# A CONTRIBUTION ON SARDINIA SOILS: THE NEW ECOPEDOLOGICAL MAP AND CASE STUDIES ON SOIL CONSUMPTION BY STRUCTURES

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## Summary

*The present work, carried out in the frame of the MEDCOASTLAND project, constitutes a contribution to the knowledge of Mediterranean soil resources and of the opportunities for their conservation and valorisation, as well as the related degradation threats The study focuses on Sardinia (Italy) and touches two different but linked aspects the recent developments of the regional soil cartography, based on the new European technical guidelines and the soil consumption due to urbanisation in some areas of the island characterised by different economic development processes*

*The first aspect constitutes an example of recovery and valorisation of existing pedological information in view of systematising the available knowledge and providing support to soil conservation planning.*

*The second refers to soil loss by urbanization, which is one of the most important causes of irreversible land degradation, especially in coastal areas. The authors considered a total area of about 210,000 ha, where soil consumption was estimated both as total areas and as losses of agricultural land capacity. The results show that the relevant soil loss observed is not caused by a rise in resident population, but is driven by the strong tourism and residential development Both the Ecopedological Map and the study on soil consumption have been conducted by the NRD*

## Introduction

The United Nations Convention to Combat Desertification (UNCCD, 1994) has highlighted that Mediterranean soils are increasingly threatened by land degradation and desertification. The demographic trends, particularly on the southern coast, and the fast economic development processes, are driving extensive soil losses, mostly due to urbanisation and to unsustainable agriculture and pastoral practices. Very often the lack of planning is at the origin of the severe environmental impacts of both dynamics mentioned, in particular when urban and tourism development affect soils having great agricultural potential and when land use pattern doesn't respect actual land suitability. A good knowledge of soil resources is thus essential in view of supporting land planning. Unfortunately, as far as the Mediterranean regions are considered, the available knowledge about soil resources is highly heterogeneous both in quantitative (density of observations, scale of maps, etc.) and qualitative terms (degree of harmonisation in relation to international standards, availability of metadata, formats, etc). Furthermore, the relative importance of soil information in local and regional land planning and policymaking processes is generally not very high.

The present work focuses on Sardinia (Italy) and touches two different but linked aspects: regional soil mapping and soil loss due to urbanisation. The first contribution presented deals with the recent developments of the regional soil cartography, based on the new European technical guidelines. This constitutes an example of recovery and valorisation of existing heterogeneous pedological information in view of systematising the available knowledge according to quality standards and providing support to future soil conservation planning and to policy making related to soil resources. The second refers to soil consumption by structures in some areas of the Island characterised by different economic development processes (tourism, industrial, agricultural and urban residential development).

Soil loss by urbanization is one of the most important causes of irreversible land degradation in the Mediterranean countries. During the last decades an increasing importance has been attached to this phenomenon, both because of the demographic explosion experienced by several countries, and because of the increasing demand of new areas for industrial and tourism activities in developed countries (Dinç et al., 2004). The problem has been studied and monitored in many regions, especially in coastal areas, where it takes the form of "littoralisation", which is receiving increasing attention by scientists and policy makers as one of the most impacting and widespread land change dynamics. Some recent studies carried out in the Mediterranean (Auerneheimer, 2001; Evliya et al., 2001; Cocossis, 2001) and in Italy (d'Angelo et al., 2001; Enne et al., 2002; Madrau, 2002; Costa et al., 2001; Mininni et al., 2001; Sommer et al., 1998) can provide a picture of the phenomenon.

The authors considered a total area of about 210,000 ha, where soil consumption was estimated in the years 1954/60 1996/98 both as total areas and as losses of agricultural land capacity. The results show that the relevant soil loss observed is not caused by a rise in resident population, but is mainly driven by the strong tourism and residential development.

## The Ecopedological Map of Sardinia at 1:250,000 scale

The Ecopedological map of Sardinia at 1:250,000 scale (Fig 1) is the most recent synthesis of the current knowledge of the soils of the island. The first pedological studies in the region, aiming to define the main physical and chemical **characteristics** of soils in some zones of high agronomic interest, date back to the end of the nineteenth century and the first decades of the twentieth. The first modern studies were those published by Aru, Baldaccini and Pietracaprina at the beginning of the Sixties. These works were used as basis for the first version of the regional pedological map at 1:250,000 scale (Aru et al., 1967). In the following years, this map was deeply revised and new studies at medium and large scale, among which the fundamental one by Aru et al. (1986), on irrigable land, at 1:100,000 scale, allowed the publication of a new edition (Aru et al. 1992) at 1:250,000 scale.

