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Permanent Internal Migration as Response to Food Shortage: Implication to Ecosystem Services in Southern Burkina Faso

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1. Introduction

Mankind's exploitation of ecosystems for services such as food, shelter, fuel and fresh water has had profound effects on the natural environment for millennia (Achard *et al.*, 2002; Bottomley, 1998, Ouedraogo, 2010). Further, since the 1800s, humans have had increasingly dramatic effects on the global environment following massive increases in the global population coupled with intense agrarian and industrial development. Indeed, man has become the most powerful, universal instrument of environmental change in the biosphere today (Meyer & Turner, 1994; Miller, 1994; Ojima *et al.*, 1994). This has resulted in global climate change, forest and soil degradation, and loss of biodiversity, among other changes, to the extent that the sustainability of our planet's ecosystems is threatened (Lambin *et al.*, 2003; Sala *et al.*, 2000; Trimble & Crosson, 2000; Vitousek *et al.*, 1997).

Among all zones in the world, the tropical environment is by far the most affected by the deforestation and forest degradation. In recent decades increasingly large areas of grasslands, woodlands and forests in the tropic have been converted into croplands and pastures (Mayaux *et al.*, 2005; Lambin *et al.*, 2003; Reid *et al.*, 2000; Houghton, 1994). While in the tropical humid forest alone, the annual loss of forest was estimated at 5.8 million hectares (Achard *et al.*, 2002), the tropical dry forest however, representing 42% of the forest in the tropics, has been severely fragmented, disturbed, and in many areas it has been severely depleted (Hartter *et al.*, 2008).

In Burkina Faso (West Africa) for instance, the tropical dry forest, mainly located in the southern, eastern and western zones of the country, has experienced rapid deforestation process (Ouedraogo, 2010). Due to the repetitive severe droughts started in the 1980s in the Sahel, which caused important loss of crops and domestic animals, many farmers and breeders from the drought affected areas have been continuously migrating towards the southern, eastern and western zones of the country where food production and grazing facilities are still available. Such migration might have contributed to the rapid loss of forest ecosystem.

2. Statement of the research problem

Southern Burkina Faso has experienced rapid population increase since the 1980s resulting from a positive natural population growth and more importantly from a large immigration of farmers from drought-affected areas of the northern and central regions of the country (Ouedraogo *et al.*, 2009, 2010, 2011a, 2011b; Henry *et al.*, 2003). Prior to immigration, the southern Burkina Faso was less populated and were naturally endowed with a significant stock of dry forest (Howorth and O'Keefe, 1999). Furthermore, there was a peaceful co-existence between ethnic groups who were practicing sound agricultural activities with less impact to environment (Howorth and O'Keefe, 1999). However, with the growing migration, different farming techniques are taking place in southern Burkina Faso, since farmers move with their secular culture along with them. Implementation of new farming techniques together with the increasing demand for food to feed the growing population may have contributed to important ecosystem degradation in southern Burkina Faso.

Many works have been carried out in southern Burkina Faso at different spatial scales, highlighting the roles of population growth on deforestation (Ouedraogo *et al.*, 2009, 2010), the trajectories of forest cover change (Ouedraogo *et al.*, 2011a), forest cover transition processes (Ouedraogo *et al.*, 2011), land use dynamics (Paré et al, 2008; Ouedraogo, 2006), access to forest products (Coulibaly-Lingani *et al.*, 2009), agro-silvo-pastoral activities (Ouedraogo, 2003), etc. However, study that assesses the implication of the food production systems to forest ecosystem sustainability in southern Burkina Faso is lacking. Therefore, there is a need to carry out such study which is essential for sustainable regional and national land resource managements and for sound and environmentally harmless food production in Burkina Faso.

