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The impact of crop farmers' decisions on future land use, land cover changes in Kintampo North Municipality of Ghana

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Abstract

Purpose – This paper aims to assess the rate and land category contributing to the changes in seven land-uses in the Kintampo North Municipality of Ghana and the effect of the decisions of land users on future landscapes.

Design/methodology/approach – LANDSAT images were classified to generate land use/cover maps to detect changes that had occurred between 1986 and 2014. In total, 120 farmers were also interviewed to determine their perceptions on land use changes. Interval, category and transition levels of changes were determined. Savanna woodland, settlement and forest were mostly converted to farmland in both intervals (1986-2001 and 2001-2014).

Findings – Results showed that rock outcrop, plantation, cropland and savanna woodland increased at an annual rate of 13.86, 1.57, 0.82 and 0.33 per cent, respectively, whilst forest, settlement and water body

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decreased at 4.90, 1.84 and 1.17 per cent annual rate of change, respectively. Approximately, 74 per cent of farmers will not change land use in the future, while 84.2 per cent plan to increase farm sizes.

Research limitations/implications – The study shows that more land cover will be targeted for conversion as farmers expand their farmlands. There is the need for strict implementation of appropriate land use/cover policies to sustain food production in the region in this era of changing climate and population increase.

Originality/value – This research assessed the land use changes in the Kintampo North Municipality and its impacts on agriculture and carbon stocks release via land use changes. It identified how the decisions of the local farmers on land management will affect future landscape.

Keywords Farmers' land use decisions, Intensity analysis, Land use and land cover change

Paper type Research paper

1. Introduction

Anthropogenic activities are one of the major drivers of changes in land use and land cover (LULC) (Gamble *et al.*, 2003; Lambin *et al.*, 2003; Turner *et al.*, 2007). This currently manifests as climate change with numerous impacts. Climate change as an environmental issue is directly linked to LULC changes; and this affects the ecosystem's ability to provide goods and services to society (Loveland *et al.*, 2003). In addition, the exchange of greenhouse gases in the atmosphere is an active role LULC plays in climate change (Foley *et al.*, 2005; Vitousek *et al.*, 1997). Since 1970, cumulative CO_2 emissions from forestry and other land use have increased by about 40 per cent (IPCC, 2014). Climate change will impact agriculture in sub-Saharan Africa, which is 98 per cent rainfed by the erratic rainfall patterns, increasing temperatures and invasion of pests that do well in warm environments (Niang *et al.*, 2014). Anthropogenic land use change is putting freshwater ecosystems in Africa at risk, due to over-extraction of water and diversions from rivers and lakes, and increased pollution and sedimentation loading in water bodies (Darwall *et al.*, 2011). Climate change will likely have an overall negative effect on yields of major cereal crops across Africa, with strong regional variability in the degree of yield reduction (Liu *et al.*, 2008; Roudier *et al.*, 2011; Berg *et al.*, 2013 in Niang *et al.*, 2014).

Population growth is identified as a major contributing factor in this regard (Berakhi, 2013) because of the increase in demand for food, water, space for settlement and urban development and energy, a demand that is directly affecting land use systems, as reported by Lambin and Meyfroidt (2011). Consequently, other studies emphasize the need to address the questions of "why, where and when" these changes occur (Lambin, 1997). These questions are largely addressed by the intensity analysis technique developed by Aldwaik and Pontius (2012) at three levels, namely, the interval level, category level and transition levels. Alo and Pontius (2008) used a similar method to detect different processes that were operating in two categories of land uses (protected and unprotected regions) in Ghana. They discovered that in the past, protected regions in Ghana were almost entirely covered by forest, and the unprotected regions were mostly cultivated land which were classified as transition level by Aldwaik and Pontius (2012). The methods were extended to examine land cover changes in Ghana relative to the size of the persistence of the various land use categories (Braimoh, 2006). He concluded that the most systematic transition was from grassland to cropland, while there was little or no transformation from cropland to woodland and vice versa. This study examined the conversion between seven types of land uses within three-time periods, namely, 1986, 2001 and 2014, at interval, category and transition levels of intensity analysis. It also assessed the historical trends of land use change or conversion by farmers and the major drivers that will influence their decisions for conversions in the future. The perception of farmers on previous conversions of land use that confirm or contravene the findings of the intensity analysis will enhance the implementation of appropriate policies aimed at conserving the categories being depleted over time. More so, the impact of such conversions on the emission of carbon dioxide cannot be overlooked, if food production is to be sustained.

