United Nations University
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Institute for Environment and Human Security

Nothing Begets Nothing

The Creeping Disaster of Land Degradation

Paul L. G. Vlek

InterSecTions
'**Inter**disciplinary **Sec**urity Connec**Tions**'
Publication Series of UNU-EHS

No. 1/2005

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Foreword

I am very pleased to introduce this first issue of ***'InterSecTions'***, a series of publications launched by the United Nations University Institute for Environment and Human Security (UNU-EHS), which started operations in December 2003 in Bonn, Germany.

UNU-EHS has been conceived and established to improve the knowledge base for assessing the vulnerability and coping capacity of societies facing natural and man-made hazards in a changing and often deteriorating environment. The Institute aims to improve the understanding of cause and effect relationships, and to offer options to help reducing the vulnerabilities of societies. Interdisciplinary, science-based and human-centred, the Institute shall support policy and decision makers by providing authoritative research and information within its mandate. The Institute's motto, *'Advancing security through knowledge-based approaches to reducing vulnerability and environmental risks'*, epitomises those multifaceted aspirations.

The publications series of UNU-EHS, ***'InterSecTions'***, aims to contribute to the achievements of these objectives. Its name includes **inter**-disciplinarity, the key scientific feature of all endeavours of the Institute. It refers also to its international scope, reflecting the worldwide mandate of the UN. Human ***sec***urity, *'the freedom from want and the freedom from fear'* [1], is among the fundamental aspirations of humankind. This security is by no means an abstract concept. It is fully embedded in the intricate ***inter***connec***tions*** of social, environmental, and economic systems with their respective goals, constraints, threats, but also opportunities. ***'InterSecTions'***, the name of this series, is thus chosen to mirror these complexities. But beyond this interpretation, ***'sections'*** refer also to radical scrutiny. Like a pathologist taking tissue samples to confirm or reject a medical diagnosis and to devise a cure, this series is also meant to provide direct, knowledge-based evidence as basis for well founded decisions.

'InterSecTions' mean also crossroads. In the dynamic context of economic, social, but also scientific development, ***'intersections'*** stand for the ever changing network of paths of decisions implying uncertainties and threats, but also rewards. Crossroads of disciplines, concepts, methods, thoughts, and solutions are frequently faced. At these junc***tions*** we are confronted with the dilemma of how to continue. Will the right track be selected, or do we get dragged into a vicious downhill spiral?

'InterSecTions' is to be a forum of thought provoking articles, essays, think pieces, and other succinct publications, shedding light into problems and highlighting solutions. It is conceived to help making the right choice at the ***'intersections'***...

It is my sincere hope that ***'InterSecTions'*** shall be a source of orientation and inspiration for our readers in their challenging search for the most appropriate road to curb the manifold effects which the creeping deterioration in a changing environment may impose on human security.

J. A. van Ginkel

[1] UN Secretary General Kofi Annan, May 2000

Preface

The United Nations University Institute for Environment and Human Security (UNU-EHS) has been founded to address the interactions between the environment and human security. Environmental hazards are among the most unpredictable threats to human security. Extreme events like floods, droughts, earthquakes, landslides, and volcanic eruptions cause economic damages and immense human suffering and loss. These disasters – due to their dramatic consequences – are well imprinted on human memory and awareness. Likewise, climate variability and climate change, while their possible extent and consequences are not yet accurately estimated, have become matters of concern.

Scientific initiatives, decades, platforms, strategies, both within the United Nations system and in the scientific community, have been launched addressing disasters of natural origin as well as climate change.

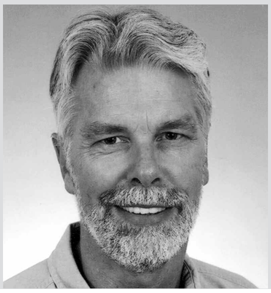
Creeping environmental deteriorations – even if their consequences entail economic loss as well as a direct threat to the survival of human societies – are among the hidden and forgotten disasters. As knowledge-based awareness raising of political decision makers, of the public, of scientists and of the media is one of the Institute's most prominent tasks, the present issue of ***'InterSecTions',*** the publication series of UNU-EHS, is dedicated to address one of the most menacing 'hidden disasters' currently affecting human security, namely land degradation. ***'InterSecTions'*** is being published and presented at the UN World Conference on Disaster Reduction (January 2005 in Kobe, Hyogo, Japan), where all these target groups shall gather.

In his thorough analysis of the worldwide phenomena of land and soil degradation, Professor Paul L. G. Vlek draws a bleak picture. Not only that land and soil degradation is progressing at an alarming pace having repercussions on food production and the environment, but, more alarmingly, these issues are still missing on the political agenda.

Raising awareness does not mean to raise fears. However, ignoring the pertinent problems would only undermine our ability to address them adequately and in a timely manner. Keeping this principle in mind, UNU-EHS is prepared to assist decision makers and to contribute to enhance human security.

Janos J. Bogardi
Director
UNU-EHS

Paul Vlek is a Full Professor at the University of Bonn, Germany and Director of the Centre for Development Research. He also serves as Editor in Chief of the International Journal 'Nutrient Cycles in Agro-Ecosystems'. Dr. Vlek is a Dutch national who obtained his M.Sc. degree from Wageningen University, The Netherlands, and his Ph. D. degree from Colorado State University, USA. His research focus is on nutrient and material flows as a function of land use and cover change in the tropics. He is a fellow of the Indian Academy of Agricultural Sciences.



