SOIL PROBLEMS IN MALTA – ADDRESSING CURRENT THREATS THROUGH STRATEGIC MEASURES

AVERTANO ROLÉ[1] AND GEORGE ATTARD[2]

1 - Geography Department, Mediterranean Institute, University of Malta
2- Institute of Agriculture, University of Malta

Summary

This contribution is meant to provide a brief overview of current soil-related issues within the Maltese Islands. The major threats to the islands' soil resources are identified and discussed within a geographical/agricultural context. The second part of the paper outlines the most significant measures, which are addressing such issues and discusses some broad outcomes. A concluding section identifies the needs for intervention.

Introduction

Soil is a scarce resource on the islands of the Maltese archipelago but, despite this, there is no commonly shared perception of the value of soil to its people. Attitudes vary from the *protective*, which produced the terraced landscapes of the Northwest, to the *indifferent*; where arable land is only regarded as useful as the number of building plots that it can yield.

Traditional positive attitudes culminated in the enactment of long-standing legislation, which is regarded as "surprisingly inspired", when compared to modern attitudes towards environmental protection. The Fertile Soil (Preservation) Act of 1973 (amended in 1983) and L.N. 104 of 1973 Preservations of Fertile Soil Regulations prohibits the dumping of soil or its burial. This ensures that any soil found on a prospective construction site must be removed and relocated to arable land or utilised within landscaping projects. Such soil must be removed according to a strict permit system governing its transport. Perhaps a more important factor in soil conservation is the continuous demand for soil, which has created a virtual market for the resource[1]. Soil is a very scarce resource on the islands and the supply has diminished considerably over the last few years. One significant reason for this is the present trend of medium to high-rise construction that has resulted in a slowing down of the rate of urbanisation and the subsequent clearing of arable land for construction. Therefore, a combination of market forces and legal provisions ensure that very little soil is lost during the realisation of development projects by the construction industry.

A more significant factor in soil loss is in the form of ignorance and indifference. The change in attitudes towards soil conservation brought about by urbanisation is probably more significant than the physical replacement of arable land by buildings. One possible reason for this change is that, for the last few centuries, the soils of Malta have been insufficient to deliver enough food to the inhabitants of the islands. Such a deficit has been determined by a combination of physical and human factors that have interacted during the unusually long history of human occupation of the archipelago. The agricultural shortfall is largely due to the high population density of the country; a fact that necessitates that we perceive the country more as a classic city-state than a country, which is comparable to its central Mediterranean, neighbours. In this regard, the issues that concern Maltese soils assume a uniquely multi-variate dimension.

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[1] Soil cannot be legally sold in Malta according to provisions within the Fertile Soil (Preservation) Act but earth moving contractors charge a fee for transporting the soil. A more detailed discussion is contained in Rolé and Attard (2004).

It is ironic to note that soil protection had enjoyed a considerable priority amongst rural communities for several centuries. This brought about extensive terrace construction and the unique landscapes of the northwest but the current lack of maintenance and neglect is threatening this, the most important and valuable form of rural capital.

Soil Threats and Land Degradation Processes

Soil Threats I - The Physical Environment

As in the case of other countries in the Mediterranean, soil erosion and associated land degradation processes in Malta are normally brought about by a set of anthropogenic factors interacting with a set of physical and geographical factors.

The islands' location at the southern end of the central Mediterranean ensures that they experience a substantial degree of "Mediterraneity" as defined by Mazzoleni *et. al.,* (1992). This means that the duration and intensity of the characteristic summer drought has a great impact upon the natural vegetation as well as on arable cultivation.

The climate over Malta is classified as semi-arid with hot, dry summers, warm autumns and short; cool winters with most rainfall falling between October and March. However, it is the irregularity of the rainfall and the variable intensity of such downpours that creates stressful conditions for local biota and results in widespread soil erosion. Torrential rainfall normally occurs during the autumn months when the surrounding warm seas and high moisture regimes create unstable conditions. The resultant thundershowers falling upon an exposed soil surface bring about accelerated surface runoff and associated soil erosion phenomena like rilling, gullying, and sheet-wash.

Another inimical climatic phenomenon is the windy character of the islands with more than 90% of days classified as windy. The strongest winds often occur during the spring season when fruit trees are in flower thus causing devastating damage to horticulturists. Moreover, apiarists report significant losses to their colonies, in exposed areas, at this time of the year.

One concomitant factor in this process of soil erosion and desertification is the Karst character of the underlying geology of the islands, which has largely inhibited the development of deep soil profiles. The calcium carbonate, of which these rocks are largely composed, is soluble in the mildly acidic environment of rainwater and soil water and leaves little long-term residue for the formation of soil. When combined with the characteristic summer drought and torrential autumn rains of the Mediterranean climatic regime, the result is quite predictable.

The processes described above are not restricted to the Maltese islands and, in fact, can be applied to most localities within the Mediterranean Basin. Figure 1 highlights the major interactions of these processes and identifies pathways by which soil erosion and desertification are brought about.

