2 Environmental assessment using a geographical information system

In order to explain this approach, this report first sets out the basic data indispensable for characterising the natural environment and the human activities. Next, the sources of these geographical data and the more technical questions regarding their collection and processing are described. This distinction is justified because the same piece of data on a particular theme could come from different sources.

2.1 The basic geographical data for describing the natural environment

2.1.1 Relief

The relief structure of landscapes. This is the situation at a given moment of the surface of the terrestrial crust resulting from the combined effect of tectonic and erosive forces.

"There are many different types of cartographic representation of relief: Figure 1 shows just three of these: On the left, contour lines, i.e. isolines joining all points of the same elevation. In the centre, a digital terrain model (DTM) coloured according to range of elevation with shading to emphasise relief. On the right, a perspective view of DTM that can be produced by computer with a fourfold vertical exaggeration of elevation."

Source: Lands and Surveys Department (1959) Topographical map 1:50 000 Series, D.O.S. 426 (Series Y732), Uganda. Aster, digital terrain model. Database IRD/UNHCR FRAME.

Figure 2: Three cartographical representations of the relief.

Relief analysis is the first stage in the study of a given space. It consists in describing the relief forms, their patterns and interrelations. The main characteristics to take into account are relative and absolute elevation, the gradients and slope exposures. These relief features are appreciated and utilised in diverse ways by different societies.
2.1.2 Climate

The climate has a diachronic significance, and it is not directly visible, unlike other geographic phenomena. It has to be defined using daily measures of atmospheric parameters. The main such recordings to take into account are rainfall and temperature. It is from these measurements that the climate of a specific space can be characterised. Mean temperatures and total annual precipitation can hence be determined, as can monthly, diurnal or seasonal variations.

The figure (left) represents the climate of Kitgum in the North of Uganda in the form of an ombrothermal diagram on which the annual rainfall and monthly average temperature curves have been plotted, using two appropriate scales. On the y axis, 10 mm of rainfall corresponds to a temperature of 5°C. Consequently, a graphic representation is obtained of the dry months when monthly rainfall figures are twice lower than the temperatures. The figure on the right shows the distribution of the average annual precipitation in map form. Making this map involved transforming point observations into isohyets, which join places recording equal rainfall. The accuracy of this type of representation varies with the number of observations available for plotting these isolines.

**Ombrothermal diagram**

**Rainfalls map**

![Ombrothermal diagram and Rainfalls map](image)

Source: Meteorological Department. Entebbe.


**Figure 3:** Two representations of climatic elements

Measurements of climatic parameters are necessarily point observations. However, the climatic parameters can vary widely in the same region. The precision of the perception of climate therefore depends on the number of observations available in the space considered. However, different levels can be distinguished: the microclimate corresponding to a particular site, the local climate which concerns a wider area and
the regional climate which prevails over an even more extensive zone. Climatic observations at the appropriate scale are indispensable for assessing the environmental situation in a space under consideration seeing that the climate often bears a relationship with other aspects of the natural environment, but also with certain human activities, notably agriculture.

2.1.3 Hydrography

Hydrography consists of the study of rivers, streams and lakes, the courses they take, their patterns and their variations. The water courses taken together make up the drainage system, drains a more or less large surface area. The geographical space drained is the drainage basin. Between two drainage basins passes the drainage divide or watershed. Calculation of the hydromorphological indices helps identify the quantities significant for defining the hierarchy, density and structure of systems, and leads to definition of the types of runoff organisation useful for hydrological modelling.

The figure shows two different types of drainage pattern. They are situated in the same climatic zone and the two maps are to the same scale. The different sections are hierarchised according to the Strahler classification. Every reach without a feeder is designated order 1; any reach formed by the confluence of two reaches of order \( n \) is of order \( n+1 \); any reach formed by the confluence of two reaches of different order takes on the order of the higher-order reach. The drainage density is higher in the drainage pattern depicted on the left. This can be explained by the rock types and the relief. This network traverses crystalline rocks in an area where elevation varies between 730 and 980 metres whereas the system on the right flows on an alluvial plain. The relative elevation varies by only 100 metres and beyond that the alluvial sediments are more permeable.