Nothing Begets Nothing: The Creeping Disaster of Land Degradation

Paul L. G. Vlek

I. Background

It is often thought that ancient societies were more prudent than ours in the way they treated basic resources such as land and water. Research has shown this notion to be far from the truth. In fact, manipulation and modification of the environment were characteristic of many societies long before the advent of earth-moving machines and toxic chemicals. Mankind started tinkering with its surroundings even before the advent of agriculture. Our ancestors did this by using fire to facilitate hunting. They cleared tracts of forest in order to encourage the growth of shrubs and grasses and thus attract grazing animals that could be hunted or trapped. Clearing trees also served to promote the growth of plants that produced edible products for direct human consumption. The collection of such products and the trapping of grazing animals eventually led to domestication and the advent of agriculture (Harlan, 1992).

'By its very nature, agriculture is an intrusion upon and a disruption of the natural environment, as humans replace a natural ecosystem with an artificial one'.

Once established, agriculture became the chief agent of environmental transformation. By its very nature, agriculture is the replacement of a natural ecosystem with an artificial one. Cultivation and the subsequent removal of the crop tend to deplete the organic matter and the nutrient reserves of the soil by speeding up the rate of decomposition; reducing replenishment though plant and animal residues, and causing topsoil erosion. In many respects a farmer can be seen as a warmonger. The moment he arbitrarily separates a tract of land from the adjoining area for the purpose of cultivation, he is in effect declaring war on the native species. The local flora and fauna are then treated as weeds or pests to be eradicated by all possible means.

As long as agriculture was confined to small localized areas, the earth's environment as a whole was not threatened. Degraded land could be abandoned and thus allowed to recover gradually, while new tracts were cleared, in succession. However, with to date's population growth, brought about by the very success of agriculture in improving food security, entire extensive regions were subject to continuous cultivation. To compensate for the loss of natural fertility and to achieve ever-higher yields, farmers recently have utilized increasing quantities of chemical fertilizers and pesticides. In arid regions, irrigation has been introduced to overcome drought. Erosion, water logging, salinization, pollution, and the eradication of numerous species – such events were the unforeseen, but now global consequences, of humanity's expansive and often injudicious management of soil and water resources.

II. Forms of Land Degradation

'Human caused land degradation, if recognized too late, may lead to disasters and human insecurity'.

'Land degradation should be considered a social problem that can be avoided'.

Even though human-caused land degradation is a creeping process, it takes place at variable rates and to variable degrees depending on environmental conditions and management systems. If recognized too late, the process may lead to disasters and human insecurity. Among the cultural factors are the intensity (mode and duration) of tillage and other forms of mechanical disturbance (including traffic and compaction, irrigation, etc.), as well as the pattern and intensity of cropping, and the persistent net export of nutrients from the field. Among the relevant environmental factors are climate (temperature, precipitation), physiography, and soil characteristics. In the humid tropics, for example, conditions differ quite markedly from those in the arid subtropics; just as conditions in the rainfed uplands differ from those in the irrigated river valleys. Hence each case must be considered and treated individually with consideration of the site-specific factors and processes at play.

Land degradation: Land is defined as the ensemble ('ingredients') of the soil, the constituent biotic components in and on it, and its landscape and climatic attributes. Except for some chaotic natural events, land degradation is mainly due to the interaction of the land with its users. By definition, land degradation should thus be considered a social problem that can be avoided. According to Katyal and Vlek, 2000, land degradation sets in:

1) when the potential productivity associated with a land use system becomes non-sustainable, or

2) when the land is not able to perform its environmental regulatory function.

If the carrying capacity of the soil is persistently exceeded, land becomes progressively degraded and loses the ability to renew itself. Also, mismatches of land use and land attributes lead to degradation. Restorative management, including appropriate inputs and technology, can reverse the negative effects of over-exploitation by humans. But lacking the capability or incentives (tenure) to invest in land, small and marginal farmers the world over are doomed to over-exploit their limited resources (Syers et al., 1996). In the process, soil, the key component of land, loses quality (SSSA, 1996) and becomes infertile, more erodible and compacted. In cultivated regions, land degradation is essentially equivalent to soil degradation. In rangelands, land degradation can be due entirely to loss of vegetation diversity due to over exploitation but the process often affects soils as well (see Table 1). Within the world's drylands, the area affected by land degradation and desertification amounted to 3592 million hectares in the late eighties (UNEP, 1991), equivalent in size to Russia, USA and China together.

'Within the world's drylands, the area affected by land degradation amounts in size to the equivalent of Russia, USA and China together'.

Table 1
Extent of soil degradation within the areas affected by it.

Land use category	Total area within drylands (M ha)	Area affected by land degradation (M ha)	Area affected by soil degradation (M ha)
Irrigated cropland	145	43	43
Rainfed cropland	457	216	216
Rangeland	4556	3333	757
Total	5158	3592	1016

Data source UNEP (1991)

Sustainable land use implies harmony between man's use of land and the land's ability to maintain or renew its quality. Degradation sets in once this balance is upset, and soil, water and vegetation – the basic elements of land – are damaged. This damage can be manifested in several different ways:

(1) Soil loses life-sustaining topsoil (through erosion) and some essential nutrients (through nutrient leaching and export). It accumulates harmful chemicals (due to salinization, alkalinization or acidification), or develops physical deformities (such as crusting or compaction);

(2) Water accumulates close to or above the soil surface (water logging), or becomes scanty or salty;

(3) Vegetation loses the productivity of useful plants due to systematic deforestation, overgrazing by livestock and invasion by less useful species. This also results in a loss of biodiversity. The denudation of arid lands and the subsequent processes of leaching and erosion caused by water and wind, resulting in the loss of productivity, may become so extreme that desert-like conditions appear.

