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EVOLUTIONS AND TRENDS IN AGRICULTURAL SUSTAINABLE USE OF NATURAL RESOURCES

ABSTRACT

A sustainable development requirement consists in the conservation and enhancement of agricultural resources, monitoring the economic development impact upon the environment, in order to ensure the support for future generations. The essential role in agricultural production is played by the rational use of natural resources. In this context, one of the most important challenges in ensuring food security for the population is represented by the increase of food production under the background of soil degradation. The evaluation of the conceptual framework of natural capital protection reveals the acceleration of soil degradation, this becoming an extremely pressing cross-border problem. At European level, Romania is one of the countries with a generous endowment in natural agricultural resources. In spite of this, our country is confronted with specific problems, i.e. a defective management of land resources, resulting in an accelerated soil degradation rate. The indicators regarding soil degradation and agricultural land quality classes can contribute to the explanation of low land productivity, together with other factors. The land use modality reveals that there is always a compromise between different social, economic and environmental needs (e.g. dwellings, transport infrastructure, energy production, agriculture, nature protection). The current trends in land occupation have a non-sustainable character, representing one of the important causes of soil degradation.

Key words*:* natural resources; land resources; soil; degradation; sustainable development; Romania.

JEL classification: Q01, Q10, Q18.

1. INTRODUCTION

The three components of the sustainable development, economic development, environmental protection and social responsibility presuppose the existence of a stable development system, sustainable from the economic, ecological and social points of view.

The different socio-economic activities lead to the change of land destination, from agricultural land areas into artificial areas: transport infrastructure facilities (highways, railroads,), urban expansion (dwellings and industrial developments), tourism and leisure. The investments in infrastructure generally determine higher land prices but they have an important impact upon the environment and upon the agricultural landscapes.

In most countries, agriculture is the main user of land resources. The changes produced in the utilization of agricultural lands represent one of the major driving

forces of the environmental changes, both at global level and at local level. The first effect of the conversion of agricultural land areas into artificial areas resides in the soil impermeabilization, together with other environmental effects upon the soil, water and biodiversity resources.

From the eco-economic sustainability perspective, the soil is, at the same time, a precious asset and a limited resource. In order to ensure soil rational utilization and preservation, a planning policy is needed. In order to design adequate soil management systems, information is needed on the distribution, potential and constraints that soils are confronted with.

Even since 1972, the European Commission adopted a Chart for Soil Protection. According to the recommendations of U.N.E.P, as the main UN body, created for the environment protection and of the Order of the Ministry of Agriculture nr. 111/1977, Romania established in 1977 "*The monitoring system of the agricultural soil quality*", as integrating part of the *National System for Environment Quality* (Răuță and Cârstea, 1983). In the period 1992-1999, an improved soil quality surveillance system was initiated. As a result of these concerns, the Integrated Soil Monitoring System in Romania (ISMSR) was created.

The sustainable development in the agricultural activity includes criteria for the ecosystems, soil, water, air protection and for the biological diversity conservation, while farm sustainable development is a concern of the scientific world, mainly from the perspective of reaching an economic optimum under the conditions of the natural resources preservation.

In order to face the challenges of the economy under continuous development and changing environment, EU designed a sustainable development strategy that covers all aspects: economic, social, environmental and finance. At the European Council from Göteborg, in June 2001, the strategy was approved, adding an ecological dimension to the Lisbon Strategy.

Since 2000, the agro-environmental payments have been part of the EU policy for rural development, which is implemented through rural development programs elaborated by the Member States for 7-year periods.

2. MATERIAL AND METHOD

The paper analyzed the agro-environmental indicators, monitoring indicators in the domains that agriculture can impact, namely: air and climate changes, energy, fertilized consumption, land, livestock herds, pesticide use, soil and water. At the same time, the paper evaluated the sustainable development level from the perspective of land use and quality of resources, revealing the land areas removed from agricultural production, as well as the evolution of non-agricultural uses.

The statistical data series of the National Institute of Statistics – yearbooks, agricultural censuses and the Tempo-Online database on the evolution of land resources lay at the basis of the analysis of the evolution of land categories of use.

The national reports on the environment situation supplied information on the factors responsible of soil degradation as well as on their intensity, thus obtaining the general framework and particularities dedicated to the greening component diagnosis.

