

Progress of Soil Survey in Portugal

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History

Soil survey in Portugal began in the last quarter of the 19th century though it was not until 1939 that systematic soil survey began. In the 1930s some soil and suitability for irrigation maps were published, for example, the soil mapping and classification of 'Campina de Faro (Algarve) and the suitability of the soils for irrigation, made by Luis Bra in 1935.

The Estação Agronómica Nacional (EAN) was established in 1936 and in 1939 one of the tasks of its Department of Soil Science was to make a Soil Map of Portugal at a scale of 1:25,000, using soil series as a mapping unit. The EAN published the soil map of Portugal at a scale of 1:1,000,000 in 1949.

Following this, in 1950, soil survey responsibilities were moved to a new organisation, the Serviço de Reconhecimento e Ordenamento Agrário (SROA), which later came to be named 'Centro Nacional de Reconhecimento e Ordenamento Agrário (CNROA), the National Centre for Soil Survey and Land Planning. CNROA was a government department of the Ministry of Agriculture, Fisheries and Food (MAPA) working under the coordination of the National Institute of Agrarian Research (INIA). It was the state department with responsibility for soil mapping.

CNROA was closed in 1993 at which time some soil science staff transferred to the Soils Division of the Instituto de Hidráulica Engenharia Rural e Ambiente (IHERA). From this time soil survey in Portugal practically stopped apart from that being undertaken by a few private companies.

Soil Mapping

Bessa (1991) and Gonçalves (1996) have provided recent accounts of the progress of soil survey in Portugal. The following sections are an update.

Small scale mapping

The first approximation of the Soil Map of Portugal, at a scale of 1:1,000,000, was published by Estação Agronómica Nacional in 1949 and was presented at the International Congress of Soil Science in Amsterdam, The Netherlands, in 1950. The final version of the map was published in 1973 by SROA as a contribution to the European Soil Map (Cardoso *et al.*, 1973).

A Soil Map at a scale of 1:5,000,000 was published in the 'World Soil Map' in 1990 (Fonseca and Marado, 1990). The map was obtained from a simplification of the 1:1,000,000 scale map with modifications and adjustments to take account of the new FAO legend of 1988.

Large and Medium Scale Mapping

Systematic soil mapping, begun in 1958 by the Serviço de Fomento Agrário, SROA, was carried out at a scale of 1:25,000, with publication at a scale of 1:50,000. The soil mapping unit was the Soil Family. The soil maps were used as a basis for Land Capability Maps, and the aim was that there should be a Land Capability Map alongside each soil map to impress on government the usefulness and importance of the soil mapping programme. The Land Capability Maps alerted government to the fact that in only 28 per cent of the country were there few or no limitations to agricultural use and measures ensued to promote rational soil use.

The mapping of the soils of southern Portugal (south of the Tejo river) was completed in 1965 (Cardoso, 1965). These maps, in total 89 sheets, and the associated Land Capability thematic maps, are now available in colour at 1:50,000 scale for 55 per cent of Portugal. The soil and land capability maps are also available at a scale of 1:25,000 but only in paper or transparency form without legend. This latter series of maps can be reproduced as copies and are now being digitised (Figure 1).

Various problems have delayed the soil mapping of the other areas of the country. Part of the area between the Douro and Tejo rivers has also now been mapped but the data are not yet published and it is difficult for potential users to consult them. During the 1980s the soil map of the 'Trás-os-Montes', north-east of Portugal, was mapped at a scale of 1:100,000 and is available in coloured form but not yet digitised (Agroconsultores – Coba, 1991).

During the 1990s mapping of the 'Entre Douro e Minho' region has also been carried out at a 1:100,000 scale and is available in printed colour and digital forms (GEOMETRAL – Agroconsultores, 1996). In the same area some 350,000 hectares of agricultural soils are also being mapped at a scale of 1: 25,000. The soil mapping of these two regions has been carried out by private enterprises, which, in addition, have mapped 40,000 ha of agricultural soils in various parts of the country at a scale of 1:10,000 scale for irrigation projects.

Soil maps are also available for the islands of Madeira at 1:50,000 scale in printed and digital forms (Pinto Ricardo, 1992) and for Porto Santo at 1:25,000 scale in colour printed form only (Franco, 1994).

In the last year a soil characterisation based on the 1:25,000 soil map has been carried out of an area of 120,000 hectares to select areas to be mapped at 1:10,000 scale for the future Alqueva irrigation perimeter. About 800 soil profiles were described and analyses made of samples from each horizon or layer in more than 100 profiles.

