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Assessing the Impacts of Land Use and land cover change on Pastoral Livestock Farming in South-Eastern Burkina Faso

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Abstract

Conversion of pastures to cropland is one of the most important issues facing livestock farming in Burkina Faso. This study examined the impact of land use/cover change on pastoral livestock farming in Boulgou province between 1980 and 2013. Landsat satellite images (1989, 2001 and 2013) and socio-economic data were analysed. The interpretation of the classified Landsat images revealed an increase in cropland from 20.5% in 1989 to 36.7% in 2013. This resulted mainly from the conversion of woody savannah and shrub and grass savannah to cropland. Pastoral livestock farmers reported that the major drivers of vegetation loss were drought (95.1 %), population growth (91.8%), cropland increase (91.4%), extraction of fuel wood (69.8%) and increase in livestock population (65.4). These changes affect livestock farming through reduction of pasture, poor access to water and reduction of livestock mobility routes according to the farmers. This calls for regional and national policies to protect grazing areas in Burkina Faso that are similar to policies being implemented for forest and other types of vegetation cover in other countries. For such pastoral policies to be successful, issues concerning the mobility of livestock farmers must be enshrined into such policies and this study is an example of information source for these policies.

Keywords: Boulgou province, Land use and land cover change, Pastoral livestock farming, Pastoral Policy.

1. Introduction

Livestock production is undergoing a geographic shift from rural to peri-urban areas, from ruminant to monogastric species and towards source of feedstuff, thus competing directly for land, water and other natural resources in the midst of scarcity. It takes up 8% of man's global use of water, with the attendant pollution problems; Conservation International identified 23 of the 35 global biodiversity hotspots were affected by livestock production (FAO, 2006). However, the single most important human activity that makes the largest use of land from local to global scale is livestock farming. This includes 26% of ice-free land surface used for grazing and 33% of total arable land dedicated to the production of feed crops. Consequently, in drylands, where livestock farming is a major livelihood of the poor, overgrazing, soil compaction and erosion are major degradation issues that impact the land (Haan, Steinfeld, & Blackburn, 1997). Similarly, deforestation, a major contributor to climate change, occurs from the expansion of pastures and feed crop production (FAO, 2005; Steinfeld et al., 2006). Goldewijk and Battjes (1997) reported that the conversion of natural habitats to pastures and cropland accelerated after the 1850s; while in MEA (2005), it was observed that more land was converted to crops between 1950 and 1980 than in the preceding 150 years. Livestock farming is a major livelihood that is affected by these changes. If these land degradation problems are not reversed, they would inevitably affect livestock farming through the reduction of pasture and arable land required to sustain the industry.

This trend is unlikely to change soon, given the projected increase in global demand for meat from 229 million tonnes in 1999/2001 to 465 million tonnes in 2050, and that of milk to grow from 580 to 1,043 million tonnes (FAO, 2006). It is one of the contributory factors to the rapidly occurring human induced land use and land cover change that is virtually in all ecosystems (Foody, 2010; Lambin et al., 2001) across the globe and at unprecedented rates (Lambin & Meyfroidt, 2011) and they are likely to continue in the future (Ramankutty &

Foley, 1998). Human well-being (including livelihoods) may be affected either positively or negatively by these changes and with intended and unintended consequences, which have eroded the benefits and economic gains derived from these ecosystems (Hansen & DeFries, 2004). It, therefore, suffices to mention that for a comprehensive understanding of the interconnection between man and his environment, qualitative and empirical information on the distribution, pattern and dynamics of land cover at not only national, continental and global scale but also, at local scale is very vital. With the recent advances in satellite remote sensing, software and computer technology, land use and land cover studies have progressed significantly in the last two decades (Giri, 2012) and across the continents. Using the appropriate information, measures to eliminate, regulate or mitigate effects of negative land use and land cover changes can be implemented (Lambin & Strahlers, 1994).

In developing economies such as those of Sahelian West African countries like Burkina Faso, the agricultural front is progressing by 3% to 6% each year to the detriment of pastures (Kamuanga, Somda & Kagoné, 2008). The economy of Burkina Faso relies mainly on crop production and livestock sector. The latter represents an important source of income which employs more than 90% of rural population and accounts for 26% of country's exports contributing up to 18% of the country's GDP (MRA, 2010). Typically, agro-pastoral livestock farming system that is characterized by a strong dependence on natural resources is practised by majority of the rural population. For this critical mass, livestock is not only regarded as economic asset and social identity, but also represent socio-cultural and spiritual asset. Despite this role, livestock rearing as the livelihood of rural people is facing many constraints, and one of these is the increase of cultivated land to the detriment of pastoral land. Based on aerial photographs from 1956, 1972 and 1994 in Nigare, a village of Boulgou province, Hansen and Reenberg (1998) found a field expansion in the order of magnitude of 435% in 40 years and concluded that land use changes in the study region are approaching a critical point of saturation of arable land. In a similar study, Reenberg, Oksen & Svendsen (2003*)* used aerial photos from 1978 and 1994 as well as village-level surveys in Sanogo and Lergo, two villages within Boulgou Province and show an increase of cultivated land on 13.2 %. They concluded that agricultural expansion in south-eastern area of the country is more than a transformation into farmland areas that were previously used for other purposes. It directly resulted in the forced migration of pastoralists such as the Fulanis. These studies, however, focused generally on village level, thus making it difficult for generalizations to be made at a provincial level. Therefore, there was a need to comprehensively assess the trend in land use and land cover change with the use of current data and the application of transition matrix to identify the magnitude and category of change. Additionally, the consequences of these changes on livestock were assessed in this study using the perception of agro-pastoral livestock farmers. This is with the view to highlight the policy direction that could increase efficiency and sustain production, while easing pressure on natural resources.