![Drainage pattern](image)

**Drainage pattern**

**Geology**

**Drainage pattern**


Figure 4: Two different drainage patterns.
In our approach, the drainage pattern is not analysed in isolation. It is part of the landscape. The components of the network depends on other components, especially the geology and the relief. The drainage network will be denser with increasingly humid climate, more abundant rainfall, steeper gradients, and with less permeable surface rocks.

2.1.4 Soils

Soil is, in a restricted sense, the superficial portion of rocks that have been weathered and transformed by many different interacting processes. These include water infiltration, chemical reactions, mechanical wear, effects of plant growth, animals, micro-organisms; a whole set of biological and physical and chemical studied by the science of pedology. A soil is defined by its thickness, texture, acidity, and its mechanical properties; also by its mineral composition and its profile. The characteristics of a soil can vary considerably within a particular region. They depend mainly on biotic and abiotic factors like geology, climate, relief, flora and fauna but also on its age and on human activities.

Examination of a soil section shows superposed horizons formed by layers of different colour, chemical composition and material sizes. Each particular superposition forms a soil profile which can define a definite soil type. On the left is a Vertisol: black and clayey characterized by the presence of a swelling clay, montmorillonite. It is formed under a climate with seasonal contrasts revealed in poorly drained hollows at the foot of slopes. They are nutrient-rich, but difficult to work and plough. On the right, is depicted a leached tropical ferruginous soil. The soils are characterized by a high degree of leaching, in particular a drawing down of bases and silica which causes the desaturation and acidification of the humus bearing horizon. They are quite poor, but very easy to work.

Source: IRD: soil analysis in Rhino Camp. Database IRD/HCR FRAME.

Tableau 1: Exemples of two different soil types
Soil is above all the essential medium for human activities and the most precious good for agriculture. Fertility describes the capacity of a soil with regard to agricultural production. It is often perceived as in a subjective way by those who cultivate it because it depends not only on these properties but also on its usage and on cultivation practices.

2.1.5 Vegetation

The plant cover is the last component of the natural environment. The definition and classification of vegetation is carried out following physionomic criteria, but also in accordance with the criterion of floristic composition. The biomass is estimated in tonnes of dry matter per hectare.

The photo on the left illustrates the type of vegetation currently found at an observation point in the North of Uganda in 2001. It shows a savanna characterised by a grassy cover dotted with trees. The figure on the right shows an extract from a vegetation map which distinguishes different vegetational formations. It was made during the 1960s from aerial photographs and field observations and covers this same region.


Figure 5: Mapping of vegetation types

The current vegetation describes the state of a plant cover at a specific moment. The climax vegetation is the final stage of a series of changes, in equilibrium with climatic and soil conditions. The series of changes is progressive if the successive stages get close to the climax community. It is regressive if the action of an exogenous factor causes a return to the less advanced state.

2.1.6 Geosystem

The physical components of the environment have been deliberately presented in isolation. In fact, they interact constantly. This whole set of interactions constitutes what it is convenient to call a system or a geosystem. Human societies intervene or have intervened in this geosystem, by exploiting or developing the resources found in the environment. The following chapter describes the basic geographical data...
necessary for describing the interrelation between the physical environment and human activity.

2.2 The population and economic activities

Environmental studies demand abundant diversified information on both natural resources and the societies which utilise these resources. The following account sets out in detail the different pieces of information that should be collected, analysed and compared.

2.2.1 Organisation and administrative division

Detailed information on organisation and administrative division is essential. A large number of thematic maps can be produced from cartographic survey of this division. The HCR and its partners are usually well informed on the first point. From the Head of State to the local leaders, the power hierarchy is usually well known. This varies evidently from one country to another depending on a model of differing degrees of centralisation (whether a federal system or not), the size of the country and the population volume. The higher the population, the larger the number of administrative levels tends to be and the smaller the area of the basic administrative unit.

