reduction and Prevention – International Edition.* London: The Institute of Highways and Transportation.

The International Bank for Reconstruction and Development. 1996. *Sustainable Transportation: Priorities for Policy Reform.* Washington, DC: The World Bank.

Kenya National Road Safety Council. 1990. *Manual on Accident Prevention Using Low-cost Engineering Countermeasures.* Nairobi: Ministry of Public Works; Finland: Ministry of Foreign Affairs.

Lee, James A. 1985. *The Environment, Public Health, and Human Ecology: Considerations for Economic Development.* Baltimore: The Johns Hopkins University Press (for the World Bank).

Listori, James A. 1995. *Environmental health in Africa – A Detailed Look at Sub-Saharan Infrasructure Projects, 1984-1994.* Washington DC: World Bank.

Local Authority Association (UK). 1989. *Road Safety: Code of Good Practice.* London: Association of Country Councils.

National Association of Australian State Road Authorities (NAASRA). 1988. *Guide to Traffic Engineering Practice: Part 4 – Road Crashes.* Sydney: NAASRA.

Organization for Economic Cooperation and Development. 1990. *Integrated safety management in urban areas.* Paris: OECD.

Organization for Economic Cooperation and Development. 1979. *Traffic Safety in Residential Areas.* Paris: OECD.

Organization for Economic Cooperation and Development. 1977. *Hazardous Road Locations: Identification and Countermeasures.* Paris: OECD.

PADECO Co., Ltd. 1995. *Non-Motorized Vehicles in Ten Asian Cities: Trends, Issues, and Policies.* Report TWU20. Washington, DC: World Bank.

PADECO Co., Ltd. 1993. *Non-Motorized Vehicles in Asian Cities, Part II, Technical Guidelines; Final Report.* Washington, DC: World Bank.

The Swedish Road Safety Office. 1987. *Report No. 3: Traffic Education and Traffic Environment.* Borlänge: Swedish National Roads Administration.

The Swedish Traffic Safety Group. 1983. *Road Safety in Developing Countries.* Stockholm: SVTI/SWEROAD/SWECO.

Southern Africa Transport and Communication Commission (SATCC). 1987. *Organizing Road Safety Work in Southern Africa.* Oslo: The Institute of Transport Economics.

Transport and Road Research Laboratory. 1989. *Microcomputer Accident Analysis Package.* Crowthorne: Overseas Unit Leaflet, Transport and Road Research Laboratory.

Transport and Road Research Laboratory, Overseas Development Administration. 1991. *Towards Safer Roads in Developing Countries. A Guide for Planners and Engineers.* Crowthorne: Transport and Road Research Laboratory.

World Health Organization. 1989. *New Approaches to Improve Road Safety.* WHO Technical Report 781b. Geneva: WHO.

18. Environmentally sound construction and facility management practices

HOW TO USE THIS CHAPTER IN THE CONTEXT OF EA AND ROAD PLANNING

Stage in road planning (A)	EA activity (B)	Involvement in addition to EA team (C)
	Screening	
	Scoping	Proponent
Concept	Consultation	Key regulatory agency
Pre-feasibility	Determining baseline conditions	Other government agencies
Feasibility	Selection of preferred solution	NGOs
Engineering design	Assessment of alternative designs/methods	Research groups
Construction	Development of environmental management plan	Public/community organizations
Operation & maintenance	Effects and compliance monitoring	Advisory experts
	Evaluation	
	Reporting	

Shaded area = (A) Stages of EA covered in this chapter; (B) focus of this chapter; and (C) primary target readers.

KEY QUESTIONS ADDRESSED:

- **?** What are the major road construction activities that can lead to potentially serious impacts?
- **?** What are some useful actions that can be planned to prevent construction impacts from occurring?
- **?** How should environmental clauses in construction and facility management contracts be prepared?
- **?** What are some key environmental risks associated with road projects, and how can they be avoided?

Direct impacts of road projects can often be significantly reduced and sometimes eliminated through the application of environmentally sound construction and operations management practices. For such actions to occur, two basic conditions need to be in place:

i) a knowledgeable construction and operations management team, which is sensitive to environmental issues; and
ii) an enabling environment where regulatory agencies and government planners look for and encourage sound resource use.

This chapter discusses environmentally sound construction practices, as they apply to new, rehabilitation and maintenance road projects. Readers should refer to the technical chapters (Chapters 7-17) for information on specific impact areas.

Knowing at which stages specific types of impacts are likely to occur, and the best time to apply corresponding measures to deal with them, is crucial to the effective limitation of negative impacts. Table 18.1 outlines the major impact areas and the relative efficiency of dealing with them at certain project phases.

18.1 NEW CONSTRUCTION PROJECTS

18.1.1 Settings and impacts

The main project activities associated with road construction, their likely impacts on the environment and suggested mitigative measures are presented in this section of the chapter. It is clear from Table 18.1 that implementation of mitigative measures during the project construction phase will yield the greatest benefits.

Construction camp establishment

Construction camps include workers' living and eating areas, and the grounds where equipment is stored and serviced and where materials are stockpiled. Careless construction camp design and management can lead to serious environmental degradation including

- sewage and garbage pollution;
- depletion of fauna and flora through illegal harvesting (poaching);
- infrastructure overloading—health services, sewage treatment, schooling and law enforcement; and
- spills from construction equipment operation and servicing.

Traffic disruptions may also be created by carelessly planned detours and road closures. In some agricultural areas, closures can create additional problems during harvest seasons. The temporary settlements built for construction workers can have significant impacts (some positive) on local economic activities and resources. For major projects, work-site accommodations are often like makeshift towns,

TABLE 18.1
BENEFITS GAINED FROM IMPLEMENTING MITIGATIVE MEASURES AT THREE KEY PROJECT DEVELOPMENT STAGES

	Development stage		
Component of the environment	*Construction*	*Rehabilitation and maintenance*	*Added value of operational changes*
Soil and erosion	+++	++	+
Water	+++	++	++
Air quality	++	+	+++
Natural environment	+++	++	++
Community life and economic activities	++	++	+++
Land acquisition and resettlement	+++	+	-
Indigenous or traditional peoples	+++	+	++
Cultural heritage	+++	+	+
Aesthetics and landscapes	+++	+	-
Noise	++	++	+++
Road safety	++	++	+++
Environmental health	+++	+++	+++

Note: +++ Excellent gains for resources expended. ++ Good cost efficiency. + Limited cost efficiency.

usually autonomous and difficult to integrate into the surrounding social environment.

Equipment servicing and fueling

On large road projects, thousands of liters of diesel fuel and many other petroleum products are transported and used throughout the work site each day. Experience shows that, without a fueling and servicing protocol as part of the project's Environmental Management Plan (see Section 4.8), chronic oil product pollution often takes place, leading to the contamination of surface and ground water. This is of particular concern where road projects involve crossing rivers and streams, since the construction activity sometimes takes place in and over the water body. If such waters are used for fishing or aquaculture, fish tainting can become a serious problem. Designated fueling areas and servicing centers significantly reduce this potential impact. Construction equipment generates large amounts of waste oil, and its proper handling is critical, since haphazard storage and leakage can result in the contamination of groundwater aquifers.

Site preparation and clearing

Site preparation may involve demolition of buildings, clearing of brushwood, tree removal, temporary rerouting of utilities, topsoil stripping, and diversion or rechanneling of waterways. This brings risks of erosion of exposed ground or stored topsoil, and increased water runoff and siltation of watercourses. The use of herbicides to eliminate vegetation on the right-of-way is a potential source of contamination. The use of heavy equipment on steep slopes to clear construction corridors can result in serious compaction and erosion problems.

Earthworks

The removal and placement of earth can bring further risks of soil erosion. Alignments through the upper parts of watersheds often encroach on groundwater aquifers, sometimes seriously affecting local groundwater recharge, well-water supply, and quality. Excavation that cuts into an aquifer, for example, can cause the water table to drop, disturbing the supply of water to nearby wells and modifying water availability to vegetation. In steep terrain, material taken from cuts is often simply pushed over the edge of the road bed, sometimes traveling hundreds of meters downslope, and in so doing permanently destroys trees and stream channels in the valleys below. Road projects around the world are replete with examples of how not to undertake earthwork activity. Construction machinery moving around the right-of-way can create soil compaction, which may harm the soil's future potential as farmland, impair drainage, and increase the risk of flooding. Slope protection and roadside planting measures are illustrated in Figures 18.1 and 18.2, and are discussed further in Section 18.1.2 and in Chapter 7.

Quarries and borrow sites

These facilities, which are the sources for road-building materials, can have substantial environmental impacts on soils, water, and the natural environment. Significant environmental problems can develop if these sites are not rehabilitated. Impacts range from chronic erosion and siltation to air quality and noise impacts during their use, as well as permanent visual and aesthetic intrusion if rehabilitation is neglected.

FIGURE 18.1
RELATIONSHIP OF GOOD ENVIRONMENTAL PLANNING AND MAINTENANCE PHASE

(A) Erosion occurs due to incorrect shaping of the subgrade and the failure to plan for runoff, plus insufficient upkeep.

(B) Correct shaping of the subgrade, careful compacting, plant coverage, and the installation of channeling help prevent erosion. Taking the environment into consideration avoids subsequent pavement maintenance costs.

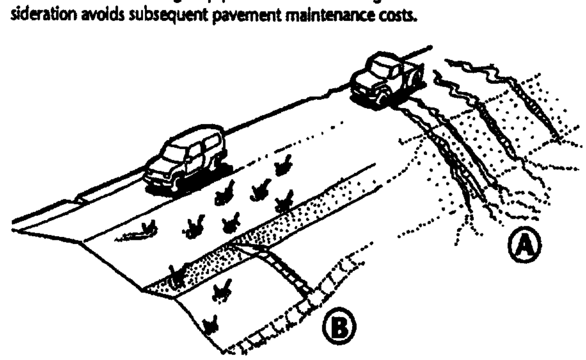
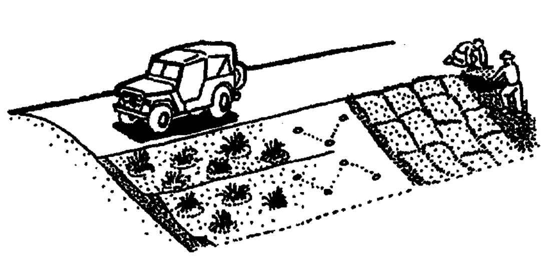


FIGURE 18.2
DIFFERENT TECHNIQUES FOR SLOPE VEGETATION RENEWAL



A basic technique: alternate rows of herbaceous plants

A sophisticated technique: laying of sod over a layer of top soil

Asphalt plant siting and operation
On larger projects, a temporary bitumen production plant or concrete batch plant is often constructed along the road right-of-way. Siting of these facilities should reflect the sensitivity of the area, and operation should not take place before site-specific limits have been established. Serious air, noise and water pollution can easily occur if this impact is not identified and if effective preventive measures are not taken.

Drainage works
Roads, as linear engineering features, often modify water flow and drainage patterns over wide areas, causing rising water levels, excessive drying, erosion and vegetation die-off. An understanding of hydrogeology and drainage patterns in the watersheds to be crossed, and of the placement of drainage structures such as culverts and porous materials, plus consideration of where cuts and fills have the least detrimental effects, can go a long way in alleviating serious and chronic drainage problems. The cost of ignoring or reducing efforts in this area can be exceedingly high later on during the construction phase, or during the operating life of the road.

Waste management
Construction crews, which on larger projects can exceed 1,000 people at any one time, may generate up to 3,000 kilograms of solid waste per day, and liquid wastes (sewage) of up to 60,000 liters per day. Uncontrolled and untreated, these wastes are major sources of pollution, disrupting the ecosystem and contributing to local (and sometimes much broader) health problems. The inclusion of these considerations in the EMP and the implementation of a waste management plan usually minimize this potentially costly impact.

18.1.2 Remedial measures

Impact avoidance, mitigation, and compensation options are discussed for three stages of the construction process: a) preparing the construction site; b) managing the construction activity; and c) restoring the site after completion of the road work.

Preparing the construction site
Many potential impacts may be avoided by taking preventive measures when setting up a work site. Careful siting of borrow pits, stockpiling areas, work depots, and work camps can avoid sensitive areas, reduce air and noise pollution, minimize visual intrusion, and help to prevent local traffic congestion. Confining the handling and use of hazardous materials at the construction site can go a long way in reducing the risks of accidental spills.

Management of construction activity and workforce
Construction activities that can contribute to serious environmental degradation include accidental spills, compaction of the area, poor waste treatment or management, and inadequate local services (such as law enforcement) to support the influx of construction workers. Well thought-out environmental construction guidelines (usually contained in an EMP) can effectively prevent these impacts.

Measures to prevent erosion are of major importance during the work phase, and can include

- planting on cleared areas and slopes immediately after equipment belonging to a specific site has been moved, and reusing stripped topsoil;
- temporarily covering the soil with mulch or fast-growing vegetation;
- intercepting and slowing water runoff; and
- protecting slopes by using reshaping techniques, rock fill, and other methods.

Dust problems can be avoided by watering[1] the site, following a predetermined schedule and as required. Construction noise problems can be minimized by using well-maintained and "silenced" equipment, operating within existing noise control regulations and limiting work hours near residential areas. Traffic control for both construction vehicles and diverted traffic should minimize impacts across the entire affected area.

Pollution from chemical products can be limited by following recommended procedures for containing and confining their use (e.g. bitumen production) and by not using them during extreme meteorological events such as high winds or rainstorms (monsoon weather).

Construction site rehabilitation
Site rehabilitation requires a well-designed planting program utilizing native vegetation where possible, with follow-up maintenance over several years and repairs as required. Quarries and large borrow sites can be landscaped and developed for a variety of natural, economic, or recreational uses. Work site facilities, such as wells, water storage, sewer systems, and buildings, are sometimes converted for local use upon completion of a project.

TABLE 18.2
CONSTRUCTION: MITIGATIVE MEASURES

Theme	*Observation*
Soils	• choose the best work period to limit risks of erosion—avoid rainy season • create a specific stockpile for topsoil to be reused • plan dialogue with local authorities for use of excess soil
Water	• do not locate site installations or production plants in sensitive places (e.g. near drinking water intakes) • provide a used motor oil recovery system • avoid water accumulation points, casual water from empty containers, old tires, etc., which act as mosquito breeding areas, i.e. provide good temporary drainage of site • provide sufficient settling for pollution from particles
Air, noise	• during work execution, noise impacts can be limited by using quiet equipment, installing temporary barriers or screens, and by working during regular business hours • limit dust with a sprinkler system • be careful when setting off explosives that can cause vibration damage
Flora and fauna	• limit clearing to surfaces absolutely necessary for the road project • control poaching and firewood collection by workers
Population, economic activities	• maintain access during work execution • enclose the work site with fencing for safety (especially to keep children away from heavy machinery) • plan specific itineraries for site machinery traffic • define traffic rules encouraging contractors to respect highway regulations
Risks	• plan emergency procedures in case of accidents, or spills of pollutants • define safety rules for work site personnel—dangerous materials handling, fires, etc.

Environmental features of road projects vary considerably, so common sense and ingenuity must be employed when examining each one. Environmental protection measures should be included in the specifications to the contractors, and may require special briefing or on-site training.

