

Turning the tides of soil degradation in Africa: capturing the reality and exploring opportunities

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Abstract

Soil degradation means loss of biological and economic productivity of the land. Measurements of land degradation need to take cognizance of land properties (e.g. soil, water and vegetation) as well as productivity indicators. While land degradation in sub-Saharan Africa is a subject of an on-going debate, conflicting perspectives arise about its extent at regional and at lower scales, about methodologies and robustness of indicators and the impacts of past and present degradation on food security, about rural livelihoods in general, and on African posterity. This paper presents evidence of land degradation from selected case studies across East Africa, and analyses them against the robustness of indicators used at regional, national and lower scales in order to unravel the hidden myths and realities of land degradation. The results are corroborated against time-series such as yields of major crops, environmental data (rainfall, soil fertility) and management data. Land degradation assessments need to move away from empty rhetoric to capturing reality by integrating effects of farm management practices and technologies, including their social and institutional dimensions, on soil loss, yields and nutrient budgets. Influencing factors and socio-economic environments surrounding land degradation and the specific environments under which degradation takes place should not be overlooked.

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Introduction

The earth's system is regulated by physical, chemical and biological processes that sustain human livelihood. Adverse changes in the earth's system due to negative interactions between these natural processes and human activities and social systems have been at the centre of an on-going debate on land degradation (HDP, 1994; Oldeman et al., 1990). Land degradation refers to loss in productivity of the land and its ability to provide quantitative or qualitative goods or services as a result of natural and human-induced changes in physical, chemical and biological processes (Blaikie and Brookfield, 1987). It is a permanent decline in the rate at which land yields products useful to local livelihoods within a reasonable time frame (Scoones and Toulmin, 1999).

Land degradation is often mentioned as a threat to the basis of many farming communities and their

livelihoods (Bationo et al., 1998). Others have postulated that land degradation, especially due to declining soil fertility, is the fundamental biophysical cause of declining per capita food production in sub-Saharan Africa (Sanchez et al., 1997; Lynam et al., 1998). Sub-Saharan Africa is the only region in the world where per capita food production has been on the decline for the last two decades. Thus qualitative and quantitative measurements of the extent of land degradation without considering its impacts on livelihoods demand an answer.

Studies at supranational scales indicate that land degradation is continuing unabated in sub-Saharan Africa. Global Assessment of Soil Degradation estimates that 65% of African agricultural land, 31% of permanent pasture land, and 19% of forest and woodland is degraded. The report further mentions that water and wind erosion, respectively, account for 46% and 38% of total soil degradation in Africa (Sivakumar and Wills, 1995). Chemical degradation accounts for 12% and physical degradation, 4% of total degradation.

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Causes of soil degradation in Africa were reported as overgrazing (49%), agricultural mismanagement (28%), deforestation (14%) and overexploitation of vegetation for domestic and industrial use (13%).

Other seminal assessments, using nutrient balances as a land management indicator, reported annual average nutrient deficits for N, P and K of 22, 2.5 and 15 kg ha⁻¹ in sub-Saharan Africa with East Africa (Kenya, Uganda and Tanzania) being reported as having intense nutrient depletion (Stoorvogel and Smaling, 1990).

While these studies on land degradation and the importance of their empirical roots are widely acknowledged, there are conflicting reports of degradation processes at the micro-level (at farm and catchment levels) and their real past and present impacts on rural livelihoods. Recent studies have questioned the generalizations on land degradation in sub-Saharan Africa (Tiffen et al., 1994; Fairhead and Leach, 1996; Leach and Mearns, 1996).

Poverty and economic pressure, high rates of population growth, insecure land tenure, agricultural mismanagement of soil and water resources, lack of agricultural intensification, deforestation, overgrazing and shifting cultivation are widely claimed as responsible for land degradation (FAO, 2001; Cleaver and Schreiber, 1994; Bationo et al., 1998; Gruhn et al., 2000). Thus, land degradation is largely a consequence of socio-economic constraints, dynamics of natural resource systems and policy distortions.

There is a need to corroborate supranational assessments with micro-level studies to capture the reality of land degradation and to reverse its impacts on rural livelihoods. The objective is to explore evidence of land degradation and to inventory opportunities for reversing the trend. Causal linkages between changes in land properties and their impacts on agricultural productivity and livelihood systems have been examined, as well as the relation between land degradation and rising population, intensification of agriculture, loss of vegetation cover, land tenure and land-use policies. The paper is based on plot-level studies in East Africa.

