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# VEGETATION COVER AND LAND USE MAP OF AFRICA BASED ON SATELLITE REMOTE SENSING

# VEGETATION COVER AND LAND USE MAP OF AFRICA BASED ON SATELLITE REMOTE SENSING

## Summary

The rate of degradation and depletion of natural resources in Africa has been accelerated as a result of the increasing population pressure. The lack of reliable quantitative and qualitative information on vegetation cover and land use at national and regional levels has been the major limiting factor in development planning, sustainable management of agriculture and forestry resources, the food security early warning systems, environmental monitoring as well as in biodiversity assessment and protection.

The overall objective of the project is production of vegetation cover and land use map at 1:1 million for the whole of Africa and at 1:200 000 (91:250 000) for priority areas, based on satellite remote sensing and GIS.

Equally important objectives are strengthening of indigenous capacities for vegetation cover and land use mapping and for monitoring of changes at the regional and country levels in order to maintain new geographic database update.

## CONTEXT

The renewable natural resources of many African countries have come under severe strain over the past two or three decades and most indicators point toward a continuation of this trend. The rate of degradation and depletion of these resources has been accelerated in proportion to the increasing population pressure. Deforestation, desertification, soil erosion and salinisation have degraded the environment so that the food security and economic development of many countries are threatened. Whilst a large amount of new remote sensing data for the assessment of natural resources is available, and technologies exist for its storage, analysis and integration, the actual situation in Africa shows a severe shortage of country-wide, as well as regional and sub-regional, quantitative and qualitative information on vegetation cover and current land use. This fact has proven to be the major limiting factor in proper planning, development and sustainable management of renewable natural resources in Africa.

## INSTITUTIONAL FRAMEWORK OF THE SUB-SECTOR

The objectives for the economic, social and cultural development of Africa were set out in 1980 in the Lagos Plan of Action (LPA). The implementation strategy of the LPA is based on self-reliant and self-sustaining development as well as on economic integration leading toward the eventual creation of an African Economic Community. In the field of food and agriculture, the LPA's priorities include food security, food production, forestry and rural development, in order to bring about an immediate improvement in the food situation and to facilitate achievement of self-sufficiency in cereals, livestock and fish products.

In response to the LPA's objectives and priorities, the Food and Agriculture Organization of the United Nations (FAO) has reoriented and strengthened some of its programmes to provide maximum support to the improvement of the food and agricultural situation in Africa. An example of such support is FAO's assistance to Member Countries in the development, management and conservation of agricultural, fisheries and forestry resources and in the reclamation of degraded resources. FAO assistance in this field promotes assessment and development of land and water resources, improvement of soil and water management, and implementation of agro-ecological zone studies at country level in order to identify and facilitate optimum land use.

New technologies are utilised whenever appropriate for implementation of these programmes. One such technology which is being increasingly used for inventories of natural resources and environmental monitoring in Africa is remote sensing.

Africa has so far benefited less than any other region from advances in satellite remote sensing technology. An important step toward introducing and coordinating remote sensing activities in Africa was taken by the Conference of Ministers of Economic Planning, organised by the Economic Commission for

Africa (ECA) in Nairobi in February 1975. This Conference of African Ministers passed Resolution No. 280 (XII) concerning the introduction of remote sensing technology into Africa with the aim of expediting the exploration of Africa's natural resources and the monitoring of environmental changes resulting from such action.

In 1976, at a follow-up Intergovernmental Meeting convened by ECA in Addis Ababa, the following resolutions were adopted:

- Establishment of an African Remote Sensing Council
- Establishment of two initial regional receiving and processing stations for satellite remote sensing data in Kinshasa (Zaire) and Ouagadougou (Burkina Faso)
- Establishment of training and user centres in Nairobi (Kenya), Cairo (Egypt), Ile-Ife (Nigeria), Kinshasa (Zaire) and Ouagadougou (Burkina Faso).

