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AGRICULTURAL PRESSURE ON IRON CRUST DYNAMIC THROUGH SPATIAL DATA AND INDIGENOUS KNOWLEDGE IN TWO COMMUNITIES OF BURKINA FASO

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ABSTRACT

This study examines farmers' perceptions of iron crust dynamics influenced by agricultural pressure in two communities in the sahelian zone of Burkina Faso. The study combined spatial analysis of the land cover/land use data and of iron crust/gravel zones extension data and individual interviews data, to explore farmers' views on iron crust dynamics influenced by agricultural pressure. The results revealed rapid changes of land cover/land use units and also of gravel surfaces. The consequence of the iron crust dynamic is that crop lands are becoming more and more gravelly. From only the spatial data analysis of this relationship, it is difficult to know if the dismantling of iron crust is conducting gravel in crop land or if it is rather the farmers who go toward these zones. However, according to individual interviews, 80% of the farmers are arguing using those gravelly zones for cropping linked to agro-demographic pressure. The study finds that the environmental and socio-economic impacts of agricultural pressure are the driver of his connection with iron crust dynamics. Then, decision makers must focus their acts to reinforce smallholders' organization and their capacity building on protecting natural resources. However, each act from decision-makers, politic or research, must consider greatly the indigenous knowledge of the community.

Keywords: Land cover/land use, Gravel surfaces, Demographic pressure, Burkina Faso.

1. INTRODUCTION

Burkina Faso land modification is most lying to the action of rainwater through principally soil erosion (Kabré, 2009). This concerned also the iron crust areas that are widespread in most region of the country. The water erosion participates in the iron crust dynamic through their dismantling process (Alexandre, 2002). According to Beauvais and Tardy (1991), the set of processes that intervene on iron crust dismantling depend greatly to the climate. Thus, in the sahelian regions, the iron crust dismantling would be the result of mechanic erosion process (Leprun, 1979). This process is based on the combination of many factors such as rainwater, macro and micro fauna and human activities. If the impacts of the first two factors have been mostly characterized in Burkina Faso (Kabré, 2009 ; Guillobez *and al.*, 2000 ; Mando *and al.*, 2011), the third has been less. This study aims to improve knowledge about the iron crust dynamic from indigenous perceptions. Research was guided by the three following questions: - what are the state of agricultural pressure and iron crush dynamic in the two villages according to farmers perceptions, - have they relationships - How these indigenous knowledge can be benefic for natural resources protection in the both villages?

2. MATERIALS AND METHODS

2.1. Study sites

The study took place in two villages of Burkina Faso. The principal biophysical characteristics of these villages are from Ouédraogo (2005). The first village is Koumbia, located in the South-soudanian zone, in the southern part of Burkina Faso. The coordinates are: 11°13’60’’ N and 3°42’00’’ W. This zone occupies 36% of Burkina Faso territory, with a population density of 20 inhabitants /km² and a rainfall average of 900 mm per year. The second village, Korsimoro is located in the Nord-soudanian zone, in the median part of Burkina Faso. The coordinates are: 12°49’24’’ N and 1°04’12’’ W. This zone represents 33,7% of the country, with a population density of 50 inhabitants /km² and a rainfall average of 600 - 900 mm per year.

2.2. Tools and methods

- Firstly, investigation forms have been used to point out famers’ knowledge about agricultural pressure, iron crust dynamic and the possible relationship between them. This indigenous knowledge has been assessed through individual interviews. The data have been statistically analyzed with SPSS version 20.0. The variables concerned are from descriptive statistic (average, percentage and variance).

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- Secondly, Landsat satellite images from USGS website have been processed: Landsat ETM (1987) and ETM+ (2000) for both villages and Landsat OLI (2013 for Korsimoro and 2014 for Koumbia). We used supervise classification method (parallelepiped algorithm) with ENVI4.8 to process the images. For each image classified, the Kappa index was calculated for validation. The proportion of each cartographic unit (land use and land cover units and gavels surfaces units) has been extracted and used to explain the changes of each unit, based on the confusion matrix table.