III. Loss of Soil Fertility

'The nutrient balance worldwide is in equilibrium, though, regionally, the story is quite different'.

The changes wrought by humans in nutrient cycling and budgets are complex and vary widely in magnitude across the globe. Vlek et al. (1997) estimate that 230 million tons of plant nutrients are removed from agricultural soils annually. Balanced against this is the global fertilizer consumption of nitrogen (N), phosphorus oxide (P2O5) and potassium oxide (K2O) of 130 million tons. In the case of nitrogen the fertilizer supplements are augmented by an estimated 90 million tons from biological fixation. Thus, within the margin of error, the nutrient balance worldwide is in equilibrium. Regionally the story is quite different. Developing countries consume half the global fertilizer production, with much of it used on cereal crops grown on the irrigated lands of Asia, or on cash crops. Large rainfed areas producing food crops in the tropics, particularly in sub-Saharan Africa, receive little or no fertilizer. Low inputs and limited re-cycling of nutrients by poor smallholders in these areas lead to negative nutrient balances that render continued crop production unsustainable (Stoorvogel and Smaling 1990). This exploitation of native soil fertility is coupled with a decline in organic soil matter which is respired as carbon dioxide (CO2) which, in turn, contributes to climate change.

The negative nutrient balance, due to inadequate external inputs, and the inequitable distribution of nutrients between and within countries, is exacerbated by the transport of nutrients in harvested products. On a global scale, Miwa (1992) showed that international trade in food commodities led to a significant negative balance in exporting countries and accumulations in importing countries. The environmental impacts of inter- and intra-national nutrient flows are commonly concentrated in the burgeoning cities. For example, Faerge et al (2001) estimated that 20,000 metric tons of nutrients were annually imported in food into Bangkok, and that large amounts of these nutrients were lost, mainly due to drainage to the waterways. Coping with high concentrations of nutrients in the environment is a major problem facing urban administrations, and the problems are likely to get worse with the continuing trend towards urbanization. Similar problems occur in areas with intensive animal production systems. Income growth and expanded demand for animal products in developing countries will increase international and intra-national trade in animal feed. This will negatively aggravate the 'mining' of rural soils where these products originate and the environmental problems in animal production areas where they end up. Nutrients can be re-cycled through the addition of waste to crops and forages. In spite of the obvious benefits, the extent of re-cycling is limited in most cities as the transport costs are often prohibitive.

'Coping with high concentrations of nutrients in the environment is a major problem facing urban administrations, and the problems are likely to get worse with the continued trend in urbanization'.

In marginal areas, erosion of upper-catchment soil by water (and in some cases by wind) enriches surface waters with nutrients. Sediment may be deposited which enriches lowland areas. However, annual net ocean outflows of sediments in Asia are as high as 7,500 million tons, representing a major loss of nutrients to the contributing countries concerned (Milliman and Meade 1983). Global net outflows of dissolved inorganic nitrogen to the oceans have been estimated at 18,300 million tons (Seitzinger and Kroeze 1998). Fortunately, the nitrogen thus disposed of will enter the global nitrogen (N) cycle which has strong feedback mechanisms. The situation is different for phosphorus (P). An estimated 33 million tons per year are lost to the ocean annually (Howarth et al., 1995), which will find their way back to terrestrial systems over geological time scales rather than years. These flows of nutrients today are greatly enhanced by human intervention in the natural ecosystem. Reversing these trends through better management is certainly within our reach, but there will be a price for it.

IV. Nutrient Depletion in Africa

African countries have a great diversity in their endowment of agricultural resources. It has been estimated that about 196 million hectares are presently cultivated, out of which – taking into account requirements for fallow – about 108 million are harvested yearly. One third of Africa's land area is too dry to support rainfed agriculture. However, most of the unused agricultural land in Africa lies in the central humid region.

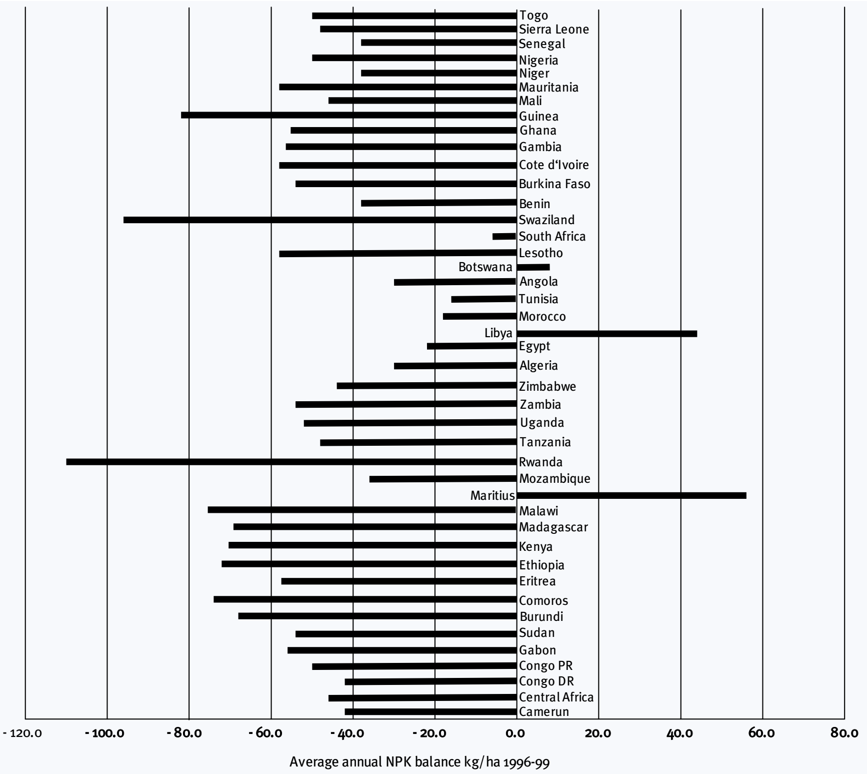
Rates of nutrient depletion range from moderate (30 to 60 kg of nitrogen, phosphorus and potassium per hectare per year in the humid forests and wetlands in southern and Central Africa) to high (more than 60 kg in the East-African Highlands). The nutrient imbalances are highest where fertilizer use is particularly low, and nutrient losses, largely from soil erosion, are high.