The establishment of the African Remote Sensing Council (ARSC) in 1978, with its secretariat in Bamako (Mali), provided Africa with a central body for adopting and implementing a unified and comprehensive remote sensing programme.

Establishment of the two ground receiving stations for earth resources satellite data has not been implemented due to lack of funding. Nevertheless, the feasibility studies are progressing. Nigeria is planning to establish a ground receiving station within the next two years.

Establishment of five training and user-oriented remote sensing centres was more successful, although there are considerable differences in the scope of the activities among these centres.

Only three centres, in Nairobi, Kenya; Ouagadougou, Burkina Faso and Ile-Ife, Nigeria, have so far succeeded in developing regional programmes:

- The Regional Remote Sensing Facility, Nairobi, was established in 1977. The facility is well equipped and has an extensive remote sensing image library. It organises training courses and is executing pilot projects.
- The Regional Remote Sensing Centre in Ouagadougou has well equipped training facilities as well as image analysis and photographic laboratories. It organises training courses and is executing pilot projects.
- The Regional Centre for Training in Aerospace Surveys (RECTAS), Ile-Ife, lays main emphasis on remote sensing and GIS training activities. It was significantly strengthened in 1990 through funding support by the Commission of the European Communities, which will permit upgrading of RECTAS' regional training activities.

Centres which have so far functioned as national centres include Cairo, Egypt, Kinshasa, Zaire, Abidjan, Cote d'Ivoire and Harare, Zimbabwe.

- The Remote Sensing Centre in Cairo focuses mainly on execution of pilot projects in Egypt, although several were executed in Sudan. The Centre is well furnished with analog as well as digital image analysis equipment. It also organises remote sensing and GIS training courses.

- The Remote Sensing Centre in Kinshasa is well equipped and its activities include pilot projects as well as training programmes. All its activities have been limited to Zaire.

## PROJECT JUSTIFICATION

African countries urgently need to be able to assess the status and trends of the various components of their resources. They must be able to identify areas where ameliorative action should be taken and must have the possibility of integrating environmental with other socio-economic data to identify where development opportunities exist. Furthermore, sound management of renewable natural resources requires reliable maps. This situation provides a strong argument for improving the mapping and monitoring of agricultural, forestry and water resources. Information on vegetation cover and current land use at regional and sub-regional level is almost totally lacking. At country level it is non-existent in many cases and, when available, has numerous shortcomings: most of the maps are old or based on old data, and are often inconsistent in terms of legend, scale, content, reliability and mapping accuracy.

Work on the FAO study Agriculture at 2000 has brought to light the poor level of information on current land use in Africa. It was recognised that satellite remote sensing could provide the required improvement in information on vegetation cover and land use but lack of funds has prevented the undertaking of such an extensive task.

Reliable vegetation cover and land use information for Africa will form an important database for national Geographic Information Systems (GIS), which are becoming an indispensable tool for development planning and management of land and water resources. Its availability will fill the gaps in vegetation cover and land use mapping coverage of Africa and improve the quality of available geographic information, urgently needed for applications such as land potential assessment, crop production forecasting, irrigation potential, etc..

The fast development of GIS techniques for computer-based storage, manipulation and integration of location-specific data has greatly improved the possibility of assisting African countries in development planning and sustainable management of natural resources. In the near future large amounts of data will be acquired, to be systematically integrated to produce a series of derived output products such as land potential assessments, crop production forecasts, irrigation potential assessment, etc.. In addition to this, systematic monitoring of natural resources and environmental parameters at both regional and country levels will be possible, fulfilling an all too evident need to keep the data updated.