3. Objectives

The main objective of the study is to generate knowledge to support sound and informed decision making for sustainable food production systems in southern Burkina Faso. The study explores specifically:

1. The dynamics of cultivated land in southern Burkina Faso from 1986 to 2006
2. The dynamics of the population of southern Burkina Faso from 1986 to 2006
3. The relationships between cropland area and population densities
4. The dynamics of farming practices in southern Burkina Faso from 1976 to 2006

4. Study area

The study was carried out in southern Burkina Faso (Figure 1). The study area lies between latitudes 10° 58'N to 11° 52'N and longitudes 2° 40'W to 1° 12'E. It is characterized by a low relief with an average altitude of 300 m a.s.l. Phytogeographically, the area is situated in the Sudanian regional centre of endemism in the south Sudanian zone (Fontes & Guinko, 1995). The natural vegetation comprises mostly dry forest and tree savanna community types. The climate is tropical with a unimodal rainy season, lasting for six months (May to October). Based on data collected from the nearest *in situ* mini-weather station at Léo, the provincial city of Sissili, the mean (±Standard Error) annual rainfall from 1976 to 2007 was 883±147 mm. Mean daily minimum and maximum temperatures ranged from 16 to 32 °C in January

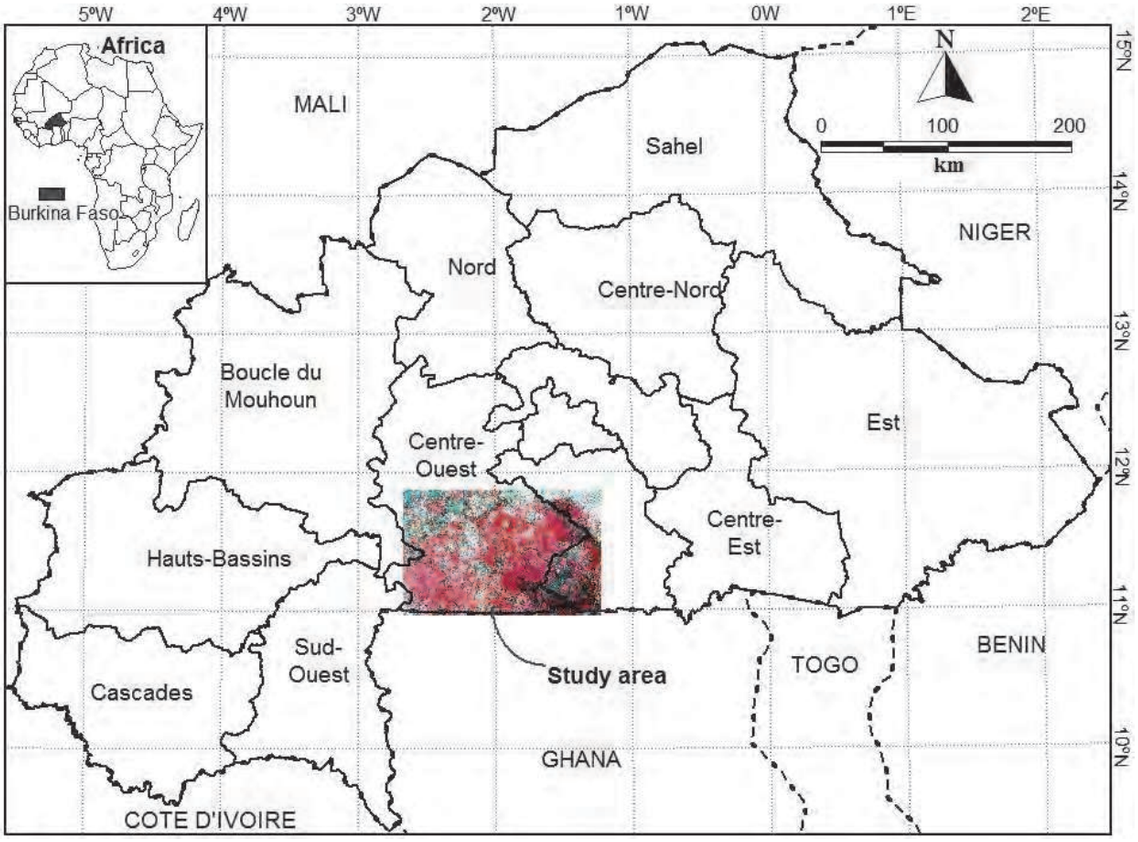

Fig. 1. Study area

(the coldest month) and from 26 to 40 ºC in April (the hottest month). According to the FAO soil classification system (Driessen *et al.*, 2001), the most frequently encountered soil type is Lixisol (tropical ferruginous soils), which is poorly to fully leached, overlying sandy, clayey-sandy and sandy-clayey material.