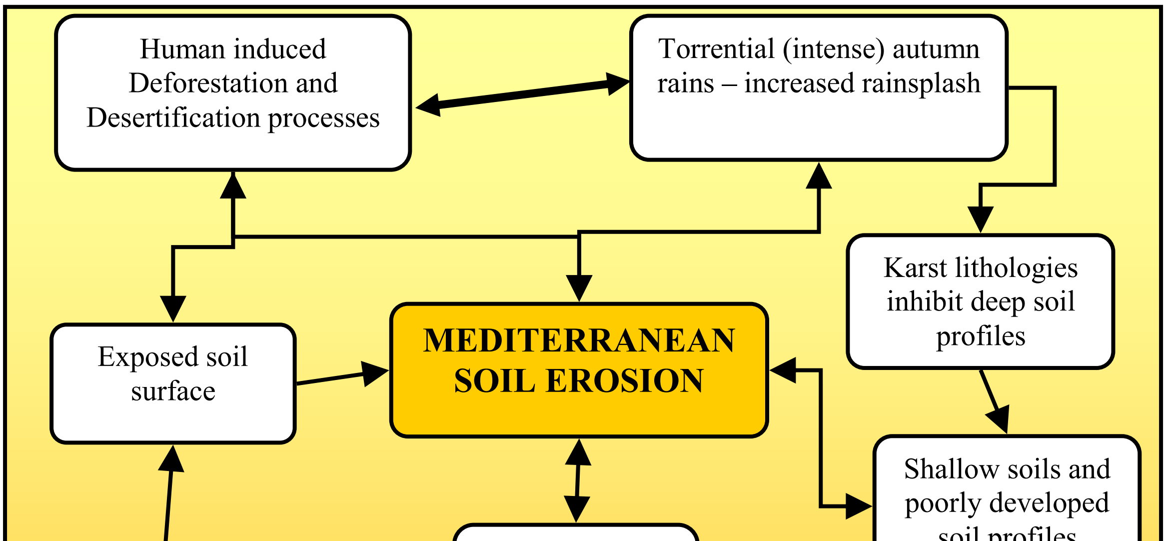

Figure 1. Mediterranean soil erosion processes

In the light of all of this it is quite easy to appreciate that misguided agricultural practices in Malta have such a severe and long-term impact upon soil erosion.

Soil Threats II – Anthropogenic Processes

The Maltese islands have a long history of human occupation. In fact, the ruins of the megalithic temple cultures are testimony to a sustained human occupancy for at least 8,000 years. Tiny remnants of forested areas indicate that the islands were originally covered by a patchy sclerophyllous forest largely composed of Holm oaks (*Quercus ilex*) and Aleppo pines (*Pinus halipensis*) but human activities, and settlement, probably contributed to episodes of severe deforestation at various times.

As a consequence of such forest clearance, accelerated soil erosion and desertification processes became widespread throughout the islands. The islands are now completely deforested and show little traces of the original post-glacial sclerophyllous forest cover. There is also evidence that land degradation has been occurring for several millennia. The garigue and steppe vegetation communities may be seen as remnants of once forested areas. It is evident that parts of Malta have lost most of their soil cover possibly following deforestation practices, which must have occurred several hundred years ago.

Urbanisation and peri-urban activity

The process of urbanisation and the associated spread of settlement are major contributors to soil erosion in Malta and both of them are important factors in land degradation processes. Urban growth has spread out from the hub of human settlement located around the two main harbours on the north eastern side of the island of Malta and has, gradually, enveloped the nearest towns (Figure 2). Suburban growth has also occurred around, practically, every other form of settlement; including villages. Some of these have coalesced into shapeless suburbs along main transport links cutting off any vestiges of arable land. A particularly curious form of development occurs through so-called By-pass Development in which the construction of road by-passes, meant to alleviate town centre congestion, encompasses arable land which eventually succumbs to urban development.

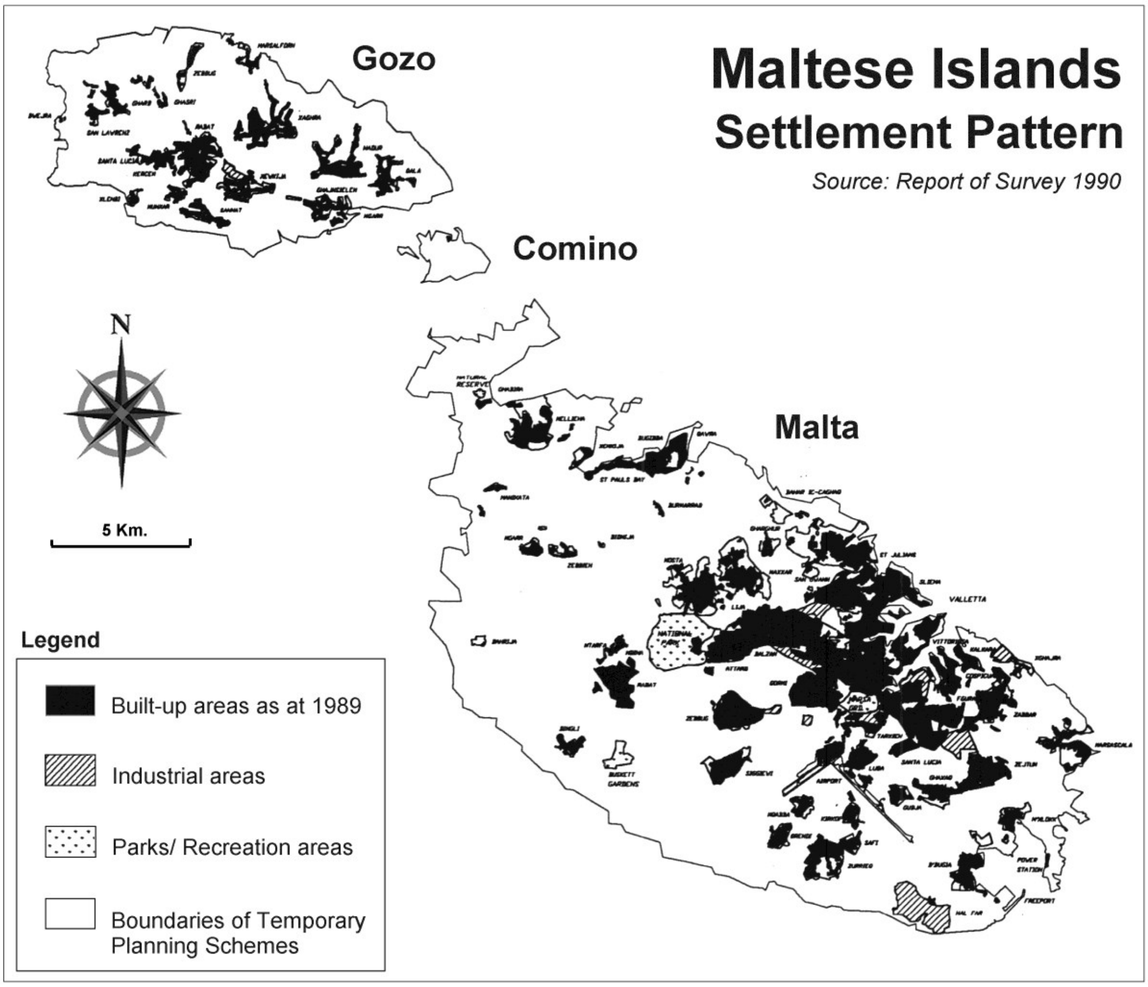

Figure 2. Urban spatial pattern of Malta

Many landowners thus exert pressure on authorities to include their rural holdings into urban development zones in the expectation of windfall sales. All of this is occurring despite the enacting of strategic planning legislation and draconian powers bestowed upon the Malta Environment and Planning Authority (MEPA). The latest revision, i.e. expansion, of the development boundaries was put into effect in 2007 and caused considerable protest. It seems that economic interests have an all-powerful effect upon the political elites.