The development, effective usefulness and success of these techniques largely depend on the quality and reliability of the data they will use. In the case of GIS, where the synergy from the combination of different information is basic to the system, all the various data must satisfy special requirements in order to make their integration possible. Furthermore, since the complexity of data outputs will increase in order to satisfy a wide range of users of the same integrated database but with different requirements for its processing and the type of products, the data inputs will have to be standardised as much as possible. In this context, the prerequisites for renewable resources data at regional and sub-regional level should be uniform reliability of information (homogeneity of mapping accuracy), a systematic and unified legend content (hierarchical legend according to the level of detail required), and similarity or near-uniformity of input data age (limited differences in the age of maps and/or the remote sensing data from which they were derived).

The lack of such data precludes any realistic attempt to build up an assessment of natural resources. A design for a continuous monitoring of vegetation cover and land use in Africa needs data which not only fulfil the requirements mentioned above but will also be compatible/comparable with the data to be used in the near future. In other words, there must be a certain consistency with the remote sensing data that will be used to map natural resources today and those that will be used in the future. All these arguments lead to the same conclusion: information on vegetation cover and current land use in Africa is far from complete and when it exists, it cannot be fully utilised in a GIS. There is an urgent need to have a standardised assessment of natural resources at regional, sub-regional and country level to be linked with other information already having the necessary characteristics, in order to permit the creation of a reliable base to which a regular monitoring design can be referred.

Efficient management of Africa's natural resources requires an up-to-date and reliable information database. Conventional mapping techniques are too slow and costly and thus not suitable for small-scale vegetation cover and land use mapping at regional, sub-regional and country levels. Much faster techniques are urgently needed. The following example illustrates the seriousness of this situation and the accelerating rate of natural resources depletion.

In the Middle Jubba District of Southern Somalia, the recent history of forest loss has been as follows:

| | | | |
|---|---|---|---|
| Forest cover | 1960 | - | 4,993 ha |
| | 1984 | - | 2,012 ha |
| | 1986 | - | 407 ha. |

Satellite-based remote sensing mapping and monitoring techniques have been successfully used for reconnaissance and semi-detailed vegetation cover and land use mapping in many projects during the past twenty years. The proposed satellite-based vegetation cover and land use project will take advantage of the considerable amount of experience which FAO's Remote Sensing Centre has acquired over the years.

## EXPECTED END-OF-PROJECT SITUATION

It is anticipated that at the end of the five years of project activity, satellite images will have been interpreted at 1:500 000 scale for the whole of Africa and at 1:200 000 scale for selected parts of the continent. A hierarchical legend for vegetation cover and land use will have been developed, and the data presented both in digital and cartographic formats. As a consequence, improved information on the status of renewable natural resources will be available to the target beneficiaries.

Another important outcome of this project will be developed indigenous capacities for collecting, production and analysis of vegetation cover and current land use data through training and effective participation in the project activities by selected personnel. Six training courses for a total of approximately 200 participants are programmed.

The availability of the complete coverage of Africa with satellite remote sensing data will facilitate their application in other fields and will thus strengthen the benefits of space technology to African countries, which up to now have only had limited access to it.

## TARGET BENEFICIARIES

The target beneficiaries of the project will be the following:

- Decision-makers responsible for development planning and management of natural resources and for environmental protection at national, provincial and district levels

- Bilateral and international development agencies.

In the long term of 10-15 years, the ultimate beneficiaries will be the people of Africa, because the improved information will permit the sound development and sustainable management of their natural resources.

PROJECT STRATEGY

The project strategy will involve the utilisation of modern satellite remote sensing products integrated with existing aerial photographs, maps and the results of aerial surveys and field checking, to undertake a vegetation cover and land use survey of all Africa at varying scales. The project design has been based on the following strategy:

(a) the critical review of existing maps, reports, imagery, aerial photography and other relevant information and the incorporation of such information into the mapping process

(b) the development of an hierarchical legend for vegetation and land use classes

(c) extensive involvement in the execution of the work by African remote sensing centres at sub-regional and country levels;

(d) flexibility of outputs to satisfy specific needs at regional and sub-regional as well as country levels;

(e) ability to integrate data with other kinds of information to be utilised in a GIS;

(f) a strong training component to be integrated in project activities to ensure the adequate development of national remote sensing capacities for the project follow-on activities.