3. RESULTS AND DISCUSSIONS

3.1. AGRO-ENVIRONMENTAL INDICATORS

The main objectives of sustainable agriculture reside in ensuring the agricultural production growth, while taking into consideration the preservation and protection of the renewable natural resources; meeting people's essential needs; health and environment protection; maintaining the possible risks under control; development and implementation of certain integrated plans and programs, of good agricultural practices and last but not least of the assessment and monitoring measures. In this respect, monitoring indicators were developed by different institutions for the domains that could be affected by agriculture: air and climate changes, energy, fertilizer use, land, livestock, pesticide use, soil, water.

Ammonia emissions

Ammonia emissions are strictly linked to the animal farms and are associated to acidification and eutrophication. Agriculture is the main source of ammonia emissions, with percentages ranging from 80% to 99%. Ammonia, together with sulphur dioxide (SO_2) and nitrogen oxides (NOx), contributes to the soil and water acidification, when combined with water, in the atmosphere or after they are deposited.

Energy consumption in agriculture and sylviculture

Agriculture consumes energy both directly for crop production and stock raising (machinery, etc.), and also, indirectly, through fertilizers and pesticides. As an energy user, agriculture contributes to global warming (mainly through CO_2 emissions), air pollution (mainly through the natrium and sulphur oxides emissions and to the depletion of fossil energy resources. In the agricultural sector, the important energy users are the horticultural activities under greenhouses and the milk production.

Agriculture also produces energy from biofuels obtained from biomass, for example bioethanol. The biomass production for the energy production has important effects upon the rural development, upon the economy and the environment:

– It supports the rural economy through the creation of jobs and offers to farmers a source for additional incomes for food production.

– Biofuels reduce the dependency on the oil-producing countries.

– High pressure upon the water resources, the deforestation (for land areas devoted to the cultivation of fuel crops).

– Change in the utilization of the land areas initially devoted to food production.

Fertilizer use

The mineral fertilizers emerged together with the industrial revolution having an important role in supporting the increasingly numerous population. Fertilizers can have a negative impact upon the environment, the eutrophication and poisoning of water, soil pollution, for example: heavy metal pollution, with organic persisting pollutants, soil acidification. The fertilizer manufacturing is also a great energy consumer and the exploitable reserves of phosphorus are finite.

Livestock Density

The livestock density offers an indication on the volume of the manure and its subsequent emission in the atmosphere and the water environment, of gas emissions with greenhouse effect from digestion, and of the pressure upon the available agricultural land.

Pesticide use

Pesticides reduce the side effects of the weeds, diseases and pests on the level of harvests and on their quality, and as a result they play an important role in agricultural production. The values of this indicator are reported into terms of active ingredient but they do not include the other components of the final product. The application rates are expressed per hectare of agricultural land.

Soil erosion

Erosion is the process by which the soil is driven away from a certain region by the action of the natural factors (wind, water, ice). Erosion is a natural process, but the human activities can much influence its rate, mainly through agriculture and deforestation. According to the UN assessment, approximately 40% of the agricultural land areas in the world are seriously degraded. Under natural conditions, only the severe weather events can result in erosion, as the natural green cover protects the soil, by attenuating the rainfall impact. The elimination of the natural green cover through deforestation, excessive grazing or farming practices leave soil exposed to the action of the weather factors, such as wind and rain.

The demand for data on soil is increasing, as their crucial role in food security, climate regulation and other global problems is widely recognized.

At global level, man-induced soil degradation is monitored by the study *Global Assessment of Human-induced Soil Degradation* (GLASOD). The study was jointly prepared by ISRIC – World Soil Information and United Nations Environment Program (UNEP) in the 1980s. The database GLASOD is the only set of data at world level available in soil degradation issues. GLASOD identifies five degrees of soil degradation: non-degraded (0), easily (1), moderately (2), strongly (3), extremely degraded (4). The definitions of the degradation degrees are given according to: agricultural adequacy, level of affecting the biotic functions, possibility of productivity restoration.

Soil quality

The soil quality is defined according to the soil functions (for example, production function, habitat function, resource function) and cannot be measured by a single parameter. However, soil content in organic carbon was defined by

EUROSTAT as the most adequate soil quality indicator. The high organic carbon content corresponds to good agro-environmental conditions. The soils with organic carbon content less than 1% in weight are generally affected by soil degradation and erosion processes. On the other side, the soils with 1-10% contents of organic carbon have a high agricultural value.