Urban impacts on the rural environment extend far beyond the development boundaries. There are no current statistics that document the area of arable land which is put to alternative uses but one of the most prominent of such land uses is quarrying and the construction-related industry. A particularly destructive practice is the indiscriminate dumping of excavated material. Other prominent land uses include bird hunting and trapping sites (Figure 3), small hobby farms[2], and off-road driving areas.

[2] These hobby farms are quite similar to the British allotments in size and scope and most would possess a small room or shed. In the Maltese case, however, such hobby farms are not allotted but are the remnants of larger farm holdings, which were split into unproductive parcels through inheritance. Inheritors keep such holdings as weekend retreats and as an investment anticipating future urban development.

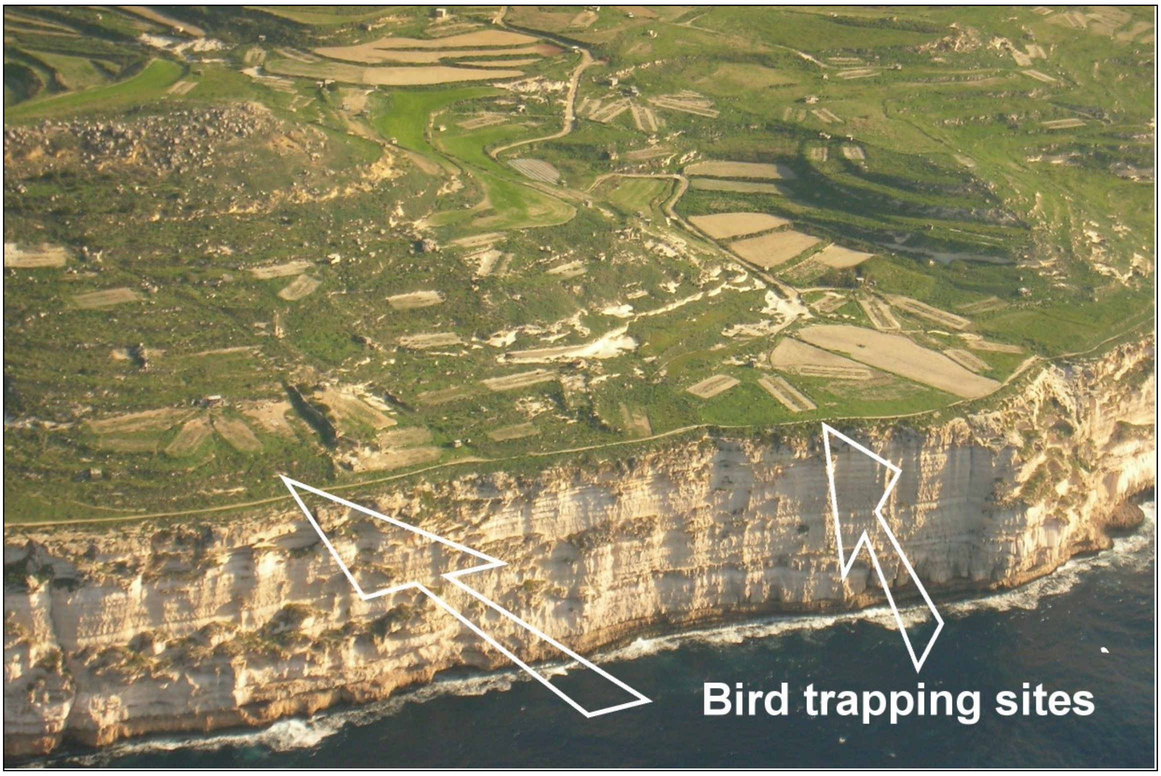

Figure 3. Bird hunting and trapping sites are prominent features in the Maltese landscape

Road construction has also exerted a negative impact on soil erosion. In some cases, insensitive road construction has led to the channelling of stormwater runoff onto adjacent fields resulting in the wholesale removal of topsoil (Figure 4). The demand for such roads increased dramatically with the rise in urbanism but even farmers apply pressure on local authorities for the construction of service roads. The fragmentation of landholdings often creates pockets of arable land, which are remote from service roads, and tenants or landholders demand rights of access.

Figure 4. Removal of topsoil from a farm at Dingli (Malta) following road construction in the area

Agricultural Practices

Soil erosion, of course, also occurs through misguided farming practices. Land abandonment and consequent soil erosion are brought about by a combination of factors. These include marginal economic returns; insecurity in land tenancy; aging structure of the farming population; lack of irrigation facilities[3]; and, where applicable, the costly maintenance of terrace walls.

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Another contributor to soil erosion is the poor way that some recent terraces have been constructed. In some notable cases, piles of rubble were bulldozed down a slope to form a rough level gradient and soil was placed on top of this, near-horizontal, level area. No attempt had been made to armour the steep slope with the traditional dry rubble walls. Such "terraces" are doomed to failure and shall create massive problems downslope in the near future.

The agricultural sector has undergone some recent changes, which have resulted in a process of industrialisation of agriculture. Foremost amongst these is the proliferation of glasshouses that have had a significant impact on the rural landscape. Such intensive cultivation requires high inputs in terms of energy, water, labour, and agri-chemicals and the potential for soil erosion can be considerable.

Less intensive forms include cloches, tunnels, and plastic mulching. Soil erosion around these areas is often localised depending upon the type of glasshouse used but, too often, the plastic residue is not disposed off properly and ends up clogging watercourses. Such clogging has been responsible for rises in stormwater levels and massive erosion along the channel banks (Figure 5).

Figure 5. Massive erosion of watercourse channel following intense rainfall in November 1999. Half the field was carried away by stormwater.

Another threat to soil integrity is caused by changes from traditional farming practices, which have occurred over the last few years. The current focus on the cultivation of cash crops has brought about a great reluctance on the part of farmers to follow the age-old fallowing system. In most cases these fallowing systems involved the incorporation of a leguminous cycle utilising sulla (*Hedysarum coronarium*) and other winter vetches and pulses. Such crops were cultivated for fodder and supplied the local livestock that are practically all kept in feedlots. Their other major benefit, however, was the restoration of soil nitrogen and the maintenance of sound soil ecology through complex organic processes within the soil profile.