The project will have a duration of five years. The work will be carried out with full involvement of the sub-regional remote sensing centres and participating national centres. The CTA will be stationed in the centre where the coordination of all regional activities will be undertaken. The project will make preparations for an international workshop where the preliminary legend will be defined. The vegetation cover and land use mapping will be executed by interpreting satellite images at 1:500 000 scale using the "multiphase approach" (see Annex I). At the end of the second year approximatively 40 percent of Africa should have been mapped and the interpreted data stored in digital format, and priority areas will have been selected where a more detailed interpretation (1:200 000 scale) is to be performed. Criteria for the selection of the priority areas will be the complexity and type of vegetation cover and current land use and population density. The interpretation based on 1:500 000 scale satellite images will be completed over four years; that based on 1:200 000 satellite images will take three years. The 1:500 000 scale interpretation will be done in the regional centre. The sub-regional centres will perform the interpretation at 1:200 000 scale for the priority areas will organise part of the training activities. Results of all interpretations will be stored in digital format in the regional centre, where the final editing of the maps and the preparation of the image interpretation manual will also take place.

DEVELOPMENT OBJECTIVES

The project's overall development objective is to strengthen the capacities of African countries for sound planning of natural resources development and their sustainable management by producing reliable vegetation cover and land use maps and strengthening the indigenous capacities in operational applications of remote sensing.

The project's specific development objectives are as follows:

(a) To provide reliable information on the main agriculture and forestry land use and water resources categories at regional and country levels. Such information provides homogeneous baseline data for realistic assessment of renewable natural resources and for planning their further development.

(b) To provide standardised and homogeneous information on renewable natural resources compatible with other regional cartographic/GIS programmes.

(c) To assist the planning and implementation of the regional, sub-regional and national food security projects by providing more accurate information on areas, distribution and major categorisation of actual and potential agricultural cropland.

(d) To establish a basis for monitoring the changes in renewable natural resources, such as the rate of deforestation, in order to protect them against degradation or depletion.

(e) To assist in identification of areas requiring international development assistance, based on updated information on changes in vegetation cover and land use and water resources. Such assistance may involve projects dealing with irrigation, reforestation, aquaculture, etc.

IMMEDIATE OBJECTIVES

The project has six immediate objectives:

(a) To develop a flexible and hierarchical classification legend to be adopted for vegetation cover and land use mapping at scales ranging from 1:1 000 000 to 1:200 000/1:250 000;

(b) To produce maps at 1:1 000 000 scale for the whole of Africa and at 1:200 000/1:250 000 for selected areas, based on visual interpretation of satellite images at 1:500 000 and 1:200 000 scales respectively;

(c) To store in digital format all the thematic information;

(d) To tabulate acreage statistics of areas of the vegetation cover, current land use and water resources categories mapped at country level;

(e) To train approximately 200 African technicians in field data collection, image interpretation and GIS applications, and to strengthen the capacities of regional and national remote sensing centres in these fields;

(f) To produce a satellite image interpretation manual in order to standardise all future interpretations of vegetation cover and land use.

## ACTIVITY FLOWCHART

| Activities | Year 1 | Year 2 | Year 3 | Year 4 | Year 5 |
|---|---|---|---|---|---|
| Survey/review of existing maps, remote sensing imagery, aerial photography and other supporting data | | | | | |
| International Workshop on methodology and legend definition | | | | | |
| Selection and acquisition of satellite images | | | | | |
| Definition of procedures for digital storage of thematic data | | | | | |
| Interpretation of satellite images at 1:500 000 scale | | | | | |
| Interpretation of satellite images at 1:200 000 scale in priority areas | | | | | |
| Training courses (3) on basic remote sensing and field data collection | | | | | |
| Training courses (3) on satellite image interpretation and cartography | | | | | |
| Training courses (3) on vegetation cover/land use mapping and monitoring and GIS applications | | | | | |
| Preparation and printing of image interpretation manual | | | | | |
| Printing of colour map at 1:1 000 000 scale | | | | | |
| Printing of black and white maps at 1:200 000/250 000 scale | | | | | |
| Final editing of vegetation land cover/land use interpretation at 1:500 000 and 1:250 000 or 1:200 000 scale | | | | | |
| Final report | | | | | |

