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LAND USE CLASSIFICATION FOR AGRI-ENVIRONMENTAL STATISTICS/INDICATORS

Submitted by Statistics Division, FAO, Rome[1]

Land is one natural resource that is at the centre of all economic activities. An inventory of land, skilfully classified according to various economic uses, has been an important database for governments, planners and policy makers for a long time. At the country level, these databases are being produced using available resources and reflecting local needs. Keeping in view the functions of land, land quality and other attributes, it is not possible to define one unique classification of land use that will satisfy all the requirements of different users (local, national and international). The United Nations Economic Commission for Europe (ECE), taking into account needs for land use statistics to study environment related issues, recommended a standard statistical classification of land use in 1989 (ECE, 1989). Work is being done in the Eurostat and the FAO to develop a land use classification to compile an inventory of land in member countries for supporting policy decisions. UNCED's Agenda 21, taking into account various sectoral land use issues, recommended "an integrated approach to land resources planning and management" to meet the challenges of supporting the world's growing population in a sustainable manner. A large amount of work on studying various aspects of land is also being done by scientists to facilitate agricultural and environmental decision making. An illustrative summary of the work being done by the FAO (in collaboration with other organizations) to support decision making for sustainable use of land for agricultural and rural development is given in Annex 1.

In the last decade, a great deal of work has been done by international and national organizations to develop environmental indicators. In general, it is difficult to review all of the work being done in this field. However, in the "Indicators of Sustainable Development: Framework and Methodologies" alone, prepared by the UN on recommendations from the Commission on Sustainable Development (CSD), there are about twenty indicators based on different types of land. Each of these indicators requires a consistent and dependable estimate of land use/land cover.

The concept of land use in the CSD list of indicators ranges from the general summary statistic of "total surface area," which is neither a land use nor land cover class, but the summation of either, to the very specialised category of "area of land contaminated by hazardous waste." Focusing only on the indicators related to agricultural activity and agri-environmental issues—on one hand, data are required on the simple classification of land involving study of changes in land use, consumption of agri-chemicals (pesticides and fertilizers) per unit of arable land, irrigated area as percent of arable area, changes in the forest area, protected forest area, etc.—on the other hand, specialized information is needed on items such as land affected by salinization, water logging, desertification, and dry land. The work being done by other organizations is somewhat similar, although in some cases more detailed information is required by users.

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[1] Prepared by P. Narain and R. Koroluk.

P. Narain is a Senior Officer, and R. Koroluk is a Consultant in the Statistical Analysis Service, Statistics Division, FAO, Rome. The views expressed are those of the authors and do not necessarily reflect the position of the Food and Agriculture Organization (FAO).

In the above scenario, the need for an internationally comparable articulated system of land use classification for supporting work on the compilation of agri-environmental statistics/indicators cannot be denied. The present paper looks at the efforts made in the direction of developing land use classifications and practical considerations that need to be taken into account from the point of view of preparing an inventory of land for deriving agri-environmental indicators. The paper has been divided into two sections. The first goes into the details of experience gained in the collection of land use statistics in the FAO and its presentation in the form of derived indicators. The second section raises two general issues that need to be taken into account for developing a comprehensive system of land use classification: 1) conceptual framework of land classification, and 2) details pertinent for satisfying users. The paper concludes with a proposal for developing a suitable system.

I. FAO Experience in compiling internationally comparable databases on land use

1. The FAO Statistics Division compiles data of land use that form a statistical time series starting with the year 1961. The statistics are published in the Production Yearbook and appear on the FAO web site. The land use classification adopted in this connection is linked to the FAO's recommendations for censuses of agriculture. The FAO land use statistics, which are thus more connected to the use of land for agriculture, is historically based on point estimates derived from data collected in periodic agricultural censuses and estimated in intercensal years using a variety of information and data sources.

2. Data on land use available in the FAO's databank[2] relate to 'Total Area' (including area under inland water bodies), 'Land Area' (excluding area under inland water bodies), 'Arable Land,' 'Land under Permanent Crops,' and 'Non-Arable Land and Non-Permanent Crops' (including built-up areas, roads, barren land, etc.) covering the country as a whole. The FAO Statistics Division (ESS) compiles these data from questionnaires forwarded to countries, national statistical publications and an array of other sources such as project reports, including studies available in other FAO Divisions, economic journals, etc. This database is not always up-to-date for several reasons. In many countries, there is no established statistical system to generate such data. Gaps have been filled by FAO estimates using a variety of information and assumptions.