The paradoxes of population increase and land degradation

As populations grow, degradation of the soil resource base has been on the increase in East Africa (Woomer and Muchena, 1993). Recent analyses have shown that land degradation is more severe at high population density in sub-Saharan Africa (FAO, 2001). Growing population triggers a cobweb of processes including accelerating deforestation, declining land holdings and rising food shortages. Parts of East Africa such as the Lake Victoria basin support some of the densest rural populations in the world, at 500–1200 persons km⁻²

(Hoekstra and Corbett, 1995). It is estimated that there are 0.28 hectares per person of cultivated land in East Africa and that there are approximately 57 million hectares of land that could potentially be brought under cultivation (Fischer and Heilig, 1997). However, the productivity of the new land can hardly be as high as that of the currently cultivated land, as much of it is marginally suitable for crops.

Increasing pressures on agricultural land have resulted in much higher nutrient outflows and the subsequent breakdown of many traditional soil-fertility maintenance strategies, such as fallowing and the opening of new lands. Farm sizes, especially in the high-potential areas, have also been reduced to the point where adequate living can only be obtained if land is farmed intensively and if there is an off-farm income (Sanchez et al., 1997). Soil regeneration through long-term fallow can no longer be maintained (Giller et al., 1997; Padwick, 1983).

As population pressure increases, there has been a population shift from the high agricultural potential areas with fertile soils, adequate rainfall and mild temperatures to the marginal areas with less fertile soils, extremely variable and unpredictable rainfall, fragile soils, frequent crop failures and limited resources for improving livelihoods. Some authors argue that the migrant populations are partly responsible for the continued degradation of natural resources in the marginal areas due to the adoption of inappropriate farming technologies and the struggle for a living that does not conserve the natural resource base (Gachimbi et al., 2002; Ndiritu, 1992).

Despite the above reports on the effects of increasing population on land degradation, conflicting perspectives emerge at farm level regarding the real impacts of increasing population on land quality. A study of population growth across a wide range of population densities in Burkina Faso, West Africa, has not proved any evidence of widespread soil degradation and fertility decline in the cereal cultivated fields (Mazzucato and Niemeijer, 2001). This work is corroborated by Tiffen et al. (1994) who concluded that “with more people there is less erosion” in the semi-arid areas of Eastern Kenya. Similarly, in the semi-arid areas of India, Walker and Ryan (1990) have reported that villages have been managing natural resources for centuries without the land showing symptoms of irreversible degradation under rising population pressure.

These reports point to the fact that rising population pressure may not necessarily be the precursor of the widespread land degradation claimed for East Africa and other parts of sub-Saharan Africa. This view, however, does not preclude existence of local spots of severe degradation nor suggests that soils in East Africa are particularly fertile, but calls into question the widespread belief that developing countries

are degrading their soils simply because of rising population pressure, “overcultivation” and shifting cultivation practices. A need to move away from empty rhetoric and capture reality by comparing supranational studies and micro-level studies therefore exists.

Productivity of arable land as an index of land degradation

The number of studies on the relation between land degradation and productivity loss are limited in sub-Saharan Africa. It is estimated that losses in productivity of cropping land is in the order of 0.5–1% annually, suggesting productivity loss of at least 20% over the last 40 years (Scherr, 1999).

Studies at farm and catchment level in high and low agricultural potential areas of East Africa have revealed that nutrient depletion is threatening the productivity of arable lands (Table 1). Soil nutrients are being depleted through crop removals, leaching and soil erosion, especially where farmers have been unable to sufficiently compensate these losses by replenishing soil nutrients via crop residues, manures and mineral fertilizers (Shepherd and Soule, 1998).

In a study in Uganda that evaluates rates of soil fertility decline in a shifting cultivation system, Jones

(1972) reported that a 3-year resting phase was required to restore soil organic C, N, P, K and Mg depleted in a 3-year arable phase. In the semi-arid areas of Kenya and the low agricultural potential areas of Uganda, N is being mined at the rate of 3–43 kg N ha⁻¹ year⁻¹ representing nutrient stock depletion rates of 0.4–0.5% (Onduru et al., 2001; Gachimbi et al., 2002; de Jager et al., 2003).

