Theoretical and Empirical Researches in Urban Management
Volume 16 Issue 2 / May 2021

LAND USE/LAND COVER DYNAMICS AND URBAN AGRICULTURE IN TARKWA-NSUAEM MUNICIPALITY, GHANA

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Abstract
Achieving food security is now a priority of both international and national development agendas. However, this can be realised depending on measures put in place to regulate land use/land cover (LULC) activities from hampering agricultural development in rural and urban areas. This paper sought to assess the LULC dynamics of Tarkwa-Nsuaem Municipality (Ghana) and its implications for urban agriculture between 2002 and 2015. A descriptive research design was adopted with much emphasis given to the mixed-method approach. A remotely sensed satellite images were processed and analysed using ERDAS Imagine v.2013 and ArcMap 10.1. This was supplemented with qualitative data from key informants. The findings of the study revealed a loss of substantial cultivated and managed vegetation (agricultural lands) to artificial surfaces and associated areas (built-up) with the resultant consequences affecting urban agriculture in diverse ways. The immediate effects have been loss of over 100km^2 of agricultural lands, farmers losing their jobs and for that matter diversifying into other economic activities which put the future food security of the area at risk. It is therefore recommended that the city authorities in collaboration with relevant stakeholders should reclaim the lost agricultural lands and undertake urban growth boundary strategies to protect agricultural lands.
Keywords: Land use/land cover; urban agriculture; dynamics, Tarkwa-Nsuaem; Ghana.

1. INTRODUCTION

Land is a key natural resource available for the continuity and existence of man (Osei, 2009). It is used for agricultural purposes, mining, infrastructures and other activities to meet the demands of the human population. Land has become a finite and shrinking resource due to pressure from urbanisation, infrastructure, ecology, manufacturing, mining and agriculture (Food and Agricultural Organisation [FAO], 2011). The excessive use of land has therefore led to the alteration and modification of land cover which in the context of this study refers to the physical attributes of the earth's surface, distributed in the forms of vegetation, water, soil and other physical features of the land, including those created entirely by human activities (United Nations Environment Programme, n.d). Land use, on the other hand, is the intended employment of land management strategy on the land cover by human agents or land managers to exploit

the land cover and reflects human activities such as industrial zones, residential zones, agricultural fields, grazing, logging and mining among many others (Zubair, 2006).

Studies have shown that changes in land use and land cover (LULC) in different parts of the world is having a significant impact on the world's ecosystems such as the agricultural lands, forests, grasslands and wetlands by modifying or altering the natural surfaces of these lands to satisfy the needs of man (FAO, 2011; Food and Agriculture Organization (FAO), 2016; Harrison, 2006; Rawat, Biswas, & Kumar, 2013). In Europe for instance, almost 1000 km^2 of agricultural or natural lands have been found to disappear every year due to anthropogenic activities such as farming, construction works (building, roads and so forth) and several other activities undertaken by man (European Commission, 2016; Zubair, 2006). The United States of America forest cover was found to have been decreased by 400,750 km^2 between 2000 and 2010. In Africa, a study by Tappan et al. (2016) in West Africa between 1975 and 2013 among other things found a loss of about 406,432 km^2 savannah vegetation and 100,176 km^2 loss of forest lands in the sub-region.

Laying much emphasis on urban areas which now globally harbours more than half of the world's population and nearly 50 percent of Africa's population living in urban areas (UN, 2014), evidence shows that there are substantial effects of LULU change on the natural environment especially agricultural lands. For example, in urban Africa, physical expansions are shrinking the coverage of vegetative lands, including agriculture lands (Lasisi, Popoola, Adediji, Adedeji, & Babalola, 2017). Specifically, in Nigeria, it has been observed that settlement/built-up-areas increased from 978.03 hectares (6.60865%) in 1986 to 2976.39 hectares (20.11178%) in 2014, to the detriment of farmland/vegetative cover which reduced from 9277.71 hectares (62.69045%) in 1986 to 7995.33 hectares (54.02527%) in 2014 (Lasisi et al., 2017). In Egypt, agricultural lands decreased by 2377 and 1339 ha in Tanta and Quttour districts, respectively between 1972 and 2005 in the Al Gharbiya governorate (Belal & Moghanm, 2011). In addition to this, between 1999 and 2014 a total of 24.32 hectares of the farmlands in Nairobi got lost to other land uses while on the contrary in Bamako farmlands gained 4.12 hectares in the same time interval (Murayama et al., 2015). A recent study on Ghana's oil city (Senkodi-Takoradi) by Mensah et al. (2019) also revealed about 297 hectares of agricultural lands been lost to the built-up environment. The above statistics show how urban agricultural lands, major urban green spaces are predominantly lost to different land uses which the current sustainable development goal 2 and11 (sustainable cities) and AU Agenda 2063 guard against.

