Preparing the soil survey of Italy at scale 1:250,000.

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Introduction

The soil survey of Italy at scale 1:250,000 should be considered as an opportunity for setting up or reinforcing existing Italian regional services, as well as for creating a national centre for soil cartography. Furthermore, it will provide an opportunity for supporting pedological activities in Europe, in particular those co-ordinated by the European Soil Bureau (ESB) and, all in all, a chance to enhance soil culture in Italy and in Europe.

Technical motivations are related to the practical applications of the contemplated database, i.e. the ones stated in the ESB manual: the assessment and georeference of groundwater vulnerability, soil pollution, drought and erosion hazards, land capability, land suitability for crops and agricultural practices, etc.

On the other hand, methodological motivations concern the progress made over the last few years with the diffusion of information systems, which has led to considerable innovations.

Traditional and innovative soil data gathering and organisation

In traditional soil surveying and mapping, all information is summarised within the closed system constituted by the soil map and the report (fig 1). The survey activity begins with the subdivision of the studied territory into different macroscopic physiographical environments, based, when possible, on of a geomorphological map. This is followed by a further subdivision of the territory into landscape units, as the relations between soil and some land characteristics, such as lithology of the parent materials, slope, erosion, land use, anthropic works (e.g. terraces, ditches) are only discovered during the field survey. The singling out and delimiting of soil and landscape variations produces the soil map, in which each unit contains information on soils and landscapes at a given scale. The information is summarised in the map legend and in the soil report, where general and thematic information, the soil distribution model and benchmark profiles are illustrated.

The advent of soil information systems has allowed us to store a greater amount of the surveyed data, and has also enhanced the possibilities of data processing, up-dating and retrieval. A major characteristic of the system is that geographical and typological information are jointed, thus creating a unique integrated database that can produce several outputs, which also include the soil map. For this reason, we no longer speak of cartography in terms of "soil map" production, but rather in terms of "georeferenced soil database" creation. The state of the art of most soil information systems is at present constituted by two software units, namely a GIS connected to a database (fig.2).

Basic concepts

Moreover, from a conceptual point of view, soil mapping activity has remained the same, i.e. it is based upon the deterministic approach formulated by Jenny in the early forties. In his famous equation, Jenny stated that soil (S) is the result of five forming factors: climate (c), organisms (o), rock (r), topography (m) and time (t).

$$S = f(c, o, r, m, t) \quad \text{(Jenny, 1941)}$$

The same equation can be rewritten as follows:

$$Sm (r (c, o), t)$$

which means that the soil we observe in a determined morphological position (Sm = the pedon) is the result of rock weathering and time, where rock weathering (r (c, o)) is itself a function of pedoclimate and organisms.

Geographically speaking, the polypedon (PP) is the union of soils whose forming factors are so similar that they give morphological and functional characteristics which fall into specific ranges.

$$PP = \bigcup_{i=1}^{n} Smi (r (c, o), t)$$

On the other hand, the pedolandscape (or soilscape PL), which in a broad sense can be defined as the landscape with pedological meaning, is the set of climatic, lithological, morphological, soil (s) and land use (us) elements which characterise a tract of the earth surface at a given time.

$$PL = \{c, r, m, s, us\}$$

The pedolandscape may coincide with the polypedon at the detailed scale, when all the soil forming factors are approximately constant, but it is nearly always different at the reconnaissance scale.

$$PP \equiv PL \quad \text{when} \quad c, r, m, us = K \quad \text{(detail)}$$

$$PP \neq PL \qquad\qquad \text{(reconnaissance)}$$

Obviously, at the 1:250,000 scale we map pedolandscapes which do not coincide with polypedons.

Pedolandscapes are usually singled out by thematic mapping, photo-interpretation and free survey. We all know very well that the last two techniques introduce a high level of inference and uncertainty. The interpretation may, or may not, correspond to the reality, but the main problem is that the stakeholders have essentially a unique objective index of confidence: the observation density.