2. Materials and methods

2.1 Study area

Kintampo North Municipality in the Brong Ahafo region of Ghana has a surface area of about 5,108 km^2 and is located between latitudes 8°45' N and 7°45' N and longitudes 1°20' W and 0°1' W (Figure 1). The Municipality is within woody savanna and transitional agro-ecology zone and within the tropical continental or interior savanna type of climate. Every transitional zone is believed to have once existed as forest. Its current transformation is attributed to prevailing savanna conditions resulting from man's activities. This is evident by the existence of riparian forest where anthropogenic activities are limited (SEA, 2010). Kintampo North Municipality is found within the Voltain Basin and the Southern Plateau physiographic regions and is elevated between 60 and 150 m above sea level. Voltain plateau occupies the southern part of the Municipality with series of escarpments. There are numerous water bodies available but are not reliable for irrigation. The vast expanse of flat land makes it suitable for large-scale mechanized farming, especially the savanna zone at the northern part of the Municipality (SEA, 2010). The mean annual rainfall in the region is 1,400-1,800 mm. The mean monthly temperature ranges from 30°C in March to 24°C in August, with mean annual temperatures between 26.5°C and 27.2°C. Relative humidity ranges from 90-95 per cent in the rainy season to 75-80 per cent in the dry season. The climate of the Municipality exhibits drier tropical continental conditions.

2.2 Study methods

2.2.1 Image processing and intensity analysis. LANDSAT images for 1986, 2001 and 2014 were acquired from US Geological Survey (USGS) GLOVIS and Global Land Cover Facility website. The satellite images were taken at Datum WGS84 in UTM zone 30 at 30 × 30 m spatial resolution and geo-referenced. Ground control points (GCPs) were collected using a hand-held Garmin eTrex 10 GPS. Supervised classification was performed on the image by using the maximum likelihood algorithm in ENVI 4.7 with 168 GCPs as part of the process of identifying the various land cover and land use in the Municipality for the year 2014. The images of 1986 and 2001 were classified using geological maps from the Geological Survey Department of Ghana and pixel identification from current images. GCPs from field and reference maps were divided into two, one half for the training (classification) and other half for the accuracy assessment, by using the post classification confusion matrix method in ENVI 4.7. The seven classes used in the maps were savanna woodland, forest, cropland, plantation, settlement, water body and rock outcrop. The overall accuracies for the three maps using kappa statistics were 93.44 per cent, 0.9038; 93.14 per cent, 0.9088; and 94.13 per cent, 0.9221 for 1986, 2001 and 2014, respectively. After classification, change statistics were extracted from 1986-2001 and 2001-2014 maps to produce the two matrices used in change detection analysis. For each of the selected images, areas covered by the different land use categories, the net and annual rates of change were determined (Table I). The cross tabulation matrix for each time interval (first interval: 1986-2001; second interval: 2001-2014) were examined using intensity analysis software (Aldwaik and Pontius, 2012) for the three level analyses, namely, interval, category and transition levels. These three levels examined the total change in size and annual rates of change within each time interval; the variation of both gross gains and losses in size and intensity; and the transition (targeted or avoided) of the different land use types (Aldwaik and Pontius, 2012).