Soil Monitoring

Soil erosion has been monitored on an experimental site in Vale Formoso, Alentejo since 1960 (Mota Ferreira *et al.*, 1984). It is the oldest experimental site in Europe applying the methodology of Wischmeier and colleagues. One of the objectives of the experiment has been to test the application of the Universal Soil Loss Equation

(USLE) (Wischmeier *et al.*, 1958, 1978) to local Portuguese conditions in order to advise on soil conservation measures. There are fifteen plots (20.0 x 8.33 m), with slopes varying from 10 to 20% and orientated from east and south-southwest. The soil studied, a Chromic Luvisol, has been subjected to different crop rotations (vegetation cover) and management practices. Soil loss, runoff, infiltration and, more recently, the loss of nutrients are being investigated.

Soil Database

Data from representative soil profiles have been collected to support soil mapping. Available data include: soil texture (International Classification), organic carbon and organic matter contents, total N, C/N ratios, carbonate content, free iron content, exchangeable cations, cation exchange capacity, clay type, bulk density, water holding capacity, water content at pF 2.0, 2.7 and 4.2, and saturated hydraulic conductivity. The soil hydraulic data were obtained from disturbed soil samples. Only in the most recent soil mapping at scales of 1:10,000, 1:25,000 and 1:100,000 have undisturbed samples been collected. These data are to be found in various reports and scientific papers.

The Soil Science Department of EAN became concerned about the lack of consistent information about soil hydraulic properties and from 1992-1994 established a project whose principal objective was to measure the hydraulic properties of soils using undisturbed soil samples, to develop pedotransfer functions for those properties and to contribute to the establishment of a database of such properties. Some of the information obtained from this project was included in the database of soil hydraulic properties of European soils (HYPRES) (Wosten *et al.*, 1998).

The project demonstrated the value of such a database for Portuguese soils and their use. As a result of the range of climate and lithology the soils of Portugal are diverse and there is a need for sufficient analysis of the different soils to enable their behaviour under a range of uses to be understood. Now, whenever possible, more analyses are undertaken and the database enhanced. About 130 horizons from 50 soil profiles have been analysed for soil hydraulic properties. There are many more data available for soil water retention curves than for hydraulic conductivity but until now only those soil horizons with both soil water retention and hydraulic conductivity data are included in the database (Gonçalves, 1998). Microsoft Access was the chosen software for the soil hydrological database.

The attributes stored in each table closely resemble those in the HYPRES database.

Applications of Soil Maps and Databases

The knowledge of soil properties gained over the years has been vitally important in the development of thematic maps including the following:

1. suitability of soils for irrigation
2. soil nutrient status
3. delimitation of the National Agricultural Reserves (RAN)
4. delimitation of the National Ecological Reserves (REN)
5. soil erosion risk and land resource maps of Portugal for the CORINE programme
6. soil erosion map and land resource maps of Algarve as part of the Transfrontier Algarve-Andalucia Project (CORINE programme)
7. the EU Soil Map at a scale of 1:1,000,000

Soil data have been used to: develop irrigation projects (Baixo Vouga, Mondego valley, Lezíria, Xévoa, Sotavento, Algarvio); undertake surface and ground-water studies and environmental impact studies, for example in the case of the future Alqueva irrigation project; make fertiliser use recommendations; support public works, evaluate changes in land use and problems associated with sewage sludge disposal; support the execution of national and international research projects.

Outlook

There is increasing demand for soil information at all scales to address land use and environmental problems. Soil survey information is increasingly being used for purposes that were originally unforeseen. This has often led to a gap between the information that is available and that which is required.

The completion of the unfinished soil survey projects needs to be given high priority and there needs to be more investment in data collection activities because some of the information is obsolete and because new information is required.

Over the past few years the National Service of Geographic Information (SNIG) has been digitising the CNROA soil maps at a scale of 1:50,000. SNIG has the responsibility for the central database of soils information but only for the geographical (geometrical) component. In order to make the soil geographical information more useful it is important to link it to soil profile analytical data.

It is important to develop a geo-referenced soil database for Portugal which should include the morphological description of soil profiles and the corresponding analytical data, linked to a geographic information system to make available to all users national information about soils to support their better management, protection and use.

Acknowledgements

We should like to thank Dr Carvalho Cardoso for his suggestions.

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