Standards in soil survey

The advent of GIS and databases has meant that information on soil map units and polygons can easily be differentiated from data regarding typological units (Gardin et al., 1996). It is therefore possible to distinguish the “geographical” intensity of pedological observations (auger holes, profiles, etc.), from the “typological” intensity. For this reason survey standards should be considered both in terms of "observations by surface unit" (n/ha) and "observations by soil unit” (n/n) and, when possible, “observations by polygon” (n/n) and “observations by pedolandscape” (n/n).

Moreover, with the aid of information technology, it is possible to deal with typological units such as soil series, or soil bodies, at both detail and reconnaissance level (Finke et al., 1998; Napoli et al., in press). In other words, the two approaches differ essentially in the way they spatialise information, not necessarily from the point of view of the information typology.

For this reason, it is evident why soil geography assumes a prominent role in the creation of a Soil Information System.

Procedures to be tuned and formalised in soil geography

In the ambit of the 1:250,000 soil database, we need to tune and formalise a number of procedures, especially in the field of soil geography. First of all we have to standardise the geographical bases on which to operate, such as aerial photographs, raster and vectorial images, as well as geographical reference systems. Then it is necessary to become skilled in the use of geographical tools such as DEM and satellite for pedological purposes.

For example, at the Soil Science International Congress of Montpellier, Dobos and other Hungarian geographers showed the easy use of satellite and DEM to obtain a quick small scale soil map (Dobos et al., 1998). Although their approach cannot be utilised as such, especially in countries like Italy, which have a great deal of paleosols and a strong anthropic influence, it seems unrealistic that the 1:250,000 soil map should not use these tools.

Thus, the field soil survey should follow not only the photo-interpretation, but also the DEM and remote sensing analysis phase: basically, in the field we should gather information on soils occurring in pedolandscapes which have previously been defined in terms of their constituting elements. Moreover, field borings should allow us to defining the short distance differences, i.e. the internal variability of the polypedon (or soil body), as well as its geography in terms of form, dimension, distribution and relations.

As to the standards in soil uncertainty assessment, it is well known that total observation density follows a set of variables: cartographic scale, soil distribution complexity, site accessibility, remote sensing, financial budget, thematic maps and information technology available; nonetheless, the same quantity of observations can be used either to improve soil typological knowledge, or to assess their geographical distribution. Thus, the fewer the observations, the higher the uncertainty about soils, in terms of the number and kinds of soils which are really present and relevant for the study area, and/or the precision of the soil limits, and/or the soil map purity (i.e. inclusions inside the polygons). As it will not be possible to survey all the soilscapes, the choice between the different strategies has important implications for the selection of the windows in which the detailed surveys are to be carried out (cp. Finke et al., 1998).

A consistent approach could be to start from the Soil Region and arrive at the soilscape through different pedolandscape levels, thus giving a preliminary overview of geographical variability. On this basis it would be possible to carry out a preliminary field soil survey, aimed at defining the number of significant soils in each study area and the number and dimension of windows for the different pedolandscape levels.

In this phase, as well as in the phase of ascertaining the soil map purity, the use of geostatistic, and in particular of non-parametric tests, seems to be possible.

Soil correlation among the different databases

Soil correlation is another activity which concerns soil geography. It is possible to deal with different subjects of correlation, as well as distinct levels of correlation. In particular, we have to bear in mind that we are going to build up databases at three geographical levels: Europe, Italy and Regions, where soil typologies should be comparable in terms of classification and management.

In order to make this correlation activity possible, the information gathering process and the creation of the database must be well organised, and common, sound, robust and easy to use operative tools must be acquired.

The soil survey manual is certainly one of the most important of them.

At the moment we have several soil manuals in Italy. There is not much difference between them, for they all refer to the same international references, but they are different enough to make digital data circulation impractical. As this is also the case at the European level, the European Soil Bureau has promoted the creation of a “Manual of Procedures of the Georeferenced Soil Database for Europe”.

