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The impact of agriculture on natural resources (water, soil and biota)

Introduction. The rural landscape: different approaches, biodiversity and natural indicators

The landscape is a complex structure that is generated by the interaction between the natural environment and anthropic component. In recent years, the concept of rural landscape, understood as sustainable development, has sparked an interest in science by opening the de- bate on the real meaning of this terminology. The sustainable environmental management is a slow and complex process, aimed at achieving a certain degree of environmental, economic, social and institution- al improvement. The objective of this type of management is represented by the satisfaction of the needs of the current generation with- out compromising future generations. A major difficulty of operating a landscape is represented by the space-time variability of the very concept of rurality, in relation to the continuous and rapid transformation of society. According to the National Institute of Rural Sociology (IN- SOR) the rural landscape can have four different meanings (Merlo et al., 1992). The *first* affirms the concept of rural landscape as a micro-society, defined as the relation of the demographic size of human settlements. Rural settlements are identified as inhabited areas only when and if they reach at least two thousand inhabitants. However, this criterion does not always allow the appreciation of the real degree of rurality of an area due to the different degrees of dispersion of rural com- munities throughout the country. According to the *second definition*, rurality is entirely associated to agriculture, especially in reference to the sectors staff (INEA, 2006). This definition is applicable only in certain historical periods. Consider, for example the gradual specialization and mechanization of farming which has greatly reduced the use of manpower. The *third approach* identifies rurality as the socio-economic delay of any given territory. There are numerous parameters defining this delay, which are taken into consideration. Greatly pervasive, for ex- ample, are the level of education and the conservation status of housing (Somogyi, 1959, Vitali, 1983; ISTAT, 1986). Even this definition ac- cording to the INSOR apparently is updated, but is incapable of de- scribing the complex reality of rural areas in advanced economies. The *fourth definition* contemplates 'rurality' as the interstitial space within specific studies of territorial zoning describing the 'functional regions' as socio-economic development. Even this approach appears partially outdated as it does not recognize the autonomy of the countryside, which becomes residual space instead of dominant as described in the former approaches (INEA, 2006). Evolutionary processes in place that characterize the developed countries make the above definitions of rural landscape previously described inadequate to express a concept in a constant evolution. According to the most recent

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definition proposal from INSOR 'the country' is a natural environment, characterized by the majority of 'green areas' than 'built' (Brunori, 1994; Storti, 1998). Green areas in this context are distinguished from those built, by the presence of ecological specificity, which make them able to perform functions that are not only productive, but if properly exploited can also become scenic and cultural. The conservation of agricultural re- sources, the habitats of many species of plants and animals, and the biodiversity, which includes the totality of animal and plant species, genetically dissimilar and within their ecosystem, absolves primary importance in the national and international policies (http://www.coop- erazioneallosviluppo.esteri.it). It is worrisome, based on the data pro- vided by many authoritative sources as the Millennium Ecosystem Assessment and the Global Biodiversity Outlook, that two-thirds of eco- systems worldwide are in decline with over 16.000 species threatened with extinction.

The increase of cultivated areas and those intended to pasture for livestock, land use, the removal of hedges, which are designed as eco- logical corridors, the abuse of pesticides and the constant withdraw- al of surface water for irrigation are among the main causes of biodiversity loss in ecosystems. 2010 is the year declared by the General of the United Nations as the 'International Year of Biodiversity' with the goal of halting by 2020 the loss of biodiversity and the depletion of European ecosystems, favoring when possible their reconstruction. The same organization has defined by 2050, as a long-term goal, the protection and restoration of the natural habitat within the European Union through:

– promoting the development of ecosystems, through the creation of *'green infrastructure'*;

– upgrading sustainable forms of agriculture and forestry;

– encouraging sustainable fisheries; – halting the spread of invasive non species; – globally decreasing the loss of biodiversity.

Green infrastructures are networks of natural and semi-natural areas, planned at the strategic level with other environmental elements and managed so as to provide a broad spectrum of ecosystem services, including supplying goods (food, water, timber), regulating (climate, water), and favoring the protection of water, air and soil and general well- ness (cultural and recreational activities) (http://www.fondazionesvi- lupposostenibile.org). Agriculture, if practiced in a sustainable manner, is able to play a positive role in maintaining biodiversity. The adoption of sustainable farming practices and diversified land usage are in fact the major contributing factor for the conservation of natural re- sources. There are many international projects halting the biodiversity loss. Among these was the Countdown 2010, the working group established by the association of several European countries, governmental organizations and international bodies, which defines biological diversity as the foundation for sustainable development (http://www.iucn. org). Even outside Europe you can identify similar initiatives. We mentioned among them the local development project of nature conservation promoted by the NGO Africa 70 made in some countries such as Benin, Niger and Burkina Faso with the following purposes (http://www. africa70.org) to promote decentralization in the management of natural resources:

– promote the decentralization in the management of natural re- sources;

– promote eco-tourism; – improve and increase production; – develop adequate environmental education.

The evaluation of naturalness degree of a rural area can be achieved by various indicators. Among them, the agricultural area with a high natural value (HVN) and the index of a bird farm (Farmland Bird Index, FBI) are the most established national and international indicators, frequently cited by the Rural Development program and used as a bench- mark. Both indexes were created on the basis of a common methodology among all EU member states.

The calculation of the HVN ties the high naturalness of an area to the presence of semi-natural vegetation (mainly meadows and pastures), the natural elements of the landscape and unique species as an indicator of the degree of biodiversity conservation.

The HVN actually represents areas where "agriculture embodies the main use of the soil and maintains the presence of a high abundance of habitats and/or species considered of great value for all the communi-y" (INEA, 2004; Trisorio et al., 2013). These areas are divided into three categories:

– areas with a high proportion of semi-natural vegetation, such as natural pastures;

– areas with a mosaic of low intensity agriculture and of natural, semi- natural and structural such as hedges, stone walls, groves, vineyards, small streams;

– farmland supporting rare species or a richness in species of specific interest to Europe or the world.

