A REVIEW OF THE ENVIRONMENTAL IMPACTS OF AGRICULTURE IN THE DEVELOPING WORLD: LESSONS FOR SOUTH AFRICA

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This article reviews the existing work on environmental degradation resulting from agricultural practices in the developing world, and presents the empirical facts and figures thereon. This is followed by the identification and analysis of the underlying factors, causes and effects of the agricultural environmental degradation in these regions. The "subsistence effects" which arise from poverty and the changing face of subsistence farming; the "green revolution effects" which arise from the adoption of green revolution technology, and the "externality effects" which arise from the consumption of common proprty are identified as some of the main underlying factors that determine the environmental impacts of agriculture in developing areas. The above factors, the macrosocial and microsocial factors that determine the adoption of conservation practices, and the short- and long-term implications of government policies in the developing countries are deemed some of the most important considerations for environmental policy analysis and decision-making at national and international levels. Environmental policies directed at the developing regions of South Africa are then suggested, based on the said considerations.

1. Introduction

In a world concerned with key global environmental issues such as the greenhouse effect and the changing global climate, the depleted ozone layer and the effects of ultraviolet rays on human and other lives and the contamination resulting from nuclear radiations and toxic wastes, the environmental impact of the rural populace of the developing world seem to be of little relative significance. This view is considered simplistic in view of the facts and figures presented here. While the environmental impact of manufacturers and commercial farmers in the Northern hemisphere cannot be underrated, the survival of the human race and the ecological integrity of the biosphere we live in will soon depend on how the degrading impact of the impoverished masses of humanity in the Southern hemisphere can be controlled (Lopez, 1992b; World Bank Annual Report, 1989:34).

This article attempts to provide a review of the nature of the environmental degradation caused by specifically agriculture in developing areas. It will identify and examine the "subsistence effects", the "green revolution effects" and the "externality effects" of this degradation. The three effects interact, leading to a vicious circle of poverty and environmental degradation that is perpetuated and aggravated with time (Lopez, 1992b). The causes of environmental degradation in the developing world will be shown to originate from either the "green revolution effects" or the "subsistence effects" of degradation. The identification, differentiation and analysis of the three factors are shown to be critical for environmental management and policy-making for developing areas.

The above factors, the macrosocial and microsocial factors that determine the adoption of conservation practices, and the short- and long-term implications of government policies in the developing countries are some of the most important considerations for environmental policy analysis and decision-making at national and international levels. Environmental policies directed at the developing regions of South Africa will be proposed.

The developed North is aware of their own contribution to the current environmental degradation and there have been signs of willingness to assist the developing South not to repeat the same mistakes but to develop in a manner that will conserve vital environmental public goods for global use. Examples are the proposed $1.5 billion Global Environmental Facility (World Bank Annual Report, 1991:61) and the new fund created to help developing countries change their technology to one based on chlorine-free compounds. This fund will total $240 million for the first 3 years (World Bank Annual Report, 1990:37). For the sake of their own survival and that of future generations, the South cannot expect the North to cleanup the global pollution alone. The South needs to realise the extent of their own contribution to global pollution and the extent to which they can assist its control. Development policies will have to introduce principles of sustainable development at both macro- and micro-economic levels (Goodland, 1993).

2. The 'subsistence effects' of environmental impact

The environmental impact of agriculture in the developing world can be shown to originate from two agricultural, but also socio-economic sources, i.e., the subsistence and the green revolution sources. Their impact on the environment is revealed in the "subsistence effects" and the "green revolution effects". These can be identified and separated from each other because they cause different forms of environmental damage. While the "green revolution effects" arise only after the adoption of green revolution technology (modern agricultural technology), the "subsistence effects" result from traditional subsistence farming practices.

The "subsistence effects" arise in rural areas of the developing world when population growth and, often, macroeconomic policies (e.g., high taxation of agricultural exports) impoverish the rural population. Poverty and the resultant economic pressures lead to the breakdown of traditional institutional structures that govern the exploitation of natural resources. Until recently, these institutional structures had created location specific subsistence farming systems that cooperated with nature and the broader ecological systems, in such a way that there was an efficient and sustainable use of resources. "The collapse of traditional systems leads to a vicious circle of environmental degradation and further impoverishment" (Lopez, 1992b). Rural communities have always been poor by urban standards, but they had sufficient means to satisfy their basic needs while

ensuring the maintenance of their environment. Institutional collapse and over-exploitation of natural resources rapidly leads them to desperate poverty, such that they are unable to satisfy even their most basic needs.

