CHAPTER 3

THE UNEP/UNCHS MODEL FOR EVALUATING COMPATIBILITY BETWEEN DEVELOPMENT AND ENVIRONMENT

3.1 Introduction

A growing emphasis on environmental quality has prompted many counties to adopt legislation and guidelines that will ensure the consideration of the natural environment in land-use planning and site selection processes. This has resulted in considerable research and development of models and techniques that can support the spatial planning and decision-making processes. One example is a system developed by UNEP/UNCHS that assists the planners to identify and predict potential conflicts between development and environment at an early stage of the planning project. The model was developed as part of a joint effort to promote environmentally sound planning and management. It has been applied on several occasions but within the framework of manual processing techniques. The methodological and conceptual background of the model is described in the following publications:

- UNEP/UNCHS (Habitat), 1987, Environmental Guidelines for Settlement Planning, vol.II, Environmental Considerations in Metropolitan Planning and Management, Nairobi, Kenya;

- UNEP/UNCHS (Habitat), 1987, Environmental Guidelines for Settlement Planning, vol.III, Environmental Considerations in Regional Planning and Management, Nairobi, Kenya.

These publications were the product of a major joint UNEP/UNCHS (Habitat) project designed to compile available knowledge about the relationships between the natural and the man-made environment and to provide guidelines for planners and decision-makers that would help them use that knowledge in settlement planning and management. This chapter briefly reviews and summarizes the model, along with its fundamental conceptual elements.

3.2 Purpose of the Model

The main purpose of this model is to support the process of anticipating potential conflicts between proposed developments and the environment at an early stage of the planning process. The model offers the possibility to identify potential problems and introduce environmental and social concerns. The early identification of these problems and concerns allow the planners to study them and resolve the conflicts. The model has been found to be useful for regional or general development planning activities but also for independent site suitability analysis. Because this model is applicable to the early stages of a development project it requires very little data.

The model has been used on several occasions as a part of environmental planning and management routines with the main aim to make urban, regional and metropolitan development planning more responsive to environmental considerations. One of the examples is its application within the framework of Lagos Metropolitan Area Master Plan (UNCHS/Habitat/UNDP, 1980). There, as pointed out by J. Eigen (UNEP/UNCHS (Habitat), 1987) it contributed to at least two tasks of the Master Plan effort, namely:

1) *Definition of Future Urban Development Pattern:* where the model was used for defining growth patterns that preserve significant environmental resources and prevent damages from natural hazards.

2) *Establishment of Development Controls:* where the model contributed to the identification of potential development-environment conflicts and establishment of development control procedures at the very early stage of plan making.

3.3 Conceptual Elements of the Model

From the user perspective the model can be understood as an early-stage procedure supported by an appropriate information system. It contains data and facts for determining compatibility between the environment and development within the area concerned. As illustrated in Figure 3.1, this information system is composed of the following components:

1) *Environmental Zone Map* - the composite map identifying all critical issues relating to environmental resources and hazards for each location within the study area.
2) *Projects (Development actions) Impact Identification Checklists* grouped into two categories:
   (i) Impact of development (development actions classified by their potential impact on environmental sensitivity);
   (ii) Sensitivity of development (development actions classified by their susceptibility to environmental hazards and resource shortages).
3) *Interaction Matrix* relating resource-related sensitivities and hazard-related risks within the study area to development actions and their implications.

Once the above components of the model are adequately prepared and organized, the identification of potential development-environment conflicts can than be formalized and applied. Identification is done by relating the site-specific environmental resource/hazard characteristics to the proposed project, i.e. to its development implications that might affect environmental sensitivities or might be affected by environmental hazards. As illustrated in Figure 3.1 the evaluation procedure is based on:

1) Available data on environmental constraints/hazards found at the project location (*Environmental Zone Map*),
2) Potential implications/sensitivities of the proposed development action (*Project's Impact Identification Checklist*),
3) Set of pre-defined facts for assessing and grading the likelihood of potential development – environment conflicts (*Development-Environment Interaction Matrix*).

The outputs are reports containing the following information:

1) Environmental constraints/hazards found at the project location;
2) Potential development implications/sensitivities for the proposed project;
3) A list of potential environmental conflicts that can be expected for the proposed project (development actions) at the selected site.