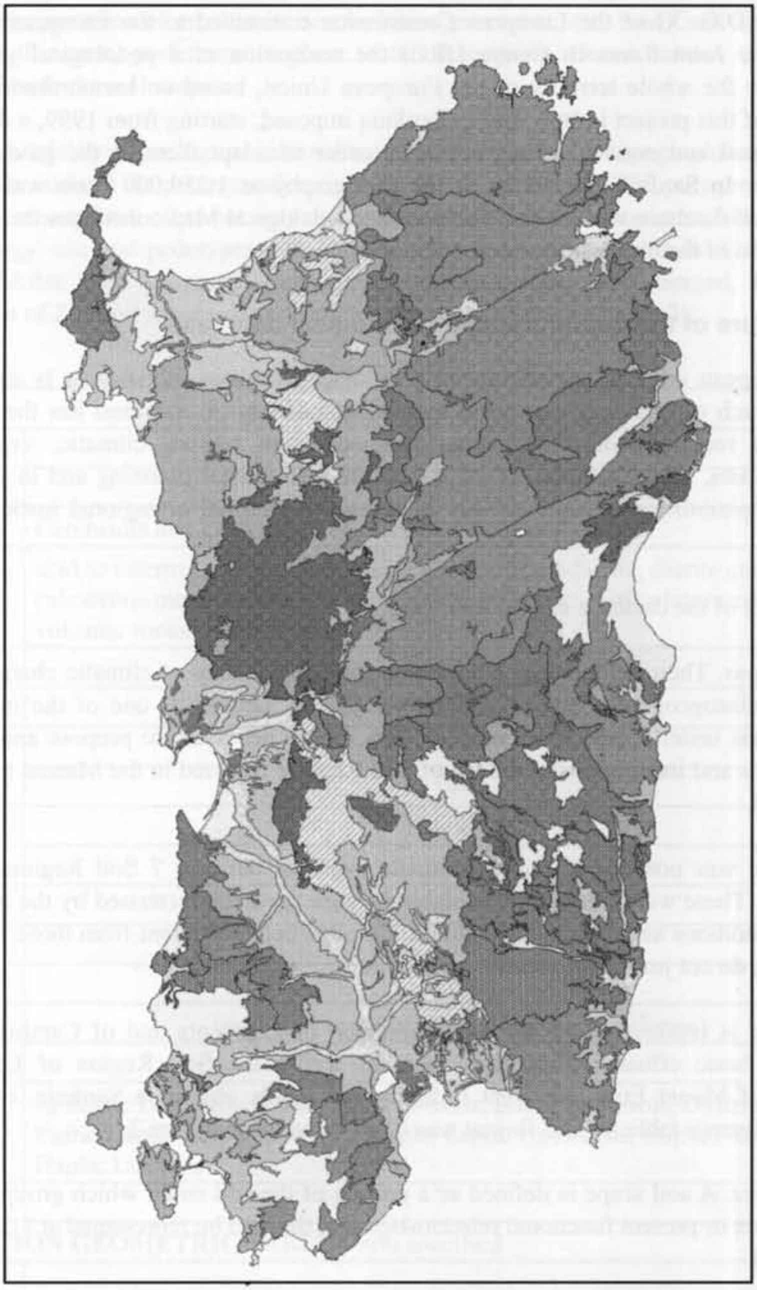

**Figure 1. The Ecopedological Map of Sardinia at 1:250,000 scale**

In 1996 the D.G. XI of the European Commission committed to the European Soil Bureau (ESB) of the Joint Research Centre (JRC) the realization of a pedological georeferenced Database for the whole territory of the European Union, based on harmonised criteria. The realization of this project in Italy and in Sardinia imposed, starting from 1999, a deep revision of the regional and national cartographies in order to adapt them to the guidelines of the Commission. In Sardinia a revision of the cartography at 1:250,000 scale was done and a georeferenced database was set out. The new Ecopedological Map constitutes the cartographic representation of the database.

## The structure of the georeferenced pedological database

As the European one, the georeferenced pedological database of Sardinia is an informatics structure which can manage a relevant number of pedological data and has the objective to provide the required soil parameters, combined with terrain, climatic, vegetation and lithological data, at a resolution which is suitable for regional planning and in a way which ensures compatibility and comparability of dataset of national or regional institutions (ESB, 1998).

The elements of the database are the following:

*i- Soil Regions*. Their delimitation is based on the homogeneity of climatic characteristics, of substrate, palaeogeography and of dominant soils. As Sardinia is one of the most complex Italian regions under a geological point of view, it was necessary to propose and adopt some modifications and integrations to the list of Soil Regions reported in the Manual of procedures (ESB, 1998).

Therefore, it was possible to recognise in the regional territory 7 Soil Regions and 2 Soil subRegions. These were introduced to highlight some areas characterised by the prevalence of substrate conditions and morphology, which, although being different from those typical of the Soil Region, do not justify the creation of new ones.

An example is represented by the Soil subregion of Leptosols and of Cambisols on plio-pleistocene basic effusive formations (basalts) within the Soil Region of Leptosols and Cambisols of Mount Etna, prevalent in Sicily, but totally absent in Sardinia. For each Soil Region a reference table in XLS format was filled in, as for in Figure 2.

*ii- Soil scapes*. A soil scape is defined as a portion of the soil cover which groups soil bodies having former or present functional relationships and that can be represented at 1:250,000 scale (ESB, 1998).