According to Andersen et al. (2003), the use of soil resources, the definition of farming systems and distribution of species, birds in particular, represent three complementary approaches to define HVN areas. Ac- cording to Cooper et al. (2013) an agricultural system with a high natural value must be characterized by a combination of an appropriate land use and landscape (the state) for adequate management (the determining force). A central role is attributed to farms, defined as a technical and economic unit in the territory (also non-contiguous), with its various fixtures and equipment, which the agricultural production and forestry or livestock is generated through different techniques. In fact, these techniques exert dynamic pressure on the 'state' of the system. The processes of intensification and specialization triggered in recent years by technology have contributed to more separation of farms from the sustainable management of natural resources. Understanding the mechanisms leading farms to move away from the 'virtuous' paths is essential to implement appropriate measures of a sustainable agri-environmental policy. From an estimate made in 2013 by INEA, it emerged than 50% of the utilized national agricultural area (UAA) can be considered as high natural value, although only 16% falls within the classes of higher values. The largest contribution is represented by areas, in- tended for permanent grassland, which are concentrated in the northern regions and mountainous areas. At the regional level, the situation is significantly diverse due to different geological areas of Italian territory. The percentages of SAU at high natural value range from 30% in Veneto to a maximum of 90% for Valle d'Aosta, followed by Trentino-Al- to Adige (Trisorio et al., 2013).

The bird farm index (FBI), quoted above, is used as an ornithological indicator used to obtain information about the health of an environment, in relation to the presence of certain species in a specific territory. Birds are great ecological indicators, easily observable through systematic surveys. Responding quickly to changing environments, birds reflect the changes occurring to other groups of wildlife acting as "spies" of the environmental health of a region (Beaufoy - Cooper, 2008). Twenty-five species of birds have been selected in Italy, considering their overall performance since the year 2000. The estimated value of FBI by INEA in 2012 amounted to 88%, down from the initial value set equal to 100% in 2000. A gradual decline in line with the trend in re- cent years is confirmed. Such trend is concentrated in level areas, probably due to a progressive simplification of agricultural systems. This in turn is caused by loss of structural elements of the landscape and the progressive urbanization. Evaluating data in details, significant differences emerge among the different Italian regions. In some regions, like Umbria, Abruzzo, Molise, Campania, Basilicata, Calabria and Sicily, the situation is much improved if compared to 2000, while it worsened in others, such as Lombardy and Sardinia. Other regions follow the national average (INEA, 2012).

The management of irrigation resources: legislative, statistics and other problems

The protection of the quality and quantity of water resources is a priority for the sustainable development of rural areas, especially in Mediterranean countries, in relation to the increasing effects of climate change (EEA, 2012). The importance has become increasingly emphasized in recent years partly because of the strengthening link between some re- cent European directives and the common agricultural policy. This fact led to the definition of common standards of protecting water resources in addition to introducing the issue of rates in reference to the usage, including agriculture. The most important European legislation on water protection are the WFD (*Water Framework Directive,* WFD) 2000/60 / EC and GD (*Directive Groundwater,* GD) 2006/118 / EC specification for the protection of groundwater. Directive 2000/60 / EC, implemented in Italy by Legislative Decree 152/2006, defines the framework for community action through an innovative approach to environmental and management of water resources. The law protects the integrity of rivers, pre- venting all phenomena of deterioration of water quality and quantity, improving their status and ensuring sustainable long-term use. Specifically, the directive pursues the following objectives:

– extend protection for both surface and underground water;

– proceed through an action that combines the limits of emission and quality standards;

– reach the state of 'good' for all water by 31 December 2015;

– manage water resources on the basis of 'hydrographic basins', regardless of the administrative structures;

– permit water services to all at the correct price or rate, taking into account its true economic cost;

– citizens participation in the decisions adopted in the field.

The Directive 2000/60/EC also provides that each member state must protect its water resources at 'river basin' level. The territorial unit of reference for the management of the basin is represented by 'river basin district'. The district is an area of land or sea composed of one or more neighboring river basins together with their associated groundwater and coastal waters. Within each district the individual state must commit to conduct a comprehensive analysis of its characteristics, the specific economics of water usage and to evaluate the impact caused by human activities. The set of analyses carried out with the objectives to be achieved must be indicated in the 'management plans', created for each river basin. Any basin, sectors and issues can be integrated into plans through special programs. Plans then take the meaning of instrument programming and implementation of the WFD. The management plan for each district is represented as a particular instrument of government for surface and underground water bodies through measures of basic implementation, additional protection, rehabilitation and improvement with the ultimate goal of sustainable management. Basic measures are the implementation of EU legislation and are aimed at the recovery of the cost of water service, ensuring an efficient and sustainable use of water resources. Instead, the supplemental concern measures that complement those that are the base. Among the additional measures there are the *river or lake contracts* representing a 'multilevel governance' of a river area. These contracts are realized by signing a voluntary and non-bind- ing agreement among different entities (institutional, economic and social) of a basin for a multidisciplinary and integrated management of the issues involved. The measures to be implemented then, being perceived by the population no longer as 'above', appear to be more effective. The responsible involvement of the population has fundamental importance for the definition of shared policies and effectiveness. The importance of this strategy 'social' appears to be thus established, especially in collaborative projects with countries in the developing world as well as in developed countries. The most advanced experiences in the sector of river contracts concern French watersheds, as early as the 1980's, which led to the creation of over 200 *Contract de Rivière* (CR) followed by those of Belgium, the Netherlands and Spain. Even in Italy contracts are spreading rather quickly especially in some regions such as Lombardy and Piedmont. In Italy eight river basin districts were established through which individual regions define the necessary measures to protect quality and quantity of their water system (Bastiani, 2011). To be effective, the plan needs to be updated periodically. The most innovative aspects of this instrument compared to similar traditional measures are:

– participation, information and active consultation of the public (stakeholders) intended as a responsible citizen and stakeholder through public meetings and also via web;

– grouping in a single means the content of other directives relating to different sectors (agriculture, soil conservation);

– a punctual analysis of each technical and economic adopted strategy.

The Directive 2006/118/EC transposed in Italy by the Legislative Decree 30/2009 enacted in order to protect deep water by the phenomena of deterioration and pollution. Groundwater represents the reserves of freshwater as being the most delicate and substantial in the entire EU territory, and as such must be protected. The directive establishes which ones they are:

– criteria for assessing the chemical status of groundwater;

– criteria for the identification and reversal of significant and sustained upward trends of pollution;

– guidelines for the setting of “thresholds” on the part of the countries.

The same also complements the provisions already provided by the Directive 2000/60/EC intended to prevent or limit input of pollutants into groundwater by defining different states of quality. The environmental state in quality or ecology of a body of groundwater is determined on the basis of its quantitative and chemical status. The quantitative monitoring has the purpose to obtain information relating to aquifer vessels. This is important to the definition of water balance of the basin, that allows the characterization of individual aquifers in terms of potential, productivity and degree of exploitation. The chemical status is determined by the presence of pollutants derived from anthropogenic pressures (nitrates, phosphates, heavy metals). According to the ecological status it is possible to classify underground water in five categories.