Phosphorus and K are rather balanced in arable lands of the semi-arid areas of Kenya and Pallisa District, Uganda due to nutrient import from grazing areas under the free-range livestock production system (de Jager et al., 2003). Such systems are, however, not sustainable and P deficiency is considered a major biophysical constraint to food production across various agro-ecological zones. Table 1 further shows that the rates of K depletion are rather variable and low for the semi-arid lands of East Africa. It has been reported that K deficiencies are not as common as N and P deficiencies, except for sandy savanna soils (Ssali et al., 1986) and that crop responses to K fertilizers are rare, probably due to high K stocks in many soils of East Africa and probably that K deficiencies may be more observable after N and P deficiencies have been removed.

In order to adduce evidence for productivity loss attributed to land degradation at the farm level, trends

Table 1
Nutrient balances in East Africa

| Site | Author | Study site | Nutrient balances (kg ha ⁻¹ year ⁻¹) | | |
|-----------------------------------|---|---|---|--------------------|------------------|
| | | | N | P | K |
| Low agricultural potential areas | Onduru et al. (2001) | Machakos District, Kenya (LUZ 4 and 5) ^a | -25 to -21 | +1 to +2 | -9 to +2 |
| | Gitari et al. (1999) | Mbeere District, Kenya (LUZ 4 and 5) | -43 to -26 | +2 to +15 | -4 to +60 |
| | Gachimbi et al. (2002) | Kionyweni, Machakos, Kenya (LUZ 4 and 5) | -6.6 to -3.8 | -0.1 | -4.3 |
| | de Jager et al. (2004) | Palissa District, Uganda | -4 to -3 | 0 | +1 to +2 |
| High agricultural potential areas | Shepherd et al. (1998) | Vihiga District, Kenya | -44 to +50 | -3.6 to +32.7 | Not reported |
| | de Jager et al. (1998); Van den Bosch et al. (1998) | Kisii District | -102 | -2 | -34 |
| | | Kakamega | -72 | -4 | 18 |
| | | Embu | -55 | 9 | -15 |
| | Smaling et al. (1993) de Jager et al. (2004) | Kisii Kabalore District, Uganda | -112 -126 to -95 | -2.5 -70 to -57 | -70 -55 to -7 |
| East African Highlands | Stoorvogel and Smaling (1990) | Burundi, Ethiopia, Kenya, Madagascar, Rwanda, Tanzania and Uganda | -36 | -5 | -25 |
| Kenya | Stoorvogel and Smaling (1990) | Aggregates at country level | -46 to -42 | -3 to -1 | -36 to -29 |
| Tanzania | Stoorvogel and Smaling (1990) | Aggregates at country level | -32 to -27 | -5 to -4 | -21 to -18 |
| Uganda | Wortzmann and Kaizzi (1998) | Palissa District, Uganda | -21 | -8 | -43 |
| Sub-Saharan Africa | Smaling et al. (1997) | Aggregates at regional level | -22 | -2.5 | -15 |

^a Growing of food crops is the dominant practice in Land Use Zones 4 and 5 except for tobacco, which is grown as a cash crop on a limited scale in Land Use Zone 4. Although indigenous livestock are kept in both zones, the keeping of livestock is dominant in Land Use Zone 5.

in crop yields and levels of nutrient balances were compared in semi-arid areas of Kenya (Figs. 1–4, Table 1). Crop yield dynamics are a reflection of changes in soil conditions. Yields of major food crops (maize, sorghum and beans) in semi-arid areas of Eastern Kenya (Mbeere District) have been fluctuating, with a general declining, stagnating or sub-optimal trend in the last decade. The crop yields in Mbeere District reflect general crop trends in semi-arid areas of Eastern Kenya. Although there is no indication of a drastic and sharp yield decline, soil nutrient depletion could, partly, be a contributing factor among other variables such as variability in rainfall (Fig. 4). Downing et al. (1988) have reported that rainfall variability is an important factor in influencing production in the semi-arid areas and that its management is still a challenge. Variability in rainfall threatens outputs, savings and farm investments.