The main diagnostic criteria to delimit the soil scapes are the morphological attributes: altitude, slope angle, slope length, curvature, landscape dissection, etc. To define all pedogenetical aspects within a soil scape, for example transport of materials in solution or in suspension along a slope, presence of erosion or accumulation processes, etc, many soil bodies may be required. In this case, preference is given to the description of soil catenas if they can be recognised inside the soil scape.

The wide availability of geological information at large scale and of topographic cartography at medium scale allowed the determination, in the regional territory, of 736 polygons/sites, which are different among each other not only due to their geological characteristics, but also in terms of morphology, use and pedotypes. For each polygon a descriptive table in XLS format was drawn up. After that, polygons with similar characteristics were merged, allowing the individuation of 285 soil scapes, also described with an XLS table (figure 3).

| **SOIL REGION TABLE** | |
|---|---|
| **Soil region** | 59.2 |
| **code** | 59.11.43 |
| **sr_nome** | Cambisols and Leptosols Regions of Sardinia and Corsica |
| **sr_pmas** | acid to intermediate plutonic rocks: granite, granodiorite, diorite and non calcareous metamorphics rocks: phyllite, quartzite; acid to intermediate volcanic rocks: rhyolite, andesite |
| **sr_matlo** | 10,6 |
| **sr_mathi** | 19,6 |
| **sr_maplo** | 390 |
| **sr_maphi** | 1495 |
| **sr_hipre** | Nov - Feb |
| **sr_droug** | Jun - Sept |
| **sr_lowt** | ------- |
| **sr_altmin** | 0 |
| **sr_althi** | 1792 |
| **sr_mlf** | level land to steep land (composite landforms) |
| | |
| **Soils** | Epileptic Leptosols, Endoleptic Leptosols, Eutric Leptosols, Dystric Leptosols, Eutric Cambisols, Dystric Cambisols, Leptic Umbrisols, Eutric Fluvisols, Haplic Luvisols |
| | |
| **SOIL REGION GEOMETRIC TABLE** - non specified | |
| | |
| | Soil Region area: 6.534,905 Kmq |

**Figure 2. Example of Soil Region table**

| **General** | | **Physiography** | | **Landcover** | | **Parent material** | |
|---|---|---|---|---|---|---|---|
| soilscape Key | 59.2SS16 | ss_mlf | SH | ss_lu | 323 | ss_surmat | 312 |
| ss_aut | UNISS | ss_resl | R0 | ss_lu2 | | ss_surmatst | |
| ss_ymap | 1999 | ss_hyps | 6 | ss_veg | ------ | ss_submat | 312 |
| ss_date | 02/02/2000 | ss-ddis | 2 | | | ss_dmat | 0 |
| ss_qual | 3 | ss_pws | 0 | | | ss_submatst | ----- |
| ss_doms | le dy CM | ss_altlo | 0 | | | | |
| ss_doms2 | dy LP | ss_althi | 250 | | | | |
| ss_doms3 | li LP | ss_slint | 110 | | | | |
| soil region (key) | 59.02.00 | ss_sllen | 1000 | | | | |
| | | ss_ssfr | I | | | | |
| | | ss_wetn | ----- | | | | |
| Geometric features | | | | geographical reference | | | |
| area (Kmq) | 42,47 | | | | | | |
| perimeter (Km) | ------ | | | | | | |
| soil scape ID (arc-info) | 25 | | | | | | |
| soil scape ID utente | 59.2SS16 | | | | | | |
| soil scape (key) | 59.2SS16 | | | | | | |

**Figure 3. Example of soil scape table**

Polygons and soil scapes were given an alphanumeric code, constituted by the Soil region code and by a progressive number. The individuation and description of soil scapes underlined the necessity of keeping the lists of parent materials proposed by ESB open, in order to include the greatest possible number of litotypes which characterise the European territory.

*iii- Soil body.* The third element of the database is the soil body, described in the Manual of procedures *as an artificial but recognizable three-dimensional entity in a soil continuum*, (ESB, 1998). Every soil *body is composed of a number of soil horizons and or layers, which may vary in thickness and properties within a soil body as long as this does not violate the definition of the soil body* (ESB, 1998). The diagnostic criteria proposed by ESB for the definition of soil bodies coincide with diagnostic horizons of FAO-WRB. These criteria are further integrated by the description of parental materials, texture, the limit of root penetrability, etc.

The univocal identification of soil bodies within every Soil Region is allowed by an alphanumeric code. For each soil body an XLS table was created according to the Manual of procedures. The table is divided in two sections. The first one concerns the station, the second one the horizons in the soil body. During the first phase of the work it was decided to input in the DB only the profiles whose description and analytical data were more complete, in order to reduce to a minimum the fields filled with data obtained by "expert estimates" and not by direct measurements. In this way more than 200 profiles were selected. Starting from these profiles and by eliminating the most similar situations in terms of station or chemical-physical characteristics, 133 soil bodies were proposed. These were considered as the first group of reference for the database of Sardinia. At present about 400 profiles are available for the region.

