preferably 1:50,000 or larger. For preference, large-scale surveys should be supplemented by grid-pattern soil sampling undertaken for the specific purpose of measuring soil salinity, along with measurements of other soil properties and the depths to the water-table and underlying impervious strata. The most important single soil property to be measured in this way is the electrical conductivity of the soil water, which can be related to the concentration of salts in the soil. Electrical conductivity can be easily measured using a conductivity meter on a saturation extract sample of soil water, undertaken according to standard laboratory procedures which have been extensively described in the literature. Electrical conductivity can be correlated with the concentration of specific solutes in the soil solution, to give an accurate indication of salinity hazard. The US Salinity Laboratory has established criteria for the categorization of salinity hazard according to the value of electrical conductivity so obtained.

In recent years, a number of field techniques for the rapid assessment of salinity hazard using geophysical technology have been developed and refined. The electrical resistance of the soil can be measured *in situ* by various means and the results related to soil salinity by correlation. The two methods in most common use are to measure electrical resistance directly using sensor probes buried in the soil or to use portable electromagnetic induction (EMI) equipment.

The most usual probe method involves driving a set of four electrode probes in a line in the soil, applying an electrical current between the outer probes, and measuring the potential difference between the inner pair. The electrical conductivity of the soil is calculated from an empirical relationship. Whilst the probe method has the advantages of simplicity and cheapness, it has the major disadvantages that it is a slow and time-consuming process and that it is difficult to make accurate measurements when soils are dry.

The EMI method does not require electrodes to be inserted in the soil. It involves the use of a magnetic coil above the soil surface to create a magnetic field within the soil, the signals from which are measured by a second suspended coil. The equipment can be calibrated to read directly in electrical conductivity units Small units can be mounted on light tractors or all-terrain vehicles and very rapid and detailed surveys can be undertaken in this way. It is also possible to tow larger instruments behind vehicles or even to mount the equipment in aircraft for rapid, large-scale survey purposes.

5. Damage cost assessment

The various categories of water-based natural disaster described in Chapter III and the various categories of land degradation described in Chapter II all have adverse consequences in economic, social and environmental terms. Most of these consequences can be measured, estimated or at least ranked as a basis for comparison in economic terms, sometimes directly, sometimes indirectly and otherwise intangibly or by inference.

Where new works, facilities, schemes or policies for the prevention or mitigation of future disasters or further degradation are under investigation, a range of alternative solutions will usually become apparent. It then becomes necessary to find some means for ranking these alternatives in order of merit and choosing the best alternative in terms of a selected set of criteria. Most commonly, these criteria are expressed in monetary terms, because this provides the most convenient yardstick for the ranking and comparison of a wide range of alternative plans or designs. Good integrated watershed management practice requires that other yardsticks, both quantitative and descriptive and assessing environmental, social and other parameters, be also used for ranking alternatives on a multi-objective basis. Nevertheless, the use of economic yardsticks remains essential, partly because of their universal application, partly because of the precision with which they can be assessed by comparison with other criteria, and partly because they can be manipulated in a timestream sense to place present and future costs and benefits on a comparable basis.

Where a set of disparate alternatives is identified, each offering as its outcome a different potential level of community satisfaction, the most appropriate basis for economic ranking is to express all the outcomes in monetary net benefit terms. Where each of the alternatives provides the same outcome, a much simpler economic comparison on the basis of least cost or cost effectiveness is possible. Whichever approach is to be used, the starting point is a detailed measurement of the past costs of damages associated with disasters or degradation of the kind under investigation, preferably at the subject site. Once details of damage costs are known, the benefits of mitigation alternatives can be assessed in terms of the reductions in damage cost that can be expected to accrue from them.

A considerable background of experience, literature and data is now available regarding flood damage costs, probably because floods are recurring and site-specific. Less information is available about the costs of cyclone damage, land instability or droughts or the various forms of land degradation, but most countries within the ESCAP region are progressively accumulating data in this regard. The techniques employed for flood damage assessment can be transferred with little difficulty to the measurements of other forms of disaster damage. The costs of land degradation are more difficult to assess, largely because of the progressive and incremental nature of this form of damage and the fact that many forms of land degradation arise from land-use practices which, at least in the initial stages, are undertaken because they are considered to be profitable and therefore beneficial.