The data collected by numerous experimental stations located in all Italian regions revealed that 84% of surface water samples is characterized by good ecological status, and high in some cases. With regard to the quality of groundwater it has been found that 70% of the samples are in a good state while the remaining 30% are poor. Sardinia, Sicily and Lombardy are the regions with most problems in the quality of deep water (INEA, 2012). The *Plan for the Protection of Europe's water resources* (Blueprint) drawn up by the European Commission in 2012 shows that 43% of freshwater analyzed at a European level presents a good ecological status (http://ec.europa.eu/environment/water/blueprint). This percentage is expected to rise to 53% by 2015 by means of additional measures required by the river basin management plan. Agriculture represents a significantly important industry for the impact that human activity may have on water resources in terms of quantity and quality. The first are caused by the massive withdrawal of water from surface and underground water bodies. According to a recent survey by the OECD at the Europe- an level 33% of total water consumption is behalf of the agricultural sector. The southern European countries like Portugal, Spain and Italy are the biggest consumers, in fact, reaching peaks up to 80% in certain seasons (EEA, 2012). It is also demonstrated in the data obtained from a survey carried out at the national level in 2010 by ISTAT. An apparent increased incidence of utilized agricultural area (UAA) in the North, while a slight reduction in the Center-South (ISTAT, 2010). A third of UAA present in northern regions is irrigated, with high values for arable and permanent crops while reduced for meadows and pastures in mountainous areas. The central regions have low water consumption due to the spread of crops with low water requirements such as the olive tree and grapevine. In the South, irrigation use turns out to be slightly higher than the previous case especially for vegetable crops and citrus groves. Inorganic substances such as nitrates, sulfates, fluorides, chlorides, boron, with some heavy metals and pesticide residues are among the chemical parameters which contribute most to the phenomenon of qualitative scarcity of a water body. From Italian waters monitoring performed by INSPRA in 2010 was demonstrated a fairly high level of pesticide contamination, especially in the Po Valley because of the specific hydrological characteristics and agricultural production intensity (INEA, 2012, 2013). Thirty-four per- cent of the selected points for monitoring surface water and 12% of those for deep water present values over the maximum limit allowed for drinking water. The monitoring has also shown an increase of 28% relative to the number of detected pesticides in various samples. In most cases, it is due to residues of plant protection products used in agriculture, but also of biocides, which are applied in various fields of activity. The improvement in analytical techniques for the analysis of chemical residues allowed in recent years to detect levels of contamination by triazine herbicides and their metabolites. Note also the consistent detection of glyphosate and its metabolite AMPA (INEA, 2012). The increase of other substances in water such as inorganic nitrogen (nitrate, nitrite, ammonium form) and phosphorus (inorganic phosphate) deriving from other than the agricultural sector is the increasing industrialization that has fostered over time the appearance of eutrophic phenomena resulting in higher algal organ- isms (*bloom*) above levels considered physiological. The progressive increase of fertilization levels in water has led to the development of 'border species' such as cyanobacteria and blue-green algae producing toxins (cyanotoxins and microcystins) that are toxic to man and animals. This problem has affected many countries over the years not only in the European belt, but even the United States of America, Australia, Japan and South Africa. The gradual warming of the earth and water with reduced levels of oxygen solubility, the reduction of pre- cipitation especially in some areas of the globe, the sharp drop in the level of water due to withdrawals for domestic, industrial, agricultural and recreational use have contributed to worsen this problem. Ac- cording to some authors, besides some of the toxins produced and accumulated on the lacustrine basin it appears that they can penetrate through the geological strata until they reach the water table. These can then migrate to water of artesian wells, reaching the city water supply (ISTISAN, 2011). Proper manure management in areas with intensive farming with high specialization has therefore a strategic importance to reduce the eutrophication, as stated by the EU Nitrates Directive 91/676 / EEC, implemented in Italy with Legislative Decree 152/1999 and replaced by Legislative Decree 152/2006.

In particular, the Directive defines: – the vulnerable zones from nitrates of agricultural sources" (VZNs), as areas where water quality is or could be compromised, if nothing is done promptly due to the presence of pressures of an agricultural type; – the degree of impairment of water resources, based on the levels of nitrates in groundwater that should not exceed 50 mg/L; – 'program of action' that sets specific constraints to the use of agronomic livestock manure and wastewater from small agribusiness companies. Between those most relevant, the maximum annual contribution of nitrogen source in livestock VZN areas equal to 170 kg/ha with possible exemptions.

Nationally the majority of livestock productions is concentrated in the northern regions, which are consequently also the most vulnerable. Ac- cording to the population census conducted in 2010 nationwide, there were 305,000 farms raising 10 million adult cattle units (LUs). They generate a load of cattle equal to 0.8 LU/ha with peaks of 1.5-2 LU/ha in Lombardy, Emilia Romagna, Piedmont and Veneto. In these, the percentage of nitrates was estimated to be equal to 25-30% of the utilized agricultural area (UAA).

The livestock unit per hectare of agricultural useful (LU / ha) is an important indicator to describe the overall livestock pressure on agro- ecosystems, with particular reference to its impact on the quality of soil and water. This unit is obtained by applying a system of weighted coefficient amounts, measured on an annual basis, to the different species of animals bred, in order to make them consistent and comparable over time.

Throughout the Italian national territory between 2004 and 2011 in relation to water pollution caused by nitrates, highlights show the situation is improving on average with regard to surface water while it is stable for deep water (INEA, 2012). A high factor in deterioration of the quality of water resources is represented by the rising values in acidity and salinity. The phenomenon of acidity is strongly linked to progressive industrialization, the main cause of acid rain due to the contamination of rain-water, which emits gases into the atmosphere such as carbon dioxide, sulfur dioxide and nitrogen dioxide. There are several harmful effects up- on the aquatic and terrestrial systems. These effects may be direct for the increase of water toxicity, resulting in the indirect disappearance of some aquatic species that are most sensitive such as diatoms and brown algae. In time, consequential damages can also affect humans. It was demonstrated that plants or animals, such as fish that were grown or raised, respectively, in water with 'acidic' tendency will easily bio-accumulate heavy metals (Cr^{6+}, Hg^{2+}, Cd^{2+}, Cu^{2+}) (http://www.ISPRAmbiente.it). Even an improper use of irrigation practices, in addition to exercising a negative impact on the reproducibility of water resources, can cause a reduction in soil fertility due to the level of salinity. More than half of the irrigated areas in the world have high levels of salinity because of the inadequate irrigation methods, in addition to poor water quality (Netwet 3 project). This problem is increasing in an exponential way in respect to irrigated areas causing a significant limitation for agriculture in many mediterranean countries, especially in coastal areas. In fact, the withdrawal of water from aquifers, often exceeding the regenerative capacity of aquifers, causes a reduction in river flow, alteration at the ecological level, de- crease in groundwater levels and infiltration of salt water.