In the high agricultural potential areas of Kenya and Uganda, net negative nutrient balances have also been reported at farm and catchment level (Table 1) with losses of up to 112 and 70 kg ha⁻¹ year⁻¹ for N and P, respectively. Potassium depletion has been as high as 70 kg K ha⁻¹ year⁻¹. Fig. 5 shows that the yields of major food crops in the high agricultural potential area of Nyeri District (Kenya) has been decreasing for nearly three decades while the yields of cash crops such as tea has been increasing. A long-term experiment in the highland areas of Kenya has shown that continuous cropping of an inherently fertile soil (Nitisol), without adequate application of combined organic and inorganic inputs, leads to maize yield decline and deterioration of soil chemical properties (Swift et al., 1994). However, a different situation emerges from the high agricultural potential areas of Embu District where cash crop production has shown an upward trend (Fig. 1). Cash

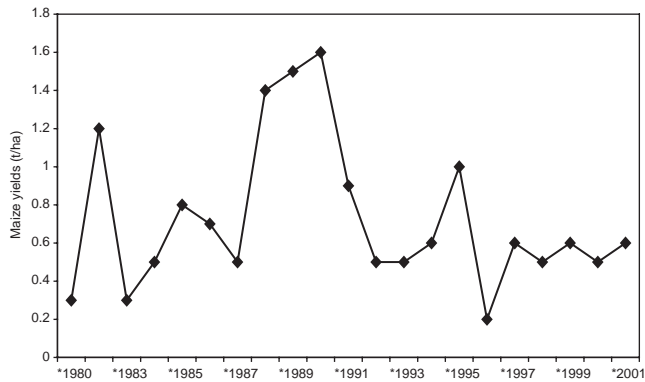


Fig. 1. Trends in maize grain yields in Embu and Mbeere Districts, Eastern Kenya (t ha⁻¹). (1980–1990: Broader Embu District before subdivision; 1991–1995: Data synthesized for administrative divisions that presently make up Mbeere District.)

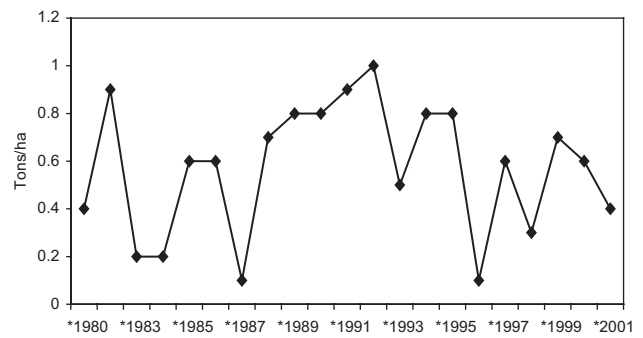


Fig. 3. Trends in bush bean yields in Embu and Mbeere Districts, Eastern Kenya. (1980–1990: Broader Embu District before subdivision; 1991–1995: Data synthesized for administrative divisions that make up present Mbeere District.)

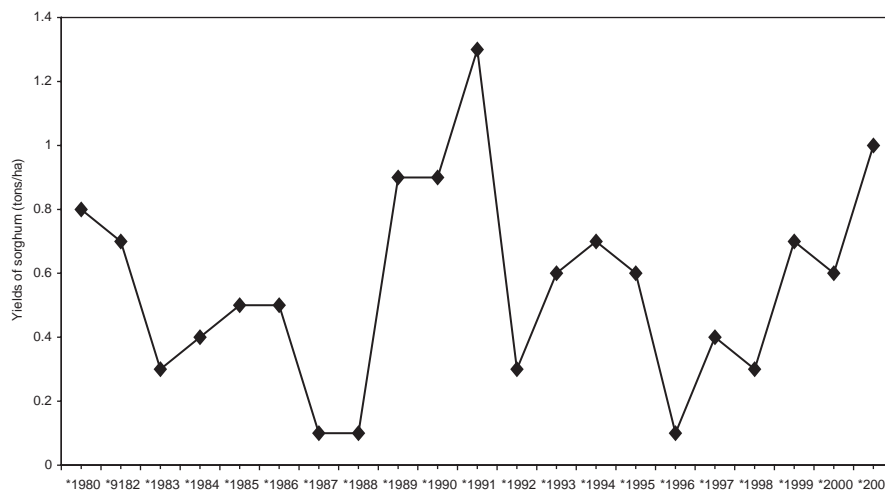


Fig. 2. Trends in sorghum grain yields (t ha⁻¹) in Embu and Mbeere Districts, Eastern Kenya. (1980–1990: Broader Embu District before subdivision; 1991–1995: Data synthesized for administrative divisions that presently make up Mbeere District.)