The losses caused by a natural disaster may be classified under one of three headings as:

(a) *Direct* losses, actual or apparent, which can be evaluated in terms of the costs of replacement or repair of all the physical damage caused by the disaster event;

(b) *Indirect* losses, which can be expressed as the value of business, services or economic activity either lost or made necessary by the disaster event;

(c) *Intangible* losses, which are not capable of direct monetary evaluation, which include loss of life and effects upon health, social and economic security.

Damages within these three categories may be scheduled under a list of headings which could include:

- residential
- commercial
- industrial
- utilities
- rural
- transport
- public

Residential losses include damage to buildings and grounds, furnishings and personal possessions. In extreme events, dwellings might be completely destroyed; in less severe events, they may be extensively damaged by inundation, filled with mud, silt or debris, or undergo various forms of structural impairment, requiring substantial repair or refurbishment. The costs of evacuation during the event, the provision of emergency accommodation, damage relief costs and so on would constitute indirect costs under this heading.

Commercial losses comprise the losses sustained by establishments engaged in trade, such as shops, markets, banks, restaurants, hotels, professional offices, service providers etc. In addition to costs associated with the repair or reconstruction of buildings, damages in this category might include loss of goods and merchandise and loss of business accounts and records. Indirect losses under this heading might include lost wages, salaries and revenues, the loss of contracts and other business and additional operating costs imposed by the disaster event.

Industrial losses refer to losses incurred by the manufacturing and industrial sector and may include loss of, or damage to, buildings, land, equipment, raw materials and stored products. Indirect losses under this heading will be of a similar kind to those discussed under commercial losses.

Utilities as categorized here include all agencies and private or government organizations that provide or sell some kind of consumer service, such as electricity, gas, water, telephone and telegraph services. Destruction or damage of buildings, property, plant, equipment and distribution systems might all be included under this heading. Indirect losses would include the effects of interruption of service, loss of revenue and other income and the costs of providing emergency supply.

Rural losses might include a wide variety of losses resulting from damage to, or loss of, agricultural, grazing and forest land; damage to buildings, fences, and farm equipment; degradation of land or reduction of its productivity through deposition of mud, silt, debris and so on; or the loss of crops and livestock. Indirect losses under this heading would be similar in many ways to those incurred under the residential and industrial headings, along with loss of revenue because of the destruction or reduced quality of farm products and the costs of replanting or restocking.

Transport losses are those incurred within the transport infrastructure and may include damage to road surfaces, railway tracks, airports, harbours or canal systems; loss or damage of bridges, causeways, tunnels, and similar ancillary features; destruction or damage to buildings such as railway stations and airport terminals; damage to rolling stock, vehicles or equipment; and the loss of goods or freight in storage or transit. Indirect losses may be due to service and traffic interruptions, the costs of rerouting or alternative arrangements and loss of passenger or freight revenue.

Public losses relate to losses incurred by national, state, regional and local government bodies, and may include destruction of or damage to buildings, property, equipment and facilities, loss of records and accounts and interruption to services. Direct and indirect losses incurred under this heading will be generally similar to those discussed under the heading of commercial losses.

Under each of the foregoing headings, losses might also be categorized as *recurrent* and *non-recurrent* losses. The former category refers to all those losses which can be expected to recur every time a major disaster event takes place. The latter refers to losses which will not occur when a future event takes place, because of the nature of the repairs or replacements undertaken after the first event For example, a bridge destroyed in a flood event may be replaced by a new bridge constructed at a new location well above flood level, or a damaged residential area might be relocated to a flood-free zone. In general, it is only recurring losses that need to be considered in the estimation of future flood benefits from a proposed mitigation measure, although the costs of zoning or relocation might be considered as part of the cost of such a measure.

To determine the magnitude of the losses associated with a disaster event, as a basis for the planning of measures to mitigate or prevent damage from future events, an extensive damage survey becomes necessary. For preference, such a survey should be undertaken as soon as possible after the event and on as comprehensive a basis as the available resources permit.