**OUTPUTS**

(a) Hierarchical vegetation cover and land use classification legend for mapping scales ranging from 1:1 000 000 to 1:200 000 for all Africa

(b) Vegetation cover and land use colour map of all Africa at 1:1 000 000 scale (44 sheets)

(c) Digital database of vegetation cover/land use units based on 1:500 000 scale satellite imagery interpretation at regional, sub-regional and country levels

(d) Black and white vegetation cover/land use maps at 1:250 000 or 1:200 000 scale for selected areas (20-25% of Africa)

(e) Digital database of vegetation cover/land use units based on 1:200 000 scale satellite imagery interpretation (20-25% of Africa) at the sub-regional and country levels

(f) Acreage statistics of vegetation cover/land use classes at regional, sub-regional and country levels

(g) Satellite image interpretation manual for Africa

(h) Establishment in the two Regional Remote Sensing Centres, Nairobi and Ouagadougou, of two PC-based GIS vegetation cover and current land use databases for natural resources management.

(i) Complete coverage of Africa with satellite images at various scales.

(l) Strengthening of the capabilities and activities of the regional remote sensing centres.

(m) About sixty technicians trained in basic remote sensing and methodology for field sample collection.

(n) About sixty technicians trained in satellite image interpretation and cartography.

(o) About sixty technicians trained in land vegetation cover and land use mapping-monitoring and in GIS applications.

(p) Strengthening of remote sensing activities at country level.

**ACTIVITIES**

**YEAR 1**

(1) Survey/review of existing maps, remote sensing imagery, aerial photography and other supporting data

(2) International workshop on methodology and legend definition of vegetation cover and land use map of Africa using satellite remote sensing data

(3) Selection and acquisition of satellite images

(4) Two training courses on basic remote sensing and field data collection

(5) Definition of procedures for digital storage of thematic data and training of GIS operators

(6) Interpretation of satellite images at 1:500 000 scale using the "multiphase visual interpretation" approach

(7) First training course on satellite image interpretation and cartography

**YEAR 2**

(8) Third training course on basic remote sensing and field data collection

(9) Two training courses on satellite image interpretation and cartography

(10) Interpretation of satellite images at 1:500 000 scale using the"multiphase visual interpretation" approach

(11) In the area already interpreted, selection on the basis of land cover complexity and population density of priority areas for an improved interpretation at larger scale (1:250 000 or 1:200 000)

**YEAR 3**

(12) Interpretation of satellite images at 1:500 000 scale using the "multiphase visual interpretation" approach

(13) In the priority areas selected at item 11, improvement of the interpretation using 1:200 000 scale images

(14) Selection (as at item 11) of further priority areas for improved interpretation at larger scale (1:250 000 or 1:200 000)

YEAR 4

(15) Interpretation of satellite images at 1:500 000 scale using the "multiphase visual interpretation" approach

(16) In priority areas (selected under item 14) improvement of the interpretation using 1:200 000 scale images

(17) Selection (as at item 11) of priority areas for improved interpretation at larger scale (1:250 000 or 1:200 000)

YEAR 5

(18) Three training courses on vegetation cover/land use mapping and monitoring and GIS applications

(19) Preparation and printing of the image interpretation manual

(20) In priority areas (selected under item 17) improvement of the interpretation using 1:200 000 scale images

(21) Printing of colour map at 1:1 000 000 scale

(22) Final editing of vegetation cover and land use interpretation at 1:500 000 and 1:250 000 or 1:200 000 scale at regional, sub-regional and country level

(23) Printing of black and white vegetation cover/land use interpretation map at 1:250 000 or 1:200 000 scale

(24) Final report.