Water utilization

Irrigations represent the main utilization of water in agriculture and one of the main utilizations of water resources in general. The trends in water catchment for irrigations depend on several factors, such as the crop type, the irrigation technology, water price, and also the weather conditions. Water withdrawal from its natural circuit for agricultural purposes is a serious reason for concern mainly in the arid and semi-arid areas, where the water resource is rare and quite variable from year to year. In the dry areas it is necessary to irrigate certain crops to obtain reasonable yields.

The agro-environmental indicators were developed by OECD and EUROSTAT in the last 20 years. These can describe and assess the situation and trends in the environmental performance of agriculture in order to supply useful indications to scientists and decision-makers on the effects of different policies, as well as on the efficiency of the financial resources provided for environment protection.

Box 1. Agro-environmental indicators

Field	Sub-field	Indicator
Air and climate changes	Ammonia emissions	Ammonia emissions (NH_3) from agriculture in total ammonia emissions
Energy	Energy consumption in agriculture and sylviculture	Energy consumption in agriculture and sylviculture as % in total energy consumption
	Bioenergy production	Bioenergy production as % of total energy production from renewable sources
Fertilizer consumption	Nitrogen consumption	Utilization of nitrogen fertilizers on arable land and land under permanent crops (tons of N/1000 ha)
	Phosphorous consumption	Utilization of phosphorous fertilizers on arable land and land under permanent crops (tons of P_2O_5/1000 ha)
	Nitrogen and phosphorous	Utilization of nitrogen and phosphorous fertilizers on arable land and land under permanent crops (tons of N+ P_2O_5 /1000 ha)
Land	Agricultural land	Agricultural land as % of the land area
	Change of agricultural land destination	Modifications in agricultural land (% per year)
	Land area equipped with irrigation facilities	Land area equipped with irrigation facilities as % of din agricultural land
	Conservative agriculture	Area under conservative agriculture (>30% group coverage) as % of agricultural land
	Type of crops	Area under permanent crops as % of agricultural area
		Area under permanent pastures and meadows as % of agricultural area
		Arable land area as % of agricultural area
	Organic farming area	Area under organic farming as % of agricultural area
	Protected areas	Protected land areas as % of agricultural area

Box 1 (*continued*)

Livestock herds	Animal density	Density of animals per agricultural hectare (total number of animals/ ha)
	Bovines and buffaloes	Bovines and buffaloes as % in total livestock herds
	Pigs	Pigs % in total livestock herds
	Sheep and goats	Sheep and goats % in total livestock herds
	Poultry	Poultry % in total livestock herds
Pesticides	Pesticide use	Pesticides applied on arable land and land under permanent crops (tons/1000 ha)
Soil	Soil erosion – GLASOD	Average soil degradation expressed in GLASOD erosion degrees
	Land degradation – GLASOD	Average degradation of land expressed in GLASOD erosion degrees
	Carbon in the top soil layer	Average carbon contents in the top soil layer as % in weight
Water	Water utilization in agriculture	Water utilized in agriculture as % of total utilized water

Source: Food and Agricultural Organization of the United Nations (FAO).

3.2. ASSESSMENT OF THE SUSTAINABLE DEVELOPMENT LEVEL FROM THE PERSPECTIVE OF LAND UTILIZATION AND THE QUALITY OF SOIL RESOURCES

For the identification of the changes produced in the land categories of use in Romania, the year 2006 was taken as reference, which was the year previous to Romania's accession to the EU, highlighting the areas withdrawn from the agricultural circuit, as well as the evolution of the non-agricultural utilizations. The series of statistical data regarding the land resource evolution lay at the basis of the analysis of the categories of land use. The national reports on the environment situation supplied data on the factors responsible for the soil degradation process and its intensity, thus obtaining the general framework and particularities dedicated to the ecological component diagnosis.

Land utilization in Romania

Lands utilization is influenced by the natural components such as: relief, weather, land reclamation works, the legislation into effect on the change of the utilization categories, agricultural technologies, etc.