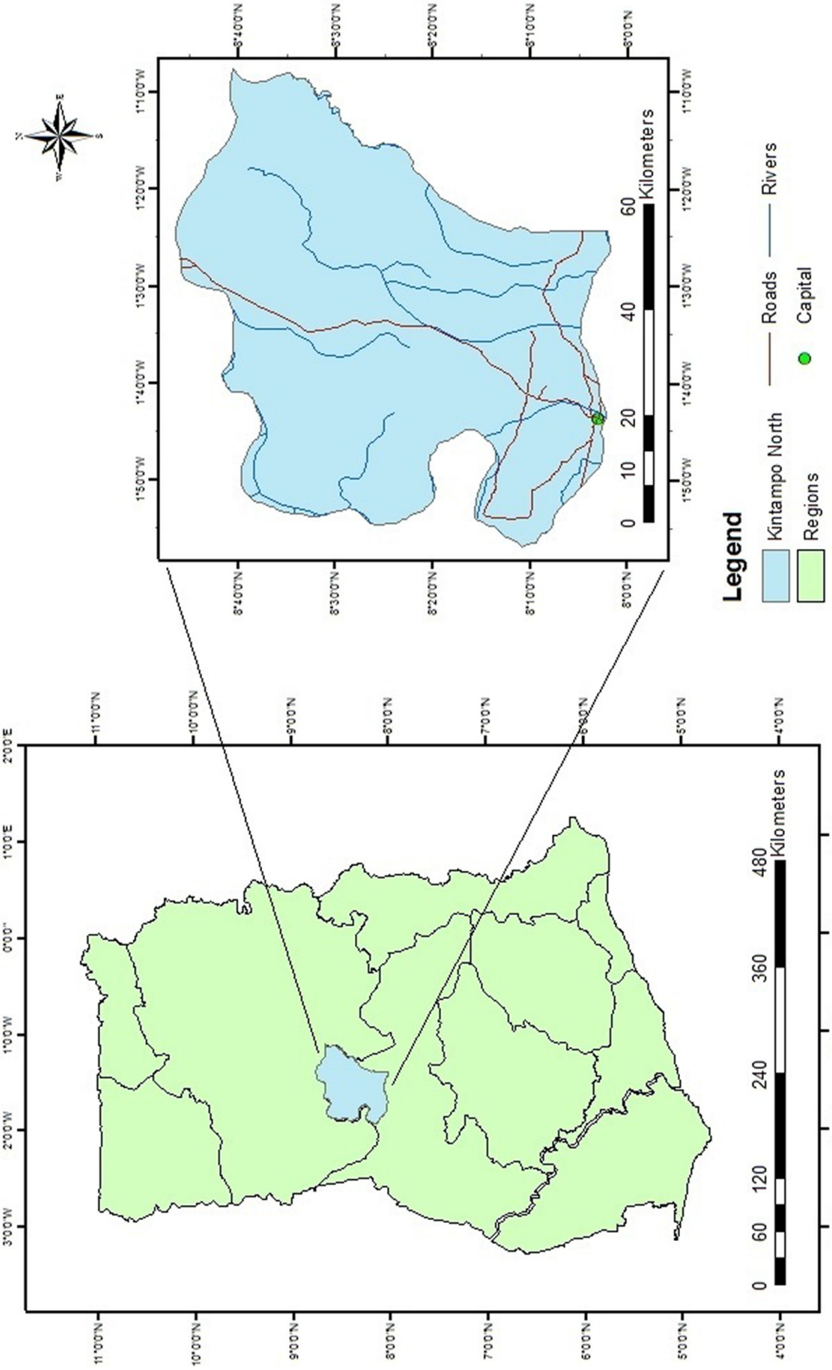

Figure 1.
Map of Ghana
showing study area

Table I.
LULC changes for two time intervals: 1986-2001 and 2001-2014

Land use	1986 (ha)	2001 (ha)	2014 (ha)	First period net change (ha)	Second period net change (ha)	First period net change (%)	Second period net change (%)	First period annual rate of change (%)	Second period annual rate of change (%)
Cropland	42,963.12	48,262.23	129,859.4	5,299.11	81,597.15	12.33	169.07	0.82	13.01
Water body	1,675.89	1,381.5	1,799.55	−294.39	418.05	−17.57	30.26	−1.17	2.33
Forest	33,373.71	8,833.95	2,341.17	−24,539.76	−6,492.78	−73.53	−73.50	−4.90	−5.65
Plantation	2,615.13	3,231.72	8,548.56	616.59	5,316.84	23.58	164.52	1.57	12.66
Savanna woodland	372,047.7	390,243.1	301,178	18,195.39	−89,065.08	4.89	−22.82	0.33	−1.76
Settlement	6,404.67	4,640.49	6,153.66	−1,764.18	1,513.17	−27.55	32.61	−1.84	2.51
Rock outcrop	1,196.46	3,683.7	10,396.35	2,487.24	6,712.65	207.88	182.23	13.86	14.02
Total	*460,276.7*	*460,276.7*	*460276.7*						

Notes: First period: 1986-2001; second period: 2001-2014

2.2.2 Questionnaire survey. To obtain farmers' perception on the changes that occurred and their future plans on land usage, a semi-structured questionnaire was designed. In total, 120 farmers were randomly selected from ten settlements and interviewed. The settlement was purposely sampled based on crop production and participation in agriculture programmes under the Ministry of Food and Agriculture in the Municipality. The choice of respondents was based on farming system practiced and accessibility to the farms (Ceesay *et al.*, 2016). The questions were grouped under their socio-economic characteristics, type of land cover conversion and the rate of conversion, as well as their land use activities and decisions. The questions were interpreted in one of the Ghanaian languages (i.e. *Twi*) for farmers who could not understand the English language. Finally, the questionnaire was coded and analysed using descriptive statistics in SPSS version 20.

3. Results

3.1 Land use and land cover changes

In 1986, savanna woodland had the largest areal coverage of 372, 047.7 ha. It was followed by cropland, forest, settlement, plantation, water body and rock outcrop with areal coverages of 42,963.12, 33,373.71, 6,404.67, 2,615.13, 1,675.89 and 1,196.46 ha, respectively. In 2001, savanna woodland increased to 390,243.10 ha.

However, in 2014, there was a significant change in the areal coverage of the different types of LULC. Savanna woodland, which still maintained the largest areal coverage, reduced to 301,177.98 ha. Cropland, rock outcrop, plantation, settlement and water body increased to 129,859.4, 10,396.35, 8, 548.56, 6153.66 and 1,799.55 ha, respectively, whilst forest further reduced to 2,341.17 ha at an annual rate of 5.65 per cent. Figure 2 shows these changes within the period of study.

Additionally, results showed that rock outcrop, plantation, cropland and savanna woodland increased at an annual rate of 13.86, 1.57, 0.82 and 0.33 per cent, respectively, whilst forest, settlement and water body decreased at 4.90, 1.84 and 1.17 per cent annual rate of change (Table I).

