### Key steps involved in undertaking an environmental assessment

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

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

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

#### KEY QUESTIONS ADDRESSED:

1. What sequence of steps should be followed when undertaking an EA?
2. How does one plan a field investigation?
3. How is the valued ecosystem component (VEC) concept used in EA?
4. How should mitigation and monitoring be incorporated into EA?
5. 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.

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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

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**FIGURE 4.1**
SAMPLE DESIGN DECISION KEY

1. Has the impact already occurred?
   - NO
   - YES

2. Is “when & where” known?
   - YES
   - NO

3. Is there a control area?
   - YES
   - NO

Main sequence

<table>
<thead>
<tr>
<th>No.</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Permits an optimal impact study design</td>
</tr>
<tr>
<td>2</td>
<td>Impact must be inferred from temporal change alone</td>
</tr>
<tr>
<td>3</td>
<td>Baseline or monitoring study</td>
</tr>
<tr>
<td>4</td>
<td>Impact must be inferred from spatial pattern alone</td>
</tr>
<tr>
<td>5</td>
<td>“When &amp; where” is the question</td>
</tr>
</tbody>
</table>

Source: Green, 1979.
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 multidisciplinary, 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.

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 weighs 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.
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-dimensional quality value of every impact category is then multiplied 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

![Noise Level Value Function Graph]

### Weights for Impact Categories (Xx)

<table>
<thead>
<tr>
<th>Environmental Type</th>
<th>Noise</th>
<th>Vibration</th>
<th>Air quality</th>
<th>Sunlight</th>
<th>Water quality</th>
</tr>
</thead>
<tbody>
<tr>
<td>Human Environment</td>
<td>164</td>
<td>71</td>
<td>108</td>
<td>60</td>
<td>36</td>
</tr>
<tr>
<td>Community Life</td>
<td>79</td>
<td>45</td>
<td>32</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Natural Environment</td>
<td>39</td>
<td>44</td>
<td>43</td>
<td>50</td>
<td>71</td>
</tr>
<tr>
<td>Cultural Environment</td>
<td>65</td>
<td>53</td>
<td>44</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

| Total                        | 1,000   |           |             |          |               |

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.”

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. 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. Variousely 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-a-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>
<thead>
<tr>
<th>TABLE 4.1</th>
<th>EXAMPLES OF THE USE OF MAPS AT VARIOUS STAGES OF EA AND SUGGESTED OPTIMAL SCALES</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Environmental intervention</strong></td>
<td><strong>Role of information, use and optimal map scale</strong></td>
</tr>
<tr>
<td>Screening</td>
<td>Basic maps at scale ≤ 1:100 000</td>
</tr>
<tr>
<td>Scoping</td>
<td>Maps presenting the main factors for environmental study. Scale ≤ 1:100 000</td>
</tr>
<tr>
<td>Environmental Assessment Report or Environmental Impact Statement</td>
<td>Detailed thematic impacts and synthesis maps showing key issues. Scale ≤ 1:75 000 - 1:100 000</td>
</tr>
<tr>
<td>Environmental Evaluation</td>
<td>Updating of data, confirmation of models, confirmation of impacts. Scale ≤ 1:50 000</td>
</tr>
<tr>
<td>Environmental Monitoring</td>
<td>Cartographic comparison of initial state, actual and expected impacts. Scale ≤ 1:50 000</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th><strong>Summary of suggested scales</strong></th>
<th><strong>Type of data being mapped</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>≤ 1:500 000 to 1:100 000</td>
<td>Useful at preliminary study stage for presentation of:</td>
</tr>
<tr>
<td></td>
<td>* main population centers</td>
</tr>
<tr>
<td></td>
<td>* important roads and infrastructure</td>
</tr>
<tr>
<td></td>
<td>* main relief features</td>
</tr>
<tr>
<td></td>
<td>* main hydrological network</td>
</tr>
<tr>
<td>&lt; 1:100 000 to 1:10 000</td>
<td>Of interest at feasibility study stage for presentation of:</td>
</tr>
<tr>
<td></td>
<td>* type of housing (scattered, grouped)</td>
</tr>
<tr>
<td></td>
<td>* relief symbolized by contour lines</td>
</tr>
<tr>
<td></td>
<td>* main and secondary hydrographic network with watering places and water supply</td>
</tr>
</tbody>
</table>
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 4.3
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.

Tree plantations: Vulnerable to alterations in groundwater flow.

Mixed forest: Sensitive to disturbance of wildlife, alterations in groundwater 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