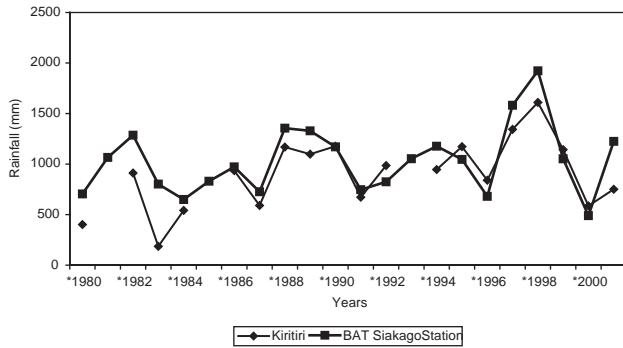


Fig. 4. Annual rainfall trend (mm) in Mbeere District, Eastern Kenya. (Figures for Mbeere refer to data gathered from divisions that make up Mbeere District.)

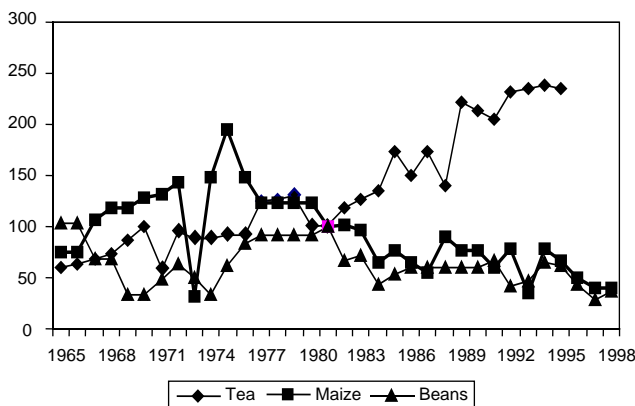


Fig. 5. Productivity index in Nyeri District (kg ha^{-1}) (1983 = 100).

crops such as tea and coffee have been reported to show positive partial nutrient balances as a result of mainly inorganic fertilizers and manure application (van den Bosch et al., 1998).

The above cases show that there is need for taking care in interpreting nutrient balances and the widespread belief that Kenya and other East African countries are heading for an environmental disaster considering the net negative nutrient balances reported at country levels (Table 1). Similar views have been expressed by Scoones and Toulmin (1999) who demonstrated that the yields of major food crops in East Africa have been increasing in the period 1961–1997 despite reports of severe soil degradation as a result of negative nutrient balances.

Due to the above conflicting perspectives, there is need for a closer look at the relation between land degradation, food security and resilience of livelihood sources in sub-Saharan Africa. Rural livelihood systems in the semi-arid areas have, by their persistence over several decades, demonstrated resilience, which runs counter to some predictions of imminent irreversible degradation or collapse (Mortimore et al., 2000). In the Sahel, West Africa, it is reported that “experts” on land

degradation, as well as nutrient budget models may be overestimating land degradation. The inherently poor West African soils and drought-related declines in production and vegetative cover has been confused with signs of irreversible degradation, which has led to an overestimation of land degradation (Mazzucato and Niemeijer, 2001).

Myths of agricultural intensification, land degradation and productivity

Adoption of modern technologies for land intensification for improved livelihoods, such as inorganic fertilizers, irrigation and draft power, is relatively low, despite the fact that Africa needs a sustained annual growth rate in agricultural production of 4% to offset the current food deficits (Badiane and Delgado, 1995; Rowland, 1993). Inorganic fertilizer use on food crops in sub-Saharan Africa is estimated at less than 5 kg ha^{-1} , the lowest in the world (Quinones et al., 1997). The developing world aggregated figure for fertilizer consumption is 89 kg ha^{-1} (World Resources Institute, 2000). These reports have been confirmed by FAO (2001), which estimated inorganic fertilizer consumption in sub-Saharan Africa to be $10 \text{ kg nutrients ha}^{-1} \text{ year}^{-1}$ (N, P_2O_5 , K_2O), compared to the world average of $90 \text{ kg ha}^{-1} \text{ year}^{-1}$. The low use of inputs partially accounts for the observed net negative nutrient balances across East Africa. Factors such as variable responses to inorganic fertilizer application in already degraded soils, limited purchasing power and opportunities for rural credit, as well as escalating fertilizer prices have militated against fertilizer use (Nandwa and Bekunda, 1998).