2. Materials and Methods

2.1 Study area

With an area of 6,520 km^2, Boulgou province is located between at latitude 10°54'N to 11° 58"N and longitude 0°02'E to 0°54'W in the south-eastern part of Burkina Faso (Figure 1). The study area is characterized by ferruginous leached sandy to silt soils and deeper brown soils with silt to clay texture. It belongs to the north-Sudanian zone (Fontes and Guinko, 1995) with a unimodal rainy season that starts around June and lasts for 4 months. Based on data collected from three (3) stations (Zabre, Tenkodogo, Garango), the mean annual rainfall between 1980 and 2012 was 818 ±147 mm and the number of the rainy days per annum was 50 ±4. Mean daily minimum and maximum temperature ranged from 18^{o}C to 33^{o}C in January (coldest month) and from 26^{o}C to 38^{o}C in April, the hottest month (Kima, Okhimamhe, Kiema, Zampaligre & Sule, 2015). Rainfall is highly variable and the onset of the rains is erratic. The rainfall intensity is very high in the months of July and August. Boulgou's land cover consist primary of settlement, savannah woodland and shrubs. The natural vegetation comprises of trees and shrub savannah and some gallery forest near Nakambe and Nazinon river (Red and White Volta) and Nouhao river which drain into the Nazinon. The flora is dominated by annual grass species such as *Loudetia togoensis, Schoenefeldia gracilis, Cenchrus biflorus, Pennisetum pedicellatum* and perennes grass such as *Andropogon gayanu, , Brachiaria ruziziensis.* The ligneous species are represented mostly by *Combretum* spp., *Acacia seyal, Dichrostachys cinerea, Piliostigma thonnigii, Crossopteryx febrifuga, Guiera senegalensis.*

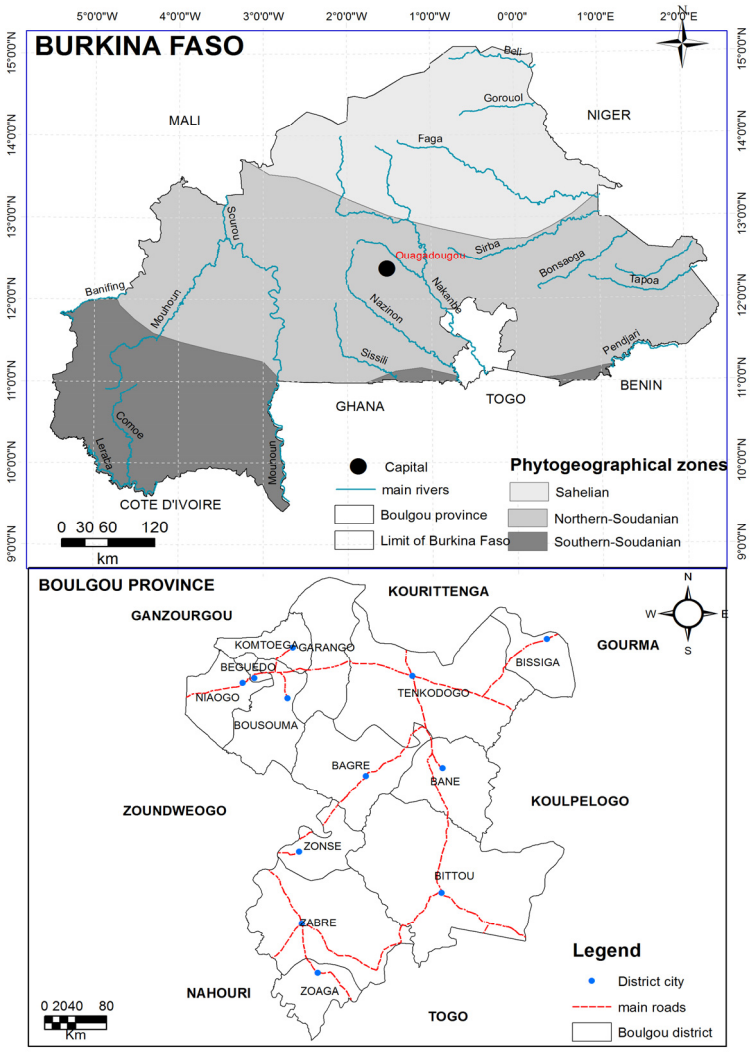

Figure 1. Location of the selected districts in Boulgou Province of Burkina Faso (Source: adapted from *Institut Geographique* du Burkina Faso data)

Until 1970s, the Nakambé river side was poorly inhabited due to high risks of *Onchocerciacis* (river blindness) and *trypanosomiasis* (sleeping sickness), but the completion of Bagré dam attracted settlers from the northern and western province which came for crop farming and livestock rearing. The total population was estimated at 642 401 inhabitants in 2012 (INSD, 2013). Most of these populations live in rural area. The dominant ethnic groups are Bissa followed by Mossi and Fulani. The Bissa and Mossi are sedentary farmers while Fulani are sedentary pastoralists (Oksen, 2000). Extensive agriculture (both crop production and animal husbandry) constitutes the main economic activities in the area. Sorghum, Maize, Millet are the main crops grown in the province. Almost all cultivation is exclusively rain fed and water availability during the dry season is one of the main problems (Oksen, 2000). The area is an important transit zone for the transhumant livestock coming from the north of Burkina Faso towards Ghana. Almost all cattle in the province are Zebu hunchback cattle (*Bos indicus*).

2.2 Data and Methodology

2.2.1 Land Use and Land Cover Mapping

The study utilised ortho-rectified and cloud free Landsat images of 1989 (ETM), 2001 ™ and 2013 (OLI) of path 192 and row 52 to determine the magnitude and trends of land use and cover changes. They were downloaded from the Global Land Cover Facility website (www.glcf.umiacs.umd.edu). Topographic maps and satellite image colour composites were used for the ground truth data collection. A field survey was conducted in January to February 2014 to collect ground-truth with the help of a global positioning system (GPS) with ±5 m error. The

maximum likelihood classifier was used to classify the satellite images using the Burkina Faso's Land Use and Land Cover Classification System (IGN-FI/ IGB 2005). Six categories (gallery forest, woody savannah, shrub and grass savannah, cropland, bare land and water body) were found suitable for Boulgou Province (Table 1 and Figure 2).