In Ghana, Tarkwa-Nsuaem Municipal Area, which is the study area is endowed with mineral resources such as gold and manganese and has a beautiful land cover. It also falls within the tropical rain forest vegetation zone of Ghana, which has favourable climate and soils conditions that support agricultural

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activities, especially farming. The presence of mineral resources has attracted various land use activities in the area (Baah-Ennumh & Adom-Asamoah, 2019). In addition to this, the changing economic activities of the area from agriculture to the services industry is having some effects on the LULC dynamics of the area (Tarkwa-Nsuaem Municipal Assembly, 2018). These together with the current national agricultural policy of Ghana (planting for food and jobs) supporting urban agriculture (Ministry of Food and Agriculture, 2017 as cited in Adjei Mensah, Kweku Eshun, Asamoah, & Ofori, 2019) makes it critical to look more into the current LULC dynamics of the area and how they are affecting agricultural activities. However, the available studies appear to be broad, not given much attention to LULC changes and urban agriculture in particular (Baah-Ennumh & Adom-Asamoah, 2019; Kumi-Boateng, Boye, & Yakubu, 2010). It is, therefore, as a result of this backdrop that this paper was written. The paper aims at assessing the LULC dynamics of Tarkwa-Nsuam Municipality and its implications for urban agriculture using satellite images between 2002 and 2015. In this study, much emphasis is given to urban farming, an aspect of urban agriculture that focuses on the cultivation of crops in an urban area. The findings would help policymakers to make informed decisions to sustain the development of urban agriculture in the study area and other mining areas of Ghana. It will also guide city authorities and land management institutions to put in place strict development controls to reduce the rate of LULC transformation from natural and semi-natural land cover to other land uses.

1.1. Urban agriculture and LULC change

In promoting food security and eradicating poverty, the concept of urban agriculture has received much attention since the MilleniuMillenium Development Goals era through to the current sustainable development goals era which will end in 2030 (Hoornweg & Munro, 2008). This has led to a growing awareness about the role of urban agriculture in local economic development. Urban agriculture focuses on the growing of plants and the raising of animals for food and other uses within and around cities and towns, and related activities such as the production and delivery of inputs, and the processing and marketing of products to support urban livelihoods in diverse ways (Veenhuizen, 2014). It complements rural agriculture to increase food stock to ensure the efficiency of national food systems.

Urban agriculture contributes to local economic development and poverty alleviation as well as to the greening of cities and the productive reuse of urban wastes (Hoornweg & Munro, 2008; Veenhuizen, 2014). Urban agriculture and its related activities employ about 200 million people, contributing significantly to the food source of about 800 million urban inhabitants (Nelson, 1996 cited by Appiah, 2016). Furthermore, it aids in the reduction of the urban heat-island effect, avoids a stormwater runoff, nitrogen fixation, pest control, and energy savings (Clinton et al., 2018). In sum, urban agriculture provides economic, recreational and ecological benefits to city dwellers (FAO, n.d.). These additional benefits

make urban agriculture worth as much as $160 billion annually around the globe (Clinton et al., 2018). This provides enough evidence of the need to promote urban agriculture.

Notwithstanding the above benefits, Hoornweg & Munro (2008) have found out that urban agriculture largely remains an informal sector that is not integrated into agricultural policies or urban planning. This makes it vulnerable and also jeopardises its sustainability.

According to the FAO (n.d.), there are some factors which promote urban agriculture, and these include increasing urbanisation in the developing world; worsening conditions of the urban poor; natural disasters that disrupt food supplies from rural areas; environmental degradation and resource limitations that cause greater food scarcity. Regardless of these factors promoting urban agriculture, some studies have shown factors leading to the decline or loss in urban agriculture in developing countries. Generally, the challenges facing urban agriculture in developing countries include the construction of infrastructures to meet the demand of the growing population, access to secure land, unemployment, lack of appropriate land use planning, government policies, migration along the suburbs and expansion of the metropolitan periphery and adjoining rural areas (Mensah et al., 2019; Lasisi et al., 2017; Aduah & Baffoe, 2013; Son & Tu, 2008; Cohen, 2006; Pérez, 2001; FAO, n.d.). Furthermore, government policies specifically on land use planning aim to segregate land uses that appear to conflict and have little or no experience in discovering ways to integrate agriculture with other activities (FAO, n.d.). All these direct and indirect factors affect the sustainable development of urban agriculture.

1.2. Study area

Tarkwa-Nsuaem Municipality has a population of 90,477 with relatively more males (51.6%) than females (48.4%) (Ghana Statistical Service, 2014). It is absolutely located between Latitude 4°0'N and 5°4¹N and Longitude 1°45'W and 2°1'W. The municipality shares boundaries with Prestea Huni-Valley District to the north, Nzema East District to the West, Ahanta West District to the South and Mpohor District to the East (Figure 1). The Municipality has a total land area of 978.26 km^2 with major rivers such as River Ankobra and River Bonsa and their tributaries including Buri, Anoni, Sumin and Ayiasu rivers (Tarkwa-Nsuaem Municipal Assembly, 2018). The Municipality has Forest Reserves of about 440.15 km^2. The Forest Reserves comprise the Bonsa Reserve (209.79km^2), Ekumfi Reserve (72.52km^2) and Neung Reserve (157.84km^2). The relief of the municipality falls within the forest disserted plateaus physiographic region which is generally undulating. The elevation of the land above sea level is about 240 meters to 300 meters. The soil type is mainly Oxisol, which is suitable for plant growth, hence the extensive cultivation of cassava, maize, plantain, rubber, cocoa and oil palm among others. The geological formations in the Municipality are mostly the Birimian and Tarkwaian rocks. The Birimian is endowed with minerals such as Gold and Manganese. The increasing number of mining activities in the Municipality is gradually