The most effective method of survey is to undertake a detailed survey of the entire area affected by the disaster under investigation. This will require a team of engineers, quantity surveyors and other assistants equipped to locate and interview every property owner or tenant within the disaster area. The investigators should be provided with detailed maps or airphotos of the area and a set of standardized data sheets embodying a carefully-designed questionnaire or set of questionnaires for appropriate categories of building or property As a guard against exaggeration, the investigators should undertake independent evaluations of the losses incurred at a representative sample of sites within the area. The data so obtained should be supplemented by the data collected by the relevant state and local government agencies responsible for the area under investigation.

Where sufficient resources are not available, the investigators might have to be satisfied with a sampling survey. Where this becomes necessary, much care needs to be taken in the design of the survey, to ensure that the sample is reasonably representative. There is a variety of sophisticated sampling procedures available for such purposes.

Because major natural disaster events are sporadic in occurrence and vary widely in intensity and frequency, it is highly desirable that data from a range of such events be available for the planning and design of mitigation measures. For preference, it is desirable to establish relationships between levels of disaster intensity and the magnitudes of consequential damage costs, as a basis for determining the level of intensity for which protection or mitigation is provided. In the case of flooding, it is usually possible to relate the extent of damage costs to the depth of flooding. This is most commonly achieved through the preparation of stage-damage curves, which relate the total amount of damage to the river stage or depth. Where data from a range of past flood events is not available, it is still possible to prepare estimations of the stage-damage relationship through careful questioning and investigation, undertaken during the progress of a detailed damage survey by estimating what the levels of damage would have been at different flood depths. If data from two or more flood events is available, the accuracy of this procedure can be much enhanced.

For flood-prone areas, where adequate data relating flood depth to river discharge are available, stage-damage data can be readily converted to discharge-damage data and, if a reasonably long record of hydrological records exists, this information can be used to prepare relationships between flood damages and frequency of occurrence. This leads to the evaluation of information about average annual flood damages or expected values of flood damages on a present worth basis, which can then be used to determine the benefits associated with alternative flood mitigation schemes.

In many parts of the ESCAP region, floods occur annually and it is possible to accumulate sufficient data for the preparation of stage-damage and frequency-damage curves in a comparatively brief period of time. For other kinds of short-lived natural disaster such as tropical cyclones and land instability, occurrence is much more sporadic and it becomes necessary to transfer data from other locations where similar disasters have occurred. Major droughts present a different kind of problem again, because of the long-term duration and extensive areal coverage of such events. Apart from the study of State, regional and local government records relating to past drought events, well-designed sampling studies and carefully-worded questionnaires, including hypothetical scenarios of possible drought circumstances, might be utilized to build up scale-of-intensity/damage or frequency/damage relationships as a basis for drought mitigation planning.

Once a reasonable set of data regarding relationships between natural disaster damage and the intensity and/or frequency of occurrence is established, the economic benefits of proposed disaster-mitigation alternatives can be assessed in terms of the reductions in damage costs expected to result from them. Because of the unpredictable nature of natural disaster events, simple comparisons based on average annual damages or benefits, or expected values of damages or benefits in present worth terms, are an inadequate basis for decision-making. A statistical analysis is needed, in which careful consideration of the probabilities or levels of risk associate with events of a given magnitude is presented and the probability distributions of damage costs and mitigation benefits are assessed.

E. Hazard evaluation

1. Flood inundation mapping

In order to reduce the adverse impacts of flood disasters, it is essential to accurately delineate areas which are prone to future flooding. The exercise of assessing and delineating the zones subject to floods of different magnitude and different frequencies is usually termed flood risk mapping.

Accurate delineation of flood prone areas is a basic step in the formulation and effective implementation of either structural or non-structural flood mitigation measures. Flood risk maps are a particularly guide for the planning and implementation of land-use measures, including watershed management techniques and land-use zoning and regulation.

The approaches to flood risk mapping can be grouped into two general categories, *viz.*,

(a) Those which determine flood run-off or peak discharges in a river and then determine the area inundated under peak level conditions;

(b) Those which define the flood hazard directly from recorded or assumed inundated areas.