Table 1. Land use and land cover classification schemes

Land use and land cover category	Description
Gallery forest	Dense trees along the rivers with crown recovery estimated at 40% or more
Woody savannah	Land cover by trees and shrubs which both canopy covers between 20-50% and the tree canopy covered more than 10%.
Shrubs and grass savannah	Land covered by shrubs and grass. The crown of the shrubs is between 10 and 50% while the trees present in the area are less than 10% of crown.
Cropland	Rainfed cropland, irrigated cropland, and garden. Due to the fact that, rural population mostly live within their farmlands, settlement is included in this category.
Bare land	Area with almost no vegetation cover such as exposed rocks, sand and gravel with traditional gold extraction area. Burnt areas are included in this category.
Water body	Rivers, lakes and small reservoirs

Source: adapted from IGN-FI/ IGB (2005).

A total number of 147 points were collected by cluster sampling method based on the different colours on the composite image. This provided practical advantages in terms of accessibility to the land use and land cover categories. These points were identified and overlain on the classified image using ENVI version 4.7 and ArcGIS 10.0.

The kappa accuracy index that indicated the degree of accuracy were 83.2%, 82%, 92.1% in 1989, 2001 and 2013 respectively. These percentages are considered acceptable by Congalton (1991). In this study, post-classification change detection technique was applied to the classified images. The temporal change in each land use and land cover category was first determined by computing the difference in their statistics over two consecutive periods.

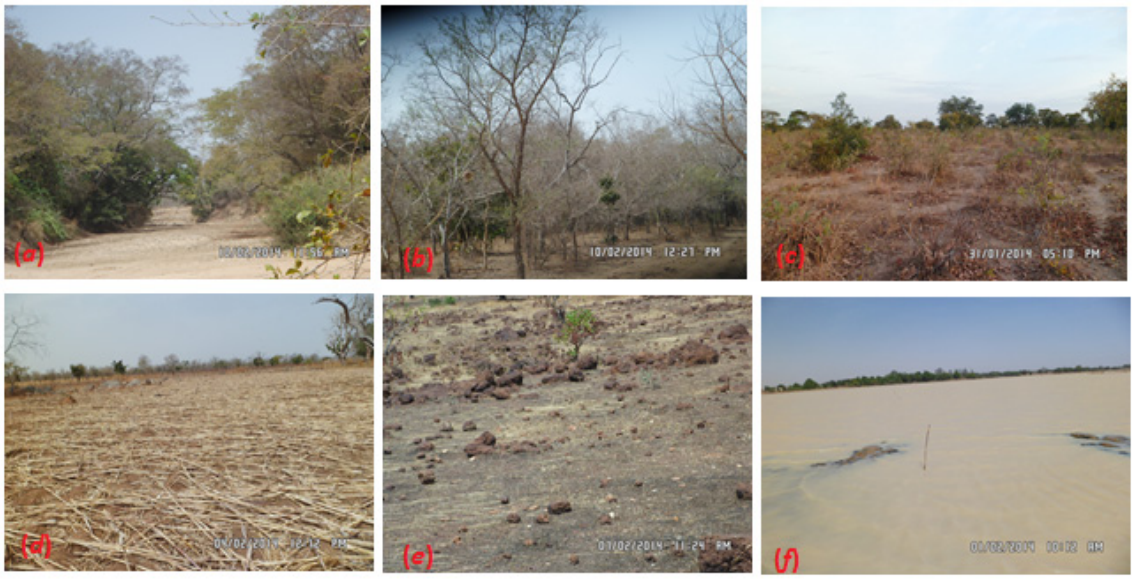

Figure 2. Pictorial representation of the six land use and land cover categories: (*a*) Gallery Forest; (*b*) Woody savannah; (*c*) Shrub and grass savannah; (***d***) Cropland; (***e***) Bare land; (***f***) water body

The land use and land cover change during the study period was analyzed using the transition matrix (Table 2) technique used by Pontius, Shusas and McEachern (2004). The proportions of different land use and land cover classes that did not change from 1989 to 2013 are shown in the diagonal. The row displays the land use and land category of the first period (.i.e. 1989) and the column displays the value of land use and land cover category of the second period (.i.e. 2013). The values on the diagonal indicate land use and land cover that persisted between the time-period, while the values off the diagonal indicate a transition from category "*i*" to a different category "*j*". In the total column, the notation "C_{i+}" denotes the proportion of the land use and land cover in category "*i"* in the first period, sum of overall "*j"* of "C_{ij}*"* meanwhile, the notation "C_{+j}*"* in the total row denotes the proportion of the land use and land cover in category "*j"* in second period, sum of overall "*i"* of "C_{ij}*"*.

Table 2. Transition matrix for comparing 1989 and 2013 maps from different points in time

	2013						
1989	Gallery forest	Woody Savannah	Shrub/grass savannah	Cropland	Bareland	Water body	Total 1989
Gallery forest	**C_{11}**	C_{12}	C_{13}	C_{14}	C_{15}	C_{16}	C_{1+}
Woody savannah	C_{21}	**C_{22}**	C_{23}	C_{24}	C_{25}	C_{26}	C_{2+}
Shrub/grass savannah	C_{31}	C_{32}	**C_{33}**	C_{34}	C_{35}	C_{36}	C_{3+}
Cropland	C_{41}	C_{42}	C_{43}	**C_{44}**	C_{45}	C_{46}	C_{4+}
Bareland	C_{51}	C_{52}	C_{53}	C_{54}	**C_{55}**	**C_{56}**	C_{5+}
Water body	C_{61}	C_{62}	C_{63}	C_{64}	C_{65}	C_{66}	**C_{6+}**
Total 2013	C_{+1}	C_{+2}	C_{+3}	C_{+4}	C_{+4}	C_{+5}	

Note: C is the conversion from any land use land cover category to another.