3. Some of the problems that are faced in collection, compilation and presentation of data on land use are given below:

- *Concepts and definitions* : There is no universally accepted concept and definition for some of the items in the classifications. Three important points in this connection are as follows:

  (a) For certain items, definitions of the categories of land used by various countries are at times different from those given by the FAO. The best example of this is that most countries take arable land as the land that is potentially cultivable, whereas the FAO's definition refers to land under temporary crops, meadow and pasture. This problem is so widespread that it may be necessary to make countries understand the utility[3] of the 'arable land' concept adopted in the FAO terminology. This is more so since one cannot arrive at an estimate of arable land by some easy method such as summing areas sown or harvested because of multiple sowing and harvesting and inter-cropping, which lead to double counting.

  (b) Definitions used by reporting countries vary considerably and items classified under the same category often relate to differing kinds of land. For example, once we arrive at definitions of pasture and forestland, we are confronted with the concept of wooded land. Wooded land is applied by some countries to refer to what statistician prefer to call 'woodland.' In most developed countries, animals graze in these areas. Statistically, the areas where animals graze are classified as pasture

[2] Until the reference year 1994, the series also contained data on 'Permanent Pasture' and 'Forests and Woodland' (land under natural or planted stands of trees, whether productive or not), now included in 'Non-Arable Land and Non-Permanent Crops.'

[3] Arable land is used for deriving environmental indicators relating to use of agri-chemicals as well as deriving measures of cropping intensity needed for making plans for agricultural development.

while those involved in resource assessment classify them (on the basis of satellite imagery) as wooded land. Similarly there are also problems with classification of area under some plantation crops. For example, should rubber plantations be classified as wooded land, woodland or forest?

(c) Forestlands also present classification problem. In many developing countries, area under forest is normally that area that has been declared forest in legal terms, irrespective of the fact that it may not have adequate forest cover. Contrary to this, in developed countries stress is put on the forest cover.

- *Mixed coverage* : Data on fallow areas, pasture, shifting cultivation and forestland are very rarely available and are very often mixed-up with arable land, grasslands or forest land.

(a) Fallow area : Fallow area is generally of two types, land that has been left idle in the current crop season to improve the productivity of the land, and land that is fallowed for a longer time period and for which no cultivation activity has been planned. Many countries do not distinguish between these two types of fallow area and count them under arable land. This treatment prevents the linking of the data to the use of agri-chemicals or harvested area.

(b) Pasture : In some countries pastures are being cultivated as a regular crop that involves use of agri-chemicals. It may be necessary to distinguish the cultivated pastures from the native pastures.

(c) Shifting cultivation : Shifting cultivation presents considerable environmental problems and is one category where data are not available for various reasons. This activity can be defined as cultivation involving the removal or burning of vegetation for pasturage or other purposes to support human life. There are two distinct types of shifting cultivation, the rotation system and the abandonment type. In both types, farmers/tribe members/nomads cut down and burn trees without considering their value in maintaining the ecosystem. This practice is being done in both fallow areas (which are of a permanent nature) as well as in forest areas. Many countries include this category of land under arable land. Some countries also include area under shifting cultivation in the harvested area.

(d) Multiple-use forestland : With respect to land use, forestland in particular presents a high degree of complexity in a land classification system because of the high level of multiple use. Problems are especially related to properly surveying land use and presenting results statistically and in maps. Three classification methods to include the reporting of forestland have been used by countries: 1) reporting on the basis of “primary use,” 2) reporting in separate “multiple-use categories,” or 3) reporting land proportionally under each of the individual use categories. Furthermore, there remain questions such as are managed woodlots to be considered agro-forestry or agriculture and when does a land unit switch categories.

(e) Grassland and forestland mixes : A second difficulty with forestland, particularly in the case of land use classifications, occurs when it is mixed with grasslands. Definitions on the basis of land cover need to be devised that would classify these combinations into forestland, grasslands or some mixed categories. Further complications occur when the forestlands/grasslands are also used for grazing as well as some combination of wood or non-wood forest production.