3. RESULTS

3.1. Characteristics of the respondents

For individual investigation on indigenous knowledge, a sample of 120 farmers were questioned, 60 farmers for each village. Their age average is 46 years at Koumbia and 51 years at Korsimoro. The sample counts 50% at Koumbia and 60% at Korsimoro of native people and 40% at Koumbia and 50% at Korsimoro of migrant. Agriculture is the main with 95% of them in the both villages. The second activity is the livestock breeding which concerns as follows: 75% of farmers at Koumbia and 80% of them at Korsimoro. The schooling level is: 28,3% of no schooling and 71,7% of schooling composed by 5,4% of secondary level, 16,3% of primary level, 17,4% for koranic education and 32,6% of informal education. The contribution level from NGO and technical offices is there very important and estimated at 97, 8%.

3.2. Agricultural pressure status

The results of individual investigation showed that agricultural pressure on natural resources is a reality in the both villages. It is confirmed by 75% of farmers at Koumbia and 50% of farmers at Korsimoro. Their views on the main factors that influence the land use / land cover change are in order of importance: the increase of crop land, the increase of farmer's number and the decrease of fallow practice. The main causes of agricultural pressure that they mentioned are: the increase of population, the decrease of rainfall and the decrease of the soil fertility. The results of the spatial analysis of images are summarized in table 1. They show that the year 1987 is characterized by abundant vegetation in Koumbia (55, 35%) as well as in Korsimoro (74%). This vegetation cover was reduced during the following decades. In year 2000; it was 42, 6% at Koumbia and 48% for Korsimoro. During the period 2013/ 2014, the percentage of vegetation over was 27,42% at Koumbia and 35% at Korsimoro. In the same time agricultural zone increased from 13, 73% in 1987 to 26, 6% in 2000 and 42, 25% in 2014 at Koumbia. The same trend is observed at Korsimoro where the percentage of agricultural zone increased from 24, 5% in 1987 to 50, 6% in 2000 and reached 63,8% in 2014.

Table 1: Land use/land covers data in both sites

		1987		2000		2014	
Unit	**Sites**	**Koumbia**	**Korsimoro**	**Koumbia**	**Korsimoro**	**Koumbia**	**Korsimoro**
Unclassified		0,9	1,2	0,72	0,96	0,3	0,5
Natural vegetation	Savannah	55,35	74	42,6	48	27,42	35
	Proteste Forest	30	-	30	-	30	-
Agricultural zones (Fields + fallows)		13,73	24,5	26,65	50,6	42,25	63,8
Water		0,02	0,28	0,03	0,42	0,03	0,42
Bare soil		-	0,02	-	0,02	-	0,03

3.3. The dynamic of iron crust

According to the farmers, the dismantling of iron crust process occurred in both villages, but the intensity is different by site. They referred to the gravel deposits to estimate it. Thus, at Koumbia 16% of farmers mentioned that the dismantling is very important, 60% found it important and 24% mentioned that it is less important. At Korsimoro, 60% found it very important, for 25% it is important and 13% mentioned that it is less important. The investigation revealed that 92% of the farmers in both villages found that the gravel has negative impact on crops growth. They cited as negative impacts: the decrease in soil fertility, the hard workability of these soils and the bad rooting system. The results of the multi-date analysis of gravel zone, in order to verify their extension, are given in table 2. This table shows that gravel zone were increased during the 27 last year in both villages. At Koumbia the percentage was 8,5% in 1987, and remained similar in 2000 with 8,6%, but increased to 14,4% in 2014. At Korsimoro, the percentage was 38,28% in 1987, increased to 43,6% in 2000 and reached 53,3% in 2013.