3.2 Interval-level intensity analysis

At the interval level, the rate of annual change was analysed. This could be decreasing or increasing across the entire Kintampo North landscape, implying that there was a slowing down of the general process of LULC change, perhaps because of economic recession (Aldwaik and Pontius, 2012). The rate of annual LULC change in Kintampo North Municipality was rapid (4.72 per cent) in 1986-2001 at 4.68 per cent uniform intensity and was slightly slower at 4.64 per cent in 2001-2014. (Figure 3). Observed changes were as high as 70.87 per cent in the first interval (1986-2001), implying that there were more changes in LULC within this interval compared with the second interval (2001-2014).

3.3 Category-level intensity analysis

Category-level intensity analysis examined the dormant or active LULC categories in their gain or loss of other LULC types in the entire district within both time intervals. In the first time interval (1986-2001), forest, cropland, plantation, settlement and rock outcrop gained actively at a uniform intensity of 4.72 per cent, with savanna woodland and cropland indicating an active loss. Cropland was actively losing to and gaining from other LULC types, perhaps because of the conversion of other LULC to cropland; and from cropland to other LULC. Savanna woodland and cropland categories were active as both categories recorded losses in areal coverage in the second interval (2001-2014). Rock outcrop,

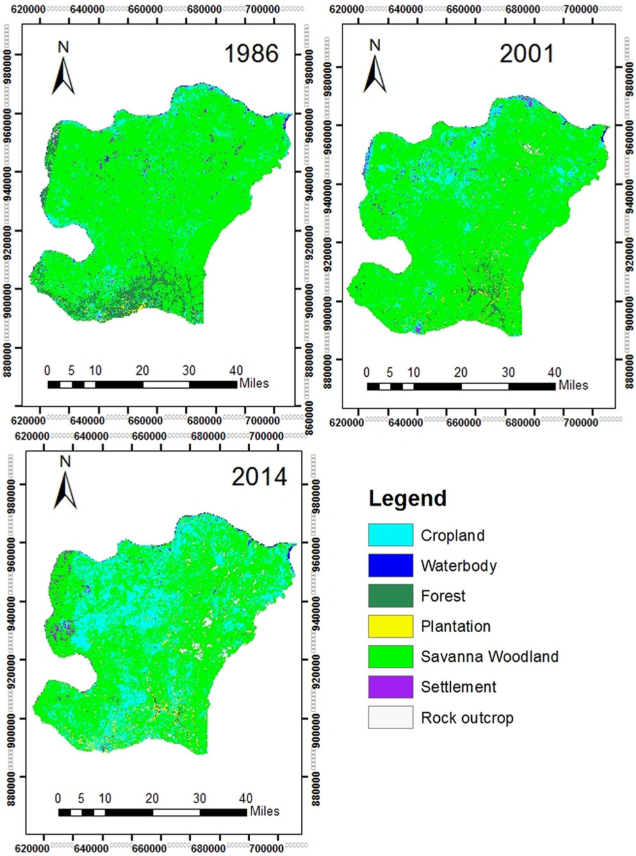

Figure 2.
LULC maps of 1986, 2001 and 2014

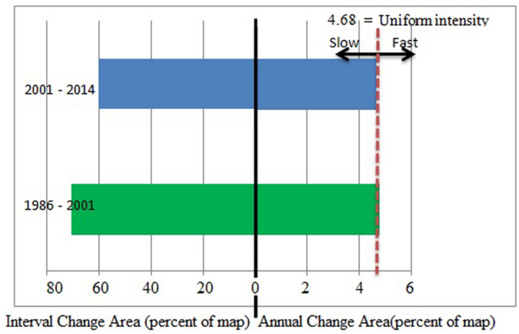

Figure 3.
Interval intensity analysis for two time intervals: 1986-2001 and 2001-2014

settlement, forest and plantation actively gained in this second interval. These losses, which are depicted in Figure 4, could be explained by the recent improvement in the implementation of forest conservation policy, population growth, increase in built up areas and exposure of more rocks by erosion.