2.2.2 Household Survey on the Drivers and Impacts of Land Use and Land Cover Change

The current study used household survey data which was carried out in four (4) villages (Malinga-Nagsore, Sanogo, Loaba, and Benya) within four (4) different Districts (Tenkodogo, Garango, Bittou, Zabre) in Boulgou province. The sample villages were purposely selected with the help of livestock extension services workers base on the high frequency of conflict over natural resources, the scarcity of pasture. For each village, the respondents constituted 10% of the total number of households which corresponded to 58, 63, 70 and 57 households in Malinga- Malinga-Nagsore, Sanogo, Loaba and Benya respectively; which amounted to 248 households in the four villages The respondents were owners of livestock (.i.e. minimum of 5 cattle and 5 goats/sheep) and also at least forty (40) years old in order to be able to appreciate the change occur in land use land cover during the and the difficulties of livestock rearing. This survey sought information regarding the drivers of land use and land cover change, the causes of cropland expansion, the perception of land use and land cover change and the consequences of land use and land cover change on livestock husbandry. The household survey data was coded and analysed using Microsoft Excel spread sheets and the PASW Statistical Package software version 18.1 and presented as tables and charts.

3. Results and Discussion

3.1 Land Use and Land Cover Dynamics

The result from the images processed showed considerable changes in all land use and land cover categories within the 24 years of study (1989-2013). All other categories of vegetation decreased whereas cropland, bare land and water body increased in size. Gallery forest which occupied 10.5% of the total area in 1989, increased slightly in 2001 (11%), but reduced in 2013 to 4.2% (Table 3). Most of the gallery forests are located in the eastern part of the province towards the Nouhao river valley (Figure 3). The area was designated as pastoral zone under the Nouhao Valley Project whose first phase took place from 1997 to 2002. The protection of this area combined with the recovery of vegetation after the 1980s' drought may be the reason for the increase in gallery forest between 1989 and 2001. Fisher, Mustard and Sanou (2005) also observed an increase of 5 to 15% of the vegetation around Nouhao valley between 1984 and 2002. However from 2001 to 2013, gallery forest lost 59% of its cover and became the most decreased land cover category. During the period of study, gallery forest decreased at a rate of 2.5% per annum (Table 3). Woody savannah decreased continuously during the period of study; from 7% of the total area, to 3.8% and 3.5% in 2001 and 2013 respectively. The rate of decrease of woody

savannah was estimated at 2.1% per annum (Table 3). Shrubs and grass savannah with the largest coverage of 60.6% of the area in 1989 reduced in 2001 to 50.9% of the total area and slightly increased in 2013 (51.5%). Comparatively, cropland increased over the period of study in both intervals. In 1989, cropland areal coverage was already high, representing 20.5% of the total land cover. It increased to 31.8% and 36.7% in 2001 and 2013 respectively. Over the period of study, cropland increased at a rate of 3.3% at the expense of vegetation cover. On the other hand, bare land nearly doubled in size during this period. From 1.4% of the total land cover in 1989, bare land increased to 2.6% in 2013 at a rate of 3.6% per annum. It can be deduced from the land use and land cover maps of 1989 and 2001 that the changes that occurred in cropland and bare land were persistent in the northern part of the province. However between 2001 and 2013, bare land appeared in the southern districts. Water body recorded the highest degree of increase in land use and land cover categories within the period under consideration. In early 1990's, Bagre reservoir and some other smaller reservoirs were built in Boulgou province contributing to the increase in water body from 0.1% to 2.0%.

Table 3. Land use and land cover status and change from 1989 to 2013

Land use and land cover categories	State (%)			Change (%)			Annual rate
	1989	2001	2013	2001-1989	2001-2013	1989-2013	
Gallery forest	10.5	11.0	4.2	5.4	-61.5	-59.4	-2.5
Woody Savannah	7.0	3.8	3.5	-45.2	-9.3	-50.3	-2.1
Shrub/Grass Savannah	60.6	50.9	51.5	-16.0	1.2	-15.0	-0.6
Croplands	20.5	31.8	36.7	55.1	15.5	79.1	3.3
Bare land	1.4	0.5	2.6	-61.7	389.1	87.2	3.6
Water body	0.1	2.0	1.5	2165.2	-22.2	1663.0	69.3
Total	100	100	100				