- *Measuring forestland* : As seen earlier, forestlands, also most easily measured as coverage, causes a host of classification problems. The problems arise not just because of its multiple-use character, but also because forestlands can be agricultural (agro-forestry, plantation, grazing) or built-up areas (urban forests, city parks) as well as productive forests (timberlands, pulpwood forests) and non-productive forests (conservation areas, recreation areas). The multiple-use characteristics of grasslands and forestlands affect the basic design principle of the absence of overlap in that many of these areas can fall into different categories. Should land then be classified under each of its uses, under its primary use (often recommended for agricultural areas) or under a series of specifically defined multiple-use categories? Problems arise in determining the primary use or defining a reasonably manageable number of multiple-use categories.

- *Non-agricultural land use* : A review of the international efforts to devise land use classification systems also yield a number of insights and general principles with respect to handling common classification problems. Built-up and residential areas are relatively easy to measure in terms of land coverage and less so in terms of land use, even though their very existence is the result of human activity, a land use principle. Furthermore, built-up areas need to be further divided in lower level categories to provide useful information. The difficulty becomes choosing these categories. As an example, the Young approach (1994) divides built-up areas, called "settlement" into residential, commercial, industrial and infrastructure. But this division does not separately identify the important area of public services associated with government, health, defence, etc. (Duhamel, 1998), of particular relevance to the issues of rural development.

4. It follows from the above that there is a need to have an international classification system (similar to ISIC, CPC, SITC, etc.,) for compiling comparable land use statistics. In this connection, the question that arises is whether one should develop a new system that is founded on basic principles like an aggregable hierarchical structure, the absence of overlap (re. multiple uses), the integration of land cover attributes, etc., or whether one should adapt and elaborate upon an existing one. The ECE has in fact proposed an international classification system for development of internationally comparable statistics on land use to be used in deriving environmental indicators[4]. However, in considering this system, one should take into account the fact that land use is defined in terms of human activity on land so that it is important to define categories on the basis of human activities and not to rely too heavily on physical and environmental attributes. In the following section the issues involved are examined.

II. Issues

Issue number 1 : Is it necessary to have a 'pure' land use classification?

5. Work on development of a comprehensive land cover classification has proceeded quickly at the FAO and has culminated in the Land Cover Classification System (LCCS) and software program. Work on land use classifications has progressed more slowly, partially because land use is more difficult to observe. It is relatively easy to determine grassland or forest areas from remote sensing techniques. But it is more difficult to determine if the grasslands are being grazed or if the forests are being harvested. However, work continues in the FAO to develop a comprehensive and consistent reference land use system. By a reference system, the FAO refers to a means of developing a bridging or harmonization mechanism between existing national systems so that the investment in and time series nature of these systems will not be lost.

6. In the past, there have been several efforts at devising a land use system that provides useful information to a wide variety of users and maintains principles such as completeness of data and lack of overlap, independence of observation tools and links with internationally recognized socio-economic classifications. In addition, the reference system requires that the classification be independent of scale and independent of the data collection method used. The efforts in creating a land use classification fall into two broad approaches, the functional approach and the sequential approach or sequence of operations approach.

- *Functional approach to land use* : The functional approach is defined as "the description of land in terms of its socio-economic purpose" and has been defined to be applicable for all land use purposes such as agriculture, forestry, residential, etc. (Duhamel, 1998). As such, functional uses of land can be made at a single point in time or over a shortened period of time. There are several classification systems that use the functional approach.

[4] ECE has recommended a classification of land use that has three levels represented by a three-digit code. The first digit classifies the land into seven classes that are somewhat similar to land cover classes. At the second digit level, the classification goes into details that are more pertinent for land use classification. The third digit level, which goes into further details of specific land use, is optional.

- *Sequential approaches to land use* : The sequential approach, also called the sequence of operations approach, was designed primarily for classifying agricultural lands. The approach defines land use as "a series of operations on land, carried out by humans, with the intention to obtain products and/or benefits through using land resources." (Duhamel, 1998). By definition, the sequential approach requires observation over an extended period of time. There is currently only one well-known sequential approach land classification system devised by Mücher, Stomph and Fresco in 1993 (Duhamel, 1998).

7. Several classification schemes, the US Geological Survey, the ECE Standard Statistical Classification of land use, are a mixed classification of land cover and land use categories. This is also the typical system being followed in many countries, which tend to have a combination of land use and land cover classifications for a variety of reasons. Land use and land cover are complementary in many cases (e.g. the land use category permanent cropping is equivalent to the land cover category permanent crops). A system focused on agriculture can reasonably treat other land uses in a more cursory and less in-depth manner. For example, in an agricultural land classification system, built-up and related land can be treated in a more summary form, without going into the details of purpose or management practices.