In this evaluation approach (Figure 3.1) the emphasis is placed on the analysis of the interaction between three sets of mutually related factors namely, location, development actions and environmental settings. It means that in the case of processing certain development proposals it is possible to identify the most and least suitable sites for those proposals, or if the location and proposed development is known, then the potential conflicts can be qualitatively listed. This concept incorporates a close connection between site suitability assessment and environmental impact prediction and at the same time casts both in a larger perspective.

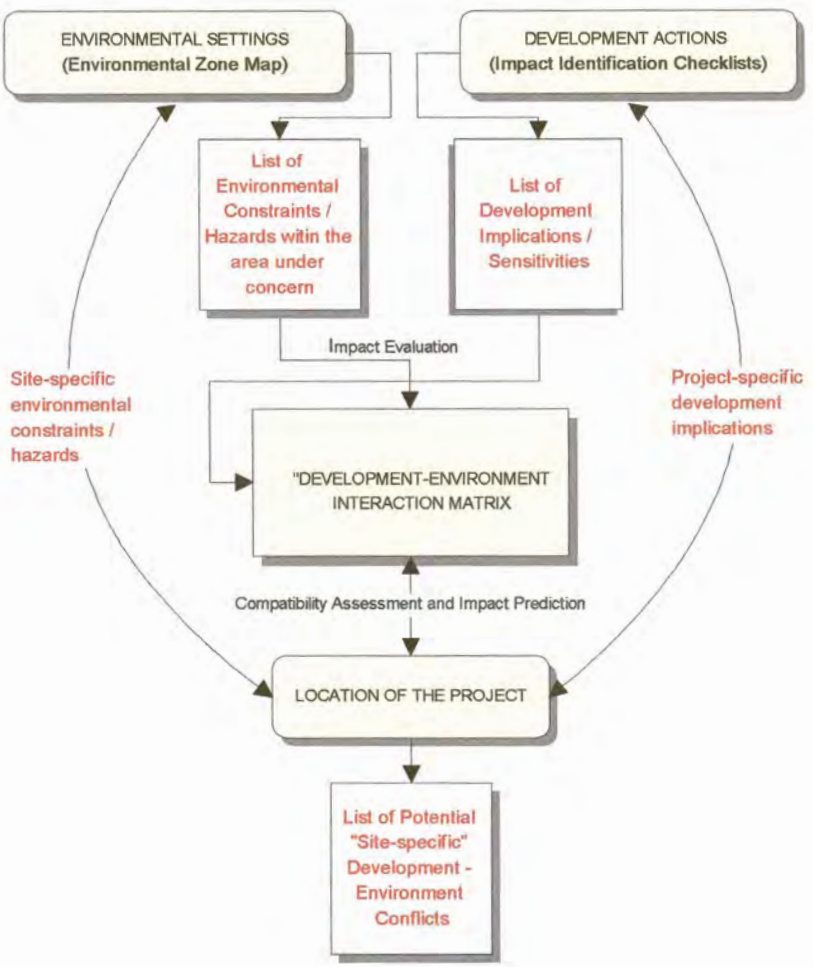


Figure 3.1 Flow diagram illustrating components and procedures for development- environment compatibility assessment

3.4 Steps in developing the Model

The development of the model typically consists of two steps, namely:

1) Environmental Zoning of the area concerned (Establishment of the Environmental Zone Map);

2) Identification of potential interactions between the proposed development activities and the environmental resources/hazards (Establishment of the Projects Impact Identification Checklists and Environment-Development Interaction Matrix).

The following sections provide a more in-depth description of these steps.

3.4.1 Environmental Zoning of the Area Concerned

The overall objective of this step is to divide the study area into zones based on the sensitivity of the environment to development actions (UNEP/UNCHS Habitat, 1987). The process actually begins with the collection of relevant information resulting in an inventory of environmental resources and hazards within the area of concern. The type of information usually required for the environmental zoning task is illustrated in Box I.