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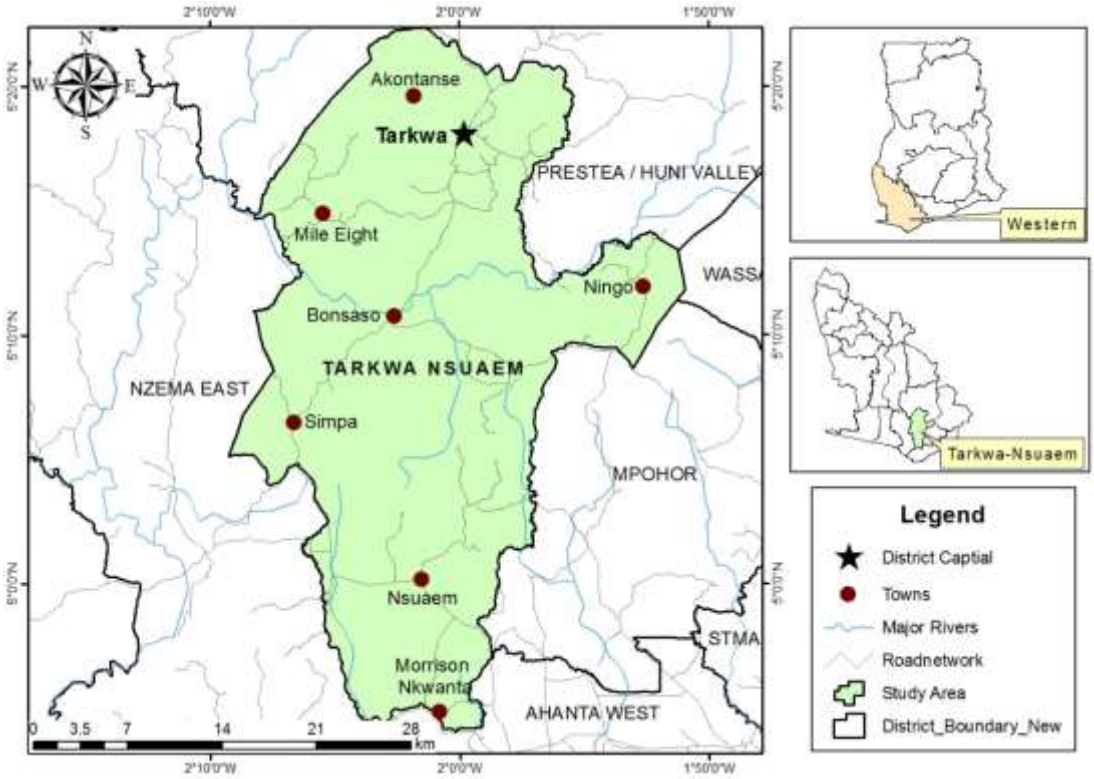
degrading the forest and polluting water bodies which pose threats to the environment. Economically, agriculture is the highest employer of the labour force employing 31.5 percent followed by mining and others (Tarkwa-Nsuaem Municipal Assembly, 2018).

Agriculture activities within the Municipality can be broadly categorised under three themes: crop cultivation, livestock and fishing (Aquaculture). By the end of 2013, the annual agricultural growth rate was 5.4%. Maize, cassava, rice, plantain, cocoyam and yam serves as the major staple/food crops in the area while cocoa, oil palm, rubber and to some extent citrus constitute the main cash/tree crops in the Municipality. Livestock rearing is done on a smaller scale in the area with animals such as poultry, sheep, goat, pigs, cattle and fish reared for some economic gains. In terms of forestry, trees such as Wawa, Odum and Sapele among others and grown which are sometimes exported to earn foreign income. During the period covering 2010-2013 improved agriculture technologies were pursued to enhance agricultural productivity in the Municipality (Tarkwa-Nsuaem Municipal Assembly, 2018).



Source: Department of Geography and Regional Planning, UCC (2019)

FIGURE 1 - MAP OF THE STUDY AREA

2. MATERIALS AND METHODS

The study adopted a descriptive research design which provided the researcher with the opportunity to describe, acquire new insights and discover new ideas as well as expand knowledge on the new and

existing phenomenon. Also, in order to provide better understanding and in-depth analyses on the topic under study, the mixed-method approach was adopted. In this regard, both qualitative and quantitative (statistical derivation from remotely sensed image) research approaches were employed for the study (Creswell, 2012).

The quantitative data, which was a time-series remotely sensed data, was obtained from the United States Geological Survey (USGS). The data obtained from the United States Geological Survey (USGS) were remotely sensed imagery from the Landsat satellite between the years 2002 and 2015 (Table 1).