The first category is referred to as "the hydrological and hydraulic approach". In this approach the following methods of determining peak flows may be used:

- flood frequency analysis
- the regional flood method
- flood formulae

Flood frequency analysis uses records of past flood events on the river under investigation to define the statistical probability of floods of different magnitudes. For example, flood discharges likely to occur or to be exceeded once in twenty, once in fifty or once in one hundred years can be defined by this method. However, the method is demanding both of data and of expertise in computation.

Where river gauging records do not exist, or where the length of record is too short to be useful, discharges may be estimated by rainfall-run-off models or by statistical comparisons with adjacent river basins where records do exist. When the flood peak discharges have been determined by any one of these methods, the discharges must be routed through the river reach to determine the areas of inundation and to produce a flood risk map.

The geometric configuration or cross-section of the stream channel and adjacent overbank areas can be obtained using ground or aerial survey. The dimensions of culverts, bridges, flood control structures and other encroachments upon the floodplain are included within the cross-sectional information Hydraulic analysis is used to determine how much of the floodplain is required to pass a given flood discharge and the corresponding flood elevation.

Using these methods, flood boundary maps can be prepared for floods of different magnitudes, say the 10, 20, 50 and 100 year floods. When combined, they provide a flood risk map which indicates the extent of the zones inundated by each of the indicated flood magnitudes. When superimposed on topographic maps, these permit an estimate to be made of the depth of flooding at specific locations.

The second category of flood hazard mapping methods includes methods based on recorded flows, geomorphological surveys, soil surveys and intelligent guesswork.

Perhaps the simplest way to define a flood hazard area is to equate it with the area actually inundated by a historic flood. Whilst this defines the hazard area, it does not provide information about the magnitude of the flood or its recurrence interval. To be useful, the recorded flood should be a fairly large one, but it may not be possible to determine just how large it is in relation to other possible floods, as in many cases the streamflow records required for flood frequency analysis will not be available.

Aerial photographs or satellite imagery taken at the height of a flood can be most useful in determining the flood outline. Excellent maps can be compiled from past flood surveys, from information collected on the ground, although this approach is generally more time-consuming. Ground survey has one major advantage, however, for not only can a record be made during or shortly after a flood event, but, if necessary, the outlines of past floods can be mapped even a decade later using local anecdotal or historical information about past flood events.

Geomorphological and soil mapping are generally useful where streamflow records are lacking or inadequate. They may be particularly suited to the study of large, wide floodplains where floodwaters may cover extensive areas to varying depths and velocities. A study of topography and sediments can reveal much of the history of past floods in the valley and can indicate the patterns of flooding likely to occur in the future. A detailed survey can indicate the extent of the area submerged by large floods, the direction of flood currents and the incidence of sediment deposits and erosion.

It should be appreciated that a certain degree of uncertainty can be associated with the boundaries of floods as delineated on the basis of the mapping methods discussed above, including methods which use past flood records. The pattern of future floods can be affected by a number of factors such as the accuracy of topographic mapping, hydrology, hydraulics and changes within the watershed and the river channel. Many land-use practices have the capacity to alter the run-off regime and increase flood risks. The many forms of watershed degradation can, either singly or in combination, accelerate the rate of delivery of floodwater to the river, thus producing higher flood peaks and more extensive inundation. Intensive urban development may produce similar effects. In addition, flood behaviour can be altered by changes in the river channel, caused by sedimentation or erosion, or the construction of bridges, levees and other works.

2. Erosion hazard survey and prediction

In areas which are susceptible to water and wind erosion, systematic surveys of soil erosion should be undertaken to assess the magnitude of the particular forms of erosion present, including the areal extent of occurrence and level of severity, and to determine whether there is potential for further erosion. For watershed management purposes, these surveys are best undertaken on a whole-of-watershed basis. They might also be undertaken on a whole river-basin, regional or provincial scale as part of a road-scale survey of existing and potential land degradation.

Erosion surveys are usually undertaken in association with soil surveys or land evaluation surveys. If they are mounted specifically for watershed management or river basin management purposes, they should be based on remote sensing techniques, supplemented as necessary and appropriate by field survey.