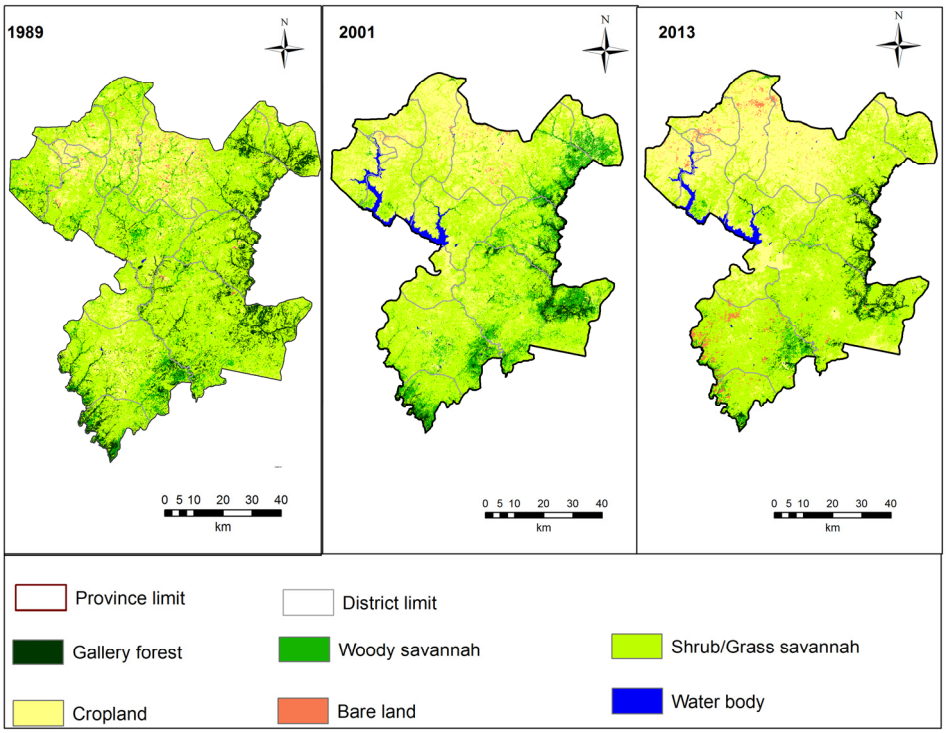

Figure 3. Maps of land use and land cover change from 1989 to 2013 in Boulgou Province

From the transition matrix (Table 4), it was observed that some vegetation categories present in 1989 persisted in 2013. These represented 2%, 0.7% and 35.6% of the total area covered by gallery forest, woody savannah and shrubs and grass savannah respectively, amounting to 38.3% of the Province. During the period of study, deforestation took place in two ways. First, gallery forests (0.9%), woody savannah (1.6%) and shrubs/grass savannah (19.4%) were converted to cropland implying that 21.9 % of the Province or 142,786 ha had been converted to cropland. Thus, the annual rate of deforestation due to crop production was 1.6%. This rate of deforestation due to crop production is slightly higher than the result obtained by Ouédraogo (2007), which was 1.025% in Sissili Province, located also in the southern part of Burkina Faso, between 1986 and 2002. Secondly, 4.2% of the land occupied by woody savannah was transformed into shrubs and grass savannah, while 1.2% and 6% of the total landscape occupied by gallery forest were transformed into woody savannah and shrubs and grass savannah respectively. The annual rate of deforestation due to other factors outside crop production was 0.47%, implying that crop production is a major cause of deforestation from 1989 to 2013 in Boulgou Province. It confirms the study of Ouédraogo (2007) which demonstrated that cropland expansion due to lack of improved technology for agricultural intensification is the most important direct cause of land use change in Sissili province. Vegetation recovery occurred in some of the land use and land cover categories. About 0.3% of the landscape covered by woody savannah was transformed into gallery forests. Additionally, 1.8% and 1.5% of the landscape covered by shrubs and grass savannah was transformed into gallery forest and woody savannah respectively. Several factors such as overgrazing (Archer, 1994; Ward, Hoffman & Collocott, 2014), reduction of bushfires (Archer, 1994; Veach, Dodds & Skibbe, 2014), increase in rainfall (Veach et al., 2014) and increase in atmospheric carbon dioxide (Polley, Johnson & Tischler, 2002) may have interacted to influence this transformation. It is also important to note that most of the woody plants are unpalatable and/ or inaccessible to animals.

Table 4. Transition matrix between 1989 and 2013

1989	2013						Total 1989
	Gallery forest	Woody savannah	Shrub/grass savannah	Cropland	Bareland	Water body	
Gallery forest	**2.0**	1.2	6.0	0.9	0.2	0.2	10.5
Woody Savannah	0.3	**0.7**	4.2	1.6	0.1	0.1	7.0
Shrub/grass savanah	1.8	1.5	**35.6**	19.4	1.4	0.8	60.6
Cropland	0.1	0.1	5.5	**13.7**	0.8	0.3	20.5
Bare/burn land	0.0	0.0	0.1	1.0	**0.2**	0.0	1.4
Water body	0.0	0.0	0.0	0.0	0.0	**0.1**	0.1
Total 2013	4.2	3.5	51.5	36.7	2.6	1.5	

3.1 Respondents' Perception of Land Use and Land Cover Change

Table 5 shows the perception of land use and land cover change during the last two decades. An increase in cropland and bare land was perceived by 89 % and 66 % of the respondents respectively. However, as many as 95% of the respondents perceived a decrease in pasture land and gallery forests, while 97 % perceived that water bodies had decreased. In Burkina Faso, except in the protected forests, most of the vegetated land is used for grazing (*Gouvernement* du Burkina Faso 2002). To the respondents, encroachment into these protected forests is mainly to increase crop production. Like other rural areas, crop production is the main income source. Valipour (2015) reported that in Burkina Faso, 92% of the economically active population is involved in agricultural activities. Another constraint resulting from the reduction of vegetation cover is the reduction in non-timber forest products (NTFPs), which play an important role in food security and poverty reduction in rural areas.

Unfortunately, the loss of vegetal cover in favour of cropland has been at the price of increase in bare land. Barbier (2000) opines that converting unproductive land into fertile land is costlier than investing in maintaining the long-term productivity of existing cultivated land.

The perception of increased cropland and bareland is in agreement with the statistics generated from the classification of Landsat images of the study area. Palé (2000) reported that, in 1994, degraded land occupied 47% of the total land area of Niagho and Beguedo districts, which are located in northern part of Boulgou province. The solution to this problem of increasing bareland, according to some farmers, was the use of manure and soil and water conservation techniques such as the use of earth or stone bunds as well as individual or collective tree-planting efforts. The livestock farmers believe that their efforts in this area would be more visible if support is provided in developing their capacity to use modern techniques in these activities. In addition, because of the changing climate, 46% of cultivated areas globally are unsuitable for rainfed agriculture (Valipour, 2013, 2014a) and this calls for investment in irrigation system to attain sustainable agriculture Unfortunately, Boulgou province attracts neither major investors nor unusually high number of development projects that can aid farmers (Dafinger, 2013).

