Chapter 2
Geopedological and Landscape Dynamic Controls on Productivity Potentials and Constraints in Selected Spatial Entities in Sub-Saharan Africa

Yazidhi Bamutaze

Abstract Soil-landscape relations play an important role in the agricultural production systems of Sub-Saharan Africa. As the demands on elevated agricultural productivity grows in the face of increasing demographic pressure and the adverse impacts of global environmental change, we must identify socio-ecological production landscapes that are resilient to environmental changes. This paper analyses a spectrum of spatial and non-spatial datasets covering soil, terrain, land use, and geology in a GIS environment to derive spatial entities that inform the production potentials and constraints of East Africa. Landscape analysis, premised on the geopedological and elevation constructs, culminated in a spatial coverage of lowlands (40 %), plateaux (46 %), highlands (11 %) and mountains (3 %) across the East African region. Regional-level analysis reveals spatially variable soil typologies dominated by Cambisols (24 %) and Ferralsols (13 %). In these geomorphic landscapes and soil types, there are two outstanding anthropogenic threats to productivity: soil erosion and land use/cover conversions and transformations. These must be delicately tackled with site-specific tailored interventions that not only recognize geopedological landscape sensitivity, but also the inherent social systems.

Keywords Geopedological • Geomorphology • Landscape dynamics • Productivity

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2.1 Introduction

Sub-Saharan Africa (SSA) is one of the most dynamic, diverse, and heterogeneous biophysical landscapes in the world. The landscape's complexity manifests in the geomorphological, soil, and geological settings, posing a range of challenges and opportunities that underpin the continental development pathways from household to national levels. The central geomorphological feedback processes associated with its complex and dynamic socio-ecological landscape strongly influence production patterns. Therefore, understanding the inherent ecological fragility of this coupled landscape is fundamental to reduce the effects of geohazards, sustain ecological integrity, and secure people's livelihoods. The need for sustainable landscapes and livelihood systems is critical for SSA because of rapid demographic changes, increasing land degradation, stagnant or declining crop yields, and relatively new threats linked to the increasing variability and changes of the climate.

Sustainable land use practices recognizing a landscape's ecological sensitivities and maintain agricultural productivity are gathering attention. Soil resources are fundamental to fighting the traditional challenges of land degradation, as well as effectively buffering communities from the dangers of climate change. For example, the Comprehensive Africa Agriculture Development Programme (CAADP) has an ambitious annual agricultural growth target of 6 %, a harbinger of development transformation on the continent (Kolavalli et al. 2010). Due to the fundamental importance of quality geopedological resources for agricultural production, only sound landscape stewardship can achieve this goal. Although agricultural production in SSA relies on heavily inherent natural soil fertility, the general understanding of soil geomorphology systems remains dismally low compared to other continents.

It is impossible to underestimate the importance of healthy soil resources for sustainable livelihoods in SSA (Eswaran et al. 1997; Henao and Baanante 2006; Bationo et al. 2006). Because so many livelihoods in the region depend on natural resources, the relationships between soil quality, productivity, and poverty levels are strongly interdependent. However, despite their productive role in agricultural livelihoods, the importance of soils and the multitude of associated environmental services are not widely appreciated in Africa (Dewitte et al. 2013). Consequently, limited efforts have been undertaken to address a range of soil-related issues at a finer scale crucial to improve productivity. In most SSA countries, low crop yields indicate an abundance of poor quality soils (Sanginga and Woomer 2009). Under these conditions, there is need to improve understanding of spatially explicit soil-geomorphic settings crucial for agricultural productivity.

A geopedological perspective embeds geomorphic and pedologic processes throughout the landscape, as well as recognizing biophysical feedback and sociological processes. Thus, this geographically-oriented soil-landscape nexus yields a better understanding of the production systems and ecosystem servicing crucial for the sustainable development of agriculture and biodiversity (Sayre et al. 2013; Griffiths et al. 2011). This paper helps correct the paucity of soil-based landscape studies by using geomorphic and pedologic analysis to present information on productivity potentials and constraints.

2.2 Geographical Settings

This study is confined to the East African region of SSA covering five countries: Uganda, Kenya, Tanzania, Rwanda and Burundi. The region is located approximately between 4°N and 12°S latitude and 29°E to 42°E longitude, as shown in Fig. 2.1.

Fig. 2.1 Location map of East Africa

Table 2.1 Key socio-economic characteristics of the East African countries

Parameter	Uganda	Kenya	Tanzania	Rwanda	Burundi
Size (km^2)	241,248	593,116	933,566	24,550	28,062
Population (millions)	35.6	42.7	47.7	11.3	8.7
Population density (persons/km^2)	148	72	51	460	310
Human development index in 2012	0.456	0.519	0.476	0.434	0.355
Annual population growth rate (%)	3.3	2.7	3.0	2.8	3.2
Life expectancy at birth (years)	58	60	60	63	53
GDP per capita by 2012 (US$)	547	943	609	620	251
Agricultural area in 2011 (km^2)	168,874	284,696	392,098	19,149	24,133

The region exhibits a high level of ecological and social diversity in its geology, geomorphology, climate, and vegetation. It displays significant geomorphological features of the East African Rift valley, the Lake Victoria basin and a range of highland and mountainous landscapes. Climatic conditions of the region are diverse and variable. The climatic geography is a function of global, regional, and local factors, notably the Inter-Tropical Convergence Zone (ITCZ) and physiographic features, including topography, latitudinal position, and relative location from major drainage bodies such as Lake Victoria. Major mountain landscapes such as Mt. Kilimanjaro, Mt. Rwenzori, Mt. Elgon, and Mt. Kenya also significantly control the local and regional climatic conditions. Annual rainfall amounts vary from about 250 mm in semi-arid regions to over 2,500 mm in the highlands. The region has a distinctly uneven spatial and temporal rainfall distribution, exhibiting both unimodal and bimodal distribution structures. However, most crop production is confined to areas less than 2,500 m above sea level. The key socio-economic characteristics of the region are found in Table 2.1.

The region's population was estimated to be 142 million people in 2013. The highest and lowest population densities are 460 and 51 persons/km^2 in Rwanda and Tanzania respectively. Agriculture is essential to the East African economy and is dominated by small-scale farming which relies heavily on rainfall. Land degradation is a serious production constraint, principally because of soil erosion and nutrient depletion, a more variable and changing climate, increasing incidences of natural hazards and disasters, biodiversity loss, land use changes and conversions, and rapid population growth.

2.3 Data Sources and Analysis

The data sets used, their characteristics, and sources are given in Table 2.2. The data consist of both geospatial and non-spatial data, gathered from secondary and primary sources. Geospatial data were obtained from an array of sources in formats compatible with digital Geographical Information System (GIS).