[1] In the past, waste oil was used as a cheap dust suppression material until road managers realized that runoff contaminated with waste oil affects the quality of local potable surface and groundwater water supplies, and reduces the health of local livestock. Rehabilitation costs are extremely high and often unsatisfactory. Waste oils should not be used for dust suppression.

BOX 18.1
EXAMPLES OF SIMPLE ENVIRONMENTAL CLAUSES IN CONTRACT SPECIFICATIONS

Installation of work site
The contractor shall submit the work site for inspection and shall define the facilities to be created.

The contractor shall limit disturbances to the environment for the site selected and for residents in the immediate vicinity, both in surface (clearing of brush or trees, water flow, waste storage) and in depth (rupture or pollution of ground water).

The contractor shall execute, upon work completion, all work necessary to restore the site. The inspector shall write up a report outlining the site reclamation prior to official delivery.

Preparation and supply of quarry material
During the work phase, the contractor shall

- preserve trees during materials stockpiling;
- level stripped materials to facilitate water percolation and make natural grass planting possible;
- restore the natural flow to its previous state; and
- create runoff recovery ditches and conserve access ramps, if the quarry is declared fit for use as a watering point for livestock or residents.

The contractor shall, upon work completion and at own expense, restore the environment around the site. A report will be submitted by the inspector certifying that such site restoration work has been completed.

Tree planting
The contractor shall plant trees at locations defined by the inspector, provide the recommended protection (clay brick wall, fencing, etc.), supply the required water and if necessary replace dead trees. The contractor shall provide complete maintenance for a period of one year after planting, including: watering, cleaning out the bed at the foot of the tree, etc.

The number of trees planted, along with the execution of protection and the digging of beds at the foot of the trees, will be noted down by the inspector on the site records.

This record will be used at the official delivery to evaluate the services actually rendered. Once road maintenance work has been completed, the contractor shall indicate on the itinerary map the planting carried out (position, number).

Table 18.2 organizes mitigative measures by theme, and Box 18.1 provides some simple examples of contract clauses. These are dealt with in greater detail later in this chapter.

18.2 MAINTENANCE AND REHABILITATION (M & R) PROJECTS

In many countries, an increasing share of land transportation budgets is being allocated to rehabilitation and maintenance of existing roads, rather than going toward new road construction. This section summarizes some of the environmental issues which may accompany these projects and broadly, how they can be mitigated.

18.2.1 Defining maintenance and rehabilitation

Routine maintenance refers to activities such as grading, grass cutting, drain clearing, pothole patching, and shoulder repairs, which are performed at least weekly, if not more frequently.

Periodic maintenance activities are typically scheduled over periods of several years and include resurfacing and bridge repairs. Other maintenance activities considered to be periodic include seasonal maintenance, such as snow clearing and flood repairs, emergency maintenance to reinstate roads after major failures, and the regular upkeep of safety features and road signs.

Rehabilitation involves more substantial intervention to strengthen a road, repair structural defects, and restore the road to its initial condition, often after it has deteriorated to an unmaintainable state. Rehabilitation sometimes also includes changes or improvements to previous characteristics; for instance, by widening, making small alignment changes, or providing footpaths.

18.2.2 Setting and impacts

As with other road construction activities, road maintenance and rehabilitation works can contribute to soil erosion, disturbance of water flows, chemical pollution, traffic disruption, noise, and other impacts on surrounding communities and natural life (Table 18.3). These are discussed in the previous section dealing with construction and off-site activities, and in earlier sections on specific impact types. Four issues especially relevant to this section are:

i) chemical pollution caused by herbicides used for weed control, the application of salt used in winter maintenance, and chemicals used in pavement stripping and resurfacing;
ii) waste materials from drain clearing, pavement reconstruction, and other activities disfiguring the landscape and finding their way into waterways;
iii) safety of road workers and other road users, sometimes put at risk by inadequate traffic management and work zone controls; and
iv) displacement of existing dwellings and businesses resulting from shoulder improvements and widenings.

Erosion, flooding, road accidents, traffic noise, and deteriorating landscape quality are examples of environmental impacts which may be commonly avoided by timely maintenance actions. An example of good management of runoff water is illustrated in Figure 18.1.

Grass and other roadside vegetation provide erosion protection by slowing flow and trapping suspended matter. Too much vegetation can be a safety and fire hazard.

In some intensively farmed agricultural areas, roadside environments provide important habitats for local wild plant and animal species. These can be preserved and enriched through appropriate maintenance actions. Maintenance work can also generate positive impacts by eliminating or reducing environmental problems caused by the deterioration of road surfaces, drains, and shoulders.

TABLE 18.3
EFFECTS OF MAINTENANCE ACTIVITIES ON THE BIOPHYSICAL AND SOCIOECONOMIC ENVIRONMENT

	Soil	*Water*	*Biota*	*Local population*
Paved roads				
Surface dressing (wearing course)	moderate	none	moderate	none
General reshaping of shoulders	moderate	moderate	moderate	moderate
Complete resurfacing of shoulder	moderate	moderate	moderate	moderate
Unpaved roads				
General resurfacing of wearing course	moderate	moderate	significant	moderate
Reshaping of sub-grade and reconstruction of wearing course	significant	moderate	significant	significant
Maintenance actions common to all roads				
Repair of drainage structures	none	moderate	moderate	none
Construction of drainage structures	moderate	moderate	moderate	none
Construction of concrete lined ditches	moderate	moderate	moderate	none

18.2.3 Mitigation

Perhaps the most important mitigative measure related to maintenance and rehabilitation projects is to ensure that maintenance measures, included in the road design, operate effectively.

Protection of the biophysical environment can be assisted by regular drain clearing, upkeep of vegetation on slopes and exposed surfaces, maintenance of flow speed reduction devices in drains, removal of waste materials arising from road works, and avoiding the use of herbicides and other toxic or polluting substances.

Impacts on the community and social environment can be mitigated through well-designed traffic management plans, the use of quiet equipment, operating during daily periods of high ambient noise (see Chapter 16), and focusing attention on improvements in the quality of signs, guardrails, footpaths, and other features which contribute to safety and local accessibility.

Environmental "hot-spots" or problem locations, such as easily-eroded sites or notoriously unstable slopes, can be identified during the VEC identification step and during the execution of rehabilitation and maintenance works.

Experts in roadside vegetation, traffic management, and transportation safety should monitor maintenance activities to ensure that work practices meet environmental objectives. Understanding the functions and techniques of roadside planting, signs, and guardrails is important for their proper functioning. Training road crews in these issues can help them considerably in correctly executing and managing maintenance works.

18.3 THE IMPLEMENTATION OF ENVIRONMENTAL REQUIREMENTS

Environmental requirements left as statements in an EA will rarely be implemented, unless local regulations specifically identify EAs as legally binding documents. Implementation of environmental requirements can be ensured by either attaching the EA report as a legal condition to all contract documents or by preparing a set of environmental clauses to be placed directly into the contract documentation.

Each environmental clause should contain at least four pieces of information specifying:

i) what needs to be done;
ii) where it needs to be done;
iii) when and how the action will take place; and
iv) who is responsible.

These data can be presented in the form of a matrix table (see EMP in Appendix 2) or in a more narrative style (Boxes 18.2-18.4). Ideally, well-prepared clauses combine the two forms, providing a written description with details presented in a table.

The overriding characteristic of an environmental clause should be that it is prescriptive, precisely defining what needs to be done and what the deadline is, leaving little room for misinterpretation. Ideally, environmental management plans (EMPs) should contain all the basic materials from which environmental clauses can easily be created. In fact, EMPs can be attached to contracts as binding implementable tasks.

Finally, the usefulness of environmental clauses in contracts will only be as good as the technical capacity and environmental sensitivity of the people assigned to implement the actions. Therefore, the investigation of contractors' and operators' past environmental record and experience should be another essential step in environmentally-sound project management.

18.4 ENVIRONMENTAL RISK

18.4.1 The failure of mitigative measures

The failure of environmental mitigation can result in serious impacts such as erosion, lowered water tables, permanent loss of wildlife, community severance, increased road accidents, and disruption of indigenous lifestyles.

Construction of a road also involves occupational health and safety risks to road workers, primarily in the areas of the storage and handling of dangerous materials, and in the operation of heavy machinery close to traffic, slopes, power lines, and watercourses. Some specific examples are:

- exposure to dust particles or toxic fumes from chemicals used in road works and materials testing;
- exposure to lead paint in maintenance of old steel structures;

- potential for collapse of trenches and scaffolding; and
- risk of accidents involving passing traffic.

Daily operation of road construction requires the transportation of hazardous materials which, if an accident occurs, can spill, resulting in polluted ground water, streams and drinking water, as well as contaminated soil.

Roads can also be the vector for involuntary transport of diseases or parasites by vehicles, plants animals and people (see Chapter 17), which can seriously affect the regional ecosystem.

Natural disasters can damage a road and its environment, or, conversely, a road can be a factor in mitigating the impacts of a disaster. Examples include:

- fire spreading along a road reserve, yet unable to cross a wide road;
- floods washing away a road, yet being somewhat contained by the road embankments;
- road embankments stabilizing a slope sub-

BOX 18.2
EXAMPLE CONTRACT CLAUSES FOR USE IN ROAD MAINTENANCE STUDIES

Documents to be submitted by the consultant

The maintenance works study document shall include the route plans, with the physical, geometric and geotechnical data, and the structures and drainage systems; the following complementary information on the road environment shall be specified in it:

Road environment data: Indication of land areas reserved for villages, classified sites, and wooded areas; existing tree plantations and areas suitable for such plantations; existing quarries and borrow pits (location, depth, surface area, water retention issues, site to be improved); positions of existing side and diverging ditches; areas suitable for construction of diverging ditches or laying-up basins.

Data on the state of the road and its deterioration: Location of eroded areas along the road: slopes, ditches, and approaches to structures; location of drainage areas which have become silted up; general state of structures; erosion or siltation of watercourses.

Special clause: Preparation of the content of the priced bill of quantities

The consultant shall establish the preliminary estimates of quantities and prepare the special conditions by (a) separating the opening and closing of quarries and borrow pits from the haulage and application of the materials; and (b) including the cost of a diverging ditch and, if necessary, a laying-up basin. The text that the consultant must include in the works contract is shown in italics.

Price no. x Preparation of materials at quarry or pit. The preparation of gravel materials at the quarry or pit (stripping, bulking, and piling) and the restoration of the pit site to its original state upon completion of the works shall comprise the following operations, remunerated at the price no. x:

* ....
* *storage of the stripped material where it will not disrupt water drainage*
* *restoration of the natural site around the pit by spreading out the heaps*
* ....

Price no. xx Reshaping/compacting with the addition of materials. The operations of loading at the pit, transportation (optional, because a transport price per tonne per kilometer can also be set) and application (reshaping, moistening, compacting) shall be remunerated at price no. xx, the quantities being measured after compacting. The consultant shall specify the volume of material, its position on the road, the final thickness and the source.

Price no. xxx Construction of diverging ditches. The price xxx shall remunerate the construction of diverging ditches designed to drain runoff from the roadway to a point where it will no longer be likely to cause erosion harmful to the road or to the environment. This price will be paid per lineal meter. The consultant shall define these diverging ditches by specifying their location along the road, technical characteristics, planned length, and minimum lengthwise slope. The consultant shall also propose diverging ditches that will enable flooding of old pits.

Price no. xxxx Construction of laying-up basins. The price xxxx shall remunerate the construction of diverging ditches designed to carry runoff from the roadway to an old pit. This price shall be paid per lineal meter. The consultant shall propose construction of the laying-up basins wherever the natural site is suitable, avoiding tree cutting. The consultant shall specify the dimensions, volume, and location of the basin with respect to the road and stipulations regarding protection of the environment.

BOX 18.3
EXAMPLE CONTRACT CLAUSES FOR USE IN ROAD MAINTENANCE SUPERVISION CONTRACTS

Article ... records to be kept by the consultant responsible for supervision
The consultant responsible for supervision shall keep the following records: site report; route report updated to record work done; and proposals with a view to future studies.

Site report. A monthly report on execution of the works shall be submitted by the consultant and shall summarize information regarding environmental improvements effected by the work performed during the month: steps taken by the contractor to preserve the environment and improvements observed upon closing down the site; trees planted (location, number, method of protection, maintenance, monitoring); data on quarries and borrow pits used (location, area, depth, improvements made); length of diverging ditches (partial and cumulative for all new and old ditches); position and volume of laying-up basins constructed; position of strengthening works carried out on approaches to structures.

Updating of route plans. The supervisor shall update the route plans, on which shall be shown all environmental data reported in the monthly reports, specifically: location of tree plantations; locations of quarries and pits used, with updated characteristics of each; location of diverging ditches; state of structures after sand removal upstream and downstream; location, type, and number of anti-erosion devices in the drainage system.

Proposals with a view to future maintenance studies. Once the work is completed, the supervisor shall propose, for the road sections covered, specific arrangements with a view to studying the subsequent maintenance program. These proposals shall cover: improvement of the contract environmental clauses; special features of the road environment; urgent tasks to be undertaken to improve the environment; and any comments of supplementary data regarding the state of quarries, pits, and drainage.

Special clauses

Article ... Supervision of utilization of quarries and borrow pits. The supervisor shall ensure proper utilization, by the contractor, of the quarries and pits designated by the detailed design with the aim of lessening the impact on the environment.

- Preparation of materials in the quarry or pit. The supervisor shall designate trees to be protected and oversee storage of stripped material where it will not hinder water drainage; the supervisor shall oversee restoration to a natural state, including spreading of stored stripped material to facilitate water percolation and natural replant growth.
- Volume of stocks of material stored in each quarry or pit.

Article ... Supervision of the construction and maintenance of drainage works. The supervisor shall specify location and technical detail of drainage works and debris placement.

- Construction of diverging ditches
- Construction of laying-up basins
- Cleansing of side ditches, diverging ditches, and summit slope and foot slope ditches.

Article ... Tree planting. The supervisor shall instruct the contractor where trees are to be planted and the type of protection to be provided. The supervisor shall ensure that the contractor makes provision for the water needed for the trees to grow, and promptly replaces any dead trees. The supervisor shall draw up a report stating the number and good condition of the plantings at the time of final acceptance.

ject to landslides, falling rocks, or avalanches; and

- access roads and traffic management plans specifically tailored to disaster response needs.

18.4.2 Mitigating environmental risk

The risk of failure of environmental mitigative measures is always a possibility which should be considered, but it can be reduced to some extent through

- strengthening staff skills and training in environmental management;
- ensuring management support for environmental policies and action plans;
- monitoring environmental actions and responsibilities and making provision for remedial actions; and
- planning for remedial measures in case initial planned actions are not successful.

Yet failures are still possible. For example, soil erosion may still occur even after preven-

BOX 18.4
EXAMPLE CONTRACT CLAUSES FOR USE WITH ROAD MAINTENANCE WORKS CONTRACTS

Special clauses

Article ... Work-site installations. The contractor shall propose to the supervisor the location of work site installations and detail proposed measures to reduce impacts on the environment of these sites and the people living in the immediate vicinity, as regards both the surface area used (clearing, brush and tree removal, drainage, trash dumping) and underground impacts (disruption or pollution of the water table). On completion of the work, the contractor shall do everything necessary to restore the sites to their original state. The supervisor shall draw up a report confirming the restoration before acceptance of the works.

