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An Integrative Approach of the Geography of Soil Organic Matter (SOM) Management Practices to prospect BGBD erosion, in the Taita Hills South-East Kenya

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Abstract

The issue of land intensification impacts on Below-Ground BioDiversity (BGBD) erosion is often addressed by linking soil micro-, meso- and macro-fauna quantity with land cover. However, it is also possible to adopt a deductive approach by drawing the geography and the dynamics of farming practices - related to Soil Organic Matter (SOM) management - with a direct bearing on BGBD. This integrative approach is based on an analysis of the socio-economics of land cover, e.g. determinants of farming practices. It helps building scenarii on future evolution of soil fertility.

This paper presents the outcomes of two fieldworks in the Taita Hills and their surrounding semi-arid plains, South-East Kenya. Small-scale farmers adopt various strategies to cope with increasing land scarcity. Some strategies are particularly outstanding, e.g. the intensification of the farming practices in the more humid highlands or the agrarian colonisation of the semi-arid foothills and lowlands.

This study required a multidisciplinary and systemic approach. Based on an extensive data collection on a 52 square km area, in-depth interviews and fool-proofing process, involving 150 farmers and key informants, eleven farming systems were identified. The farming systems segmentation relies on ***(i)*** *combination of cash and home-consumption production (horticulture, dairy, coffee beans, maize, beans, and extensive livestock),* ***(ii)*** *farm acreage,* ***(iii)*** *livestock, (iv) labour force and (v) possible casual labour. It was hence possible to link the localisation of each farming system with the identified farm trajectories: highland valley bottom, rainfed highland and midland, foothills and lowlands. Furthermore, main SOM management practices were identified in each system, such as organic and inorganic fertiliser application, mulching, composting, fallow rotation, etc. Areas where SOM was decreasing and BGBD could be severely reduced were eventually located.*

At a larger scale, the diversity of farming practices results in a mosaic of soil fertility status. The key drivers are pedoclimatics (natural resources distribution) and socio-economics (livelihood systems). Further consequences of BGBD erosion and fertility decrease are to be expected on land use and livelihood systems.

Keywords: Below-Ground BioDiversity (BGBD), farming practices, Kenya, land intensification, soil organic matter management, Taita Hills

Introduction

To measure the consequences of land intensification on Below Ground BioDiversity (BGBD) erosion, scholars often carry out quantitative research studies on soil fauna and link afterward with land cover. A study based on a deductive approach using the geography and the dynamics of farming practices, can usefully complement it. This paper illustrates the methodology and outcomes of such an integrative approach on farming practices determinant.

This paper presents the outcomes of two master research studies in the Taita Hills and their surrounding semi-arid plains, South-East Kenya. The two studies were carried out between May to August, in 2005 and 2006.

Materials and Methods

A systematic observation of soil and landscape components in the study area (50 square km) first enabled to distinguish different agro-ecological zones in each of which pedoclimatic constraints and opportunities for farming were homogeneous. These observations were complemented by cross-checked interviews with farmers, taking into account their local knowledge on soil distribution and climate pattern in the area.

In a second time, in-depth interviews with older farmers (45) were carried out to analyse the leading socio-economic factors that have influenced farming evolution during the last century. Attention was paid on production choices, farmed surface areas, and fertility restoration practices. As farmers were interviewed in different agro-ecological zones, it was hence possible to model farm trajectories in each zone.

Building upon this first analysis, a farm typology based on farm trajectory and localization was drawn.

In a third time, semi-directive interviews with farmers (40) in each of the types pre-identified enabled to deepen the analysis of the present farming practices, related with both cropping systems and livestock systems. Farmers met belong to all age class and a gender ratio was respected.

The integration of those systems led to prospect the organic-matter management practices, and, as types were spacialized, to draw a conceptual map of areas threatened by a soil fertility status crisis and BGBD erosion.

Results

1. The Taita Hills geographic context

The Taita Hills are situated between longitudes 38°15' and 38°30' E and latitudes 2°15' and 2°30' S. They belong to the Coast Province, southeast Kenya, in Taita-Taveta District which shares its frontier with Tanzania. The Taita Hills, whose total surface area is 200 km square, rise abruptly from a vast semi-arid peneplain at an average elevation of 800 m. The average altitude of the Hills is 1 500 m, although the culminant peak is 2 200 m high. Due to their mild and humid climate, Taita Hills are more densely populated than the average district. Indeed, while the population density in the study area division is 78 inh/km^2, the District population density is 14 inh/km^2 (last population census, 1999). The study area is one of the most populated interior valley of the Taita Hills, called Werugha and its growing territory to the Lowland (50 km 2)

2. Agro-ecological zonation

The conjunction of precipitation pattern and uneven topography results in a variable rainfall distribution. Additional factors of geology variation lead to high soils variability. The combination of those biophysical factors enables to model four agroecological zones: Uplands, Midlands, Valley Bottom and Lowlands.

