SOIL CONSUMPTION BY URBANISATION: A CASE STUDY IN NORTHERN SARDINIA (ITALY)

M. d'Angelo, G. Enne, S. Madrau, C. Zucca,
Interdepartmental Centre –Research team on Desertification,
University of Sassari, Italy.

Introduction

Desertification as "…land degradation in arid, semi-arid and dry sub-humid areas resulting from various factors, including climatic variations and human activities" (UNCED, 1992) represents a major environmental issue for all the Mediterranean basin.

The Convention to Combat Desertification (UNEP, 1994) recognises a land degradation issue in the European Mediterranean countries arising from the abandonment of marginal areas and the concentration of economic activity in coastal areas (urban growth, tourism, irrigated agriculture) interesting wide areas of Spain, Portugal, Southern Italy, Greece (Brandt and Thornes, 1998; Mairota et al., 1998; van der Leeuw, 1998).

Urbanisation is considered a desertification cause when its effects are taken into account: the irreversible loss of productive soil suitable for agricultural crops, the loss of fragile ecosystems, the overexploitation of water resources, and more in general the alteration of hydrological equilibria (Aru, 1997). These environmental problems are particularly severe in Sardinia, a region were the lack of land planning has caused severe land degradation phenomena (Aru, 1999). Studies carried out in the main urban areas of Sardinia showed high soil consumption in the areas suitable for agricultural use (Aru *et al.*, 1983; Madrau, 1993).

The aim of this short communication is to present a case study of competition between urbanisation, environment and agriculture for the Alghero municipality, a coastal Mediterranean area where a high urban growth has taken place during the last 50 years.

Materials and methods

The study area

The study area is located in north-western Sardinia (Italy) over an area of about 22,400 ha (fig.1). The climate is typically Mediterranean dry sub-humid, with a mean annual temperature of about 17.1°C and mean annual precipitation ranging from 591 to 688 mm.

Fig.1. Location of the study area

From a morphological point of view, the area is characterised by a series of terraces of various ages, ranging from the Mio-Pliocene to the Holocene, which origin is related to the deposition activity of two main watercourses. This plain is surrounded on the west side by the calcareous relieves of Capo Caccia – Punta Cristallo, and from the east to the south-eastern sides by a series of effusive hills of the Sardinian Miocene.

The geology of the area is heterogeneous; the oldest formations are represented by the Permian-Triassic sandstones, while the western relieves belong to the Jurassic-Cretaceous period and the eastern ones to the Miocene effusive flows. The oldest terraces of the plain refer to the late-Miocene epoch. The intermediate relieves and the great fossil sandstone dunes, which surround the built-up area from the Calik pond to the Om Mort channel, belong to the Pleistocene. With reference to land use, agricultural areas including the forested ones (maquis and artificial forest stands) amount to 19,313 ha (83% total area), being 50% of it represented by arable lands and permanent crops (De Meo *et al.*, 1991).

The methodology for soil consumption assessment

The material used in the present work are summarised in Table 1. The *Carta Tecnica dell'Italia Meridionale* (Technical Map of Southern Italy) at 1:10,000 scale was used as reference topographic map, while thematic information on urban growth were acquired by using aerial photographs taken in 1956, 1977 and 1997.

Tab.1. Materials utilised

Aerial photographs	*Topographic Maps*
IGM (1956) b/w scale 1:33,000	Carta Tecnica Italia Meridionale 1:10,000
RAS (1977) color scale 1:10,000	
IGM (1997) b/w scale 1:33,000	

In order to delimit the continuous urban area and the industrial one, a buffer zone of about 10-15 m around the marginal buildings was considered. The scattered urban area (scattered settlements in the countryside) was quantified by counting the buildings and assuming for each of them, after field survey, an average area of pertinence of 300 m^2.

The road network was classified into main and local systems, defining for each typology a fixed buffer. Similar criteria were used for the rail network.

In order to obtain qualitative information on soil losses, the multitemporal maps of artificial area were overlaid to a land capability map produced for the study area (Madrau and d'Angelo, 1999) according to the USDA scheme (Klingebiel and Montgomery, 1961). With reference to the land capability map, most of the map units were not assigned to a single capability class, but to a range of classes due to their heterogeneity thus allowing to take into account the variability of some pedological characteristics (soil depth, superficial rockiness, slope, etc.), which define land capability.