The levels of use of land management technologies such as draft power and irrigation practices are also low. Animal draft power is only used in one-sixth of arable land in Africa. The rest is under manual cultivation, negating the prospects of intensification on a large scale. The few existing centralized, technology-driven irrigation schemes in parts of sub-Saharan Africa have been reported to be suffering from various administrative and technical constraints characterized by salinization and degradation of the watersheds as a result of siltation and other problems like outbursts of weed growth (Rowland, 1993). Thus at the present state of technology use, it is environmental conditions and land quality that could be the major determinants of productivity in East Africa. However, Lynam et al. (1998) have reported that there is little consensus on sources of productivity including genetic improvement, improved control of pests and diseases, better agronomy and crop management or improved plant nutrition and soils management.

Furthermore, there is uncertainty regarding adoption of modern technologies for improved management of

land resources. Fairhead (1992) has reported that the capacities of local farmers to manage land resources have been grossly underestimated. Local land users have developed flexible management decisions about the allocation of scarce resources and available technologies to a limited range of options in their environment, as well as addressing temporal and spatial dimensions associated with land constraints. In some regions, farmers have also developed robust social institutions and resource sharing arrangements to insure against adversity (Eyasu, 2000; Mortimore et al., 2000).

Vegetation cover and land degradation

Loss of vegetation cover is seen as one of the major causes of land degradation. It is estimated that, among other loss pathways, Africa loses its vegetation cover through annual deforestation rates of 0.7%, which is over twice the world average (FAO, 2000). Sivakumar and Wills (1995) have further revealed that 19% of Africa's forest and woodland have already been degraded. In East Africa, due to increasing poverty, most of the rural households depend on fuel wood, as they do not have enough cash to use alternative sources of fuel. In Kenya alone, rural households account for 72% of total fuel wood consumption and trees are being cut at a rate that is 43% higher than sustainable yields. Thus the vegetation cover, in East Africa, has been increasingly dwindling as more and more rural households cut down trees for fuel wood without replacement, as overgrazing takes place and as exploitation of natural forest products continues in a non-sustainable manner. These reports are alarming given that 70% of Kenya's forest resources are found in the arid and semi-arid lands.

Despite these alarming reports, conflicting perspectives still exist on the extent that land degradation is caused by loss of vegetation cover at the micro-level and at supranational scales. Probably this could be due to limited studies that have been conducted on the relation between vegetation loss and its impacts on rural livelihood in sub-Saharan Africa. Such conflicting perspectives have been reported at different levels. For example, Howel et al. (1986) have reported that pure nomadism, semi-nomadism, transhumance, partial nomadism and other forms of livestock production in the semi-arid areas rarely pose much environmental problem unless the land's carrying capacity is exceeded in the long term. Tiffen et al. (1994) found that loss of vegetation due to improper grazing management in the semi-arid areas of Kenya is neither irrational nor inherently degradational, but admits that irreversible soil degradation may be imminent without good management in pastureland and in areas with gullies or that are already severely denuded. However, Melack

and MacIntyre (1992) have reported escalating soil erosion and siltation of water reservoirs and of coastal areas and in some cases, eutrophication of rivers and lakes, including Lake Victoria in East Africa, as a result of vegetation loss.

It appears that there is still much to be done to capture the reality of the impacts of vegetation loss (as a precursor of land degradation) on livelihoods and the reality of land degradation attributed to soil erosion. Estimates of land degradation, which involve extrapolating figures obtained from small plots to wider and wider scales without acknowledging scales of measurements, only serve to obscure the "bright" and "hot" spots where urgent attention could be required. Conclusions drawn from such measurements are meaningless (Stocking, 1993).

Conflicting perspectives on land tenure and land degradation

In many parts of East Africa, access to land is granted under diverse arrangements with different degrees of tenure security. Security of tenure is a determinant for investment in land improvements, especially when such improvements are associated with high initial cash and non-cash capital investments (e.g. the use of family labour and the associated off-farm opportunity costs). Investments in soil and water conservation structures and planting of trees are likely to be affected in situations where land is under short-term lease, where the tenure is not secure and where labour is scarce. The myth of abundant cheap labour and/or family labour for such activities is increasingly being questioned even in densely populated areas such as Kisii in Kenya (800 persons km⁻²); a number of farms are already experiencing shortage of labour as off-farm incomes become more attractive.