The joint FAO and IIASA Global Agro-ecological Zones (GAEZ) portal supplied data on soil and terrain conditions which was used to assess the regional spatial variability of agricultural suitability. A digital soil data set grid from FAO was used to quantitatively analyse the predominant soil types at the national level. A Digital Elevation Model (DEM), based on Shuttle Radar Topography Mission (STRM) 90 m spatial resolution data, was obtained from the Makerere University archives and used for deriving and classifying landscapes. Geomorphic landscapes based on altitude thresholds were delineated as: mountains (>2,000 masl), highlands (1,500–2,000 masl), plateau (900–1,500 masl) and lowlands (<900 masl). The Makerere University archives also supplied a geology shapefile for Uganda to depict geology types spatially. Columbia University's Center for International Earth Science Information Network (CIESIN) provided digital gridded population data, projected for the year 2015. The data was used to map population density hotspots and relate them to landscape typologies. Because the sources of geospatial

Table 2.2 Datasets used, sources and characteristics

No.	Variable	Source	Type	Spatial extent	Usage/ analysis
1	Soil type	FAO & IISA (http://webarchive.iiasa.ac.at/Research/LUC/GAEZv3.0/)	Spatial	East Africa	Spatial typologies
2	Soil erosion	Field and published data	Spatial	Uganda	Magnitude and variability
3	Geology	Archives	Spatial	Uganda	Types and distribution
4	DEM	Archives	Spatial	East Africa	Landscape delineation
5	Suitability	FAO and IISA (http://webarchive.iiasa.ac.at/Research/LUC/GAEZv3.0/)	Spatial	East Africa	Quantitative variability
6	Forest cover	World Bank (http://data.worldbank.org/)	Tabular	East Africa	Trend analysis
7	Arable land	World Bank (http://data.worldbank.org/)	Tabular	East Africa	Trend analysis
8	Population	CIESEN (http://sedac.ciesin.columbia.edu/)	Spatial	East Africa	Hotspot sites
9	Erosion Risk	Derived using GLASSOD methodology	Spatial	Uganda	Hotspot landscapes
10	Production data	FAOSTAT (http://faostat.fao.org/)	Tabular	East Africa	Trend analysis

data were so diverse, I employed a range of data quality control measures and standardized all data sets to World Geodetic System (WGS 84) datum in a GIS environment to enable a spatial multiple overlay analysis. After standardizing the data, the East Africa region was clipped out of the continental and global datasets. Relevant tabular and statistical data were then extracted in a GIS and further plotted or statistically analysed in appropriate programmes. Geospatial analyses used ARCGIS 10 software from ESRI. Statistical and tabular data was obtained from the FAOSTAT and World Bank data portals and published data in literature. Data was subjected to an array of statistical analyses, including descriptive and inferential statistics. Descriptive statistical data used mean, standard deviation, coefficient of variation, and percentages. Inferential statistics included linear regression analysis for detecting temporal trends in forest cover change.

2.4 The Geopedological Construct

Geopedology refers to the contribution of geomorphology to pedology, and the resulting feedback (Zinck 2013). It is premised on the fact that geomorphology and pedology constitute intricately inseparable landscape characteristics through geoforms and soils. The geopedological construct thus analyses prime biogeochemical processes to facilitate inferences of landscape constraints and opportunities for agricultural productivity. Thus, coherence and synergies of landscape elements that geomorphology and soils reveal are the most important land quality aspects regarding agricultural productivity. Current agricultural production in SSA is mostly low-input and heavily depends on soil quality. Lucid interfaces between soil-geomorphologic systems and the relevant social systems strongly influence production potentials and constraints. The geopedological construct, therefore, provides a holistic biophysical structure and coupling that represents a socio-ecological production system, as depicted in Fig. 2.2.

2.5 Landscape Dynamics and Agricultural Productivity

2.5.1 Geomorphological Landscape, Productivity Constraints, and Opportunities

A landscape is the highest level in the geopedological hierarchy. The significance of geomorphic landscapes for agricultural productivity is well documented, particularly regarding crop types, production patterns, and yields. The landscapes' influence is largely manifested through moderation of climatic conditions, weathering, soil formation, soil quality, and ultimately soil resilience. From a geomorphological perspective, four landscape typologies based on altitudinal variability and

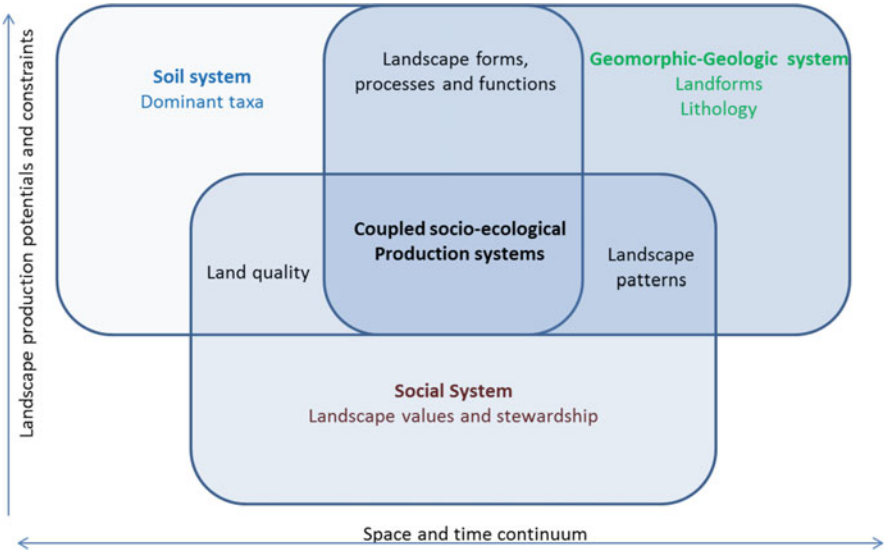

Fig. 2.2 Schematized interfaces of elements influencing productivity dynamics in the geoepedological construct

thresholds were delineated for East Africa: lowlands, plateau, highlands, and mountains. They are associated with diverse challenges and opportunities for agricultural productivity. The spatial distribution and major characteristics of East Africa's landscapes are shown in Fig. 2.3. These landscapes reflect a complex of past and current geomorphological processes, such as volcanicity, faulting, folding, weathering, and erosion. The diverse geographical operations of these processes have resulted in the current terrain configuration of East Africa.

Mountain landscapes are more than 2,000 m above sea level, the highest altitude landscape hierarchy. They cover about 3 % of the area of East Africa. Mountain landscapes are extremely diverse even at short distances. With the exception of urban centers, mountain landscapes have the highest population densities in the region (See Fig. 2.3b). They are attractive for settlement because of good conditions for crop production such as high levels of soil fertility and annual rainfall. The most important perennial crops, such as coffee and bananas, are productively grown in mountain landscapes in what is agro-ecologically classified as montane farming systems. However, mountain landscapes possess high erosive energy because their steep gradients encourage high runoff, which if not managed well greatly damages crops. Consequently, mountain landscapes are prone to a range of geohazards (Table 2.3).