'The two main factors contributing to nutrient depletion are erosion, crop grain plus residue removal. In Africa nutrient depletion represents a total loss of US$ 1.5 billion per year in terms of the cost of replacing nutrients with fertilizers'.

The net annual losses of nutrients vary considerably among countries. Estimates of nutrient inputs and outputs for agricultural areas in selected countries in West Africa show the following total nutrient depletion per year: 52 kg per hectare for Ghana, 38 kg per hectare for Benin, and 49 kg per hectare for Togo (see Fig. 1). The two main factors contributing to nutrient depletion are erosion as well as crop removal. These factors constitute about 70% of all nitrogen (N) losses, nearly 80% of all potassium (K) losses, and 95% of all phosphorus (P) losses. In Africa nutrient depletion represents a total of US$1.5 billion (based on 1996 fertilizer prices) per year in terms of the cost of replacing nutrients with fertilizers. Forfeited yields cause additional financial losses.

Figure 1

National nutrient (NPK) balance of arable land for sub-Saharan African countries (1996-99)



Yet, the average use of mineral fertilizers in most countries of sub-Saharan Africa is still below 10 kg per hectare. A few countries, Nigeria, Zimbabwe, Kenya, Sudan, and Ethiopia account for about 75 % of the total fertilizer use in sub-Saharan Africa. Fertilizers in these areas tend to be used mostly on cash and plantation crops (cacao, cotton, coffee, groundnuts, tobacco, tea, sugar cane, and oil palm). This is due to the high profitability of fertilizers in the production of export crops. Unfavourable crop/fertilizer price ratios, particularly for food crops, and financial constraints are key factors explaining the current low levels of fertilizer use (see Box 1). Most production estimates (yield kg/ha) in Africa are low and within the range of average rainfed smallholder yields with moderate to low soil fertility as compared with production numbers of other tropical areas.

'Unfavourable crop/fertilizer price ratios, particularly for food crops, and financial constraints are key factors explaining the current low levels of fertilizer use'.

'If governments and international donors wish to avoid soil mining and degradation by poor farmers, fertilizer subsidies or crop price support may have to be seriously considered'.

BOX 1

Fertilizer: the way forward for the well-off in Africa

A recent study by ZEF (Kaizzi et al., 2004) in Eastern Uganda explains why fertilizer adoption rates are low in this region. In a series of on-farm experiments (20 farmers per location), farmers tested the use of moderate amounts of fertilizer in alternate crop seasons with the farmers' practice of continued maize cropping without inputs. The studies covered two areas with low and high environmental potential for crop production. In each area, fields of below and above average production potential were included. The overall maize yields over two seasons were recorded and are listed in Table 2, clearly showing the benefits of fertilizers in three out of four production systems. However, given the current prices of inputs, produce and labour, the capital-intensive fertilizers were not, or only marginally, economical for the farmers as a way to improve soil fertility for most systems. Ironically, only farmers in the best endowed environments, and even then only those farming the better soils, could expect a reasonable return on investment (see Table 2). This leaves the farmers in the remainder of the country little option but to mine their soils. Under current market conditions, fertilizer marketing strategies should be directed toward the more favourable environments. Thus, promoting fertilizers in areas where their use will not result in markedly increased land and labour productivity and profitability is indeed a misdirection of scarce resources (Vlek, 1990). However, if governments and international donors wish to avoid soil mining and degradation by poor farmers, fertilizer subsidies or crop price support may have to be seriously considered.

Table 2

Total maize grain yield (t/ha) and resulting benefit to cost ratio* (B/C) for two seasons of alternative crop management systems on soil with different productivity in contrasting production environments

TREATMENTS	ENVIRONMENT POTENTIAL Low		High		SOIL PRODUCTIVITY
	Yield	B/C ratio	Yield	B/C ratio	
Farmers practice	2.6	0.79	3.2	0.73	Low
+40 kg N/ha/year	4.0	0.99	4.4	0.84	Low
LSD 5%	1.0	0.25	1.0	0.28	Low
Farmers practice	4.2	1.38	5.5	1.14	High
+40 kg N/ha/year	4.6	1.15	8.3	1.59	High
LSD 5%	1.4	Not significant	1.9	0.27	High

* The higher the value, the more profitable the strategy

B/C = 1 indicate that farmers are recovering costs

B/C < 1 indicate that farmers are not recovering costs
LSD: least significant difference

'In 1997 sub-Saharan Africa imported the equivalent of 26% of its fertilizer consumption in food and this may increase to 62% in 2020. But if the nutrients imported in food end up as wastes in the major cities, the rural lands will not benefit'.