Sulla has also lost its favour amongst livestock farmers. It has been reported that most sulla producers allow the crop to mature much too far thus producing a greater percentage of lignin and losing its nutrient value in the process. Mechanised harvesting is still poorly developed for sulla crops and the tendency is to allow the crop to dry before harvesting. The current farming practice is to cultivate wheat instead of sulla and utilise dried hay or straw as fodder. This, of course, has to be supplemented by the input of artificial fertilisers to maintain acceptable yields.
The threat of **salinization** is localised to two particular contexts. The first applies to the low-lying graben valleys of Burmarrad, Pwales, and Ghadira. These valleys are underlain by salt-water intrusions and have very shallow water tables. Any groundwater abstraction causes immediate saltwater cones of ascension thus safe-well yields are severely limited. Most of the farmers in these areas have adapted their farming practices by cultivating mildly salt-tolerant crops and avoiding halo-phobic crops (Conrad 2004).

Another context of salinity is more artificial; these are the irrigated areas supplied by recycled water from the San Antnin sewage treatment plant. Much of this area is located within the Marsascala – Zabbar localities and farmers of the area have been utilising this water for the last couple of decades. In addition to the recycled water, these farmers have been applying compost to their soils derived from a fermented blend of sewage sludge and organic domestic refuse.

Studies conducted over the last few years (Pace 2004; Pullicino 2000) indicate that the utilisation of these by-products has had mixed results. Many farmers complained about high salinity levels in irrigation water and that such salinity varied unpredictably. Other farmers stated that they stopped using compost since it contained high levels of salts and also contained an appreciable amount of sharp glass fragments. There is also a general perception, amongst wholesalers, that crops grown in these areas are far more prone to perishing and have a very restricted shelf life. All of this raises serious questions about the long term physical, chemical, and biological integrity of the soils of the two localities.

Measures

A number of initiatives have been launched to address some of the issues outlined above. Some have been concluded while others are in the process of initiation. They also vary in scope and range from taxonomic studies to risk assessment mapping, contamination monitoring, and indicator formulation.

MALSIS

Until a few years ago, the only taxonomic soil survey available was that carried out by D.W. Lang, published in 1960 at a scale of 2 inches to 1 mile (1:31,680). Lang adopted the Kubiena classification system, which yielded 13 mapping units.

MALSIS (Malta Soil Information System) goes much further than this and addresses the long standing need for a modern, systematic, soil information system that can be utilised for sound environmental decision making.

The MALSIS project is composed of three stages (MAF 2003):

1. The first stage consists of a national grid-based inventory of the soil resources at 1km interval. The soil survey methodology followed the FAO Guidelines for Soil Profile Description (FAO & ISRIC, 1990) and incorporated minor adaptations to reflect local conditions. Site and soil characteristics were described from field surveys and pits (80cm) and such information was used to classify the soils of Malta and Gozo using the World Reference Base for Soil Resources (WRB) (Figure 6). Six soil reference groups were identified, with Calcisols identified as the dominant soil group in the Maltese Islands (Table

1). This classificatory exercise has integrated the Maltese Islands within the Soil Map for Europe (1:1,000,000 scale; Joint Research Centre, 2001).

2. The second stage of the MALSIS soil survey involved the identification of soil landscapes containing a range of soil types with a defined relationship within the landscape (Figure 7). This stage of the MALSIS soil survey programme was designed to characterise the small scale variability of important soil properties and limitations within these landscapes and to provide a basis for estimating the uncertainty associated with measurements of soil properties at any specific point.
3. The third stage of the MALSIS project was to establish a comprehensive soil monitoring programme for the Maltese Islands. It is anticipated that ongoing monitoring programmes will involve detailed survey investigations at 5km intervals and focus investigations onto local, environmentally sensitive, areas. Two vulnerable sites have been selected and sampled at high density in the local sites investigations. The areas selected are

    - the south east area of Malta, which receives treated sewage effluent from the San Antnin Sewage Treatment Plant and
    - the agricultural land surrounding the land-based landfill at Maghtab in the north east part of the Island (Figure 8).