Article ... Preparation and supply of gravel materials in pit or quarry. During works execution, the contractor shall ensure: preservation of trees during piling of materials; spreading of stripped material to facilitate water percolation and allow natural vegetation growth; re-establishment of previous natural drainage flows; improvement of site appearance; digging of ditches to collect runoff; and maintenance of ramps where a pit or quarry is declared a usable water source for livestock or people living nearby. Once the works are completed, and at own expense, the contractor shall restore the environment around the work site to its original state. The supervisor shall provide the contractor with a report confirming the restoration before acceptance of the works.

Article ... Cleaning of side ditches, diverging ditches, and summit slope or foot slope ditches. Debris shall be dumped upstream of the ditch at a sufficient distance from the roadside and spread with a counterslope, with respect to the ditch, to prevent surface water runoff from being polluted with fine materials.

Article ... Tree planting. The contractor shall plant trees in the locations fixed by the supervisor, with protection as specified (mud, brick walls, wire netting, etc.) and provision of the necessary water, and shall also remove any dead trees. The contractor shall take care of all required maintenance for one year from the time of planting, including watering, cleaning the area at the base of the tree, and maintaining protection in good condition. The number of trees planted with the installation of protection and the digging of a basin at the base of the tree shall be entered by the supervisor in the site record. This record will be the basis for payment for work actually done at the time of final acceptance. When the road maintenance is completed, the contractor shall enter the plantings made (position, number) on the route plan.

Article ... Documents to be furnished by the contractor. Upon completion of works the contractor shall provide the route plan with the work performed marked on it and also showing the environmental improvements made (description, location, numbers).

Priced bill of quantities (details as specified in Box 18.2)
Price no. x Preparation of materials in quarry or pit.
Price no. xx Reshaping/compacting with application of materials.
Price no. xxx Digging of diverging ditches.
Price no. xxxx Construction of laying-up basins.

tive measures have been included in the road construction program. This failure may be due to a lack of technical expertise or simple negligence. These risks need to be understood and anticipated, through the identification and repair of weaknesses in the environmental management plan.

Occupational health and safety risks of road works can be limited by clearly defining procedures for handling materials, conducting tests, paving, operating heavy equipment, and constructing trenches. These are sometimes defined in laws and regulations and, in an EA, are contained in the EMP as the *environmental construction guidelines.* Specific requirements and training may be needed to

- limit time of exposure to dust particles, chemicals, and noise;
- enhance safety and inspection procedures; and
- improve safe handling of toxic materials, explosives, and other hazardous substances.

The contractor's responsibilities to workers and the environment may be identified during pre-bid conferences, to ensure that potential bidders are aware of contract requirements and can submit proposals which adequately address the necessary tasks and their costs. This can minimize the likelihood of contractor defaults.

Transport of hazardous materials needs to be regulated and monitored, with possible restrictions on routes and time of travel to avoid the most populated places and busiest times. The clear marking of vehicles as to the type of material carried also reduces the risk of major spill damage by facilitating effective clean up. Many road agencies develop policies on hazardous goods movement, with specified transport restrictions, requirements on containers and labels, and special permits and police escorts for particularly hazardous materials.

Involuntary transport of diseases or parasites is generally managed by signs and checkpoints which restrict the transport of contaminated fruits or other plant materials and livestock in areas affected by specific plant or animal disease problems.

Natural disaster mitigation has two aspects of interest to road managers:

i) It should take into account possible rare disaster events and incorporate steps to minimize their impacts. Firebreaks, fire access roads, avalanche control measures, and flood reduction measures such as floodways and spillways, are examples of design features commonly used to mitigate known problems which affect particular routes.

ii) It should involve the road agency to ensure that key roads can be kept open or reopened as quickly as possible, and that traffic diversion can be implemented as needed. Simple recording of disaster response measures and responsibilities, and regular training and dissemination are important to the success of disaster mitigation.

18.5 REFERENCES AND BIBLIOGRAPHY

Asian Development Bank. 1990. *Environmental Guidelines for Selected Infrastructure Projects.*

Cete Ouest. 1984. "Impact of Road Works on the Environment" (in French). Nantes, France.

France, Ministry of Cooperation. 1992. "Roads in Tropical and Desert Zones" (in French, 3 volumes). Paris: BCEOM, CEBTP.

Ontario Ministry of Natural Resources. 1990. *Environmental Guidelines for Access Roads and Water Crossings.* Toronto: Queen's Printer and Publications Ontario

Sinha, K.C. et al. 1991. *Environmental Assessment of Land Transport Construction and Maintenance.* (Draft prepared for World Bank Infrastructure and Urban Development Department). Washington, DC.

Tarrer, A.R. 1993. "Impacts of Environmental Regulations on Highway Maintenance." *Transportation Research News* 167. Washington, DC: Transportation Research Board.

United Nations. 1982. *Road Maintenance Manual. Vol. 1: Maintenance of facilities, drainage structures and signs. Vol. 2: Maintenance of unpaved roads.* Cologne, Germany: Economic Commission for Africa, BCEOM, LCPC, CEBTP.

US Department of Labor. 1991. *Construction Industry Digest.* Washington, DC: Occupational Safety and Health Administration.

19. Economic valuation of the impacts of road projects on the environment

HOW TO USE THIS CHAPTER IN THE CONTEXT OF EA AND ROAD PLANNING

Stage in road planning (A)	EA activity (B)	Involvement in addition to EA team (C)
	Screening	
	Scoping	Proponent
Concept	Consultation	Key regulatory agency
Pre-feasibility	Determining baseline conditions	Other government agencies
Feasibility	Selection of preferred solution	NGOs
Engineering design	Assessment of alternative designs/methods	Research groups
Construction	Development of environmental management plan	Public/community organizations
Operation & maintenance	Effects and compliance monitoring	Advisory experts
	Evaluation	
	Reporting	

Shaded area = (A) Stages of EA covered in this chapter;(B) focus of this chapter; and (C) primary target readers.

KEY QUESTIONS ADDRESSED:

? What is the particular contribution of the economic valuation of environmental impacts to the road planning process?

? What are the key policy considerations that shape the valuation process?

? What is required procedurally to enable the valuation process to be effective?

? What are some of the more common techniques available to road planners for measuring the economic value of project impacts on the biophysical and social environments?

19.1 ECONOMIC VALUATION OF ENVIRONMENTAL IMPACTS (EVEI)

19.1.1 The fundamental problem

There are three basic questions confronting the planner:

i) Is the *proposed solution* to the perceived transport problem worth pursuing?
ii) If so, is the *route* selected the most beneficial taking into account all its impacts?
iii) Is the *design*, on balance, the most beneficial taking into account all of its impacts?

Building new roads, rehabilitating existing roads, and upgrading road infrastructure all involve the use of economic resources; yet all may involve environmental side-effects in the process of generating mobility benefits. In EA the impacts of road development activities on the biophysical and socio-economic environment are predicted and measured in physical terms. The problem confronting society in general and the road planning agency in particular is how these non-market, unpriced, effects should be taken into account in the design and decision-making process.

19.1.2 Alternative institutional approaches

There are several different ways of confronting this problem. In some countries separate economic and environmental appraisals are undertaken, with the results of the two (and of other issues such as social and distributional effects) brought together in a public enquiry or consultation process. No formal weights are attached to the different dimensions of impact and the outcome is determined on the situation-specific perception of the balance of the arguments presented. In other countries a more formal attempt is made to combine effects through some form of multi-criterion analysis, with weights which are predetermined for a particular period or decision category, but which may be altered from time to time. A third approach, considered in this chapter, is to attempt to establish monetary values for unpriced environmental impacts—as is commonly done for the valuation of time savings—in order to address the economic consequences of decisions on the environmental effects of road projects. More specifically, this approach attaches prices to the impacts imposed, and hence treats environmental damage as a resource cost and environmental improvement as a resource gain within a conventional cost-benefit analysis framework.

19.1.3 The cost-benefit evaluation format

The basic approach in cost-benefit analysis is to measure and add together all benefits and costs, irrespective of the form in which they appear or to whom they accrue, in a format which will be acceptable and easily understandable by decision-makers. The three most common ways of doing this are the calculation of the net present value of a project, calculation of the internal rate of return, or calculation of the benefit-cost ratio. The nature and use of these indicators is described in Box 19.1.

The discount rate

Benefits and costs which arise at different points in time must be added together in any of the basic evaluation . The discount rate is the means of converting impacts arising over time into a common "present value".

The higher the discount rate the less account is given to the future environmental benefits. The discount rate may be derived in a number of different ways. Dixon and Hufschmidt 1986 identify three: a) the opportunity-cost-of capital method; b) the cost-of-borrowing-money method; and c) the social rate of time preference method, which involves relation of over-consumption at present to conservation for the future and consideration of what that means in the present. The dilemma facing politicians is that the efficient allocation of scarce capital for all investments is likely to suggest higher discount rates than would seem to be appropriate for planning very long life investments in environmentally sound development. In reality discount rate is, and in fact should be, chosen based on an informed political decision.

BOX 19.1
ALTERNATIVE FORMATS FOR COST-BENEFIT APPRAISAL OF PROJECTS

Net Present Value (NPV)

The most widely used measure in project analysis is the *net present value* (NPV) of a project. Also known as net present worth, the NPV is obtained by discounting the streams of benefits and costs back to the beginning of a base year at a prespecified discount rate. If budgets are unconstrained at the given discount rate the test of project acceptability is that the NPV is positive. If budgets are constrained at the specified discount rate the test of acceptability is that the ratio of net present value to capital cost exceeds a threshold determined as the minimum present value to capital cost ratio defining a set of projects just exhausting the budget.

Internal Rate of Return (IRR)

The *internal rate of return* (IRR) is that discount rate which will equates the present value of benefits and costs. If budgets are unconstrained the test of project acceptability is that the IRR exceeds the cost of capital. If budgets are constrained the test of acceptability of a project is that the IRR exceeds a threshold determined as the minimum IRR requirement defining a set of projects just exhausting the budget.

Benefit-Cost Ratio (B/C)

The *benefit-cost ratio* (B/C ratio) is a simple derivative of the net present value criterion comparing the discounted benefits with discounted costs. If budgets are unconstrained the test of project acceptability is that the ratio should exceed 1. If budgets are constrained the test is that the B/C ratio should exceed a threshold determined as the minimum B/C requirement defining a set of projects just exhausting the budget.

Adapted from: Dixon and Hufschmidt, 1986.

19.2 EVEI IN THE CONTEXT OF PUBLIC INVOLVEMENT[1]

The answers to the three questions raised in Section 19.1 should obviously reflect social priorities. Whatever approach is adopted two things are clear:

- Where both economic benefit and environmental impacts are involved reaching a decision inevitably involves some implicit judgment about the rate at which they are being "traded off."
- For large projects, with significant environmental impacts, the decision will almost certainly involve some ultimately political judgment.

Public involvement (consultation and communication with various interested groups) is the key to building concensus about social priorities and has been recommended as an integral part of the EA process throughout this handbook. Attempts to secure concensus, however, are rarely easy, not only because one is essentially dealing with (environmental) impacts on which there may be a wide range of social attitudes but also because the mobility gains and the environmental losses may be very differently distributed. The design of institutions and processes to attempt to build that concensus can only be undertaken in the context of the relevant national cultural and political heritage. Chapter 5 presents some of the methods which can be used to promote effective public involvement at various stages of the project cycle. The purpose of the information that is prepared and presented by planners is thus to inform the judgement of decision-makers; it can very rarely be a complete substitute for it.

Despite this "fuzziness" about the relationship between technical appraisal and either political or consultation and concensus building processes, it may be helpful to quantify the decision elements in monetary terms for two reasons:

- Prior agreement on some general conventions of monetary appraisal, independent of any specific project, may allow subsequent discussion of funda-

[1] Public is referred to here as those who are within the geographic and political area affected by the proposed project.

mental distributional issues to be more clearly focused.

- Because gainers and losers are frequently also taxpayers, an indication of the money costs involved in avoiding or recouping specific environmental impacts may be of help in informing personal as well as political judgments of what is worth doing.

19.3 PROCEDURAL CONSIDERATIONS

19.3.1 Some prerequisites

Before commencing a valuation, the valuation team will require certain information. Assuming that the environmental assessment was thorough, it should provide the team with the following data:

- a list of impacts, and the valued ecosystem components (VECs) that will be affected for each road alignment and design under consideration. The identification of VECs in the biophysical and socio-economic environments, and associated indicators, is discussed in Section 3.2.3;
- the geographic scale, duration, intensity and reversibility of each impact;
- the geographic boundaries of the project, as determined by the area over which the impacts on the economic, social and biophysical environments are manifest;
- the temporal boundaries of the project, as determined both by the duration of the project—from the start of construction to the end of its operating life—and by the condition of the area affected by the project and the capacity of the human and natural ecosystems within that space to recover from any disturbances introduced by the project; and
- information on the changes that can be expected, over the geographic area of each project alternative considered, as well as the "no-project" future. The information should cover those changes expected in the biophysical as well as the socioeconomic environments. The attention given to this information reflects the recognition that project-induced change would not be the only change to occur if the project were to go ahead. This helps to clarify the impacts that are attributable to the project and that have to be valued in economic terms.

19.3.2 Choosing a valuation technique and scheduling the procedure

The selection of the valuation technique will be influenced by

- the effect to be valued;
- the information available;
- the time and financial resources available; and
- the characteristics of the techniques available.

The techniques that are commonly used in, or that readily lend themselves to, the valuation of environmental impacts in economic terms are discussed in turn in Sections 19.4 and 19.5. In Table 19.1 these techniques are identified against the applicable common environmental impacts discussed in this handbook. Although only negative impacts have been listed, the EVEI process should also address positive impacts. As is clear from the table, there are generally a range of techniques available for valuing any one impact. More often than not, it will be necessary to utilize several techniques on a particular road project. It may also be desirable to try different techniques on an impact in order to come up with a value that appears to be a reasonable measurement of the potential benefit or cost.

The techniques identified in Table 19.1 are those most likely to be feasible for road projects in developing countries. The list does not claim to be exhaustive. There are other techniques that are not included here either because of the conditions they require (for example the wage-differential approach, which requires very competitive labor markets) or because of the complexity of the data and their analysis (for example various macroeconomic modeling approaches). The intent is to provide the user of this handbook with a sense of what is involved in conducting an EVEI.[2]

[2] In the following section liberal use (sometimes in the form of direct quotations) is made of materials from a number of World Bank and other publications. These are fully referenced in Section 19.6 of this chapter. They are: Dixon et al (1988), Munahsinghe (1993), Serageldin & Steer (1993), and World Bank (1991).

In scheduling the procedure, one should be guided by the simple rule of starting with the most obvious and direct impacts that can be measured in terms of market prices. This will generally involve the use of what is called the changes-in-productivity approach. One then works through to the more complex impacts that may require the use of more sophisticated techniques such as contingent valuation.

19.4 COMMON VALUATION TECHNIQUES

19.4.1 A valuation typology

There are several different ways in which valuation can be approached, the most appropriate choice depending largely on the nature of the environmental impact concerned. The techniques can be grouped into five main classes, namely:

i) direct valuation approaches;
ii) surrogate market approaches;
iii) preventive expendituresapproaches;
iv) replacement cost approaches; and
v) contingent valuation approaches.

