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IECA International Erosion Control Association — SECS Sociedad Española de la Ciencia del Suelo — Universitat de Lleida

EGU European Geosciences Union — Soil and Water Conservation Society — IUSS International Union of Soil Sciences, Commission 3.2 – Soil and water conservation, Commission 3.6 – Salt Affected Soils

ICEA Institució Catalana d'Estudis Agraris, Secció de Sòls — WASER World Association for Sedimentation and Erosion Research — International Union of Soil Sciences, International Decade of Soils 2015-2024

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CONTENT

ANTHROPOGENIC SOILS AND SOIL SECURITY: ENVIRONMENTAL AND ECONOMIC CONSIDERATION

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1. INTRODUCTION

Long before the 20th century and up until the '60s of the last century, soil with its diversity, was considered almost exclusively in the context of farm management and food production.

In the second half of the last century, the remarkable increase of the global impact of humankind on the natural resources has lead in the public opinion an equal increase of the awareness of the importance of the environmental resources. The soil was no longer considered only a domain of agriculture but it was projected onto a broader and more appropriate scale, much more suitable to its environmental importance.

This started in the 1960s, and in conjunction with the beginning of the Anthropocene (Crutzen, 2002), an era influenced by agricultural, industrial and urban developments, that has affected the ability of soils to produce goods and services in greater quantity and better quality. In many cases, the human pressure on land was of such intensity as to transform the original soilscape pattern to a total disorganization, a pedological chaos that consequently led to the annihilation of the soil diversity (Lo Papa et al., 2011). The scientific debate that has developed in recent years on matters relating to the role of soil-systems in the environmental balance, allowed us to attribute to soils, properties and concepts that commonly characterize the living beings, such as that of genetic erosion (Dazzi, 1995) or diversity (Dazzi, 1995; Ibañez et al., 1995). These new ideas have led in time to the definition of the concept of Soil Security (McBratney et al., 2014).

2. ANTHROPOGENIC SOILS AND SOIL SECURITY: ENVIRONMENTAL AND ECONOMIC CONSIDERATION

Soil scientists have long been writing of the importance of soil to provide for growing human demand for food, water and energy, also expecting soil to provide ecosystem services that affect climate change, human health and maintain biodiversity.

A number of large existential environmental challenges have been recognized for the sustainable development of humanity and planet Earth. These are Food Security, Water Security, Energy Security, Climate Change Abatement, Biodiversity Protection and Ecosystem Service Delivery (Bouma and McBratney, 2013). They all have similar characteristics; namely, they are global, they are complex and difficult to resolve, and they are inter-related.

The inter-relationships between soils and social issues – such as food safety, sustainability, climate change, carbon sequestration, greenhouse gas emissions, degradation by erosion, loss of organic matter and nutrients – are fundamental elements of the recent proposition of the concept of "soil security" (Figure 1).

"Soil security" was define as the maintenance and improvement of the world's soil resource to produce food, fibre and freshwater, contribute to energy and climate sustainability, and maintain the biodiversity and the overall protection of the ecosystem (Bouma and McBratney, 2013).

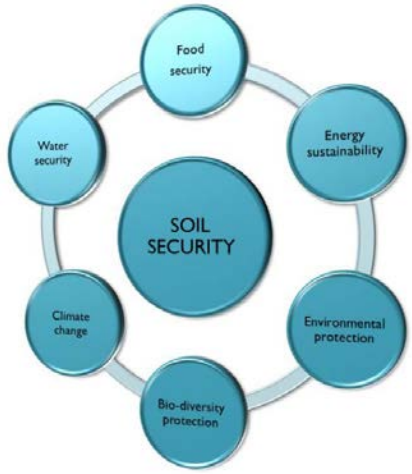

Figure 1 – Food safety, sustainability, climate change, carbon sequestration, greenhouse gas emissions, degradation by erosion, loss of organic matter and nutrients – are fundamental elements of the "*soil security*" concept.

Soil security is linked to the six global societal challenges through the soil's Ecosystem Services (ES). These last are defined as the benefit that people derive from soils (Dominati et al., 2010) and, according to the widely adopted Millennium Ecosystem Assessment (MA) framework for ES (MEA, 2005), could be grouped in four categories: provisioning services; regulating services; cultural services; supporting functions.

Soil security also requires a value to be placed on soil. This value is aligned with the need for policy to aid in securing soils by encouraging correct soil management and protecting against mismanagement. Correct soil management form is also one of the main goal of pedotechniques, a new and interdisciplinary branch of soil science, which tries to understand and integrate the effect of soil handling on the soil qualities (Van Ouwerkerk and Koolen, 1988; Dazzi et al., 2009) and, obviously, on the soil's ecosystem services. In spite of this, in applying pedotechnique, farmers frequently do not take into account its fundamental aim: i.e. to satisfy the human needs avoiding any undesirable environmental threats that might occur during the handling of earthy materials. In agricultural management, the main aim of pedotechniques is to make agriculture more profitable.