The population is comprised of four main ethnic groups: Nuni, Wala, Mossi and Fulani. The Nuni and Wala groups have been living in the area for centuries and are considered indigenous, while the Mossi, who originate from the Central Plateau in Burkina Faso, and the Fulani, herders from the northern region of the country, are considered migrants. The latter two groups were attracted to southern region during the 1980s in search of arable land and green pasture, respectively (Howorth & O'Keefe, 1999). The dominant agricultural production methods in the study area are traditional subsistence farming systems with cereals (such as sorghum, millet and maize), tubers (yam and sweet potatoes) and animal husbandry. However, over the last ten years, there has been intense competition for land between the traditional farming systems and more lucrative production systems.

5. Materials and methods

The methodology used for the study combines land cover change detection, analysis of population dynamics and, inventory and analysis of farming techniques.

5.1 Land cover detection

Land cover change detection was based on time-series satellite images processing (Landsat: 1986, 1992, 2002; ASTER: 2006). All images were geometrically and radiometrically corrected and then classified using the maximum likelihood classifier based on training samples, available topographic maps and in-situ observations. Three appropriate classification schemes of the study area were used to assign pixels to land use classes: cropland, open woodland and dense forest.

5.2 Population data

We extracted the population data of the study area from the national population census reports (1975, 1985, 1996 and 2006). To estimate the inter-census period population data (1992 and 2002), we used the population projection methods (Weeks, 1999).

5.3 Inventory of farming practices

A household survey was performed in selected villages using semi-structured questionnaire to record information related to farming techniques, production acreage, crop yields and reasons for migrating if respondent was migrant.

5.4 Data analysis

To relate land cover change with population dynamics, Pearson correlation analysis was performed for each land cover class. Correlation test was also performed between area of cultivated land and population density. Data from the household survey was analyzed using descriptive statistics. All statistical analyses were performed with SPSS 18.

6. Results

6.1 Land use dynamics

Results from the image processing revealed a significant change within land use classes. In general, there was an increase in area of cropland at the expense of shrinking open woodland and dense forest covers in Southern Burkina Faso (Table 1, Figure 2). Comparing the area of cropland for the four series of assessment, it appears that there was an increase in cropland over time. In 1986, at the onset of the study period, cropland occupied 7.5% of the study area. It was more than doubled in 1992 and increased by three-fold in 2002. In 2006, it increased to nearly 27%. Over the study period, the annual rate of increase in area of cropland was 0.96% (Table 1).

Dense forest land covered ca. 70% of the study site in 1986 and decreased to 40% at the end of the study period in 2006. The rate of decrease in dense forest cover during the study period was estimated at 1.45% per annum (Table 1). The area of open woodland decreased slightly between 1986 and 1992, but the rate of increase in this land use type was nearly

doubled in 2002 (Table 1). Over the study period the overall annual increase rate was 0.5% (Table 1).