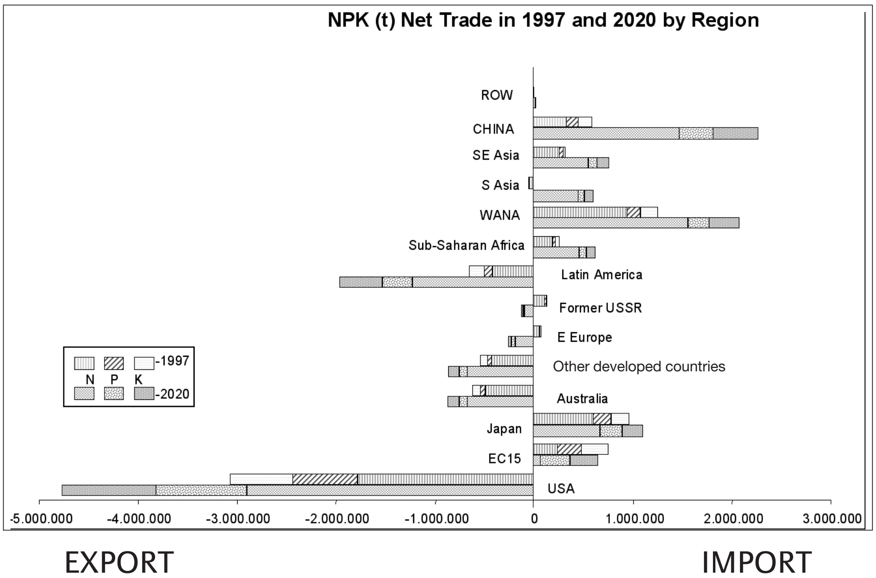
In 1997 sub-Saharan Africa imported the equivalent of 26% of its fertilizer consumption in food and this may increase to 62% in 2020. This hardly solves the major problem in sub-Saharan Africa of nutrient depletion in rural areas due to low rates of fertilizer use. If the nutrients imported in food end up as waste in the major cities, the rural lands will not benefit. The result highlights the potential for nutrient re-cycling in peri-urban and urban agriculture. But nutrients disappear from Africa in trade as well. Vlek (1993) estimated that in 1987 the export of nitrogen (N), phosphorus oxide (P2O5) and potassium oxide (K2O) in agricultural commodities from sub-Saharan Africa, mainly in cotton, tobacco, sugar, coffee, cocoa and tea, was 296,000 tons; more or less negating the positive balance due to imports of food.

'Each country must consider the effects of nutrient flows in food trade on its own ecosystem'.

The total net global flows of nitrogen (N), phosphorus (P) and potassium (K) in the form of commodities, estimated in the study of Craswell et al, (2004), are 4.8 million tons in 1997 which will be 8.8 million tons in 2020 (see Figure 2). The results show the proportional dominance of nitrogen (N) in nutrient movement. Potassium transfers are also significant and may provide opportunities for the eventual re-cycling of this important nutrient, especially given its high cost of mining and transportation. Nitrogen is the most dynamic nutrient and after transformation can move in the atmosphere, as well as in aquatic systems. The amounts of nitrogen (N) involved in transfers through trade are ecologically significant, especially when the 2020 projections are considered. As Miwa (1992) points out, each country must consider the effects of nutrient flows in food trade on its own ecosystem.

Figure 2

Net flows in tons of N, P and K in traded agricultural commodities in 1997 and 2020 (IMPACT model). Data presented are averages across and within countries.



ROW: Rest of the World
WANA: West Asia and North Africa

V. Soil Erosion in Africa

The major cause of soil degradation is soil erosion (e.g., Oldeman, 1994; Morgan 1995) which is also perhaps one of the most serious mechanisms of land degradation and soil fertility decline in tropical environments (e.g., El-Swaify, 1997; Enters, 1998). The processes and impact of soil erosion are more pronounced in tropical regions due to intensive rainfall, highly weathered and erodible soils: poor vegetation cover, and greater potential water flow energy in steeply sloped areas (e.g., Lo, 1990; El-Swaify, 1997).

Nitrogen, phosphorus and potassium losses primarily arise from soil erosion, crop harvesting and, for nitrogen (N) and potassium (K), from leaching. Soil fertility problems are often related to the predominant crop management practices such as continuous cropping of cereals; lack of rotation systems; inappropriate soil conservation practices, and inadequate fertilizer use. The losses due to erosion in African countries can be broken down as follows:

- 33% to 64% of the total nitrogen loss;
- 18% to 77% of the total phosphorus loss; and
- 33% to 50% of the total potassium loss.

Stocking (1986) estimated the economic costs of the annual losses of nitrogen (N) and phosphorus (P) in Zimbabwe alone to amount to US $ 1.5 billion per year.Cropping intensification and poor crop management practices have made the mountain and hilly areas of sub-Saharan Africa prone to excessive water runoff, soil erosion, and soil nutrient depletion. Areas identified by UNEP (1991) as warranting serious attention include the Fouta Djallon Mountains in West Africa (Guinea), the East African highlands (Kenya, Burundi, Ethiopia, Rwanda, Tanzania, and Zimbabwe), and the highlands of southern Africa (Botswana, Lesotho, and Swaziland). Due to severe shortages of energy and fodder, the continuous cropping on steep slopes, and the low use of fertilizers and crop residues, the land has been severely degraded in some areas, principally in Ethiopia, Rwanda, Burundi, and Lesotho.