## Case studies on soil consumption by structures in Sardinia

Sardinia has always been characterised by a scarce density of population and by a mainly agricultural economy (cereal growing and livestock). From the end of the Fifties, the island underwent several deep transformations. The development of industrial sectors and of services encouraged the abandonment of marginal areas, favouring processes of internal migration towards main tourist and industrial centres and major towns. Internal migration and tourist development caused a relevant increase in soil consumption due to urbanization which cannot be justified by the natural growing of the population only, but is related to specific processes, particularly to the building of secondary houses. This soil consumption is widely documented by topographic cartography, which was produced after the first one realized by IGM between the Fifties and the Sixties.

In the present work, soil consumption from 1954/60 to 1996/98 was quantified for 18 Sardinian municipalities (Figure 4), on a total surface of about 210,000 ha (around 9% of the total regional area). The areas considered are characterised by different development dynamics: tourism, industrial, agricultural and urban residential development.

## Materials and methods

To calculate soil consumption two series of topographic maps were compared (Figure 5). The initial datum is represented by the 1:25,000 IGM (Military Italian Institute of Geography) Map, referring to the years 1954 - 1960, period in which the Institute updated its maps (based on surveys of 1895 and 1940) based on aerial photographs. The final datum is represented by the Regional Technical Chart (CTR) at 1:10,000 scale realised by the Region on the basis of aerial photographs taken in the years 1996 - 98.

Different types of soil sealing structures were distinguished; settlements, urban and industrial areas, services (airports, equipped tourist areas, etc.), roads and railways networks and recorded according to the following classification and calculation methodology:

**a- continuous settlements** (urban areas, scattered settlements, industrial areas, airports, military areas, other uses) were considered as polygons and their perimeter was recorded;

**b- isolated rural and industrial buildings**, where possible, were recorded as described above. If too small, or marked on the maps as small a-dimensional rectangules, such as scattered houses, they were considered as measuring 300 $m^2$ each as an average, including the main building and the possible accessory structures (parking areas, warehouses, etc.) not reported by the maps;

**c-roads and railways** area has been considered according to categories, to which the following standard widths have been attributed:

| | |
|---|---|
| - ***roads:*** | |
| - highways | 20.0 m |
| - two lanes roads | 9.5 m |
| - single lane roads | 4.5 m |
| - loose surface roads | 3.5 m |
| ***railways:*** | |
| - state railroads (single track, normal gauge) | 10.0 m |
| - regional railroads (single track, narrow gauge) | 9.5 m |

**Figure 4. Soil consumption by structures was quantified for 18 Sardinian municipalities**

Soil consumption in terms of quality loss was estimated by classifying the soils lost according to the Land Capability classes (Klingebiel and Montgomery, 1961).

In the study area the variability of some land features, such as soil depth, rock outcrops, vegetation cover etc., is very high. Because of this complexity, and considering the relatively low level of detail of the available pedological cartography, it was difficult to assign some soil units to a specific class of Land Capability. Some complex land capability classes were thus created, by considering both the maximum and the minimum land capability class to which a soil unit could be assigned. As an example, the class IV-VI include soils whose capability can vary between class IV and class VI.

