

Full Length Research Paper

Impacts of water and soil conservation strategies on households' food security in North West of Benin

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This study aims at analyzing the impact of water and soil conservation strategies on households' food security in the North-western part of Benin. It was conducted in the municipalities of Boukombé and Ouaké. Three villages were studied. From random way, 180 producers were investigated. The causes of soil degradation, water and soil conservation strategies, available food supply and food consumption frequency were collected. Degradation factors were analyzed using discourse analysis and prioritized using the Friedman test. Food supply and frequency of consumption were compared between beneficiaries and non-beneficiaries of the projects using the Student t test. Land degradation is caused by socio-cultural factors (overexploitation of lands, trees' cutting, late bush fires, grazing, agroforestry and monoculture) and natural factors (heavy rains and steep gradient of the soils). The first three factors are respectively the exploitation of land, trees' cutting and late bush fires practice in both towns. Food reserves before the new crops were not affected by exogenous strategies released by the erosion control projects. But the frequency of food consumption is improved statistically among project beneficiaries than non-beneficiaries. This confirms the theory of Boserup.

Key words: Soil degradation, water and soils conservation strategies, impact, food security, North-west of Benin.

INTRODUCTION

The satisfaction of the increasing needs of the population submits the natural resources of the planet to increasing pressures (FAO, 2012; Malthus, 1798). These increasing pressures put in peril the agriculture whose development is seriously threatened by the degradation and the decrease of soils fertility in developing countries in general and mostly in Benin in particular (Baco et al., 2012). Though agriculture in Benin occupies 75% of the population (MAEP, 2010), it is not articulated yet around the techniques and the methods (the most modern) for fully satisfying the needs of the population. Its development as well as the level of production performances as the conservation, the transformation

and the commercialization of agricultural products are limited (SCRIP, 2007). It becomes gradually mining and causes the quasi irreversible degradation of the lands and ecosystems in the North-west region of Benin (Floquet and Mongbo, 1998). In this region, the farmers work on sloping lands (Amadji et al., 2006). Most of the soils are washed out of tropical ferruginous soils and characterized by a small content in organic matter, a

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sandy texture, a structure with particle tendency (Azontondé, 1991). The soils suffer of water deficit and are exposed to water erosion (*ibid*). The increasing of the population in the North-west of Benin accompanied by socio-economic pressures drove to the decrease of the soils fertility, the shortening of the fallows period, the increasing overexploitation of the pasture and the extension of the industry or food crops areas (Roose, 1989; Adégbidi et al., 1999). This includes the crops yield and the durability of the production system.

The populations of the North-west are confronted to a severe food insecurity estimated in the departments of Atacora and Donga respectively at 29 and 19% of their population (Bongi et al., 2009).

Several strategies of water and soils conservation (WSC) were developed and spread in the North-west of Benin by development projects since 1960. These projects cited that the State Society for Agricultural Development (SEDAGRI) promoted the construction of benches and dams from 1963 to 1969, the Project of Natural Resources Management (PGRN), the Project of Management of the Lands and Natural Resources respectively from 1984 to 1989 and from 1999 to 2005 and the Program of Natural Resources Management and Conservation (ProCGRN) funded by GTZ from 2004 to 2010. These projects aimed at the anti-erosive planning based on the realization of benches and sloping beds made from vegetables in the versant basin of the Atacora and Donga regions. Strategies such as the ridges perpendicular to the slope, cloisonné ridges, bees nests, stony cord came from the farmers. Since the realization of these anti-erosive works, their incidence has not been studied yet. The causes of the soils degradations stayed unknown in the area.

The present study funded by the project INuWaM « Integrate Nutrient and Water Management for sustainable food production in the sahel » aims at analyzing the causes of the soils degradation in order to evaluate the impacts of the WSC strategies spread by projects on food security on the households of the North-West Benin.