BOX I. Type of Information Required for Environmental Zoning

Natural Resources:

- ***Water Supply Sources*** (e.g. surface water and their catchment areas, ground water and their recharge areas);
- ***Land with Agricultural Potential*** (e.g. soils quality, suitable land for traditional farming, rained crop production, etc.);
- ***Forest Resources & Pasture Land*** (e.g. area under forests, potential priority areas for afforestation, grassland etc.)
- ***Fishery & Aquatic Resources*** (e.g. lakes, rivers, estuaries, wetlands, fishing grounds etc.);
- ***Areas with Recreation & Tourism Potential*** (e.g. areas of particular natural beauty, scenic areas, water fronts, etc.);
- ***Natural Heritage Resource*** (e.g. valuable habitats and species, areas with important ecosystem functions etc.);
- ***Minerals And Energy Resources*** (e.g. exploration areas, potential row material finds etc.)
- ***Air Quality*** (e.g. extreme and prevailing winds-direction and velocity, urban air-shed etc);

Environmental Hazards:

- ***Floods*** (e.g. flood prone areas, flood plains, flood ways etc.)
- ***Earthquakes*** (e.g. seismic zones and micro-zones characteristics, earthquake prone areas etc.)
- ***Slope And Soil Related Hazards*** (e.g. land prone to subsidence, landslides, erosion, engineering constraints etc.);
- ***Man Made Hazards*** (e.g. air pollution, noise pollution, areas prone to conflagration, landfill sites and Other areas with unsanitary environmental conditions etc.)

Land Use and Man Made Heritage:

- ***Land Use*** (e.g. existing land use, planned land use characteristics and policies, zoning regulations etc);
- ***Man Made Heritage*** (e.g. archaeological, historic, cultural and landscape resources etc.);
- ***Demographic Areas*** (e.g. population distribution, population density etc.)

Adopted From: Environmental Guidelines for Settlements Planning and Management, Vol II.. UNCHS(Habitat)/UNEP, 1987.

To avoid unnecessary data collection and data redundancy, the first step is to formulate general "environmental objectives" and rank them according to their significance for the study area. For illustration purposes a set of environmental objectives could be as follows:

Preservation of resources

- Water supply;
- Agricultural resources;
- Forest resources;
- Wildlife and recreational resources;

Avoidance of hazards

- Erosion hazard
- Slope constraints
- Terrain stability

The "environmental objectives" should also be translated into a set of environmental factors that could be surveyed and documented (e.g. site slope, land formation, soils carrying capacity, prevailing winds etc.). These environmental factors in turn need to be ranked and mapped according to their significance for each of the "environmental objectives". The final products of this procedure are separate maps showing individual environmental sensitivities/constraints and their ranking in respect of a single resource/hazard concern (environmental objective). An example of the environmental factor maps prepared for the Lagos Metropolitan Area Master Plan is provided in Box II.

BOX II

EXAMPLE OF A LIST OF ENVIRONMENTAL FACTOR MAPS AND THEIR RANKING WITH RESPECT TO A SINGLE RESOURCE/HAZARD CONCERN (ENVIRONMENTAL OBJECTIVE)

ENVIRONMENTAL FEATURE [FACTOR MAP]	ENVIRONMENTAL OBJECTIVE	RANKING OF ATTRIBUTES BY DEGREE OF CONSTRAINTS
Land Formation	Avoidance of Unconsolidated Land	0 – Coastal Plain Sand 1 – Older, Consolidated Dune 2 – Alluvial Plain 3 – Unconsolidated Dune
Soils and Subsoil	Avoidance of Unstable Soils	0 – Normally no Constraints 1 – Moderate Foundation Constraint 2 – Severe Foundation Constraint
Soils and Subsoil	Preservation of Agricultural Potential	0 – Soils Not Suited for Agriculture 1 – Soils with Fair to Good Agricultural Potential
Drainage Conditions	Avoidance of Floodplains	0 – Dry Land 1 – Reclaimed Land 2 – Area Flooded as a result of Urban Develop. 3 – Naturally Flooded Area 4 – Areas with Severe Reclamation Constraints
Catchment Areas	Preservation of Water Supply Sources	0 – Outside Critical Catchment Area 1 – In Catchment Area 2 – Wetlands in Catchment Area 3 – Wetland in Catchment Area close to Intake
Flora and Fauna Fishing Community	Preservation of Fishery Resources	0 – No Identified Significance 1 – Fishing Grounds 2 – Wetlands Significant for Subsistence Fishing 3 – Access to Fresh Water Habitat 4 – Wetlands Significant for Fresh
Noise Pollution	Avoidance of Noise Zones	0 – Below 25 Noise Exposure Factor (NEF) 1 – NEF 25-30 2 – NEF 30-40 3 – NEF > 40
Existing Agriculture and Forestry	Preservation of Agricultural Potential	0 – No identified Significant Farming 1 – Traditional Farming 2 – Mechanized Farming 3 – Forest Reserves
Prevailing Wind	Preservation of Clear Air-shed	0 – Outside Air-shed 1 – Areas from which Air-mass is generally replaced
Site Slope	Avoidance of Slope Constraint	0 – No identified Significance 1 – Too Flat (Run-off Constraints) 2 – Hilly terrain 3 – Steeply Dissected Terrain
Air Pollution etc.	Avoidance of man-made Hazards	0 – No identified Significance 1 – Areas Affected by Emissions 2 – Unsanitary Environmental Conditions