## DONOR INPUTS

Donor assistance will include the following inputs:

(1) Personnel

- The services of a project manager with specialisation and proven experience in remote sensing, thematic mapping and GIS. The project manager will be appointed full-time for the whole project duration (60 months)

- The services of one remote sensing vegetation cover/land use mapping specialist, with duty station in the regional centre, for a duration of 60 months

- The services of a GIS expert with remote sensing background for a period of 30 months

- The services of a cartographer for a period of 16 months

- The services of four remote sensing experts/image analysts for a total of 180 m/m

- The services of local consultants for field sampling and improvement of interpretation for a total of 102 months. All local consultants to be used will be specially trained.

- Unspecified consultancies for a period of 25 months

- The services of 9 image interpreters.

  Necessary qualifications: at least five years practical experience in aerial photography and satellite imagery interpretation. Four interpreters will be located in the regional centre for a total duration of 192 months, the other five in the two Regional Centres for a duration of 128 months.

- The services of one support image interpreter for a duration of 42 months and three GIS operators for a duration of 144 months.

- The services of four cartographic draughtsmen for 178 m/m.

  Necessary qualifications: technical drafting certificate and at least three years of practical experience in cartographic drafting. Two will be located in the regional centre for a total of 106 person/months, the other two in the two Regional Remote Sensing Centres for a total of 72 person/months.

- The services of a secretary-typist to be stationed in the regional centre for a duration of 60 months.

- The services of a one data clerk for a total of 60 months.

Materials and equipment

- One digital scanner
- three digitising tables
- three GIS (PC-based)
- three PC stations with approximately 300-400 megabyte disk capacity (486 microprocessor) as support for the scanner and the GIS
- four cartographic projectors/enlargers
- ten GPS
- two video cameras
- complete coverage of Landsat TM or MSS of Africa with additional NOAA, SPOT, SAR images, video survey data and aerial photographs or photomosaics.
- base maps for all Africa
- cartographic supplies and materials
- three plotters AO
- three inkjet printers plus other printing equipment
- GIS and remote sensing software packages
- one electrostatic plotter
- three vehicles

Sub-contracts

- paper prints of satellite FCC films
- reproductions of colour and black and white maps
- digitisation of maps
- digital image processing
- 150 flying hours for video camera survey
- image interpretation
- field checks

Training

- nine training courses on field sample collection, vegetation cover/land use mapping and GIS applications
- workshop at the beginning of the project to set up the preliminary legend

Miscellaneous

- operation and maintenance
- reports
- sundry

## RISKS

Good cloud free coverage of Landsat satellite data is a basic requisite for this study. In equatorial areas cloud cover can be a very serious constraint, and the presence of atmospheric haze can also severely limit the quality of data. Special attention, therefore, will be given to this aspect. For the more problematic areas the data interpretation schedule will be shifted to the end of the project activity in order to have more chances of obtaining good data. In these zones particularly, it is practical to consider the utilisation of multi-source high resolution satellite data such as SAR, SPOT, KFA 1000.

Delays in the provision of base maps at different scales by the various countries, in the execution of field checks or in the clearance of consultants who are to make short periodic visits would have a detrimental effect on the implementation of the workplan.

## PROJECT MONITORING, REPORTING AND EVALUATION

Six monthly progress reports will be prepared by the Team Leader. These will be consigned to the countries participating in the project and to the Donor in accordance with FAO procedures. The reports will describe the status of the project's scheduled activities and evaluate progress achieved.