TABLE 1 - SATELLITE DATA USED FOR THE STUDY

Satellite	Sensor	Path/Row	Spatial resolution	Acquisition date	Source
Landsat 7	EMT	194/057	30	2002-01-15	USGS, 2017
Landsat 7	EMT	194/056	30	2002-01-15	USGS, 2017
Landsat 8	OLI TIRS	194/057	30	2015-12-29	USGS, 2017
Landsat 8	OLI TIRS	193/056	30	2015-12-06	USGS, 2017

Source: Author's construct, 2018

The remotely sensed images were preprocessed and processed using ERDAS Imagine Software, version 2013 and ArcMap version 10.1. At the preprocessing stage, the images were initially stacked. Corrections such as geometric correction and radiometric corrections were rendered images. The images were reduced to the size of the study area through the process of subsetting. All the images were later categorized into the various land cover classes using a supervised classification technique. The output was further classified into four (4) major land cover classes. The classified images were sent to ArcMap to generate the land cover maps.

The supervised file was then imported into ArcGIS version 10.1 for further analysis with the combination of other files to produce more processed data. The change detection analysis was run to check the various changes that have occurred. The change map and matrix was developed for the 2002 and 2015 time interval. The study adopted the land cover classification scheme (Table 2) based on the Food and Agriculture Organisation classification scheme (Food and Agriculture Organization (FAO), 2000).

TABLE 2 - DESCRIPTION OF LAND COVER TYPES

Land Cover	**Description**
Artificial surfaces and associated areas	This area is comprised of areas of intensive use with much of the land covered by structures such as residential, industrial, transportation, utilities, and mining site.
Cultivated and managed vegetation	Land used primarily for production of food and fibre, Cropland, pasture and other commercial and horticultural crops.
Natural and semi-natural vegetation	Areas where a tree-crown areal density (crown closure percentage) of 10 percent or more, are stocked with trees capable of producing timber or other wood products.

Source: Food and Agriculture Organisation, 2002

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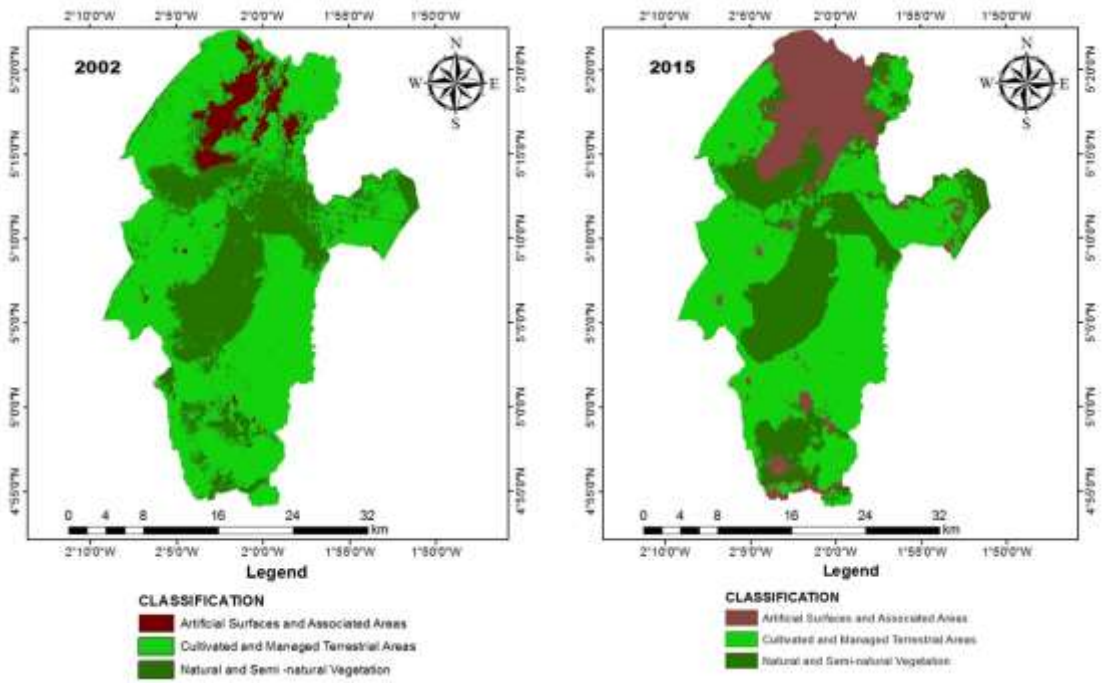
Some qualitative data were collected to supplement the above quantitative data to provide in-depth analysis and have a broader understanding of the topic under study. In doing this, some key informants within the study area who possessed vital information and necessary experiences relevant to the study were purposively selected. These key informants were the District Planning Officer, the Environmental Protection Agency Officer and the Forestry Commission Officer. They were purposively selected as a result of the nature of their work, which focuses more on managing LULC and hence made their involvement in the study very critical. In addition, two opinion leaders and five farmers, who have stayed in the study area for over three decades were included to share their personal experiences on LULC situation of the study area.

3. RESULTS AND DISCUSSION

The land cover maps produced results from the integrated analysis of two multi-temporal remotely sensed data and vector data. Here, two different time points were used, 2002 and 2015. The maps were classified using the FAO classification above in Table 2.