For broad-scale, regional or large river basin-scale surveys, the survey is best based on Landsat imagery, supplemented in areas of apparent severity of erosion by black and white or panchromatic aerial photography. Landsat-based mapping at a scale of 1:100,000 is appropriate for this kind of survey. For specific watershed management purposes, where land-use controls and/or modifications are expected to be necessary for erosion control purposes, larger scale mapping based on standard airphotos is most appropriate. Maps for this purpose might be presented at a scale of 1:50,000 or, for smaller upland watersheds, 1:25,000 or even larger.

The field verification or supplementation of the remote sensing survey may be undertaken in several ways, involving either grid sampling, transect sampling or stratified sampling in which areas identified from airphotos are selected and then subjected to more detailed ground survey. Where previous soil or land resource surveys have been undertaken using a land systems approach, the land systems already identified will provide a good picture of erosion occurrence or erosion hazard potential and a good basis for the selection of areas for the stratified erosion survey.

The susceptibility of an area of land to soil erosion, as well as the prediction of the likely effects of changes in land-use and farming practices on the extent of such erosion, can be readily assessed by using one of the several computer models available for this purpose. The best-known soil erosion prediction model is the Universal Soil Loss Equation (USLE), originally developed by the Soil Conservation Service of the US Department of Agriculture. In its original form, derived for the quantitative prediction of soil loss under arable farming conditions for the mid-Western states of the USA, it is an empirical equation which depends upon several parameters, which comprise a rainfall erosivity parameter, a length and slope parameter, a cropping practice factor and a management practice factor. These parameters are specific to the site for which they were derived, so that application of the model in other locations requires that they be re-evaluated. Extensive studies have now been undertaken to modify the model for use elsewhere in North America, Europe, Australia, Indonesia and other countries within the ESCAP region and various computer model formats are available. Typical of such a format is the SOILOSS programme developed for Australian conditions by the former NSW Soil Conservation Service.

Other more advanced modelling procedures have recently been developed in North America, Europe and Australia. In the USA, The USLE has been largely replaced by a computer-based modelling procedure called WEPP (Water Erosion Prediction Project), for which information is available from the US Department of Agriculture. Several more advanced models have been developed in Australia, notably by Professor Calvin Rose of Griffith University in Queensland.

3. Land instability hazard survey and prediction

In areas which are known to be susceptible to land instability, it is important to undertake hazard surveys and make detailed investigations of existing landslides and other instability events in order to provide a scientific basis for hazard management and future hazard prediction.

Reconnaissance hazard surveys are most conveniently undertaken using large-scale aerial photography. The airphoto interpretation should be accompanied by any existing large-scale topographic maps and geological maps, together with any other geotechnical survey information that might be available. If the region under investigation has already been surveyed or evaluated on a land systems basis, the land system mapping units will probably already have identified areas of potential instability hazard and will provide a useful basis for the concentration and stratification of the airphoto survey and any supportive field investigation. A special map showing in detail the areas of existing instability should be prepared, using as large a scale as possible e.g. 1:5,000 or even 1:1,000. Airphotos enlarged to the appropriate scale form an excellent base for such a map.

Detailed field investigation of any major instability features identified should be undertake to measure the extend of the landslide or slip and any potential downslope danger areas and also to determine the cause of the instability as a basis for the prediction of future movement. Such an investigation might include:

(a) A detailed site survey, involving a contour survey of the unstable area and mapping if its outline and the location of any surface cracking, slump circle features etc;

(b) An onsite geological and geophysical survey aimed at an understanding of the geological characteristics of the sliding area; depending upon the extent and significance of the site, this might include exploratory drilling and the use of a geophysical technique such as a seismic survey, an electrical resistivity survey or an electromagnetic induction (EMI) survey;

(c) A groundwater investigation looking at groundwater quality, depths to water table, drainage paths, pore pressures etc. which might also include geophysical investigation;

(d) Soil sampling for geomechanical analysis including soil classification, soil physical properties, shear strength etc.;

(e) Analysis of weather information and rainfall characteristics of the site;

(f) Collection and evaluation of historical data, newspaper records, and local anecdotal evidence.

On the basis of this information, a geological and engineering analysis should be undertaken with the specific objectives of establishing the causes of the existing stability, assessing the degree of danger of further instability, slope failure, landslip etc., and planning precautionary countermeasures. These might include engineering solutions, such as improved drainage, slope stabilization, retaining wall construction etc., as well as non-structural measures such as land-use rezoning, changed forms of land management, revegetation with deep-rooted species, or the introduction of warning systems and evacuation schemes.