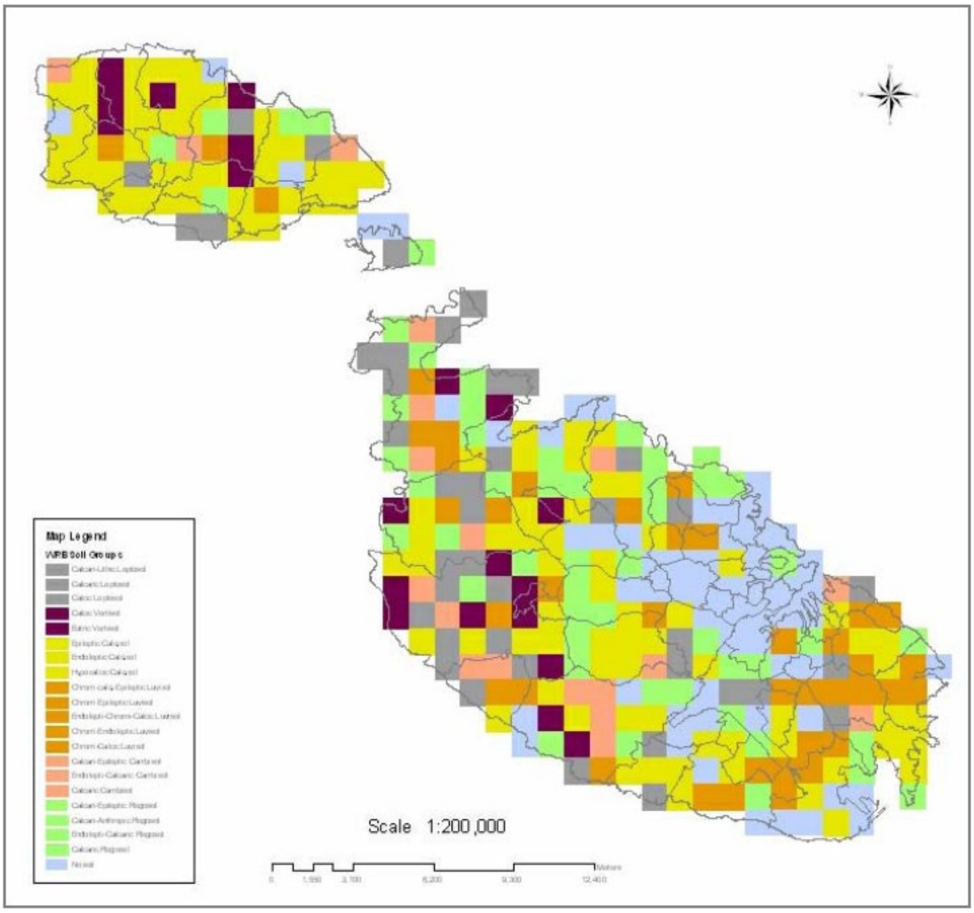


Figure 6. MALSIS – Classification of Maltese Soils (WRB system)

Figure 7. MALSIS soil landscape types

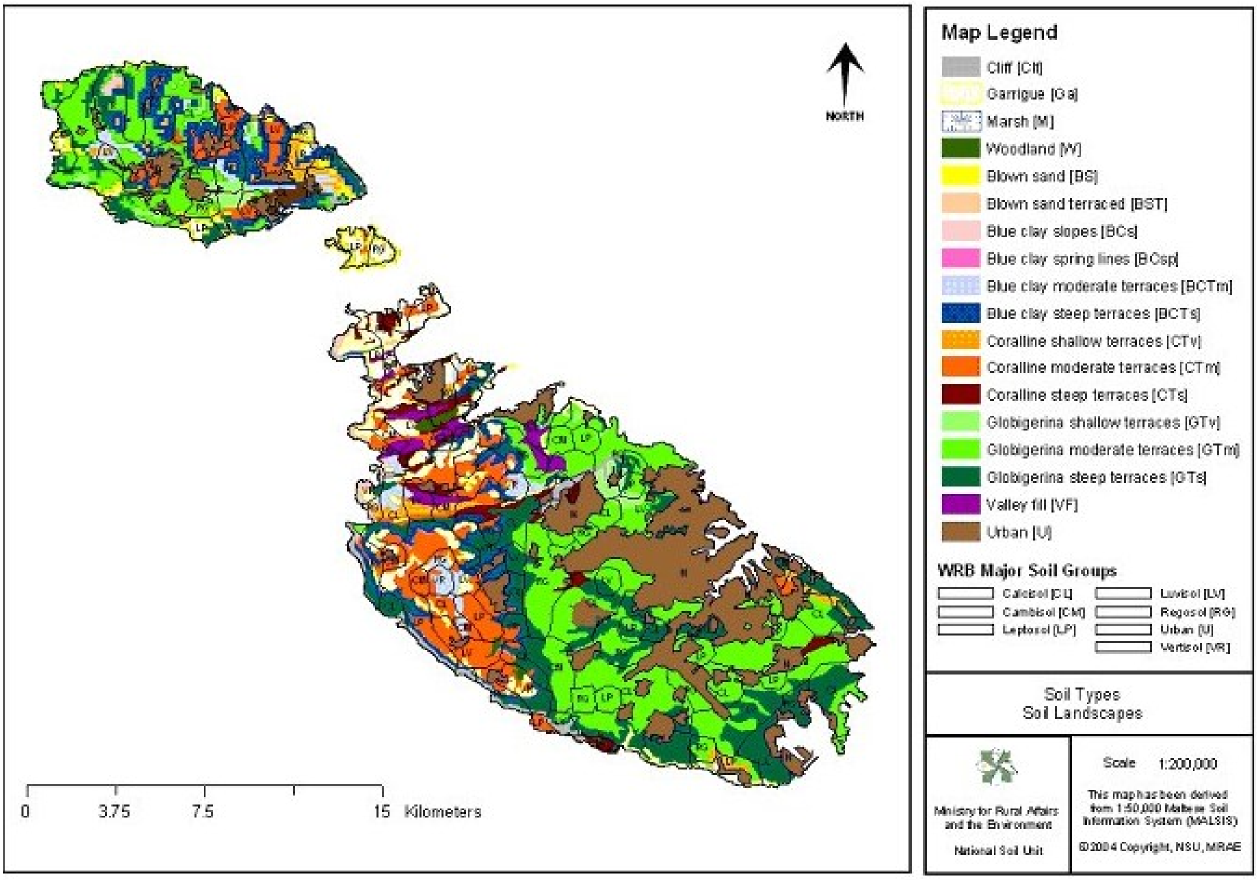


Table 1. MALSIS - Soil units identified in the National Grid Survey of Malta and Gozo

Soil Reference Group	Soil Unit	Number of sites	% of total (272 sites)
Leptosols	Calcari-Lithic Leptosols	5	2
	Calcaric Leptosols	35	13
	Calcic Leptosols	1	0
Vertisols	Calcic Vertisols	16	6
	Eutric Vertisols	4	1
Calcisols	Epileptic Calcisols	32	12
	Endoleptic Calcisols	50	18
	Hypocalcic Calcisols	18	7
Luvisols	Chromi-Calci-Epileptic Luvisols	13	5
	Chromi-Epileptic Luvisols	2	1
	Endolepti-Chromi-Calcic Luvisols	13	5
	Chromi-Endoleptic Luvisols	9	3
	Chromi-Calcic Luvisols	3	1
Cambisols	Calcari-Epileptic Cambisols	13	5
	Endolepti-Calcaric Cambisols	3	1
	Calcaric Cambisols	3	1
Regosols	Calcari-Epileptic Regosols	24	9
	Calcaric-Anthropic Regosols	19	7
	Endolepti-Calcaric Regosols	6	2
	Calcaric Regosols	3	1