- Example 1: Rwanda is divided into prefectures, communes and commune sectors.
- Example 2: Kenya is divided into provinces, districts, locations and sub-locations,
- Example 3: Uganda is divided into districts, counties, sub-counties, parishes and villages.

How this hierarchy is applied in concrete territorial terms is, however, less well known. In other words, it is rare that HCR officials have any clear vision of the cartographic representation of this administrative division which is, quite precisely, a division of space. The proof of this is that refugee camps or rural settlements often occupy land under the jurisdiction of several different authorities; with the attendant risks of multiplying the number of local representatives and therefore of controversy and conflicts between divergent interests.

![Figure 6: Settlements located in two administrative units](image-url)
It is essential to have a map of the administrative division not only to avoid that type of situation but also, and primarily, because such a map will be the essential basis for managing populations, calculating population densities, and so on.

It is often difficult to obtain locally an accurate administrative map, even if the authorities there know perfectly the boundaries of the territory they administer. It is usually the central government departments, in particular the cartographic service, who have to be approached for this. Keen attention must be paid, in all cases, to past or ongoing administrative reorganisations. These can mean that there are great differences between the map, official maybe but out of date, and reality. In this perspective, comparison with other maps such as those drawn up for population censuses or elections can be extremely useful.

2.2.2 Protected areas

There are a variety of categories of protected area. Such zones are often the focus or the cause of major issues between the different national and local protagonists. They could fall into the sphere of nature reserves, fauna and flora reserves, sacred woodlands, springs or of reaches of rivers or streams. A detailed knowledge of these protected areas, the associated rights of use, the bodies responsible for ensuring compliance with these rights, and also of the disputes that this type of territory never fails to generate, is absolutely essential. Knowledge of the location and exact delimitation of these zones, as much as the listing of the natural resources they hold, is indispensable. Universities and research centres often conduct scientific studies in these protected zones. Consultation of the literature or with the researchers involved often provides another viewpoint on the problems surrounding the conservation of protected areas.

In all these cases, it is useful to compare the official point of view at national or regional level – often represented by the forestry departments responsible, - and the “locales” bodies and representations, whether traditional or official.

2.2.3 Population

Data on the local population is paramount for successfully inserting the refugees as harmoniously as possible. From this point of view, analysis of population censuses proves extremely useful. These provide a wealth of socio-economic information gathered in a territorial framework closely defined with geographical references (district, county, and so on). Beyond the population figures by sex, a census gives the breakdown by age group and, in many countries, by ethnic group. A great deal of data is usually provided also on the distribution of numbers between urban and rural areas, occupations (socio-professional category) and schooling. Detailed study of the population census is essential; it can provide an accurate socio-demographic description of the region in which the humanitarian organisations are called on to work.

2.2.3.1 Settlement and population density

Studies on settlement and population density involve making use of both census data and mapping techniques. Map analysis often yields valuable information on the forms of residence adopted. Rural areas can see population distributed in space in different
ways: in villages grouped together, hamlets or, in contrast, completely scattered. Dual use of cartographic and statistical sources can result in density maps (the population number divided by the surface area in km²). Population densities are an excellent indicator of the limits of what it is possible to do with refugee populations, taken along with data gathered from other sources on the natural resources, the agrarian system in force and the standard of living of populations (food self-sufficiency).

2.2.4 Infrastructure (roads, airstrips, hospitals, schools, …)

Taking stock of existing infrastructure does not raise any particular problems. The HCR usually has good knowledge of this seeing that needs for aid largely depend on it. However, GPS can bring improvements to the information available by offering updated mapping of elements of infrastructure. The references for roads and airfields, water points, health centres, and schools registered systematically.