THEORETICAL AND ANALYTICAL FRAMEWORK OF THE STUDY

Two great theories were applied in the analysis of natural resources (the soil included). The Malthusian theories stipulated that population growth is responsible for the degradation of natural resources (Malthus, 1798), while Boserupian theories gave a favorable vision to population growth in the intensification of agriculture (Boserup, 1965). This study starts from the causes of the soils degradation to the restoration strategies to enlighten these two theories in North-west region of Benin. It begins from the hypothesis that the exogenous strategies of WSC spread by the projects improved food security in the households. A household is in food security when all

its members have, at any time, a physical, social and economical access to a sufficient, healthy and nutritive food allowing them to satisfy their energetic needs and their foods preferences for a healthy and active life (Bongi et al., 2009; FAO, 2009; Bachelier, 2010). Four pillars characterize food security (Wongkaew, 2010): (i) physical availability of foods relative to agricultural production and commercial exchanges, (ii) the economical and physical access which mean the capacity of the individuals of acquiring foods, (iii) the use of foods in correspondence with the individual needs, and (iv) the stability which means the regularity of the access and absence of penuries. These pillars have been divided into two measurable variables: the food supply available before the new harvests which informs on the physical availability of the foods and the physical and economical access. The food consumption frequency (number of times that the household members ate per day) informs on the use and the stability. The appreciation of these indicators has been based on maize for it is the most spread food of the population of the North-west Benin in comparison to the sorghum and "fonio". These indicators allowed seeing if the different spread strategies helped the households to have available and accessible maize in the way of using it to satisfy permanently their food needs.

The apprehension of the impact of these exogenous strategies was based on the experimental (random) and quasi-experimental (non random) conceptions (Da, 2008). The first conception, based on the approach "with-without", compares the control group (composed of the households who did not benefit from the exogenous strategies) to the experimental group (households having benefited from these strategies). The second bases its sense on the situation before and after the anti-erosive projects interventions ("before-after" approach). This conception presents some insufficiencies for it does not allow isolating the effects linked to the non factual elements (pluviometry, natural disasters, economic and agricultural policies, etc) (Bauer, 2000). These insufficiencies are put into account by the experimental conception which takes into account the socio-economic characteristics of the individuals composing each group (non-beneficiary and beneficiary). This random conception was used for comparing the food supply available and the frequency of food consumption between the two groups of households (non-beneficiary and beneficiary). This gave less biased results and easy to interpret from statistical methods (Yabi, 2004; Bassi, 1984; Cochrane and Rubin, 1973).

MATERIALS AND METHODS

Study area and villages' selection

The present study was conducted in the districts beneficiaries of the project INuWaM in the departments of