Adopted From: Environmental Guidelines for Settlement Planning and management, Vol. I, UNCHS(Habitat)/UNEP, 1987.

With these environmental factor maps, environmental zones can then be defined by combining (overlaying) these maps and by delineating areas within which the environmental characteristics are homogenous. The overall result of this procedure is a composite map (Environmental Zone Map) containing the combination of resource-related sensitivities and hazard-related risks that can be expected for each location in the study area. Figures 3.2a and 3.2b are examples of the "Environmental Zone Map" and its accompanying legend manually prepared within the framework of the Lagos Master Plan effort.

3.4.2 Identification of Interactions between Development Implications and Environmental Resources/Hazards

The second stage of developing the model is the identification of interactions between development implications and the environmental resources and hazards within the study area. This process involves the creation of an interaction matrix that will provide a basis for the site-specific environmental compatibility assessment and the identification of conflicts between development and environment.

As illustrated in Figure 3.1, construction of the Development-Environment Interaction Matrix consists of three steps:

1) Preparation of a list of all environmental constraints found within the area of concern,

2) Preparation of a list of all development implications and sensitivities,

3) Impact identification and evaluation – analysis of the development implications/sensitivities in respect of their potential conflicts with each of the environmental constraint factors.

While the list of environmental constraints (resources/hazards) within the area of concern can be extracted form the Environmental Zone composite layer, identifying the development implications and sensitivities requires the definition of development actions along with their possible impacts on the environment and vice versa.

As illustrated in Figure 3.1, definition of development actions and related potential environmental implications/sensitivities can be treated at a site-independent level and thus with generic data that can be compiled *a priori* in order to provide input for the construction of the Development-Environment Interaction Matrix. For this purpose, the information system as suggested by UNEP/UNCHS (Habitat), uses a "Simple Impact Identification Checklist" approach. In this approach, development actions are pre-defined and grouped into general (urban and non-urban) land-use classes. The classification principle is based on the impact of the land-use options (development actions) on the environmental resources and hazards. The land-use implications are grouped into two categories:

1) *Impacts of development* (development implications that might affect environmental sensitivity);

2) *Sensitivities of Development* in respect to environmental hazards and resource shortages.

Figure 3.2c provides an example of such an Impact Identification Checklist manually prepared within the framework of the Lagos Metropolitan Area Master Plan.

The final and the most difficult step is the identification and evaluation of the interactions between development and environment. This step involves a cross-reference between the checklist of development implications/sensitivities with respect to their potential interactions (conflicts) with each environmental resource/hazard factor retrieved from the "Environmental Zone Map". The information

for cross-referencing is provided in a matrix, where the columns contain the description of the environmental constraints (resource/hazard factors), while the rows contain the potential development implications/sensitivities.

An example of the Interaction Matrix prepared to support the assessment of compatibility between development and environment within the framework of the Lagos Metropolitan Area Master Plan is given in Figure 3.2c. It can be regarded as the site-independent overview of all potential development-environment conflicts that can be expected within the Lagos Metropolitan Area.

3.5 Development-Environment Conflicts Evaluation

The purpose of this section is to provide an example of a typical evaluation process to determine conflicts between development and environment. The example summarizes the forms and formats of the UNEP/UNCHS model and illustrates the evaluation approach and procedures as they where manually applied in the Lagos Metropolitan Area Master Plan. (J. Engen, UNEP/UNCHS (Habitat), 987). Once the components of the model are prepared ("Environmental Zone Map", Projects Impact Identification Checklists, Development-Environment-Interaction Matrix), the evaluation procedures can be formalized so that users (planners, development control staff, etc) can apply them with limited training.