Highland landscapes lie between 1,500 and 2,000 m above sea level, and represent approximately 11 % of the East African region. Over 60 % of Burundi and Rwanda can be categorized as either highland or mountainous. The steep slopes of highland environments and similar geohazards as mountain areas cause severe

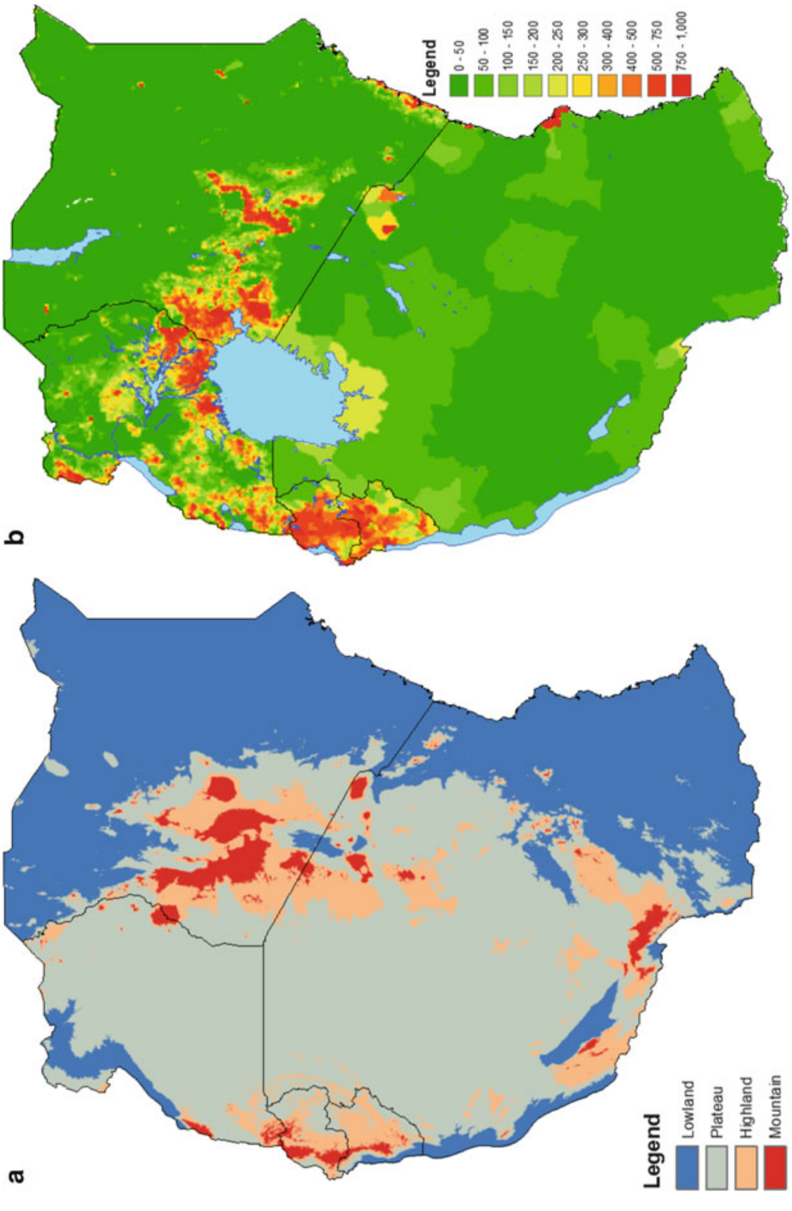

Fig. 2.3 Geomorphological landscape categories (**a**) and population density hotspots in East Africa (**b**)

Table 2.3 Selected landscape characteristics in East Africa

Landscape	Altitude (masl)	Coverage	Productivity[a]	Major geohazards
Mountains	>2,000	3 %	High	Erosion, slope failure, land cover transformation
Highlands	1,500–2,000	11	High	Soil erosion, nutrient mining,
Plateau	900–1,500	46	Medium to high	Soil erosion, floods, nutrient mining
Lowlands	<900	40	Low to medium	Flooding, drought

[a]Productivity hinged on low input conditions (natural nutrient conditions)

agricultural production constraints. Geomorphologically, highland and mountain landscapes have high transportation capacities and stream densities that convey both runoff and sediment to the lower landscapes. Plateau landscapes range from 900 to 1,500 m above sea level and represent the largest part of the entire region. Agricultural productivity in the plateau landscape is highly varied and also depends in part on rainfall levels. The Lake Victoria Basin is the most attractive region of the plateau landscape in East Africa. Despite their relatively lower slope gradients, plateau landscapes also experience erosion and nutrient mining. Lowlands, which are below 900 m, constitute a north–south axis in the eastern part of the region parallel to the Indian Ocean. Lowlands occupy about 40 % of the region's landscape, including much of Kenya and a significant part of Tanzania. They are generally characterized by transport-limited slopes, and are prone to flood hazards. For lowland inland regions such as eastern Uganda, flooding is also strongly linked to the climatic and geomorphological conditions in the mountain landscapes that consequently supply runoff to the lower areas.

2.5.2 Soil and Terrain Influences on Agricultural Suitability

Agricultural systems in East Africa are typically rain-fed systems. Land suitability under rain-fed conditions depends on the ecological interfaces between climate, soil, and terrain which determine productivity levels and yield dynamics. The spatial extent of rain-fed agricultural suitability in Eastern Africa under low and high input conditions constrained by soil factors alone is found in Fig. 2.4, while that constrained by both soil and terrain conditions is depicted in Fig. 2.5.

Evidently, a change from the low input conditions of traditional subsistence land management and crop varieties, to high input conditions characterized by market-oriented land management practices would change landscape suitability and ultimately improve crop yields by about 24 %. This provides, in part, the rationale for the region's agricultural policy changes which Uganda's Plan for Modernization of

