THE 18TH POST-GRADUATE COURSE "REMOTE SENSING AND NATURAL RESOURCES EVALUATION"

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ABSTRACT

The Istituto Agronomico per l'Oltremare, which is a branch of the Italian Ministry of Foreign Affairs, has been organising regularly since 1974 a Post-graduate Course aimed at training technicians in natural resources survey and evaluation for rural development. In this non-conventional paper, after a short history of the Course, an overview about the cultural and didactic organisation of the Course is given. Finally, the results of the final stage of the last edition are presented. The study area is an Andean valley near Cochabamba, Bolivia.

1. A SHORT HISTORY

The Post-Graduate Course "Remote Sensing and Natural Resources Evaluation", created at the Istituto Agronomico per l'Oltremare (IAO) in 1974, is an unique training initiative in Italy, and probably the most important Italian post-graduate course in the field of Remote Sensing and GIS.
Originally denominated "Aerophotogrammetry and Photointerpretation for the Management of Terrestrial Resources", its contents have been continuously updated in the direction of natural resources inventory and evaluation for rural development, according to the tradition and institutional mandate of the IAO. This trend is witnessed by the large number of students coming from developing countries, about the 30% of the total.
Since the first editions, the theoretical part was followed by a practical stage, that has become more and more important, being now the qualifying element of the Course. At the beginning, the stage consisted of small case studies, carried out by the students individually or in small groups. With the 10th edition, we moved to a more ambitious project, i.e. a common interdisciplinary work in which the whole group could participate. At the beginning a study area was selected in Italy where to realise a complete set of thematic cartography, both basic and derived maps. These first experiences were carried out with a very limited logistic support by the IAO.
In 1985, with the 12th edition, we had the first stage experience abroad, in Tunisia (Ongaro, 1996): it was a very important step forward from the training point of view, but also a huge raise of costs for the organisation, not only financially but also in terms of human resources. However the results were enrapturing, and turning back unthinkable.
So we decided to undergo a deep reorganisation of the course's structure, in order to make it more and more aimed at training technicians to work in the field of development co-operation, both Italian and international. As a consequence, the Course changed its denomination into "Remote Sensing and Natural Resources Evaluation", was expanded to an overall duration of seven months, and started the present biennial periodicity.
In the following editions the Course went on updating programs and contents to cope with the tumultuous evolution of the techniques. In the meanwhile, the IAO has been working to develop its own way to natural resources evaluation for rural development planning (Giordano, 1989, and Ongaro, 1997). More than a methodology, IAO's can be considered as a framework for a holistic approach to land unit mapping, similar to those developed by, for example, FAO, CSIRO, ITC etc. The IAO has utilised land unit mapping as a base for GIS in different development projects, i.e. in an application context, but this approach has also proved to perform very well in teaching and training. Moreover, we could state that the Course has been our experimental laboratory, profiting by the continuous transfer of expertise from our application work.
With the 17th edition, we decided that English was to be our official working language, to give a full opening to international participation. In these last editions, the final stages have also widened their range, to countries such as Tunisia again (IAO, 1993), Eritrea (IAO, 1995 and Ongaro & Sarfatti, 1995) and Bolivia.

2. HOW IS THIS COURSE NOW

The participation is restricted to 16 students, having an university degree in Geology, Agriculture, Forestry and other related disciplines. An official announcement is sent to Italian Embassies, that are also in charge for promoting fellowships. The applications received at the IAO are evaluated according to curricula and professional position. Once the panel of foreign participants is defined, the remaining places are assigned to

Italians, that have to undergo a severe selection process, as we always receive a large number of applications from Italy.
The Course is free of charge, being entirely financed by the IAO, through funding provided by the Ministry of Foreign Affairs. The timetable is based upon thirty hours per week, with compulsory attendance.
The Course is divided into two parts. The first one covers about three months, and is made up of lessons, exercises, visits and seminars. The lessons' topics, in the last edition, were:

- *Methodological aspects of natural resources evaluation (12 hours)*
- *Introduction to informatics (18 hours)*
- *Cartography (18 hours)*
- *Geographical Information Systems (24 hours)*
- *Principles of Remote Sensing (18 hours)*
- *Photointerpretation (18 hours)*
- *Digital image processing (30 hours)*
- *Climatology (18 hours)*
- *Geology (24 hours)*
- *Geomorphology (24 hours)*
- *Rangelands (24 hours)*
- *Agriculture and Land Use (18 hours)*
- *Forests (18 hours)*
- *Soils (24 hours)*
- *IAO methodology: a framework (18 hours)*