- **The Highland rainfed areas** (1800 - 1400 m) receive more than 1200 mm annual rainfall and have a cool climate. Soils are lixiviated with a sandy-loamy texture (acrisoil). Water for irrigation is not a constraint although soils are poor if they are not fertilized. Crops grown are coffee, Napier grass and seven months cycle maize.
- **The Midland rainfed areas** (1400 m – 1000 m) are drier and warmer. Soils texture varies according to the bedrock from sandy to loamy. The soils (cambisoil type) can be partly lixiviated. Maize varieties are transitional between five and three months cycle to maximize the rainy season.
  Due to slope inclinations those two areas are sensible to soil erosion unless agricultural terraces had been built and maintained. Soils which have been deeply eroded have lost the organic layer, and farmers are directly cultivated on the rock eroded.
- **The Valley Bottom areas** (1700 – 1200) benefit from access to irrigation water. Soils are alluvial soils with high chemical nutrient content. Regular floods carry new alluviums annually. Cultivation of vegetables and maize is intense, since three to five crop cycles a year are cultivated.
- **The Lowlands or semi-arid surrounding plains** (1000-800 m) are drier and warmer. Ferrallitic soils are deep (several meter) with high content of clay. Chemical fertility status is high as the development of agriculture is recent, although the main constraint for agriculture is the erratic precipitation patterns with higher risks for farmers. The area is mainly used as grazing lands for livestock; maize is cultivated here with three to four months cycle varieties.

3. Outstanding socio-economical and historical factors explaining farm differentiation

Outcomes of interviews with older farmers illustrate the progressive farming practices intensification related with an increasing population pressure, as well as a progressive social differentiation. Several leading factors can be underlined:

The growing population in itself on a limited territory was source of increasing pressure on land. Progressively, remaining forests had been cut and the whole agricultural area cultivated. Nowadays, the forest remnants are localized on the higher peaks of the Hills where soils are shallow and climate too cold and humid for cultivation. The former way for the population to lived (grazing and fruit gathering) is not any longer allowed in order to sustain to whole population.

The land adjudication of the land reform program in 1963 has fixed each farmer's property to one agro-ecological zone, whereas before an equalitarian distribution of access to different kind of soil and climate was performed. Hence, some farmers were attributed land in shallow sloppy areas, while others benefited from land in valley bottom. This adjudication process accentuated differentiation among farmers since some had the opportunity to specialize their farming system in cash production as horticulture in valley bottom or dairy production in the humid highlands. The more disadvantaged farmers were forced to out-migrate to cities or to the Lowlands, which started to be a new agricultural place to colonize in the 1960's.

The Green revolution played a relevant role in the area with an increasing use of inorganic fertilizer, extensive cultivation of maize instead of millet or sorghum. Terraces, agroforestry trees, maize hybrid varieties, improved cattle breeds and inorganic fertilizers were spread in the area. Coffee and vegetables were the main cash crop crops that benefited from inorganic fertilizers while home-consumption crops were cultivated in rotation with legume and fallows to restore fertility.

The rising of the monetary economy, pushed by the colonial and then independent government, further increased pressure to produce cash productions. The cash earned from cash crops enable to intensify the production system by acquiring more race-improved dairy cows or selected crops. On the other side, farmers without the opportunity for cultivating cash crops had to sell their labour force as casual labourer in the other farms. Therefore, two dynamics could be differentiated: the intensification virtuous cycle working with cash and the involution decapitalization vicious cycle of those farmers with no access to cash.

Moreover, the several successive structural adjustment programs suggested to the Kenyan Government by the IMF led to a decrease in the subsidies to agricultural sectors. Agricultural technical advices started to be paid instead of given for free during the "green revolution" period.

The local economy monetarization was exacerbated with the existence of increasing school fees for primary and secondary schools in Kenya. Some small-holder farmers are nowadays using a relevant part of their income to pay their children's education. Therefore, the farm differentiation is taken over by an information and education level differentiation.