Source: Remotely Sensed Image, 2018

FIGURE 2 - LAND USE/LAND COVER MAPS

Figure 2 shows the distribution of LULC within the study area for the 2002 and 2015 time interval. From the results, in 2002, cultivated and managed terrestrial areas were found as the dominant land cover type in the area with an area coverage of 584.0289 sq.km, followed by natural and semi-natural vegetation with an area of 266.1804 sq.km and the least was artificial surfaces and associated areas with an area

coverage of 54.7371 sq.km. However, after 13years, substantial changes were found in the distribution of the LULC of the study area (Table 3). The two leading land cover classes in 2002 (Cultivated and managed terrestrial areas, and natural and semi-natural vegetation) were observed to have reduced at a relatively high rate compared to artificial surfaces and associated areas (Table 3).

TABLE 3 - COVERAGE OF VARIOUS LAND COVER CLASSES IN THE STUDY AREA IN SQUARE KILOMETRES AND PERCENTAGE.

Land cover land use classes	2002		2015		Rate of Change
	Area (sq. km)	Percentage (%)	Area (sq. km)	Percentage (%)	Percentage (%)
Artificial surfaces and associated areas	54.7371	6.0487	167.5755	18.5177	206.146
Cultivated and managed vegetation	584.0289	64.5374	484.9308	53.5867	-16.968
Natural and Semi-Managed Vegetation	266.1804	29.4139	252.4401	27.8956	-5.162
Total Area	904.9464	100	904.9464	100	

Source: Remotely Sensed Image, 2018

On the contrary, the artificial surfaces and associated areas were observed to have increased in size, greatly threatening the rainforest vegetation of the study area. This observation is in line with the findings of European Commission (2016) that about 1000 km^2 agriculture or natural lands disappear every year because they are converted into artificial areas such as buildings and roads to suit anthropogenic demands as observed in the study area.

In probing further to get detailed information on the nature of the land cover change, a change detection analysis was run using the Combinatorial And in ArcMap. The result from the Combinatorial And was used afterwards to generate the change map (Figure 3) and statistics to show the changes in the various land cover classes.

From the analysis, most of the artificial surfaces and associated areas are located in the north of both maps showed in Figure 2 , which is indicated by the shade of brown. This type of land cover has increased at a rate of 206.146% from 2002 to 2015.

The change in artificial surfaces and associated areas can be linked to the increase in infrastructural development, mining and settlement. It can be realised that the slightest increase in mining areas have a corresponding decrease in farmland and built-up areas (Peprah, 2015). The increase in this cover is at the detriment of other classes such as the natural and semi-natural vegetation, and cultivated and managed vegetation. This would lead to a change in the biodiversity of the area, reduction in agriculture produce, high population density and climatic conditions.