19.4.2 Direct valuation approaches

Direct valuation approaches assume that an environmental impact will affect the actual production or production capability within the study area boundaries.

DVAs are the most widely applied valuation approaches, since they are based on more directly observable values than those of intangibles derived by inferences from more complex behavior observations. However, when dealing with ecological and social impacts, these approaches must be used with great caution, since they can oversimplify the impacts by representing them as simple direct economic consequences. Environmental[3] specialists should prepare the precise definitions of impacts to avoid any significant undervaluation of the impacts.

There are generally three subgroups of DVAs:

i) those that directly value changes in outputs of economic assets (the change in productivity approach);
ii) those that value the physical assets lost in terms of potential market value (the opportunity cost approach); and
iii) those that address impacts which affect people's outputs in terms of lost earnings.

Change in productivity approach

Development projects can affect production and productivity in positive or negative ways. For example, a land management project employing soil conservation measures may yield increased agricultural output. The incremental output can be valued by using standard economic pricing.

An empirical example of the changes in productivity approach is a road project in Nepal, where road cuts were not stabilized. This caused siltation and landslides and affected safety as well as agricultural productivity. These physical changes in productivity could be measured in terms of reduced income from the affected fields.

Opportunity cost approach

In the case of a road project, this approach could be used to place a value on land or other resources that, until the time of the proposed road project, had been used for an unpriced or unmarketed purpose (such as a park, a mangrove reserve or a heritage property). The value is arrived at by calculating the income that could be derived from using the land or other resources for some market-based purpose. This represents the opportunity foregone. The opportunity cost is therefore a way of measuring the cost of preservation, by simulating the gains which could have been achieved by using the resources. These data can then be used in a standard cost-benefit analysis to establish whether the economic cost of not using or changing a resource is acceptable in light of the benefits. Since new roads generally require the use of land, this technique helps to identify the cost of preserving one area over another, and is therefore useful in site or alignment selection.

Loss of earnings approach

This approach may be relevant, for example, when considering road and industrial plant

[3] Including biophysical and social components.

safety, or projects that affect air pollution in major cities. Changes in environmental quality can have significant effects on human health. Ideally, the monetary value of health impacts should be determined by an individual's willingness to pay for improved health. In practice, "second best" techniques may be necessary, such as valuing earnings that are foregone through premature death, sickness or absenteeism, and increased medical expenditures. The approach is also known as the "value-of-health," "human capital" or "foregone earnings" approach

In the case of an increase or reduction in the number of deaths, a first estimate is made by evaluating the projected loss of earnings of the individuals involved.

19.4.3 Surrogate market approaches

If the impacts cannot be measured as direct losses or gains to VECs (for example, reduction in mangrove area due to road alignment); or if the impact on a receptor cannot be directly costed, indirect or surrogate market value can be substituted in calculating the cost of the impact. Surrogate market value approaches assume that necessary indirect cost data have been established at some time and can be applied. The three most commonly-used SMV techniques are:

i) the property value approach;
ii) the land value approach; and
iii) the travel cost approach.

Property value approach

This approach, also referred to as the "hedonic price technique", is used to determine the implicit prices of specific characteristics of properties. When used in dealing with environmental issues, its purpose is to place a value on improvements or deterioration in environmental quality.

The property value approach has been used to analyze the effects of air pollution in certain areas. Where pollution is localized, the method can be used to compare prices of houses in affected areas, with prices of houses of equal size and similar neighborhood characteristics elsewhere in the same urban area.

In a rural context the technique could be used to put a value on the deterioration of the aesthetic qualities of a landscape, as a result of a new road cutting across that landscape. A weakness of this approach is that a large number of variables influence property values. In particular, increases in accessibility to transport networks may be highly correlated with reductions in environmental quality.

Land value approach

This is a variant of the property value approach mentioned above. In confining the measurement to the value of open land, without improvements, one reduces the number of variables that need to be considered in order to arrive at a value for unpriced features (such as the aesthetic qualities of a view).

Travel cost approach

The time and money expenditures that people are willing to make in order to access a park or recreational facility may be viewed as a lower bound estimate of the value of that facility, and hence of the cost to society if a road project directly damages such a facility. This approach is very difficult to apply in practice, however, as a road may typically infringe on, but not totally destroy the facility. The appropriate valuation of the loss under this formulation would then be the reduction in the amount of access costs which in aggregate people would incur to access the impaired facility, which might be very difficult to estimate ex ante. Moreover, for many recreational trips the access journey itself might be part of the benefit rather than a pure cost, so that the appropriate part to attribute as the value of the facility would be difficult to determine.

A less contentious application of this approach might be to cases where roads create new barriers within communities. In such cases a travel time loss approach might be applied to the non-vehicular movements which had been disturbed or truncated as an estimate of the loss due to community severance.

19.4.4 Preventive expenditures approach

This approach, also known as the "mitigative expenditures" or "defensive expenditures" approach, is based on the observation that individuals, firms and governments are often prepared to spend money in a variety of ways in order to avoid or reduce unwanted environmental effects. Such expenditures, if actually made, would indicate that individuals, firms or governments judge the benefits greater than the costs. On this basis, hypothetical preventive expenditure estimates can then be interpreted as a minimum valuation of benefits. A case example which illustrates this concept can be found in Box 19.2.

A major drawback of this approach is that it incorporates a minimum valuation of the environmental impacts in the cost benefit calculation even in circumstances where the preventive expenditure is not actually undertaken. In these circumstances the *actual* disbenefit will be greater than that *imputed* in the calculations. This both distorts the allocation of resources between projects and redistributes welfare between individuals suffering the environmental impacts and those gaining the mobility benefits.

It may therefore be thought advisable to adopt the "preventive expenditure" approach only when a standard is applied requiring actual preventive action to occur (see Section 19.5). But in those circumstances the costs are internalized in the project costs. If the standard set is such that there is no residual environmental impact there is no need for any further evaluation of it. Where the standard is less rigorous than that, there is still a need for some value to be given to the residual impacts after mitigation.

BOX 19.2
CASE EXAMPLE OF PREVENTIVE EXPENDITURES CONCEPT IN LAOS

During the environmental assessment of the Pakse Bridge project, which involved the construction of a second bridge across the Mekong River between southern Laos and Thailand, it was found that the bridge approach road and the storm drainage from the bridge deck had been (for economic and engineering reasons) designed to be within 120 meters of the local municipal potable water intake. To address this potentially serious risk of contamination, the bridge location was moved a further 100 meters upstream, and a controlled storm water drainage system was planned for the bridge deck near the water intake. The costs involved in making the changes could be considered preventive expenditures, and were far below potential costs had a spill contaminated the water treatment plant.

Source: JICA, 1996

19.4.5 Replacement cost approaches

This approach involves estimation of the costs that would be incurred in replacing an asset, if it were to be damaged or lost altogether. These costs are interpreted as an estimate of the benefits that can be presumed to flow from the measures taken to prevent that damage from occurring. Although the rationale for the approach is similar to that of the preventive expenditures approach, in this case the estimate of the replacement cost is not based on a subjective evaluation of the potential damages to be avoided but, rather, on the true cost of actual replacement. Used in conjunction with the preventive expenditures approach, it allows one to calculate whether it is more efficient to let damage occur and then repair it, or to prevent it.

This approach is generally used to value impacts involving permanent or serious losses, such as the destruction of productive farmland, or the removal of trees required in the building of a road through a bio-reserve or forest. Three common variants of this approach are

i) the direct asset replacement cost approach;
ii) the relocation cost approach; and
iii) the shadow project approach.

Direct asset replacement approach

The replacement costs approach has been used to estimate the benefits of erosion prevention measures by calculating the cost of the fertilizer that would be needed to replace the nutrients lost through soil erosion. In this example, the method applies only if, in the absence of erosion control measures, the fertilizer would actually be used.

Relocation cost approach
This is similar to the direct asset replacement approach except that the actual expense of physically relocating a facility is used in the benefit-cost estimation. In the context of roads, this approach would be useful in cases where relocation of businesses too close to the right-of-way is necessary. Another example would be the cost of moving a residential water supply facility threatened with pollution by run-off from a new road.

Shadow project approach
Used for evaluating projects with a large number of negative environmental impacts, this approach involves the design and costing of one or more hypothetical 'shadow projects' that would provide substitute environmental goods and services to compensate for the loss of the original assets. This is a special type of replacement costs approach; it is used when one wishes to evaluate the entire range of environmental goods and services threatened by a project, and when their benefits are difficult to value. By including the shadow project costs in the calculation of the total costs of a project one has an indication of how great the benefits of the project have to be in order to outweigh the losses. Given these characteristics, the approach is being discussed increasingly as a way to put the concept of sustainability into practice at the project level. It assumes a constraint for maintaining environmental capital intact, and could therefore be most relevant when "critical" valued ecosystem components are at risk.

19.4.6 Contingent valuation approach

Contingent valuation methods (CVMs) are applied when data on costs cannot be generated or where value is not easily tangible, as in the case of visual intrusion. The CVMs rely on survey data from which values are inferred.

This approach, also known as the "hypothetical valuation" approach, is particularly valuable in the absence of market information about people's preferences. Thus it often proves useful in valuing such attributes as species preservation, historical or cultural phenomena, and genetic diversity, as well as the preservation of open spaces, unobstructed views, or public access to amenity resources.

There are actually five distinct contingent valuation methods that can be used for road projects. They are a) bidding games, b) take-it-or-leave-it experiments, c) trade-off games, d) costless choice, and e) delphi techniques. They are not elaborated on separately here.[4]

Each method tries to identify people's preferences by asking direct questions about what they are willing to pay for a benefit, and/or what they are willing to accept as compensation for tolerating a disbenefit. Thus, unlike market and surrogate-market techniques, where estimates are based on observed behavior, these methods infer what an individual's behavior would be, from the answers given. Another distinctive characteristic of this approach is that while most of the previously described techniques examine changes in the quality of the environment in aggregated form the contingent valuation methods start with the individual perception of the change. Once values for a representative set of people have been determined, they are aggregated to a total value directly dependent on the number of individuals affected.

This process of asking may be undertaken either through a direct questionnaire or survey, or using role-playing techniques in which subjects respond to various stimuli in 'laboratory' conditions. What is sought are personal valuations, by the respondent, of increases or decreases in the quantity of some good, contingent upon a hypothetical market. Willingness to pay is constrained by the income level of the respondent, whereas willingness to accept payment for a loss is not constrained. Experience shows that willingness to accept tends to be several times greater than willingness to pay.

While the contingent valuation methods have several shortcomings, most notably with regard to the difficulties in structuring the surveys, experience in both developing and industrialized countries has shown that with careful design they are reliable and economic sources of social valuations.

At the same time, by considering a broader range of external costs than normal, this approach helps society to respond to the challenge of valuing the environment, as

[4] A useful overview can be found in Dixon et al, 1988.

posed in Section 19.1, and thus become more aware of what is required to move towards sustainable development.

19.5 ALTERNATIVE ECONOMIC FORMAT

19.5.1 Cost effectiveness analysis approach

Where data are particularly poor, or where the benefits are particularly difficult to measure in monetary terms, economic considerations may be limited to that of a cost-effectiveness analysis. This involves the setting of some goal or target (such as maximum air pollution levels, or maximum land-take levels for new roadways), and the subsequent assessment of the capital and operating cost implications of reaching that goal, via a number of alternative routes or designs. The approach does not monetarize benefits, but simply calculates the cost of alternative ways of reaching the set goal.

The issue which confronts the designer in situations where clear standards of environmental acceptability are set is to find the most cost effective way of managing the impacts without making the whole project economically unviable. While, in principle, the standards themselves should be subject to economic appraisal (it would be senseless to set a standard that was so high that meeting it involved costs which everyone would agree to be putting an unreasonably high price on the effect) the standards approach does also enable some concept of "equity" or reasonable burden to be built in to the procedures.

TABLE 19.1
SUMMARY OF ROAD PROJECT ACTIONS, THEIR COMMON ENVIRONMENTAL IMPACTS AND SUGGESTED ECONOMIC VALUATION TECHNIQUES

Key to Measurement and Valuation Approaches

1. Changes-in-productivity approach
2. Opportunity cost approach
3. Loss-of-earnings approach
4. Property value approach
5. Land value approach
6. Travel cost approach
7. Preventive expenditures approach
8. Direct asset replacement cost approach
9. Relocation cost approach
10. Shadow project approach
11. Contingen valuation approach
12. Cost effectiveness analysis approach

Chapter No.	Project Type and Action Affecting Environment	Environmental Effect (negative only)	Valuation Techniques 1	2	3	4	5	6	7	8	9	10	11	12
	Road Rehabilitation Projects													
	Construction stage													
7,10,18	Removal of vegetative cover	• habitat degradation	X									X		
		• species loss		X										
7, 8,18	Exposure of soil to erosion	• downstream water quality reduction	X						X					X
7, 8, 10,18	Poor quality cut and fill operations	• landslides							X	X	X			X
		• waterway blockages	X											X
		• habitat loss	X											
		• species degradation		X									X	X
8, 10, 18	Interference with surface and ground water hydrology	• reduced water supply	X											
		• excessive water blockage or drainage	X	X										X

TABLE 19.1 continued...

Chapter No.	Project Type and Action Affecting Environment	Environmental Effect (negative only)	Valuation Techniques 1	2	3	4	5	6	7	8	9	10	11	12
9, 16, 18	Faulty construction materials handling • bitumen • aggregate • concrete	• degraded air quality											X	X
		• increased noise											X	X
		• increased odors											X	X
8, 17, 18	Work-camp operations: • liquid and solid waste mismanagement • over-use of local services	• reduced water quality	X						X					X
		• increase in bacterial diseases (for example dysentery)			X				X					X
7, 8, 17, 18	Construction equipment operation and servicing • inadequate petroleum product handling • inappropriate operating schedule	• water and soil contamination	X						X					X
		• tainting of food			X				X				X	X
5,12	Land acquisition and resettlement • removal of private residences • removal of businesses	• property loss								X	X			
		• residence loss								X	X			
		• business loss			X					X	X			
		• reduced community cohesion											X	X
15	Spoiling of views • road across landscape • road close to dwelling	• reduced quality of living conditions				X	X						X	
		• reduced land values					X							
11	Restriction of access	• increased transportation costs						X						
		• increased travel time						X						
		• business losses	X											
14	Damage to cultural heritage	• loss of cultural identity							X				X	X
11,13	Community disruption (incl. indigenous people)	• loss of sense of community											X	X
		• loss of community cohesion											X	X
	Post-construction stage													
18	Failure to implement mitigation measures	various (as above)	depends on effect											
18	Failure to rehabilitate work-site • borrow areas • work camps	various (as above) • erosion							X					X
		• increase in bacterial/insect-borne diseases			X				X					X
	Construction of New Roads													
	All stages													
All	Encroachment on valued ecosystem components	• loss of these components	X	X					X				X	X
8, 10	Impairment of fisheries/aquatic ecology and of other beneficial water uses	• reduced beneficial water uses	X	X					X			X		X
7, 8	Exposure of soil to erosion	• excessive soil erosion and water quality degradation	X	X					X					X
9, 17	Pollution of air	• nuisance and health hazards for travelers and workers											X	

TABLE 19.1 continued...