Table 1 - *Environmental state of deep water*

Status	*Description*
HIGH	Negligible or nil human impact on the quality and quantity of the resources, with the exception of the provisions in the natural state
GOOD	Reduced human impact on the quality and/or quantity of the resource
ENOUGH	Human impact on the amount reduced, with significant effects on the quality that would require targeted actions to prevent their deterioration
POOR	Relevant human impact on the quality and/or quantity of the resource with the need for specific rehabilitation
PARTICULAR AND NATURAL	Qualitative and/or quantitative that while not presenting a significant anthropic impact have restrictions on use of the resource for the presence of specific natural chemicals or due to the potential low quantity

Possible strategies for water conservation: reduce consumption by increasing efficiency in usage

It is necessary to begin from the cause of the actual failure according to Hamdy et al. (2002), based on the frequent water usage disconnect- ed from the real needs of cultivation, for a sustainable management of water resources through a diffusion of sustainable agricultural practices that promote:

– an increase in water productivity (*water productivity*); – a smaller, but more efficient use (*water use efficiency*, WUE).

The 'Water productivity' (product units/m^3) measures the ability of a production system (agriculture, livestock-industrial) to convert the water input in products and / or services. The higher water productivity the greater the products obtained. The 'Water use efficiency' also known as 'water intensity' (m^3/product unit) represents how much water is needed to produce a unit of product. It is the inverse of water productivity (EEA, 2012). The lower the demand of water to produce a unit of product and greater will be the efficiency of the production sys- tem (Todorovic et al., 2007). Several strategies allow you to pursue these objectives, recognized and promoted in numerous documents (FAO, 2002). The transition from traditional irrigational techniques, applying large volumes of water on the whole surface of the plot (sprinkler irrigation and scroll) to localized (drip irrigation, underground, sub-irrigation) employing a more rational manner on such a resource, allows the reduction of enormous consumption in favor of improved efficient use, as well as ensure a good drainage with a decrease in soil salinization. Interestingly, the data provided by MARM/BPIA (2009) attest that from 2002 to 2008 agricultural areas irrigated with sprinkler systems in Spain had reduced from 1.4 to 1 million hectares, with an increase in drip irrigation systems from 1.1 to 1.6 million hectares. The improvement of irrigated crops, working on new varieties combined with the maintenance of the moisture content in the soil, through agricultural techniques al- ready established in time, can significantly reduce water supply, taking advantage of the meteoric, often overlooked.

This strategy has a certain importance, especially in arid and semi-ar- id regions at risk of desertification. Crop resistance depends in part by the depth of its root system. Grapevine, sorghum and alfalfa compared to corn or peas are more drought resistant crops because of their deep root system. Early sowing of some crops allows the exploitation of water re- serves accumulated in the soil during the winter months. Any additional water supplies are then reduced as well as evapotranspiration loss. How- ever, water stress of crops should not always be considered negative when it comes to the high revenues. Many studies on some crops of the genus Vitis and Aloe have demonstrated an increase in qualitative characteristics of the final product due to limited water stress over time (Fereres - Evans, 2006; Lucini et al., 2009). Meteoric waters, as previously mentioned, may represent an alternative water resource to that of groundwater. The exploitation of rainwater for agricultural purposes can occur through three main techniques for containment and conservation:

– exploitation of water resources in situ, through the creation of microstructures that channel rainwater towards rows composed of specific plants and / or varieties;

– storage for supplementary irrigation by collecting external water from the catchment area, in storage areas in the periods of non-use;

– flood irrigation by means of catchment and channeling external water from the area of catchment to the crop field.

There are several impervious surfaces such as roofs of buildings, which can be exploited to collect rainwater then stored in tanks. Each of the above strategies formulated by FAO must necessarily be combined with appropriate agricultural techniques and the specific conditions pedo-climatic territorial in order to optimize the efficient use of water re-sources (FAO, 2002).

Another interesting solution for the prevention of water waste and promoted by FAO is represented by the re-use of wastewater from sewers. These waters could be used for agricultural purposes after specific treatments for the chemical and biological stabilization, as suggested by the research Med-EUWI (2007) (http://www.sipe-rtd.info/directive/re- port-integrated). The use of 'fresh' water would be reduced and prevent spillage into the sea or lakes with subsequent environmental problems. The growing competition for water usage between different sectors is favored by water stress, increasingly low rainfall, and dense population. Search for new provisions of sources where possible result as strategic. The use of waste water especially in some sectors such as agriculture and urbans could partially answer for the growing risk of water scarcity and drought. Many problems make this path difficult:

– the free circulation of agricultural products irrigated with reused water;

– the inadequacy of water pricing models; – low awareness of the benefits of water reuse by concerned subjects; – the lack of acceptance by citizens.

Table 2 - *Measure to fight situations at risk of drought*

CONTEXT	*Strong runoff*	*Periodic crops with lack of water resources*	*Periods of drought during critical moments*
WATER USE STRATEGIES	Valorization of water in situ	Irrigation by floods	Accumulation for supplementary irrigation
SPECIFIC TECHNIQUES	Creating terraces in crescent shape that follow level lines, furrows and bumps	Use of floods for irrigation through temporary deviation of streams with groundwater recharge	Surface and underground dams

Source: FAO, 2002.

We recall in this context an interesting strategy applied for several years at the Olympic Park in London, one of the largest urban green areas, which employs 580 m^3 of purified water per day for irrigation (https:// www.gov.uk/government/publications). Even the 'gray' waters deriving from households (kitchen, showers, sinks, washing machines) with the exception of those coming from the toilet, can present many application advantages, reducing the use of fresh water. The water coming from kitchens is less preferable than others due to the increased contamination level. The use of gray water turns out to be less problematic and more sustainable than wastewater because of the limited treatment requested (EEA, 2012). Short periods of sedimentation apparently are more than sufficient to improve its biological quality.