Table 5. Respondents' perception of the dynamics of land use and land cover within the three decades

	Cropland	Bare land	Pasture	Forest	Water bodies
Increased	88.7	66.3	4.0	2.4	2.0
Decreased	5.7	32.5	94.7	94.7	97.6
Unchanged	5.7	1.2	1.2	2.8	.4

The increase in water body was not perceived by the respondents. Most of the respondents live far from the Nakanbe Rivers and available water sources were increasingly becoming silted and dry during the dry season due to the increase in crop production and inappropriate water utilization. One of the respondents, a 65-years old man stated that "The main cause of reduction of water availability is not the reduction of rainfall but crop production system. Hedge bonds which have been left in the field to reduce runoff no longer exist. Thus, rivers are silted and dry up early during the dry season". The increase in water body was mostly due to the building of Bagre dam, which was constructed to supply irrigation water. Most villagers in remote settlements have no access to safe drinking water. According to Dafinger (2013) access to water in Boulgou province is the most urgent and precarious need and competition over existing water sources and the struggle over new ones is one of the major triggers of social tensions.

3.2 Respondents' Indication of Drivers of Land Use And Land Cover Change in Boulgou Province

Land use and land cover changes are driven by many complex factors. Table 6 and Figure 4 show the main factors of land use and land cover change and cropland expansion in the study area. One of the factors that led to vegetation degradation mentioned by 91.8% of respondents is population growth. For instance, the population density of Boulgou province increased from 51.06 inhabitants/sq.km in 1985 to 101.52 inhabitants/sq.km in 2013 (INSD 2009, 2013) due to natural growth of the population and also immigration toward Bagre reservoir (MEF, 2002). Thus, the observation that cropland had expanded by 91.4% of respondents agree with the reality on ground based on the analysis of the images. Among these respondents, 98% reported that they increased the size of farmlands in response to the increase in the size of their household. From the survey, the mean household size was 18 people. It is apparent from the study that the larger the household size, the greater the likelihood of a household to increase its farmland. This argument is confirmed by the studies of Ouédraogo et al. (2010) who found a strong relationship (R^2=0.90) existing between population and change in cropland coverage in Sissili province of Burkina Faso. In addition, it was observed that all the Fulani respondents that were interviewed had adopted a sedentary lifestyle combining crop and livestock farming. Campbell, Lusch, Smucker and Wangui (2003) made the same observation about livestock herders in Kenya.

Table 6. Drivers of land use and land cover change

Causes	Agree (%)	Disagree (%)
Population growth	91.8	7.3
Increased cultivated land	91.4	7.8
Increased number of animal	65.4	33.7
Drought	95.1	4.1
Collection of fire wood	69.8	29

In comparison to the human population, 65% of the respondents observed that the increase in livestock population is a major factor contributing to land use and land cover change. In the past, livestock farming was practised by only the Fulanis, but today, the Bissa and Mossi crop farmers have adopted this means of livelihood. Nowadays, Fulanis settle in Mossi and Bissa villages and practice crop production and this leads to increase in the competition over use of the land. In addition, Boulgou province is a transit zone for transhumance from the north and central Burkina to Ghana and Togo. They perceived scarcity in land impacts negatively on the large livestock population because of the increasing pressure from grazing and destruction of fodder trees. Consequently, reduction in the natural vegetation of the area gradually leads to land degradation.

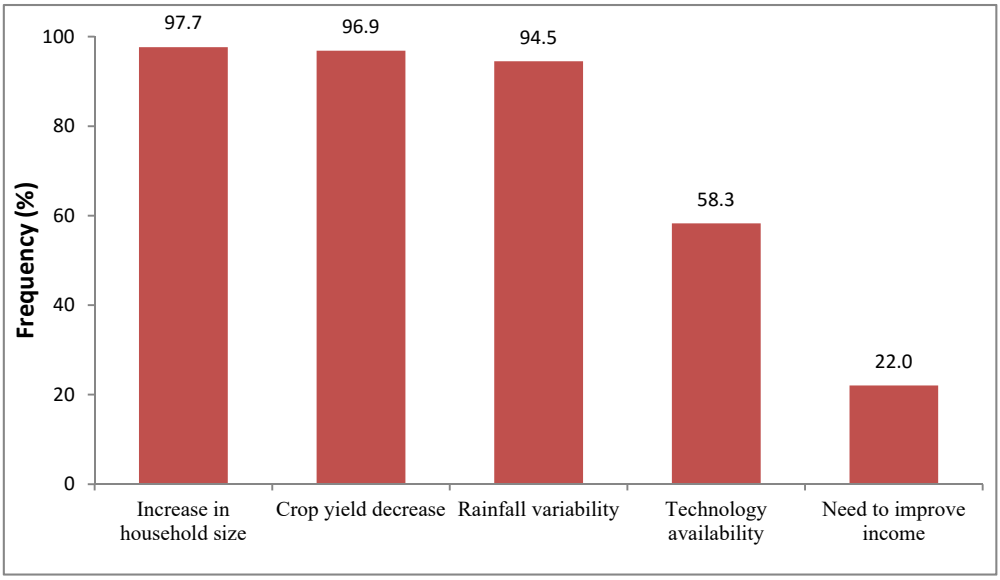

Figure 4. Causes of cropland expansion in Boulgou Province

Approximately, 91.8% of the respondents believed another major driver of cropland expansion and land use and land cover change is the frequent drought events, which contributed to decrease in crop yield and vegetation growth. In a recent study, Kima et al. (2015) found that 57% of yearly total amount of rainfall were lower than 818.9mm, the average of the 33 years under consideration (i.e. 1980 to 2012) with 1984, 1990, 1993 and 2002 being the worst hit. Extensive farming is seen as a strategy used by farmers to compensate decreasing crop yield due to inadequate crop production techniques (Hansen & Reenberg, 1998; Reenberg et al., 2003). A similar perception linking deforestation to the decrease in rainfall was reported by Ouédraogo et al. (2010). In addition, farmers' responds to low rainfall by expanding their cropland (Hansen & Reenberg, 1998; Reenberg et al., 2003; Paré, Söderberg, Sandewall & Ouadba, 2008).