Engen (UNEP/UNCHS (Habitat), 1987) uses the example of a municipality that wants to construct a new car battery plant on a site shown in Figure 3.2a. How would the development-environment compatibility assessment of this proposal work? First, the practitioner performing the assessment task would locate the project site on the "Environmental Zone Map", as illustrated in Figure 3.2a and identify the code of the zone within which the site falls (in this case, zone C.14). Using the legend of the "Environmental Zone Map", illustrated in figure 3.2b, the type of environmental constraints at the proposed site would be determined. In this example, the legend indicates that the site lies:

- Inside the catchment area critical for the municipality water supply;
- Inside an area with soils suitable for agriculture;
- Inside the air-shed from which the air masses of existing urbanized areas are being replaced;
- On older consolidated dunes
- In the area with moderate foundation constraints; and
- In the area that is seasonally flooded.

Next, the practitioner would use a checklist relating development actions (land use options) to a list of potential development implications, as illustrated in Figure 3.2c. For heavy industry (car battery plant) this checklist would indicate, that in terms of development implications that might affect environmental sensitivity, all items on the list are applicable. In terms of sensitivities to environmental hazards the checklist would indicate that the proposed development is (a) sensitive to flooding, (b) requires high foundation loads; and (c) requires extensive infrastructure.

Having identified the environmental constraints for the proposed site and the development implications/sensitivities for the proposed development, the practitioner would finally compare them to determine the potential conflicts. This procedure is based on the use of an interaction matrix. As illustrated in Figure 3.2d a variety of potential conflicts are flagged for review. Most important (large dot) in this case are the problems of emissions in the urban air-shed, a series of potential impacts on water supply sources arising from grading and reclamation during construction activities and potential

problems arising from storm water runoff and waste disposal. Other issues deserving attention include flooding and potential foundation problems, as well as issues related to the provision of access to environmentally sensitive areas.

The ultimate result of this routine evaluation procedure would be a report containing a list of potential development-environment conflicts that can be expected for the proposed development at the selected site. It would provide a basis for the introduction of environmental concerns at the very early stage of project planning in order for them to be studied.

The conceptual approach to environmental evaluation and the organization of the model's components illustrated in the example above served as a starting point in the preparation of the prototype of a Knowledge based GIS (KBGIS) developed in this research.

Figure 3.2a
An example of the manually prepared "Environmental Zone Map" (identifying for each location within the area concerned all critical resources/hazards issues)

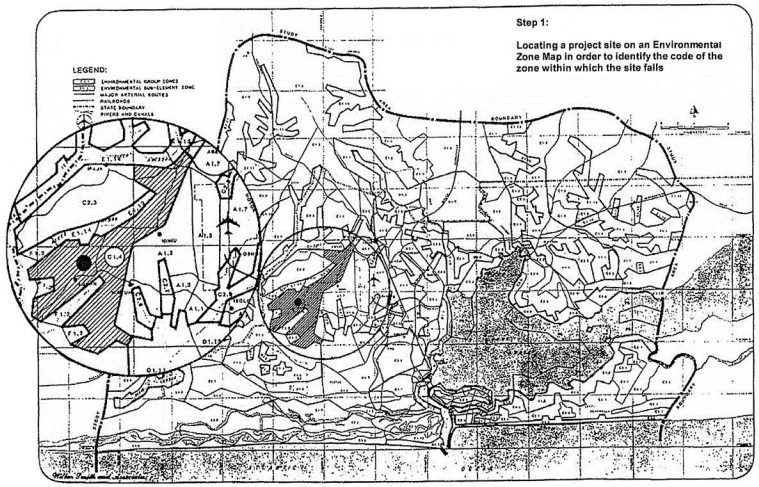


Figure 3.2b
Legend of Environmental Zone Map showing incidence of constraints (resource-related sensitivities and hazard-related risks) in each environmental zone

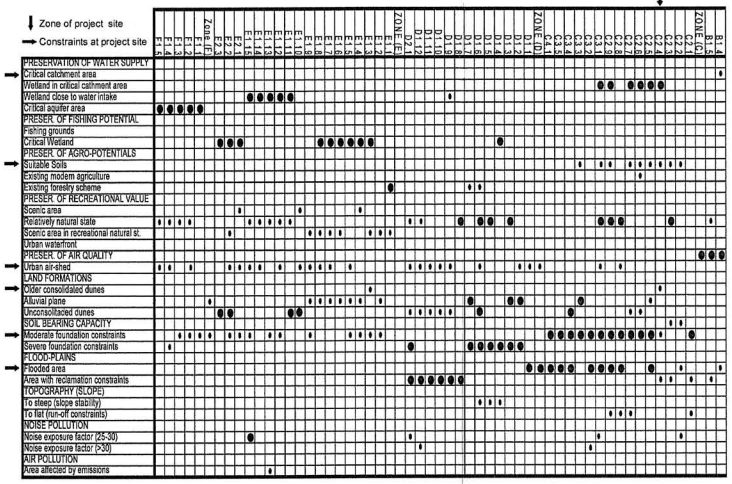


Figure 3.2c
An example of the manually prepared checklist relating development actions (land use options) to their potential development implications