Soil: a resource to protect from different forms of decay

The soil is a thin, porous and biologically active medium, resulting from complex and continuous phenomena of interaction between human activities and chemical and physical processes that take place in the contact zone between the atmosphere, hydrosphere, lithosphere and bio- sphere (ISPRA, 2013; European Commission, 2012 46 COM, SWD 101). Composed of mineral particles, organic matter, water, air and living organisms contribute in forming it in an extremely long time. For man- kind, according to the European Commission, soil in natural conditions provides many necessary ecosystem services for its own support (European Commission, 2006; Turbé et al., 2010): – procurement of food, biomass and raw materials; – climate regulation services, capture and storage of carbon, control of erosion and nutrients, regulation of water quality, protection and mitigation of the hydrological phenomenon;

– services of physical support for the decomposition and mineralization of organic material, creating habitats for species, gene pool and biodiversity conservation;

– recreational facilities that define the soil as 'natural heritage'.

Because of this wide range of services and for the extremely vast time period for soil formation as a limited resource, the need to preserve it in time arises (ISPRA, 2014). Incorrect farming, zoo technics and forestry as well as the dynamics of settlement are the main causes of the degradation process (European Commission, 2012 46 COM, SWD 101). The latter are mainly attributable to three major categories:

– chemical degradation; – biological degradation; – physical degradation.

The whole process of acidification, salinization and local contamination are often spread into the environment due to man-made sub- stances such as pesticides and heavy metals, which are the main causes of chemical degradation of the land. Salinization, as specified in the section of water, is an accumulation of soluble salts in soil followed by natural events or human interaction. It has been estimated as in developing countries irrigation activity made with shoddy pipes and canals contributes to the phenomenon of salinization of about 500,000 hectares/year of land (http://www.arpa.emr.it). Pumping water from the subsoil combined with the entrance of saline water in groundwater tends to foster processes of subsidence inducing a progressive de- cline of land in respect to the ground level (Netwet 3 project). The chemical degradation, in this context, is strongly connected to the physical, which jeopardizes the hydrogeological stability of entire regions. The change in the composition of telluric micro-fauna causes the reduction of biodiversity and organic matter content resulting in biological degradation. Physical degradation, which often manifests visually with landslides and floods, is caused by the set of numerous processes such as erosion, waterproofing, compression and desertification. Erosion is a removal of soil particles. It is wrought from atmospheric agents, but also by living organisms and gravitational phenomena in response to some human practices, which cause the loss of fertile soil, an increase of sediments in surface water and the phenomenon of eutrophication. According to the latest estimates made by the UNEP (Environmental Program UN), about 39% of the land surface is subject to erosion while 70% of cultivated arid land has obvious signs of deterioration (Iannetta, 2007; http://cordis.europa.eu). When a permanent cover is made on part of a land with artificial materials and not permeable it triggers the phenomenon of sealing, al- so known by the term of cementification, now exceeding inasmuch its limit (ISPRA, 2014). Recently released data by ISPRA showed how at a national level the sealed soil increased from 2.8% in 1956 to 6.9% in 2010 (ISPRA, 2014). In this context, agriculture within certain limits as already mentioned in the section of water, is capable of preserving the land. The agricultural sector is to be connected to this phenomenon as the indirect and not as the primary cause. For example, con- sider the highways or areas of loading/unloading for the transportation and storage of raw materials of farms. Waterproofing is the most impactful artificial form of coverage that can cause partial or total loss of soil resources (Gardi et al., 2013). Its removal for excavation represents a form of total loss, while the phenomena of contamination and compaction following the construction of industrial plants, but also unsustainable intensive farming involves a partial loss (ISPRA, 2014). This problem is mainly due to the urban and productive extension to- ward the agricultural areas favoring the passage from an agricultural coverage, natural or semi-natural (soil not consumed) to an artificial (soil consumed) able to permanently alter all of the functions of the initial space. In this context, the growing waterproofing of the territory generates a negative phenomenon known as ‘land use’ to be associated, as a concept, according to the Directive 2007/2/EC, as a loss of natural resources for biological and physical occupation of agricultural land, wooded, semi-natural areas and water bodies (Pilieri, 2009; ISTAT, 2012). The land use in Italy is a complex process and not homogeneous due to the different morphology of the country. In its cur- rent state there are still few accurate and detailed data because of the absence of standard methodologies recognized as the measure (Iannetta, 2007). Lombardy, Veneto, Emilia Romagna and Lazio are the regions most affected by this issue that is already manifest since fifty years and which has worsened in the last decade. The majority of the regions of the South are characterized by the presence of urbanized areas still inferior by 5% than the national average (ISTAT, 2012). According to the results of the Lucas project at a European level, Italy is in fourth place after the Netherlands, Belgium and Luxembourg for land use (European Project Lucas). The phenomenon of waterproofing and the consequent land consumption due to the difficult and costly exercise irreversibly causes many negative effects on the environment (Pilieri, 2007). For example, consider the problem of surface water retention that struggles to penetrate the soil, compromising the productive function of the soil as a result of the reduction in the level of fertility and biodiversity, alteration of the landscape, eco- system, climate and hydro-geological structure. Relatively, the level of biodiversity present in the subsoil as well as in the surface is compromised. Also, the fundamental processes such as decomposition of the organic substance, nutrient recycling, the capture and storage of car- bon directly connected to the productivity of a soil are strongly altered (Turbé et al., 2010). The same level of evapotranspiration of a sealed soil is compromised, reducing considerably. The interaction between human activity and land coverage can define the concept of 'use of soil', a description of the type of programmed socio-economic use of a planned territory (Directive 2007/2/EC). The report that the agricultural sector shows with respect to the previous issue results to be narrower. An example of this phenomenon is given by all the areas converted to agricultural, forestry as well as residential, industrial, commercial and recreational with the exception of those open in natural and semi-natural urban areas (ISPRA, 2013). The growing number of areas covered by buildings, roads, mining areas, landfills, construction sites, areas and other paved areas or packed dirt, permanent covers, airports and ports, waterproof sport fields, railways and other infrastructures, photovoltaic panels and all other waterproofed areas, not necessarily urban, represent the most cases of territorial trans- formation (ISPRA, 2013; European Commission, 2012 46 COM, SWD 101; Romano - Zullo, 2013). In order to clearly define the concept of 'land use', the European Environment Agency and the Joint Research Center have created the triangle transitions. Each vertex represents a possible cover, each side a possible transformation transient or permanent, with a natural, artificial or semi-natural result.