Fuel wood extraction for cooking and production of charcoal was also mentioned by 69.8% of respondents as a contributor to land use and land cover change and environmental degradation. Another important driver of land use and land cover change through cropland expansion may be the need to improve the income and availability of suitable technology which were mentioned by 58% and 22% of the respondents respectively. Ploughing is the most advanced technology used for crop production in the study area. Most of the respondents own ox-drawn ploughs which they use in cultivating their fields. Kamuanga et al. (2008) reported that a family with a pair of oxen is able to cultivate two or three times more land than with handheld farming implements. Thus, in the context of technology improvement, farmers need this to improve on cultivation techniques (Hansen & Reenberg, 1998; Osken, 2000; Lambin et al., 2003). It is worthy to mention that the farming system adopted was principally subsistence farming, with some commercial farming involving cash crops like groundnut, cotton and rice. Rice is mostly cultivated in Bagré district of Boulgou Province, hence the need to use more advanced technology in the farms of Boulgou Province. Studies show that improvement in crop market prices influence land use change (Hansen & Reenberg, 1998, Lambin et al., 2003, Rasmussen et al., 2012).

3.3 Consequences of Land Use and Land Cover Change on Livestock Farming

The effects of land use and land cover change on crop production and animal husbandry is graphically depicted in Figure 5. About 97 %, 95.8 % and 90.9 % of respondents observed that the perceived land use and land cover

change had led to the reduction of in pasture size, crop yield and water accessibility respectively; whereas 96.8% and 67.6% had reported an increase in land degradation and reduction in the transhumance activities. In addition, 89.0 % of respondents mentioned that conflicts had increased between livestock and crops farmers as a consequence of land use and land cover change.

Reduction of grazing land due to the expansion of cropland affects vegetation resources and the biodiversity of the ecosystem negatively. Thus, ruminant livestock rearing depends mainly on natural pastures as the major and only source of food. Human population growth along with various land tenure and land-use changes have forced migration of pastoral livestock onto areas that are too small and infertile to sustain animal production (Galvin, Thornton, Boone & Sunderland, 2004). Although integrated crop and livestock production system is practised in the study area, generally areas with fertile soils are used for crop production while the marginal and bare lands are reserved for livestock production. The species of herbaceous plants found in the study area include *Schoenefeldia gracilis, Loudetia togoensis, Borreria spp, Elionorus elegans* which are unpalatable during dry season due to their less value in terms of nutrient qualities, and therefore reduce feedstock for livestock.

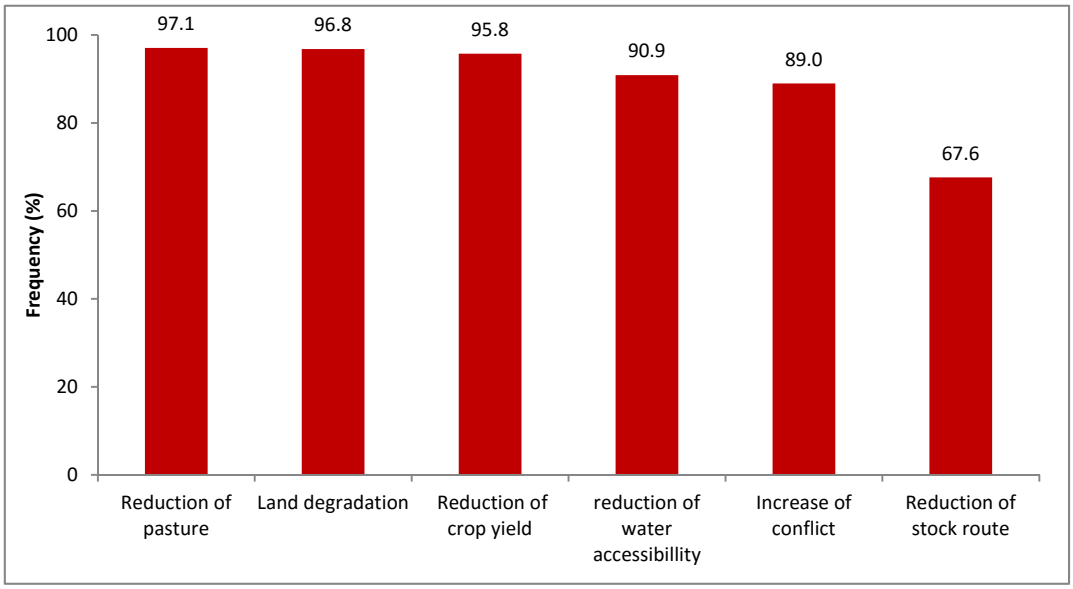

Figure 5. Effects of land use and land cover change on livestock. The responses from respondents imply that reduction of pasture and land degradation are the main impacts of land use and land cover change

Additionally, livestock farmers do not have rights to the land that they use for grazing. Indigenous people believe that the forests are potential agricultural areas, not grazing areas. In the study by Reenberg & Lund (1998) in Boulgou Province of Burkina Faso, it was revealed that rights to land have generally been established through clearing of woodlands, and based on 'first come, first serve' basis. In the Sahel, the farming communities claim the status of first-comers and see themselves as 'owners' or 'guardians' of the land (Dafinger & Pelican, 2002). Therefore pastoralists are regarded as a "landless' group who do not own the land they use and settle on (Dafinger & Pelican, 2002). When land is scarce or its access is highly contested, pastoralists who constitute the "landless and powerless" group are greatly disadvantaged (Shettima & Tar, 2008). At district level, there is inadequate land available to support an appreciable number of livestock in the northern part of Boulgou Province. Therefore, livestock farmers are compelled to move towards the southern and eastern part of the province and also towards the neighbouring countries of Ghana and Togo, where pasture is still available. Reenberg et al. (2003) reported that agricultural expansion in this area leads to forced migration of pastoralists.