2.2.5 Access to land and land-ownership systems

An environmental diagnosis will be of limited value unless the conditions governing access to land are taken into account. Access to natural resources (and possible damage to them) necessarily implies a right of access to the land where they are found. This right is more or less explicit and more or less tolerant but it does exist. Thus, in the case where there are frequent complaints of degradation of vegetation near refugee camps two conditions have coincided to make such damage effectively possible: 1) humanitarian aid does not provide for supplying refugees with firewood or the timber necessary for building their huts; 2) by letting refugees use the bush as source of materials they lack, humanitarian aid is implicitly ceding a kind of land right (albeit limited) which is not necessarily recognized by the national and local bodies as its to assign. This question becomes even more imperative in that the host country’s decision (refugee camp or settlement) is in itself a choice about land which links directly back to the rights of access it is desired to give the refugees. In the case of camps, that choice corresponds to a refusal to accept refugees practising cultivation or pastoral activities on land which does not belong to them. In the case of rural settlements, it is on the contrary a right of access – even if limited in time – which is granted.

In parallel with the refugee policy decide, it is also useful to know the regulations of land access and ownership practised by the local population. These can vary considerably between ethnic groups but are tightly bound to agrarian systems. Population growth and the introduction of commercial crops are however bringing changes to customary law and growing privatisation of land tenure is giving land a monetary value which is considerably altering social relationships. Numerous conflicts arise between farmers or between cultivators and stockbreeders. These indeed stem from disagreements over land rights and intensified competition for access to resources.

2.2.6 Agriculture and stockbreeding (land use, crop characteristics)

Land use for agriculture or stockbreeding is a valuable indicator of the state of the combination social structure/natural environment. The visible landscape is highly instructive from this point of view. The kind of crops and the techniques employed
(slash-and-burn, fallowing, irrigation, combined cropping, ploughing method, and so on) are elements which give specialists quite a sharp picture of a given local situation. Rainfall regime, soil fertility, the surface areas cultivated, customary practices and the food security risk on the one hand and even population densities and the social organization, on the other, are all at least partly reflected in the observed landscape. Surveys and data acquisition conducted subsequently often confirm such first impressions.

2.2.7 Markets and small-scale trades

Alongside information given by existing infrastructure, markets and small-scale trades shed light on different facets of a region’s economic dynamics. Observation of products exchanged at markets and changes in price of staple foodstuffs bring complementary information useful for understanding agrarian systems. Moreover, the volume and diversity of small-scale trades give clues as to the functioning of the non-agricultural sector and the monetarisation of the economy. But the presence of refugees who receive only modest and unvaried aid changes supply and demand. The refugees themselves are often initiators of a market which is then joined by the local people. It is not rare therefore to see milk, meat, condiments, sugar, wood, or construction posts exchanged for the food distributed to the refugees (maize, oil).

2.3 Information concerning the refugees

The different sectors of the aid effort produce abundant statistical information. Monthly or annual reports are published on aspects as protection, education, health, food, logistics, environment. However, although these reports – scattered in the different departments of the HCR – bear witness to actions accomplished, they are rarely used to make comparative analyses which would improve overall knowledge about these populations.

By the same token, the HCR conducts population censuses at regular intervals. These exercises involve substantial resources. Their main objective is to obtain a reliable up-to-date figure of the number of refugees needing assistance. A wealth of information is gathered yet little use is made of it. As well as locating precisely the head of family in the camp or in the settlement (which makes a map representation of data conceivable), the survey gives valuable information on the sex, age, kinship, ethnic group, arrival date and vulnerability.

The humanitarian organisations furthermore conduct ad-hoc surveys on different aspects of everyday life. Enquiries on nutrition or firewood consumption, and also inventories of tree plantations, or crop yield assessment in settlements are examples. The methods used for setting such surveys in operation are often rudimentary and not always extremely rigorous. Sometimes therefore there are doubts about the reliability of results which, in any case, are generally underexploited.

2.4 Habitat/societies interaction and environmental dynamics.

As has already been highlighted, environmental diagnosis or impact studies require abundance diverse information if the complexity of interactions between physical and human factors are to be demonstrated and understood. These interactions are at work
at several levels. There are many illustrations. For example, soil erosion – as a natural process – is known to result from the combined effect of factors such as climate and rainfall pattern and volume, gradients and vegetation cover. However, it is an easy assumption that this erosion can be substantially altered depending on the type of human occupation. Degradation of vegetation cover – owing to overgrazing for example – can accelerate erosive processes. Conversely, development of the area with tree plantations or by constructing terracing can limit such natural processes. Yet such investments, unlike those for annual crops, are almost always associated with great security of land tenure because the developer must have the assurance of profit in the long term. Such situations demonstrate the prime importance, when studying environmental questions, of taking things in the proper order.