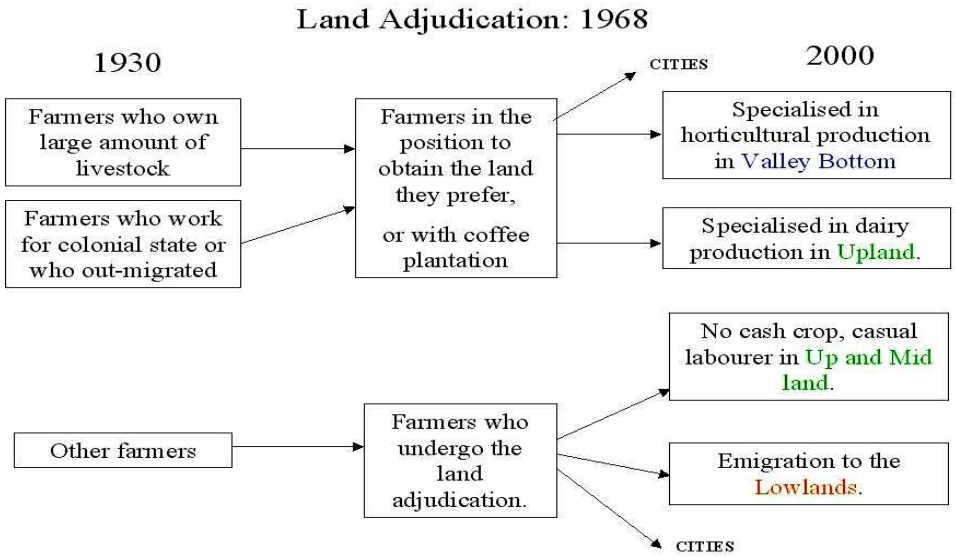

Figure 3: Farm differentiation pattern

4. Evolution and intensification of farming practices

In the 1930's, farming systems were based on the complementary agro-ecological zones. Each farmer could cultivate several plots in different areas. There were no tiling practices because seeds were plants in hole dug with a stick. Nutrient restoration practices were performed thanks to bush fallow, since plots were not permanently cultivated. Grazing was the main use of the land, especially in the Mid and Lowlands. Cattle, goats and sheep of several families were gathered together on the midland and semi-arid areas, but manure was not valorized.

In the 50's, cultivation of coffee enhanced the use of inorganic fertilizer in the area and lead to a zero-grazed livestock system.

The growing population pressure has changed radically the agrarian landscape. Land available per capita was decreasing, and therefore fallow rotation practices as well. Nowadays, fallow is no longer carried out in the Highland areas where population pressure is higher (500 hab/km2), although some of the farm still perform it in the Midland area which is less occupied (200 Hab/km2). The Highland plots are permanently cultivated, most of them twice a year during the two rainy seasons, which exacerbate the need for nutrient restoration.

Livestock keeping practices have also intensified from a herd keeping to a highly intensified zero-grazing system in the Highlands area.

At the end of the 60's, agriculture has to be practiced also in the Lowlands, a wild territory only used for grazing. The grazing area is pushed further away and maize and adapted legumes varieties began to be grown.