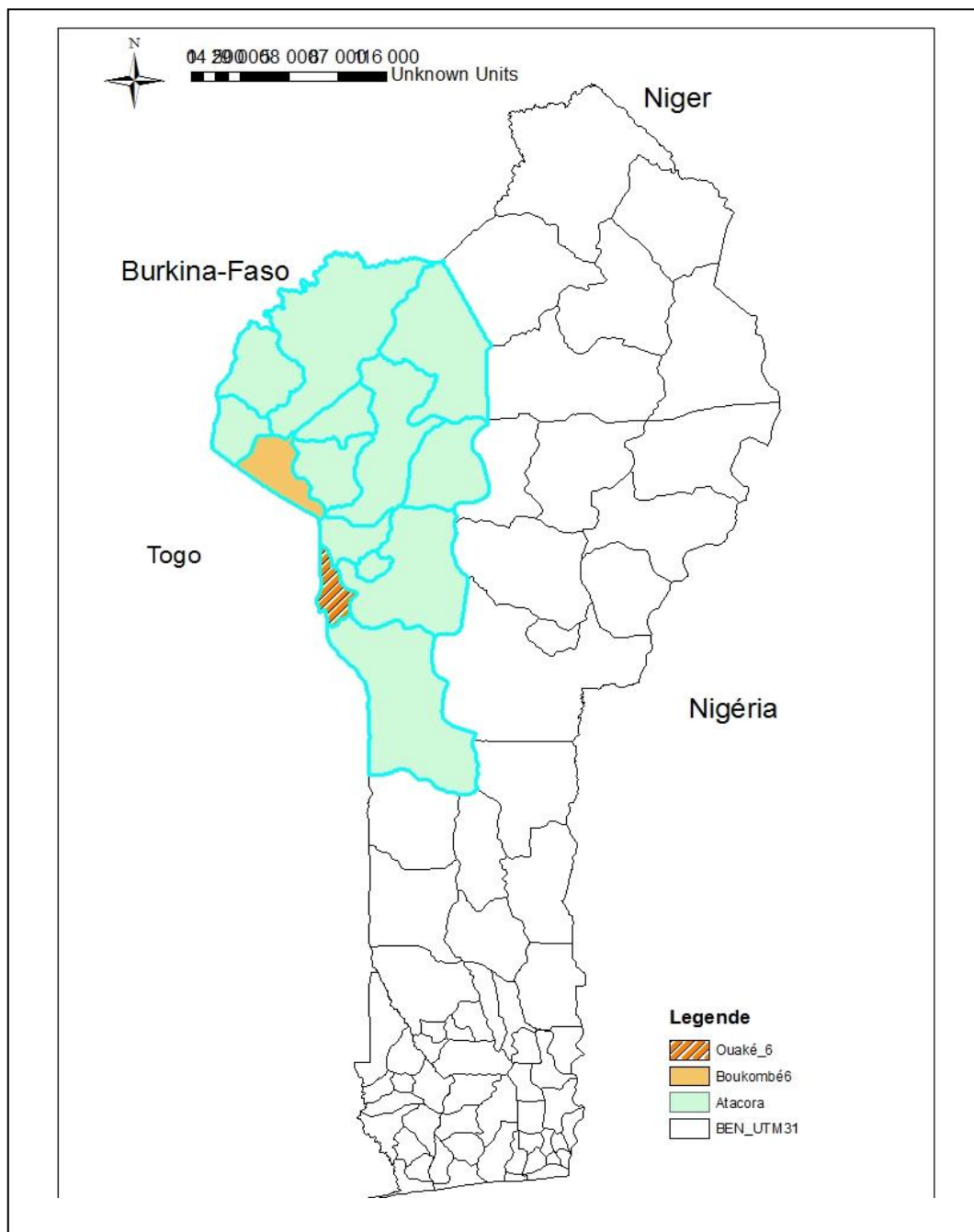


Figure 1. Map of the survey area.

Atacora and Donga. They are the districts of Boukombé in Atacora and Ouaké in Donga (Figure 1). The soils of these districts are characterized by a low erodibility and water deficit (Azontondé, 1991). The climate is of Sudano-guinean type with one rainy season and one dry season in Atacora and Donga departments. The precipitations vary between 900 and 1000 mm. The villages having hosted this study are those which have benefited from the supports of the project INuWaM. They

are Koumagou B, Koukoua and Koudogoun in Boukounbé and Alayomdè, Tchaladè and Awanla in Ouaké. They have been retained because they benefited from the actions of the planning projects.

Selection of the research units

The research units were the households represented by their heads. They were chosen randomly in order for

Table 1. Hierarchical organization of peasant perceptions on soil degradation factors.

Factors of soils degradation and water losses	Ouaké		Boukombé	
	Average rank	Rank	Average rank	Rank
Deforestation	2.19	2nd	3.09	2nd
Late bush fires	2.13	1st	3.17	3rd
Soils overexploitation	4.37	3rd	2.80	1st
Farming practice	6.10	6th	5.34	4th
Agroforestry practice	5.48	4th	7.10	7th
Overgrazing	5.60	5th	7.32	8th
Rains intensity	7.51	8th	6.12	6th
Soils slope	7.16	7th	5.85	5th
	Khi-deux	326.62	282.483	
Friedman test	Ddl	7.00	7.00	
	P	0.000	0.000	

Source: Field Enquiry (2012).

there to be a representative of the population in the sample. The sample is composed of 180 households (30 households per village due to the financial means given to the study).

Data, collection and analysis tools

Data such as the households' perceptions on the causes of the soils degradation and of the loss of water, the quantity of harvested maize, percentage which represents the remaining quantity before the new harvests and the frequencies of food consumption were collected through semi structured individual interviews. The WSC strategies and the actors at the basis of their origin were obtained during *focus-groups* in each of the villages studied.

The food supply available (*Rad*) was obtained by multiplying the percentage which represents the remaining quantity (*Pqr*) by the total quantity (*Qt*) of maize harvested:

$$Rad = Pqr \times Qt \text{ with } Pqr \text{ in } \%, Qt \text{ in Kg and } Rad \text{ in Kg.}$$

The households perceptions on the causes of the soils degradation and of water loss were analyzed by the discourses analysis.

Friedman test allowed prioritizing them according to the damages caused and the space affected by each soils degradation factor. The choice of these criteria is explained by the fact that the farmer (head of the exploitation) aims at obtaining a good yield of the agricultural production. This yield determines in great part the food security since according to these farmers, one part of the harvested crops is prepared for consumption. The food supply available before the new harvests and the frequency of food consumption were compared

between the two groups of the investigated households through the 'Student *t* test'.