F. Simulation modelling of watershed systems

1. Watershed system modelling concepts

Since the early 1960s, when digital electronic computers began to become readily available to engineers and hydrologists, these machines have increasingly been used to simulate the behaviour of watersheds and water resources systems for a variety of planning, design and operation applications.

Early watershed models, which were principally developed for flood estimation purposes, were essentially mathematical models involving sets of differential equations which were difficult to solve analytically. The development of the electronic analogue computer, which could rapidly solve differential equations by a process of successive integration, made it initially possible to use simple catchment models for flood routing and flood prediction. Hardware limitations considerably restricted the applicability of analogue computer solutions to complex water resource systems, however, and the rapid development of the digital computer, able to solve differential equations rapidly using finite difference techniques, soon made analogue approaches obsolete. With the development of catchment process models and water quality models based on discrete time-series computation using simple mass balance equations, the advantages of the digital computer soon became apparent. Digital computers have particular advantages for such purposes, firstly because they are able to store and process very large quantities of data, and secondly because they are able to undertake a very large number of calculations extremely rapidly.

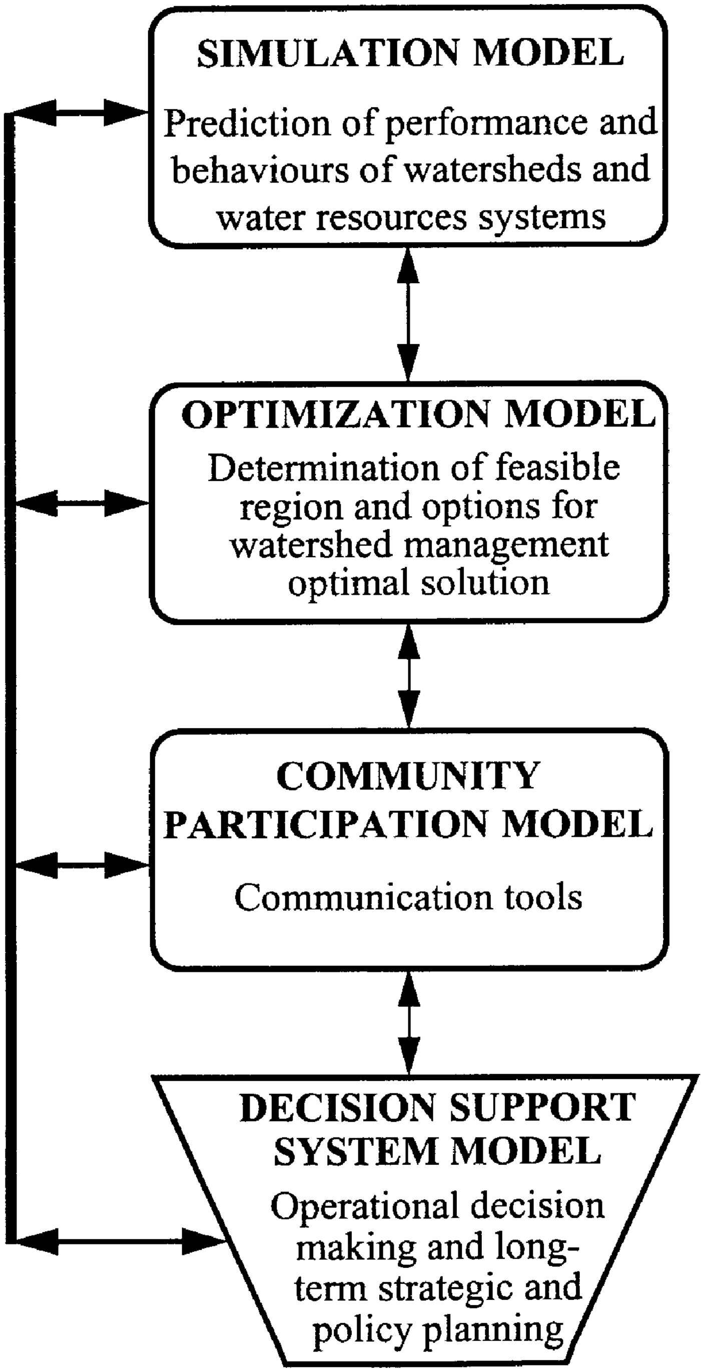
Within the last two decades the use of watershed models for a variety of planning and design purposes has expanded enormously, firstly through the increasing availability of comparatively low-cost computer work stations to academic and engineering organizations, and more recently, through the development of the personal computer (PC), which has made it possible for most engineers to have a sophisticated computer work station, capable of handling very complex modelling applications, available on their desks.