The Manual of Procedures of the Georeferenced Soil Database for Europe

The manual is a good first attempt at reaching a standard procedure in soil data acquisition and organisation. It is useful for the international circulation of this data and its processing at European level. Since 1:250,000 is a regional scale, mandatory attributes regard only a minimum number of characteristics, while most of the pedological information is optional. The choice of the different options has to be made in relation to the scope and nature of the applications.

The manual takes up classical pedological assumptions, but also introduces new methodologies. The principles for distinguishing the main soils of a given region are their morphology and characteristics, as results of the soil genesis factors, as well as their behaviour in the landscape context. This means that the subject of the survey is the soil body, i.e. a natural body defined in terms of genetic processes and functional qualities; precisely for this reason, most of the manual is dedicated to the definition of soil body attributes.

Special attention is also given to the description of the pedolandscape, defined as a portion of the soil cover which groups together soil bodies having former or present functional relationships, and of the Soil Region, which represents a part of the soil cover characterised by a typical climate and parent material association; in other words, the “natural” regional unit to which soil bodies and pedolandscapes are primarily related.

The manual recommends a further hierarchisation of landscapes at national level, i.e. the creation of other levels between Soil Region and soilscape.

Besides the question of landscape hierarchisation, in order to use the ESB manual in Italy a translation of the document and harmonisation with Italian conditions and methodologies are necessary. These activities will firstly assess the mandatory and not mandatory attributes of the database, then a validation of the structure and parameters will be carried out, with possible modifications to the attributes, survey methodologies and standards.

Subjects of the soil map of Italy at 1:250,000 scale

Although the project should aim at involving the entire community of Italian soil cartographers, the bodies having the main co-ordination tasks are the Regional Administration, the Experimental Institute for Soil Study and Conservation (ISSDS) and the European Soil Bureau. The main task of the Regional Administrations should be to lead and supervise soil surveys within their administrative boundaries; the ISSDS has the duty of co-ordinating the methodological standardisation, while the ESB’s job is to give the project a European framework and to co-ordinate the work related to the so-called “Ecopedological map of Italy” (fig.3).

The Project “Pedological Methodologies”: criteria and procedures for the creation and up-dating of the soil map of Italy (scale 1:250,000)

The project aims at providing methodological standard for the creation, management and utilisation of georeferenced soil databases. Standards will be in the form of procedures, manuals, file-cards and software and they will be calibrated and validated on pilot areas. They should take into account the national and international state of the art, in particular in the case of the European manual. Moreover, they will have to deal with the actual operative reality of the regional services.

One of the objectives of the project is the creation of a soil cartography centre, aimed at gathering and processing soil information at a national level, with the collaboration of Regional centres.

The Italian National Observatory for Pedology and Soil Quality of the Italian Ministry for Agricultural Policies is the advisory committee for the project. In addition to the collaboration with the Regional administrations and European Soil Bureau, the project is integrated with the "Moncapri" project (soil cartography monitoring in the Italian Regions), the northern Italy pilot area of the European database, co-ordinated by the ESB and the Lombardia Region, and the "SINA" project (soil database for areas at risk of pollution) led by the Environment Ministry and the Emilia-Romagna Region.

Framework of the project

The project has been organised in eight sub-projects, the co-ordinators of which belong to the ISSDS and the Regional Administrations (fig. 4).

As previously stated, the project aims at involving all national experts on soil cartography with three participation levels:

"operating": constituted by the co-ordinators of each sub-project, as well as invited experts,

"participating": formed by those who want to actively take part in the sub-project and group work,

"consulting": which includes all those interested in following the work, without the obligation of attending the meetings or providing contributions.

It is possible to determine four project knots, corresponding to same number of goals.

Activation: the first objective of the project is to define the guidelines that will be developed in each sub-project.

Initial drafts: the second step is the production of an initial procedures draft from each sub-project group, which will then be discussed and approved in an ad-hoc meeting.

Validated drafts: in the third phase validation activity will allow the calibration of the previously drawn up procedures; if necessary, a preliminary proposal of a second set of standards will be put forward.

Final drafts: the last meeting will be devoted to the approval of the calibrated and validated standards and procedures.