The collapse of traditional systems may however be traced to the existence of the "dinosaur effect" inherent in the adaptation of traditional systems to change. These systems and institutions were like the dinosaurs, they could not adapt fast enough. Traditional farming practices in most places were outdated technology which could not adapt to the demands for expansion in output and agricultural productivity.

In their review of about 30 case studies that considers the relationship between development and the environment in Asia, Africa and Latin America, Kates and Haarmann (1992) concluded that the key source of rural environmental degradation is the disruption of the traditional institutions of the poor, which until recently had permitted on efficient and sustainable use of resources that left environmental capital intact. A determination of the causes of institutional collapse is an important step in the diagnosis of rural environmental problems. Studies in Latin American in particular, but also Asia, report displacement and loss of entitlement of resources originating in factors external to the communities. Similar studies in Sub-Saharan Africa emphasize internal factors.

In South Africa the Group Areas Act and the subsequent displacement of rural dwellers to marginal lands (Deneinger & Binswanger, 1992) is an external factor that preceded the internal factor of population growth.
Large scale agriculture, export-oriented forestry operations, and major public infrastructure projects are repeatedly mentioned among the external factors. Often these factors operate together. For example, when a rural land intensive project is authorised by the government, rural communities are displaced to marginal upland or similar ecologically sensitive or unstable lands, the forest lands evacuated are then allocated for large scale livestock or crop farming (eg oil palm), or forestry operations, requiring roads, irrigation and other public infrastructure projects. The large-scale farms and logging operations expose the sensitive soil to erosion, cause the destruction of biomass, loss of biodiversity; and sometimes the accompanying burning contributes to the greenhouse effect. The displaced rural population rapidly degrades the marginal lands into which they have been pushed with the inevitable result of poverty and food insecurity. Tragedies of this nature have been reported by Stonich (1989) for Southern Honduras, Browder (1988) for areas in Brazil, and Anderson (1987) for the lowlands of the Philippines.

Implicit in this phenomenon is the prevalence of hysteresis in environmental degradation. As was the case in Latin America, a temporary price boom for commercial agricultural products, created by government policies (aimed at export drive) and complementary public investment in infrastructure leads to a drastic reallocation of land use, to deforestation and biomass loss and to the collapse of traditional peasant practices due to the loss of their entitlement to environmental resources. When the temporary boom is over the disrupted institutions and other conditions in the rural community do not revert to their original state. Instead a second round of degradation of rural marginal areas commences as a result of the rural population that lose their formal employment in the agricultural project (López, 1992b). This happens because the subsistent farmers that were turned into farm labourers do not get their land back. They have no alternative but to farm the marginal lands reallocated to them for their subsistence.

Population expansion has been identified as the main internal factor leading to the collapse of traditional systems and institutions in Africa. For example, López (1992a) and López and Niklitschek (1991) have reported how population density in Côte d' Ivoire villages increased the pressure on village leaders to allow greater use of forest areas and fallow lands for cultivation. Accompanying population expansion is the problem of land fragmentation, as the same stock of farm land is transferred from one generation to an expanded next generation. At the same time, as the population increases and new value systems are introduced, traditional village hierarchies tend to weaken.

In southern Africa, the main factors leading to the collapse of traditional institutions could be found in the household economics concept and the racial reallocation of land. La-Anyane (1985) reports that during pre-colonial times the ownership and claim to land in Eastern and Southern Africa, like in other parts of Africa, was communal. This also implies that existing traditional institutions ensured that land and other environmental assets were exploited with efficiency and sustainability. However during the colonial era, with the introduction of legal title to land, vast areas of land were declared crown lands and much of the land was distributed to white settlers (as in South Africa, Zimbabwe and Kenya (Deneinger & Binswanger, 1992)). The poorer lands were assigned to the local people. Cultivation of such marginal lands, which were previously avoided by the locals, sometimes under high population density, led to rapid environmental degradation, stemming mainly from over-grazing (Rau, 1985).