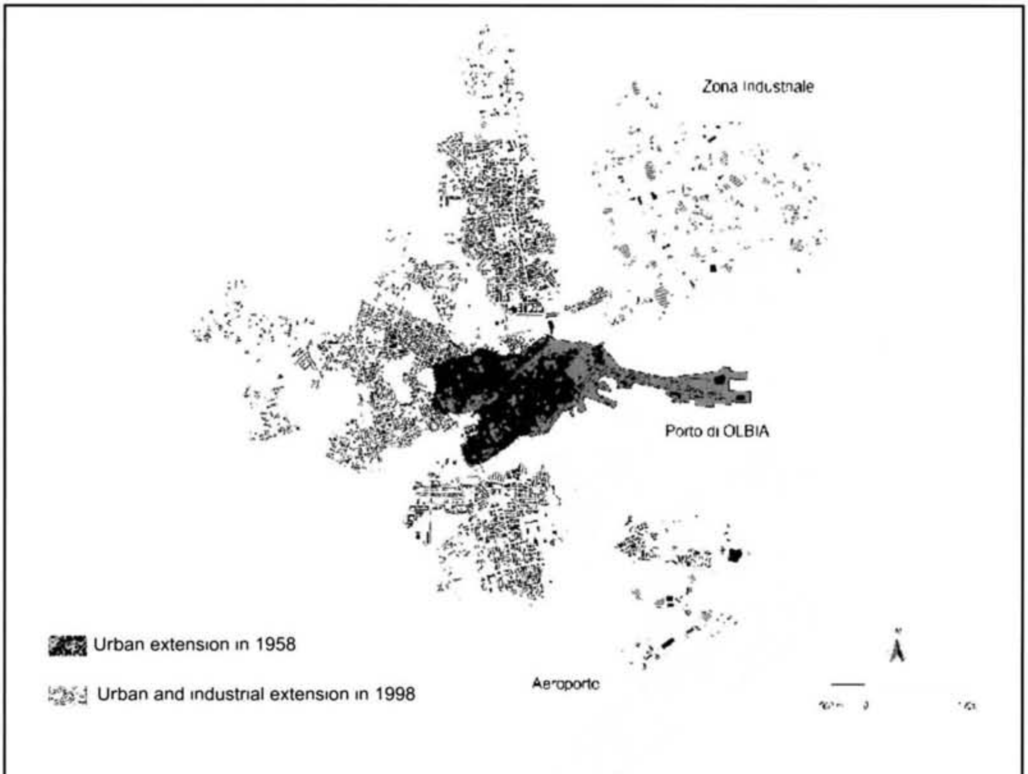


**Figure 5. Olbia municipality. Soil consumption in 1954/60 (highlighted in gray) and in 1996/98**

## Results

The results are shown in table 1 to 4. Tables 1 and 2 show the detailed data on soil consumption in 1954/60 and in 1996/98, by municipality and by structure type. The municipalities are grouped according to the prevailing socio-economic dynamic (tourism, industrial, agricultural and urban residential development). The strong increase related to the main towns (Cagliari, Sassari, Oristano) and the related residential areas (Elmas, Monserrato, Quartucciu, included in Cagliari's metropolitan area) is evident. This is in part the direct result of internal migration and population increase. In particular, for Cagliari and its suburban areas the expansion of the continuous urban tissue is dominant, followed by industrial, services and communication network areas. Oristano shows a quite similar trend, while in Sassari, second town of Sardinia, the isolated residential buildings dominate the dynamic.

This is due to a trend toward the construction of villas in the countryside, which is eroding the traditional olive plantations of the hills surrounding the town. Another component of interest to interpret Sassari's and Oristano's dynamics is given by table 4, which reports about 19-20% of not occupied houses. These are typically secondary houses built on the seaside. The latter trend is particularly characterising, as a sort of fingerprint, the mainly tourist areas (Alghero, Arzachena, Golfo Aranci, La Maddalena, Loiri - Porto San Paolo, Palau, Olbia, Stintino), where the percentage of not occupied houses can even reach 88 (Stintino). In these areas, several new settlements ("tourist villages", but also new small towns) were created, which are recorded as secondary small urban areas.

Porto Torres is an example of prevalent industrial development, where past national investment policies favoured the creation of a large continuous industrial concentration and of the industrial port. Finally, the three rural municipalities considered (Marrubiu, Terralba, Uras) present a prevailing trend toward the expansion of the areas of the main village or urban settlement.

Table 3 describes soil consumption in terms of quality loss, by making reference to Land Capability classes. It can be observed that the main towns and their suburban residential areas are responsible for the heavy consumption of first and second class soils (by considering classes I, II, I-II), summing up to thousands of hectares.

This is particularly relevant for Cagliari's city and metropolitan area. Also in the three rural municipalities the loss of potentially very productive soils is relevant (18 to 30%). As far as third and fourth class are considered (classes III, II-III, II-IV, III-IV, IV), soil loss is particularly significant around Oristano, Sassari, Alghero, Olbia and also, in general in the rural municipalities. The lower capability classes, and particularly the eighth, with some exceptions, present a very high consumption in the mainly tourist areas, especially on the north-eastern coast of Sardinia, the so-called "Costa Smeralda". Here, wide extension of Mediterranean maquis and other ecosystems were lost or deeply transformed to leave space to the new tourist villages.