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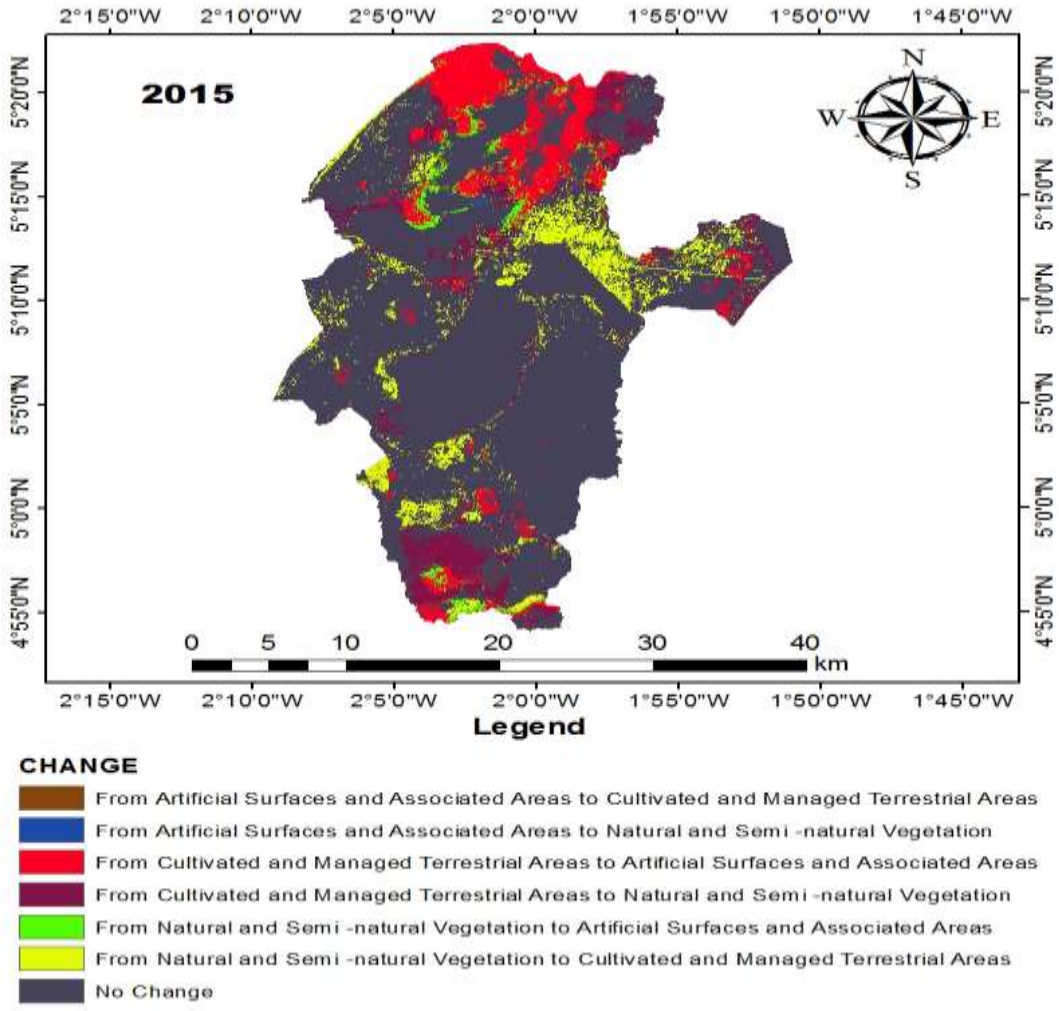
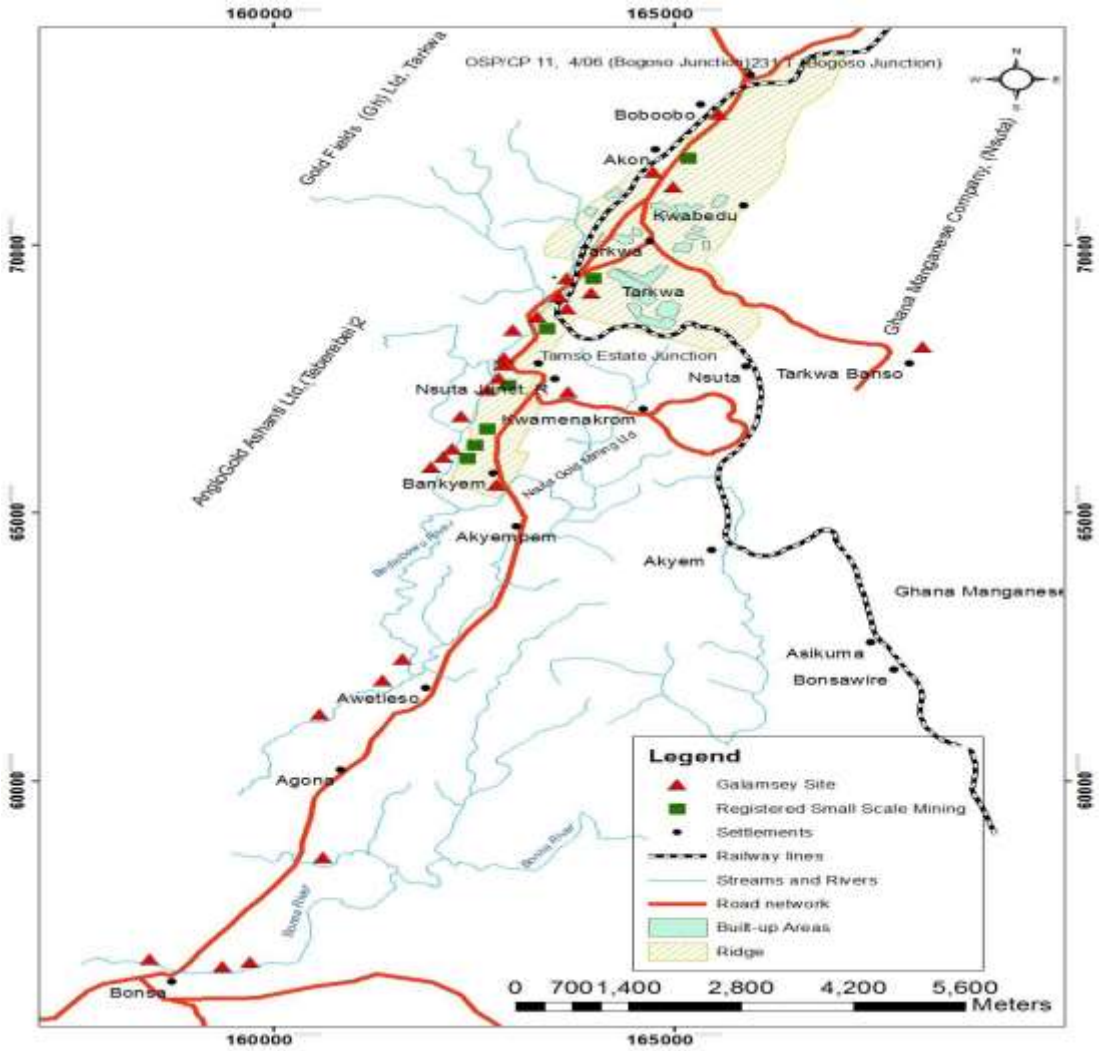


Source: Remotely Sensed Image, 2018

FIGURE 3 - A CHANGE DETECTION MAP

The reduction in the natural and semi-natural vegetation, and cultivated and managed vegetation is as a result of the conversion of the natural and semi-natural vegetation, and cultivated and managed vegetation into artificial surfaces and associated areas by illegal surface mining and lumbering to meet the needs of human beings. Tarkwa-Nsuaem Municipality was found to be one of the hot spots for illegal surface mining activities in Ghana with a study by Kwesi et al. (2015) confirming this. In the said study, as many as 25 illegal surface mining sites (galamsey sites) were found in Tarkwa-Nsuaem and its environs alongside several registered small scale mining sites as at 2015 (Figure 4). The intensity of these mining activities especially the illegal ones were therefore found to have put much pressure on other land uses resulting in natural and semi-natural vegetation decreasing at a rate of -5.162%, and cultivated and managed land use by -16.965% within the time interval (2002 – 2015) under study.