Five one-day seminars have been held:

- *Microwave remote sensing*
- *Hyperspectral remote sensing*
- *Close range applications of remote sensing techniques*
- *Remote sensing applications to agricultural statistics*
- *The farming system approach*

Teachers are from IAO's staff, private companies, national and international organisations, universities and research institutes. There is a close co-operation with the Italian Remote Sensing Society.
The second part of the Course, as said above, is a complete interdisciplinary case study, which engages the whole group of students during four months. The stage is entirely under the technical and scientific co-ordination of IAO. An area is chosen, in collaboration with other local institutions, that presents a good "didactic vocation", i.e. the area must be interesting from various point of views, such as geology, vegetation, agriculture, climate and so on. Of course, it shouldn't be an area of extreme logistic difficulties. Contacts with local counterparts are taken largely in advance, and one or more preliminary missions are carried out by IAO's staff to prepare the field survey.
At the end of the Course, the results of the stage are presented by the students during a public ceremony.

3. THE STAGE: SCIENTIFIC FRAMEWORK

At the IAO we are convinced that the environment can be studied only in an interdisciplinary way, and this is what we try to teach, using a holistic approach to land unit mapping.
Land is a portion of terrestrial surface, whose characteristics embrace "all reasonably stable, or predictably cyclic, attributes of the biosphere vertically above and below this area, including those of the atmosphere, the rocks, landforms, soil and underlying ecology, the hydrology, the plant and animal populations and the results of past and present human activity, to the extent that these attributes exert a significant influence on present and future uses of the land by man" (FAO, 1976). Thus, the landscape is the visual result of the interrelations of all these elements, both in time and space; it is the object that we can recognise in remotely sensed data.
So we adopted a land classification system, using three different, scale-dependent, hierarchical levels: site, facet, and system. The site is the smallest, the truly holistic unit: we could also say that it is also the only one which does exist in the reality, i.e. apart from any cartographic generalisation. It corresponds to a concept which is widespread and well acknowledged in most environmental disciplines: for example, the phytocoenosis in vegetation science or the polypedon in soil science. In ecological terms, it is the ecotope. The facet is a portion of land formed by a combination of sites, which are related both spatially and in terms of land attributes, for at least one land attribute (typically geomorphology, but often also vegetation and/or land use). From a pragmatic point of view, a land facet should be defined as a management unit, i.e. a portion of land which is homogeneous from a management perspective; this means that agricultural practices, vegetation management, animal stocking etc. (both actual and potential) should be the same throughout the unit, and that the expected results from a management practice should be homogeneous. The system is a combination of land facets together, forming one convenient mapping unit on a reconnaissance scale. In other words, it is made up of geomorphologically and geographically associated land facets, which form recurrent patterns; the boundary of these recurrent patterns coincides with that of some discernible geological or geomorphologic feature or process.
Both the preliminary mapping (using aerial photographs and satellite imagery) and the field survey must be carried out by an interdisciplinary team, including at least a geomorphologist, a soil scientist and a botanist. They should analytically describe all different components of each mapping unit, along with their interrelationships. The final legend of a land unit map is usually made up by more than a single hierarchical level, with a well defined system of relative percent composition.
All the data are the basic input for a GIS, build upon this system of relative percentage composition. In practice, when compared to a traditional multi-level GIS approach, a land unit map is composed by a single synthetic level, and not by a mechanic sum of different analytical processes (see fig. 1). This characteristic offers many advantages from a scientific point of view, but moreover makes this type of approach very useful for carrying out basic resources surveys in developing countries, where the environmental information is very often scarce, inadequate or obsolete, if not lacking totally.