2.5 Sources and access to basic information

Refugee settlements are generally in remote areas for which little or no exact information on the environmental situation in the broad sense is available. This section therefore presents the various sources that do exist for obtaining the necessary information.

2.5.1 Existing maps

Cartographic information exists for every region of the world as printed maps or in computerized form. The two main types are topographic and thematic maps. The topographic variety represent the relief, drainage pattern, inhabited areas, arteries of communication, place names and sometimes administrative divisions. Thematic maps show the distribution of all kinds of aspect that can be spatially located, whether quantitative or qualitative such as the geology, rainfall, vegetation, soils, population density and land use.

The figure shows as an example two map extracts, one topographic and the other thematic, of the North of Uganda. On the right: a 1:50 000 scale topographic map. It covers about 9 km². On the left: a geological map of the same region at 1 : 100 000. It represents the rocks that outcrop at the ground surface or are hidden by a thin cover of superficial formations.

All maps have a scale which is the measure of a numerical ratio between a distance measured on the map and its real value on the ground. It is expressed as a fraction. The 1 :50 000 scale means that 1 cm on the map represents 500 metres on the ground. Maps are classified by scale into three categories:

- Large-scale: 1 :1 000 to 25 000
- Medium-scale: 1:25 000 to 1:100 000
- Small-scale: 1:100 000 to 1:500 000
- Very small-scale: less than or equal to 1:1 000 000
Each country has an institution responsible for mapping. In the developing countries these services often work in poor conditions. The topographic maps – if they are still available - are not updated. The cartographic survey department is often placed under the control of the Ministry of Defence topographic maps constitute information to which access is sometimes difficult. In order to find topographic maps of a region it is possible to contact international map libraries. That can take time. Such a step is justified though because a topographic map is always useful as baseline information for each intervention in an unknown area.

2.5.2 Remote sensing

Remote sensing embraces all the processes and technological methods allowing distance acquisition of information on terrestrial objects, taking advantage of properties of electromagnetic waves that these objects emit or reflect. Remote-sensing data is collected either by aircraft or satellites. At present the term refers primarily to data obtained by satellites. There is a multitude of satellites in orbit which are observing the
state of various aspects of the Earth’s surface. The figure below shows images from different sensors.

Remote sensing is not only useful for providing satellite images for determining the state of the Earth’s surface. It can also be employed to elaborate three-dimensional models of the latter. The figure below shows some examples. These digital terrain models were devised from observations of a space shuttle mission whose objective was to map the Earth’s relief. The distribution of these images began in 2002. These images are to be available globally at the end of 2004.

All these remote-sensing systems have their specific characteristics. They can be classified according to their spatial, spectral or temporal resolution or by the surface area covered by a scene. This report does not deal with the technical aspects in detail. The table below summarizes just some of the main characteristics which determine the...
application images can have. By comparing properties of the different sensors, it can be seen that the perfect system does not exist. Each system has its advantages and drawbacks. There is often a need to use different sensors types in order to meet the requirements of a particular application.

<table>
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<tr>
<th>Platform</th>
<th>Sensor</th>
<th>Spectral resolution</th>
<th>Spatial resolution</th>
<th>Temporal resolution</th>
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<td>684</td>
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<td>1 90 m</td>
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<td>1 10 m</td>
<td>26*</td>
<td>60 × 60</td>
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<td>4 2.8 m</td>
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* Spot, Aster, Ikonos et QuickBird can have a higher revisit capability because the sensor is pointable.

**Figure 10:** General characteristics of remote sensing system used during the project

The images from the satellites Ikonos and QuickBird have opened up a new era in satellite sensing. Their resolution is very high which puts them on a par with aerial photographs. However, they do not give directly a three-dimensional stereoscopic view of the ground. They were extremely expensive at first, but with time their cost has fallen. Nevertheless, compared with standard high-resolution images each scene covers only a small surface area of about 100 km². Their use is therefore limited to applications pertinent to the local level, concerning a refugee camp, for instance.