Agriculture represents an important factor of the natural environment, which is revealed by the share of the agricultural land in the country's total territory, i.e 61.8% in the year 2006, down to 61.3% in 2013, under the background of land withdrawal from the agricultural circuit. In the sustainable development context, the permanent pastures have a multifunctional value, having, besides the production factor, the function of preserving the biodiversity of specific flora and fauna, the soil protection function and finally the landscape quality preservation. In this context, the changes produced in land utilization are significantly negative. From 2006 to 2013 over 119 thousand hectares were withdrawn from the agricultural

circuit, representing a decrease by 0.81%. Over 50% of this land withdrawn from the agricultural circuit was the result of the decrease of the land area under pastures. The next utilization category affected by this phenomenon was the arable area, followed by the permanent crops (Figure 1).

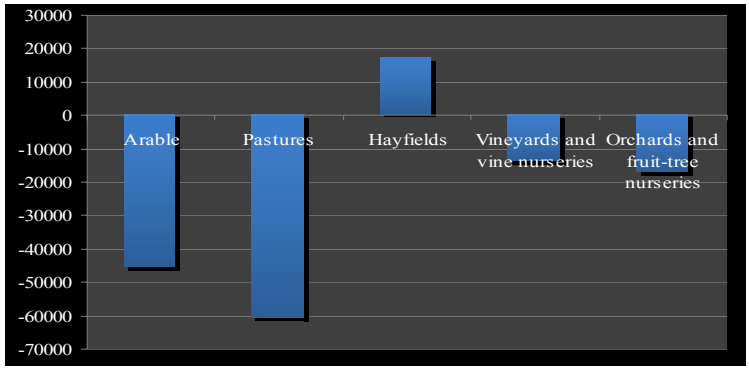

Figure 1. Net modifications in agricultural land utilization in the period 2006-2013, hectares.

The only utilization category with positive evolution is that of hayfields. The withdrawal of land areas from the agricultural circuit were materialized into the increase of land areas dedicated to constructions and last but not least into degraded land areas (Figure 2).

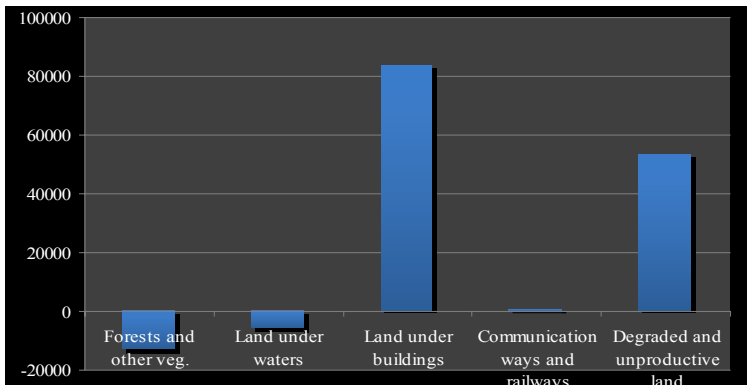

Figure 2. Net modifications in non-agricultural land utilization in the period 2006-2013, hectares.

Soil quality

The monitoring of soil quality situation in Romania, published by ICPA Bucharest, identifies the main restrictions with which soils are confronted in Romania. These restrictions are determined by weather factors and natural processes:

precipitations, temperature, gleyization and pseudo-gleyization processes, erosion, etc. The most intense losses are caused by 1) surface erosion through water and 2) depth of ground water in over 80% of the investigated sites.

Soils are also affected by certain unfavourable physical characteristics (gross or medium fine texture, strong and moderate soil subsidence) and unfavourable chemical characteristics (acid/extremely acid soil reaction, small/extremely small humus reserve, high/extremely high content in carbonates).

At present, soil experience a constant deterioration both by the land withdrawal from the agricultural circuit and by the increase of degraded areas. The analysis of the factors contributing to soil degradation, by different intensities, shows that the modality of resource utilization does not reflect the application of the rationality principle, expressing a deterioration of the environment protection principle. The natural and anthropic processes are largely responsible for soil degradation.