Chapter No.	Project Type and Action Affecting Environment	Environmental Effect (negative only)	Valuation Techniques											
			1	2	3	4	5	6	7	8	9	10	11	12
16, 18	Generation of noise and vibration	• nuisance and health hazard for local community											X	
14	Encroachment on cultural areas and monuments	• loss of these values		X					X				X	X
15	Disturbance of landscape aesthetics	• loss of scenic values				X	X						X	X
	Construction stage													
7, 8, 18	Exposure of soil to erosion	• impairment of downstream water quality	X						X					X
18	Failure to monitor	• various (as above)	depends on effect											
	Operational stage													
8	Uncontrolled highway runoff	• local watercourse contamination	X	X					X					X
7, 8, 10, 18, 17	Unmanaged highway spills	• health threat/hazard			X									
	Rural Road Projects													
	All stages													
All	Encroachment on valued ecosystem components	• loss of or damage to these components	X	X					X				X	X
8, 10	Impairment of fisheries/ aquatic ecology and of other beneficial water uses	• reduced benefical water uses	X	X					X			X		X
7, 8	Exposure of soil to erosion	• excessive soil erosion and water quality degradation	X	X					X					X
9, 17	Pollution of air	• nuisance and health hazards for travelers/workers											X	
17, 16	Generation of noise and vibration	• nuisance and health hazard for community											X	
14	Encroachment on cultural areas and monuments	• loss of these values		X					X				X	X
15	Disturbance of landscape aesthetics	• loss of scenic values				X	X						X	X
	Construction stage													
1, 8, 10, 18	Exposure of soil to erosion	• loss of habitat and water quality	X						X					X
	Failure to monitor	• various (as above)	depends on effect											
	Operational stage													
8, 18	Uncontrolled road runoff	• local watercourse contamination	X	X					X					X
7, 8, 10, 17, 18	Unmanaged road spills	• health threat/hazard			X									

Adapted from: Dixon et al., 1988; ADB, 1988.

19.6 REFERENCES AND BIBLIOGRAPHY

Asian Development Bank (ADB). 1988. *Environmental guidelines for selected infrastructure projects.* Manila, Philippines.

Dixon, John A. and H.H. Hufschmidt (eds.). 1986. *Economic Valuation Techniques for the Environment: A Case Study Workbook.* Baltimore, MD: Johns Hopkins University Press.

Dixon, John A., R.A. Carpenter, L.A. Fallon, P.B. Sherman and Supachit Manipomoke. 1988. *Economic Analysis of the Environmental Impacts of Development Projects.*, London: Earthscan Publications Ltd., in association with the Asian Development Bank, Manila, Philippines.

Japan International Cooperation Agency (JICA). 1996. "The Feasibility Study for Construction of Mekong Bridge at Pakse in the Lao People's Democratic Republic. "Tokyo. Japan.

Munasinghe, M. 1993. *Environmental economics and sustainable economics.* World Bank Environment Paper No. 3. Washington, DC: World Bank.

Rodd, R. Stephen. 1991. "Rural Resource Accounting to Aid Local Rural Development and the National Natural Environment." Unpublished paper given to the Annual Meeting of the Community Development Society, Saskatoon, Canada.

Rodd, R. Stephen, 1992. "Building Community Resource Evaluation into Planning and Assessment for Sustainability." Unpublished paper given to the Annual Meeting of the International Association for Impact Analysis, Washington, DC.

Serageldin, Ismail and Andrew Steer (eds.). 1993. *Making Development Sustainable: From Concepts to Action.* Environmentally Sustainable Development Occasional Paper Series No. 2. Washington, DC: World Bank.

World Bank. 1991. *Environmental Assessment Sourcebook. Vol. I Policies, Procedures, and Cross-Sectoral Issues.* Washington, DC: Environment Department.

Appendices

APPENDIX 1
EXAMPLE OF ENVIRONMENTAL MANAGEMENT PLAN

China National Highway II Project
Hunan Xiangtan-Leiyang Highway and Linking Roads
EAP Key Elements of Loudi-Lianyuang and Tianaishan-Yishuhe Roads

Environmental Issue	Measures taken or to be taken	Implementing Organization	Responsible Organization
A. Design Phase			
1. Alignment	The alignment is selected from 3 alternatives so as to minimize the land occupation, air pollution, and noise impact on residences, to avoid unfavorable geological conditions and cultural relics. The alignment selection of Loudi-Lianyuang and Tianaishan-Yishuhe roads have also taken into consideration of environmental elements.	Designing Unit	HPCD
2. Interference on People	416 passageways (including 22 overpasses) are designed for Xiangtan-Leiyang highway; 48 underpasses and 3 overpasses are designed for Loudi-Lianyuang highway; as to Tiantaishan-Yishuhe road, 6 underpasses are designed to meet the needs of the local residents and vehicles.	Designing Unit	HPCD
3. Soil Erosion	• In slopes and suitable places along the roadside, bush grass will be planted, and retaining wall, water intercepting ditches, and masonry rubbles will be built to prevent soil erosion. • Temporary and permanent drainage systems are designed to minimize the soil erosion and the impact on irrigation canals. The affected ponds should be re-excavated (relocated) affected pond (irrigation pond).	Designing Unit	HPCD
4. Dust/air Pollution	Besides the measures in Item 1, earth borrowing sites, waste disposal sites, and asphalt mixing sites are identified to concern with the environmental issues like dust and similar residences.	Designing Unit	HPCD
5. Water Pollution	Sewage disposal facilities are designed at the 3 service areas of Xiangtan-Leiyang highway to treat the sewage before entering into public water source.	Designing Unit	HPCD
6. Noise	Besides the measures in Item 1, measures such as sound barriers, building and heightening fencing walls, are identified and incorporated into the design and tendering documents.	Designing Unit	HPCD
7. Cultural Relics	Survey has been made on the line. 3 ancient tombs discovered along the alignment will be excavated prior to construction.	Hunan Provincial Archaeological Institute (HPAI)	Hunan Provincial Cultural Relics Bureau (HPCEB)
8. Flood	Bridges and culverts have been well designed for the purpose of the flood discharge (Xiang-Lei highway: 300 year flood frequency for big bridges, 100 year flood frequency for others; Loudi-Lianyuan highway and Tian-Yi roads: 100 year flood frequency for big bridges and 50 year flood frequency for small bridges.)	Designing Unit	HPCD

APPENDIX 1 continued...

Environmental Issue	Measures taken or to be taken	Implementing Organization	Responsible Organization
B. Construction Phase			
1. Dust/air pollution	• Water should be sprayed during construction phase, in the line and earth mixing sites, asphalt mixing site, and temporary roads. In filling subgrade, water spraying is needed to solidify the material. After the impacting, water spraying should be regular to prevent dust. • Coal ash to be used should contain 30% water content or more to prevent the ash from dispersing. In warehouses and piling yards, esp. The coal ashes should be covered, except where they are to be used immediately. • Vehicles delivering materials should be covered to reduce spills. • Residences should be 500m from downward wind direction of asphalt mixing sites. • Mixing equipment should be well sealed, and vibrating equipment should be equipped with dust-remove device. Operators should pay attention to their health.	Contractor	HPECDC Xianglei Highway Co. Loudi-Lianyuang Highway Co. Hunan Provincial Highway Administration
2. Soil Erosion/ Water Pollution	• In slopes and other suitable places along the roadside, trees and grass should be planted. On sections with high filling and deep cutting, their slopes should be covered by stone walls and planted with grass, etc. If existing irrigation and drainage system ponds are damaged, they should be rebuilt or recovered by suitable methods • Limestone and coal ash should be stacked together, fenced by bricks or earth wall, and kept away from water. • In sections along the river, earth and stone will be properly disposed of so as not to block rivers, resulting in adverse impact on water quality. • In building permanent drainage system, temporary canals and culverts will be built for the sake of irrigating drainage. • All necessary measures will be taken to prevent earthworks and stone works from impeding the rivers and water canals or existing irrigation and drainage system. • All justifiable measures will be taken to prevent the waste water produced in construction from entering into rivers and irrigation system.	Contractor	HPECDC Xianglei Highway Co. Loudi-Lianyuang Highway Co. Hunan Provincial Highway Administration

APPENDIX 1 continued...

Environmental Issue	Measures taken or to be taken	Implementing Organization	Responsible Organization
3. Construction Camp	• Sufficient measures will be taken in the construction camps, i.e. provision of garbage tanks and sanitation facilities. Waste in septic tanks will be cleared periodically. • Drinking water will meet China National Standard. • Garbage will be collected in a tank and disposed of periodically. • Special attention shall be paid to the sanitary condition of camps.	Contractor	HPECDC Xianglei Highway Co. Loudi-Lianyuang Highway Co. Hunan Provincial Highway Administration
4. Noise	• Noise standard of industrial enterprises will be strictly enforced to protect construction workers from damage. Workers in vicinity of strong noise will wear earplugs and helmets and their working time should be limited. • In construction sites within 150m where, there are residences, noisy construction should be stopped from 22:00-6:00. • Maintenance of machinery and vehicles should be enhanced to keep their noise at a minimum.	Contractor	HPECDC Xianglei Highway Co. - Loudi-Lianyuang Highway Co. Hunan Provincial Highway Administration
5. Conservation of Eco-resources	• To preserve the forest, earth borrowing, piling, and building temporary camps are prohibited in forest lands. • Arable lands should not be used as earth borrowing whenever possible. If needed, the topsoil (30cm) should be kept and refilled after construction is over to minimize the impact on ecosystem and agriculture. • Construction workers should be told to protect natural resources and wild animals. Hunting is prohibited. • Construction vehicles should run at temporary accesses to avoid damaging arable lands and cattle-raising lands.	Contractor	HPECDC Xianglei Highway Co. Loudi-Lianyuang Highway Co. Hunan Provincial Highway Administration
6. Accidental Risks	• To ensure safe construction in the temporary accesses during construction, lighting devices and safety signal device will be installed. Meanwhile, traffic rules and regulations will be actively enforced in these temporary accesses. • During construction, effective safety and warning measures will be taken to reduce accidents. The blasting time, signal, and guarding will be regulated. The people and vehicles within blasting area should be removed in time. • Prior to blasting, thorough inspection should be conducted. • Safety lookout will be built to prevent people and vehicles from passing after blasting. Blasting will not be carried out during rush hours so as not to cause traffic jams and injuries.	Contractor	HPECDC Xianglei Highway Co. Loudi-Lianyuang Highway Co. Hunan Provincial Highway Administration

APPENDIX 1 continued...

Environmental Issue	Measures taken or to be taken	Implementing Organization	Responsible Organization
	• The management and use of blasting materials will be in strict conformity with the safety requirements for public security.		
7. Cultural Relics	• If valuable or invaluable articles such as fabrics, coins, artifacts, structures, or other geographic or archeological relics are discovered, the local related department should be notified immediately. The excavation should be stopped until authorized department identifies articles. • Archaeologists will supervise the excavation to avoid any damage to the relics.	HPAI	HPCRB
8. Communications and Transportation	• Local materials should be used as much as possible so as to avoid long distance transportation, esp. that of earth and stone. • If there are traffic jammed during construction, measures should be taken to move the jam with the coordination of transportation and public security department. • Temporary access should be built at the interchange of the highway and other roads. • Passing time on National Highway 107 will be limited, similar measures will also be applied to roads with traffic jams.	Contractor	HPECDC Xianglei Highway Co. Loudi-Lianyuang Highway Co. Hunan Provincial Highway Administration
	• Materials may be delivery in advance in relatively leisurely season of traffic (Jan/Dec, Sept/Oct) • A transportation plan of materials will be formulated to avoid delivery of them at peak hours, esp. on existing roads.		
C. Operation Phase			
1. Accident of hazardous materials	• Regional or municipal transportation bureaus will set up respective transportation coordination unit for hazardous substances. • For delivery of hazardous substances, three certificates issued by transportation department are required—permit license, driving license, and guarding license. Vehicles delivering hazardous substances will be printed with unified signs. • Public security, transportation and fire-fighting departments will designate a special route for these vehicles. These vehicles can only harbored at designated parking lots. • This project's hazardous substances will be administered by highway management department registration system. • In case of spill of hazardous materials, report to the relevant departments at once and deal with it in accordance with the emergency plan.	Xianglei Highway Co. Loudi-Lianyuang Highway Co. Hunan Provincial Highway Administration	Xianglei Highway Co. Loudi-Lianyuang Highway Co. Hunan Provincial Highway Administration EPO of HPCD

APPENDIX 1 continued...

Environmental Issue	Measures taken or to be taken	Implementing Organization	Responsible Organization
2. Vehicle management	• If the noise of vehicle is excessive, the vehicle is not permitted to run on this highway until the problem is solved. Exhaust inspection will be enhanced. Unqualified vehicles are not allowed to run on this highway. • Public will be educated about the regulations on air pollution and noise of vehicles. • Bulk cargo such as coal, cement, sand, etc. easily spilled or polluted over the highway, will be inspected; prohibited vehicles carrying these cargo, but not having protection measures, will be prohibited from running on this highway.	Xianglei Highway Co. Loudi-Lianyuang Highway Co. Hunan Provincial Highway Administration	Xianglei Highway Co. Loudi-Lianyuang Highway Co. Hunan Provincial Highway Administration
3. Noise	According to monitoring results, at places with excessive noise, sound barriers or other measures will be adopted.	Xianglei Highway Co. Loudi-Lianyuang Highway Co. Hunan Provincial Highway Administration	Xianglei Highway Co. Loudi-Lianyuang Highway Co. Hunan Provincial Highway Administration EPO of HPCD
4. Maintenance of Drainage System	The drainage system will be periodically cleared so as to ensure water flow.	Xianglei Highway Co. Loudi-Lianyuang Highway Co. Hunan Provincial Highway Administration	Xianglei Highway Co. Loudi-Lianyuang Highway Co. Hunan Provincial Highway Administration EPO of HPCD
5. Others	Buildings are prohibited within 50m of the road. No schools and hospitals are allowed within 200m from the roadsides of Xianglei highway, 100m from the roadsides of Loudi-Lianyuan and Tianyi roads	Xianglei Highway Co. Loudi-Lianyuang Highway Co. Hunan Provincial Highway Administration	Xianglei Highway Co. Loudi-Lianyuang Highway Co. Hunan Provincial Highway Administration EPO of HPCD

APPENDIX 1 continued...