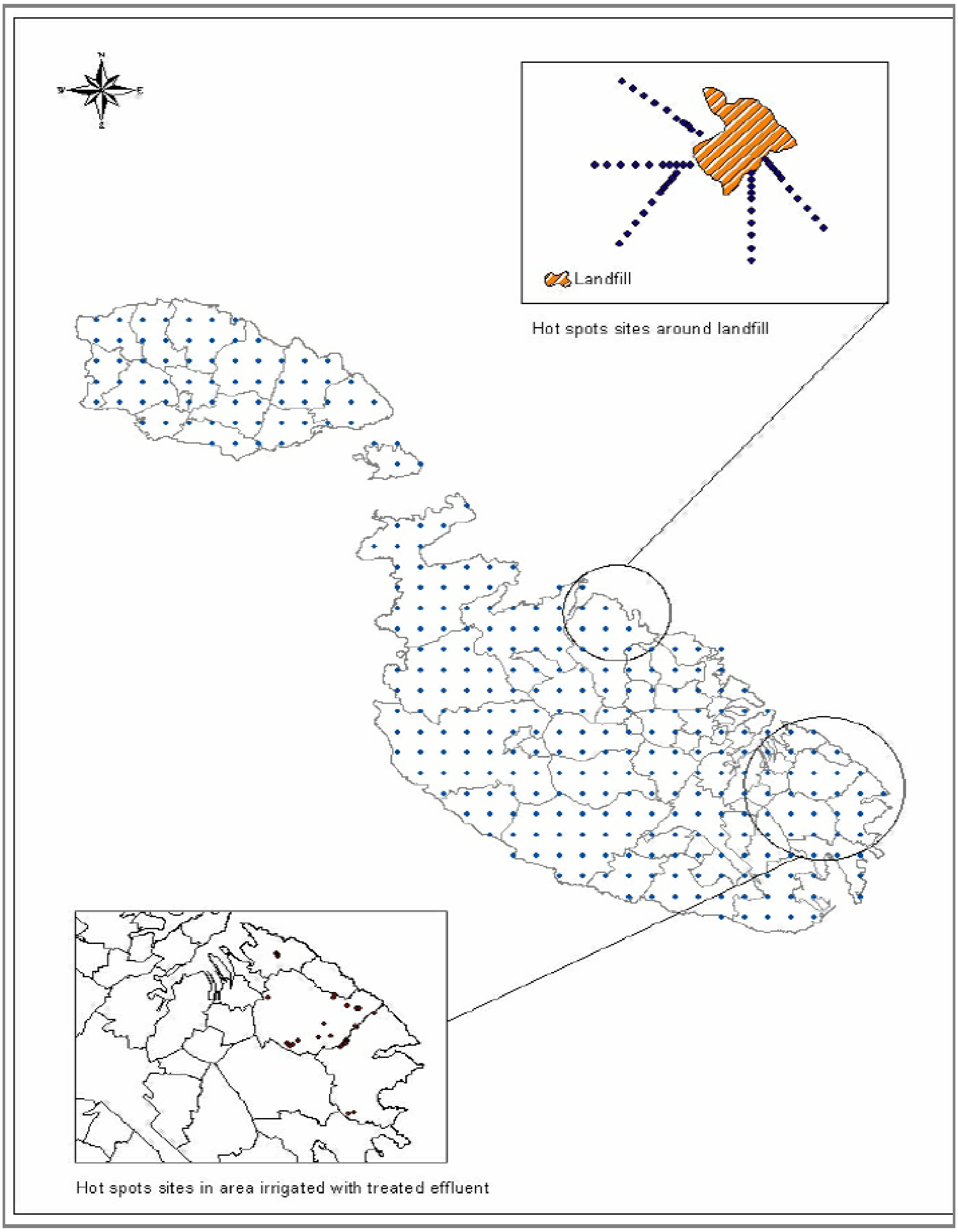


Figure 8. MALSIS soil monitoring program: San Antnin and Maghtab

Another MALSIS output is the compilation of soil databases that permit the manipulation of soil georeferenced data within a geographic information system. The results show that 51% of the agricultural and semi-natural land in the Maltese Islands has a topsoil horizon (plough layer 0-15cm) that contains less than 2% OC (3.4% OM). Preliminary findings on the content of trace and heavy metals in topsoils and subsoils show that the highest levels of copper have been found in the south east region of Malta where treated sewage effluent is used for irrigation. Most of these levels, however, are below the upper limit value for soils with a pH >7 as stipulated in the Sewage Sludge Directive, 86/278/EEC (EEC, 1986).

CAMP (Malta) Soil Erosion/Desertification Thematic Activity

MAP CAMP Malta was the first exercise carried out for the Maltese Islands in integrated coastal area management (Vella, *et. al.,* 2003). This was achieved through the implementation of a series of five thematic activities (complemented by three horizontal activities), which addressed specific sectors regarding different problems and issues pertaining to the Maltese coastline.

The Soil Erosion/Desertification Thematic Activity (Tanti *et. al.,* 2002), therefore, addressed soil erosion issues within an integrated planning framework. This was achieved through:

- undertaking and completing systematic erosion/desertification surveys and mapping activities at different levels;
- providing proposals for remedial measures and elaborating conservation/rehabilitation/protection recommendations for the implementation of global and site specific actions;
- contributing to the protection, rehabilitation and rational exploitation of the rather limited soil resources, scenic beauty and biodiversity, by applying updated and adapted erosion/desertification control management strategies and techniques.

The Project activity was implemented through the application of the newly consolidated erosion mapping and assessing methodological procedure as defined in the "Guidelines for Erosion and Desertification Control Management with particular reference to Mediterranean Coastal Areas" (UNEP/MAP/PAP, 2000).

The mapping survey procedures mainly identified and assessed physical parameters and processes that were integrated during the synthesis phase with socio-economic factors such as land use, cropping practices and urbanisation.

During the implementation of the activity, there was a constant concern for participatory approaches, sustainability assessment, monitoring and integration of sectoral surveys. Since the participatory approach was considered as a pre-requisite for proper determination of priority areas and elaboration of sustainable remedial options, special emphasis was placed on formal and informal contacts with the Project stakeholders. In fact, involving the main stakeholders, i.e. local authorities, the population involved in agricultural activities, the scientific community and NGOs, was an asset to the activity. A close link was therefore kept with the participatory programme within the CAMP project.

Sustainability indicators for soil-erosion and desertification were identified. These were meant to be used as tools for the development of trends on erosion/desertification processes and control management strategies. The development of these indicators involved several discussions with the main land users/stakeholders who also endorsed the indicators.