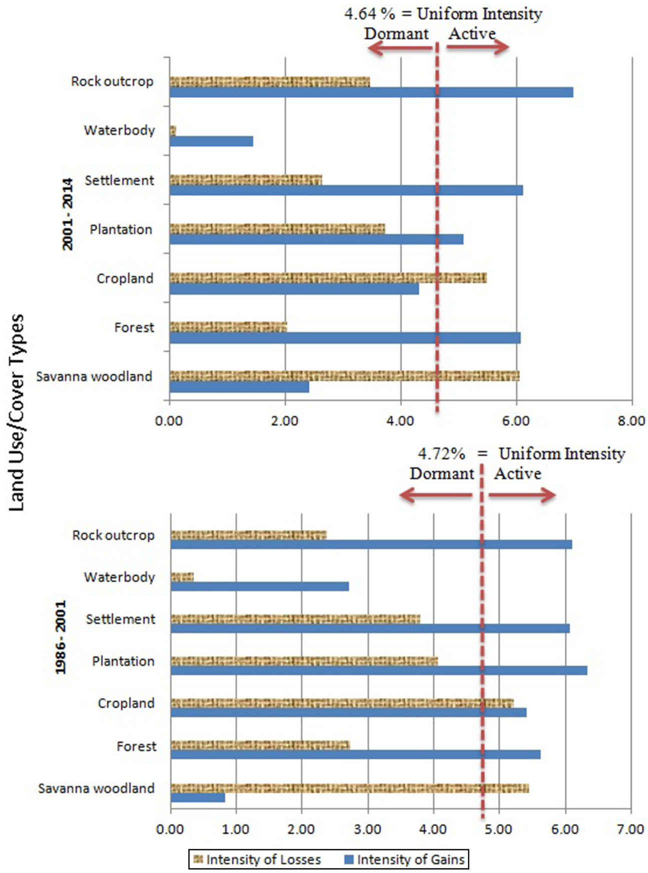

Figure 4.
Category intensity change in two intervals (1986-2001 and 2001-2014)

3.4 Transition-level intensity analysis

Figure 5 illustrates the transition intensity analysis. This level of analysis explains the transition between the LULC categories in terms of whether a particular LULC had been targeted (the highest contributing category to the changes) or avoided (was not a major focus category) during the process of change. For example, forest gained mainly from plantation in both time intervals. This implies that plantation was the major type of LULC that was converted into forest in both time intervals compared with all other land use categories (Figure 5).

Also, in the first time interval, settlement and rock outcrop were converted mostly to cropland, and this may have been due to the increase in bare land from harvested farms in dry seasons and the exposure of rock outcrops by soil erosion. During the second interval, settlements and savanna woodland gained from the transition of cropland to other LULC types. For example, cropland gained from savanna woodland in both time intervals, but less intensively from settlement in the first time interval. Forest, cropland and rock outcrop were the major contributors to the gain by plantation in 2001-2014. The various levels of transition from and to other LULC types are shown in Figure 5.

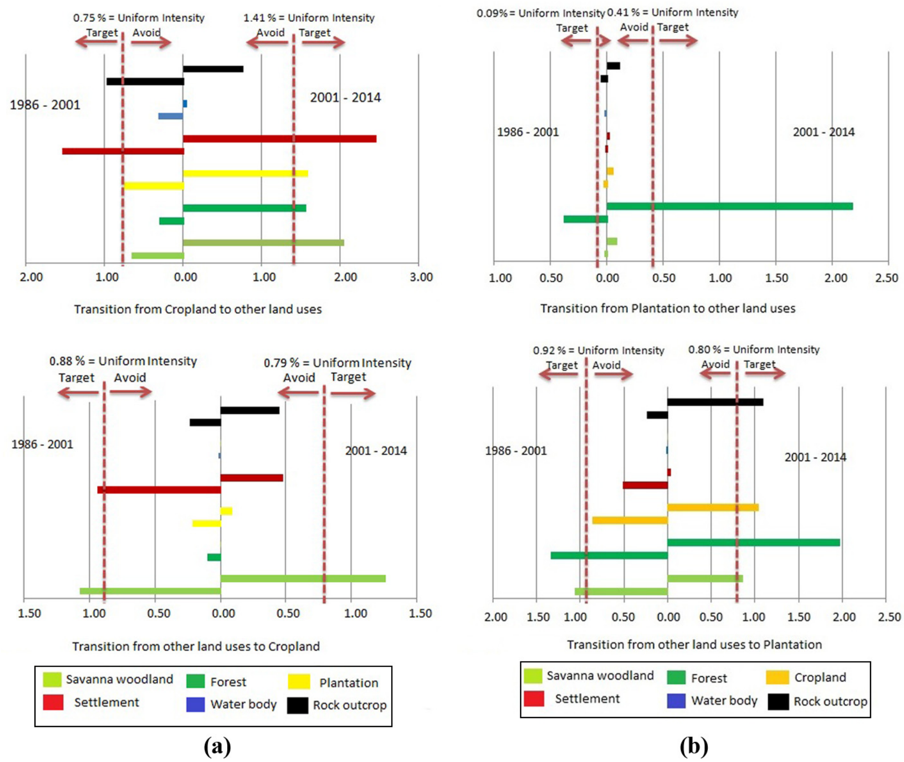

Figure 5.
Transition intensity analysis (per cent of category) from and to (a) cropland and (b) plantation for two time intervals: 1986-2001 and 2001-2014

Figure 6 shows the categories that gained and/or contributed to other LULC types in the Municipality. Specifically, savanna woodland and forest gained from cropland, rock outcrop and plantation, perhaps because of afforestation activities and adoption of bush fallow system of farming. This occurred in both the first and second time intervals of transition. These fallow lands and rock outcrops had gradually transformed into savanna, while forest, plantation, cropland and rock outcrop were targeted for transition from savanna woodland.