RESULTS

Peasant perceptions of the cause of the soils degradation

The causes of the soils degradation are perceived through two factors: (i) socio-cultural factors, which include overgrazing, agro-forestry practices (teak, eucalyptus, etc.), farming practice, and overexploitation of lands, late bush fires and deforestation; and (ii) natural factors, which include heavy rains and soil slopes. The main factors causing the degradation of soils are the overexploitation of the soils, the late bush fires and the deforestation in the two districts (Table 1).

The differences observed might be due to the nature and the relief of the soils. At Boukombé, the soils are stonier and more characterized by slopes. At Ouaké on the other hand, they are more favorable to the production. Due to the availability of the lands, the farmers practice the extensive cropping system. This justifies the important place of late bush fires in their farming system.

WSC strategies and households food security

The analysis of the impact of the WSC strategies on the household food security has been axed on maize supply before the new harvest and on the consumption frequency. The strategies are applied collectively as well as individually. The exogenous strategies are collective while the endogenous ones (ridges perpendicular to the slope, cloisonné ridges, stony cord, bees nest) are individual. For determinist reasons linked to the study area relief, the farmers' recipients of the exogenous

Table 2. Frequency of investigated households' types.

District	Type of farmer	Frequency (%)
Ouaké	Non beneficiary	31
	Beneficiary	69
Boukombé	Non beneficiary	26
	Beneficiary	74

Source: Field Enquiry (2012).

Table 3. Food reserve and water and soil conservation strategies.

District	Type of farmer	Frequency (%)	Average food supply (in kg)	Standard deviation (in kg)	Student <i>t</i> test
Ouaké	Non beneficiary	31	199.3	254.1	$t_c = -1.337$; $ddl = 85$; $p = 0.185$
	Beneficiary	69	297.3	340.0	
Boukombé	Non beneficiary	26	144.2	1024.1	$t_c = 0.384$; $ddl = 90$; $p = 0.702$
	Beneficiary	74	363.9	823.8	

Source: Field Enquiry (2012).

Table 4. Comparison of food consumption frequency.

Commune	Type of household	Consumption average frequency	Standard deviation	Student <i>t</i> test
Ouaké	Non beneficiary	2	0.501	$t = -3,367$; $ddl = 85$; $p = 0.001$
	Beneficiary	3	0.623	
Boukombé	Non Beneficiary	3	15,910	$t = 1,777$; $ddl = 90$; $p = 0.079$
	Beneficiary	3	1,349	

Source: Field Enquiry (2012).

strategies combine them with the endogenous ones (Table 2).

Food supply available before the new harvests

The comparative analysis reveals statistical indifference of the food supply available before the new harvests between the beneficiaries and the non beneficiaries (Table 3). The combination of the exogenous strategies with the endogenous ones has no effect on the food supply available before the new harvests. This might be due to the management made of the harvested maize (consumption, selling, donation, etc.) by the beneficiaries.

Frequency of food consumption and WSC strategies

The frequency of food consumption is significantly different between the beneficiaries and the non beneficiaries of Ouaké contrary to Boukombé (Table 4). The exogenous strategies of WSC combined with the endogenous ones contribute to the improvement of the

food security through the frequency of food consumption of the households in the districts of Ouaké. The indifference observed at Boukombé might be due to the fact that Boukombé population associates the fonio with maize for food consumption.

DISCUSSION

The soils degradation and water losses are caused by socio-cultural factors in the two districts in the North-west of Benin. This confirms the work of Adegbedi et al. (1999) according to whom the three main causes of soils degradation are deforestation, soils overexploitation and late bush fires. Bush fires accelerate the mineralization of the organic matter present in the soil and indirectly the streaming and the erosion of the soils (Roose and Sabir, 2002; Saïdou et al., 2007). Deforestation or trees cutting denudes soils and submits them to degradation (Saïdou et al., 2007).