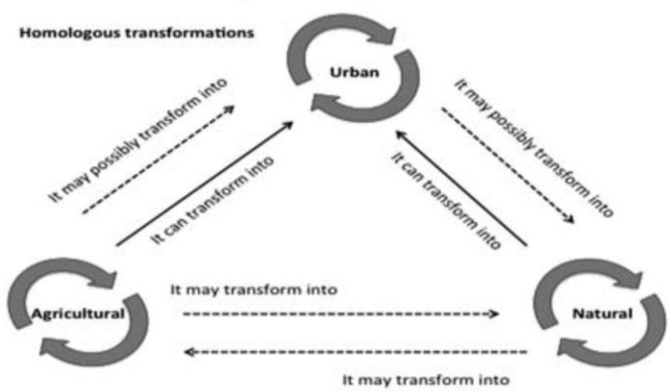
The balance between land use and the increase of agricultural land, natural and semi-natural after recovery interventions, demolition, de-sealing is possible to determine the 'consumption net soil' (European Commission, 2012 46 COM, SWD 101). The processes of use and consumption of soil raise some interest at a legislative level, but with some delay. In fact a demonstration of the national bill concerning the enhancement of agricultural areas and containment of the consumption of soil:

– establishes a maximum extension of consumption in annual agricultural land nationwide;

– proposes processes of recovery and regeneration of urban areas, but unused;

– establishes the prohibition of use, for purposes other than agricultural, land which benefited from state agricultural incentives for at least five years from the last delivery. All instrumental interventions to the running of farms including agriturisms are excluded.

Figure 1 - *Triangle transitions*



Source: National Observatory on consumption of land, 2009.

At present there are only proposals in this regard and no official law. Even at a European level, the regulatory framework appears to be rather weak (European Commission, 2002). In 2012, the Commission published an interesting report aimed at reducing the risk of agricultural land sealing. The EU documents affirm the importance of maintaining the agro-forestry areas of hills and mountains in order to properly maintain them as well as prevent the instability and land degradation phenomena (land- slides, erosion, compaction and loss of organic matter). According to the ISPRA 2012 report, active and inactive landslides in Italy were more than 486,000, including 5,700 municipalities or 70% of the total. 30% of the Italian territory also presents the phenomena of soil loss by water erosion estimated at more than 10 tons/ha/year (INEA 2012, 2013). In this context, reforestation programs in addition to promoting the use of sewage sludge and compost certified in agriculture for the recovery of the organic substance serve a great importance for soil conservation. Excessive mechanical pressures, exercised for a long time on the same surface, cause the problem of compression. Just think, for example of some intensive farming techniques still frequent in some areas, involving the use of heavy equipment, the overgrazing with the elimination of useful vegetation for protecting soil from erosion, the total removal of organic material from the soil (after the phases of harvesting and pruning) that during the rainy season remains bare, irrigation systems damaging soil structure, removal of riparian stabilizing river banks and even the adoption of monoculture as a practice prevalent in some areas to the detriment of biodiversity (Netwet 3 project). The abandonment of some traditional agricultural practices always deemed sustainable has favored land degradation. Planned grazing, maintaining wooded areas for stabilizing the sloping areas, crop rotation contribute to reducing soil degradation and preserving the quality (Netwet 3 project). The loss of fertility that numerous lands face and the fragile ecosystem often precede the phenomenon of desertification, the most extreme stage of degradation of a territory that affects arid, semi-arid and dry sub-humid areas. Aridity is a real climatic characteristic that concerns diverse degrees of intensity in the 47% of the land surface of the planet, characterized by lack of rain, high temperatures and a scarce presence of vegetation. Recent studies suggest that this environ- mental emergency tends to spread gradually in stages from limited areas to those more extended of the planet (http://www.arpa.emr.it). World- wide more than one hundred countries are at risk of desertification. The situation is dramatic in Africa where 73% of cultivated arid lands are subject to this phenomenon accentuating the existing problems such as poverty, famine, migratory exoduses and political, economic and social tensions as stated by the National Committee to Combat Drought and Desertification (UNCCD; Ministero dell'Ambiente, 1999, GU n. 43). These are- as are more at risk than others because of the unfavorable characteristics of its soils associated with water balance protracted negative in time. Similar problems are also present in Asia and Latin America as well as in developed countries as the United States and Russia, mainly due to the presence of fragile ecosystems (http://www.arpa.emr.it). The desertification phenomenon is triggered by the combination of a series of natural and anthropic causes as claimed by the United Nations Convention to Combat Drought and Desertification (UNCCD) (Sciortino et al., 2000). The main natural causes are:

– predisposing morphology and topography. Land slopes reduce the penetration of water in the ground, increasing the strong exposure of the slope to sunlight and the wind, causing a favorable microclimate for plant growth;

– changes in decline in rainfall patterns with prolonged periods of drought and rising of average annual temperatures;

– aridity, namely a rapid evapotranspiration in conjunction with the lack of rain with the consequent removal of moisture in soils and vegetation;

– disintegration and transport of soil particles devoid of vegetation cover, due to the increasingly short and intense erosive rain as previously reported by the National Action Programme Combat Desertification (PAN) to Italy in 1999;

– abrupt alternation between dry periods, in which the phenomenon of desertification rapidly extends and humidity regresses temporarily.

The anthropogenic causes include: – high frequency of forest fires with reduction of the plant coverage

and the degree of soil permeability, alteration of the components of animals and plants, destruction of organic matter and alkalization of land; – erroneous irrigation techniques which increase the risk of soil erosion as a result of alteration of some structural parameters;

- unsustainable use of surface and ground water resulting in the salinization phenomena, especially in coastal areas; – abandonment of many extra-marginal areas especially the most internal;
- – removal of fertile agricultural land with consequent waterproofing for the growing urbanization (expansion of cities and villages, illegal construction, tourism and landfills).