3.5 Land use decisions

The transition level of farmland (cropland and plantation) and other types of land cover (forest and savanna woodland) were compared with farmers' land use decisions obtained from the sample survey. From the 120 farmers interviewed, only 4.2 per cent of the respondents were below 30 years of age, with the highest population of respondents (53.3 per cent) ranging between 30 and 50 years of age. Aged farmers (70-100 years) comprised 15 per cent of the respondents. This result indicates that majority of the farmers in the study area are still strong and active. Also, female farmers comprised approximately 42.5 per cent. Thus, the involvement of women in crop production was very significant. Only 23.3 per cent of the respondents listed farming as their second income generation activity. Others were involved in public service (1.67 per cent) and trading (12.5 per cent). These figures are indicative of the importance of farming in Kintampo North Municipality. Approximately 47.5 per cent had no formal education, 1.67 per cent acquired tertiary education level and 30.8 per cent completed junior high school. Regarding their farming activities, crops

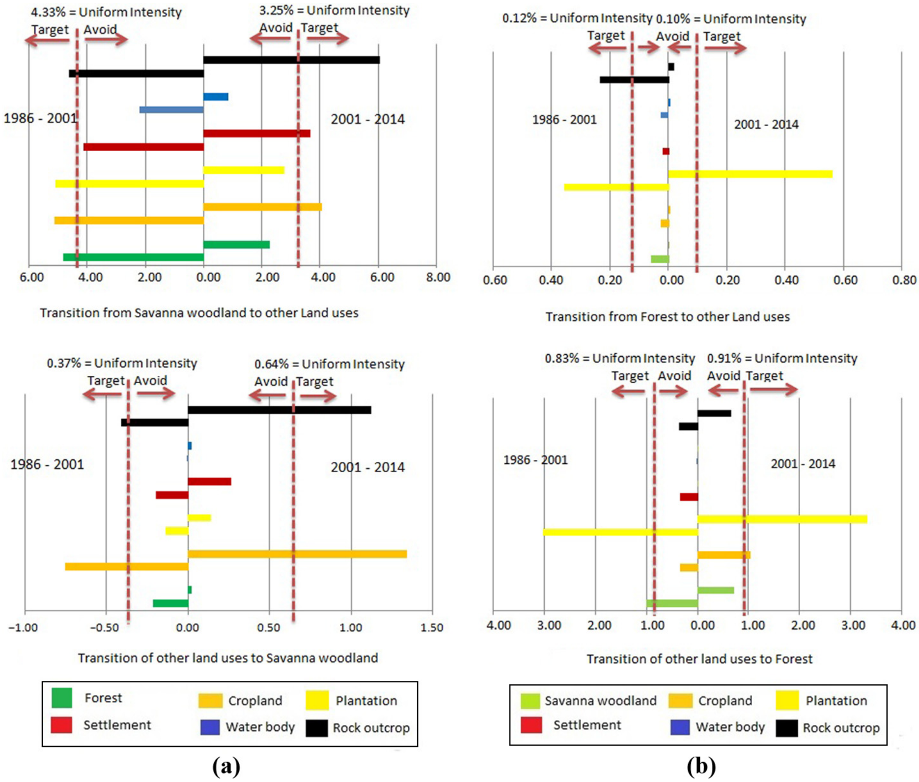

Figure 6. Transition intensity analysis (per cent of category) from and to (a) savanna woodland and (b) forest for two time intervals: 1986-2001 and 2001-2014

cultivated by respondents in the previous 5-10 years were tree crops, cereal, tubers, vegetables and fruits, which resulted in the conversion of forests to farm lands, as shown in Figure 7. This finding agrees with the land use change analysis from satellite images that found forest decreasing at annual rate of 5.65 per cent and cropland increasing at 13.01 per cent between 2001 and 2014. Transition analysis further showed that conversion was more from savanna woodland to cropland in both time intervals (1986-2001 and 2001-2014). However, it was observed that most of the respondents reported savanna woodland as forest or grass land. This may be attributed to the low level of literacy in the Municipality. Therefore, the high conversion from forest and grassland (68.30 per cent), as shown in Figure 7, can be referred to as transition from savanna woodland.