Results

Soil consumption; the quantitative assessment

Soil losses due to urbanisation in the period 1956-1997 amounted to 1,796 ha, corresponding to 8.1% of the area suitable for building of the municipality (tab.2). The highest increase occurred from 1956 (752 ha) to 1977 (1,368 ha).

The population growth recorded during the period considered (tab.3) can not completely explain the urban growth being related to the expansion of tourism and the related building of secondary homes utilised only during summer.

In 1997, the surface occupied by the various residential typologies in the area amounted to 777 ha, corresponding to 43.3% of the total building area of the municipality (table 3), out of which 441 ha are represented by continuous urbanised areas (57.1%) and 228 ha (29.3%) by scattered settlements in the countryside.

The growth of the continuous urban area was relatively constant; a different trend was observed for the scattered settlements in the countryside showing a light increase in the first 21 years (48 ha) and a gradual increase (132 ha) in the subsequent 20 years, mainly in the southern and eastern part of the municipality interested permanent crops (olive groves) and arable lands.

Tab. 2. Dynamics of artificial areas (ha) for the Alghero municipality (1956-1997)

	a. Urbanised areas			
Year	*Continuous*	*Discontinuous*	*Tourist areas*	*Total*
1956	149.9	47.6	-	197.5
1977	315.5	95.7	65.1	476.2
1997	441.4	227.8	108.0	777.2

	b. Road and rail networks			
Year	*Main roads*	*Local roads*	*Railways*	*Total*
1956	78.4	134.7	6.5	219.6
1977	97.4	199.4	6.5	303.3
1997	100.2	257.7	6.5	364.4

	c. Other artificial areas			
Year	*Industrial areas*	*Banned areas*	*Other*	*Total*
1956	0.4	334.7	-	335.1
1977	38.4	494.4	55.9	588.7
1997	96.2	494.4	63.9	654.6

Tab. 3. Dynamics of population for the Alghero municipality (1951-1991)

Year	Resident population	Evolution of population	
		n°	%
1951	21,374	-	-
1961	26,688	+ 5,314	+ 24.9
1971	32,187	+ 5,499	+ 20.6
1981	36,424	+ 4,237	+ 13.2
1991	39,026	+ 2,602	+ 7.1

Tourist settlements (hotel and residential settlements) amounted to 108 ha and they were created mainly in the 1970-1985 period; after 1985 their increase was negligible (0.4 ha).

With reference to road and railways network, the total area occupied was 364,4 ha, being equal to 20.3% of total artificial areas of the Alghero municipality, being the railways network negligible (6.5 ha).

Other types of utilisation (industrial areas, banned areas) resulted in a reduction of 655 ha, corresponding to 36.4% of the urban areas in 1997.

Soil consumption; the qualitative assessment

The main map unit of land capability present in the study area are summarised in table 4. The most frequent land capability class is the II – IV, with 11,734 ha (52.3 % of the total area), in which most Pleistocene lands are included, followed by the class VI – VIII con 6,567 ha, in which all units with uneven morphology are included.

Tab. 4. Total and artificial areas by land capability map unit (1956-1997)

Land capability map unit	*Potential intensity of utilisation*	Total area		*Soil loss (ha)*		
		ha	*%*	*1956*	*1977*	*1997*
I–II	Intensive agriculture	783	3.5	3.3	7.3	8.4
II	Intensive agriculture	319	1.5	5.0	7.5	9.5
II–III	Intensive agriculture	1,922	8.6	150.9	317.7	505.5
II–IV	Intensive/semi-intensive agriculture	11,734	52.8	554.6	794.6	1,008.3
III–IV	Intensive/semi-intensive agriculture	129	0.6	1.9	2.8	5.6
IV	Intensive/semi-intensive agriculture	40	0.2	0.3	0.8	0.9
IV–VI	Extensive agriculture and forestry	713	3.2	4.5	11.9	17.8
VI–VIII	Forestry and wildlife	6,567	29.5	29.5	223.3	237.9
VIII	Recreational use and wildlife	29	0.1	2.3	2.3	2.3

The class I – II is limited to 783 ha (3.5 %), all on the recent alluvial soils. The class VIII, in which only naturalistic and touristic-recreational utilisation is possible, included the 29 ha mainly located along coastline.

The higher soil losses where recorded in map unit II –IV, (1,008 ha corresponding to 55.9% of the total soil consumption) and II-III (505.5 ha).

Other high losses are for map unit VI – VIII, which included 237.7 ha.