The Terminal Report will be prepared by the Team Leader not later than three months before the end of project operations for clearance at FAO Headquarters and submission to the countries participating in the project and to the Donor(s). The report will assess in a concise manner the extent to which the project's scheduled activities have been carried out, its immediate objectives achieved and the results utilised toward the realisation of the related development objectives, and recommendations for any future work arising from the project.

## MULTIPHASE VISUAL INTERPRETATION

The multiphase approach is a further development and adaptation of procedures already successfully tested and adopted by various FAO projects. The method has been built up in order to provide a practical solution to the numerous technical problems such work will generate (for example, the time needed to complete all the interpretative work, the homogeneity of the interpretation, the rational use of field and ancillary data etc.). The approach has seven basic aims:

- To execute the mapping exercise in the quickest way possible by standardising interpretation procedures
- To unify the level and the accuracy of the interpretation
- To fully utilise both field and ancillary data
- To monitor the accuracy level of the interpretation constantly during the project activity
- To model the classes in the legend in accordance with the accuracy level of the interpretation
- To ensure a routine cross-check of the interpretation of each scene to avoid mistakes or lack of homogeneity in the interpretation
- To use the synergy resulting from the integrated work of several groups fully specialised in the execution of specific aspect of the interpretation work

The multiphase visual interpretation will be executed by four coordinated units in nine different phases. The units are as follows:

- Interpretation unit: This will be composed of five image interpreters under the supervision of the remote sensing vegetation cover/land use expert, and will be specialised in pure interpretation work (see various Phases).
- Cartographic unit: This will be composed of two cartographic draughtsmen under the supervision of the remote sensing vegetation cover/land use expert, and will be specialised in the transfer of the thematic interpretation on to the topographic base. This unit, through the services of a cartographer, will finalise and supervise the production of the colour vegetation cover and land use map of Africa.

- Interpretation accuracy and GIS unit: This will be composed of one support image interpreter and a GIS operator, and will be specialised in the preparatory work for field data collection and re-elaboration, and storage in digital format of the thematic interpretation. This unit, through the services of a GIS expert, will make the thematic interpretation compatible with other GIS activities.

- Field data collection unit: This will be composed of about 60 African technicians, and will be specialised in the collection of field and ancillary data. The technicians will be specifically trained before being used in the project activities.

The phases of the work will be as follows:

- Phase 1 will be executed by the interpretation unit, which will be divided into three sub-groups of two interpreters each. Each of these sub-groups will start the preliminary interpretation over a set of ten scenes, in order to ensure that the two photo-interpreters have a holistic view of the area being interpreted. At this stage the interpretation will be related purely to the discrimination of classes as shown by their spectral separability. When the preliminary interpretation is completed, the photo-interpreters will have a full overview of the area. At this stage they can select areas and classes needing to be verified in the field. The selection of areas will be done by clustering the samples over scenes representative of the total study area. The selection of representative scenes can range from a maximum of one scene out of two to a minimum of one scene out of ten, depending on the complexity of the land cover being interpreted. Taking an average between these two possibilities, it is reasonable to expect that one scene out of four or five will be selected.

- Phase 2 will be executed in the cartographic unit and will consist of the transfer of the preliminary interpretation from the satellite image to the topographic base.

- Phase 3 will be executed in the interpretative unit and will be a quick check by the image interpreter of the correct transfer of the interpretation.

- Phase 4 will be executed in the interpretation accuracy and GIS unit and will consist of two different types of work. The first task is the clustering and localisation of the samples selected in Phase 1 on the topographic base, taking into account the accessibility of the areas. Copies of the topographic bases, forms and itinerary will be sent to the local consultant in the field. The second task is the scanning and editing of the preliminary interpretation.

- Phase 5 will be executed by previously trained local consultants, who will collect field data, locating the sampling area with the aid of the topographic base and the use of a GPS. The data for each sample will be summarised in a suitable form. The local consultants will collect and catalogue the ancillary data also, according to a specified procedure. All the material will be sent back immediately to the regional centre.