Source: Kwesi et al. (2015)

FIGURE 4 - A MAP OF TARKWA-NSUAM MUNICIPALITY SHOWING THE GALAMSEY OPERATIONS

The above loss of natural and semi-natural areas, and cultivated and managed vegetation (such as farmlands and croplands) to artificial and associated areas (such as built-up environment) was found to follow a similar trend in urban areas in many developing countries, especially in Asia and Africa. For example, a study by Murayama, Estoque, Subasinghe & Hou (2015), covering a 14-year time interval just like the current study found forest and cropland of the following urban areas been lost to the built-up environment and other land uses: Bangkok Metropolitan Region (Forest -20 and -31 hectares), Beijing Metropolitan Area (Forest -38, and forest -6 hectares), Jakarta Metropolitan Area (Forest -13, and cropland -19 hectares) and Nairobi (Forest -1, and cropland -24 hectares). A similar observation was made by Tappan et al. (2016) as cited in Adjei Mensah et al. (2019) using the West Africa LULC Time Series data analysis from 1975 to 2013. In the analysis made by Tappan et al. (2016) West African

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countries such as Nigeria, Mali, Senegal, Guinea, Togo and Ghana were found to have lost substantial portions of their natural vegetation to artificial and associated concrete surfaces.

However, in Tarkwa-Nsuaem Municipality, the dominant nature of illegal surface mining activities, causing destructions to the natural environment makes the LULC change in the area quite unique and very critical. This is because apart from these surface mining activities (especially the illegal ones) resulting in immediate clearance of the natural vegetation, their activities such as excavation of trenches, and grinding and washing of earth materials using chemicals like mercury or cyanide to extract minerals such as gold and diamond from the ore put the land under severe destructions which often takes a long time to repair. This was found to have started manifesting in the study area with some forest and farmlands lost through illegal surface mining not been able to regain their original status several years after the closure of mining activities on those lands. For instance, one key informant remarked as follows:

> *I have lived in Tarkwa all my life because I was born here and also worked here without moving to any place. In fact, surface mining is really worrying the community because galamsey people (illegal mining) and other small-scale mining companies are all over the place. I am over 60 years now, but growing up in this community there were many forests and farmlands around but since about 20 years when galamsey activities intensified in the community, we have lost many of our farmlands, forests and some of our water bodies as they have become polluted. What pains me much is that some of the farmlands and forests that were previously used for galamsey activities but are no more used for such activities cannot perform their original functions. Because over the last 5 years we have tried all our efforts to make such lands function well again, but the destructions they were subjected to by galamsey activities have not made our efforts to materialised (A male opinion leader in Tarkwa, In-depth interview, March 24, 2017)*

The above comments by the opinion leader clearly show that surface mining activity aside causing much LULC change is having a devastating effect in the study area. This finding is not different from a similar study in a mining community in Ghana by Suleman, Mariwah, & Mensah (2013) which found several natural assets such as forest, water bodies, and farmlands lost through unregulated mining activities. These developments suggest that the current LULC change of the area dominated by artificial surfaces and associated built environment with surface mining activities been a major cause have several implications on the natural environment especially farmlands which support the livelihoods of many residents of the study area.

3.1. Implications for urban agriculture

The present LULC change of the study with a substantial decreased in cultivated and managed vegetation, and natural and semi-natural vegetation against increased in artificial and associated areas was found to have several implications for urban agriculture especially farming which was predominantly

practices in the study area. These implications were found in the area of loss of jobs, change of livelihoods, and food insecurity.

In terms of loss of jobs, urban agriculture is well recognised for supporting thousands of urban dwellers worldwide. However, with the loss of about 100 km^2 of cultivated and managed vegetation over a 14-year period in the study area, this benefit may not be well felt in the area. This suggests that farmers who rely solely on farming for their livelihoods and a source of income to support their families have either completely lost their farmlands or substantial portions of such lands. One key informant remarked as follows:

> *In fact, my office has received several complains from the indigenes of Tarkwa about losing their farmlands to surface mining activities. In addition to this, through our routing checks on the activities taking place within the natural vegetation and the general environment of Tarkwa-Nsuaem Municipality, I can strongly confirm that most farmers in this community are jobless now because the farmlands they depend on for their survival have been destroyed or taking away from them for surface mining activities (A representative from the Environmental Protection Agency, In-depth Interview, 18th March 2017)*

Reconciling the above sentiments with the statistics from Ghana Statistical Service (2014) which showed that as at 2010 about one-third of the general population of Tarkwa-Nsuaem Municipality were employed in the agricultural sector means if the above situation continues the unemployment situation in the study area will be worsened. The forgoing defeats the purpose of the current national agricultural policy of Ghana (planting for food and jobs) which requires more farmlands for the cultivation of farm products (Ministry of Food and Agriculture, 2017 as cited in Adjei Mensah et al., 2019).