In the context of agriculture sustainable development objectives, the efficient use of resources is essential. As agriculture largely depends on soil fertility, mainly on the availability of nutrients, a policy efficiency component resides in the conservation and improvement of soil resources. The specialty studies in our country indicate the depletion of soil fertility determinants, as follows:

– 7,485 thousand hectares of agricultural land, i.e. 50% of soils have a very small – small humus reserve (in the 0-50 cm layer), and in the case of the agrochemical layer, more than 70% of the soils from our country have a total humus content extremely low and only 23% have a medium humus content

– 6,330 thousand hectares of agricultural land have a low and very low content of mobile phosphorous, i.e. almost 70% of soils have values ranging from extremely low-very low, followed by the sites with medium values (19.28 % of cases); 11.21% of cases have high and very high values;

– more than one-third (5,110 thousand hectares) of the agricultural land has nitrogen deficit.

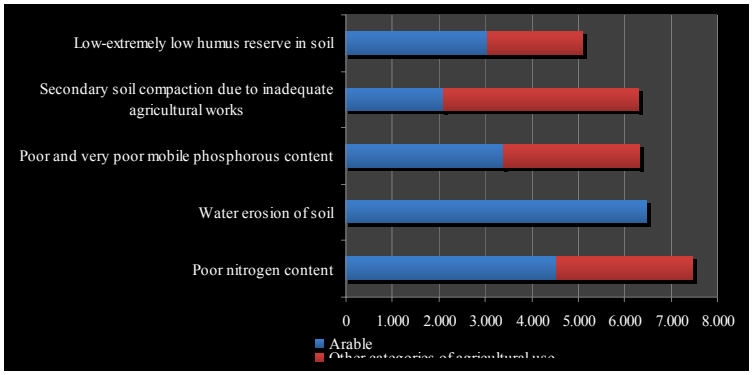

Figure 3. Main limiting factors of the productive capacity of agricultural land, thousand hectares.

Other unfavourable characteristics consist of:

– deficits of microelements, zinc in particular, on an area of 1500 thousand hectares;

– poor soil endowment in mobile kalium, on about 800 thousand hectares of agricultural land;

– strong and moderate soil acidity on about 3,400 thousand hectares agricultural land and moderate-strong alkalinity on about 200 thousand hectares agricultural land.

From the perspective of soil productivity and fertility conservation, the information on the nutrients in soil, as well as on the organic matter, represents important entries for the soil management system. The surplus or deficit of nutrient and organic matter affects quite a large part of the agricultural land area, with different intensities. The land quality classes give their suitability for agricultural uses. The number of soil rating scores is obtained through a complex operation of comprehensive knowledge of a given area, expressing its favourability for given crop requirements, under normal weather conditions and rational use.

As a result, land suitability for agricultural uses, expressed by its distribution into quality classes, reveals that the land areas under quality classes I and II have an extremely low share, i.e. 4.7% and 21.6% respectively. The land areas under quality class III have the highest share (34.9%), while classes IV and V sum up almost 39% of total agricultural area.

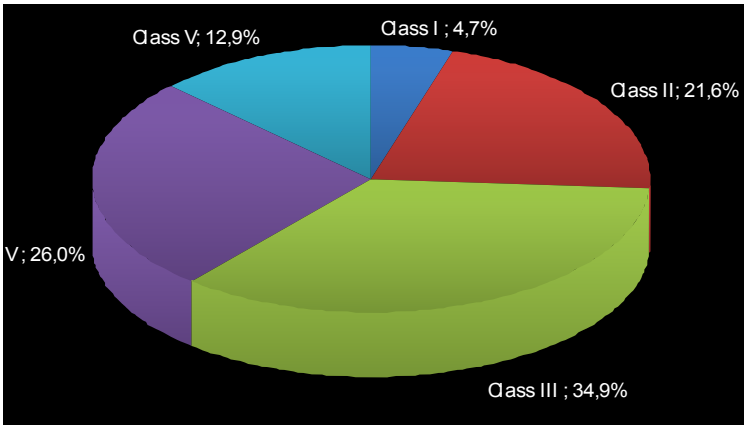

Figure 4. Distribution of agricultural land by quality classes, according to the soil rating scores.

The indicators referring to the degradation processes and agricultural land distribution by quality classes can explain the low land productivity, together with other factors, such as the applied technologies, deficient from the agro-technical point of view.

From the perspective of natural resource improvement and conservation, the specific support measures for the agricultural sector had different effects. Thus, in

the period 2007-2012, the modifications of agricultural uses according to the fertility classes reveal that:

– the efficiency of direct payments, accompanied by the respect of the good agricultural and environmental practices, is materialized into a relatively deficient management of agricultural land; this lost more than 165 thousand hectares from the quality classes I and II, while the less fertile arable area (classes III, IV and V) increased;

– the agro-environmental measures generated positive changes in the case of meadows and pastures.

