Soil Resilience in Stressed Agro-ecosystems

I. LÁNG

Hungarian Academy of Sciences, Budapest

The most important message to mankind from the UN Conference on Environment and Development, held in Rio de Janeiro in 1992, was the appeal for the realization of sustainable development. Everybody is entitled to satisfy his or her basic human needs. The values of our environment can only be preserved for future generations, while satisfying basic human needs at the same time, if we have sustainable development prevail, the main characteristic of which is economy in the use of energy, materials, and water, rational and thrifty consumption, moreover, the conservation of resources.

In agriculture sustained development is impossible without sustainable land use, which can only be achieved by an integrated approach. AGENDA-21, accepted at the Rio Conference, lays great emphasis on the necessity of an integrated approach. "Integration should take place at two levels, considering, on the one hand, all environmental, social and economic factors (including, for example, impacts of the various economic and social sectors on the environment and natural resources) and on the other, all environmental and resource components together (i.e. air, water, biota, land, geological and natural resources. Integrated consideration facilitates appropriate choices and trade-offs, thus maximizing sustainable productivity and use" (Agenda-21, Chapter 10). The concept of integration also includes the interrelations of soil and plant, together with their specific properties and responses.

Integrated approach will also be necessary in the future because of the unambiguous trend that in the next 30 years world population will increase more quickly than the territory of arable land. As a result, the index of cultivable land per capita will decrease. This phenomenon will first of all ensue in developing countries where population is going to increase by 900 million per decade. As an example we can mention the projected decline in potentially cultivable land resources per capita in West Asia and North Africa. In the latter in 1990 this value was 0.22 ha, in 2025 it is expected to be 0.11 ha. In Asia, excluding China, it was 0.22 ha in 1990, and is expected to be 0.12 ha in 2025.

This lack of land resources to meet future demands exposes three main problem areas to be addressed by the science agenda:

a) competition for land;
b) land degradation and land management;
c) other biotic and abiotic stresses.

The competition for arable land appears together with the competition for water in several countries. The use of water for irrigation decreases the supplies available for meeting the requirements of households and industry, and irrigation may lead to soil degradation.

Competition also exists between agricultural expansion and the size of areas under wood. The consequences of deforestation and forest mismanagement and their negative impacts on stream flow, soil erosion, agricultural productivity, availability of wood for fuel, loss of biodiversity, and on both local and global climate are well known. Competition may arise between crop and livestock production. The ploughing of rangelands and pasture for crop production has forced pastoralists onto drier and more marginal land. This pressure, together with the increase in livestock numbers, concomitant with human population growth, has led to overgrazing and eventual desertification.

There is further competition for land between agricultural production and urban as well as industrial development. We have to reckon with the loss of significant territories, including valuable croplands, as a result of urban and industrial development.

Table 1

Land area and area of land in use of the Earth (1991)

Land Area	in million hectares	expressed as %
Area of land of the Earth	13,041	100
Arable land of the Earth	1,438	11
Grassland area of the Earth	3,354	25
Forest area of the Earth	3,894	30

Table 2

Land area and area of land in use of the Earth (1991), in million hectares

Continent	Arable land	Grass-land	Forest	Arable land: grassland
Africa	181	900	684	1 : 4.97
Asia	457	759	531	1: 1.66
North and Central America	271	362	709	1 : 1.33
South America	113	493	829	1 : 4.36
Europe	138	83	157	1 : 0.60
Soviet Union	229	326	827	1 : 1.42
Oceania	49	431	157	1 : 8.95

(Source of Table 1 and 2: World Resources, 1992-1993)

Table 1 shows the land area of the Earth and the area of land in use.

Arable land constitutes 11% of the land area of the Earth. Grassland represents 25%, whereas forests 30%. This means that there are significant potential resources for supplying the growing population with food.

The ratios change by continents, which is shown in Table 2.

It is worth comparing the ratios of arable land and those of grassland (Table 2).

Africa, South America and Oceania still have significant areas of grasslands which can be used for animal breeding or could be used as arable land. The areas affected by land degradation (water erosion, wind erosion, nutrient loss, salinization) in the developing countries come to 934 million ha. With some simplification we can say that one third of the territory, which is the subject of human activities (crop production, grazing), is under the influence of potential degradation.

Abiotic stresses include:
- drought, or insufficient water and heat;
- mineral toxicities and deficiencies;
- lack of an adequate supply of nitrogen, or other nutrient elements;
- low temperature.

Biotic stresses due to pests are a major constraint to increasing crop production. Huge losses are caused by insects, diseases, weeds, and nematodes at both pre- and post-harvest stages. Infectious and non-infectious diseases of animals are stresses that significantly reduce livestock productivity in both industrial and developing countries.

The factors enumerated above, i.e. the competition for land, the decrease of agricultural land per capita, the degradation of land in increasing proportions, and the effects of the various forms of stress are all to be contemplated in one complex system, so that we can find ways to solve the problems. In this context soil resilience, i.e. the natural resistance of soils to adverse effects, is of great importance.

In the case of plants the capability of resistance to abiotic and biotic stresses has special significance. The utilization of both properties (the resilience of soils and the resistance of plants) could greatly contribute to the sustainable development of agriculture as they mean the realization of inherent natural qualities. Intensive research is in progress into both, and more and more pieces of scientific information appear on this subject.

The stability of agro-ecosystems is subject to environmental factors, among them, to a great degree, to soil properties, including resilience. This stability also has biological factors which are related to the population-genetic properties of the species and varieties constituting the agro-ecosystems. This way the interrelationship of soil resilience and ecosystem stability may call our attention to new correlations which may result in information useful for the continued development of a sustainable agricultural system.

In the past two decades the so-called high-yield varieties, which are the result of genetic research, have been tested in several countries. Yields have doubled in many cases. However, these HYVs need more input - water, fertilizer, pesticides, machinery -, so production became more expensive. Moreover, as the genetic basis of these varieties was narrower, they soon became sensitive to various diseases and microclimatic changes. Therefore, newer genetic research is primarily aimed at developing greater adaptation capacity of the varieties, rather than at achieving maximum yield.

It is worthwhile to pay significant attention to the tasks of developing new species and hybrids with improved resistance and tolerance to stress. Awareness of the resilience of soils in the different growing regions and taking the latest results of plant breeding into consideration may together increase crop safety.

References

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