**Table 1. Soil consumption in 1954/60, by municipality and by structure type**

| 1954- 60 | Buildings and services areas | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Urban continuous | Secondary small urban areas | isolated residential buildings | Rural and industrial buildings | Continuous industrial areas | Other uses, services (camping, sport, etc ) | Military areas and airports | Total buildings and services | Total roads and railways networks | TOTAL URBAN | Municipality surface | TOTAL CONSUMPTION (% of municipality surface) |
| **Main Sardinian towns** | | | | | | | | | | | | |
| Cagliari | 851.25 | 139 53 | 22 83 | 2 47 | | | | 1,016 08 | 102 32 | 1,118 40 | 8,398 | 13 32 |
| Sassari | 322 60 | 50.70 | 369 30 | | | | | 742.60 | 290 48 | 1,033.08 | 55,358 | 1 87 |
| Oristano | 274 40 | 70.39 | | 18 09 | 1 50 | | | 364.38 | 161 49 | 525 87 | 8,643 | 6 08 |
| **Mainly tourist areas** | | | | | | | | | | | | |
| Alghero | 109.00 | 40 86 | 47 63 | | | 2 70 | 332 00 | 532 19 | 219 59 | 751.78 | 22,440 | 3 35 |
| Arzachena | 18.60 | 11.72 | 22 22 | | | | | 52 54 | 228 16 | 280.70 | 22,681 | 1 24 |
| Golfo Aranci[1] | 15 72 | | 1 44 | | | | | 17.16 | 29 91 | 47 07 | 3,797 | 1.24 |
| La Maddalena[2] | 70 06 | 2.05 | 9.03 | | | | | 81 14 | 36 94 | 118.08 | 3,697 | 3 19 |
| Loiri - Porto San Paolo[3] | 0 66 | 2.10 | 6 75 | | | 0 15 | | 9 66 | 48.95 | 58 61 | 11,775 | 0.50 |
| Palau | 137.50 | 10 00 | 32 16 | | | | 50 00 | 229.66 | 315.12 | 544 78 | 37,610 | 1 45 |
| Olbia | 17.09 | | 2 52 | | | | 7.05 | 26.66 | 31 10 | 57 76 | 4,438 | 1 30 |
| Stintino[4] | 8 20 | 1 60 | 14 15 | | | 0 70 | | 24 65 | 22 23 | 46 88 | 5,282 | 0 89 |
| **Mainly industrial areas** | | | | | | | | | | | | |
| Porto Torres | 60 33 | | 1 89 | | | | | 62 22 | 214.48 | 276 70 | 5,167 | 5 36 |
| **Mainly agriculture areas** | | | | | | | | | | | | |
| Marrubiu | 63 72 | 22 60 | 4.56 | 0.15 | 2.02 | | | 93.05 | 95 93 | 188.98 | 6,134 | 3 08 |
| Terralba | 131 30 | 9 92 | 2 13 | 0.12 | 4 59 | | | 148.06 | 67 91 | 215.97 | 5,186 | 4 16 |
| Uras | 60.06 | | 2 07 | 0 18 | | | | 62 31 | 64 14 | 126 45 | 3,936 | 3.21 |
| **Mainly residential areas** | | | | | | | | | | | | |
| Elmas[5] | 22 43 | | 4.32 | | | | | 26.75 | 34 26 | 61 01 | 1,326 | 4.60 |
| Monserrato[5] | 95 22 | 3.70 | 0 90 | | | | | 99 82 | 20 83 | 120 65 | 652 | 18 50 |
| Quartucciu | 43 35 | 2 26 | 7 65 | 3 10 | | | | 56 36 | 48 10 | 104 46 | 2,791 | 3 74 |

[1]Included in Olbia in 1954; [2]just the two main islands of the archipelago; [3]Included in Tempio Pausania in 1954; [4]Included in Sassari in 1954; [5]Included in Cagliari in 1954

**Table 2. Soil consumption in 1996/98, by municipality and by structure type**

| 1996 - 98 | Buildings and services areas | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Urban continuous | Secondary small urban areas | isolated residential buildings | Rural and industrial buildings | Continuous industrial areas | Other uses, services (camping, sport, etc ) | Military areas and airports | Total buildings and services | Total roads and railways networks | TOTAL URBAN | Municipality surface | TOTAL CONSUMPTION (% of municipality surface) | Total ha consumed after 1960 |
| **Main Sardinian towns** | | | | | | | | | | | | | |
| Cagliari | 1,726 85 | 57 21 | 19 53 | 10 15 | 322 36 | 578 18 | 39 40 | 2,753 68 | 60 25 | 2,813 93 | 8,398 | 33 51 | 2,088 52 |
| Sassari | 1,007 85 | 265 75 | 1,902 11 | 47 65 | | 162 04 | | 3,385 40 | 729 01 | 4,114 41 | 55,358 | 7 43 | 3,791 82 |
| Oristano | 444 30 | 120 47 | 45 78 | 6 25 | 80 82 | | | 697 62 | 260 57 | 958 19 | 8,643 | 11 09 | 477 31 |
| **Mainly tourist areas** | | | | | | | | | | | | | |
| Alghero | 360 88 | 80 51 | 227 78 | | 96 15 | 112 66 | 489 75 | 1,367 73 | 364 42 | 1,732 15 | 22,440 | 7 72 | 1,796 04 |
| Arzachena | 97 56 | 811 90 | 89 13 | 17 54 | | | | 1,016 13 | 323 07 | 1,339 20 | 22,681 | 5 90 | 1,058 50 |
| Golfo Aranci | 77 20 | 53 72 | 4 92 | 4 75 | | | | 140 59 | 44 65 | 185 24 | 3,797 | 4 88 | 138 17 |
| La Maddalena[1] | 315 90 | 69 71 | 21 45 | | | | | 407 06 | 70 05 | 477 11 | 3,697 | 12 91 | 359 02 |
| Loiri - Porto San Paolo | 20 21 | 114 29 | 25 27 | | | 6 85 | | 166 62 | 89 59 | 256 21 | 11,775 | 2 18 | 196 63 |
| Palau | 67 63 | 155 41 | 11 53 | 13 99 | | 26 76 | | 275 32 | 43 20 | 318 52 | 4,438 | 7 18 | 248 96 |
| Olbia | 851 70 | 514 60 | 195 30 | 301 10 | | | 192 40 | 2,055 10 | 581 16 | 2,636 26 | 37,610 | 7 01 | 2,091 49 |
| Stintino | 18 65 | 240 56 | | 20 26 | | 1 90 | | 281 37 | 56 45 | 337 82 | 5,282 | 6 40 | 337 82 |
| **Mainly industrial areas** | | | | | | | | | | | | | |
| Porto Torres | 273 88 | 32 41 | 15 15 | 0 53 | 1,171 95 | | | 1,493 92 | 275 44 | 1,769 36 | 5,167 | 34 24 | 1492,66 |
| **Mainly agriculture areas** | | | | | | | | | | | | | |
| Marrubiu | 107 47 | 16 87 | 9 84 | 83 42 | 69 89 | 72 93 | | 360 42 | 118 07 | 478 49 | 6,134 | 7 80 | 289 69 |
| Terralba | 187 40 | 34 16 | 13 71 | 34 42 | 51 43 | 60 27 | | 381 39 | 60 41 | 441 80 | 5,186 | 8 52 | 226 27 |
| Uras | 82 21 | 5 73 | 6 90 | 32 52 | 9 69 | 18 45 | | 155 50 | 72 69 | 228 19 | 3,936 | 5 80 | 95 1 |
| **Mainly residential areas** | | | | | | | | | | | | | |
| Elmas | 77 86 | 9 25 | 12 84 | 12 76 | 204 06 | 56 33 | 264 64 | 637 74 | 27 53 | 665 27 | 1,326 | 50 17 | 660 55 |
| Monserrato | 210 64 | 11 31 | 6 12 | 6 80 | 34 68 | 27 48 | | 297 03 | 18 89 | 315 92 | 652 | 48 45 | 202 73 |
| Quartucciu | 89 37 | 45 27 | 31 74 | 12 20 | 44 78 | 33 34 | | 256 70 | 63 80 | 320 50 | 2,791 | 11 48 | 206 01 |