The change in the composition of the rural population caused by wage employment in the mines and on the large commercial farms (in South Africa, Zimbabwe and Zambia), as well as the pressure on some arable lands while other portions of land lie unused due to village squabbles over such lands (e.g., in KwaZulu - Lyne & Nieuwoudt, 1991). Rural-urban migration leaves the aged, women and children on the land who could neither produce enough food nor instill the required discipline over the use of common grazing lands (Low, 1984; Deininger and Binswanger, 1992). Lyne & Nieuwoudt (1991) identified the reason for the idle arable lands to be the fear of loss of user-rights which discouraged renting by migrant workers who have access to land. This fear makes transaction cost greater than rental value. The solution may be institutional changes to create a rental land market. They also found that stocking rates on common grazing land is determined not only by the pasture's physical carrying capacity but also by the private cost (Pc) of keeping cattle on the common and the perceived value of keeping cattle (Py). Herd size increases when Py increased relative to Pc.

The other aspect of significance is the existence of externalities in the farmers' resource allocation decisions. The farmers do not fully consider the entire social (or community) value of the environmental resources. This lack of consideration seems to worsen as pressure from population expansion increases. López (1992) shows that farmers in western Côte d'Ivoire internalise less than 30% of the community value of the biomass and forest resources because the local financial value of these resources is quite different from their social value. This leads to excessive cultivation and fallow periods that are too short, with the consequent loss of income for the villages of the order of 20 -24%.

Internal factors related to population expansion have been reported extensively in parts of Africa and Asia. Metz (1991) has documented the interaction between popula-

tion growth and deforestation in Nepal. Campbell (1981) has provided evidence for the importance of population pressure for degradation in semiarid areas of Kenya. Jolly (1989) has considered environmental destruction and deforestation caused purely by the activities of smallholder farmers in Madagascar.

On the other hand, Garcia-Barrios and Garcia-Barrios (1990) studying evidence in Mexico, and Collins (1987) in Puno, Peru, conclude that a major source of environmental degradation and agricultural productivity loss is insufficient rather than excessive population growth. They argued that resource conservation practices in highland areas, such as those they analyzed, are highly labour intensive. The phenomenon of under population and environmental degradation seems to be common in the highlands of Latin America where rural-urban migration is intensive. In Southern Africa, similar causes of environmental degradation may be found in highland regions (eg, Lesotho) as well as lowland regions (eg, Lebowa) due to the same rural-urban migration(Aihoon, personal communication,1994).
The subsistence effects of environmental impact characteristically lead to resource depletion and not environmental pollution. The main causes of this depletion are soil degradation and erosion, desertification, deforestation, over-grazing and shifting cultivation.

2.1 Soil degradation and erosion

Soil degradation and erosion is not caused solely by subsistence farming, it is also caused by commercial farming. In the developing world, however, it results from the combined effects of subsistence farming and the green revolution. In most parts of Africa, commercial farming is not prevalent,leaving subsistence farming as the main agricultural source of soil degradation and erosion(Aihoon, personal communication,1992).

Soil degradation and erosion usually begins with the removal of the vegetation cover, loss of soil fertility and impaired soil structure. Soil erosion in turn further reduces soil fertility by selectively removing the smallest and lightest particles,thereby reducing the proportion of soil colloids and increasing that of the large, inert particles of sand. A vicious circle is therefore created: the fertile topsoil is gradually removed, leaving the far less fertile subsoil exposed; because the latter is relatively compact, water infiltration into it is slow and limited; tillage becomes more difficult and less efficient; biological activities in the soil are slowed down, as a result of impaired soil structure and deficiencies of available nutrients.

The main factors influencing soil erosion are the slope of the land, the amount of rainfall or wind velocity, the vegetation cover and human activity (Arnon, 1980). The effect of slopes, amount of rainfall and vegetation cover on the rate of soil loss is illustrated by Table 1 below, which covers parts of Franco-phone West Africa.

Much arable land which was previously under cultivation has been abandoned in many developing countries owing to soil erosion. The severity of erosion in South America has earned it the nickname of the "vanishing continent". Benham and Holley (1960) estimate that a quarter of the total land under cultivation (past and present) has lost its topsoil through erosion. A survey of soil erosion in Chile, on 1 200,000 ha showed that only 12.6% was not affected, while 40% has been badly damaged (Pawley, 1963).

An FAO study of erosion and salinization carried out in Africa north of the equator indicate that 36% of the soils in this part of the continent have been affected by some degree of water erosion, 17% by wind erosion and 8% by salinization.