The severity of land degradation in these latter countries is now greater than ever before. The top soil in many areas has been eroded to such an extent that farmers are now plowing rocks. The loss of top soil and its nutrients results in poor crop

'Soil fertility problems are often related to the predominant crop management practices such as continuous cropping of cereals; lack of rotation systems, inappropriate soil conservation practices, and inadequate fertilizer use.'

'The top soil in many areas has been eroded to such an extent that farmers are now plowing rocks. The policy response by the government will be futile if they do not address the root cause of soil degradation to begin with.'

yields worsening the food security situation of people already stressed by rainfall shortage and variability. Farmers and governments are often at a loss in devising effective control mechanisms and appropriate management interventions. For instance, the northern part of Ethiopia which is characterized by low rainfall; high rainfall variability; complex terrain with dissected relief, and very poor vegetation cover, is especially known for its highly degraded and degrading landscape (e.g., Eweg et al 1997). The policy response from the government to the periodic drought and food insecurity was a dam-building program in the North, in order to intensify agriculture and a trans-migration program to the South. However, such measures are futile if they do not address the root cause of soil degradation to begin with (see Box 2).

BOX 2

Small Dams in Northern Ethiopia

Of a total of 60 small dams planned for the Tigray region, only 20 were actually completed. In a detailed study of the fate of these dams Lulseged (2005) measured the sedimentation of the reservoirs in order to assess the erosion rates from the catchment areas and the projected life time of the dams. They were originally designed to have a life span of 20 years. The major morphometric properties of the catchment areas such as drainage network and associated bank erosion correlated well (R2 = 0.65) with erosion as measured by sediment yield per unit area (SSY).

Sediment core data and bathymetric surveys further indicate that the soil erosion rate in the catchments of the northern part of Ethiopia, with catchment size ranging from 230 to 1970 hectares, ranges from about 5 tons per hectare per year to over 40 tons per hectare per year. The rate of sedimentation (SSY) does not correlate with catchment size, but correlates well with mean catchment slope (MES, see Figure 3), except when measures are taken in the catchment to minimize soil erosion. Three such catchments were present in the sample (triangles), all having erosion rates (SSY- values) of less than 10 tons per hectare per year, irrespective of their slopes. The three catchments (highlighted as triangles) are well protected by terracing and by well managed enclosures that exclude human and livestock interference. The vegetation cover density of enclosures also progressively increases with slope steepness for these three catchments.

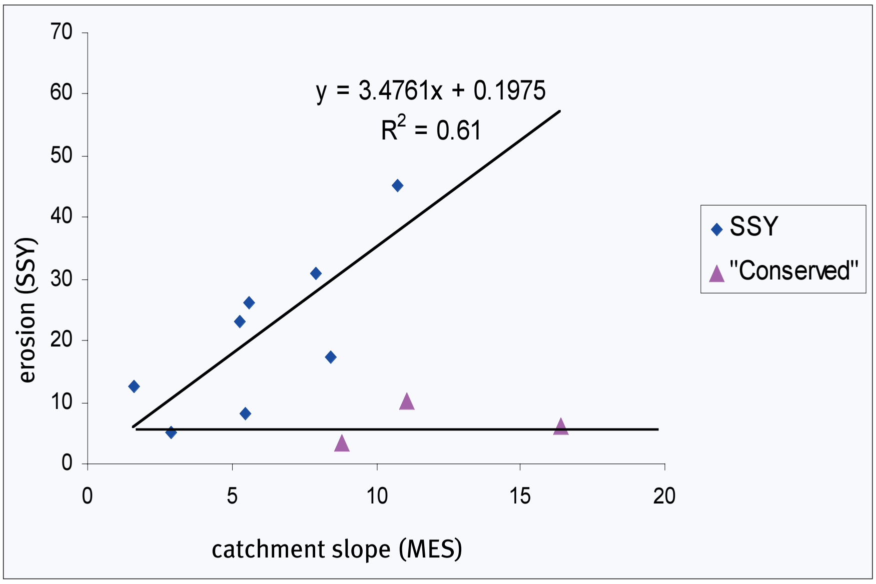
Thus, erosion not only affects on-site crop productivity, but it also accelerates the sedimentation of reservoirs. Most of the reservoirs, built to improve the livelihood of people, have lost more than 50% of their water storage capacity within 5 years of entering service. Faced with this lamentable ‘success rate’, the government has all but stopped its dam-building activities in Tigray.

‘Erosion not only affects crop productivity on-site but it also accelerates sedimentation of reservoirs.’

'Reduced fallow cycles, now often 50% shorter than traditionally needed to restore soil fertility, and in some cases complete failure to rest the land, have gradually diminished the productivity of the system.'