8. Availability of data has also influenced the mixed land use/land cover design of national land classification systems. In many countries, the land use classification system has focused on agricultural lands for which it is much easier to design a land use classification. In fact, this suggests the primary reason for the development of mixed systems. Natural land areas like forests and grasslands are easier to measure on a land cover basis while agricultural land and built-up areas are more easily defined on the basis of land use. So while total land area classifications can typically be considered as mixed land cover/land use, it can be argued that most national land classification schemes are primarily pure/truncated land use systems because the focus has been on agriculture. To understand if it is necessary to have a pure land use classification, we need to understand the basic differences in the concepts of land use and land cover:

- *Land use classification* is based upon the function and the actual purpose for which the land is currently being used. "Thus, a land use can be defined as a series of activities undertaken to produce one or more goods or services. A given land use may take place on one, or more than one piece of land, and several land uses may occur on the same piece of land." (Di Gregorio and Jansen, 1996). Inventorying of land by such a classification provides a quantitative measure of land in relation to the economic and environmental outcomes/impacts of various human activities and natural events for precise and quantitative analysis and future planning. Such information is generally based on mapping of land area using techniques like aerial photography, cadastral surveys, etc. supported by ground truthing.

- *Land cover classification* is based on the observed (bio)physical cover of the earth's surface irrespective of its uses (including vegetation, construction works, water, ice, bare rocks or sand surface). (Di Gregorio and Jansen. 1997). Such information is obtained from ground surveys or through remote sensing.

9. Thus a piece of land can be used for the production of goods and services that can be either economic or environmental, or tangible or intangible. The same piece of land can be used to produce more than one type of good or service. A piece of land can be classified according to its principal use or according to each of its multiple uses under land use classification. Duhamel (1998), for example, recommends a separate recording of land in the classification system for each of the multiple uses. Contrary to this, land cover classification does not take into account use of land, but depends upon its physical appearance and characteristics. Therefore, whereas a land cover classification can be very easily defined in a unique way for multiple users, land use classification can be subjected to interpretation according to the interests of the user.

10. Developing a system that combines both land use and land cover classifications is obviously more complex, but less costly, than concentrating on only one of the classifications. Recognizing that the systems are related, the FAO's approach has been to support efforts to develop land use and land cover classification systems separately, while encouraging co-operation between the two initiatives.

11. Therefore, from the perspective of environmental assessment and rural development, the basic issue is whether it is necessary to go into the details of land use and prepare a precise inventory for each segment of land, or whether a mixed classification by land cover only is sufficient. This question is asked keeping in view the cost of collection of the data, as remote sensing, which focuses primarily on land cover, is now improved and more readily available. Such a question is more valid for land cover categories like 'Wet Open Land' (ECE Classification category no. 4), 'Dry Open Land with Special Vegetation Cover' (ECE Classification category no. 5), 'Open Land without, or with Insignificant, Vegetation Cover' (ECE Classification category no. 6) or 'Water' (ECE Classification category no. 7), etc., which may not be under the current plan of affecting improvement of land. Human interaction on these land cover classes constitutes land use and may have implications for the environment and rural development. However, it is another question if a more useful classification can be suggested to replace these categories. This question becomes more relevant because the technology of remote sensing has developed more capabilities in the last decade and the cost of using this technique has come down substantially.

Issue number 2 : What details need to be included in a land use classification?

12. Apart from considering uses, as well as non-uses, of land (taking the extended concept of economic activity as proposed in environmental accounting), it is often necessary to go into the details of the inventory of land classes depending upon economic and social needs. For example, an efficient agricultural land use plan requires details of agro-climatic regions, soil type, sustainability criteria, land under permanent and temporary crops, irrigation status, mono-cropping or multiple-cropping, etc. It is also well known that destabilized weather and soil conditions, and erosion of plant genetic resources coupled with population pressures and crop production practices, are effecting agricultural land adversely. Very often policy makers would like to identify such areas according to the degree and causes of soil degradation. In the absence of required data, decisions are being taken for changing land use patterns due to the needs of development without considering whether the land is suitable for the alternative uses or if the changes are going to affect the ecosystem. There are a number of items for which details are being asked by policy makers dealing with numerous other economic activities. For example, forestry policy analysts and rural/urban development analysts have their own specific requirements and interests related to forest areas and settled areas, respectively. Ideally, a classification system must meet the needs of a variety of uses. The only method of accomplishing this is a hierarchical system that can be aggregated to different levels or across levels and that can be linked to other databases, depending on user needs.