Table 2: Gravel zone extension at Koumbia and Korsimoro

Years	1987		2000		2014	
Sites / Units	**Koumbia**	**Korsimoro**	**Koumbia**	**Korsimoro**	**Koumbia**	**Korsimoro**
Unclassified	3,90	7,94	0,50	8,70	1,30	1,20
Iron crust and rock	2,70	5,62	0,35	2,60	0,40	1,30
Gravel surfaces	8,50	32,64	8,60	41	14,00	52
Authers	84,90	53,40	90,55	47,70	84,30	45,5

Spatial analysis showed that the field numbers are more and more important in zones occupied by gravel and iron crust. This was confirmed by 45% of farmers at Koumbia and 40% at Korsimoro. According to all of them, it is laid on agricultural pressure. The investigation results show also that 95% of farmers at Korsimoro and 85% at Koumbia agree that agricultural activities and pasture participate to iron crush dismantling. In order to capture the relationship between agricultural pressure and iron crust dynamic, the percentage of agricultural zone covers by gravel was estimated during the 27 last years (figure 1). The figure show that from 1987 to 2013-2014 the field surface covered by gravel increased from 30% to 60% at Korsimoro and from 0,05 to 3,2% at Koumbia.

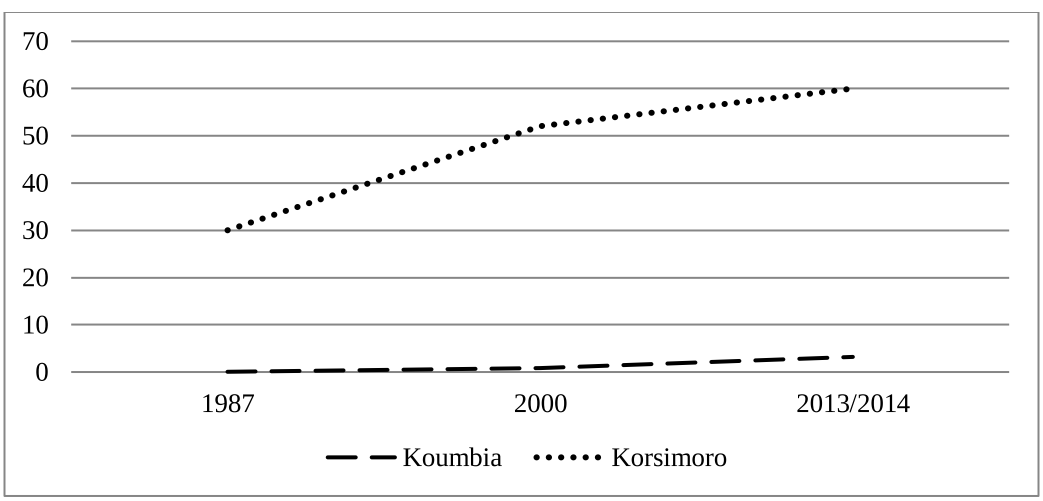

Figure 1: Estimation of agricultural zone covers by gravel (%)

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4. DISCUSSIONS

The agricultural pressure in both villages can be clearly perceived through the changes occurred in the two main units: vegetation zone and agricultural zone. Vegetation zone at Koumbia decreased progressively during the two periods (1987 to 2000 and from 2000 to 2013-2014) respectively 12,75% and 15%. During the same period, the decreased of vegetation area is also noticed at Korsimoro, with respectively 26% and 13%. These changes are translated into an important decrease of vegetation cover. These results corroborated those obtained by PNGT (2002) and USGS (2014) in Burkina Faso; they found that the changes on natural vegetation concern both the structure (cover) and the floristic composition. According to Zoungrana (1981), Sawadogo *and al*. (2008), the natural vegetation dynamism is strongly affected by human activities, through an important increased of the agricultural zone, that have been noticed in the both villages. These results are similar to those obtained by PNGT, (2002) and USGS, (2014), they mentioned that the increase of agricultural zone is frequently followed by the decrease of vegetation cover. The reasons of agricultural area increase in both villages are generally linked to an increase of farmer's populations (INSD, 1991 and 2008; Wittig and *al.*, 2007; Mahé and Paturel, 2009). However, DREP-west (2001) and INSD (2008) mentioned the migration as the principal reason of population increase at Koumbia. In their annual report, the population of Koumbia during the period 1985 to 2000 comprised many young farmers and around 70% were migrants. At Korsimoro, the principal reason is the high-growth rate of the local population (ISND, 2008). In its report, ISND showed that Korsimoro is characterized by a high population density being the second most important in Burkina Faso, with 60 inhabitants/km^2. Other reasons of agricultural zone increase in both sites are the adoption of new technologies such as mechanization, the use of organic and inorganic fertilizers (Bene, 2011). Another factor is the cultivation of cotton and also the maize, which occupied larges areas. This agricultural pressure evolved into a competition between farmers (Vall and Diallo, 2009), and it is leading to the progressive use of gravel and iron crust areas by farmers to survive.