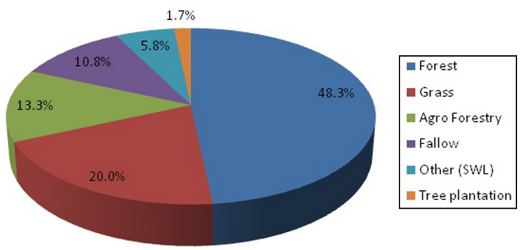

Figure 7. Land cover converted to farm lands

For the past 5-10 years, only 7.5 per cent of the respondents maintained their farm size of 1.5-5 acres and 36.7 per cent increased the size by 2-5 acres. Most of the respondents belonged to this group. Also, only 7.5 per cent increased the size of their farms to above 10 acres. This implies that food supply in the Municipality should be on the increase, as most (70 per cent) of the farmers practised mixed cropping of cereals and tuber crops such as cassava, yam, maize, soybeans and groundnuts. The proportion of respondents that had no plans to increase farm size was 15.8 per cent, a majority of whom were quite advanced in age. A minimum of 25.4 per cent had plans to change the land use type currently being practiced, as shown in Table II. The respondents listed finance (80.6 per cent), soil fertility (7.5 per cent), land tenure system (3.4 per cent), labour (2.5 per cent) and climate (1.8 per cent) as the main constraints militating against expansion of their farmlands. Only 1.8 per cent indicated that the changing climate was their main constraint. This shows that climate change and its impact on farmers' activities in the Kintampo North Municipality is not a pressings issue in the limitation to their work. This could be due to the fact that farmers are already conversant with the changes in the climate and probably have devised their own indigenous strategies to cope with the situation or the other high ranked constraints are perceived to be devastating and pressing than climate change. Other constraints (4.2 per cent) listed by farmers were destruction of farms by the cattle reared by Fulani herdsmen (1.3 per cent), inadequate management ability to maintain large farms (2.8 per cent) and limited time for supervision of more farmlands (0.10 per cent). Studies have shown that Fulani nomadic herdsmen's migration within West Africa in search of pasture is a result of climate change (Olaniyan *et al.*, 2015; Santuah *et al.*, 2015; Cabot, 2017). The respondents, however, acknowledged that the movement of herdsmen from Burkina Faso and Northern Ghana into the Municipality is recent.

4. Discussion

Forest cover recorded the highest loss in areal coverage compared with other LULC types in Kintampo North Municipality of Ghana. In the first time interval (1986-2001), 73.53 per cent of forest cover was lost to other LULC types at 4.90 per cent annual rate of change, while approximately 73.50 per cent was lost at the annual rate of 5.65 per cent in the second time interval (2001-2014). This confirmed the observation, on a global scale, that most forest lands were converted to croplands (Bruinsma, 2003). Cropland and plantation were observed to have recorded high net change during both time intervals. Mango, cashew and other crop plantations had increased in areal coverage over the years. Hence, the Municipality is known for its abundant fruit harvest in August (MoFA officer, personal communication). Rock outcrop also had a high net change, but this is not directly attributed to human activity. The exposure of rock outcrops within this period indicates that the top soil had been removed. It

Table II. Future land use decisions by respondents

Land use types	Frequency	(%)	Future change (%)
No change	89	74.17	0
Mixed cropping	13	10.83	41.94
Tree plantation	11	9.17	35.48
Crop plantation	4	3.33	12.90
Mono cropping	2	1.67	6.45
Agro forestry	1	0.83	3.23
Total	*120*	*100*	*100*

is evident that soil erosion is still very active in the Municipality (Nil *et al.*, 1996; Pamdu, 1997). Also, deforestation in the Municipality has uncovered most of the rocks that were not visible through satellite because of canopy cover previously.

Savanna woodland decreased in size because of the expansion in farmlands (cropland and plantations). In 1986, farmers cultivated and lived on family lands "informal interview conducted during the sample survey". These farms have been converted to plantations, thus contributing to the reduction of settlements in the first interval. Some of the respondents have had to move to other neighbouring districts. Also, in 1986, most of the farm lands were devoid of vegetation, and some of these were converted to settlements, a consequence of the 1983 drought (Berry, 1995). The increase in the size of water bodies within the 28 years' period is an indication of increased inflow of run-off from the catchment areas of some major rivers within the Municipality. However, in the second interval, this was mainly caused by deforestation. The limited availability of water in 2001 (Brew-Hammond and Kemausuor, 2007) was the reason for reduction in the size of water bodies in the first time interval. This affected the normal inflow of water into the Volta Lake, causing frequent power outages in Ghana in 2002. Additionally, increasing farmlands confirmed that population growth calls for larger demand in space for settlement, energy, food and water.