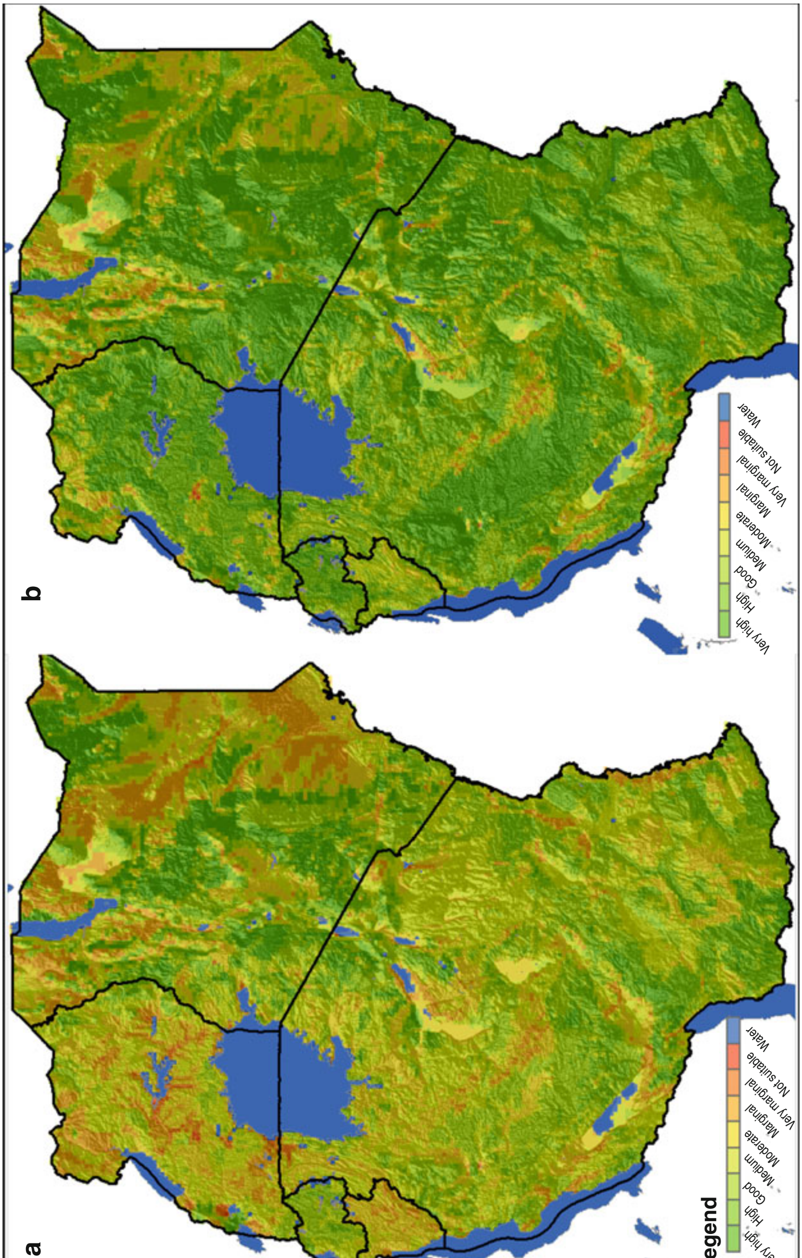

Fig. 2.4 Spatial variability of rain-fed agricultural suitability as constrained by soil under low (**a**) and high input (**b**) conditions

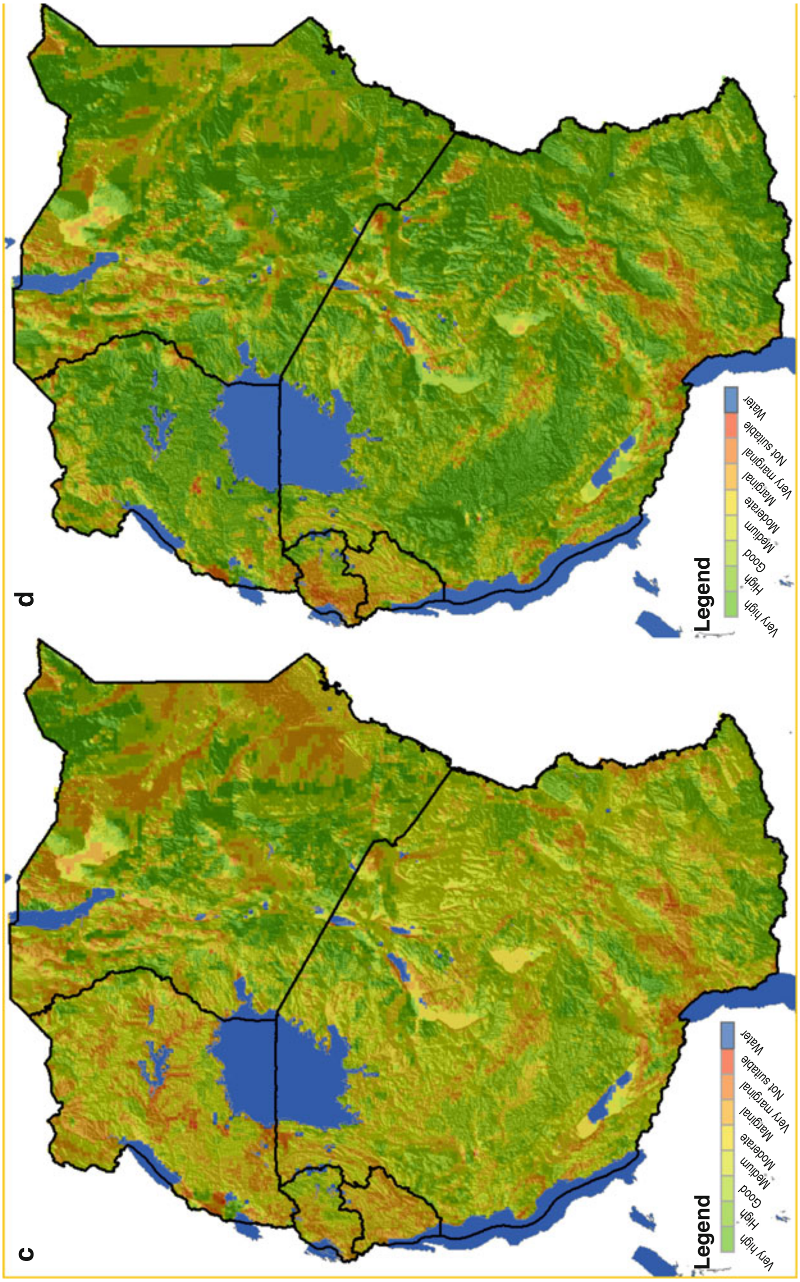

Fig. 2.5 Spatial variability of rain-fed agricultural suitability as constrained by soil and terrain factors under low (**c**) and high input (**d**) conditions

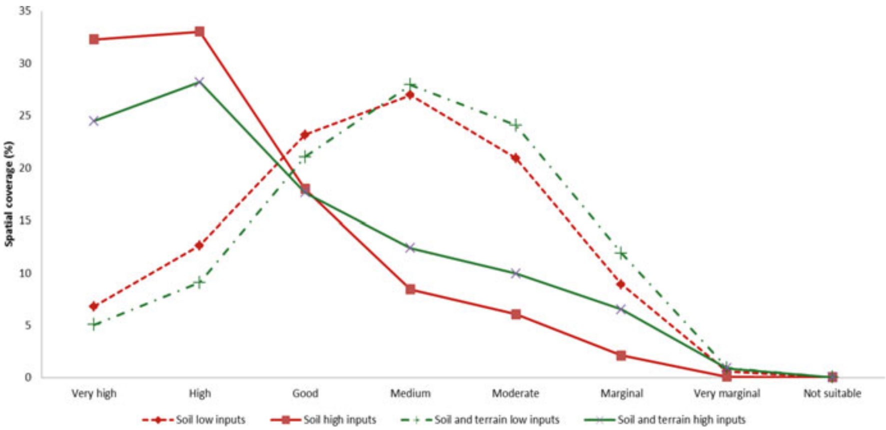

Fig. 2.6 Variation in suitability under low and high input conditions

Agriculture (PMA) exemplifies. This plan focuses on market-oriented agriculture and sustainable management of land resources.