The analyses of gravel areas extension through agricultural area during the 27 last years confirmed an increasing pressure from agricultural activities on land in both villages. This increase of gravel areas is higher in Korsimoro (38% and 53%) in comparison to Koumbia (8,5% and 14%). These results corroborated those of Caillault *and al.*, (2012), who found that during the ten last years, the new fields are more gravely linked to their location on iron crush area or no so far from it. The gravel origin could be linked to the dismantling of iron crust located on the top side of the toposequence and the action of rainwater which brought gravel on the low side of the toposequence (Tardy, 1993; Temgoua, 2002), especially where many fields are generally concentrated. The presence of gravel in the fields can be also explained by the action of water erosion. According to Tardy (1993), Guilloberz *and al*. (2000), rainwater remove fine particle

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from soil surface and bring them in the lower part of the toposequence, letting in place coarse texture dominated by gravel. This concentration of gravel is called by Karambiri *and al.*, (2004) as “gravel paving”. It is a visible consequence of water erosion result, and is usually met in cultivated areas or on pasture zone (Karambiri *and al.*, (004).

The connection between agricultural pressure and iron crush dynamics could be interpreted through two possibilities. The first connection is the environmental impact of agricultural pressure through the actions of water erosion. According to Hibra-Samgue (2004), Gomgnimbou *and al.* (2010), Ouaba *and al.* (2014), the environmental impact of agricultural pressure is characterized by the degradation of vegetation cover, the soil degradation and the loss of biodiversity. The active factor of soil and vegetation degradation is water erosion which dismantles iron crust structure with as outcome the propagation of gravel deposit everywhere. Guillobez *and al.*, (2000) ; Kabré, (2009) mentioned that rainwater also destroys soil structure and remove fine particle from soil surface letting in place coarse texture dominate by gravel. The second connection is the socio-economics impact. The pressure obliges more and more farmers to use these gravel and iron crust zones activating therefore iron crust dynamics.

5. CONCLUSION

The main objective of the study was to investigate the indigenous knowledge on iron crust dynamics from two communities of Burkina Faso. The results show that land cover and land use units undergo fast changes. The visible indicators of these changes are the decrease of natural vegetation units, the increase of agricultural area, and the intensification of agricultural activities in iron crust zones. The results show also a strong encroachment of gravel deposits on agricultural zone making iron crust dynamic as a reality, but most important at Korsimoro than Koumbia. The opinions of the farmers confirmed the links between agricultural pressure and iron crust dynamic. The present survey pointed out a dilemma inside farmer’s communities. In the one hand, farmers needed place for cropping linked to agro-demographic pressure. On the other hand, they are conscience that the use of these instable areas favors iron crust dynamic with negative impact on natural resources. Research suggests that smallholders’ organization must be created or reinforced. It recommends the reinforcement of farmer’s capacity building. This will favor the sharing of information and knowledge. Research suggests also the improvement of soil fertility by a combination of organic and inorganic fertilizers, adaptation of crops and tillage technique to the soil type. Each act from decision-makers, politic or research, must consider greatly the indigenous knowledge from the community.

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