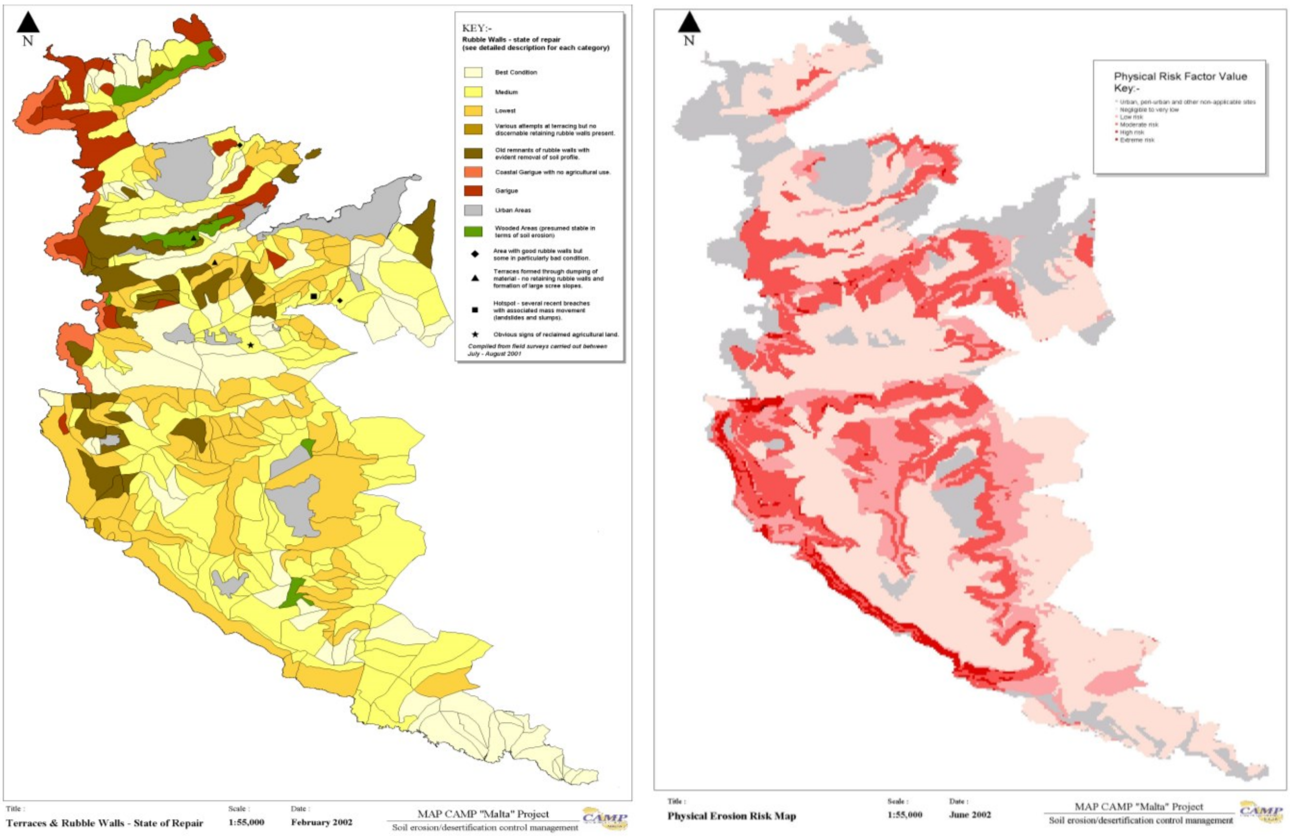
For integration of mapping outputs with socio-economic parameters, a report on the relevant socio-economic patterns and strategies was prepared. The main patterns identified to have an impact on soil erosion/desertification processes are:

- *population* (population changes and urbanisation, road development, farming practices)
- *exploitation of freshwater resources* (irrigation, salinization, nitrate pollution in water table, irrigation with 2nd class water)
- *costs of soil erosion* (cost of soil replacement, cost of preventing soil erosion)
- *soil as a non-agricultural resource* (hunting and trapping, quarries, ecotourism)
- *industrialisation of agriculture* (greenhouses, hydroponics, animal husbandry, irrigation techniques, reservoirs and bore-holes, crop type, viticulture)
- *land tenure* (fragmentation of holdings, land abandonment).

As a result of the field surveys, predictive mapping and the integration of the socio-economic parameters, priority areas for immediate intervention were identified and categorised as below (Figure 9):

- Clay soils with a low degree of maintenance of rubble walls
- Steep slopes with a current agricultural use or abandoned fields and neglected rubble walls
- Valley beds/flood prone areas
- Areas under the influence of runoff water from non-absorbent sealed surfaces (roads and buildings), where storm water runoff is not taken into consideration in the planning or construction stage.

Figure 9 – CAMP: state of rubble walls (left) & Soil erosion risk map (right)



The Rural Development Programme (RDP)

RDP is a new initiative, and has only been active since Malta's EU accession in 2004, but it is at the forefront in the process of transforming traditional, inward-looking, Maltese agricultural activity into a European-oriented, vibrant, and environmentally sound, sector of the economy. The main objectives of Malta's rural development strategy concern the preservation of the multifunctional character of agriculture by enhancing its economic and environmental stability and by improving the natural and social fabric of the countryside. The three key areas that will be applied in implementing this strategy shall thus focus on:

- Addressing inherent structural weaknesses by promoting and improving the competitiveness of agriculture and further complementing this through processing and marketing food quality support further assisted by training, information and diffusion of knowledge, as well as access to advisory services;

- Improving the environment and the countryside by consolidation of the Less Favoured Areas measure as the stepping stone on which to add other actions that favour countryside stewardship and improve natural and rural habitats;
- Diversifying economic activities and improving the quality of life in rural areas through local initiatives that bring together different local actors so as to stimulate cooperation and innovation whilst strengthening cultural identity and traditions.