Inadequate access to water was reported by 91% of farmers as a major impact of the changing climate. Given the affirmation by Campbell et al. (2003) that water is the key resource for all land uses, it is important to emphasize the implication of the inaccessibility of water points for the consumption of livestock. This is due to the fact that market gardening and irrigated crops' cultivation along the river banks and water reservoirs have blocked the free flow of water. Valipour (2014b) reported that the agricultural sector puts more pressure on renewable water resources and that irrigation has the maximum water withdrawal in agriculture. The use of Fadama land is seen as one of crop producers' adaptation strategies to climate change (Ouédraogo et al., 2010). Consequently, it is

very logical to conclude that conflicts between livestock and crop farmers in the study area occur because of the expansion of croplands into grazing area, the obstruction of livestock mobility route, the inaccessibility of water sources as well as damage to crops by herds. The Ministry of Animal Resources of Burkina Faso reported 579 conflicts between livestock and crop farmers in 2012 (MRAH, 2013). Respondents reportedly opined that in the event of any damages to crops from the livestock farmers, compensations should be paid irrespective of the cause of the conflict. Shettima and Tar (2008) posed the following question. "Why should the blame for crop damage and hence, compensation always be pushed on the pastoralists even when crop production has apparently encroached on grazing areas and colonised cattle passages?" This brings to the fore the need to enact and implement appropriate laws and policies that protect pastoral livestock farmers' well-being and improve livestock production in the West African semi-arid countries.

4. Implication of results on Pastoral Policy in Burkina Faso

Agriculture is one of the major economic growth generators in Burkina Faso but it has been on a steady decline since 1998 with the growth in the service sector. AfDB/OECD/UNDP (2014) reported that, in 2013, crop production, extractive industries, commerce and livestock farming sub-sectors accounted for 19.0%, 13.1%, 11.8% and 11.0% of almost 50% of the country's Gross Domestic Product (GDP). Evidently, land is very critical and access to it is a priority. Hence, over the years, conflicts have become synonymous with the struggle for land as crop farmers and livestock farmers strive to increase productivity. This study shows through the use satellite image analysis that cropland and bare land increased by 3.3% and 2.6% respectively between 1989 and 2013 and respondents in the household survey agreed that this increase had occurred. Prior to these, other studies had depicted a steady increase in both land use and land cover categories (Ruelland Levavasseur, & Tribotté, 2010; Kindu, Schneider, Teketay, & Knoke, 2013). If herders are to access grazing resources through locally negotiated resource management agreements (Hesse, Anderson, Cotula, Skinner, & Toulmin 2013), well-articulated development interventions that are developed using information extracted from remote sensing and GIS are a necessity. Some of these include not only the results of this study, but also studies involving the assessment of the spatio-temporal variability of pasture availability and quality (Tsegaye, Moe, Vedeld & Aynekulu, 2010; Keno & Suryabhagavan, 2014). These show that enclosing pasturelands could led to land degradation; identifying and re-establishing effective routes for livestock passage (Moritz et al., 2013) to encourage transhumance, etc monitoring land allocation as well as rangelands in order to identify fragmentation (African Union 2010). Hesse et al. (2013) had identified key interventions that could derive information from applications of these techniques, which include the re-opening traditional transhumance routes and demarcating new ones; developing either permanent or temporary water sources (deep wells or water pans) along the migratory routes and in grazing areas etc.

Nomadic livelihood is increasingly being threatened due to restricted mobility through intensively cultivated fields and the removal of valuable communal lands e.g. wetlands, flood plains and woodlands (CRS, 2014). Generally, rural policy direction has always been geared towards the promotion of crop production to the detriment of pastoralism (Gonin & Gautier, 2015)**.** For instance, the agricultural policy introduced by Burkina Faso's government in the 2000s, was mainly aimed at increasing cotton production at the national level (Kaminski & Thomas, 2011). Therefore, like other Sahelian countries, both the government and rural communities in Burkina Faso, face a dilemma in protecting grazing lands as these categories increase (Gning, 2005). Most decentralization policies aimed at implementing contemporary statutory reforms over customary practices have resulted in conflicts over land. From recent reviews of relevant policies (FAO, 2009; African Union, 2010; Hesse et al., 2013) starting with the "*Réorganisation Agraire et Foncière*"of 1984, the Pastoral Policy Act of 2002 to the Rural Land Tenure Law of 2009, it is evident that the problem encountered by provinces like Boulgou in Burkina Faso is capacity development and policy implementation. For any pastoral policy to be successful the mobility of livestock farmers must be enshrined into such policies and this study is an example of information source for these policies.

5. Conclusion

The study has demonstrated that land use and land cover changes have been taking place in Boulgou Province, South-eastern Burkina Faso. The analysis showed clearly that the highest degree of change occurred in the water body category because of the construction of Bagré reservoir. However, the increase in water body was not perceived by livestock farmers, who considered water to be one of the major challenges of livestock farming in the dry season when most of the rivers had dried up. The second highest increase occurred in the bare land category which had an increase of 87.2 % between 1989 and 2013 followed by cropland, expanding from 20.5 % in 1989 to 36.7% in 2013. Cropland had an increase of about 79.1 %. This is a very critical increase because of its impact on the grazing lands upon which livestock depend. But in the northern part of the study area, the

intense pressure on utilizing the cropland due to high population density has led to land degradation. Consequently, this has led to transhumance at Province level forcing a southward movement of livestock farmers to Bittou and Zabre. Therefore, there is an urgent need to develop appropriate strategies and policy to protect grazing areas. The orientation law on pastoralism should be known by all the resources users and applied. With the decentralization, authority has been given to local people for their land management. To derive maximum benefits, livestock herders should organise themselves in associations and influence local decisions. In addition, efforts should be made, with assistance from private individuals and the Government, towards the intensification of crop production.

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