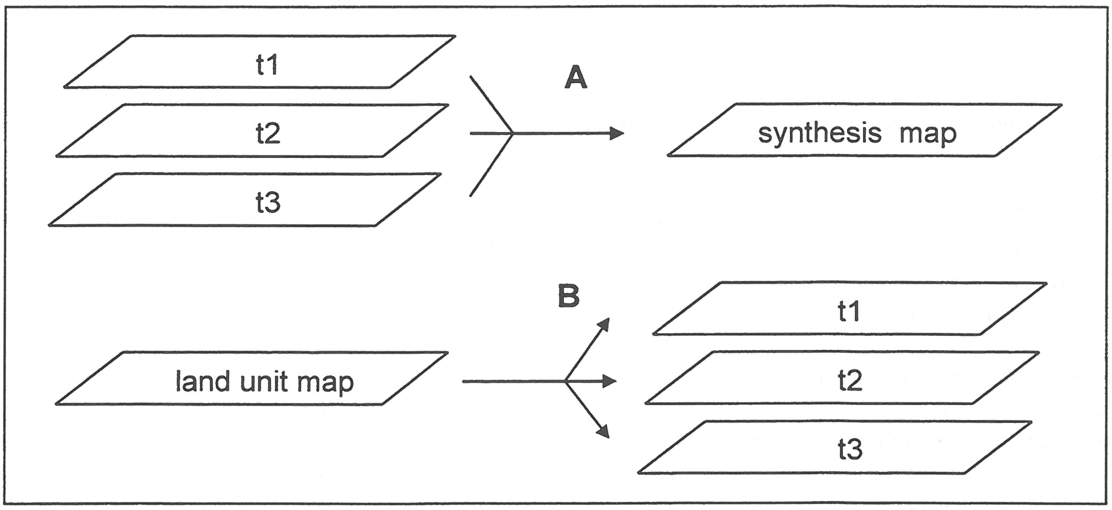

Fig.1 - The conceptual difference between a "traditional" GIS approach (**A**) and a holistic approach (**B**); **t1**, **t2** and **t3** are different single thematic maps. In case A the different themes are overlaid to produce a synthesis, while in case B the different themes are derived from the land unit map, which is produced directly from the remotely sensed data and the field survey.

4. THE STAGE: DIDACTIC FRAMEWORK

The final stage is divided into three distinct phases.

The first phase (five weeks) begins with a critical review of existing documentation, available data sources and outstanding environmental issues of the study area. Three interdisciplinary groups are set up, and each group has the task to realise its own preliminary maps using a holistic approach, having full access to all available remote sensing data (satellite imagery, both digital and printed, and aerial photographs) as well as to processing equipment. The three products are discussed and critically compared; another group is set up to realise a final version. In the same time, other groups are formed, to help preparing the field logistics, the databases and the GIS structure. At the end of the first phase, all the students are involved in planning the field survey, i.e. how many relevés* are to be executed and where.

The second phase is the field survey, about one month. The students are preceded by a IAO official in charge of logistics, and are accompanied by other two IAO people, a technical-scientific co-ordinator and a soil lab technician, for soil sample pre-processing. Other two or three specialists (in soils, vegetation or geomorphology) are also present at the beginning for the kick off. In the field, the students are divided into four interdisciplinary groups, each one having a four-wheel car, a complete set of field equipment and a set of copies of satellite images, aerial photos and topographic maps. Each group is then responsible for its operations. Every day, in the evening, a meeting is scheduled for discussion, co-ordination, exchange of impressions and data pre-processing. Processing of soil samples is initiated already during the field, as it is a time-consuming task. Every week the four groups are scrambled, in order to avoid methodological drifts.

The third phase begins when the group is back to Italy, and covers about six weeks. This is the phase that requires the maximum co-ordination efforts. The overall work is divided into four main "axes": vegetation and land use, soils, geology and geomorphology, GIS and cartography. Inside each axe many "activity guidelines" are defined, with a time schedule designed to respect some "notches": these notches represent also critical dates in which the work in progress is to be evaluated. Due to the interdisciplinary nature of the activity, results from one axe or activity guideline are essential also for the others. The students are assigned to the activity guidelines in groups of two or three, and each students is always assigned to more than one guideline, in order to assure in practice the circulation of updated information. Once a week, a general meeting is scheduled in which each student has to present his/her work, which is then discussed; everybody can then criticise and/or formulate new proposals.

The final output is a GIS, based on a land unit map. From this GIS many maps are produced: these are basic theme maps such as the soil map, the geomorphologic map and the land use/land cover map, and derived maps such as maps of the erosion risk, the land capability and the land suitability for several different land utilisation types. In fact, the final result is aimed at serve as a basic set of environmental information for decision makers in the fields of land use planning and rural development.

* With this term, originating, I believe, from ITC, we indicate the measurement and recording of environmental parameters (soil, vegetation, geomorphology, land use, etc.) that will be used for legend construction and land evaluation; the relevé is usually done in an integrated way by a multidisciplinary team. It is a quite unusual term: we adopted it to underline the difference with the traditional sampling techniques.