The advantages of the MODIS sensor lie in its high repetition capacity and the size of the area covered, around 1 200 000 km² (10° * 10°). However, its spatial resolution is 250 to 1000 m, depending on the wavelength range recorded, which limits it to small-scale applications covering a country or a continent.

Spot 4 and Aster offer the possibility to point on well-defined zones and to have images realized for a precise date. Spot or Aster scenes cover 3 600 km² (60 * 60 km). Consequently such images are suitable for regional-scale applications. A Landsat scene, however, covers about 34 000 km² (185 * 185 km), in other words the same surface area as 9 Spot or Aster scenes. Beyond that, the spatial resolution is comparable with that of Spot and Aster and the price, 632 Euros per scene, remains reasonable. It therefore stands out as the best option for region-level applications.

Remote sensing contributes to improved knowledge of the Earth’s surface. Satellite images are often the only credible information for identifying, drawing and mapping of the land cover in the developing countries which often lack basic maps for many areas. Identification of the land cover type is essential for resources management and for
planning. It also provides an image of the situation at a given moment on the basis of which monitoring and change detection can be performed.

Remote-sensing systems on board Earth observation satellites guarantee repeated recordings of all places observed at regular intervals. Up to now the sensors used for commercial ends do not offer the possibility of obtaining immediate images of a specified area. There are currently two methods for accessing images. The first consists of a search for available images for the area in question. A wealth of databases for this are accessible on the Internet. They hold images recorded by different sensors during their life-cycle. Identified images can be ordered directly. In this way, only a short time is needed to get hold of the information.

**Available Landsat 7 ETM+ images for the year 2001 (Path 172 Row 58)**

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**Figure 11:** Result of a search for Landsat 7 images acquired in 2001 for the North of Uganda in the EOS database.

The figure shows the result of a search for Landsat 7 images acquired in 2001 for the North of Uganda in the EOS database. Landsat 7 has a 16-day passage cycle. In 2001 therefore it flew over that region 20 times. However, for the area in the North of Uganda only 5 useable images resulted for 2001. The others were either affected by more than 20% cloud cover or were not available.

The second method of obtaining an image by order is suitable above all for very high resolution systems. It requires knowledge of the exact geographical coordinates of the selected zone. These coordinates are then used to program the satellite to take the image of that zone. Cloud cover can, however, hinder observation. For this reason
suppliers ask clients to indicate a period of about two months during which they attempt to take an image with less than 20% cloud cover. This method therefore demands more time for accessing information than the previous one.

### 2.5.3 Global Positioning System (GPS)

The Global Positioning System is a navigation system based on a network of 24 satellites. Originally, it was used for military purposes but since the 1980s, it has become freely available for public use. It is not subject to any permission and is free of any payment for intellectual property rights. Anyone equipped with a GPS receptor can, free of charge and at any moment, determine his position on the Earth’s surface.

![Satellite constellation](http://www.clarku.edu/faculty/marcano/geo298/GPS.ppt)  ![GPS receptor](http://www.garmin.be/FR/producten/summit.htm)  ![Position](http://www.garmin.be/FR/producten/summit.htm)

**Figure 12: Principles of the GPS system**

The figure shows the principle of how it works. GPS satellites circle the Earth twice a day, in a precise orbit and send signals to Earth. GPS uses a system of triangulation to calculate a position: the GPS receptor compares the time of emission of the wave by the satellite with the time of reception of this wave. The difference in time represents the distance between the satellite and the GPS receptor. The receptor can determine the exact position, by doing this measurement for waves emitted from several satellites.

The GPS system is controlled by the USA. Until 1 May 2000 selective availability (SA) affected the accuracy of all civil GPS receptors. The US government abolished SA on 1 May 2000. From then on, the civil signals emitted by the constellation of GPS satellites have no longer been affected by SA. That means in practice that the precision of civil GPS receptor apparatus is no longer subject to chance. It is now down to a minimum of 15 metres. Accuracy can be improved even further if a differential system is used.