[1] just the two main islands of the archipelago

**Table 3. Soil loss by land capability class (as percentage of the total urbanised after 1960)**

| LAND CAPABILITY CLASS | I | I - II | II | II - III | II IV | III | III - IV | III - VI | IV | IV - VI | VI | VI - VIII | IV - VII | VIII | *Total (Ha)* |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | | | | | | |
| *Main Sardinian towns* | | | | | | | | | | | | | | | |
| Cagliari | 0 24 | 0,00 | 55 83 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 4,35 | 0,00 | 0,00 | 0,00 | 0,00 | 39,57 | ***2,088.52*** |
| Sassari | 19 73 | 0 22 | 14 42 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 19,73 | 38,67 | 0,00 | 0,00 | 5,47 | 1,76 | ***3,791.82*** |
| Oristano | 26 77 | 0,00 | 4 78 | 0,00 | 0,00 | 57.20 | 0,00 | 0,00 | 0,01 | 0,00 | 9,44 | 0,00 | 0,00 | 1,80 | ***477.31*** |
| *Mainly tourist areas* | | | | | | | | | | | | | | | |
| Alghero | 0,00 | 0 47 | 0.53 | 28 14 | 56.14 | 0,00 | 0 31 | 0,00 | 0,05 | 0,99 | 0,00 | 13,25 | 0,00 | 0,13 | ***1,796.04*** |
| Arzachena | 0,00 | 0,00 | 0 22 | 0,00 | 1 87 | 0,00 | 0,00 | 4,92 | 0,00 | 39,21 | 0,00 | 0,00 | 0,00 | 53,78 | ***1,058.50*** |
| Golfo Aranci | 0,00 | 0,00 | 0,00 | 0,00 | 1 38 | 0,00 | 0,00 | 0,42 | 0,00 | 8,21 | 0,00 | 0,00 | 0,00 | 89,99 | ***138.17*** |
| La Maddalena[1] | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 4,14 | 0,00 | 0,00 | 0,00 | 95,86 | ***359.02*** |
| Loiri - Porto San Paolo | 0,00 | 0,00 | 1.29 | 0,00 | 7 47 | 0,00 | 0 05 | 25,19 | 0,00 | 49,40 | 0,00 | 0,00 | 0,00 | 16,60 | ***196.63*** |
| Palau | 0,00 | 0,00 | 1 02 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 36,24 | 0,00 | 0,00 | 0,00 | 62,75 | ***248.96*** |
| Olbia | 0,00 | 0,00 | 2 84 | 0,00 | 24 38 | 0,00 | 0 38 | 8,38 | 0,00 | 45,26 | 0,00 | 0,00 | 0,00 | 18,75 | ***2,091.49*** |
| Stintino | 2.22 | 0,00 | 8.13 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 89,51 | 0,13 | ***337.82*** |
| *Mainly agriculture areas* | | | | | | | | | | | | | | | |
| Marrubiu | 0,00 | 6 55 | 11 26 | 0,00 | 0 02 | 0,00 | 73 71 | 0,00 | 0,00 | 0,00 | 0,00 | 8,11 | 0,00 | 0,35 | ***289.69*** |
| Terralba | 0,00 | 24 66 | 5 48 | 0,00 | 50 47 | 0,00 | 9 80 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 9,59 | ***226.27*** |
| Uras | 0,00 | 17 85 | 1 32 | 0,00 | 0,00 | 0,00 | 51 49 | 0,00 | 0,00 | 27,97 | 0,00 | 1,36 | 0,00 | 0,00 | ***95.10*** |
| *Mainly residential areas* | | | | | | | | | | | | | | | |
| Elmas | 13.97 | 0,00 | 54 27 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,04 | 0,00 | 0,00 | 0,00 | 0,00 | 31,73 | ***660.55*** |
| Monserrato | 0,00 | 0,00 | 99.29 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,71 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | ***202.73*** |
| Quartucciu | 2.85 | 0,00 | 89 29 | 0,00 | 0,00 | 2 65 | 0,00 | 0,00 | 3,04 | 0,00 | 0,00 | 0,00 | 0,00 | 2,17 | ***206.01*** |