The loss of farmlands was found to have influenced many of the residents to diversify into different job opportunities especially in the services sector, interactions with representatives from the Forestry Commission and the Town and Country Planning Department of the study area revealed this. This has consequences on the sustainability of urban farming, which is needed to provide enough food crops to supplement the dietary needs and offset employment pressures on other economic activities in the area. The present distribution of economic activities shows the dominance of the services sector in the study area taking close to 70 percent (68.9%) of the working labour force (Ghana Statistical Service, 2014). A distribution which is nearly a reverse of the situation in the year 2000 where the agricultural sector employed more than 60 percent of the working labour force with the services sector given jobs to less than 30 percent of urban dwellers in Tarkwa-Nsuaem Municipality (Ghana Statistical Service, 2004). A clear indication of loss of many workers in the agricultural sector (especially farmers) to the services sector in the area of which lost of cultivated and managed vegetation (farmlands) as observed in the current study is a probable contributory factor. This can be justified by the submissions of some farmers.

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> *"…, I used to farm around the UMAT Basic school area but for some time now, the area has been used for infrastructural purposes. I now farm at the outskirt of the town which is not going on very well due to illegal mining activities so currently, I am focusing on petty trading." (IDI, 1st farmer, 2017)*

> *"Currently, farming is a secondary occupation for me because all the areas I used to farm in Tarkwa have been converted to built-up areas since family members requested the land for such purpose. I currently operate a cold store". (IDI, 4th farmer, 2017)*

In terms of agricultural productivity, these concerns are not good because more farmers and farmlands will have to be readily available to increase agricultural yields to feed the populace with surpluses exported to get additional monies to enhance the development of the area.

Closely related to the loss of farmlands and diversification of jobs into the services sector is food insecurity. The Sustainable development Goal 2 (SDG 2) talks about ending hunger, achieving food security and improved nutrition, and promoting sustainable agriculture by 2030. To achieve this goal in Ghana and the study area in particular, requires among other things, the availability of more protected agricultural lands and increased labour force in the agricultural sector. However, these two particular factors were found to be insufficient in the area with substantial agricultural lands lost to the built-up environment and other land uses, and much labour force moved to other economic activities. The implication is that the limited agricultural lands and labour force may hamper the municipality's effort to achieve food security as enshrined in SDG 2. Tarkwa-Nsuaem is noted for the production of staples such as maize, cassava, plantain, yam and coconut but taking into consideration the above analysis, the production of these staples may hugely be affected.

4. CONCLUSIONS

In all, the LULC dynamics of Tarkwah-Nsuaem between 2002 and 2015 time interval can be said to be excessively dominated by artificial surfaces and associated areas (built-up environment). Within a space of 14 years, the artificial surfaces and associated areas were found to have increased more than 200 percent from 54.7371 km^2 to 167.5755 km^2 at the expense of other LULC. A change detection analysis confirmed this development with agricultural lands and the natural vegetation experiencing a substantial reduction in their coverage under the time interval under study. For instance, agricultural lands reduced from 584.0289 km^2 to 484.9308 km^2 between 2002 and 2015. The forgoing statistics pose threat to food security in the area as Tarkwa-Nsuaem is well recognized for the production of important food and tree crops (such as maize, cassava, yam, cocoa, oil palm, rubber) and also has a higher agricultural growth rate of 5.4 percent above the national growth rate of 4.8 at the end of 2018 (Ghana Statistical Service, 2019).

In addressing the above problem, the Tarkwa-Nsuaem Municipal Assembly in collaboration with the Environmental Protection Agency of the area should make the necessary efforts to reclaim and restore some of the lost agricultural lands. It was revealed that many of such lands were cleared and used for illegal small-scale mining activities. However, with Ghana's national government strong quest to end illegal mining activities in the country many of these lands have now become vacant with mining pits on them. Good reclamation and ecological restoration strategies or processes should be pursued to close these pits and enrich the soil to fully recover the lands to its original state for agricultural purposes. Post-mining restoration practices at Zululand (South Africa) and Haller Park (Kenya) provide good examples (Festin, Tigabu, Chileshe, Syampungani, & Odén, 2019) for the application of such measures in the study area.

In addition to reclaiming the lost agricultural lands, urban growth boundary is another strategy that can be undertaken by Tarkwa-Nsuaem Municipal Assembly to protect agricultural lands in the study area. It is a policy tool used by urban planners to protect natural and agricultural lands by using it as a delineated boundary beyond which development is not permitted. This can be done by mapping all agricultural lands and making them fall outside the growth boundary with routing monitoring exercises undertaken on them to check that developments are taking place within the boundary. This strategy will help to concentrate physical developments away from conserved agricultural lands and in essence protect them for future use. The application of this strategy has been very successful in both developed and developing countries where it has helped to protect destructions of many agricultural lands (Greenbelt Alliance, 2016; Horn, 2015; Woo & Guldmann, 2014).

Lastly, an intensive educational campaign by the city authorities should be promoted. This can take a form of community fora and radio discussions to sensitize the residence of the area about the need to protect agricultural lands. The discussion should highlight on the benefits of agricultural lands to both present and future generations, sustainable land management practices that can be used by community members to conserve those lands, and available punishment available to individuals that will be found degrading agricultural lands for their selfish interest. These will give the community members the necessary knowledge and motivation to protect agricultural lands in the area.

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