Therefore, we are on the horns of a dilemma: how can assure soil security and save soil's ecosystem services in the Anthropocene era characterized by an always and always diffuse influence of humans on soil and an increasing spreading of the anthropogenic soils originated from pedotechnique?

Trying to give a solution to this dilemma, we could take into consideration a particularly meaningful case study that recently happened in Southern Sicily (Italy).

In a farm located in this area, in 2011 the landlords planned to change the land-use of their soils, used since long time to grow cereals (mainly durum wheat) and vegetables (such as eggplant, tomato, pepper, water melon). Therefore, they started to grow vines for table grape production. In 2012 using trucks, they started to cover 3 hectares of Vertisols with heaps of marly limestones. The marly limestones, that is to be considered as a human transported material (HTM), was extracted from a nearby hill making use of a Caterpillar that worked for several days. After this, In October 2012, the heaps of marly limestones were levelled above the soil surface. Three hectares of Vertisols were completely buried under a layer of marly limestone from 80 to 100 cm thick.

In summer 2013, this area was deeply ploughed at 90 - 100 cm depth, with a mouldboard one-furrow plough. This provided complete overturning of the HTM and a relatively stirring up of the topsoil of the Vertisols. Farmers, on this transformed soil, start to build a greenhouse completely equipped with a fog production system and an irrigation system. Inside the greenhouse, 4900 plants of vines were planted. At the end of these operations, the total cost was more than 120,000 euros per hectare. In 2014, vines grew rapidly and in 2015, they start to produce high quality table grape. In 2016, the greenhouse was in full production.

Therefore, we should ask a fundamental question: "What drives a farmer to do all this?" We believe that "profit" is the answer!

The profitability analysis of the table grape crop under greenhouse on anthropogenic soils, shows (from the second year of production), a high value of the Net income that is equal to € 34,561 per hectares. This is due to the higher average production per plant that amounts to 20 kilograms, sold directly on the plant at a price of €1.50 per kilo. This allows achieving a revenue of € 49,000 per hectare. The net income of the firm studied, deviates significantly from the profitability of other crops which are traditionally grown in Vertisol and in particular durum wheat, whose profitability is equal to € 488,00 per hectare. The cost/benefit analysis to evaluate the feasibility of the project highlights the greater convenience of the pedotechnique application, considering that all the economic performance indicators are highly positive.

Going back to the soil security issue, we stressed that also soil security would require a value to be placed on soil ecosystem services. Therefore, if we try to compare, even in a "qualitative" way, the ecosystem services provided by the two kinds of soil, we obtain the following information:

Soil service category	**Vertisol**	**Anthrosol**
Support (Biodiversity pool; Nutrient cycling; Soil formation; Water cycling, etc.)		
Regulating (Biological control of pest & diseases; Climate regulation; Hydrological control; Recycling of wastes and detoxification; Filtering of nutrients and contaminants, etc.)		
Provisioning (Biomass production; Clean water provision; Raw materials; Physical environment; etc.)		
Cultural (Heritage; Recreation; Cognitive; etc.)		

3. CONCLUSIONS

In the coming years, the socio-economic development of humankind and the maintenance of its prosperity will largely depend on its ability to ensure the sustainable use of the natural resources. This is a very complex task due to the impact of the human activities on the environment and particularly on soils. Soil Science will play a crucial role to achieve the need for an increasingly global and technological society. Soils must be considered in a new perspective: no longer limited to the agronomy and/or forestry issues but considered as important part of the environment and considerable element of the social and cultural systems. We believe that, in the near future, one of the issues that should be considered as a new frontier in soil science will concern the assignment of an "**economic value**" to the services offered by the soils.

Farmers consider soils as source of income, i.e. an economic resource! In large-scale farming for growing high-income crops using pedotechnique to tailor suitable soils for table grape cultivation, farmers are able to get a net income of more than 34,000 euro per hectare!

We are convinced that in overcoming the present limitations for studying and researching soil degradation processes and in the application of prevention and remediation practices, we need to change the soil paradigm, providing a new definition of soil:

"Soil is an economic resource! It is finite and non-renewable on the human time-scale since it does not regenerate at a significant rate within this time". Such revised definition stresses the economic value of the soils (the only one aspect that shake the attention of politicians and administrators!).

Being able to attribute an economic value to the processes of soil degradation by defining an algorithm to be considered in the calculation of the total GDP of a nation, would be a matter of major importance for the human society. It would cause the development of a strong perception of the importance of the soil as a resource and would increase awareness of soil importance in the environmental equilibria.

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