In an effort to meet the food and energy needs, numerous changes in LULC had occurred in the Municipality. The expansion of crop and pasture lands into natural ecosystems were the most important types of land conversion (Lambin and Meyfroidt, 2011). This explains the consistent increase in areas under cultivation in the Municipality, and the increase in the production of cereals and tuber crops (Anaafo, 2011). The finding was confirmed by the observation made by respondents on the conversion of forest and savanna woodland, which they had attributed to the expansion of cropland and plantation. Conclusively, the results of this study showed that the conversion of LULC was because of expansion of farmlands, confirming the outcome of the study conducted by Bruinsma (2003). In the second time interval (2001-2014), cropland increased through the conversion of savanna woodland, while other LULC categories, e.g. forest, cropland, rock outcrop and savanna woodland, were converted to plantation. This finding disagrees with the conclusion drawn by Braimoh (2006) that in Ghana, the most systematic transition of LULC types is from grassland to cropland, while woodland was avoided by cropland. Thus, Kintampo Municipality could be within the agro-ecological zones, where the conversion of grassland to cropland is regarded as insignificant (Braimoh, 2006). Furthermore, settlements were avoided (gained less) as shown in the transition level analysis. This compared favourably with the findings in Massachusetts, USA (Pontius *et al.*, 2004). In their study, residential category (settlement) systematically gained from forests, even though the economic status of both countries is quite different. Also, in Brazil (South America), Indonesia (Asia) and Cameroun (Africa), forest cover is changing at an annual rate of −0.4, −1.2 and −0.9 per cent, respectively, from 1990 to 2000 as a result of market expansion (Rudel *et al.*, 2005), which can be attributed to settlement expansion (development). Comparably, forest depletion in the Municipality is very high (−4.90 per cent from 1986 to 2001 and −5.65 per cent from 2001 to 2014). In eastern USA, regional forest cover had declined to about 4.0 per cent, resulting from urbanisation and other land use demands as factors for the loss in forest cover (Drummond and Loveland, 2010). This implies that forest loss for settlement and farmland expansion trend is global irrespective of the economic status and location of the country.

4.1 Implications of future land use and land cover changes

Regarding future LULC changes, 74.17 per cent of respondents are unwilling to change their current use of farm lands. Additionally, approximately 80 per cent of the farmers have plans to increase their farm sizes in future; consequently, more land cover will be converted into farmlands. By implication, forest cover may continue to decline if the net annual rate of decrease of 5.65 per cent in recent years continues. This, of course, will affect its ability to sequester carbon and contribute to the reduction of Ghana's carbon footprint. An approximate amount of 0.83×10^6 t of soil organic carbon stocks have been lost at the top 30 cm of depth by converting forest into other land uses from 1986 to 2014 in the Kintampo North Municipality (Bessah, 2014). This weakens our strongholds against global warming, as land use change in controlling CO_2 emissions in sub-Saharan Africa is very critical (Grieco *et al.*, 2012; IPCC, 2014; Niang *et al.*, 2014). Also, with less or no sustainable management practices introduced, erosions and land degradation, which is said to have contributed 33 per cent to soil carbon loss in Africa from 1985 to late 1990s (UNFCCC, 2006), will be very predominant in the Municipality considering the current rate of rock outcrop (13.86 per cent per annum in first interval and 14.02 per cent per annum in second interval) as an evidence of erosion and land degradation. Preservation of land cover (forest) will conserve biodiversity, sequester carbon and conserve soil (Rudel *et al.*, 2005) in the Municipality. Erosion, decomposition and leaching are important soil processes causing carbon concentrations to decrease in the soil (Lal, 2003). Food insecurity will threaten the land as soil loses its nutrients by alluviation and more land gets degraded. Also, the 1.8 per cent of respondents identifying climate change as their major constraints signify either lack of awareness on climate change in relation to other constraints stated by farmers or the presence of more impactful situations, which are of priority, such as lack of funds, infertile soil, land tenure systems and the Fulani nomadic herdsmen invasion in the Municipality. This is expected to affect their adaptation capacity and strategies (Kima *et al.*, 2015). Therefore, awareness on climate change as part of the National Climate Change Policy of Ghana (MEST, 2012) should be implemented in the Municipality by participation of the Ministry of Food and Agriculture and other stakeholders such as non-governmental organisations (NGOs) dealing with farmers directly.

5. Conclusion

Cropland and plantation are increasing at mean annual rates of 6.92 and 7.12 per cent, respectively, and their major target for transition contributing to this gain is savanna woodland and forest. Approximately 84.2 per cent of respondents in the Municipality have plans to increase their farm size in future. However, 25.83 per cent will change current land use to meet this increase in farm size. Consequently, it is expected that savanna woodland and forest will continue to undergo conversion by this high proportion of farmers to meet the targeted level of production. This calls for appropriate LULC conservation policies to maintain and improve on the available land cover and their ecosystems for sustainable development. Appropriate land management practices such as Sustainable Agriculture Land Management practice must be adopted and transferred via the Ministry of Food and Agriculture to intensify production without necessarily converting the remaining land cover, as well as more awareness creation on climate change in the Municipality. The consistent exposure of rocks in the area also calls for proper erosion and deforestation management practices and surveys spearhead by Ministry of Lands and Natural Resources and NGOs to control rock outcrops in the Municipality. This study used only questionnaire interview to assess the decisions of farmers on land use change, which does not allow for in-depth participatory exploration scenario exercise that considers all options and drivers of change. It is recommended that such method is adopted in future research to assess all plausible scenarios of land use change in the Municipality.

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