The percentage coverage of agriculturally suiland according to soil conditions alone is compared with that of the coupled soil and terrain conditions in Fig. 2.6. In general, the terrain factor, denoted largely by altitude and slope gradient, imposes more constraints on land's suitability for crop production. Therefore, it is not surprising that areas with proportionally higher highland and mountainous environments, like Rwanda and Burundi pale in suitability when compared to Kenya, Uganda, and Tanzania.

Under low input conditions, a suitability deviation of about 3 % is attributed to the terrain effect, while the deviation is as high as 9 % under high input conditions. In consonance with other studies (Akinci et al. 2013; Xu and Zhang 2013; Igue et al. 2004), high rates of water runoff, soil erosion, higher transportation capacities of water and nutrients, and difficulties with tillage and conservation practices are all evidence of terrain's effect on a landscape's agricultural suitability and productivity. Soil formation and development intimately depends on site topography and geomorphological characteristics, slope gradient having the greatest effect. In East Africa, FAO (2006) categorizes sites with slope gradients of more than 30 % as steeply dissected. For rain-fed agriculture, they are considered severely constrained for crop production. A spatial analysis by van Velthuizen (2007) reveals that areas with slope gradients of more than 30 % represent about 6 % of East Africa's total area and contain 9 % of the rural population.

2.5.3 *Soil Quality and Soil Types*

African soils are among the least fertile in the world, with about 80 % having inherent fertility limitations (Otter et al., 2007). Major soil limitations present huge obstacles to agricultural productivity. Some postulates to explain poor soils

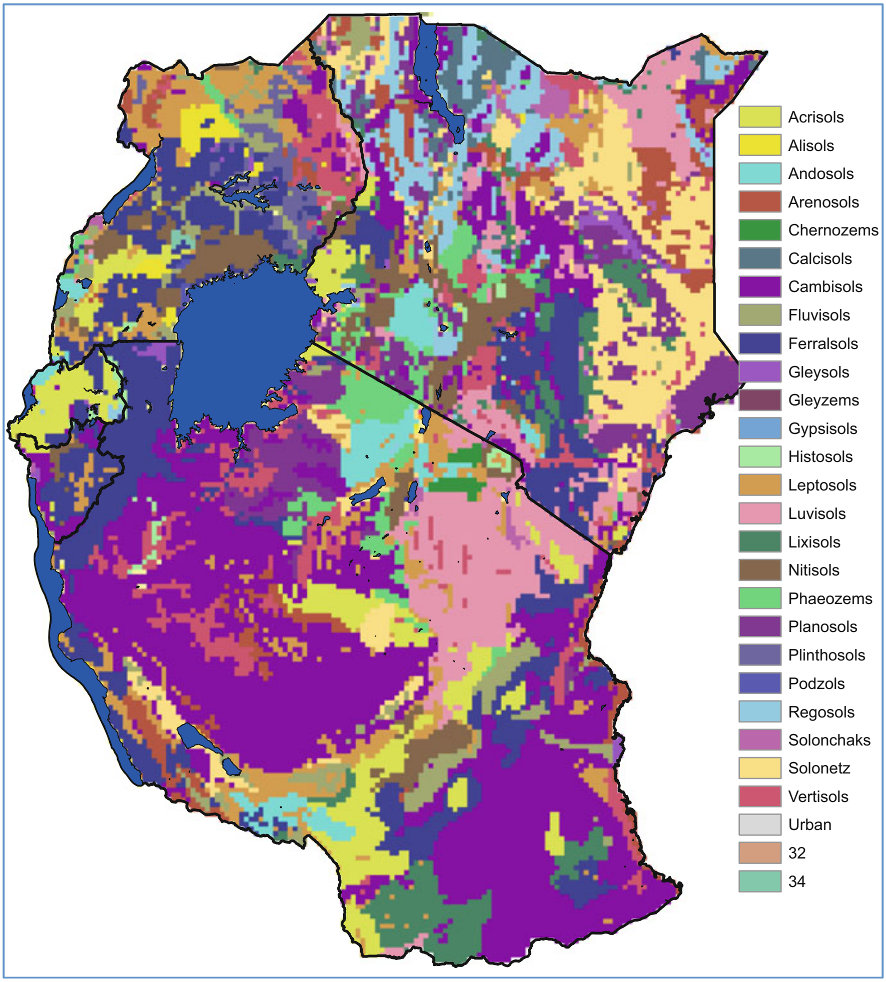

Fig. 2.7 Major soil types of East Africa based on the FAO classification system

implicate their having developed from Precambrian basement rocks as a major causal factor. SSA soils, in particular, are highly diverse and spatially variable (Voortman 2010). Despite providing livelihoods for millions of small scale farmers, the soils of Africa are poorly mapped and badly understood (Sanginga and Woomer 2009). A spatial distribution of East Africa's major soil types based on the FAO soil classification system is found in Fig. 2.7.

Figure 2.8 contains a quantitative analysis of the distribution of the region's respective soil types. The data identifies approximately 25 soil types with diverse production potentials and constraints, signifying a high level of soil diversity and heterogeneity. A recent soil mapping by Dewitte et al. (2013) identified 29 soil types for continental Africa, which is not surprising given the geomorphological, geological, and climatic complexity of the region. The most common soil types in

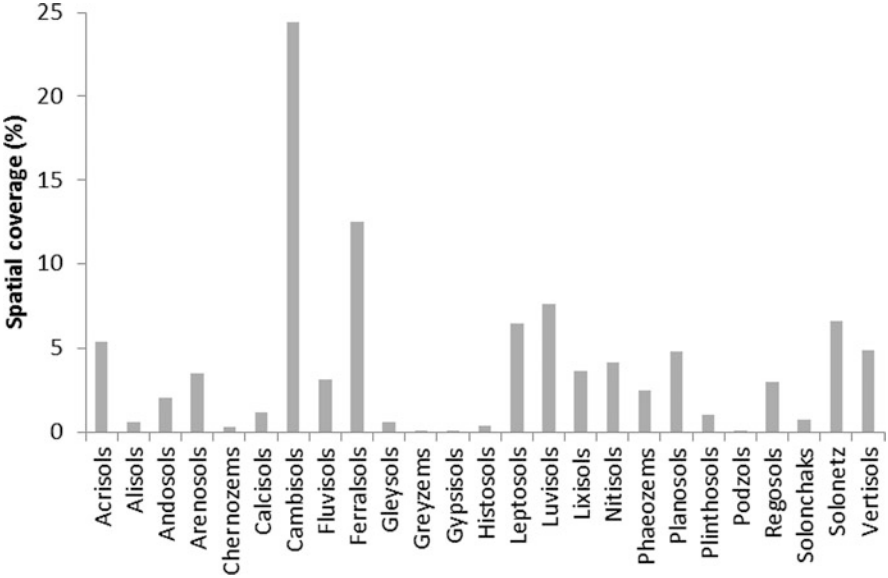

Fig. 2.8 Quantitative distribution of soil types in East Africa

East Africa are the Cambisols and Ferralsols which constitute about 24 % and 13 % respectively of soil. Other soil types with reasonable spatial distribution include Luvisols (8 %), Solonetz (7 %), Leptosols (6 %), Acrisols (5 %), Planosols (5 %), and Vertisols (5 %) as depicted in Fig. 2.8. A spatial analysis reveals that these eight soil types cover approximately 73 % of East Africa's land. The remaining 17 soil types cover only 27 % of the region, with the least common being the Gypsisols (<0.1). This means that many local factors control soil formation and development in the region. Increasing agricultural productivity requires targeted interventions and management strategies adjusted to each soil type.