Studies in Machakos District show rapid land degradation attributed to loss of soil, water and vegetation resources and a general decline of soil fertility in communally owned grazing and cultivated land in Kenya's pre-independent era (Tiffen et al., 1994). Thomas et al. (1997) have also asserted that insecure land tenure is the biggest impediment to adoption of soil and water conservation practices.

The on-going debate on land tenure is based on the view that investment in land improvements depends on farmers having secure title deeds to their land (Scoones and Toulmin, 1999). However, emerging evidence points to the fact that permanent land title encourages investment in land, but does not necessarily solve all problems associated with land degradation (FAO, 2001). Migot-Adhola et al. (1991) have also shown that land title is much less important than the underlying security, which can be assured under systems of tenure.

Platteau (2000) has further corroborated this view by reporting that issuing private titles over rural land is neither a necessary nor sufficient condition, in principle, to generate greater security, stimulate more investment in land improvement or increase agricultural production.

Opportunities for policy options in arresting land degradation

Land degradation in East Africa needs to be considered within the wider set of choices facing rural households about the allocation of resources, where they can best invest labour and capital and how they can make choices to reduce risks. Although degradation of agricultural land is in the public domain, agriculture is only one of a number of livelihood strategies—such as off-farm incomes, migration and social investments (Scoones and Toulmin, 1999). Public intervention in reversing trends in land degradation thus needs to be multi-sectoral.

While reviewing a number of doom and gloom narratives posed by development agencies and researchers, Reij et al. (1996) concluded that the rhetoric of Malthusian apocalypse, precipitated by environmental collapse, has been an enormously powerful force driving the agenda for external intervention to reverse land degradation. Roe (1991) has argued that the doomsday scenario narratives have given opportunity for development experts and institutions to claim the rights to stewardship and be “stakeholders” over land and resources they do not own, in some cases proposing interventions without considering perceptions of primary land users, the farmers.

This paper proposes that a flexible policy framework is a pre-requisite for arresting land degradation both in the short and long term. Furthermore, such policies should be based on empirical analysis, and be flexible enough to support and enable, rather than direct and control positive change in land degradation (Mortimore et al., 2000). Distortions in policies reduce incentives in arresting land degradation by their negative impacts on input and output markets, rural infrastructure, market arrangements, credit provision, networks of input and output suppliers, communication, training and information flow, extension systems, land tenure and diversification of the rural economy (Badiane and Delgado, 1995; Hilhorst and Muchena, 2000).

In the last 5 years, a number of legal reforms have been taking place in East Africa with policies being redrafted for effective management of natural resources with an objective of stemming land degradation and increasing community participation in management (Wily, 2000). However, Kinyanjui et al. (2000) have pointed out that it is not the lack of policies that have

led to land degradation, but their effective implementation.

Conclusions

While data from macro-scale assessments on land degradation have offered powerful messages to policy makers and are the present precipitants of debate and development initiatives, such data should be treated with care to avoid oversimplifications and generalizations. There is need to differentiate among a naturally bad state, “bright” spots and “hot” spots to target short- and long-term interventions. Such interventions cannot be effective without synergy between the macro-scale studies and the micro-level studies in addition to addressing temporal and spatial dimensions of the observed problems of degradation.

Without under-rating the impacts and existence of severely degraded spots of land in East Africa, there are mixed scenarios from the high and low agricultural potential areas regarding the extent and severity of land degradation at farm, catchment and at the national levels. Assessment of land degradation through analysis of agricultural statistics and environmental data in this study has demonstrated that the yields of cash crops, such as tea, have been on an upward trend while nutrient balances under such cropping systems have been positive. However, the reverse seems to hold for food crops at the farm level in areas, which are under cultivation; although overall output has been observed to increase, e.g. for maize at the national level over time due to, probably, more marginal land being brought under production. These mixed observations indicate the necessity for further validation of land degradation against agricultural statistics, environmental data and land management data to capture reality, tap into existing opportunities and to initiate an informed policy debate.

Arresting land degradation will not only depend on generating reliable data, but also on contextualizing land degradation within the biophysical environment, its causes and impacts within broader livelihood strategies and poverty-related issues. This calls for recognition of land-user abilities and management practices, exploration of investment opportunities and effective decision-making processes, application of robust technologies, as well as creating conducive policy environment and sectoral strategies linked to appropriate land management and behaviour change.

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