The project scheduled time is two years, but it is to be hoped that the activities will go on longer, as a logical continuation of the pedological network which is currently being set up.

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Fig.1 - Information gathering process in traditional soil survey and mapping.

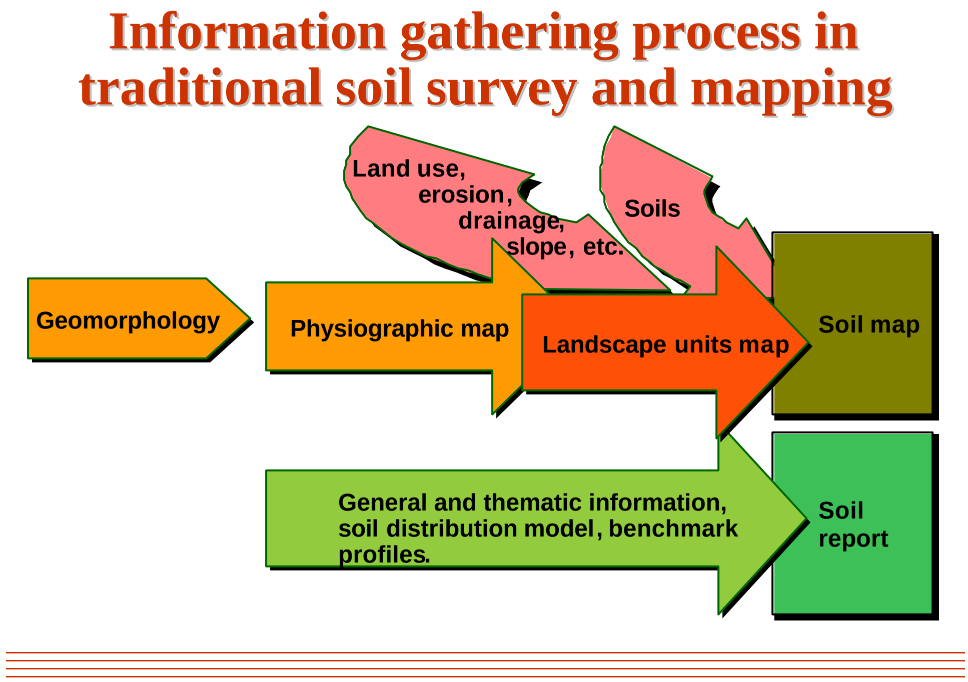

Fig. 2 – Soil Information System architecture and software.