The GPS system has therefore become a powerful tool for collecting geographical information when conducting field work. GPS receptors are simple to use. After the GPS field reading the receptor can be cabled up to a computer, the points recorded can be loaded and then displayed directly on screen.

*The figure shows a map which has been produced entirely with the aid of a GPS receptor. The extract covers a number of refugee settlements in the North of*
Uganda. A GPS receptor has been used to map the road network, the areas given over for refugee reception and the location of infrastructure created.

Integration of the collected information in the GIS makes it possible for example to calculate the surface area of agricultural land used by the refugees. This information can then be used in conjunction with demographic data in order to calculate the population density or the surface area available for each family. The map representation of this information brings out any inequalities arising in a refugee reception zone. The map will moreover first serve for a diagnosis of the situation but also as baseline information for planning and development. Several maps produced at different dates could subsequently be used for a follow-up to trace changes in the situation.

2.5.4 Statistical data and surveys

Most of the statistical data have a geographical aspect. Taking into account their location, they can be represented as thematic maps. These data can come either directly from existing databases or indeed from statistical reports such as from population censuses, from an agricultural census or from a survey.

All refugees assisted by the UNHCR are registered on an FBARS database. Regular updates of this database are performed after censuses of the refugee population. Each contains for individuals the demographic characteristics but also
the settlement location. All that needs doing in order to represent these data in
the form of a thematic map is collect the geographic references of each
settlement, group the data together by site and define requests with data which
need to be displayed as a map. The figure shows how the information from the
FBARS database can be represented in the form of thematic maps. This form of
representation has the advantage of allowing direct display of the spatial structure
and inequalities between settlements in a region being examined.

UNHCR FBARS database

- Demographical characteristics of the refugee population
- Origin
- Ethnic group
- Sex
- Age
- …

Figure 14: Principles of linking FBARS database with a geographical information system

The statistical data are often not directly available. In order to collect data there is
always the possibility of conducting field surveys. All data gathered on the Earth’s
surface can be located with the aid of a GPS receptor.
During the census of the local population in the Nord of Uganda, each team used a GPS receptor to locate the households counted. The X and Y coordinates for households were transferred to a computer combined with the data recorded. The result is first (left) a map which shows the local population distribution in the zone studied. By superimposing the administrative divisions it becomes possible to group data by administrative unit in order to calculate the figure for the local population by village (right).

2.6 GIS approach

The development of computer tools like the Geographical Information System has made it possible to process the geographical information cited in the previous chapters in a completely revised conceptual and material perspective. With the GIS approach different types of geographical information from diverse sources can be incorporated into a single database. It involves a technology of information integration and processing.

GIS use the principle of layers of information. Each layer corresponds to a different them. All the objects presented on a layer are associated with attributive data. A GIS can therefore answer the following questions: Where is a phenomenon located and what are its characteristics? The collection of all the layers with their associated attributive data constitutes the geographical database. In our approach this database is a reduced model of the real environment of part of the Earth’s surface.

More generally, a GIS is consequently a database-type application. All GIS software packages possess functions for database management for data capture, storage, updating, handling, analysis and presentation. However, their application is effected in georeferenced environment. This characteristic distinguishes the GIS from other systems of analysis. From a practical point of view, a GIS can be defined as an organised set of computerised materials, programs, geographical data and personnel capable of processing all kinds of geographically referenced information.
2.6.1 A GIS as a decision-making tool

The approach adopted here takes GIS first as a tool for modelling the environment of a portion of the Earth’s surface. This system can use correctly structured basic data to offer a multitude of functions which can bring into relation different layers of information with their associated attributive data. All these spatial analysis functions can be used in order to find an answer to a specific question. The principle consists of setting a question, then attempting to reply by processing data held in the base. The result of such an analysis is often a map which shows the spatial distribution of the aspect or phenomenon analysed. It is in this sense that a GIS becomes a decision-making tool.