Holeman (1968), estimated the level of water erosion in Africa, measured the suspended sediment loads in some of the major rivers of the continent. He estimated the annual rate of sediment production in Africa as a whole to be about 180 tonnes per km^2, which is about half of what has been estimated for South America. Estimating the suspended sediment loads for some of the major rivers in Africa, he found it to be high in the Madjerdah (mouth, Tunisia) and the Cheliff(mouth, Algeria), ie 705 and 153 tons per km2
respectively; and relatively low in the Niger and the Congo, ie 5 and 18 tons per km^2 respectively.

Napier (1991), reports that soil erosion in mountainous areas of the People's Republic of China has reached crisis proportions (cf Howard, 1981; Li and Li, 1990; Luo and Han, 1990).Soil erosion on some of the farm lands in northwestern China exceeds 337 tons per ha (Lee 1984), and sediment loads in the Yellow River which drains much of northwestern China is estimated to be in excess of 30 tons per ha per year. The sediment load in the Yellow River is often so high that it is characterised as "liquid soil". Pearce *et al.*,(1990) report that soil erosion in Nepal far exceeds replacement levels. Loss of forest cover and cultivation of land resources for agricultural purposes are the major contributors to soil loss(Napier, 1991). Blaikie and Brookfield (1987a) had also attributed the loss of soil loss in Nepal to agriculture and land-slides. Similarly, serious soil loss has been reported in Indonesia (Blaikie and Brookfield, 1987b; Potter, 1987; Cochrane and Huszer, 1988; Fagi and Mackie, 1988; Pearce et al., 1990; Siebert and Belsky, 1990); and the adverse effects of soil erosion have been documented in Thailand(Ruangpanit, 1985; Harper and El-Swaify, 1988; Carpenter and Harper, 1989).

The effects of water erosion include reduced permeability and water retention in the newly exposed soil, and increased run-off, which leads ultimately to floods, changes in the depth of river beds, and erosion of the banks of rivers and streams. The cutting of gullies lowers the water table in the surrounding area, so that dry periods have a more deleterious effect on vegetation. Soil particles carried in the run-off water brings problems of siltation and loss of depth to water reservoirs, navigable rivers and ports (Arnon, 1980; Bowonder, 1986).

2.2 Burning

Burning has always been part of traditional farming, with slashing and burning as an important method of land clearing in shifting cultivation. Burning of bush and grass in savannas and steppes may also occur spontaneously by lightning or accident. In traditional farming, burning clears the land of vegetation for planting and the ash returns plant nutrients to the soil. For the pastoralist, fire is a means of removing impalatable vegetation, preventing brush encroachment over the pasture, and reducing parasites and the vectors of disease. Hunters of the Savannah country in Africa also use bush burning to drive their quarry (Worthington, 1972).

Table 1: Amount of soil loss in different areas in West Africa.

Country	Slope (%)	Mean early rainfall* (mm)	Soil losses (tonnes/ha) under:		
			Forest	Cropping	Base soil
Upper Volta	0.5	850	0.1	0.6-8.0	10-20
Senegal	1-2	1300	0.2	7.3	21.3
Ivory Coast	4.0	1200	0.1-0.2	0.1-26.0	18-30
Ivory Coast	7.0	2100	0.03	0.1-90.0	108-170

*Means over 15 years of study
Source: Arnon I. (1980)

Burning during shifting cultivation was not harmful as long as the fallow period was sufficiently long to allow the original forest vegetation to recover. Burning in shifting cultivation became harmful only when population pressures shortened the fallow period beyond the critical limit. Fire therefore has been a contributing factor to the change over from forest to brush, and from brush to grass. Burning thus is one of the major factors contributing to deforestation, desertification and soil erosion. It destroys the surface cover of vegetation and of organic matter, baring the soil surface to the effects of rain, wind, trampling by stock and game, and thereby reducing its resistance to erosion and breakdown in structure. Useful trees such as oil palms are damaged and a gradual build-up of fire tolerant, low productive species occurs (Lagemann, 1977).

The sudden removal by fire of the protective cover of vegetation in general and of forest in particular, may have considerable effect on watersheds by increasing erosion and water run-off (Glendening *et al,* 1961). The overland run-off and stream flow increases that result from burning of surface vegetation reduces underground water levels drastically, because it reduces infiltration which becomes insufficient to charge the aquifer. As a result, the flow from springs is reduced or ceases entirely, and the water level of the aquifer is lowered. Shallow wells may dry up completely (Pereira, 1973).