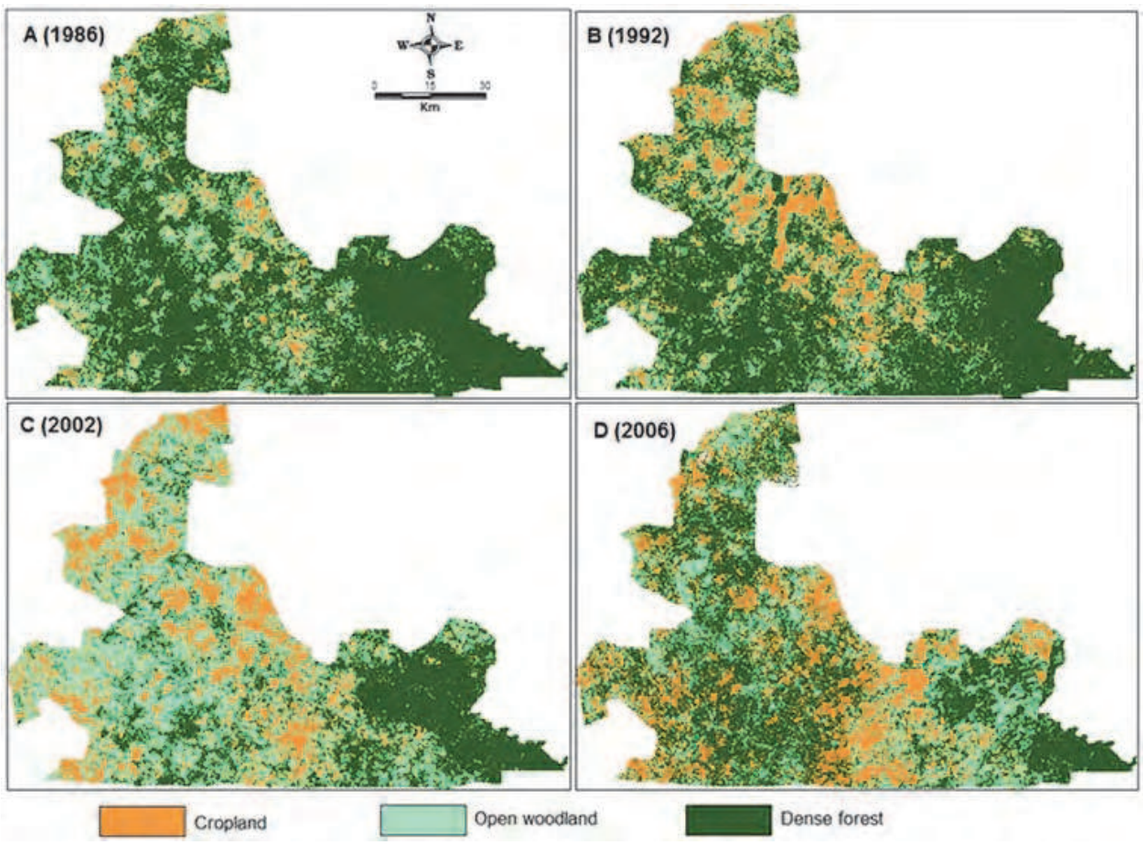

Fig. 2. Pictorial representation of land cover dynamics in Southern Burkina Faso during the study period.

Years	Cropland (%)	Dense Forest (%)	Open woodland (%)
1986	7.50	69.68	22.82
1992	16.48	63.09	20.44
2002	24.73	31.39	43.90
2006	26.62	40.61	32.08
Annual change rates	0.96	-1.45	0.46

Table 1. Land cover change from 1986 to 2006 in Southern Burkina Faso

6.2 Population dynamics

The population of Southern Burkina Faso has increased during the study period. Estimated at 119352 inhabitants in 1986, the population has nearly doubled in 20 years (Table 2) with a means annual increase of 4664 people. The density of the population has also doubled with an annual increase rate of 0.6 inhabitants/km² (Table 2). The proportion of migrant people in the selected villages were 3%, 27%, 34%, 42% and 56% in 1976, 1986, 1992, 2000 and 2006, respectively.

Years	population	Density
1986	119352	16.78
1992	134821	18.96
2002	178540	25.11
2006	212628	29.90
Annual increase	4664	0.55

Table 2. Dynamics of the population size and population density during the study period

6.3 Relationship between land use conversion and population density

The Pearson correlation analysis indicated that change in land cover could be linked to population growth. In general, there was a strong relationship between population and change in areas of cropland ($r^2 = 0.90$; $p < 0.001$) and dense forest land ($r^2 = 0.56$; $p = 0.03$); but the relationship was weak with change in area of open woodland ($r^2 = 0.11$; $p = 0.42$). Significant relationships between population and areas of cropland and open woodland were observed throughout the four time series (Table 3). The higher correlations occurred in 2002 and 2006 with cropland, and in 1986 and 1992 with open woodland ($p < 0.001$). However, the correlations were generally low between population and dense forest land and, especially it was not significant in 2002 ($p = 0.145$).