Environmental Issue	Measures taken or to be taken	Implementing Organization	Responsible Organization
D. Environmental Monitoring			
1. Atmosphere	**A Construction Phase** (i) Monitoring Item TSP (ii) Monitoring Frequency once/week (iii) Length of Time: 1 day (iv) Monitoring Point. Main construction sites and materials transportation roads near the sensitive points. **B Operation Phase** (i) Monitoring Item: TSP, NO_X, CO (ii) Monitoring Frequency twice/year (Jan. July) CO once/year (iii) Length of time: 5 days (iv) Monitoring Points: 6 locations on Xianglei highway, 2 locations at both Loudi-Lianyuan and Tianyi roads **C Monitoring Standard** Atmospheric Monitoring Standard Issued by the NEPA	Local Monitoring Station Local Monitoring Station	Supervision Co. Xianglei Highway Co. Loudi-Lianyuang Highway Co. Hunan Provincial Highway Administration EPO of HPCD
2. Noise	**A Monitoring Frequency** (i) Construction Phase: once/week (ii) Operation Phase: 4 times/year **B Monitoring Points** (i) Construction Phase: Construction sites within 150m, of which there are residences or sensitive units, waste disposal sites, delivery roads, quarries (ii) Operation Phase: 13 locations in earlier period on Xianglei highway, and 22 points in middles period; 2 locations on Loudi-Lianyuan, Tianyi, and other linking roads **C Monitoring Standard** Existing noise standard issued by the NEPA	Environment Supervision Engineer (Xianglei highway) Local Supervision Station Xianglei Co. Local Supervision Station	Supervision Co. Loudi-Lianyuang Highway Co. Hunan Provincial Highway Administration EPO of HPCD
3. Water Quality	**A Monitoring item:** BOD_5, COD, SS, OIL **B Monitoring Frequency:** Construction phase: 3 times/year/day twice /day Operation phase: once/year **C Monitoring Points:** 2 points on Xianglei Highway **D Monitoring Standard** Water quality standard issued by the NEPA.	Local Monitoring Station	Supervisory Co.

APPENDIX 2
IMPACT OF ROAD MAINTENANCE TASKS ON THE ENVIRONMENT IN THE SAHEL

Env. Impact codes (Col. 4)	(A) =	relatively SLIGHT	N.B.: This assessment is made up of a set of examples of the relative impact of road maintenance tasks on the environment
	(B) =	relatively MODERATE	
	(C) =	relatively MARKED	
Plus and minus signs (Cols. 3 and 4)	(-) =	deterioration of present state of environment	The value of the impacts must be adjusted to the environmental context and execution method of each Sahelian country.
	(+) =	improvement of present state of environment	

DEFINITION OF MAINTENANCE TASKS	Para. ref.	LOCATION ON SITE	DRAWBACKS (-) OR ADVANTAGES (+)	IMPACT (+ and -) ON ROAD ENVIRONMENTS IN THE SAHEL
Column Ref. No.	1	2	3	4
	Current Maintenance of Unpaved Roads			
Unpaved Roads: Manual Maintenance of Wearing Course	1	materials piled on road	(-) fines carried into drainage systems by rainwater (-) accident hazard for road users	(-A) water polluted by solids (-B) road user safety jeopardized
	2	wearing course	(+) improved evenness (+) smoother traffic movement (+) user safety preserved	(+B) road safety improved (+B) traffic lanes widened
Complementary operation: Supply and hauling of materials	3	wearing course drainage	(+) faster roadway drainage	(+B) improved runoff management
Unpaved Roads: Supply and hauling of selected materials	4	workshops, garage and stores	(-) oil, grease and acid spilled on road	(-A) local soil pollution
A. Preparation of borrow areas	5	materials borrowing	(-) excessive deforestation (-) area stripped, not covered evenly (-) water drainage hindered	(-B) natural environment harmed (-B) regrowth of vegetation made difficult
	6	borrow area surface	(+) less natural space taken up	(+C) less harm to natural environment
	7	borrow area	(+) water held in reserve (on impermeable soils) or flows through to replenish groundwater (permeable soils)	(+C) large quantity of water made available for human or animal use (+B) groundwater replenished
	8	stripped area (spreading of piles) and drainage ditches (to be dug)	(+) natural vegetation reconstituted (+) appearance of site improved	(+B) plant cover preserved (+C) landscape improved (+C) runoff used better
Unpaved Roads: Supply and hauling of selected materials	9	workshops, garage and stores	(-) same as para. 4	(-) same as para. 4
B. Loading and hauling of materials	10	site access lanes for maintenance vehicles and equipment	(-) during the work, increased traffic and greater risk for users of the road (-) pedestrian or animal traffic hindered or made dangerous (-) dust	(-B) vehicle traffic hindered (-B) pedestrians and animals endangered (-B) air polluted
	11	roadway: materials piled on road	(-) dangerous obstacles for road users (-) in wet season, fines are washed off into drainage systems	(-B) users placed at risk (-A) water polluted by solids

APPENDIX 2 continued...

Unpaved Roads: Control of washboard surface	12	verges and ditches	(-) lateral ridges, obstruction of drainage and entrainment of fines by rainwater (-) *filling up of side ditches*	(-B) concentration of runoff water along the ridges and erosion of slopes (-B) water pollution (-A) obstruction of access for people living nearby
	13	roadway	(-) residual ridges on surface (-) stones left behind (-) dust generation	(-C) traffic hazard
	14	road surface	(+) smoother surface (+) enhanced traffic safety	(+C) improved traffic conditions
Unpaved Roads: Light reshaping without compacting	15	verges and ditches	same as para. 12	same as para. 12
	16	roadway	(-) accentuation or reduction of roadway camber (-) stones left behind (-) dust	(-C) traffic hazard (-B) air pollution
	17	road surface	(+) smoother surface (+) enhanced traffic safety (+) better roadway drainage	(+C) improved traffic conditions (+B) better water drainage
Unpaved Roads: A. Reshaping with sprinkling and compacting without addition of material	18	verges and ditches	same as para. 12	same as para. 12
	19	roadway	same as para. 16	same as para. 16
	20	road surface	(+) better shaping of roadway (+) enhanced traffic safety (+) better roadway drainage (+) washboard surface takes longer to develop	(+C) more lasting improvement of traffic conditions (+C) better water drainage

	Unpaved Roads: Periodic Maintenance of Unpaved Roads			
Unpaved Roads: Periodic resurfacing of wearing course and Periodic resurfacing of shoulders	24	verges and ditches	(-) lateral ridges left and pooling of water with risk of erosion of roadway edges and slopes (-) entrainment of fines by rainwater (-) side ditches filled up with waste materials	(-B) concentration of runoff water along the ridges and erosion of slopes (-B) water pollution by solids (-B) obstruction of ditches and of access for local residents
By assimilation: Reshaping with compacting and addition of materials	25	roadway	(-) accentuation or reduction of roadway camber (-) stones left behind (-) dust generation and risk of traffic accidents	(-C) steep crossfall = traffic hazard (-A) air pollution (-B) impairment of road safety
Complementary operation: Supply and hauling of materials	26	road surface after works	(+) improvement in road safety (+) roadway drainage (+) washboard surface takes longer to develop (+) possibility of establishing vehicle parking area in the larger villages	(+C) improved road safety (+C) better water drainage (+C) improved quality of life

APPENDIX 2 continued...

		Impact of Current Maintenance of Paved Roads		
Paved Roads: Manual maintenance of shoulders of paved roads	30	materials piled on shoulders	(-) fines and wastes carried into drainage systems by rainwater (-) road user accidents	(-A) water pollution by solids (-B) user safety jeopardized
	31	unpaved shoulders	(+) improved shoulder profile (+) improve traffic conditions (overtaking, passing) (+) pedestrian and animal safety more assured	(+B) improved road traffic safety (+B) improved safety for local residents
Complementary operation: Supply and hauling of materials	32	pavement and shoulder drainage	(+) better runoff drainage	(+B) possibility of channeling runoff
Patching - Paved Roads: A. with multiple surface dressing and B. with coated macadam	33	site installations, workshops, garage, bitumen heater, mixer	(-) fuel, bitumen, oil and acid spills and spattering (-) fire hazards	(-A) soil pollution (-A) destruction of plant cover
by assimilation: Reshaping and patching of surface comprising the following tasks	34	surroundings of site and of fixed and movable installations	(-) entrainment of toxic products by water	(-A) water pollution by toxic products
A. with multiple surface dressing using natural aggregates, and B. using untreated crushed gravel	35	road surface and pavement edges piles of gravel and excavated materials loose clippings	(-) hazard for road users (broken windshields)	(-A) water pollution by solids (-B) hazard for road users
C. using coated materials				
Paved Roads: Localized repairs of road layers comprising: A. repair of base course, and B. repair of entire road	36	site installations, workshops, garage	(-) fuel, oil and acid spills and spattering (-) fire hazards	(-B) soil pollution (-A) destruction of plant cover (-A) impairment of quality of life
	37	surroundings of site and of fixed and moveable installations	(-) entrainment of solids and toxic products by water	(-A) water pollution
Complementary operation: supply of materials for road base	38	routes through inhabited areas	(+) establishment of vehicle parking areas in larger villages	(+C) improvement of quality of life (+B) greater safety for local people

		Impact of Periodic Maintenance of Paved Roads		
Paved Roads: Execution of general surface dressing, and Execution of general carpet using coated materials	39	site installations, workshops, garage, bitumen heater, mixer	(-) fuel, oil and acid spills, and spattering (-) fire hazard	(-B) soil pollution (-A) degradation of plant cover
	40	surroundings of fixed and moveable installations	same as para. 34	(-B) water pollution by toxic products
	41	routes through inhabited areas	(+) paving of vehicle parking areas in larger villages	(+B) improvement of quality of life (+B) greater safety for local people (+B) reduction of air pollution
Paved Roads: General remarking of surface signing	42	road surface	(+) better user guidance and information	(+B) user safety
specific task on paved roads; improvement of user safety	43	hard shoulders	(+) provision maintained for local people's movements	(+B) safety of local people

APPENDIX 2 continued...

Paved Roads: General restoration of soft shoulders	44	workshops, garage and stores	same as para. 24	same as para. 24
	45	roadway: materials piled on road	same as para. 25	same as para. 25
Complementary operation: supply of materials (A.1.2 A1) and loading and hauling (A.1.2 B1)	46	villages	(+) provide for off-road vehicle parking areas in the larger villages	(+C) enhancement of quality of life (+C) improved safety for road users and local people

	Current Maintenance of Roadside Elements			
Roadside Maintenance: Manual or mechanical clearing and pruning	47	roadway, shoulders and ditches	(-) weeds and branches left lying where cut (shoulders, ditches)	(-A) obstacles to traffic (-B) water drainage through ditches blocked
	48	villages, crops, vegetation	(-) burning of debris (-) risk of fire spreading to surroundings (-) herbicides entrained by water	(-C) harm to natural environment and crops, and quality of life affected (-C) destruction of local peoples' homes (-C) chemical pollution of water
	49	slopes, shoulders, sides of ditches	(+) elimination of burning (+) use of manual tools (+) plants not crushed by grader (+) stumps and rootstocks of bushes, etc., retained	(+C) conservation of plant cover (+C) stabilization of slopes, ditch sides and shoulders (+C) erosion reduced
Roadside Maintenance: Manual or mechanical ditch A. Clearing of trash dumped or carried into ditches	50	areas where trash is dumped in ditches	(-) water drainage blocked (-) reduction of water-carrying section of ditch	(-B) overflowing, spreading of runoff (-B to -C) draining of fouled water
	51	shoulders and roadway	(-) saturation of roadbed and slopes (-) submersion of roadway and risk of serious rutting under traffic	(-B) instability of slopes, creep of shoulders and roadway (-C) risk of users getting stuck in the mud
	52	heaps of material cleared from ditch	(-) piles close to edge of ditch	(-C) ditches become clogged quicker
	53	trash cleared from ditch	(+) natural vegetation regrowth possible with anchoring of soil	(+B) limitation of water pollution (+B) improvement of natural environment
Roadside Maintenance: Manual or mechanical ditch B. Ditch erosion control	54	ditches: bottoms and sides eroded	(-) ditch sides destabilized (-) entrainment of fines	(-C) destabilization of soil qualities (-C) regressive erosion
	55	shoulders	(-) degradation of shoulders (-) instability of saturated areas (-) regression erosion in wet season	(-B) water pollution (-B to -C) traffic hazard
	56	actions on water drainage areas: diverging ditches, laying-up basins	(+) reduction of ditch slope and slowing of water velocity (+) limitation of ditch length or of drainage area (+) reduction of runoff	(+B) soil conservation (+C) no water pollution (+C) less erosion of road
	57	actions to strengthen eroded ditch sides	(+) destruction of ditch sides reduced (+) strengthening of soil resistance	(+C) reduction of erosion and water pollution (+B) protection of natural environment adjacent to ditches

APPENDIX 2 continued...

Roadside Maintenance: Maintenance of drainage structures and Control of sand encroachment upon structures	58	structure obstructed	(-) water drainage constricted (-) bottlenecks and overflows	(-C) rapid erosion of fine soils (-C) water pollution (-C) major disruption of movements of goods and persons
Roadside Maintenance: Control of sand encroachment upon structures (continuation)	59	clearing of deposits	same as para. 53	same as para. 53
Roadside Maintenance: Control of erosion of structures	60	foundations eroded	(-) destruction of supports (-) road cut by collapse of structure	(-C) rapid erosion of fine soils (-C) water pollution (-C) major disruption of movements of goods and persons
	61	erosion of banks	(-) bypassing of abutments (-) destabilization of slopes of banks and embankments (-) road cut	(-C) rapid destabilization of soil and banks (-C) water pollution (-C) halting of movements of goods and persons
	62	repair of structure foundation and cutoffs	(+) protection of foundation soils	(+C) reduction of erosion and water pollution (+B) improved drainage
	63	rockfill or cribs on slopes (banks, embankments)	(+) improved stability of bank and embankment slopes (+) strengthened erosion resistance	same as para. 72
Roadside Maintenance: Maintenance of curbs, gutters and rain pipes	64	curbs, gutters, rain pipes	(+) limitation of erosion of shoulders and slopes	(+B) reduction of water pollution (+C) improved drainage
Roadside Maintenance: Stabilization and maintenance of slopes	65	high slopes	(-) considerable runoff (-) regressive erosion (-) slides	(-A/-B) water pollution by solids (-A) if cohesive, (-C) if sandy modification of soil stability
	66	summit ditch — limitation of drainage area upstream	(+) less runoff	(+C) less erosion
	67	steps in slope of bank	(+) runoff broken up (+) drainage split up	(+B) less modification of soil (erosion) (+B) less water pollution by solids
	68	protection of slopes in erodible soils (topsoil, planting, fascines, facing)	(+) heightened soil resistance	(+C) elimination of local erosion (+C) drainage control
Roadside Maintenance: Planting and Tree Maintenance	69	reservation outside of shoulders or roadway	(+) improvement of soil fixing	(+B) lessened soil instability (+C) improved landscape
	70	shade areas	(+) rainwater recovery (+) maintenance of soil moisture	(+B) improvement of quality of life in villages
Roadside Maintenance: Maintenance against sand encroachment upon road	71	roadway (work done with equipment)	(-) expanding of dune/road contact area (-) yearly increase in volume of encroachment	(-C) hindrance and hazard for users
	72	maintenance of means used to prevent sand encroachment	(+) better protection of road (+) less sand to be cleared	(+C) improved traffic and road safety conditions
Roadside Maintenance: Maintenance of upright signing	73	danger, priority and prohibition signs	(+) information on areas with traffic hazards	(+C) preservation of safety of users and of local residents

APPENDIX 3
GUIDE TO DEFINING NATURAL AND SOCIAL INDICATORS IN ENVIRONMENTAL ASSESSMENT

Category	Types of Indicators		
Environmental Component/ Ecosystem State	Condition (exposure/response)[1]	Human Activity Stresses[2]	Management Response[3]
NATURAL ENVIRONMENT ***Atmosphere*** Climate change Air quality *Water* Freshwater Quality Marine Quality (biota & land)			
Environment-related Human Health Drinking Water Recreational/agric. water Air Quality (indoor/outdoor) Toxic residues in food Waste management (solid, Haz.)			
Natural Economic Resources Forestry Agriculture Fisheries Water Use Energy			
SOCIOECONOMIC ENVIRONMENT ***Related to Individuals*** Housing • relocation • quality of housing • neighborhood			
Transportation • accessibility • affordability			
Health and Safety			
Family			
Social Relations			
Consumption			
Related to the Community			
Public Services			
Community Provisions			
Community Structure and Process			
Community Resources			

1. Measures of **condition** are those that refer to the quality and quantity of an environmental component or natural resource. They include the various exposures or responses (alterations/changes) of the environment to human activities or conversely the direct effect on people
2. Measures of **human activity or stress** refer to emissions and discharges, restructuring, or consumption of environmental resources that result from human activity.
3. Measures of **management response** refer to the actions, policies and programs undertaken to respond to stress on the overall state of the environment or one of its components.