- Phase 6 will be executed in the interpretation accuracy and GIS unit, and will consist of the re-elaboration of field data. The results of field data will be compared with the preliminary interpretation. Study of ancillary data (where these are reliable) will allow additional samples to be located over the area. A special computerised programme will furnish the overall user/producer accuracy of the preliminary interpretation for single scenes, groups of scenes and provincial, country and sub-regional levels. All this information will be summarised in a concise standardised report.

- Phase 7 will be executed in the interpretation unit and will consist of the execution of the final interpretation. The image interpreters will use all the material elaborated in Phase 6. At this stage they will have a holistic overview and all the necessary background information to achieve the final interpretation.

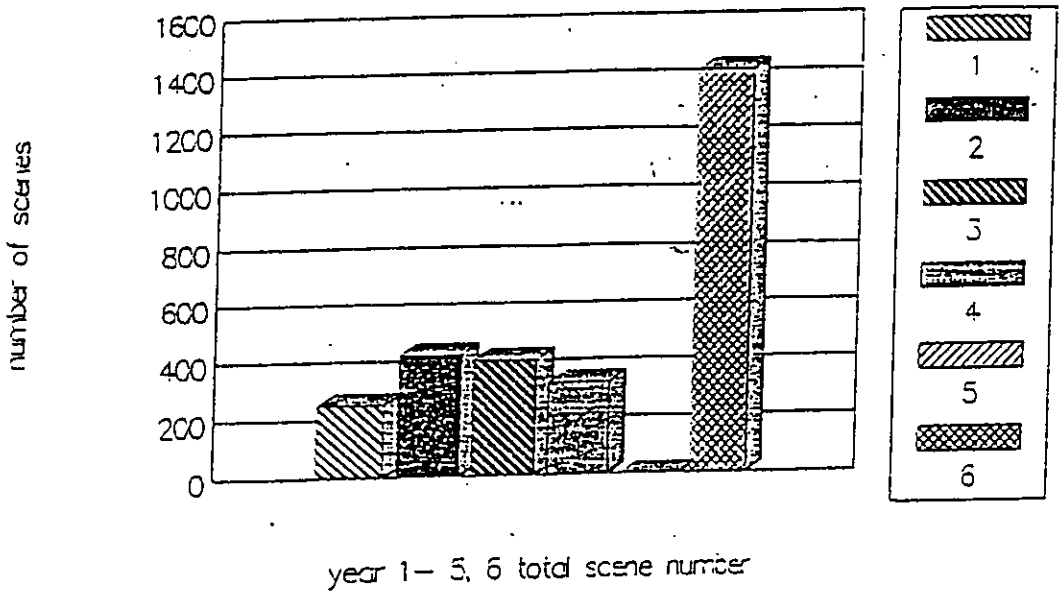
- Phase 8 will be executed in the cartographic unit. This is the final transfer of the interpretation on to the topographic base.

- Phase 9 will be executed in the interpretation accuracy and GIS unit and is the final digitisation and editing of the thematic interpretation.

| PHASES | MULTIPHASE VISUAL INTERPRETATION UNITS | | | |
|---|---|---|---|---|
| | Interpretative Unit | Cartographic Unit | Accuracy Control and GIS Unit | Field Sample Collection Un |
| 1. Preliminary interpretation | | | | |
| 2. Transfer of thematic interpretation | | | | |
| 3. Checking of correct transfer | | | | |
| 4. Field samples location storage of interpretation in digital format | | | | |
| 5. Execution of field samples, ancillary data collection | | | | |
| 6. Elaboration of the field data, assessment of the interpretation accuracy | | | | |
| 7. Final interpretation | | | | |
| 8. Transfer of the final interpretation | | | | |
| 9. Storage of the final interpretation in digital format | | | | |

# Schedule of interpretation

1:500 000 scale satellite images




# Schedule of interpretation

1:200 000 scale satellite images