	Cropland				Dense forest				Open woodland			
	1986	1992	2002	2006	1986	1992	2002	2006	1986	1992	2002	2006
r^2 (%)	85.2	76.8	91.7	96.1	63.2	56.6	20.5	70.3	91.1	92.1	87.5	66.5
F	41.3	24.2	78.3	174.6	13.0	10.1	2.8	17.6	72.4	82.6	50.1	14.8
P-value	0.001	0.003	0.000	0.000	0.011	0.019	0.145	0.006	0.000	0.000	0.000	0.000

Table 3. Coefficient of determination (r^2), together with F-statistic and p-values for significant Pearson correlation to examine relationship between areas of each cover type and population density.

6.4 Farming practices over time and environmental implication

Results from the farmers interviews revealed the presence of important migrant people in Southern Burkina Faso. They were from different origins and mostly from 14 different provinces of the central and the northern regions of the country (Figure 2). Home provinces from the central regions included Kadiogo, Boulkiemde, Sanguie, Ganzourgou, Kouritenga, Oubritenga, Kourweogo, and the northern provinces included Soum, Bam, Yatenga, Passore, Zondoma, Sanmatenga and Namentenga. From the central regions, migrants were predominantly coming from Boulkiemde and Oubritenga while from the northern regions they were mostly coming from Yatenga, Sanmatenga and Bam. Among reasons provided for migrating to Southern Burkina Faso, the respondents mentioned the declining soil fertility in the pushing village (92% of the respondents), scarcity of arable land (76%), erratic rainfall (73%), need to make income (55%), and the politico-economic unrest in Côte d'Ivoire (12%) started in 2000, which caused the return of Burkinabé from the coffee, cocoa and banana plantation areas.

