

G-1.4 Evaluation, Improvement and Preservation of Soil Productivity for the Establishment of Sustainable Agricultural Systems in Sub-Saharan West Africa

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Total Budget for FY1999-FY2000 80,947,000 Yen (FY2000; 38,265,000 Yen)

Abstract In aiming at developing the "life-size scale" technology for farmers to cope with the desertification and soil degradation, agricultural and soil conservation measures practicing by farmers in the Sahel, Sudan and Guinea savanna zones of Burkina Faso were analyzed. The changes in the farmers' behavior in the past 15 years and the socio-economic and the natural factors behind these changes were elucidated. The results obtained through intensive multi-disciplinary studies are as follows: (1) The analytical methods of satellite remote sensing data were developed to estimate the desertification and the land use pattern, distinguishing cultivated or fallow lands at the village level. (2) New technologies such as animal traction and fertilizer use increased in the Sudan and Guinea zones, while no substantial change occurred in the Sahel zone. (3) Recent banishment of temporal migration of Burkinabe to Ivory Coast through the kinship network may cause in increasing the farmers' vulnerability in the Sudan zone. (4) Nutrient cycling in the ecosystem of these regions cannot be expected to increase crop productivity, therefore, the input such as chemical fertilizers and/or animal manure is indispensable. (5) The *parcage* system (collecting and spreading cattle feces) employed at agro-nomadic region in the Sahel was shown to be effective to increase the soil fertility. (6) Multiple thin layers of finer particles existing in the surface top layer of sandy soil of the Sahel are self-protecting against wind erosion. The indigenous "no-tillage" weeding practices with push-hoe ("*gouro*") minimizes the destruction of these thin layers. (7) These findings, with the elucidation of the function of organic matter in soil, may contribute to the development of farmer acceptable technology to restore soil degradation and desertification.

Key Words Desertification, Household Economy, Soil Degradation, Sub-Saharan West Africa, Traditional Farming Practices

1. Introduction

The semi-arid tropics in the West Africa experienced repeated severe drought since 1970's. The desertification and soil degradation have become so serious to the degree to

threat the farmers livelihood, and agriculture and food production in those regions are at risk. The desertification in those regions is inherent because it is created by the daily human activities such as agriculture, livestock farming, and collection of fuel woods, which are the core life activities of the inhabitants. The local people are to utilize, destroy, and conserve the environmental resources at the same time. Therefore, the point of view to grasp the interactions between the living activities, resources and environment is necessary.

In this study, we focused on the country of Burkina Faso, where three climatic zones are identified: (1) Sahel zone (agro-nomadic zone), (2) Sudan zone (agricultural zone), (3) Guinea zone (agricultural zone). We selected three villages, one from each climatic zone, as the common survey sites and studied them from various disciplines such as geography, soil, GIS, crop nutrition, crop cultivation, agrosocio-economy, and cultural anthropology. For the local people, the decline of crop productivity and the loss of means to cope with the low productivity are the immediate problems. Therefore, we considered that the soil degradation (the decline of vegetation and crop productivity through the decrease of soil fertility, and soil erosion) or the decline of soil carrying capacity is the core problems.

2. Research Objectives

The objectives of this study were (1) to clarify the degree of desertification in Burkina Faso, (2) to evaluate the farmers' reaction and indigenous agricultural technologies to cope with the desertification, and (3) to focus the priority of investigation from the point of view of preserving and restoring the soil carrying capacity.

3. Research Methods

We pursued evaluating and improving indigenous technologies of the farmers, elucidating socio-economic measures of village people coping with the risks, and developing the evaluation technology of soil carrying capacity by GIS.

Three villages selected as the common survey sites are (1) Silguey (Sudano-Sahel transition zone), (2) Kolbila (Sudan zone) and (3) Sayero (Guinea zone). International Fertilizer Development Center in Togo (IFDC-Africa) collaborated with us in orientation and setting the frame of the collaboration with the Government of Burkina Faso.

For the GIS analysis, NDVI (Normalized Difference Vegetation Index) obtained from NOAA/AVHRR with 1 km resolution and SPOT/HRV with 20 m resolution were employed. Land use pattern of Kolbila, locating about 110 km northwest of Ouagadougou, the capital of Burkina Faso, was discriminated by adopting a decision tree method using multi-temporal SPOT/HRV data. Agrosocio-economic investigation was conducted by interviewing 32 households/village, 6 villages, including the common survey sites. In addition, intensive survey was carried out on one Mosi village, Kolbila.