There is now an extensive literature on watershed modelling and a number of excellent computer programmes is available both commercially and in the public domain for a wide range of watershed management purposes. The field is in a constant state of development, with improvements continually being made to existing models and new models frequently being introduced. Because of the speed with which the field is developing, it is not feasible in this manual to do more than provide an overview of the scope of the modelling techniques currently available, indicate likely areas of application, and list some of the widely-used programmes available in the public domain. Readers planning to make use of modelling techniques for watershed management purposes are strongly cautioned to review the current water resources literature and contact appropriate government agencies before selecting a model for application.

There is a variety of ways in which watershed models may be distinguished and categorized. The more important of these categories (see figure 6) are discussed below.

Firstly, a distinction needs to be made between *simulation* models and *optimization* models. Simulation models are models which are set up to reproduce or simulate the behaviour of watersheds, catchments, river basins and various kinds of water resources management systems, including systems which have a substantial component of man-made works and structures. Simulation models are used to predict the performance or behaviour of a water resource system when subject to various input

FIGURE 6. MODELLING PROCESS IN WATERSHED MANAGEMENT



stimuli and/or various means of internal manipulation or operation. They are the principal subject of this Section. Optimization models are models which seek to find the best way of manipulating, designing or operating a water resource system; they are essentially decision-making models. Optimization models are the subject of Section V.G of this manual.

Before proceeding to further categorization and a discussion of currently-available model types, it is important to consider the steps that need to be taken in the development of a simulation model. Even though the users of this manual are most likely to be utilizing available public-domain or commercial models, these steps need to be understood and appreciated as a preliminary to model selection and application.

The essential steps in the development of a simulation model (see figure 7) are outlined below:

(a) Formulation of objectives. This requires a clear and quantitative statement of the purpose of the model;

(b) Review of theoretical background. This requires a desk study of previous attempts to formulate models for similar situations and an analysis of the processes to be simulated in the model;

(c) Formulation of the model. This involves a decision as to the type of model to be used and the processes to be included in it, and requires a practical decision regarding the degree of complexity to be provided in the model;

(d) Creation of the model structure. This involves an identification of the components of the model and the way in which they are to be linked in the model structure. This phase is facilitated by the use of sketches and flow charts to identify the flow of information through the model and the inputs, outputs and process transformations required for the model;

(e) Formulation of the model equations. Based on a consideration of the theoretical review and the proposed model structures, this step involves the mathematical expression of the relationships involved in the processes to be simulated in the model;

(f) Formulation of methods of solution. In some cases it may be possible to solve the model equations analytically. More commonly, the model will require to be solved by numerical methods and this step requires the selection of the solution algorithms is such a way as to minimize computational effort and facilitate computational efficiency;

(g) Development of computer programme. This requires the selection of an appropriate programming language and the writing of the computer programme. For a complex programme, this may require considerable effort and a great deal of trial and error in the progressive development of a computationally-efficient solution package.

(h) Calibration and validation. Calibration requires the progressive adjustment of the key parameters of the model until it satisfactorily reproduces a past performance record of the system behaviour. Once this is accomplished, verification requires the undertaking of additional computer runs with different sets of recorded data to verify that the model will predict system behaviour with an adequate degree of accuracy;

(i) Sensitivity analysis. This final step involves the examination of the sensitivity of the model output to changes in the values of the parameters. This provides a basis for determining the practical degree of accuracy with which the numerical values for the critical parameters need to be determined.

FIGURE 7. IMPORTANT STEPS IN WATERSHED SIMULATION MODELLING