It is estimated that in the minor fire season from August to October 1979 and the major fire season from December 1979 to April 1980 in Kenya almost 4000 ha of plantations and natural forests, and more than 19 000 ha of grassland and bush were burned. This caused over US $300 000 direct loss from fire damage and a further US $20,000 from the suppression of growth. In 1968, seasonal fires removed 80 million tonnes of air-dry matter from the dry Savanna range resources in Sudan from which it may be estimated that about 16 million ha were burned (FAO, 1986:63).

2.3 Shifting cultivation

Shifting cultivation is a traditional farming system during which the land is cleared of vegetation, cropped for a few years and then abandoned when the soil fertility declines, and the farmer shifts his farming activity to a previously uncultivated land or a fallow land. The farmer may return to the abandoned piece of land only after a fallow period of 8-12 years in tropical rain forest, and after a period of 15 years or more in drier areas. It is a relatively safe method for conserving soil, vegetation and fauna, while providing subsistence to the population, as long as the population density remains below a critical figure (Wilde & Mcloughlin, 1976).

At higher population densities the natural cycle of regeneration is broken, soil degradation and erosion set in rapidly, yields fall, and the community often suffers from severe food shortages. According to Wilde and Mcloughlin (1976), an average population of 20 per km^2 may be compatible with maintaining yield levels on typical lateritic soils by using the traditional bush-fallow in the forest zone. The critical density may be extended to 40-50 per km^2 with ample and well-distributed rainfall as well as fertile soils. On the other hand, where rainfall is scant and soils are poor, the critical density will be reduced to about 10-15 per km^2. The system of shifting cultivation becomes self-destructive once the critical population density is exceeded.

Current rapid population growth in most parts of Africa, especially the humid tropics, has led to a shortening of the fallow period to 3-5 years. At the same time the number of crop species planted in a yearly cycle has generally been decreased.

Table 2 illustrates how productivity declines during the cropping period of shifting cultivation in different parts of Africa. The declines reflect climatic and soil conditions and the length of the fallow period (resulting from population pressure), and are bound to increase as the fallow period is shortened.

2.4 Deforestation

Pressure from population expansion and development projects in the developing world has led to the destruction of both closed and open forests all over the world. The FAO (1978) distinguishes between two types of forest: closed forest, where tree crowns cover more than 20% of the ground, and which has a more or less typical forest environment, and open forest, which represents all other areas carrying some type of wood vegetation, but which do not have a true forest environment.

Besides their direct economic value, i.e. the supply of wood, game, wild fruits, berries and herbal medicine, forests play other crucial roles: they protect the soil against degradation and erosion, restore soil fertility during shifting cultivation, ensure a continuous flow of clean water, reduce the danger of flooding, provide protection from desiccating winds or excessive temperatures, protect watersheds, and help to maintain the integrity of existing climate.

Large increases in recent years in the destruction of forests has resulted in problems of soil erosion, flood damage, silting and landslides in various parts of the world. The FAO (1978) reports that in the Azuero peninsula of Panama, out of a total mountainous forest area of 215,000 ha 42% were cleared within 18 years. In northern Thailand, 58% of the area of nearly 40,000 km^2 of forest was cleared in 56 years. In the Ivory Coast two-thirds of the 15 million hectares of the forest that existed at the beginning of the century is now lost. In Mindanao (the Philippines), one million ha of forest were cleared between 1960 and 1971.

Table 2: Decline in productivity under shifting cultivation in Africa

Country	Cropping period	Fallow	Decline during cropping period
	——— Year ———		%
Benin	2-3	3-10	25-60
Congo	2-5	2-10	20-50
Niger	5-6	5	50-60
Uganda	1-2	0-10	30-50

Source: Braun, 1974.