Nutrient status of soils and crops collected from upland and lowland fields throughout Burkina Faso was analyzed. Human-environment interactions under conventional farming systems in Sahel zone were carefully observed in Takabangou village, in north-eastern part of Burkina Faso, having approximately 400 mm of annual rainfall. The effect of organic matter application on the soil chemical properties was

analyzed in the two experiments, (1) three factorial effect (fertilizer x cowpea residues x manures) on pearl millet conducted in ICRISAT-Niamey, Niger and (2) "level of organic matter application x N x P" for corn in farmers fields near Dapaong, northern Togo, conducted by IFDC-Africa and local NGO (Rafia).

4. Results and Discussion

Decision tree method using multi-temporal SPOT/HRV data could discriminate cropped land, fallow, sparse vegetation, dense vegetation, and bare land. In Kolbila, cropped land distributed more densely within 500 m distance in circle from the house than over 500 m and the reduction of cultivation area due to short rainfall was 8 % within 500 m zone, whereas 38 % in outer zone (1992, normal rainfall vs. 1993, short rainfall). The area of fallow, which would be necessary to maintain the land productivity, was about 3 times of that of cropped area.

Animal traction and chemical fertilizer have become adopted more widely in Sudan and Guinea zones within past 15 years (ICRISAT survey¹⁾ done early 1980's), but very less in Sahel zone, resulting in the expansion of cropping area in some villages where land is not limited. Soil conservation measures, such as live hedge, stone lines, etc., were not practiced 15 years ago, but now they are widely adopted by the farmers, suggesting the necessity of quantitative estimation of their effect.

In Kolbila village in Sudan zone, 71 people or 54% of the married male members are migrants living in Ivory Coast, about 90% of them are practicing farming. Home remittances by those migrants constitute indispensable income for the villagers, making an important measure to cope with the risk of farmers' difficulties. This measure may become not workable soon due to political instability of Ivory Coast, causing increase of vulnerability of farmers of Burkina Faso. Thus, both micro as well as macro socio-economic change affects the vulnerability of farmers of this country.

Soil nutrient status was generally poor in both lowland and upland fields, but was relatively higher in lowlands than in upland fields, thus, rice cultivation in lowlands seems to have a comparative advantage over upland crops. No clear difference in soil fertility was found in soils among different climatic regions. The input of fertilizers and/or organic matters are necessary to promote the growth of crops, particularly in Sudan zones. Moreover, soil amendment to improve the soil physical properties is also inevitable.

In the village, Takabangou, and its surroundings, three ethnic groups (Songhai, Fulbe and Bela) dwell with different husbandry, making multi-ethnic interaction over the same land resources. The land is entirely covered with sandy soil, which is generally believed as "fragile and sterile". However, more attention should be deserved to the potentiality of nutrient and water retention of sandy soil in its large effective soil depth (>150cm). Remarkable characteristic of this soil is the existence of multiple thin layers of finer particles at an interval of a few cm in the soil profile, functioning as self-protection against desertification process, since wind erosion stops when a thin layer is exposed to the surface. "No-tillage" weeding system by a push-hoe, local name "gouro", minimizes the destruction of these thin layers and, thus, the current agricultural practices are rational and

suitable.

Major soil fertility management systems in Takabongou are grass fallow and parcage. In the grass fallow, the above-ground biomass was 3.3 ± 2.4 ton/ha (n=4) in October, at the beginning of dry season where grazing pressure was relatively low, and 1.5 ± 0.6 ton/ha (n=4) in May after entirely grazed. The latter value is less than 30 % of the above-ground biomass of pearl millet, 5.8 ± 2.3 ton/ha (n=5), at harvest, suggesting that grass fallow may not maintain soil fertility enough to sustain the crops, because of high grazing pressure. On the other hand, the cultivated field covered with cattle feces under the parcage system was 2.01 ± 1.54 ha (n=7) with the density of 2.92 ± 2.17 ton/ha. This input may substantially support the crop growth.

Organic matter was effective in increasing the cation exchange capacity (CEC) of soils in Burkina Faso and its application increased total-P, Bray 1-P, total-N and nitrate-N, but not ammonium-N. Such effect of increasing the CEC was in the order of "crop residue" >> "manure" > "fertilizer" in ICRISAT-Niamey soils. However, no clear effect was found on the organic N level extracted by neutral phosphate buffer (PEON), an index of potential N supplying capacity. Results of Dapaong soils suggested the interaction between soil organic matter levels and fertilizer utilization efficiency of corn.

Soil in Sudan zone has its own characteristic structure self-protecting against wind erosion and farmers' agricultural practices are rational and suitable to protect this structure. There is possibility in improving those practices to be more widely adaptable measures. Role of soil organic matter in maintaining soil fertility and agrosocio-economic conditions are also to be further investigated in order to develop the new measures to combat desertification in Sub-Saharan West Africa.

References

- 1) Matlon, P. J., (1988) *The ICRISAT Burkina Faso Farm Level Studies: Survey Methods and Data Files*, International Crop Research Institute for the Semi-Arid Tropics.