One of the stated aims of the RDP is that of rendering Maltese agricultural activity more environmentally sustainable and this is being addressed through a series of funding initiatives structured under Axis 2 of the NSP. More specifically, this is aimed at "Improving the environment and the countryside through encouraging the retention of agricultural activity, and promotion of environmentally friendly production methods in line with rural heritage". The key actions envisaged under this axis will focus on:

- "preserving the farmed landscape which is an important and valued feature of our rural environment, through incentives for the retention of agricultural activity and associated traditional features in all of Malta in order to conserve and improve the environment, maintain the countryside and preserve the tourist potential of the islands as well as in order to protect the coastline; and
- increasing the environmental and ecological sustainability of farming through encouraging management practices that address the adaptation measures required for climate change mitigation that lead to the sustainable use of natural resources particularly water and soil;"

In this respect, specific measures are designed to protect soil fertility, either directly or indirectly. These include:

- 5.2.3.1: *Support for reduced use of plant protection products in vineyards* – this is meant to encourage vintners to apply natural pest control measures, like nets, thus preventing the contamination of soils with pesticides. Such pesticides have unknown repercussions upon soil ecology
- 5.2.3.2: *Support for the traditional crop rotation system including the cultivation of sulla* - The main objective of this measure is to encourage and support the growth of the traditional fodder crop; sulla through its inclusion in a specified crop rotation. The cultivation of leguminous sulla would serve to preserve an important part of the island's traditional rural heritage. This measure will help combat soil degradation and to reduce the level of input of chemical fertiliser.
- 5.2.3.3: *Support for low input farming* - The objective of this measure is to reduce the use of repetitive plant protection products in forage production (wheat, barley, and oat). This would reduce ground and surface water contamination; increase biodiversity; and avoid/decrease pesticide residues in forage crops intended for animal consumption.
- 5.2.3.4: *Support to suppress the use of herbicides in vineyards and fruit orchards* - The objective of this measure is to reduce the use of herbicides in vineyards and fruit orchards by supporting the use of alternative methods of pest control. The final aim is to reduce pollution; especially of soil and water resources, and to support the maintenance of an adequate soil cover in an effort to prevent soil erosion.
- 5.2.3.5: *Support for the establishment and maintenance of conservation buffer strips* - The objective is to support the establishment and maintenance of conservation buffer strips (bio-belts). Farmers would abstain from cultivating designated parts of their fields effectively creating buffer areas to protect land-based or freshwater habitats harbouring wildlife.
- 5.2.3.6: *Support for a reduction in fertiliser use in protected cropping systems* - The objective is to prevent the pollution of groundwater and soils by excess nutrients (especially

nitrates contained in fertilisers) through fertiliser planning techniques and fertiliser accounting.

- 5.2.3.7: *Support for the conservation of rural structures providing a natural habitat for fauna and flora* - The objective of this measure is to support the protection of wildlife through the conservation of rural structures, on farmland, that provide habitats to such wildlife.
- 5.2.3.8: *Support for tree planting on farmland* - The main objective of this measure is to encourage conservation and promote biodiversity by planting native trees within farmland.

The environmental benefits include:

  - a reduction in the risk of soil erosion caused by heavy rain, flooding and wind
  - the provision of a natural habitat for birds to rest, feed and nest,
  - the creation of short wind barriers,
  - an enhancement of the aesthetic value of the rural landscape,
  - the provision of a greener environment throughout the long, hot and dry summer months.

- 5.2.3.9: *Support for the establishment and maintenance of wildlife hedges* - The objective of this measure is to increase and sustain biodiversity through the introduction of new wildlife habitats in farmland and to develop wildlife corridors for the various species present in the rural landscape. This would also reduce soil erosion and minimise pesticide applications.
- 5.2.3.10: *Support for providing a healthy forage area for bees* - The objective is to promote a richer, more varied, and healthier forage area for bees. In turn, this facilitates a healthier vegetation cover through higher rates of pollination and, indirectly, soil protection.
- 5.2.4.1: *Support for organic farming* - The objective is to promote the sustainable use of farmland and to support organic methods of production. These may include low or zero till systems, water harvesting techniques, promotion of organic material in soil, and natural pest control.

IRENA Indicators

The IRENA indicator system is a European-wide exercise, which is meant to deliver information regarding the environmental credentials of the agricultural sector within a specific region. It is meant to facilitate the establishment of environmental targets and monitor the performance of the sector in achieving such targets. IRENA is currently in the process of being applied to Malta; following the country's accession to the EU in May 2004.

While the application of the IRENA indicators to Malta is still at a very early stage, some of these indicators address soil quality and conservation measures and hold considerable promise. Indicators 23 (Soil Erosion) and 29 (Soil Quality) shall be discussed briefly.

Indicator 23 is based upon soil erosion by water. This is a serious and widespread problem throughout Europe. Physical factors like climate, topography and soil characteristics play an important role in the process of soil erosion and a distinct geographic pattern emerges. The Mediterranean region is particularly prone to erosion because it is subject to long dry periods, followed by heavy bursts of erosive rain, falling on steep slopes with fragile soils. With a very slow rate of soil formation, any soil loss of more than 1 t ha-1yr-1 can be considered as irreversible within a time span of 50-100 years.

Indicator 29 addresses soil quality but it is very difficult to establish a generic indicator to describe soil quality. In fact, there is no definition of soil quality for the EU context. The Commission has put forward a number of criteria (COM 179 (2002)) for defining well functioning soils from the European perspective and four out of five functions are directly linked to soil organic carbon content:

- food and biomass production,
- filtering and buffering capacity,
- pool of biodiversity and
- source of raw materials (peat).

The levels of soil organic carbon in topsoil have been adopted as the most appropriate indicator for soil quality for agro-environmental purposes, since it covers both strictly agricultural criteria and wider environmental concerns. A high level of organic carbon content corresponds to good soil conditions from an agro-environmental point of view. This result in limited soil erosion, high buffering and filtration capacity, a rich habitat for soil organisms, an enhanced sink for atmospheric carbon dioxide, etc. Soils with Organic Carbon content between 1 and 10 % can also be considered of high agricultural value, while soils with less the 1% can be considered as affected by severe degradation (desertification).

Conclusions

As in many other countries, Maltese soils are beset with a range of threats and problems. In our case, however, soil losses are impossible to recover within human time frames. We have no steady supply of raw material for soil formation; an inimical geological substrate, a climatic regime, which seems to be specifically designed for soil erosion, and a high population density that exerts unique pressures on whatever survives of our rural landscape.

Our ancestors were well-aware of this problem and addressed it by constructing terraces which were painstakingly armoured with dry rubble walls. Much of this terraced landscape still exists and now constitutes a form of rural capital, which is, unfortunately, poorly appreciated. It is the responsibility of geographers, agronomists, soil scientists, and landscape specialists to highlight this fact and deliver it to all the relevant decision makers before it is too late.

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