The cereals-cereals rotations and the association of two cereals on the same parcel are included in the

overexploitation of the soils, thereby exposing the soils to degradation (Saïdou et al., 2007). The extensive cereals farming exhaust the soil and in the same time weaken it by the exportation of the grains and straws without sufficient organic or mineral restitution (Roose, 2002). Moreover, the agro-forestry practices reputed as contributing to the improvement of the soils fertility are the motors of the soils degradation in the study area according to the farmers investigated. These agro-forestry practices are relative to the installation of the eucalyptus and *glyricidia* in the farms. Among the two plants, eucalyptus is the one accused. According to the farmers interviewed, the eucalyptus plants have a roots system which does not favor microbial activities of earthworms. They materialized them by the absence of soil clods coming from the microbial activities of the earthworms in the farms. The eucalyptus plants exhaust the soils in water and in crops nutritive elements. They compete with the crops. Roose and Sabir (2002) notified that the bad effects of these agro-forestry practices depend on their level of exploitation. They underline that the intensive exploitation of the plantations of pine and eucalyptus let the soil exhausted and bare. The overgrazing contributes to a progressive decrease of the vegetal cover which should protect the soil against heavy rains according to the farmers interviewed. It exposes the soil to heavy rains and occasions the soils encrusting and warping observed in the North-west of Benin. Parallel to this, the negative effects of the overgrazing stay also in the pressure exercised by the animals on the soil (Roose, 2002). In Tunisia, soils are compressed by the animals trampling which make a legs' pressure of 2.5 to 6 kg/cm² on the soil (*ibid*).

The soils degradation is mostly due to human actions. The increase in population would increase, in the absence of a controversial action, the bad effects of these factors on the soils degradation; confirming so the Malthusian theory. The human being is in the center of the degradation phenomenon of the soils. It matters having a careful regard on the natural factors (soils slope and strong intensity of the rains) which contribute the most to the soils degradation (Le Bissonnais et al., 2002). The resource soil has itself some characteristics which when combined with the climate make it more vulnerable to the erosion in the North-west region of Benin. This shows the insufficiency of the Malthusian theory by revealing that the degradation of one resource is not only external to the resource.

The realization of some anti-erosive planning works by the development projects and the farmers contributed to the reduction of the degradation effects. The WSC strategies coming from local knowledge are all mechanical while the exogenous ones are all biological (Mietton, 1986). These exogenous strategies of anti-erosive fight are without effects on the food supply available before the new harvest of the households studied. This result is similar to the one observed in

Morocco (Parent et al., 2002). According to them, planning of a hydro-agricultural project such as the irrigation project of Loukkos did not improve significantly the food supply of the households' recipients of the irrigation as compared to the others. The local knowledge seem to have the same effects on the food stock available like the imported technology. The anti-erosive techniques are less effective (Roose, 1989). It matters so to consider the existing endogenous strategies in the perspective of improving them. Nevertheless, the recipients of the exogenous strategies in Ouaké district have a significant food consumption frequency more improved compared to the non-recipients. The anti-erosive planning projects improved the food security of the households through the food consumption frequency. The improvement of the households' food situation by diverse strategies reverses Malthus theory and confirms the one of Boserup. Indeed the Malthusian theory emphasizes on the negative effects of the socio-cultural factors on the degradation of the resource (soil) (Malthus, 1798). Indeed the populations developed some innovations to reduce their food insecurity. This accords a favorable view to the demographic growth and shows that the population density appears as an important and sufficient condition for the agricultural intensification and the improvement of the natural resources management (Boserup, 1965). But these innovations are found in the sense of stopping the socio-cultural factors linked to the population growth. They are mostly oriented to the fight against natural factors (high slope, heavy rains).

In summary, the two theses have their rationale due to the fact that they explain the role of population growth in the degradation and restoration of natural resources (Jouve, 2004). The evolution of the natural resources state in Yatenga (Burkina Faso) under the increasing of land pressure confirmed Malthus theory while in other regions, the important density of the population favored the intensification of agriculture and a durable management of the productive capacities of the area (*ibid*).

Conclusion

The soils degradation is more caused by socio-cultural factors than the natural ones, confirming so Malthus theory. But the farmers developed different WSC strategies to reduce their vulnerability against soils degradations. The exogenous strategies which are collective realizations for individual interviews contributed the most to the food security of the farmers at Ouaké than at Boukombé. This invalidates the Malthusian theory and confirms the one of Boserup. Thus, the setting up of an effective system of water and soil management by the communities of high density can drive to an intensive agriculture. Nevertheless, the different strategies of WSC aim at fighting against natural factors. Therefore, some researches have to be conducted for proposing

innovations capable of stopping the negative effects of the socio-cultural factors.

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