Because of these many facets that desertification can assume, it is difficult to define and monitor in a unique way. The same level of aware- ness of the progressive loss of fertility of the land by man still seems to be nonexistent. An area subject to desertification is always characterized by a progressive reduction of the surface layer of soil and its relative capacity of production. The UNCCD aims to identify a range of long-term integrated strategies, to simultaneously focus on an integrated protection of different resources (land, water, vegetation, landscape and human labor) in areas affected by degradation. Living conditions in this way are improved. One hundred ninety-one countries adhere to the UNCCD and are defined as ‘the parties’ involved with particular attention to African issues for the known socio-economic problems. The parties differ in affect and development. It is up to the first for the implementation of specific programs of action against national desertification (PAN). Developed countries should cooperate with those affected through scientific and economic support. The PAN is associated with additional region- al programs (RAP) and sub-regional (SRAP). The PANs are developed by individual countries in order to identify the contributing factors of desertification, identifying intervention strategies. Sub-regional and regional programs integrate and reinforce, instead the PAN coordinates national interventions. Italy, in this context, is part of the Convention as a ‘donor’ country, but also as ‘affected’ by desertification and drought phenomena. Among the most significant international projects there are the ‘Integrated Rural Project Development of Keita’ implemented in Niger by numerous works of land reclamation that has helped to stop ‘the progress of sand extension’ and the ‘National Program to combat desertification’ that is contributing to the reforestation of some areas of southern Tunisia. This project provides the planting of several forest species (ornamental, melliferous and forage) in an area of about 2,000 hectares, the construction of appropriate irrigation systems and the pro- motion of a network of small agricultural enterprises for creating in- come, and avoiding the abandonment of the area. Interestingly, the European project entitled ‘Environmental recovery of degraded soils and desertified by a new treatment technology for land reconstruction’ implemented for several years in the Italian territory in the province of Piacenza, which involves the reconstruction of chemical-physical degraded soils and desertified (European Project Life +). In 1999, the Nation- al Committee to Combat Drought and Desertification (UNCCD) in implementation of the UNCCD has made certain important guidelines to combat drought (OJ No. 43 1999). The main actions, still deemed valid, identify the following areas of action:

– soil protection in particular all the agricultural areas in intensive production and marginal; areas at risk of accelerated erosion; areas degraded by contamination, pollution, fires; uncultivated and abandoned areas. Provided are a number of interventions to be implemented such as:

• sustainable management and expansion of the local forests;

• diffusion of Mediterranean species through the development of nursery production;

• land management through planning that primarily takes into ac- count the suitability of soils;

• preventing and fighting fires through information;

• establishment of a National and European Pedological Service as a function for soil data collection throughout all territories;

• naturalization of waterways, remediation measures and hydraulic-forestry adjustment of mountain basins;

• evaluation at the local level of the degree of environmental compatibility for structural territorial intervention;

• evaluation of the phenomena of biological alteration of the sea (non-native species, biodiversity, mucilage) – sustainable management of water resources; – reduction of the impact of human activities by:

• adoption of good practices truly sustainable in all sectors of agriculture, forestry and zoo-technic able to reduce physical, chemical and biological degradation;

• production of high quality compost from the organic fraction from municipal solid waste (MSW), following recycling and from the agricultural sector;

• reducing pressure from tourism activities through incentives to seasonally adjust and diversify supply, reducing water consumption especially in the most vulnerable areas – rebalancing the territory by:

• socio-economic policies for the recovery of the value of production and landscape of areas subject to degradation (remediation of contaminated sites and de-proofing);

• incentives for productive activities and sustainable tourism in marginal areas (hills and mountains);

• adoption of urban plans incorporating the use of technology oriented towards the appropriate use of resources;

• allocation of funds for the realization of infrastructure projects that create disadvantages for the desertification in countries less affected by desertification as well as in poorer countries like the African ones.

The problems of fertility in soil subject to degradation

The fertility of soil is defined as the ability in itself to provide essential nutrients and water in adequate quantities for the growth and reproduction of plants, with the absence of toxic substances (http://www.fao. org/ag). Soil is made up of five components:

– mineral particles resulting from the disintegration of rocks;

– organic material, which result from the decomposition of vegetable substrates;

– water in which the nutrients are dissolved; – land-based air (carbon dioxide and oxygen); – living organisms, including bacteria, which contribute to the processes of decomposition.

These, in turn, can be grouped in three main factors of soil fertility namely those of physical, chemical and biological from which an agronomic fertility interaction is generated, also called integral. It strongly depends on the productive level of the soil. Relative to the first two factors and compared to the biological, being generally stable over time, extensive knowledge in the scientific field is achieved. The studies of the factors of biological nature are more problematic, and are extremely dynamic because of their nature. The biological fertility refers to the activity of the biotic component of a plot, strongly linked to the nutrition- al level. Some scholars agree that the study of the biotic factors of a soil can quickly locate any state of degradation, thereby effecting rapid intervention strategies (CRA, 2009). The biotic component is represented by all the living organisms present in soil such as bacteria, fungi, actinomycetes, algae, micro and meso fauna. These are responsible for numerous processes and actions such as the protection of plant roots, fixation of atmospheric nitrogen, disintegration and degradation of the land and its organic components, mineralization, namely the release of similar substances and the production of humus. The physical components of soil are represented by the texture and structure; the latter de- fined as the ability of aggregate formation. Soil that is well structured represents good porosity necessary for the radical development as well as for water and oxygen retention. The phenomena of soil compaction subject to degradation can then alter these properties. Even the weaving understood as the percentage of the component of sand, silt and clay influence biological properties. The presence of clay in soil compared with the sandy component, for example, favors a greater retention of water and mineral elements. However, if subjected for a long time to physical pressure, it tends to compact easily, destructurizing. The nutrients and the forms in which they are present in soil, the levels of mineralization, the degree of reaction (pH) and the exchange capacity (CSC) are among the chemical components of the most influential soil fertility content. Sixteen nutrients deemed essential and classified as macro and micro nutrients are required for a plants normal growth and reproduction. Among the macronutrients there are carbon, hydrogen and oxygen supplied from the air and water; nitrogen, phosphorus, potassium and calcium that come from the soil and in part from the air; magnesium and sulfur only derived from the ground. The remaining is de- fined as trace minerals, absorbed only through the soil (http://www.in- fonet-biovision.org/default). The soil degradation phenomena caused by aridity and desertification, affects about 41% of the world surface. It supports over 38% of the food necessity required by the human population. The competitive use of arable land and its degradation have reduced the amount beyond the quality of the soil resources and available water for the productive purpose. This phenomenon does not only affect developed countries, but also developing countries. In Africa 6.3 million hectares of land are subject to physical degradation, chemical and biological enormously compromising the production capacity (http://www.fao.org/tc/exact/sustainable-agriculture). These degradations, if not mitigated and/or prevented by man through appropriate management techniques changing in time, the biogeochemical cycles of nutrients in the soil, reduce production levels. The phenomenon, as supported by research conducted in sixteen countries whose results were published in 2013 in the “Nature journal”, presents as a main consequence the reduction of content in organic carbon, nitrogen and an increase in phosphorus. The carbon and nitrogen cycles, being heavily dependent on biological processes, become changed in the context of the shortage of organic matter. The increasing tendency of values of phosphorus in degraded land is due to the increasing erosion, and the severe shortage of ground cover and moisture content in soil (5-15% less by 2099) (Cooper et al., 2013). The degree of reaction of soil can be altered, in a long period of time, for the effect of the phenomena of environmental degradation. Soils that reach values in pH tend to be acidic are rich in manganese, but often deficient in cobalt, being among the essential elements for the development of nitrogen-fixing bacteria, not compromising its function. The level of fertility is reduced. In case the levels of acidity are even higher, you can attend to the immobilization of phosphorus in insoluble complexes and therefore not available to be used by crops (http://www.fao.org/ag). By CSC, strongly dependent of the presence of clay and organic substances, however, it depends on the exchange and absorption of mineral elements of soil with the solution working. The organic substance is decomposed into mineral components through the mineralization, which is useful for plant nutrition. In the process, humus is the most stable component, which performs stabilizing functions for the structure of the soil, resisting the phenomena of depletion of the organic carbon reserve. Reduced content in humus is typical of soils subjected to desertification, which are unstructured and unstable. By the interaction of the organic substance with the three components of the soil, as previously described, the necessary synergy is generated for the preservation of land fertility that over time must maintain a very diverse and biologically active fauna and flora, a typical structure for its localization and a capacity of an intact degradation. The loss of organic substance and the related deterioration in quality represent a re- al problem for soil, especially in the area of the Mediterranean (CRA, 2009). The chemical, physical and biological factors are closely inter- connected, but different in ratios depending on the treated areas. In relation to the specific environmental issues of an area, it is possible to carry out a study of the level of fertility only after identifying the agri-environmental indicators, which are more significant of a territory. The evaluation of the integral fertility of the soil and the direction of its change represents the primary indicator for a sustainable management, in or- der to meet the needs of the world population that will double by 2050 according to the recent estimates (http://www.fao.org/tc/exact/sustainable-agriculture; Karlen et al., 1997). With the aim to alleviate world poverty, guarantee an income to the rural population, increase productivity in cultivated areas, ensure secure food production, as well as protection of soil fertility, in 1996 was founded the Soil Fertility Initiative (SFI). The initiative, aimed at all countries that are prone to agricultural land degradation, was initiated with the support of the World Bank and FAO. SFI operates through international projects aimed at the transfer of necessary agricultural strategies to restore fertility as well as to bring awareness to the issues faced by the rural population. These objectives are made possible through the implementation of training courses promoted in the territory and with the support from local governments. A good example is the Farmer Field Schools Innovative established in numerous African countries (http://www.fao.org/nr/land/sustainable).