Soil losses in the other map unit were markedly smaller, almost never exceeding 10 ha. Total soil losses for these map units amounted to 2.5% of total soil loss (1956-1997).

Considering the data aggregated by potential intensity of utilisation, urbanisation caused the loss of 515 ha of soils highly suited for intensive agricultural crops (map units I-II, II, II-III), and of 1,015 ha moderately suited for intensive agriculture.

In the intermediate situations characterised by extensive agriculture and forestry (map unit IV – VI) the losses amounted to about 18 ha (1.1% of total losses). It must be stressed that the losses of 237,9 ha of land suitable for forestry or wildlife (map unit VI-VIII) were almost completely due to tourist settlements (hotels, camping, etc.) and secondary homes located on sites having high naturalistic importance due to the presence of fragile ecosystems.

Conclusions

The data previously discussed showed high soil losses due to urbanisation in Alghero rural areas, both in quantitative and qualitative terms.

The largest soil losses were recorded in areas characterised by high land capability, where there was a potential for intensive agriculture and high income crops. Moreover, these areas were included among *irrigable* areas by the Piano Acque Regionale (Regional Water Plan), being among the most suited in the area for this use (Arangino et al., 1986).

The urbanisation of Alghero rural areas represents one of the causes of the reduction of very valuable agricultural production, for which Sardinia is short. Even more important, urbanisation is contributing to the loss of a characteristic landscapes, like the suburban belt made of olive trees, where rare examples of the traditional agricultural practices are still present.

The present case study highlighted that the lack of land planning and of land evaluation in particular, can result in severe land degradation mainly linked to the loss of valuable economic and environmental resources. In this case the conservation of the natural environment, the preservation of traditional agriculture, the maintenance of soil fertility of agricultural areas and a sustainable tourist development have to be the priorities.

References

Aru A. (1999), The Medalus Project in Sardinia, Proceedings of I° International Forum on European actions to combat desertification in the Mediterranean Basin, held in Matera, July 1997. Ministero dell'Ambiente, Rome, pp 97-114.

Aru A. (1997), La pianificazione territoriale e la mitigazione dei processi di desertificazione. Il consumo delle risorse non rinnovabili, *Genio Rurale,* 6, pp.54-60.

Aru A., Baldaccini P., Malquori A., Melis R.T., Vacca S. (1983), Il consumo delle terre a causa della espansione urbana del territorio intorno a Cagliari. Istituto di Geologia, Paleontologia e Geografia Fisica dell'Università di Cagliari.

Arangino F., Aru A.., Baldaccini P., Vacca S. (1986), I suoli delle aree irrigabili della Sardegna. Regione Autonoma della Sardegna - Piano Generale delle Acque. Cagliari

Brandt, J. and Thornes, J. (1998), *Mediterranean Desertification And Land Use,* John Wiley and Sons, Chichester.

De Meo G., Gutierrez M., Maciocco G., Nuvoli F., Prestamburgo M., Spanu A. (1991), Piano di sviluppo dell'irrigazione nei Comprensori della Nurra, della Piana di Perfugas e della Bassa Valle del Coghinas. Camera di Commercio, Industria ed Artigianato, Sassari.

Klingebiel A.A., Montgomery P.H. (1961), Land Capability Classification, U.S. Dept. of Agriculture, Agriculture Handbook n. 210, Washington D.C.

Madrau S., d'Angelo M. (1999), Lo studio dei suoli e della copertura delle terre: un contributo alla gestione del territorio, in Gutierrez M. (Ed.), *Protezione dell'ambiente e delle risorse naturali*, CEDAM, Padova, pp. 137 – 165.

Madrau S. (1993), La perdita di suolo per urbanizzazione negli anni 1958-1989 nei territori comunali di Sassari e Stintino (Sardegna nord- occidentale), Studi Sassaresi, Annali della Facoltà di Agraria, vol. XXXV (1°), pag. 77 -106, Sassari.

Mairota P., Thornes J., and Geeson N. (1998), *Atlas of Mediterranean environments in Europe: the desertification context*. John Wiley & sons, Chichester.

UNCED, 1992. Earth summit '92. The United Nations Conference on the Environment and Development. UNEP, Rio de Janeiro.

UNEP (1994), *U.N. Convention to combact desertification in those countries experiencing serious drought and/or desertification*, UNEP, Geneve.

Van der Leeuw, S.E. (1998), *The Archaeomedes Project*. European Commission - Directorate General XII, Brussels.