The FAO (1981) estimates that closed broad-leaved forests were cleared at the rate of about 1.3 million ha per annum between 1976 and 1980. More than half of the recent and prospective clearance of closed broad-leaved forest is in West Africa, mainly in Ivory Coast and Nigeria. Other areas with serious deforestation include Burundi, South Western Cameroon, South East Guinea, Madagascar, Rwanda and lower Zaire. In the more sparsely-populated parts of Central Africa, the pressure to clear land for agriculture is less severe, although the present state of deforestation is already alarming in the Kasai and Shaba areas of Zaire. In east and central Africa the situation is particularly serious in areas of heavy population density, like those around lake Malawi, in the Copperbelt of Zambia, and in Western Mozambique. In Southern Africa, deforestation is likely to be limited to populated areas, and to represent a small proportion of the existing area.

One of the major soil degrading processes in tropical areas that follows the removal of the forest cover is "laterization". It occurs when laterite (or plinthite) soils are exposed to the alternate pounding by heavy rainfall and drying under the tropical sun, become hard and compacted and are lost to cultivation. Sanchez and Buol (1975), however claim that the extent of area prone to this damage has been exaggerated.

2.5 Desertification

Desertification, or the intensification or extension of desert conditions, leads to reduced biological productivity, with consequent reduction in plant biomass, in the land's carrying capacity for livestock, in crop yields, and in human well being. It is not confined to the fringes of deserts, but also applies to all areas that for various reasons (such as overgrazing, the onset of salinity or alkalinity or the cultivation of marginal areas) lose their protective cover of vegetation and assume the characteristic of a desert (FAO, 1986:64).

The hazard of desertification is great in even the sub-humid zone, but in the arid and semi-arid zones, as much as 95% of the total land-area is exposed to the risk of desertification (Arnon, 1980). Desert encroachment is expanding at an alarming rate in the Sahelian belt of Africa, from the Sudan to Niger.

The desertification hazard is classified as very high, high or moderate, according to the rapidity with which desertification is likely to occur if present conditions do not change. Arnon(1980) estimates that the existing area of extreme desert in Africa covers 6.2 million ha, or 20% of the land area. Some 1.7 million ha (6%) are classified as having a very high degree of desertification hazard, 4.9 million ha (16%) a high degree, and 3.7 million ha (12%) a moderate degree. A very high degree of desertification hazard covering extensive areas is uncommon. The hazard is usually limited to bands of up to 20km wide around oases. Table 3 shows the extent of present and future desertification around the world, and the estimated degree of hazard.

It is estimated that in the Sudan alone, the desert has encroached, within the last 15-20 years, over land used areas in a belt of no less than 150km width (Kassas, 1972). The situation is equally bleak in India and elsewhere in central Asia. In Southern Africa, sub-tropical rainforest has been devastated and replaced by desert and semi-desert vegetation (Arnon, 1980).

The process of desertification has been re-constructed by Bryson (1972) for the area in India currently covered by the Rajputana desert, an area once occupied by a highly developed culture with an agricultural base - the Indian civilization. The desertification process he describes is basically a man-made phenomenon. Over-population in the dry regions leads to overstocking in areas that are inherently fragile ecosystems. If range management is ignored in such areas, the result is the destruction of plant cover, large-scale erosion, and finally, in many cases, desertification. The process is usually accelerated by the incidence of a series of more than usual dry years, such as recur periodically in the dry regions.

In sub-humid and mountain areas, the main elements in the desertification process are over-exploitation of the tree and shrub areas, uncontrolled cultivation on watersheds and steep slopes, unwise tillage practices, inadequate drainage in irrigation schemes, unregulated burning for land clearing, uncontrolled bush fires, improper water management, the lack of soil and water conservation measures, the concentration of livestock around watering points, the inability of landholders to respond flexibly to drought, and the absence of integrated land-use planning.

2.6 Over-grazing

Domestic animals, especially in the developing countries, depend on natural pastures or range-land, which account for nearly one quarter of the world's land-area (FAO, 1978). Forest lands or woodlands are also frequently used for browsing or grazing, and areas in the arid regions are also used for nomadic grazing.

Most of the lands used for grazing are unsuitable for arable cropping, either because rainfall is insufficient or because of waterlogging, being too steep, shallow or stony. For these reasons the productivity of natural pastures varies from 1/5 - 1/3 ha per animal unit on well managed and fertile pastures in temperate zones to 50-60 ha per animal unit in arid areas (Arnon, 1980). In humid regions pastures conserve soil fertility and may even improve it (especially if they contain leguminous species). Nutrients and humus accumulate under the sward, conditions are favourable for biological activity, a good soil structure is preserved and the vegetative cover prevents erosion.