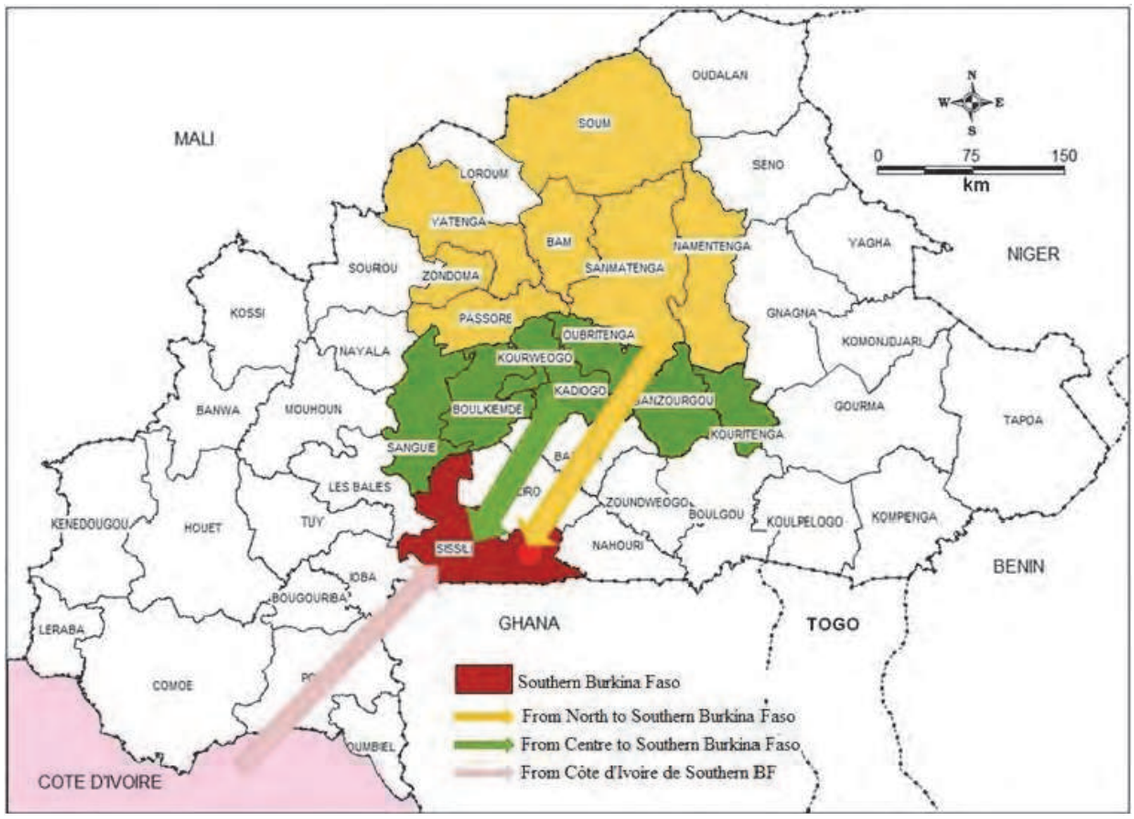

Fig. 3. Migration flow to Southern Burkina Faso

Four main sources of income generation were available in the study area, namely crop production (63%), livestock husbandry (27%), non timber forest products (6%), and wood/charcoal production (4%). The mean farm size of the migrants changed from 3.0 ha to 3.7 ha during the period from 1986 to 2007 for a mean household size of 6 ± 2 persons. During the same period, the farm size of the native population, with the same household size, changed from 2.0 ha to 3.1 ha. The main agricultural tools (Figure 3) in use were "*Daba*" (local traditional rudimentary tool based on human force) and plough (based on animal force). In the 1980s, about 95% of the respondents were using "*Daba*", but they shifted progressively to the use of plough. The change was more pronounced among migrants; in 2007, more than 83% of the migrants were using the plough while this figure was only 59% among natives.

Food production has importantly increased from 1986 to 2007 as reported by respondents and has met the food security in the region. Half of crop produced by household is send to markets for income generation. At the same time, crop yield per hectare has reduced. To produce more food, one needs to clear more lands.

7. Discussion

Results showed a net increase in area of cropland at an annualized rate of 0.96% which is much higher than estimation at the national level (0.2%) by FAO (2001). This indicates that Southern Burkina Faso is facing serious deforestation. The present cropland increase rate is rather in line with some previous study undertaken in the same region. For instance, Ouedraogo (2006b) and Paré *et al.* (2008), estimated the annual increase of cropland at 1.03% and 0.7% in Bieha district (in Sissili province) and in Sissili and Ziro provinces, respectively. Furthermore, a study made in the Volta Region of Ghana, geographically close and ecologically similar to our study area, found a comparable result regarding cropland change i.e., 1.1% per annum (Braimoh, 2004). The substantial increase in the area of cropland during the study period could be explained by the growing interest in maize cultivation and cotton production due to their high economic values in the country. Maize is one of the cereals commonly used in the country as a main source of food and is principally grown in the southern, southwestern and eastern parts of the country where fertile soil and rainfall are abundant (Ouattara *et al.*, 2008). In the 2000s, the government introduced an agricultural policy to increase cotton production. This was made by providing agricultural incentives such as ploughs and fertilizers to some farmers. In the context of technology and market improvements in the agricultural system, cultivated land is likely to increase (Bilsborrow and Carr, 2001; Lambin *et al.*, 2003; Gray, 2005). More importantly there has been a growing expansion of agribusiness in Southern Burkina Faso since 2000. The actors in the agri-business involve individual investors (Ouedraogo, 2003; Ouedraogo, 2006b; Paré *et al.*, 2008) who use machinery (mostly tractors) and casual labor to farm large areas (40-100 hectares each). They grow maize during the first few years and thereafter plantations of cashew trees.