Figure 3

Correlation between area-specific sediment yields (SSY in t/ha/year) and mean catchment slope (MES in degrees)



V. Begetting Nothing

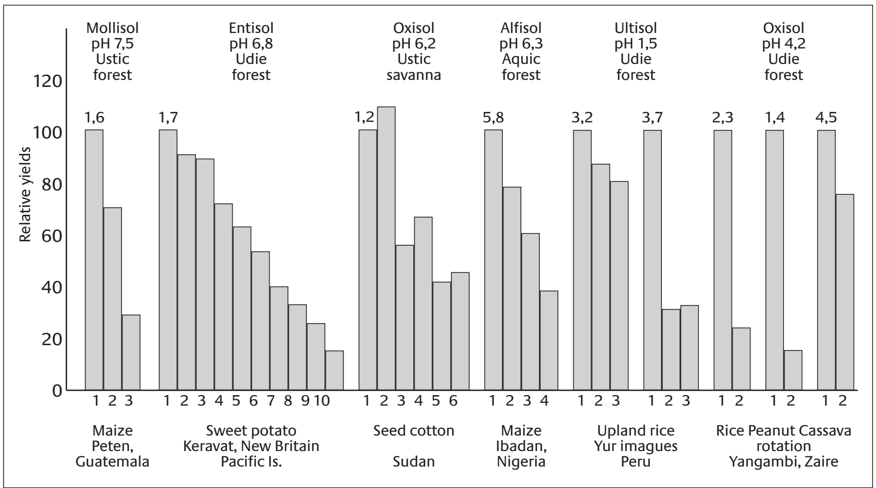
Human interference often changes the natural system from one that is stable and virtually closed, as far as nutrient cycling is concerned, to one that is degraded and more or less open depending on the severity of the human disturbance. The rapid decline in productivity of land following conversion to agriculture has been demonstrated again and again. Figure 4 shows this decline in a number of locations and provides the rationale for resting the land. Reduced fallow cycles, now often 50% shorter than traditionally needed to restore soil fertility, and in some cases complete failure to rest the land, have gradually diminished the productivity of the system. Loss of productivity is attributable in large part to the loss of nutrients from the system. The concept is aptly described by Sanchez (1976), who warned that a fallow period of less than critical length leads to incipient reductions in productivity. The problem is common in many tropical environments and has since been given ample attention in the literature. Yet, farmers often see it when it is too late.

Soil quality is the key to agricultural productivity; more so in low-input production systems when productivity enhancing technologies are largely out of reach to the farmer. Regional assessments of soil degradation on the basis of yield trends is, however, difficult as improvements in crop performance over the past few decades, a result of plant breeding or fertilization practices, have sustained yields while degradation continued (Oldeman, 1994; Smaling and Braun, 1996). Soil degradation is often ignored when depleted regions are abandoned and new ones cleared, an option only as long as new land is available for cultivation (Vlek, 1993). Yet, there is growing concern that the degradation of agricultural soil resources – that is, a decline in long-term productivity potential – is already seriously limiting production in the developing world (Lal, 1990).

'It is increasingly recognized that, in the long term, crop management systems, which do more than merely use chemical fertilizers, may be required to restore soil organic matter levels and sustain soil productivity'.

Figure 4

Yield decline of successive crops after clearing and burning natural vegetation (Source: Sanchez 1976).



Tropical soils are often dominated by low-activity clays, which store few nutrients. Organic matter in soil thus acts as the key nutrient store and as a conditioner, playing a central role in productivity. Soil organic matter levels steadily decline when fresh organic matter inputs are reduced as soils are subjected to cultivation (Vlek et al., 1997). Successful management of tropical soils requires that both inorganic and organic soil fertility be maintained. Human intervention through the use of fertilizers and soil amendments may overcome most immediate soil fertility constraints, but often only at a considerable, sometimes prohibitive cost, as elaborated in Box 1. However, these measures rarely overcome the decline of soil organic matter and few ideas are around to remedy this first step in soil degradation (Martius and Vlek, 2002). It is increasingly recognized that, in the long term, crop management systems, which do more than merely use chemical fertilizers, may be required to restore soil organic matter levels and sustain soil productivity. Some agro-ecological production systems were analysed by Vlek et al. (1997) and showed that indeed, soils that had nothing left to lose also had nothing left to offer: nothing begets nothing.

VI. Social Aspects of Land Degradation

It is widely recognized that land degradation is a man-made problem. It has been taking place since the dawn of agriculture (Barrow, 1991 and Hillel, 1991). What is new is the intensity of degradation in recent times. The soils of the world have lost, on average, 25.3 million tons of humus per year since agriculture began some 10,000 years ago. However, over the last 300 years the average loss was 300 million tons per year; and in the past 50 years this average has reached 760 million tons. (Rozanov et al., 1990). The growth of population, expansion of croplands, destruction of vegetation, global warming, and emergence of yield-enhancing technologies all seem to have played a role in this acceleration. In essence, the last 50 years have been a saga of economic growth and ecological loss. Rozanov et al. (1990) believe that the 6 million hectare annual loss to degradation is practically irreversible. The reliability of these statistics has been a subject of debate (Mainguet, 1994, and Thomas and Middleton, 1996), but even if corrected downward the magnitude of the problem remains.

'The last 50 years have been a saga of economic growth and ecological loss. Rozanov et al. (1990) believe that the 6 million hectare annual loss to degradation is practically irreversible'.

Dregne and Chou (1993) estimate that nearly 1860 million hectares, or little more than half of the desertified area world-wide, requires rehabilitation. And that is more than the size of Russia with its 1700 million hectares. The cost of rehabilitation over a 20-year period was calculated to be about US$ 213 billions. If not rehabilitated, they estimate that the income foregone (over a 20-year period) could equal a staggering US $ 564 billion. In contrast, the economic impacts and implications of perturbations to nutrient cycles have yet to be looked at. One of the exceptions in the area of nutrient balances is the work of Drechsel and Gyiele (1999) who developed a framework for the economic assessment of soil nutrient depletion. Their data shows that the cost of replacing nutrients lost from arable land in countries of sub-

Saharan Africa ranges from <1% to as high as 25% of the national Agricultural Gross Domestic Product.