The variability of soil types and their prevalence at national levels are depicted in Fig. 2.9. There are 22 soil types in Uganda, 23 in Kenya, 19 in Tanzania, 8 in Rwanda and 9 in Burundi. The Ferralsols (25 %) are the most dominant in Uganda, while Calsisols have the lowest coverage (<0.1 %). In Kenya, the Solonetz soils have highest coverage (16 %) and Gypsisols have the lowest. Cambisols dominate Tanzania, occupying 39 % of the land area, while Regosols have the lowest coverage (<0.1 %). Acrisols cover most of the land in Rwanda (62 %), while Nitisols only cover 0.3 %. In Burundi, Ferralsols cover the highest percentage of the land (48 %) while Histols cover the lowest amount (0.3 %).

2.6 Landscape Degrading Processes

Two major factors related to landscape degradation hinder agricultural productivity in SSA and specifically East Africa: soil erosion and land use cover transformations.

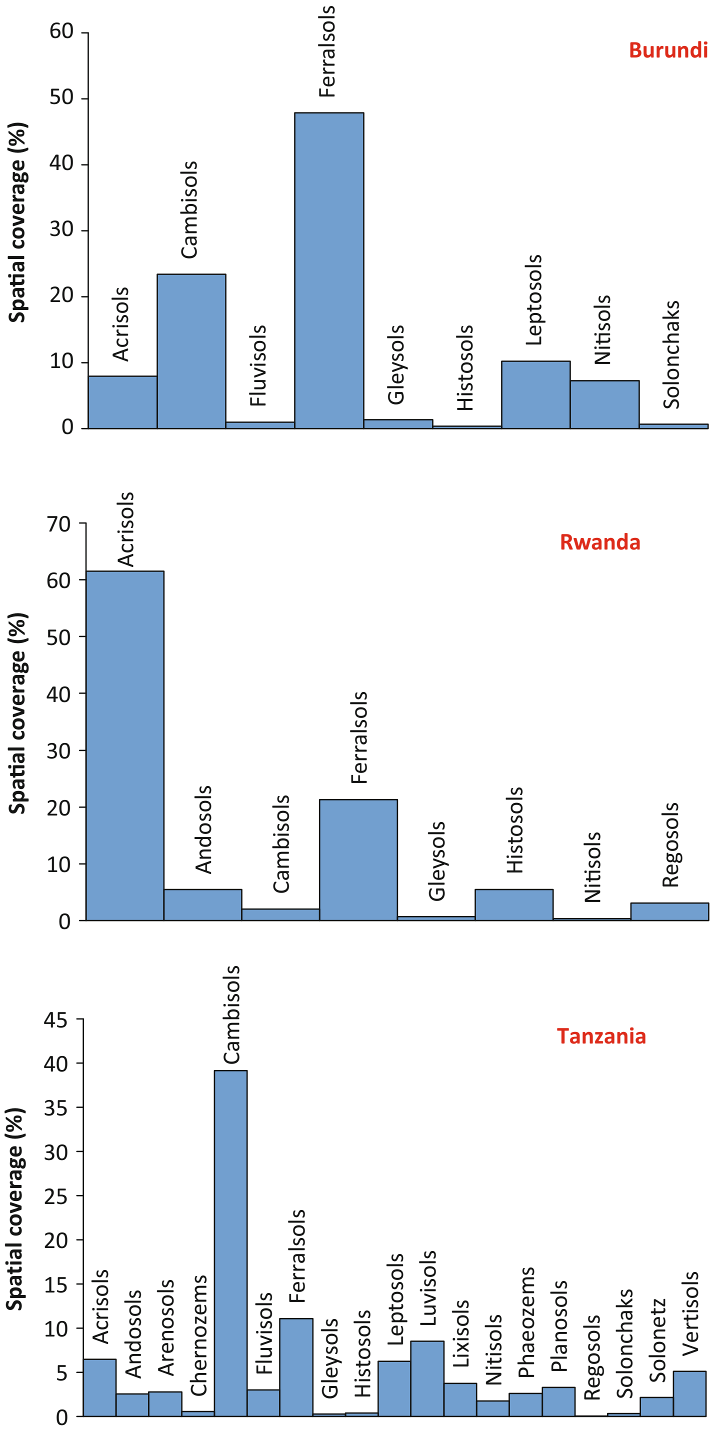

Fig. 2.9 Spatial coverage of soil types in the East African countries

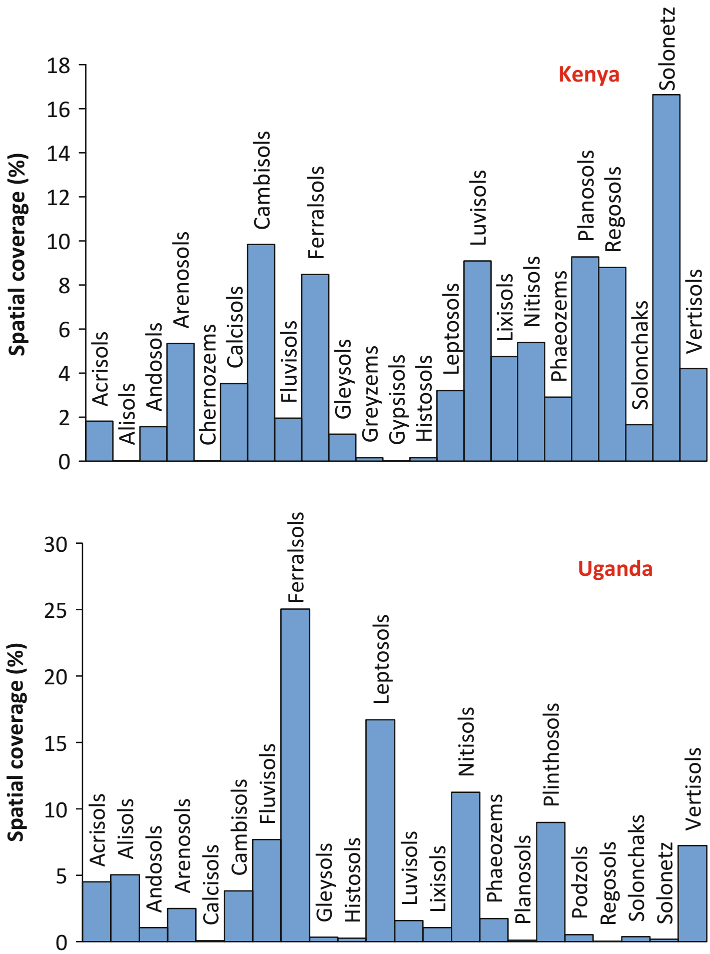

Fig. 2.9 (continued)

2.6.1 Soil Erosion

Soil erosion, particularly by water, is one of the most serious threats to agricultural productivity in SSA (Obalum et al. 2012). Soil erosion is omnipresent in the region and reported to be increasing, although comprehensive empirical studies of erosion rates for the entire East African region are scarce. However, scattered reports from both experimental runoff plots and spatial modelling verify its extent and magnitude. Results on annual soil erosion rates from diverse studies based on experimental runoff plots in major Ugandan landscapes are depicted in Table 2.4.