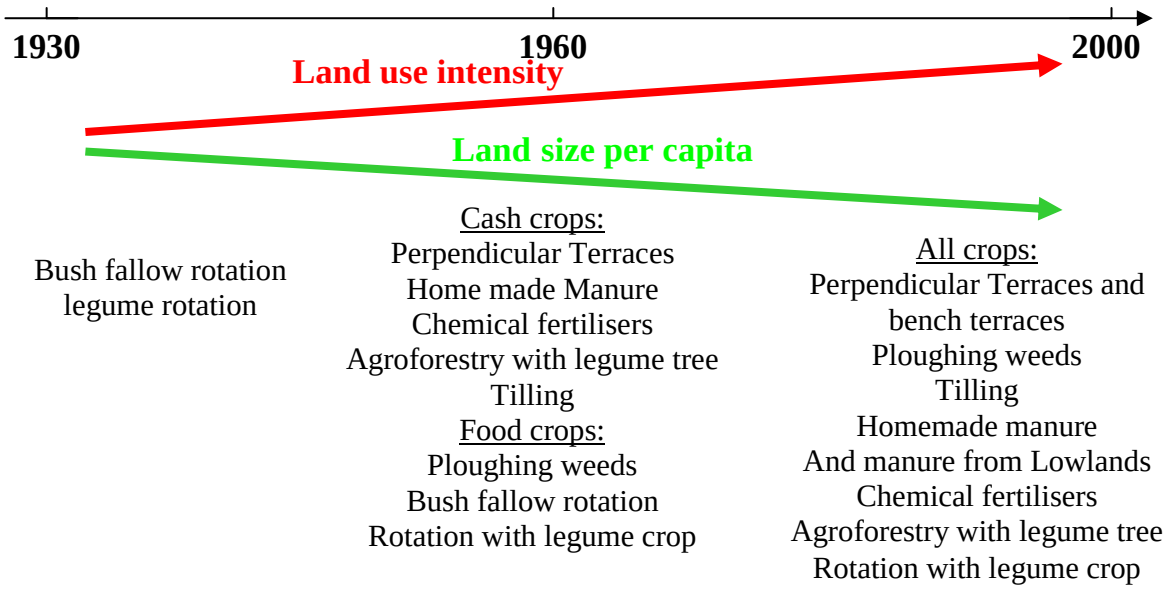

Figure 4: Farming intensification related with SOM management

5. Farm typology and spacialization of SOM practices

According to the localization of farms and the possibilities farmers have to invest capital in their lands, the intensification and the SOM management practices vary.

Farm type	Surface area	productions	Localisation	SOM management practices
Type 1		Horticultural specialized remnant of coffee 3 dairy cows	Valley Bottom	Inorganic fertilizers Lowland dry manure Farmyard manure (>10 t) Green compost Legume rotation
Type 2		Horticultural and home consumption 2 dairy cows	Highland and part of Valley Bottom	Farmyard manure (4 - 6 t) Legume rotation Inorganic fertilizers Green compost
Type 3		Dairy specialized 4 dairy cows	Highland	Farmyard manure (> 6 t) Legume rotation
Type 4		Home consumption, remnant of coffee 2 dairy cows	Highland Midland	Farmyard manure (2 - 4 t) Legume rotation
Type 5		Home consumption crops, 1 cross breed cow	Midland	Farmyard manure (< 2t) Legume rotation Fallow rotation
Type 6		Home consumption crops and no cows	Midland	Legume rotation Fallow rotation
Type 7		Home consumption crop, maize for cash	Lowland	Legume rotation Fallow rotation

Figure 5: Farm typology and SOM management practices

6. Scenario for belowground biodiversity

The Valley Bottom areas have a higher fertility status, but their frequent manual ploughing (at least 3 times a year) may damage the BGBD. Some of the farmers of this area are using extensive quantity of inorganic fertilizers because they don't have sufficient own dung to compost. Those ones have mentioned degradation in soil texture. Some of them are also buying dry manure coming from the Lowlands. This pure cow dung had a low C/N status which does not maintain the BGBD.

The Highland areas may face two alternatives. Farms that benefit from remittance from exterior income can manage sustainably a dairy livestock system which will produce sufficient quantity of organic matter. Moreover, the Napier crop do not need soils to be ploughed highly frequently. Other farmers relying on labourer work for cash earnings and with small properties (0,2 ha) do not usually apply any fertilizers, and they experience already too low yields; which is a indicator to fertility status. Many of those only have a small garden around their house in this area and must cultivate other plots in the Mid and Lowland for their home consumption.

The Midland rainfed slopes are usually in the worst state, although this statement can be nuanced. Some plots are facing relevant erosion problems, due to a long period a bi-annual cultivation with no sufficient nutrient restoration. Farmers are usually facing other socio-economic difficulties that hamper them to have a sustainable management of the terraces. However, in the lower and less populated areas were fallow is still practiced and tree density still high, we may admit that BGBD is higher.

In the Lowland, yields have recently started to decrease after 30 years of cultivation without nutrient restoration but a high soil fertility crisis can be expected if these "extractive" farming practices are maintained.

Discussion and conclusion

According to farmer abilities to intensify his/her production and thus to earn cash from their farm, social differentiation has been exacerbated. This opportunity to intensify depends on the localisation and the biophysical characteristics of the farm. Hence, the social farmers' differentiation during the last century is also a spatial differentiation: spatialisation of natural resources has led to a wealth spatialisation. Farm trajectories differ by the level of intensification and their sustainable fertility management.

Besides, the actual agrarian system highly depends for its functioning on importation from other regions, through remittance of relatives or other off-farm incomes and through importation of any kinds of agricultural inputs. Population has become too important to be able to feed only on resources coming from the area.

This paper try to give an alternative way to prospect soil management, using mainly qualitative data, but integrating soico-economical aspects that enable to lead to broader conclusions. However, the outcomes of this study should be cross-checked with quantitative data on Soil organic matter status in the same area in order to validate this methodology.

The fertility crisis and the increase of the population requires a intensive and sustainable agricultural production for the future. Therefore, finding pathways to increase soil

productivity is relevant in the study area. New techniques, and particularly those based on soil organism management, have to been discovered and implemented in the study area.

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