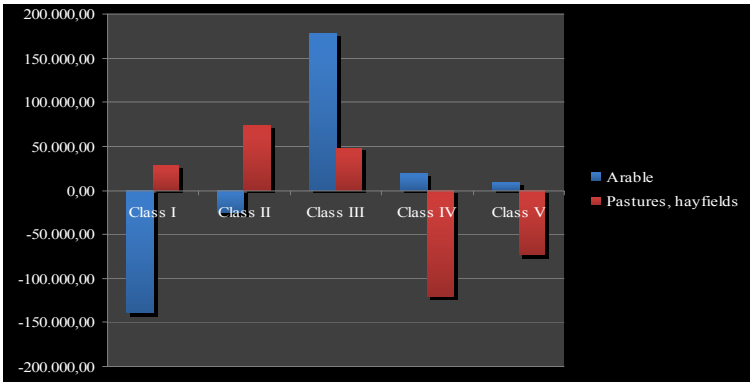

Figure 5. Net modifications in the quality classes of arable land, land under permanent pastures and meadows according to the soil rating score, 2012 compared to 2006.

The structural changes in the viticulture sector reveal a diminution of areas located on poor quality land. This was produced under the diminution of areas under vineyards (clearing), in the first place. In the second place, the viticulture sector benefited from the restructuring/reconversion market measure, under which a better location of plantations took place, in more favourable areas from the soil quality point of view. For orchards, the tendency is similar as in the case of vineyards, yet at smaller scale.

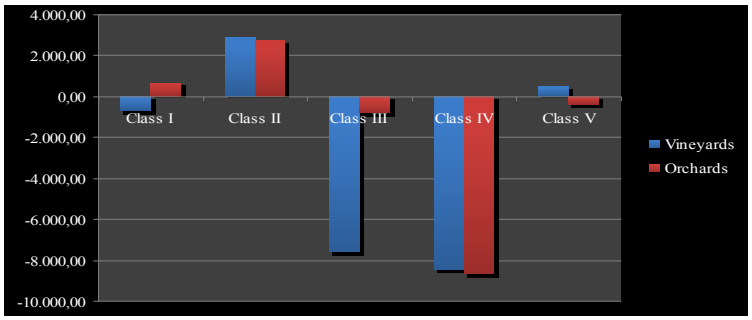

Figure 6. Net modifications in the quality classes of permanent crops, according to the soil rating score, in 2012 compared to 2006.

4. CONCLUSIONS

The decision to withdraw the agricultural land from the farming activity reveals the low attractiveness of the farming activity, having as possible causes the low subsidy level per hectare, agricultural land fragmentation corroborated with a much too permissive national legislation on the change of agricultural land destination.

From the perspective of natural resource improvement and conservation, the agricultural policy measures to support the farming sector have had different effects. These effects are revealed by the changes that were produced in the quality classes of the agricultural use categories.

The efficiency of direct payments (accompanied by the respect of the good agricultural and environmental conditions – GAEC) is materialized into a relatively deficient arable land management. For the two types of permanent crops, the structural changes by soil quality classes can be explained by the different financing measures of the two sectors, namely: viticulture through market measures, materialized into lump sums that are received by hectare, much easily to access, and the establishment of fruit plantations through NRDP, with difficult procedures for access and carrying out the investment.

The unsustainable land operation depletes soil fertility and soil degradation continues, affecting the world food security and reaching the biodiversity objectives.

As the soil degradation rate is growing fast, specific soil protection programs are necessary, together with components integrated into the different policies for the natural resource protection, conservation, improvement and putting into value. Under the Common Agricultural Policy, each farm should become responsible of the respect of a set of agro-technical principles with beneficial effect upon soil, with the main requirement to incorporate the environmental factors in measuring farm performance.

Having in view the negative changes in the evolution of agricultural land area, of soil quality degradation, the three greening measures proposed under Pillar I of the Common Agricultural Policy, i.e. crop diversification, maintaining the permanent pastures and maintaining an ecological focus area on each farm represent a necessary measure, which yields social benefits through the utilization of soil resources in a responsible manner for the future generations.

5. ACKNOWLEDGMENTS

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