The average annual degradation of the dense forest (1.45%) is closely comparable to the estimations made by Ouedraogo (2006b) for Bieha district from 1986 to 2002 (1.13 per annum) and also by Braimoh (2004) for the Volta Region of Ghana from 1984 to 1999 (2.24% per annum). This fairly high deforestation of dense forest could be linked to the observed exploitation of firewood and charcoal in southern Burkina Faso, most likely to meet the energy demand in biggest cities such as Ouagadougou and Koudougou (Krämer, 2002; Ouedraogo, 2006a, Ouedraogo *et al.*, 2009, 20010, 2011a, 2011b).

The large population growth observed in Sissili province was amplified by farmers' migration. Migration of farmers towards the eastern (Reenberg and Lund, 1998), south-western (Gray, 1999, 2005) and southern (Howorth and O'Keefe, 1999; Henry *et al.*, 2003; Ouedraogo, 2003; Ouedraogo, 2006b; Paré *et al.*, 2008; Ouedraogo *et al.*, 2009, 2010) regions of Burkina Faso originated from the 1980s when severe drought hit Sahelian countries. During that period, farmers and herders in the arid zones lost a substantial quantity of crops and domestic animals. For survival reasons, most of the affected people moved to more humid areas in the south. This massive mobility of farmers could have negatively affected forest sustainability. According to Geist and Lambin (2001) and Lambin *et al.* (2003), migration in its various forms is the most important demographic factor causing land use change both spatially and temporally. Migration operates as a significant driver with other non-demographic factors, such as government policies, change in consumption patterns, economic integration and globalization (Fearnside, 1997). Some tenure policies initiated in the 1980s have provoked the migration or were intrinsically linked with increased migration. The land reform, adopted in

1984 in Burkina Faso and revised several times, aimed at promoting wide scale migration of farmers from the drought-affected regions to the sparsely populated regions of the south and southwest (Faure, 1996; Reenberg and Lund, 1998; Gray, 1999).

The high variability in time and space of the population could indicate that multiple factors contributed to the population growth. In the 2000s, for instance, the political crisis in Côte d'Ivoire amplified the migration flow in the province with the return Burkinabé who were working in the plantations (Ouedraogo *et al.*, 2009). Most of them were settled by the government in Sissili province between 2000 and 2005.

The strong correlation between population and change in cropland in the whole province indicates the prevalence of shifting cultivation and the weak technological improvement for a large number of farmers, as new areas were cleared to increase crop production rather than improving current farming techniques. This feature is very common in the tropical regions (Reenberg and Lund, 1998; Lambin *et al.*, 2003; Ningal *et al.*, 2008).

Migrant people in Southern Burkina Faso came mainly from the central Plateau and northern region of the country. Explanation to this could be that these two regions have specific demographic and ecological characteristics which push people to migrate as pointed by migrant respondents. The central regions accounted for more than 46% of the total population of the country (INSD, 2007) from which more than 90% were farmers (Breusers, 1998). This region is nowadays crowded and the capacity of the lands to sustain agriculture and grazing under extensive subsistence practices is almost exceeded (Gray, 1999, 2005; Reij *et al.*, 2005). In such conditions, the easiest way is to migrate towards new frontiers where land is still available (Boserup, 1972; Bilsborrow and Carr, 2001). In the northern region, the rains are insufficient and unreliable resulting in an increasing aridity. The mean annual rainfall ranges from 400 to 600 mm within a rainy season which does not exceed four months (June to September). To face these conditions, farmers developed secular techniques (Figure 4) known as *Zaï* and *Demi-lunes* (plant-pit systems) (Slingerland and Stork, 2000;

Fig. 4. Agricultural tools used in Southern Burkina Faso

Sorgho *et al.*, 2005) and their success is a function of the spatial and temporal distribution of the rains. These techniques were seen as more and more laborious and hazardous by some local farmers. Therefore, they see out-migration of one or more family members as a mean of earning cash income and diversifying risk (Raebild *et al.*, 2007; Youl *et al.*, 2008). Unfortunately, during their first years of settlement in the attracted area, the first activity they practice to make rapid income for survival is to cut wood (Figure 5) for charcoal production (Ouedraogo, 2006a). This drastically impacted the sustainability of forest in the south of Burkina Faso.