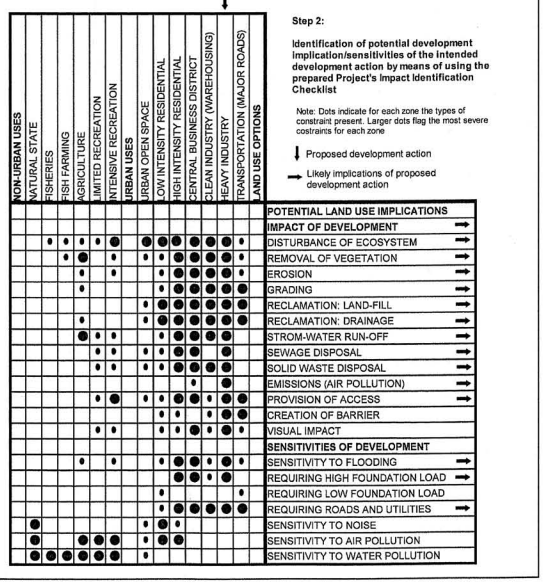
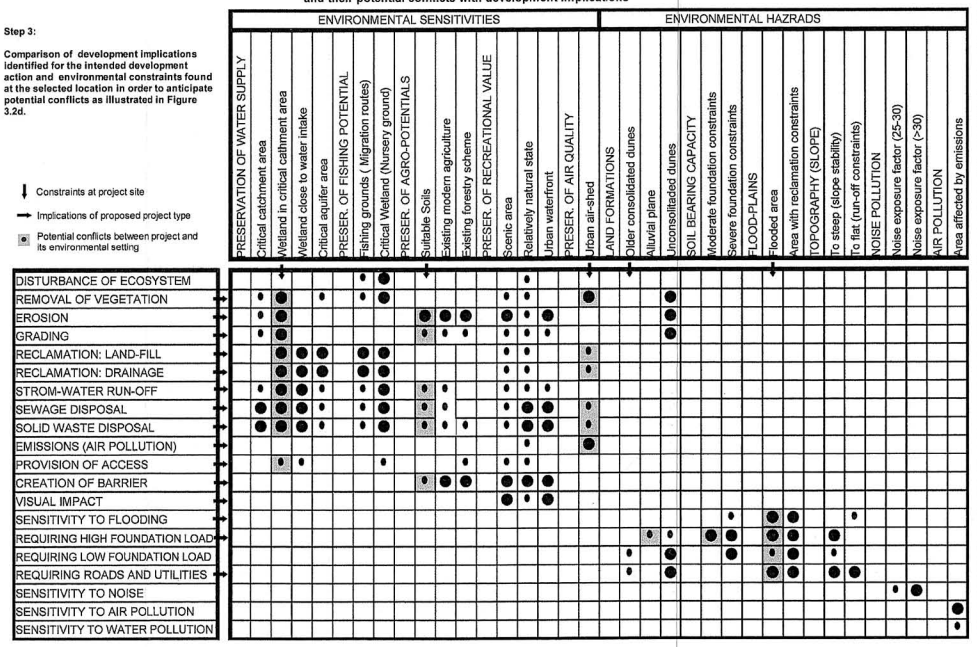


Figure 3.2d An example of the manually constructed interaction matrix indicating environmental constraints and their potential conflicts with development implications

Step 3:

Comparison of development implications identified for the intended development action and environmental constraints found at the selected location in order to anticipate potential conflicts as illustrated in Figure 3.2d.

Constraints at project site
Implications of proposed project type
Potential conflicts between project and its environmental setting



Source: Eigen, J. "Land Suitability and Physical Constraints to Urban Development, Master Plan for Metropolitan Lagos, (Lagos, Nigeria: LSG/UNCHS/UNDP/WSA),1988