13. Thus the other basic requirement is to define limits on the second or the third level classifications of land classification hierarchy while still addressing socio-economic/agri-environmental issues. The objective of a land use classification is to provide the theoretical structure to guide data collection and creation of an effective database. While looking at such a list of policy issues, one has to take into account the critical items that need to be included in the macro-level inventory of land required by policy makers. It may also be necessary to consider if the type of information that is required by scientists and extension workers at the local (micro-) level can be integrated with the land use statistics. This question become more important when one looks at the capabilities of Geographic Information Systems (GIS) and the work being done by specialists (e.g. Annex 1).

14. In this connection, a point made by Di Gregorio and Jansen (1997) may also be noted: classification systems should not be confused with legends, which constitute the majority of land nomenclature systems. The distinction is that legends do not follow the principle of non-overlap.

III. Concluding remarks

15. At various international fora, it has been recognized that information on land use and land cover is essential. What is also recognized is that the land use and land cover information must satisfy the needs of many diverse users, some of whom require linkages with policy relevant information. This requirement relates directly to those involved in issues such as environmental indicators and rural

development. There are many initiatives underway to develop a land use classification. These efforts have also been evaluated by research workers and representatives of international organizations (Duhamel, 1998; Young, 1993 & 1994) to judge their suitability from the point of view of providing internationally comparable statistics. In most of the classifications being used or propagated, the work has been motivated by keeping in view the specific final objectives with little consideration for comprehensiveness. This approach has resulted in classification systems that are biased in reference to the particular end objectives. A review of these efforts suggest that a land use classification should have following characteristics:

(a) The classification should cover the total area of land that needs to be classified. For this purpose we need to define land. The interdepartmental Working Group on Land Use Planning at the FAO (1994) proposed a definition of the land that one can take into account in constructing land use classifications. "Land is a delineable area of the earth's terrestrial surface, encompassing all attributes of the biosphere immediately above or below this surface, including those of the near surface climate, the soil and terrain forms, the surface hydrology (including shallow lakes, rivers, marshes, the plant and animal populations, the human settlement pattern and physical results of past and present activity (terracing, water storage or drainage structures, roads, buildings, etc.)." An alternative definition of land has also been given by the 1993 System of National Accounts (SNA paragraphs 10.121 and 10.122, page 234). Whereas the SNA definition is more appropriate for preparing value of land, the FAO definition may provide a more concrete basis to decide the land use.

(b) The categories of the classification should not overlap. This is essential to provide a unique dataset descriptor for any piece of land.

(c) The classification should cover all activities. Activities, for this purpose, could be taken to include (i) productive or economic activities, as for example defined by International Standard Industrial Classification for all economic activities (ISIC), and (ii) protective (environmental related) activities that may not result in any tangible result or output. At this stage it may also be mentioned that the concept of purpose is different from activity and the two should not be confused. The 'purpose' is connected with the kind of objective an activity pursues.

(d) The classification systems should not be confused with legends. Classification is the abstract representation of the situation in the field using well-defined diagnostic criteria, the classifier, while legend is the application of a classification. A system of classification is therefore independent of scale or means used for collection of data. (Di Gregorio and Jansen, 1997)

16. These requirements suggest that an ideal classification can perhaps be prepared by evaluation of each segment of land as is being done in preparing land cover statistics. Each segment can be divided into smaller units that can be identified through ownership and associated with the economic activities that are being performed on it. In building these associations, one can easily use principles laid down in ISIC for classifying activities into principal, secondary and ancillary activities and their association to the owner of the unit. To meet the needs of multiple users and satisfy comprehensiveness criteran, one may consider taking ISIC classes at the first level and incorporating purpose at the second or third level. This approach would provide a one-to-one correspondence between land and labour, capital, and goods & services produced. However, for attempting such a classification, it would be necessary:

- to consider classification of land that are connected with protective activities,
- to consider what should be the lower limit for the size of land,
- to determine how to define the ownership of water bodies and their uses, and
- to determine how to record areas that are not currently under any use.