A. Typical landscape in northern Burkina Faso B. *Demi-lunes* techniques

C. Stone-lines techniques D. Zaï techniques

Fig. 5. Water harvesting techniques for soil water holding capacity improvement in Northern Burkina Faso

The results indicated that migrants had larger farmlands and used environmentally harmful techniques (shifting cultivation, slash and burning techniques) in their land use systems while native population tended to take more care of land and environment by intensifying

the production within the same croplands instead of cutting forest to make space for new croplands. The justification for this could be that the native people have a strong and secular relationship with their ever-changing environment developed over several years (Howorth and O'Keefe, 1999, Ouedraogo *et al.*, 2009, 2010). Therefore, despite the recent introduction of cash crop productions (cotton mainly), this community has been inventive and adaptive in their resource use patterns and survival strategies. Inversely, the migrant people who came to work in a new environment have two main objectives to meet as expressed by Ouedraogo *et al.* (2009): in the one hand, they had to secure their income and domestic food, in the other hand; they had to produce more to meet also the food shortages and chronic food insecurity that their parents face in the home village. To do so, with the few labour available, migrants had to use animal traction (ploughs), thus, cutting large forest areas to make space for agriculture as compare to the natives.

Fig. 6. The way migrant people clear forest to make quick cash and space for agriculture

Results revealed that crop production has increased during the study period. This is fundamental for the food security in Burkina Faso. Cereals (mainly used for food) produced in Southern Burkina Faso are dispatched in the central and northern regions of the country to secure food access to all population in Burkina through markets. This is the reason why the government has named Southern Burkina Faso, the *grenier du Burkina Faso* meaning the "food storehouse of Burkina Faso".

8. Conclusion

Results from the present study disclosed a rapid cropland increase at the detriment of a shrinking forest covers in Southern Burkina Faso. Total population also exhibited a rapid increase in size as a result of important migration of farmers. Change in land cover types correlated with population growth which implies that more people is synonymous to more land clearance for agriculture and more deforestation and forest degradation to meet primary needs in Southern Burkina Faso. Food production has importantly increased as a result of large space exploitation for agriculture. While increased food production is a good sign for food security in the entire Burkina Faso, the induced deforestation and forest degradation are per se an indicator of unsustainable forest ecosystem management and unsecured mobility policy which may threaten the environmental balance and bring in the future conflicts due to completion for space between native and migrant population. Therefore, there is urgent need for agricultural intensification-related policy initiatives to discourage expansion of cultivated lands and its associated fragmentation of forested areas.

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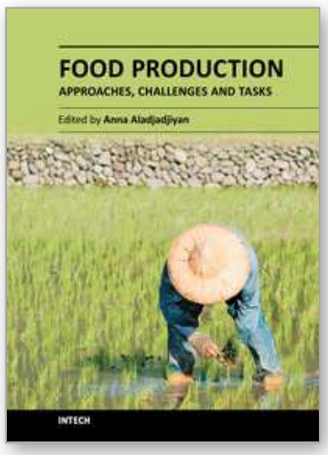

Food Production - Approaches, Challenges and Tasks

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This book is devoted to food production and the problems associated with the satisfaction of food needs in different parts of the world. The emerging food crisis calls for development of sustainable food production, and the quality and safety of the food produced should be guaranteed. The book contains thirteen chapters and is divided into two sections. The first section is related to social issues rising from food insufficiency in the third world countries, and is titled "Sustainable food production: Case studies". The case studies of semi-arid Africa, Caribbean and Jamaica, Burkina Faso, Nigeria, Pacific Islands, Mexico and Brazil are discussed. The second section, titled "Scientific Methods for Improving Food Quality and Safety", covers the methods for control and avoidance of food contaminants. Substitution of chemical treatment with physical, rapid analytical methods for control of contaminants, problems in animal husbandry related to diary production and hormones in food producing animals, approaches and tasks in maize and rice production are in the covered by 6 chapters in this section.

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