Land degradation is not a sudden event, but a gradual process or creeping event. The cost of preventing land degradation is not high if recognized and action is taken early enough. Once it reaches a point where reclamation becomes economically prohibitive, the land will be abandoned. Currently, a consistent loss in biological productivity is the general criterion employed to distinguish degraded from non-degraded lands, and the degree of this loss defines among degradation classes. It is largely a confirmatory criterion for degradation that has already occurred, since it cannot predict whether the land has an inherent tendency to degrade. Late diagnosis adds to the cost of reclamation and can render land practically irrecoverable, causing sustained environmental damage.

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Widespread land degradation (coupled with uncontrolled population growth) has had far-reaching social consequences. The traditional village-based mode of life has been undermined. Millions of people, often the most able-bodied, leave the lands that can no longer support them, and migrate to cities in the hope of a better life. However, most of the cities in the developing countries lack the economic infrastructure to employ many of these migrants, who generally lack the skills needed in a modern urban economy. Traditional family-run farms decline owing to a lack of investment in modernization and the prevention of further land degradation. Thus starts a vicious cycle that ends with land abandonment. The intimacy that long prevailed between farmers and their land has been severed, as people who had long lived on and from their own (or their communal) land, become city dwellers. Sometimes this offers opportunities to larger enterprises to take over making day labourers out of those who used to own the land.

There are many indications that degraded lands are more vulnerable to extreme events. With the absence of good soil cover, soils suffer a loss in soil biology and a loss in channels for rapid deep drainage that these soil engineers normally create. Moreover, soils that have been stripped of their forest cover have also lost the tight network of roots that provided soil stability even if the soils became saturated during heavy storms. The consequence may be catastrophic mudslides

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such as those experienced in Honduras and Venezuela and, as most recently witnessed, in Haiti and the Philippines. The results are massive economic set backs and unnecessary loss of life.

There is an urgent need to monitor the fate of our land and soils, and to develop indicators that can predict the onset of land degradation. Potential indicators should be quantitative, sensitive enough to give early warning of the impending change, widely applicable, able to assess the present status and trend, able to distinguish change due to natural cycles as opposed to anthropogenic interventions, and relevant to ecologically significant phenomena (Rubio and Bochet, 1998). Although they listed many potential desertification indicators, they did not present critical values to define the inception of desertification. Urgent efforts are, therefore, necessary to develop threshold limits or symptoms of change that can serve as a wake up call (before the effects become visible). These should provoke measures to amend the ongoing land use practices so as to arrest the process before it intensifies and wreaks havoc. The severity of the problem is such that it warrants greater international attention by monitoring what is happening to our soils analogously to what the Intergovernmental Panel on Climate Change does with regard to climate. The United Nation University Institute for Environment and Human Security, established in 2004, seems to be the appropriate institution to work on indicator development. The occasion of its establishment is used to call also for an effort in land monitoring through the establishment of an International Panel on Land Degradation (see Box 3).

There is ample evidence that, analogue to the Intergovernmental Panel on Climate Change (IPCC), an International Panel on Land Degradation (IPLD) should be created to focus awareness and research and to initiate action against causes and consequences of land degradation to world's food security as, ultimately, human survival may be at stake.

Box 3
International Panel on Land Degradation

Mandate and Membership of the IPLD

Recognizing the problem of potential global climate change, the United Nations University and the United Nations Environment Programme (UNEP) established the Intergovernmental Panel on Land Degradation (IPLD) in 2005. It is open to all members of the UN and WMO.

The role of the IPLD is to assess on a comprehensive, objective, open and transparent basis the scientific, technical and socio-economic information relevant to understanding the scientific basis of risk of human-induced land degradation, its potential impacts and options for adaptation and mitigation. The IPLD does not carry out research nor does it monitor land and soil related data or other relevant parameters. It bases its assessment mainly on peer reviewed and published scientific/technical literature. Its role, organisation, participation and general procedures are laid down in the 'Principles Governing IPLD Work'

Organisational Structure

The IPLD has three Working Groups and a Task Force

Working Group I assesses the scientific aspects of the soil and land system in relation to land use and global environmental change.

Working Group II assesses the vulnerability of socio-economic, food and natural systems to land degradation, consequences of land degradation, and options for adapting to it.

Working Group III assesses options for limiting land degradation and regulating land cover change. The Task Force on National Land Resources Inventories is responsible for the IPLD National Land Resources Inventories Programme.

The Panel meets in plenary sessions about once a year. It accepts/approves/adopts IPLD reports, decides on the mandates and work plans of the Working Groups and the Task Force, the structure and outlines of its reports, the IPLD Principles and Procedures, and the budget. The Panel also elects the IPLD Chair, the IPLD Bureau and the Bureau of the Task Force on National Land Resources Inventories. The IPLD Bureau meets two to three times per year and assists the IPLD Chair in planning, co-ordinating and monitoring progress in the work of the IPLD.

A main activity of the IPLD is to provide in regular intervals an assessment of the state of knowledge on our lands and their soils. The IPLD also prepares Special Reports and Technical Papers on topics where independent scientific information and advice is deemed necessary and it supports the UN through its work on methodologies for National Land Resources Inventories. A number of IPLD reports are published commercially.

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