The two figures below show the example of the use of GIS as a decision-making tool. Is the objective of the search to explain differences in agricultural production between settlements in the North of Uganda? Several hypotheses can be formulated to explain such an observation. One of them relates to topographic differences. The geographical database contains all the information necessary. In order to find a response to the question asked the appropriate digital terrain model is selected, then the layers with the settlements and drainage pattern are overlaid.
Why is the agricultural yield different between settlements?

- ...
- ...
- ...
- ...
- ...
- ...

Figure 17: Use of GIS as a decision making tool.

The map at lower left shows the results of this analysis. It reveals that the areas of land allocated to refugees to the North of Adjumani are located in different types of environment. The Arra settlement is situated on the edge of the Albert Nile on an alluvial plain, Nyeu is traversed from North to South by an Inselberg. It is a rocky area, the lowest point is at 630 m and the highest at 740 m. A large part of the Elema settlement is located in a zone subject to temporary flooding over the year. The topographical location therefore indicates that within settlements very different ecological situations can be found. Consequently the potential for human use for agriculture will differ greatly. This largely explains why agricultural yield between settlements can be very unequal because topography combines with important differences in soil types and rainfall. But after this analysis the salient question that arises is why certain settlements have been created in areas which are really unsuitable for agriculture.
1. Digital Terrain Model.  
2. Refugee settlements and hydrography  
3. Delimitation of the area of interest  
4. Interpretation


Figure 18: The successive stages of analysis in a GIS.

2.6.2 The multi-scale approach

Geographical information is a reduced representation of the real state of part of the Earth’s surface. It covers a surface of a certain extent and has a certain level of precision which determines the field of application.

The precision of the information represented on the map depends essentially on the scale. The map on the right at 1:50 000 scale represents a small portion of the surface of the North of Uganda and carries considerable detail, whereas the map on the left at 1:800 000 embraces a greater expanse of territory but at the
price of a great simplification of what is represented. Comparison shows that when the scale of a map is changed neither the same details nor the same information appear. It can be seen that a small-scale map is sufficient for gaining an overall view of the distribution of settlements for receiving refuges in a given region. A more detailed topographic map at medium or large-scale is essential for use to be made of cartographic information for site planning.

Figure 19: Comparisons of information represented on maps at different scale.

The question of precision arises for all geographical data which describe human activities and the natural environment. Clearly, the more precise the data carried, the smaller is the surface area covered. However, it is useful to separate three geographical levels for analytical purposes: national, regional and local. This separation is justified by the fact that the perception of the information changes depending on the level of analysis. It is indispensable to place a settlement in the national and regional context in order to be able to understand the situation.

The national level groups together the data that cover a whole country. The detail and accuracy of these data compared with the reality in the field make possible analysis of the environmental situation at national level. The regional level is an accumulation of more detailed information for a region or a refugee reception zone. It facilitates analysis of inequalities within the area focused on. The local level data give a highly detailed picture of a refugee settlement or a camp with its internal organization and its environment.
2.6.3 Conclusion

The HCR distinguishes three time-scale based levels of intervention: “emergency, care and maintenance, repatriation and rehabilitation”. It is during the first, emergency, phase that decisions are taken setting aside settlements for accommodating the refugees. The information on the environmental situation in the broad sense is essential, primarily for providing the best assistance for the refugees but also for planning appropriate for local conditions. It is therefore preferable to gather together all the information available and set in place a GIS directly during this first phase of action. The GIS will then make up the baseline information for the sustainable management of the space allocated and its resources. Regular update of the database will make it possible to follow up the situation in the course of time. GIS will be employed for map production, integrating information, envisaging scenarios, and solving complex problems in order to propose suitable solutions during the subsequent phases.

Setting a GIS in place is a process which consists first of technical aspects of design, elaboration, and maintenance of the database. But it also has a thematic aspect of application. One person can seldom have all the attendant technical and thematic knowledge and skills. For this reason successful application of a GIS often requires the work of a multidisciplinary team. Setting up and maintaining GIS demands advanced skills in the sciences of geographical information.

Figure 20: Three geographical levels of analysis.