5. A CASE STUDY: THE 18TH COURSE AND THE LAND UNIT MAP OF THE SACABA VALLEY (BOLIVIA)

The stage of the 18th Course has been carried out in collaboration with CISTEL (*Centro de Investigaciones y de Servicios en Teledeteccion* of the *Universidad Mayor San Simon* of Cochabamba, Bolivia). The selected study area was a typical Andean valley near the town of Cochabamba, including the catchment area of the upper stream of the Rocha river, before its outlet in the large *Valle Central*, where Cochabamba is located. The total surface is about 40.000 ha, with an altitude range from 2.600 m up to 4.600 m asl. The valley is a large basin of tectonic origin, filled by fluvio-lacustrine and alluvial sediments. It is delimited at north by the western ridges of the Tunari cordillera, while the southern side is a chain of lower mountains, culminating with the Cerro Tuti. Westward, a series of passes separates the valley from the escarpment edge that connects the Andean plateau to the Amazonian basin. The general climate is temperate tropical, with a dry cold winter and a rainy summer; the annual temperature excursion is quite small, and the total rainfall ranges between 400 and 700 mm. Due to the orographic conformation of the valley, the local bioclimate varies largely.

The goal of our study was the creation of a GIS for natural resources evaluation; as the state-of-the-art of resources knowledge of the area was very near to zero, we had to start form the scratch, and carry out a complete resources inventory, i.e. geology, geomorphology, soils, vegetation and land use, and bioclimate.

We have used four different satellite images, two TM (May 1990 and February 1996), and two SPOT XS (July and August 1994). Furthermore, we have largely exploited the only available aerial photographs, a good quality panchromatic flight of July 1983, at the approximate scale of 1:65.000. Also, we derived a DEM from the topographic maps 1:50.000 (the only cartographic document found), with a grid cell size of 30 m. The SPOT image of July 1994 was the best image, and thus the reference working material. So it has been orthorectified (using the DEM), stretched and filtered, then printed at the approximate scale of 1:50.000. The full set of the satellite data was available to the students, that have used different processing software, such as PCI, Idrisi, ArcView and Surfer. For the construction of the data base we used mainly Access and Excel.

The Land Unit Map, realised with the methodology described above, was the basic input for the GIS, from which the students derived:

- a set of five basic maps: geological map, geomorphologic map, soil map, land use/land cover map, bioclimatic map;
- two maps of erosion risk, comparing two different methods (ITC and PSIAC);
- two maps of Land Capability, comparing two different agricultural scenarios (traditional vs. improved);
- five maps of Land Suitability, for five different crops.

This was only a demonstration of the GIS capabilities, to give the students some application examples and operational suggestions, far from exhausting the system potentiality. Starting from this set of documents, however, we could already trace some hypothesis and guidelines about land use planning. Some of the results seem to be very interesting: in the area, in fact, there is a high anthropic pressure on the environment, caused by the overexploitation of rangelands with grazing and wood collection, and by the high rate of urbanisation in the valley. On the other hand, traditional agriculture is practised also in sloping areas, with a high degree of consciousness about soil conservation: common practices, evolved through a hundred year long process of adaptation, appear to be well fitted to this challenging environment.

The final report is presently under publication as a monograph.

REFERENCES

FAO, 1976. A Framework for Land Evaluation. Soil Bulletin n° 32. FAO, Rome.

Giordano A., 1989. Il Telerilevamento nella Valutazione delle Risorse Naturali. Relaz. e Monogr. Agr. Subtrop. Trop. n° 106. Istituto Agronomico per l'Oltremare, Firenze.

IAO, 1993. Land Unit Map of the Kebili Area (Southern Tunisia). XVI Course on Remote Sensing and Natural Resources Evaluation. IAO, Florence.

IAO, 1995. Land Unit Map of the Aini Mareb and Halhale Catchment Area (Eritrea). XVII Course on Remote Sensing and Natural Resources Evaluation. IAO, Florence.

Ongaro L. (a cura di), 1986. Studio integrato delle risorse naturali del Nefzaoua (Tunisia): carta delle unità di terre dell'area Kebili-Douz. Riv. Agric. Trop. e Subtrop.; LXXX, 2.

Ongaro L., 1997. Land Unit mapping for Land Evaluation. Dispense per il XVIII Course on Remote Sensing and Natural Resources Evaluation. IAO, Florence.

Ongaro L., Sarfatti P., 1995. Utlizzazione di dati telerilevati e GIS per la produzione della carta delle unità di terre del bacino dell'Alto Mareb (Eritrea). Atti del VII° Convegno Nazionale AIT, Chieri.