Source: Environment Canada , and Krawetz, Natalia. 1991. *Social Impact Assessment; An Introductory Handbook.* Halifax, Canada: EMDI Project Publication, Dalhousie University

Other sources of information

Further information may be obtained from numerous national and international organizations which have an interest in roads and environment, including the following:

United Nations Environment Program (UNEP)
Tour Mirabeau, 39-43
Quai André Citroen
75739 Paris, Cedex 15, France

Organization for Economic Cooperation and Development (OECD)
Road Transport Research Program
2 rue André Pascal, 75775 Paris, Cedex 16, France

Permanent International Association of Road Congresses (PIARC)
27 rue Guenegaud, 75006 Paris, France

Australia: Victorian Roads Corporation (VicRoads)
60 Denmark Street, Kew, Victoria, Australia, 3101

International EIA Network
Australian Environmental Protection Agency
Attn: M. McCabe
Tel: +61-6-274-1936
Fax: 274-1620
Email: mmcabe@mgdestmx01@erin.gov.au

Canada: Canadian International Development Agency (CIDA)
200 Promenade du Portage, Hull, Quebec
K1A 0G4 Canada

France: Service d'Etudes Techniques des Routes et Autoroutes (SETRA)
46, avenue Aristide Briand — BP 100 92223
Bagneux, France

Japan: Japan International Cooperation Agency (JICA)
Shinjuku Mitsui Bldg. 46/FL
1-1, Nishi-Shinjuku, 2-Chome, Shinjuku-Ku,
Tokyo 163-04, Japan

Japan: Overseas Economic Cooperation Fund (OECF)
Takebashi Godo Bidg.
4-1, Otemachi I-Chome, Chiyoda-Ku,
Tokyo 100, Japan

Sweden: National Road Administration
S-78187, Borlange, Sweden

United States: Federal Highway Administration
400 Seventh Street, S.W.
Washington, DC 20577, USA

United Kingdom: Overseas Development Administration
94, Victoria Street, London, SW1E 5JL, UK

Other documents which may be useful for readers of this handbook include:

- *Environmental Impact Assessment of Roads,* Organization for Economic Cooperation and Development, Scientific Expert Group E1, 1994.
- *Manual of Environmental Appraisal,* Overseas Development Administration, UK.

- *Application of Environmental Impact Assessment: Highways and Dams,* Environmental Series No. 1, ECE/ENV/50, United Nations, New York, 1987.
- *Environmental Impact Assessment and Highway Planning,* William V. Kennedy. Berlin: Ed. Sigma Bohn, 1985.
- *Environmental Impact Assessment: Theory and Practice,* P. Wathern and contributors. Unwin Hyman Ltd. 1988.
- *Environmental Design Considerations for Rural Development Projects,* United States Agency for International Development, October 1980.
- *Environmental Impact Assessment: Guidelines for Transport Development,* ESCAP – Environment and Development, United Nations, New York, 1990.
- *OECD Environment Monographs: No. 4 Environmental Assessment and Development Assistance,* OECD, Paris, 1986.
- *Design Manual for Roads and Bridges: Guideline for EA; Vol. 11, Parts 1-4.* British Highway Authority, London, 1993.
- *Vetiver Grass for Soil and Water Conservation.* Technical Paper No. 275. World Bank, Washington, DC, 1995.

Glossary

Aldehydes — A major pollutant group which includes many odorous organic compounds. Formaldehyde is one carcinogenic member of the group which is a by-product of the combustion of alcohol in engines.

Biodiversity — Short for biological diversity, biodiversity refers to the wealth of ecosystems in the biosphere, of species within ecosystems, and of genetic information within populations.

Biogeochemical cycle — Refers to the movement and transformation of energy and matter through biological and physical processes.

Biosphere — That part of the earth-atmosphere system which supports and is characterized by life, encompassing all terrestrial and aquatic ecosystems.

Biota — A collective term which denotes all the living organisms in a particular space.

Bushmeat — Refers to wild game which is hunted, usually illegally and often for purposes of sale, as opposed to subsistence. The term is most commonly applied in Africa to poaching activities. The procurement of bushmeat is one of the impacts on local fauna which commonly accompanies road projects in areas supporting game species.

Casual water — Refers to standing water which results from roadwork activities and is found in puddles, old tires and barrels on or near construction sites. Casual water can serve as a breeding ground for snails, flies and mosquitoes, which can contribute to disease problems in the area surrounding the road site.

Chain impacts — Impacts which are themselves a result of other impacts, as opposed to being caused directly by any particular event. Chain impacts are usually considered as part of a series of related impacts having a cascade or ripple effect on the environment.

Culture broker — A person, agency or other organization which, because of past experience with and knowledge of an indigenous group, is called upon to act as an intermediary between the leadership of the indigenous group and road planners whose proposed projects may affect the territory and lifestyle of the group.

Cumulative effects — Those effects which result from the incremental impacts of individual events, when added to other past, present and foreseeable future events. The individual impacts contributing to the cumulative effects may each be minor on their own, but the impacts collectively may be significant.

Ecosystem	The basic structural unit of the biosphere, ecosystems are characterized by interdependent interaction between the component species and their physical surroundings. Each ecosystem occupies a space in which macro-scale conditions and interactions are relatively homogeneous.
Ecotone	A habitat which occurs at the boundary between adjacent but significantly different ecosystems. Ecotones are generally relatively biodiverse, as they may contain species native to both bordering ecosystems.
Economic valuation of environmental impacts (EVEI)	The group of procedures used to estimate, in monetary terms, the costs and benefits arising from project-related impacts affecting both the bio-physical and social environment, in relation to a similar calculation which assumes a no-project scenario.
Endemism	Refers to a condition in which species occur only in a single spatially-limited and distinct location, such as isolated islands, mountain valleys, caves, lakes and craters. Endemic species are often highly specialized to the limited environmental conditions in which they exist, and are thus vulnerable to changes introduced from outside.
Environment	The context in which something exists. For humans this means both the biophysical world and society. Included in our environment are biophysical components such as flora, fauna, water, air and landforms, and human societal constructs such as economic activity, community interactions and buildings.
Environmental assessment (EA)	The systematic process by which the effects on the biophysical and socioeconomic environment of a proposed human action or set of actions are evaluated, producing a set of recommendations which serves as influential input to the design of the action or actions.
Environmental management plan (EMP)	The synthesis of all proposed mitigative and monitoring actions, set to a timeline with specific responsibility assigned and follow-up actions defined. The EMP is one of the most important outputs of the environmental assessment process.
Green-field	Refers to new road projects which are planned for or are being built in areas where no previous roads exist, such as wild and agricultural areas.
Indigenous peoples	Collectively, the members of those cultures which have historic, ancestral, spiritual and functional connection to the land on which and from which they live. In popular usage, indigenous peoples are distinguished from members of those cultures whose connection to the land on which they live is limited to the historical period.

Karst topography	A topography which results from the differential dissolution of limestone by water, and is characterized by extensive cave systems and dramatic outcroppings. Good examples are found in Vietnam, China, Thailand, Mexico and the Dominican Republic. Karst environments, especially caves, often harbor endemic and rare species, and are particularly threatened by disruption to groundwater flow and quarrying, both common road-related occurrences.
Key stakeholders	Those inhabitants of an area affected by a project who have the most to lose and the most to gain from the completion of the project, and whose concerns must be addressed in an environmental assessment.
Landscape	Refers to the spatial organization of an environment on a broad scale, and how that organization shapes, and is shaped by, the activities which take place within it.
Natural areas	Terrestrial and aquatic areas in which the component ecosystems are characterized primarily by native species, and in which human activities have not altered ecological function to the point where the ecosystems have changed in character or distribution.
Proponent	The agency, unit or individual who is proposing, and has responsibility for, a road project.
Public involvement	The dialogue, encompassing consultation and communication, between a project proponent and the stakeholders. It includes dissemination, solicitation, and presentation of information.
Resettlement Action Plan (RAP)	An action plan prepared as part of an EA to address the issues of involuntary resettlement, compensation and rehabilitation of people and communities affected by a road project.
Resilience	A measure of how quickly a system or environmental variable returns to its natural state following cessation of a disturbance.
Stakeholder	Any person or group having interest in or being directly or indirectly affected by a proposed or past project
Sub-project	In this handbook, refers to individual road projects which together make up sector-wide road improvement or construction programs.
Synergistic effects	Those effects which result from the combination and interaction of individual impacts. The effects are often greater than the sum of the individual contributing impacts.
Trophic	An ecological term referring to the positioning of organisms in the food chains of their respective biological communities. The lowest level is commonly associated with the primary producers, which transform the sun's energy into tissue which becomes food for higher trophic levels, and the highest level with large carnivores which normally have no predators.

UTM (Universal Transverse Mercator) A worldwide geographic location system which, as opposed to using latitude and longitude to indicate a position on the earth's surface, employs an elaborate numbering and grid system which permits one to pinpoint a location with great accuracy.

Valued ecosystem component (VEC) A social or biophysical component of an environment which is of value (for any reason) in a project area. Examples might be a watershed, fertile farmland, a clean water supply, or a nutritionally important forest area.

Index

Distributors of World Bank Publications

Prices and credit terms vary from country to country. Consult your local distributor before placing an order.

ARGENTINA
Oficina del Libro Internacional
Av. Cordoba 1877
1120 Buenos Aires
Tel: (54 1) 815-8354
Fax: (54 1) 815-8156

AUSTRALIA, FIJI, PAPUA NEW GUINEA, SOLOMON ISLANDS, VANUATU, AND WESTERN SAMOA
D.A. Information Services
648 Whitehorse Road
Mitcham 3132
Victoria
Tel: (61) 3 9210 7777
Fax: (61) 3 9210 7788
E-mail: service@dadirect.com.au
URL: http://www .dadirect.com.au

AUSTRIA
Gerold and Co.
Weihburggasse 26
A-1011 Wien
Tel: (43 1) 512-47-31-0
Fax: (43 1) 512-47-31-29
URL: http://www .gerold.co/at.online

BANGLADESH
Micro Industries Development Assistance Society (MIDAS)
House 5, Road 16
Dhanmondi R/Area
Dhaka 1209
Tel: (880 2) 326427
Fax: (880 2) 811188

BELGIUM
Jean De Lannoy
Av. du Roi 202
1060 Brussels
Tel: (32 2) 538-5169
Fax: (32 2) 538-0841

BRAZIL
Publicacões Tecnicas Internacionais Ltda.
Rua Peixoto Gomide, 209
01409 Sao Paulo, SP.
Tel: (55 11) 259-6644
Fax: (55 11) 258-6990
E-mail: postmaster@pti.uol.br
URL: http://www .uol.br

CANADA
Renouf Publishing Co. Ltd.
5369 Canotek Road
Ottawa, Ontario K1J 9J3
Tel: (613) 745-2665
Fax: (613) 745-7660
E-mail: order .dept@renoufbooks.com
URL: http:// www .renoufbooks.com

CHINA
China Financial & Economic Publishing House
8, Da Fo Si Dong Jie
Beijing
Tel: (86 10) 6333-8257
Fax: (86 10) 6401-7365

COLOMBIA
Infoenlace Ltda.
Carrera 6 No. 51-21
Apartado Aereo 34270
Santafé de Bogotá, D.C.
Tel: (57 1) 285-2798
Fax: (57 1) 285-2798

COTE D'IVOIRE
Center d'Edition et de Diffusion Africaines (CEDA)
04 B.P. 541
Abidjan 04
Tel: (225) 24 6510;24 6511
Fax: (225) 25 0567

CYPRUS
Center for Applied Research
Cyprus College
6, Diogenes Street, Engomi
P.O. Box 2006
Nicosia
Tel: (357 2) 44-1730
Fax: (357 2) 46-2051

CZECH REPUBLIC
National Information Center
prodejna, Konviktska 5
CS – 113 57 Prague 1
Tel: (42 2) 2422-9433
Fax: (42 2) 2422-1484
URL: http://www .nis.cz/

DENMARK
SamfundsLitteratur
Rosenoerns Allé 11
DK-1970 Frederiksberg C
Tel: (45 31) 351942
Fax: (45 31) 357822
URL: http://www.sl.cbs.dk

ECUADOR
Libri Mundi
Libreria Internacional
P.O. Box 17-01-3029
Juan Leon Mera 851
Quito
Tel: (593 2) 521-606; (593 2) 544-185
Fax: (593 2) 504-209
E-mail: librimu1@librimundi.com.ec
E-mail: librimu2@librimundi.com.ec

EGYPT, ARAB REPUBLIC OF
Al Ahram Distribution Agency
Al Galaa Street
Cairo
Tel: (20 2) 578-6083
Fax: (20 2) 578-6833

The Middle East Observer
41, Sherif Street
Cairo
Tel: (20 2) 393-9732
Fax: (20 2) 393-9732

FINLAND
Akateeminen Kirjakauppa
P.O. Box 128
FIN-00101 Helsinki
Tel: (358 0) 121 4418
Fax: (358 0) 121-4435
E-mail: akatilaus@stockmann.fi
URL: http://www .akateeminen.com/

FRANCE
World Bank Publications
66, avenue d'Iéna
75116 Paris
Tel: (33 1) 40-69-30-56/57
Fax: (33 1) 40-69-30-68

GERMANY
UNO-Verlag
Poppelsdorfer Allee 55
53115 Bonn
Tel: (49 228) 949020
Fax: (49 228) 217492
URL: http://www.uno-verlag.de
E-mail: unoverlag@aol.com

GREECE
Papasotiriou S.A.
35, Stournara Str.
106 82 Athens
Tel: (30 1) 364-1826
Fax: (30 1) 364-8254

HAITI
Culture Diffusion
5, Rue Capois
C.P. 257
Port-au-Prince
Tel: (509) 23 9260
Fax: (509) 23 4858

HONG KONG, MACAO
Asia 2000 Ltd.
Sales & Circulation Department
Seabird House, unit 1101-02
22-28 Wyndham Street, Central
Hong Kong
Tel: (852) 2530-1409
Fax: (852) 2526-1107
E-mail: sales@asia2000.com.hk
URL: http://www .asia2000.com.hk

HUNGARY
Euro Info Service
Margitszgeti Europa Haz
H-1138 Budapest
Tel: (36 1) 111 6061
Fax: (36 1) 302 5035
E-mail: euroinfo@mail.matav.hu