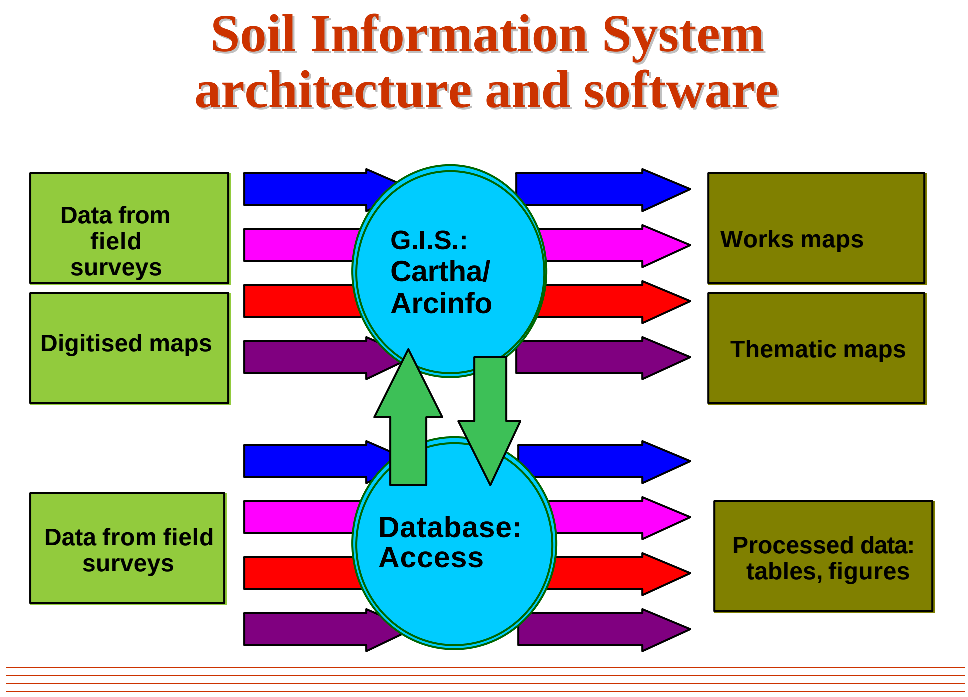

Fig. 3 - Soil map of Italy at 1:250,000 main co-ordinators.

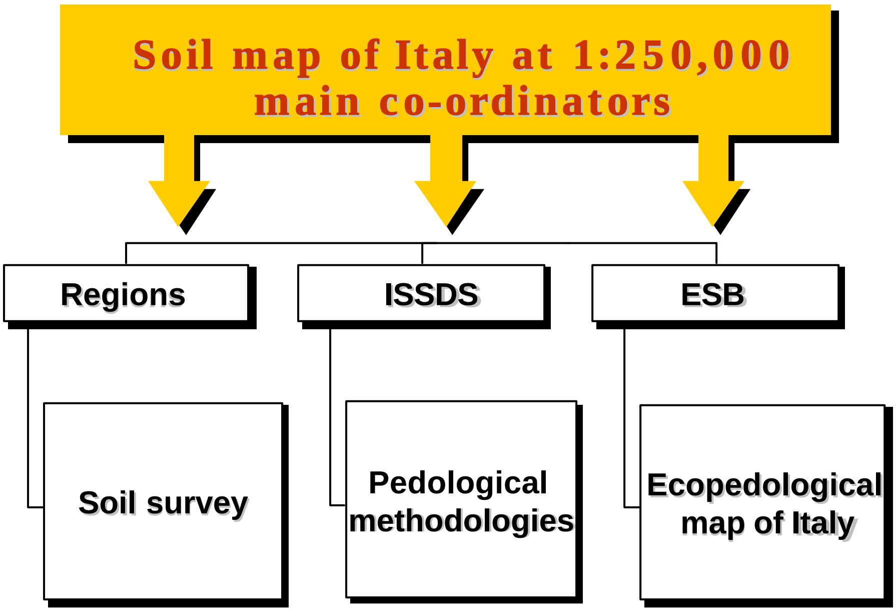

Fig. 4 - Sub-projects structure and co-ordinators.

Sub-project	Sector of activity
1	Definition of the general concepts and glossary; individuation of the Soil Regions, Pedolandscapes and intermediate landscape levels. General co-ordination of the project. *Co-ordinator: Experimental Institute for Soil Study and Conservation.*
2	Standardisation of the soil database attributes; publication of the soil survey manual and field file-card; definition of methods of information broadcasting. *Co-ordinator: Emilia-Romagna Soil Bureau.*
3	Standardisation of methodologies for the gathering and management of geographic data into the GIS; guidelines for the use of aerial photos, satellite and DTM. *Co-ordinator: Experimental Institute for Soil Study and Conservation.*
4	Standardisation of the controls for the data quality check; criteria of contracts definition with the companies. *Co-ordinator:*
5	Methodologies calibration and validation in the pilot area "plains and low hills of northern Italy". *Co-ordinator: Soil Service of the ERSAL (Lombardia Region).*
6	Methodologies calibration and validation in the pilot area “central Italy Regions”. *Co-ordinator: Soil Section of the ARSSA (Abruzzo Region).*
7	Methodologies calibration and validation in the pilot area “southern and insular Italy”. *Co-ordinator: Soil Section of the SeSIRCA (Campania Region).*
8	Realisation of a national co-ordination centre for the soil cartography and regional soil services support. *Co-ordinator: Experimental Institute for Soil Study and Conservation.*