17. In general it would be feasible to link or harmonize such a classification with the land cover classification.

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Annex 1

Technological developments[5]

Over the last two decades the Land and Water Development Division (AGL) of the FAO has been at the forefront of the development of computer-based systems to analyse data and generate information to support decisions on various land and water issues. Separate soil and land and water systems have been developed for this purpose. A brief account of important work is given below

Agro-Ecological Zoning (AEZ) System : The main system for land resource assessment is the FAO's agro-ecological zoning (AEZ) methodology and supporting software packages for application at global, regional, national and subnational levels. AEZ integrates various kinds of geo-referenced data sets in the database, which can include the following:

- topography;
- administrative boundaries;
- road/communications;
- towns and settlements;
- rivers/water bodies;
- geology;
- soil;
- physiography;
- landform;
- erosion;
- rainfall;
- temperature;
- moisture regime;
- watersheds;
- irrigable areas;
- land use/land cover and forest reserves;
- production systems
- crop requirements;
- agricultural inputs;
- crop statistics;
- markets;
- prices;
- population.

AEZ models are applied on the database to analyse potentials of land for various kinds of use. The AEZ models can be extended to include models for the calculation of length of growing period, irrigation requirements, crop biomass, land suitability and land productivity.

Multi-lingual Soil Database (SDBm) : Database tool useful for storage of primary soils information assembled at the national level, or data collected in a soil survey at the subnational and local levels. SDBm data are used in the computerized AEZ land evaluation systems. It is useful to soil scientists, agricultural extension officials and environmental modellers.

Soil And Terrain (SOTER) Database : SOTER is useful for storing soil and terrain data at the national and global scale in an easily accessible format for thematic mapping and monitoring of changes of soil and terrain resources and for AEZ evaluation of land resources potential for land use planning. It can be used by scientists, planners, decision-makers and policy makers. SOTER utilizes a Relational Database Management System (RDBMS) and Geographic Information System (GIS) to establish a World Soils and Terrain Database, containing digitized map units and their attribute data. SOTER uses a specific methodology and its own system for classification of terrain designed for universal application. SOTER has adopted the recently Revised FAO Soil Legend as a reference classification system for differentiating and characterizing its soil components.

Digitized Soil Map of the World (DSMW) : The Digital Soil Map of the World (DSMW) is the FAO's global soil database based on the paper FAO/UNESCO Soil Map of the World (scale 1:5,000,000). It

[5] Extracts from Information technology and decision support systems in an AGL Background Paper by J. Antoine, Soil Resources, Management and Conservation Service Land and Water Development Division, FAO, Rome, Italy. For further details, reference may be made to http://www.fao.org/waicent/FaoInfo/Agricult/AGL/agls/aglshome.htm

consists of ten map sheets: Africa, North America, Central America, Europe, Central and Northeast Asia, Far East, Southeast Asia, and Oceania. DSMW contains two types of files: map files and derived soil properties files. The programs produce analyses of soil inventories, problem soils and fertility capability classification. Included are maps of soil units classified according to the World Soil Reference Base and topsoil distribution, which can used in teaching soil science. The database includes information on soil moisture storage capacity, soil drainage class and effective soil depth, useful for environmental studies.

FAO/ITC Land Use Database : To store information on land use for various purposes: assessing land production potentials, monitor land use changes and human impacts on the land, soil degradation and many other damaging effects at various scales. The FAO/ITC land use database is a PC program that stores information on individual land uses and production systems in terms of activities, inputs and benefits on the physical, social and economic environment. The program comprises 1) a data entry module containing collected land use data, defined land use classes, plus program settings and options for data entry and storage; 2) a query module that searches for land use data and classes on the basis of user-defined criteria 3) a glossary with numerous terms used to describe operations, inputs and land use types and classes. These are available in the form of multiple-choice lists, from which the user makes a selection.

ECOCROP 1 (Crop Environmental Requirements Database) **:** Ecocrop 1 can be used to identify suitable crop or tree species for a specified environment or for a defined use and to create a library of crop environmental requirements. Ecocrop 1 is a database that provides the optimum and minimum-maximum ranges of crop environmental requirements for various species. The database contains information on 1700 species that can be used to facilitate the comparison of 12-20 different environmental requirements across different groups of species, or across species of different use. The database includes arable crops, grasses, trees and some other plant species with special uses. The information has proven useful to gardeners, farmers, students, agricultural development and extension staff and land-use planners.

ECOCROP 2 (Crop Environmental Response Database) : Ecocrop 2 can be applied to obtain environmental response information for 20 crops of global importance, information for crop modelling including the facility to graph the responses and organize and compare crop response information. The users can enter their own data and use the software to graph the responses on the screen and to provides statistical output for crop modelling.