[1]just the two main islands of the archipelago

**Table 4. Data referring to population and houses (from 2001 census)**

| *CENSUS DATA 2001* | Population | Total houses | % not occupied |
|---|---|---|---|
| *Main Sardinian towns* | | | |
| Cagliari | 164,249 | 70,446 | 11.6 |
| Sassari | 120,729 | 49,915 | 19.2 |
| Oristano | 31,169 | 13,902 | 19.7 |
| *Mainly tourist areas* | | | |
| Alghero | 38,404 | 23,046 | 36.0 |
| Arzachena | 10,730 | 11,798 | 68.8 |
| Golfo Aranci | 1,961 | 4,270 | 83.5 |
| La Maddalena[1] | 11,369 | 7,788 | 42.7 |
| Loiri - Porto San Paolo | 2,214 | 3,091 | 73.7 |
| Palau | 3,468 | 5,592 | 70.7 |
| Olbia | 45,366 | 24,865 | 41.4 |
| Stintino | 1,127 | 3,862 | 87.9 |
| *Mainly industrial areas* | | | |
| Porto Torres | 21,064 | 7,796 | 10.3 |
| *Mainly agriculture areas* | | | |
| Marrubiu | 4,962 | 2,405 | 30.9 |
| Terralba | 10,229 | 3,753 | 8.0 |
| Uras | 3,106 | 1,337 | 17.1 |
| *Mainly residential areas* | | | |
| Elmas | 7,930 | 2,871 | 5.6 |
| Monserrato | 20,829 | 7,591 | 6.2 |
| Quartucciu | 10,766 | 4,109 | 12.5 |

## Conclusions

The present work is a contribution to the knowledge of Mediterranean soil resources, of the opportunities for their conservation and valorisation, and of the related degradation threats. The first part of the article illustrates synthetically the pedological georeferenced database of Sardinia, as realised according to the technical guidelines provided by the EC. The database and its cartography constitute a valuable knowledge base already. In fact, the DB could be a tool for the implementation of the directives of the new Common Agricultural Policies of the European Union, and for managing degradation and desertification processes which affect Sardinia, by means of an improved land planning. But the work done so far should also be considered as the initial phase of a more complex effort aiming at promoting:

- The conservation of all the existing pedological data, such as profiles, analysis, observations, etc, stored in the two Universities of the Island (Sassari and Cagliari) and in the Public Institutions of the Region of Sardinia. It can be estimated that the potentially available data include about 2.500 pedological profiles, half of which completed with analysis data. Unfortunately, most of them are available in hard copy only and not always geo-referenced.

- The accessibility of the database and the cartography to the widest public, possibly by on-line publication. At present this objective is hindered by the scarce availability of financial and human resources to locate, collect, digitise data.

At regional level this obstacle could be overcome through the reorganisation, now in progress, of the extension services and through the reduction of the institutional constraints, which still reduce the real availability of data.

Concerning the study on soil consumption, the data presented show that a relevant soil loss related to urbanization has been reported in the study area and that this, particularly along the coast, is mainly due to tourism development and in particular to the widespread building of secondary houses. The observed dynamics are in line with similar coastal regions of the Mediterranean basin. It is worth highlighting that the main typology of settlements in the coastal area is constituted by isolated residential complexes and scattered houses. The sparse settlements prevailing in these areas are among the most "expensive" typologies of settlements in terms of economic costs, environmental impact, natural resources consumption and waste management. In fact the ecosystems have been deeply fragmented and loosed their naturality at a great extent. From a pedological point of view and in particular in terms of agricultural quality of the soil lost, the consumption recorded is moderately impacting, but the same thing can not be said from the environmental point of view. In fact, along the coast, most of the affected areas included in class VIII are among those with greater natural and landscape value of Sardinia.

In this context, adopting less impacting strategies and valorizing multifunctionality concepts should carefully plan further tourism and urban development. In particular, approaches based on Land Capability evaluation should effectively support the development and planning decisions affecting the rural-urban interface.

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