Table 2.4 Measured mean annual soil losses from dominant land use system across landscape categories in Uganda

Author	Soil loss	Landscape category	Land use system
Bagoora (1998)	10–129 t/ha/year	Highland	Maize and beans
Bamutaze (2011)	10 t/ha/year	Mountain	Intercropped annual and perennial
Bamutaze (2005)	25–45 t/ha/year	Mountain	Maize, banana, coffee
De Meyer et al. (2011)	34–207 t/ha/year	Plateau	Footpaths and agricultural fields
Kizza et al. (2013)	10–320 kg/ha/year	Plateau	Forest
Majaliwa (1998)	40–45 t/ha/year	Plateau	Maize, maize-beans intercrop
Majaliwa (2005)	20–85 t/ha/year	Plateau	Coffee, banana, beans
Mulebeke (2004)	25–71 t/ha/year	Plateau	Banana, coffee, beans
Nadhomi et al. (2006)	9–48 t/ha/year	Plateau	Banana, coffee
Nakileza (1994)	3–7 t/ha/year	Mountain	Maize, beans, mixed cropping
Nakileza (2005)	20 t/ha/year	Plateau	Annual cropping
Semalulu et al. (2013)	1–39 t/ha/year	Mountain	Banana, coffee
Tukahirwa (1996)	1–38 t/ha/year	Highland	Sorghum

The spatial variability of Uganda's erosion rate using the GLASSOD methodology is found in Fig. 2.10a. Figure 2.10b is a geopedological map coupling the dominant soils, geology, and geomorphology.

As expected, highland and mountainous landscapes experience more degradation than lower elevations. In Uganda, these landscapes receive substantial annual rainfall. They are dominated by steep slopes of more than 30 % which are especially prone to soil erosion. The ownership of land is extremely fragmented in highland and mountainous landscapes, with land size per household predominantly at less than 1 ha.

In these landscapes, soil erosion is dominated by rill and interill typologies, while gullies are confined to a few areas, particularly in western Uganda. High erosion rates are observed in the heavily populated and intensively cultivated plateau of the Lake Victoria Basin. These dangerous erosion rates are in the range of those observed in the South-western highland and Mt. Elgon in Eastern Uganda. A runoff and soil loss assessment at varied hill slope positions on the Mt. Elgon landscape under annual and perennial cropping (Bamutaze 2005) confirms high erosion across lower, middle, and upper hillslope segments, as Fig. 2.11 shows. Observed annual soil erosion rates from these hillslope segments are higher than the generally accepted tolerable limit of 5 t ha^{-1} year^{-1}. This pattern has also been observed at sites in other SSA countries, such as the Ethiopian highlands,

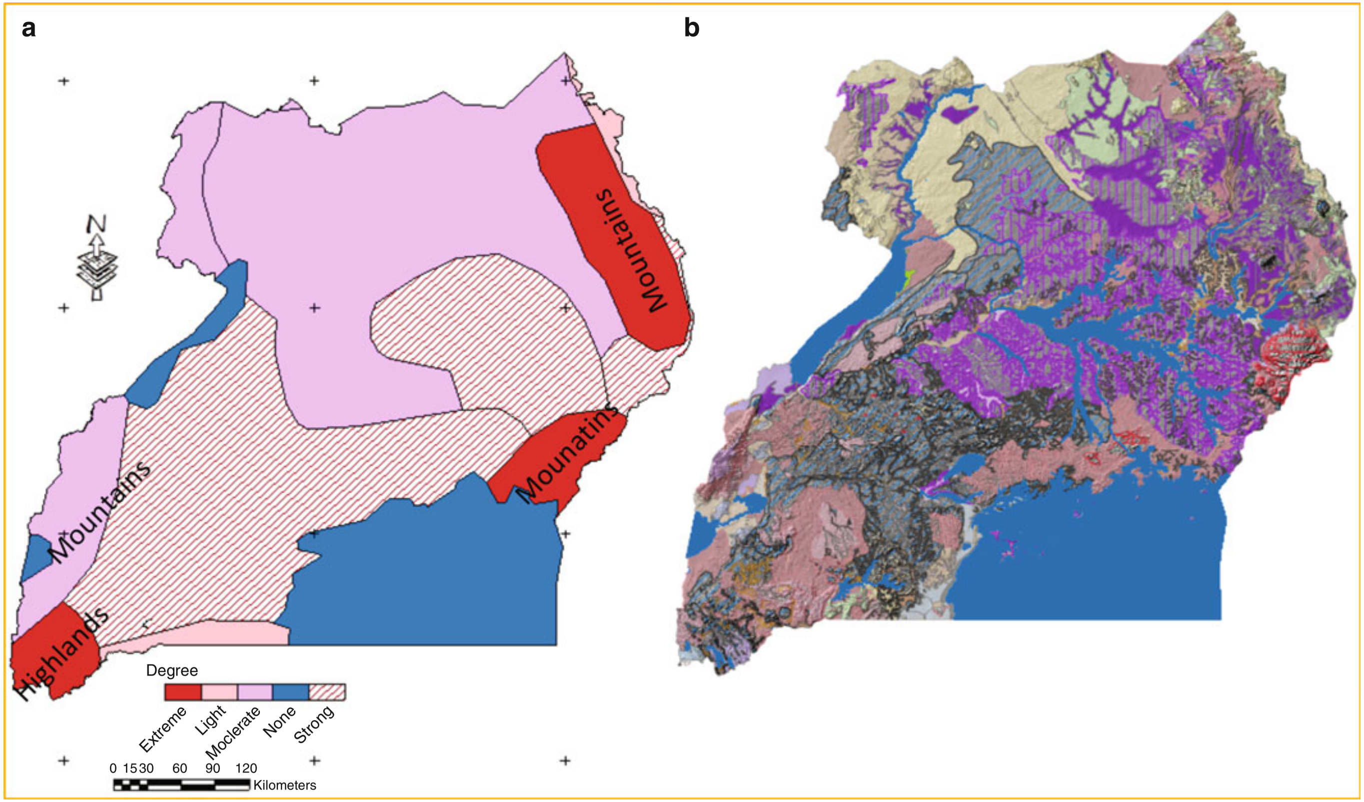

Fig. 2.10 Soil degradation status based on GLASSOD methodology (**a**) and geopedological entities of Uganda (**b**)

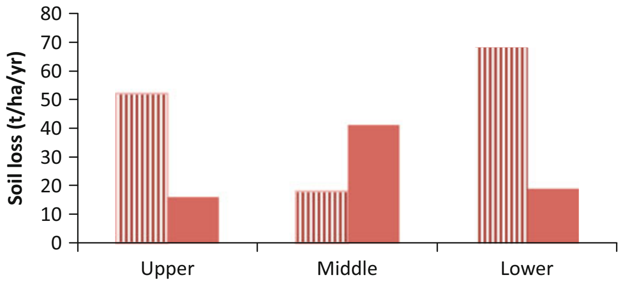

Fig. 2.11 Variability of soil loss rates at diverse slope positions on Mt. Elgon (Source Bamutaze 2005)

(Munro et al. 2008; Nyssen et al. 2009) and Tanzania's Ulugulu mountains (Kimaro et al. 2008). While a mix of natural and anthropogenic factors contribute to these high soil erosion rates (Boardman 2006), poor landscape management is the dominant cause of soil erosion in SSA.