World Overview of Conservation Approaches and Technologies (WOCAT) : WOCAT is tool that aims at promoting improved decision making on land management and transfer of appropriate technology through collection, analysis, presentation and dissemination of knowledge on soil and water conservation (SWC) worldwide. In particular, WOCAT can be used to identify options for overcoming land degradation problems. The WOCAT database will allow linkages with ECOCROP, Soil and AEZ data, and land use information.

Database Tool for Integrated Plant Nutrition Systems (DTIPNS) : To provide researchers, extension officers and development workers in the area of plant nutrition management with numerical data and other relevant information on plant nutrient management practices, plant nutrient inputs, losses, and uptakes and response to plant nutrients under a range of conditions for selected countries. This information will allow the derivation of nutrient balance sheets and the economic and agronomic evaluation of alternative plant nutrient management practices, and so assist decision making on balanced, environmentally friendly plant nutrition practices at the farm level. FAO-IPNS contains data collected at the national and local level on the following variables:

1. Nutrient content of mineral, organic and biological sources of plant nutrients (including micronutrients).
2. Nutrient losses due to erosion and run-off, leaching, crop uptake, volatilization and denitrification.
3. Response curves to one or more nutrient sources under a range of conditions.
4. Descriptions of major crop rotations and plant nutrition practices of farmers in selected countries under a range of conditions.

ALES Expert System : ALES is a PC computer program to carry out land evaluations according to the method presented in the FAO Framework for Land Evaluation (FAO, 1976). Such evaluations are location-specific, usually require many data, involve numerous repetitive calculations or references to tables and are tedious if many possibilities are to be compared. ALES is a useful tool that provides an automated procedure of evaluation to replace manual procedures that are time-consuming and error prone. ALES is not by itself an expert system, and does not contain knowledge about land and land use. It is a framework within which evaluators can express their own local knowledge. ALES can also be thought of as a model of expert judgement that is the codification in a constrained form of the inferences already present in the mind of the expert.

Aquastat Database : The AQUASTAT program has been launched in order to provide basic information on water resources and their use, in particular for agriculture and rural development, and produce country profiles on water resources development, with emphasis on irrigation and drainage. Aquastat mainly provides users interested in global or regional perspectives systematically organized and reliable information on water resources and water use existing in the countries for studies and analysis and action programs on sustainable use of water, such as irrigation potential studies and land productivity assessments and for monitoring water resources. The main quantified variables gathered in the AQUASTAT database are:

- renewable water resources (groundwater and surface water);
- wastewater production and treatment;
- non-conventional water sources;
- water withdrawal by sector;
- irrigation potential;
- irrigated areas, water control and irrigation techniques;
- origin of irrigation water;
- types of management for fully or partially controlled irrigation schemes;
- number of beneficiaries;
- cost of irrigation and drainage development and operation and maintenance;
- irrigated and rainfed crops and yields;
- drained areas and drainage technologies;
- areas salinized by irrigation and flood protected areas;
- population affected by water-borne and water-related diseases.

Climatic Database (CLIMWAT) : CLIMWAT is a multi-purpose climatic database which was developed primarily for use in providing climate data inputs for the calculation of crop water requirements, irrigation supply and irrigation scheduling for various crops in combination with the program CROPWAT (see below). CLIMWAT is also useful in providing climatic data to AEZ land resources assessments. The CLIMWAT database has been originally compiled by the Agrometeorological Group of the FAO Research and Technology Development Division (SDR).

CROPWAT (a computer program for irrigation planning and management) : The program is meant as a practical tool to help both the Irrigation Engineer and Irrigation Agronomist to carry out standard calculations for design and management of irrigation schemes. It can further help in the development of recommendations for improved irrigation practices and the planning of irrigation schedules under varying water supply conditions. CROPWAT is a computer program for IBM-PC or compatibles. Its main functions are:

To calculate:
- Reference evapotranspiration
- Crop water requirements
- Irrigation requirements
- Scheme water supply

To develop:	-	Irrigation schedules under various management conditions
To evaluate	-	Rainfed production and drought effects

SIMIS (Scheme Irrigation Management Information System) : When managing irrigation systems a tool is needed to facilitate the management tasks of irrigation systems. SIMIS can de used to provide timely and complete information for decisions with regard to the day-to-day management activities including water deliveries and other major issues such as accounting, crop production, control of maintenance, water fees and other relevant tasks.