INDIA
Allied Publishers Ltd.
751 Mount Road
Madras - 600 002
Tel: (91 44) 852-3938
Fax: (91 44) 852-0649

INDONESIA
Pt. Indira Limited
Jalan Borobudur 20
P.O. Box 181
Jakarta 10320
Tel: (62 21) 390-4290
Fax: (62 21) 390-4289

IRAN
Ketab Sara Co. Publishers
Khaled Eslamboli Ave., 6th Street
Delafrooz Alley No. 8
P.O. Box 15745-733
Tehran 15117
Tel: (98 21) 8717819; 8716104
Fax: (98 21) 8712479
E-mail: ketab-sara@neda.net.ir

Kowkab Publishers
P.O. Box 19575-511
Tehran
Tel: (98 21) 258-3723
Fax: (98 21) 258-3723

IRELAND
Government Supplies Agency
Oifig an tSoláthair
4-5 Harcourt Road
Dublin 2
Tel: (353 1) 661-3111
Fax: (353 1) 475-2670

ISRAEL
Yozmot Literature Ltd.
P.O. Box 56055
3 Yohanan Hasandlar Street
Tel Aviv 61560
Tel: (972 3) 5285-397
Fax: (972 3) 5285-397

R.O.Y. International
PO Box 13056
Tel Aviv 61130
Tel: (972 3) 5461423
Fax: (972 3) 5461442
E-mail: royil@netvision.net.il

Palestinian Authority/Middle East Index Information Services
P.O.B. 19502 Jerusalem
Tel: (972 2) 6271219
Fax: (972 2) 6271634

ITALY
Licosa Commissionaria Sansoni SPA
Via Duca Di Calabria, 1/1
Casella Postale 552
50125 Firenze
Tel: (55) 645-415
Fax: (55) 641-257
E-mail: licosa@ftbcc.it
URL: http://www .ftbcc.it/licosa

JAMAICA
Ian Randle Publishers Ltd.
206 Old Hope Road, Kingston 6
Tel: 876-927-2085
Fax: 876-977-0243
E-mail: irpl@colis.com

JAPAN
Eastern Book Service
3-13 Hongo 3-chome, Bunkyo-ku
Tokyo 113
Tel: (81 3) 3818-0861
Fax: (81 3) 3818-0864
E-mail: orders@svt-ebs.co.jp
URL: http://www .bekkoame.or.jp/~svt-ebs

KENYA
Africa Book Service (E.A.) Ltd.
Quaran House, Mfangano Street
P.O. Box 45245
Nairobi
Tel: (254 2) 223 641
Fax: (254 2) 330 272

KOREA, REPUBLIC OF
Daejon Trading Co. Ltd.
P.O. Box 34, Youida, 706 Seoun Bldg
44-6 Youido-Dong, Yeongchengpo-Ku
Seoul
Tel: (82 2) 785-1631/4
Fax: (82 2) 784-0315

MALAYSIA
University of Malaya Cooperative Bookshop, Limited
P.O. Box 1127
Jalan Pantai Baru
59700 Kuala Lumpur
Tel: (60 3) 756-5000
Fax: (60 3) 755-4424

MEXICO
INFOTEC
Av. San Fernando No. 37
Col. Toriello Guerra
14050 Mexico, D.F.
Tel: (52 5) 624-2800
Fax: (52 5) 624-2822
E-mail: infotec@rtn.net.mx
URL: http://rtn.net.mx

NEPAL
Everest Media International Services (P.) Ltd.
GPO Box 5443
Kathmandu
Tel: (977 1) 472 152
Fax: (977 1) 224 431

NETHERLANDS
De Lindeboom/InOr-Publikaties
P.O. Box 202, 7480 AE Haaksbergen
Tel: (31 53) 574-0004
Fax: (31 53) 572-9296
E-mail: lindeboo@worldonline.nl
URL: http://www .worldonline.nl/~lindeboo

NEW ZEALAND
EBSCO NZ Ltd.
Private Mail Bag 99914
New Market
Auckland
Tel: (64 9) 524-8119
Fax: (64 9) 524-8067

NIGERIA
University Press Limited
Three Crowns Building Jericho
Private Mail Bag 5095
Ibadan
Tel: (234 22) 41-1356
Fax: (234 22) 41-2056

NORWAY
NIC Info A/S
Book Department, Postboks 6512 Etterstad
N-0606 Oslo
Tel: (47 22) 97-4500
Fax: (47 22) 97-4545

PAKISTAN
Mirza Book Agency
65, Shahrah-e-Quaid-e-Azam
Lahore 54000
Tel: (92 42) 735 3601
Fax: (92 42) 576 3714

Oxford University Press
5 Bangalore Town
Sharae Faisal
PO Box 13033
Karachi-75350
Tel: (92 21) 446307
Fax: (92 21) 4547640
E-mail: ouppak@TheOffice.net

Pak Book Corporation
Aziz Chambers 21, Queen's Road
Lahore
Tel: (92 42) 636 3222; 636 0885
Fax: (92 42) 636 2328
E-mail: pbc@brain.net.pk

PERU
Editorial Desarrollo SA
Apartado 3824, Lima 1
Tel: (51 14) 285380
Fax: (51 14) 286628

PHILIPPINES
International Booksource Center Inc.
1127-A Antipolo St, Barangay, Venezuela
Makati City
Tel: (63 2) 896 6501; 6505; 6507
Fax: (63 2) 896 1741

POLAND
International Publishing Service
Ul. Piekna 31/37
00-677 Warzawa
Tel: (48 2) 628-6089
Fax: (48 2) 621-7255
E-mail: books%ips@ikp.atm.com.pl
URL: http://www .ipscg.waw.pl/ips/export/

PORTUGAL
Livraria Portugal
Apartado 2681, Rua Do Carmo 70-74
1200 Lisbon
Tel: (1) 347-4982
Fax: (1) 347-0264

ROMANIA
Compani De Librarii Bucuresti S.A.
Str. Lipscani no. 26, sector 3
Bucharest
Tel: (40 1) 613 9645
Fax: (40 1) 312 4000

RUSSIAN FEDERATION
Isdatelstvo <Ves Mir>
9a, Lolpachniy Pereulok
Moscow 101831
Tel: (7 095) 917 87 49
Fax: (7 095) 917 92 59

SINGAPORE, TAIWAN, MYANMAR, BRUNEI
Asahgate Publishing Asia Pacific Pte. Ltd.
41 Kallang Pudding Road #04-03
Golden Wheel Building
Singapore 349316
Tel: (65) 741-5166
Fax: (65) 742-9356
E-mail: ashgate@asianconnect.com

SLOVENIA
Gospodarski Vestnik Publishing Group
Dunajska cesta 5
1000 Ljubljana
Tel: (386 61) 133 83 47; 132 12 30
Fax: (386 61) 133 80 30
E-mail: repansekj@gvestnik.si

SOUTH AFRICA, BOTSWANA
For single titles:
Oxford University Press Southern Africa
Vasco Boulevard, Goodwood
P.O. Box 12119, N1 City 7463
Cape Town
Tel: (27 21) 595 4400
Fax: (27 21) 595 4430
E-mail: oxford@oup.co.za

For subscription orders:
International Subscription Service
P.O. Box 41095
Craighall
Johannesburg 2024
Tel: (27 11) 880-1448
Fax: (27 11) 880-6248
E-mail: iss@is.co.za

SPAIN
Mundi-Prensa Libros, S.A.
Castello 37
28001 Madrid
Tel: (34 1) 431-3399
Fax: (34 1) 575-3998
E-mail: libreria@mundiprensa.es
URL: http://www .mundiprensa.es/

Mundi-Prensa Barcelona
Consell de Cent, 391
08009 Barcelona
Tel: (34 3) 488-3492
Fax: (34 3) 487-7659
E-mail: barcelona@mundiprensa.es

SRI LANKA, THE MALDIVES
Lake House Bookshop
100, Sir Chittampalam Gardiner Mawatha
Colombo 2
Tel: (94 1) 32105
Fax: (94 1) 432104
E-mail: LHL@sri.lanka.net

SWEDEN
Wennergren-Williams AB
P. O. Box 1305
S-171 25 Solna
Tel: (46 8) 705-97-50
Fax: (46 8) 27-00-71
E-mail: mail@wwi.se

SWITZERLAND
Librairie Payot Service Institutionnel
Côtes-de-Montbenon 30
1002 Lausanne
Tel: (41 21) 341-3229
Fax: (41 21) 341-3235

ADECO Van Diermen EditionsTechniques
Ch. de Lacuez 41
CH1807 Blonay
Tel: (41 21) 943 2673
Fax: (41 21) 943 3605

THAILAND
Central Books Distribution
306 Silom Road
Bangkok 10500
Tel: (66 2) 235-5400
Fax: (66 2) 237-8321

TRINIDAD & TOBAGO, AND THE CARRIBBEAN
Systematics Studies Unit
9 Watts Street
Curepe
Trinidad, West Indies
Tel: (809) 662-5654
Fax: (809) 662-5654
E-mail: tobe@trinidad.net

UGANDA
Gustro Ltd.
PO Box 9997, Madhvani Building
Plot 16/4 Jinja Rd.
Kampala
Tel: (256 41) 251 467
Fax: (256 41) 251 468
E-mail: gus@swiftuganda.com

UNITED KINGDOM
Microinfo Ltd.
P.O. Box 3, Alton, Hampshire GU34 2PG
England
Tel: (44 1420) 86848
Fax: (44 1420) 89889
E-mail: wbank@ukminfo.demon.co.uk
URL: http://www .microinfo.co.uk

VENEZUELA
Tecni-Ciencia Libros, S.A.
Centro Cuidad Comercial Tamanco
Nivel C2, Caracas
Tel: (58 2) 959 5547; 5035; 0016
Fax: (58 2) 959 5636

ZAMBIA
University Bookshop, University of Zambia
Great East Road Campus
P.O. Box 32379
Lusaka
Tel: (260 1) 252 576
Fax: (260 1) 253 952

ZIMBABWE
Longman Zimbabwe (Pvt.)Ltd.
Tourle Road, Ardbennie
P.O. Box ST125
Southerton
Harare
Tel: (263 4) 6216617
Fax: (263 4) 621670

08/10/97

RECENT WORLD BANK TECHNICAL PAPERS *(continued)*

No. 345 Industry and Mining Division, Industry and Energy Department, *A Mining Strategy for Latin America and the Caribbean*

No. 346 Psacharopoulos and Nguyen, *The Role of Government and the Private Sector in Fighting Poverty*

No. 347 Stock and de Veen, *Expanding Labor-based Methods for Road Works in Africa*

No. 348 Goldstein, Preker, Adeyi, and Chellaraj, *Trends in Health Status, Services, and Finance: The Transition in Central and Eastern Europe, Volume II, Statistical Annex*

No. 349 Cummings, Dinar, and Olson, *New Evaluation Procedures for a New Generation of Water-Related Projects*

No. 350 Buscaglia and Dakolias, *Judicial Reform in Latin American Courts: The Experience in Argentina and Ecuador*

No. 351 Psacharopoulos, Morley, Fiszbein, Lee, and Wood, *Poverty and Income Distribution in Latin America: The Story of the 1980s*

No. 352 Allison and Ringold, *Labor Markets in Transition in Central and Eastern Europe, 1989-1995*

No. 353 Ingco, Mitchell, and McCalla, *Global Food Supply Prospects, A Background Paper Prepared for the World Food Summit, Rome, November 1996*

No. 354 Subramanian, Jagannathan, and Meinzen-Dick, *User Organizations for Sustainable Water Services*

No. 355 Lambert, Srivastava, and Vietmeyer, *Medicinal Plants: Rescuing a Global Heritage*

No. 356 Aryeetey, Hettige, Nissanke, and Steel, *Financial Market Fragmentation and Reforms in Sub-Saharan Africa*

No. 357 Adamolekun, de Lusignan, and Atomate, editors, *Civil Service Reform in Francophone Africa: Proceedings of.a Workshop Abidjan, January 23-26, 1996*

No. 358 Ayres, Busia, Dinar, Hirji, Lintner, McCalla, and Robelus, *Integrated Lake and Reservoir Management: World Bank Approach and Experience*

No. 360 Salman, *The Legal Framework for Water Users' Associations: A Comparative Study*

No. 361 Laporte and Ringold. *Trends in Education Access and Financing during the Transition in Central and Eastern Europe.*

No. 362 Foley, Floor, Madon, Lawali, Montagne, and Tounao, *The Niger Household Energy Project: Promoting Rural Fuelwood Markets and Village Management of Natural Woodlands*

No. 364 Josling, *Agricultural Trade Policies in the Andean Group: Issues and Options*

No. 365 Pratt, Le Gall, and de Haan, *Investing in Pastoralism: Sustainable Natural Resource Use in Arid Africa and the Middle East*

No. 366 Carvalho and White, *Combining the Quantitative and Qualitative Approaches to Poverty Measurement and Analysis: The Practice and the Potential*

No. 367 Colletta and Reinhold, *Review of Early Childhood Policy and Programs in Sub-Saharan Africa*

No. 368 Pohl, Anderson, Claessens, and Djankov, *Privatization and Restructuring in Central and Eastern Europe: Evidence and Policy Options*

No. 369 Costa-Pierce, *From Farmers to Fishers: Developing Reservoir Aquaculture for People Displaced by Dams*

No. 370 Dejene, Shishira, Yanda, and Johnsen, *Land Degradation in Tanzania: Perception from the Village*

No. 371 Essama-Nssah, *Analyse d'une répartition du niveau de vie*

No. 373 Onursal and Gautam, *Vehicular Air Pollution: Experiences from Seven Latin American Urban Centers*

No. 374 Jones, *Sector Investment Programs in Africa: Issues and Experiences*

No. 375 Francis, Milimo, Njobvo, and Tembo, *Listening to Farmers: Participatory Assessment of Policy Reform in Zambia's Agriculture Sector*

No. 377 Walsh and Shah, *Clean Fuels for Asia: Technical Options for Moving toward Unleaded Gasoline and Low-Sulfur Diesel*

No. 382 Barker, Tenenbaum, and Woolf, *Governance and Regulation of Power Pools and System Operators: An International Comparison*

No. 385 Rowat, Lubrano, and Porrata, *Competition Policy and MERCOSUR*

No. 386 Dinar and Subramanian, *Water Pricing Experiences: An International Perspective*

No. 387 Oskarsson, Berglund, Seling, Snellman, Stenbäck, and Fritz, *A Planner's Guide for Selecting Clean-Coal Technologies for Power Plants*

No. 388 Sanjayan, Shen, and Jansen, *Experiences with Integrated-Conservation Development Projects in Asia*

No. 389 International Commission on Irrigation and Drainage (ICID), *Planning the Management, Operation, and Maintenance of Irrigation and Drainage Systems: A Guide for the Preparation of Strategies and Manuals*

THE WORLD BANK

1818 H Street, N.W.
Washington, D.C. 20433 U.S.A.

Telephone: 202-477-1234

Facsimile: 202-477-6391

Telex: MCI 64145 WORLDBANK
MCI 248423 WORLDBANK

World Wide Web: http://www.worldbank.org

E-mail: books@worldbank.org

ISBN 0-8213-4031-X