Final remarks

The protection of natural resources that make up the agroecosystem is a key priority to be pursued over time, especially at a time when two-thirds of the world's ecosystems are in serious decline. The degradation of the various environmental media as a whole involves a progressive decline of biodiversity having primary importance for the sustainable development of an area. There are numerous difficulties encountered in pursuing this end. First of all, the rapid evolution of the concept of landscape, which could be described and regulated inadequately, especially in developed countries, due to the rapid evolution. The agricultural sector exerts on the territory different dynamic pressures, covered within certain limits, a central role for the preservation. With regard to the qualitative and quantitative protection of water resources most Italian shallow and deep waters, in line with the European, have good ecological status, highlighting the effectiveness of application of the numerous European and national standards in the field. The gradual lowering of the water table, in recent years in many countries of the mediterranean region, has favored a gradual infiltration of salt water, representing a significant limit for farming. The adoption of sustainable practices, to re- duce water consumption to the real cultivational needs, maximizing the effectiveness of employment has allowed to considerably lower waste in the sector. With regard to factors of degradation of soil resources, com- pared to the previous year, you can report the lack of specific regulations both domestically and internationally due to the lack of shared standard methodologies.

The greater problem among those mentioned in this essay shall be represented by desertification, extremely difficult to monitor because of the many facets that can take over its negative effects, evident only in the long term. This phenomenon is subject to almost half of the land, especially those areas with fragile ecosystems. The progressive loss of organic matter, especially fractions stabilizing structure as humus, is a factor of biological degradation of the soil, which may, if protracted, lead to desertification. The adoption of adequate intervention policies shared by the various players of the system, primarily by farmers, will increasingly approach 'virtuous' paths by an environmental point of view, helping to preserve the natural resources of the planet for future generations.

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KEYWORDS: environmental impacts; agriculture; desertification.

ABSTRACT

The loss of biodiversity is the main consequence of the degradation of the Planet’s natural resources. The water resource must be quality and quantity protect- ed. Water salinization seems to be in many Mediterranean areas an emerging problem. Greater protection, particularly in primary sectors, is only possible through the identification of many strategies aimed at reducing consumption by increasing the efficiency of use and productivity. The soil is subjected to different types of degradation (chemical, biological and physical). Desertification is a major problem, affecting almost half of the areas emerged and with fragile ecosystems. It is still little known because of the many facets that can take, making difficult to define and monitor it. There are deficiencies in soil protection regulations. The adoption of integrated security policies, sustainable and shared by different subject area seems to be the best solution to preserve the different resources over time.

RIASSUNTO

La perdita di biodiversità rappresenta la principale conseguenza di deterioramento delle risorse naturali del Pianeta. Relativamente al comparto acqua, emerge la necessità di una maggiore tutela

quali-quantitativa. La salinizzazione delle acque pare essere in numerose aree mediterranee la problematica emergente. Una maggiore protezione delle risorse, specie in alcuni settori come quello primario, è possibile solamente attraverso l'individuazione di strategie volte alla riduzione dei consumi, incrementando l'efficienza d'impiego e la produttività. Il comparto suolo è invece soggetto a differenti forme di degrado come quello chimico, biologico e fisico. Nell'ambito di quello fisico, la desertificazione risulta essere la problematica maggiore, che interessa quasi la metà delle aree emerse e dotate di ecosistemi fragili. Il fenomeno è ancora poco conosciuto a causa delle numerose sfaccettature che può assumere, rendendo difficoltoso definirlo e monitorarlo. Ne conseguono carenze normative di tutela a riguardo. L'adozione di politiche di protezione integrate, sostenibili e ampiamente condivise dai differenti attori di un territorio, come già mostrato in alcuni settori, pare essere la soluzione migliore per preservare le differenti risorse nel tempo.