Recent comprehensive quantitative data on yield reductions from erosion in SSA are very limited. According to Lal (1995), erosion-related yield reductions in Africa generally vary from 2 to 40 % with a mean of 8.2 % for the continent and 6.2 % for SSA. These reductions are projected to rise to 16.5 % for the continent and 14.5 % for SSA by the year 2020 if erosion continues unabated (Lal et al. 2004; Obalum et al. 2012). As well, it is estimated that about 1.2 % of soil nutrients in Uganda are depleted annually, which contributes to poor harvest yields (NBI 2012).

2.6.2 Trends and Implications in Land Use and Coverage Change

Land use and soil coverage changes are significant terrestrial processes altering biogeochemical processes, ecological dynamics, and the sustainability of agricultural systems (Alkharabsheh et al. 2013). Conversions of forest cover into agricultural fields in East Africa are widespread and increasing. The change in East Africa's forest cover between 1990 and 2011 as a percentage of the total land area is shown in Fig. 2.12. Figure 2.13 displays trends in arable land for the same period.

A regression analysis shows that with the exception of Rwanda, all East African countries experienced a significant reduction in forest cover between 1990 and 2011 ($p < 0.05$). Regional-level analysis shows that forest cover was reduced from about 30 % of the land area to 23 % for the same period. The highest reduction was observed in Burundi (−41 %) and lowest in Kenya (−7 %). Strikingly, all countries except Burundi at least experienced a significant increase in arable land. The observed declining trend in East Africa's forest cover corroborates observations made elsewhere in SSA (Brink and Eva 2009; Were et al. 2013; Gross et al. 2013;

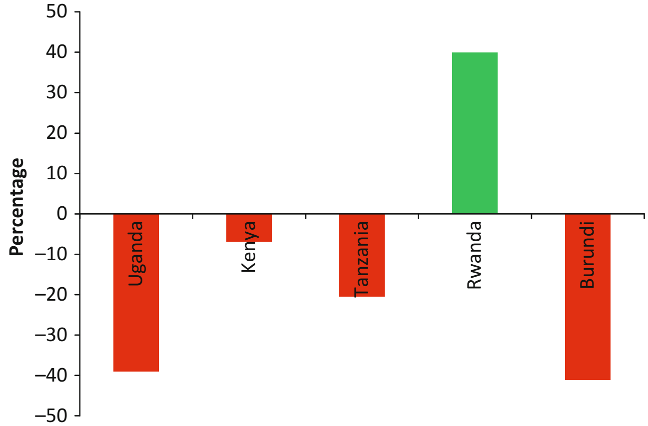

Fig. 2.12 Change in forest cover between 1990 and 2011 in Eastern Africa

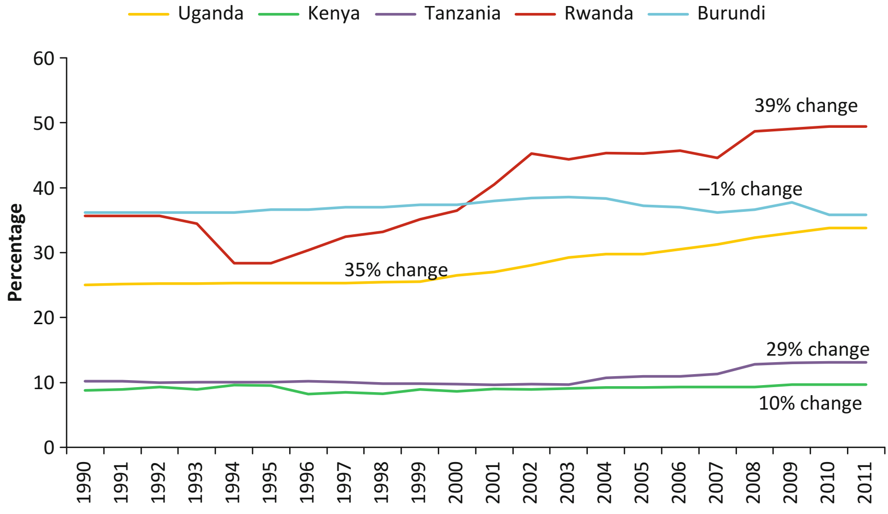

Fig. 2.13 Change in the proportional coverage of arable land in East Africa between 1990 and 2011

Brink et al. 2014). Interestingly, although Rwanda experienced the most rapid increase in arable land (39 %), its forest cover also increased between 1990 and 2011. The most plausible reason for this trend is that Rwanda has implemented environmental laws more firmly than other East African countries and begun a concerted re-forestation programme.

Fig. 2.14 Naked or raped landscape on a ferralsol on Mt. Elgon due to improper land use

Although the relationship between land use change and soil erosion is generally non-linear in the long term (Dotterweich 2013), extensive studies (Defersha and Melesse 2012; Munro et al. 2008; Heckmann 2014; Mohammad and Adam 2010) of the East African region show that land use changes result in high levels of land degradation. In the same region, studies by Mugagga et al. (2011) suggest that these landscape transformations account for the exponential increase in slope failures. Land use and cover change are more pronounced in highland and mountainous landscapes, which is more evident on the Ugandan side of Mt. Elgon than the Kenyan side. Unsustainable conversions from forest cover to annual crops have culminated in a landscape described locally as "naked or raped" (See Fig. 2.14). High soil erosion rates and related sedimentation processes compromise the immediate and long term productivity of these sites.

2.7 Conclusions

The interplay between geomorphology and pedology in tandem with climate plays a significant role in SSA's agricultural production systems. Regional landscape analyses indicate that terrain limitations prevent about 13 % of the region's highland and mountain areas from suifood production. Soil quality in many parts of the region also constrains production. Delineated geopedological landscapes are characterized by a range of geohazards, but the most significant seem to be soil erosion and land use change, particularly conversions from forest cover to cropping activities. For the landscapes to sustain the rapidly increasing human populations occupying them today and in the future, deliberate attention toward socio-ecological sustainability is required.

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