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Land Use and Land Cover Change Effects on Food Production Resources in the Offin River Basin, Ghana

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Abstract: ***The study examined land use and land cover change and its implication on crop production resources in the Offin River basin. Landsat images of Multi-spectral Scanner (MSS), Thematic Mapper (TM) and Enhanced Thematic Mapper Plus (ETM+) together with farm survey and crop production data were utilized for the study. Handheld GPS (Garmin eTrex) and farming household questionnaire were used to map 398 farmlands. Integrated applications of ERDAS imagine (10.1) and ArcGIS (10.1) software coupled with Microsoft office tools were used to analyze landsat images, farming household and crop production data. The land use and land cover change analysis revealed that natural forest and secondary forest reduced by 54.03 % and 10.05 % while degraded land and deterioration of water resources sharply increased by 95.71 % and 78.60 % respectively. The study showed that 53.27 % and 70.10 % of smallholder farmers had cropland size less than 1 hectare and farmlands less than 2 hectares respectively. Finally, the production level of maize, plantain, cassava, cocoyam and rice had decreased considerably by 50.55, 65.68, 39.70, 88.34 and 88.45 % respectively. The policy implication is that the enforcement of environmental laws to compel municipal and districts assemblies to protect productive land and water resources should be vigorously pursued.***

Keywords: Land use /land cover change; landsat images; soil degradation; food production; Offin basin.

1. Introduction

Land use and land cover change (LULC) is a major driving force responsible for global environmental change. It impacts on land has been hampering food production through deforestation, soil degradation, accelerated soil erosion and persistent flooding.

Soil degradation is a global phenomenon contributing to poor soil productivity and low food production, mainly in Africa. Accelerated soil erosion leads to decline in soil fertility and crop yields. Deforestation reduces soil's ability to hold enough water, impedes soil infiltration and thus increases surface runoff. Flooding also destroys food crops, increases surface run-off production and accelerates soil erosion.

Krause (2002) noted that land use land cover change affects roots, soil porosity and soil moisture-holding capacity. Lambin *et al*. (2000) and Sanchez (2002) indicated that soil degradation induced by land use and land cover change is among the major factors causing low food production in sub-Saharan Africa.

Land cover refers to biophysical characteristics of the Earth's surface (such as vegetation, water) while land use refers to the way in which land has been used by human actions and their habitats (such as agriculture, settlements, industry) (Ellis, 2016).

Land use and land cover change is wide-spreading, accelerating (Agarwal *et al*., 2002) and has become an important component in global, regional and local planning. However, land use and land cover change has altered the availability of biophysical resources with enormous adverse effects on land and water resources for food crop production.

In Ghana, land use and land cover change has resulted in severe environmental degradation through destruction of forests, farmlands and water resources for gold, timber and sand to the detriment of natural resources for food crop production and food security.

In Offin river basin, the effect of land use and land cover change is being felt through soil degradation, deforestation, destruction of streams and rivers and persistent annual flooding. However, the extent of land use and land cover change and its impact on food production resources in the basin has not yet been studied. The objective of this paper was to examine the land use and land cover change and its implication on food production resources in Offin river basin using GIS and Remote Sensing, farmland survey and food production data. This paper will be useful for land use planners and water resources managers in formulating environmental policy and adaptations to ameliorate environmental degradation.

2. Materials and Methods

2.1 Study Area

Offin River Basin is a sub-basin of Pra River Basin in the southwestern river system of Ghana. The basin lies between 5^{o} 30' to 6^{o}54' North Latitude and 1^{o}30' to 2^{o}15' West Longitude. It sprawls over 6,561 km^2. The average annual rainfall ranged from 1262.7 mm to 1637.3 mm. Mean maximum and minimum temperature recorded 33°C and 22°C respectively.

2.2 Remote Sensing Data

The Landsat Multi-spectral Scanner (MSS) 1986, Landsat Thematic Mapper (TM) 2002, Landsat Enhanced Thematic

Mapper Plus (ETM+) 2008 and 2015 images coupled with 239 ground control points (GCPs) were used to analyze land use and land cover change. Landsat images were imported into ERDAS 10.1 for geometric correction, spectra enhancement, stacking, mosaicking, sub-setting and classification. Maximum likelihood classifier (MLC) algorithm was employed in supervised classification together with 239 ground control points (GCPs). Image differentiation tool in ArcGIS 10.1 and change detection option in ERDAS were used to compute the extent of change in all the land use and land cover classes and the generations of thematic maps. The GPS co-ordinates, Google earth images and knowledge of the area were used in the accuracy assessment. Classification error matrix and KAPPA were used to calculate the producer's and user's accuracy level as well as the Kappa accuracy level.

2.3 Farm mapping and Farming household survey

A total of Three hundred and ninety eight farmers were randomly sampled from Jacobu, Dunkwa-on-Offin, Manso Adubia and Nyinahin in the basin using a multistage sampling technique. GPS Garmin eTrex and household questionnaire were used to map the farmlands and capture data related to the causes and consequences of land use and land cover change. Food production data of major food crops (plantain, cassava, cocoyam, maize and rice) obtained from the Ministry food and Agriculture were analyzed with Microsoft Excel.

3. Results and Discussion

3.1 Land Use Land Cover Change in the Basin

The natural forest, secondary forest, cultivated land, water bodies and degraded land were the dominant land use and cover types identified in the Offin river basin (Table.1). Over the period (1986-2015), natural forest, secondary forest and water bodies have reduced by 49, 261, 24,076 and 8,376 ha respectively whereas cultivated land and degraded land increased by 33,678 and 48,035 ha respectively (Table 2). These changes in land use and land cover classes have led to environmental degradation that could impacts negatively on soil fertility, water supply and food production. Previous studies in Ghana (Boakye, 2008; Adubofour, 2011; Adu-Poko *et al*., 2012) have reported a similar decreasing trend in forest resources and destruction of the water bodies in the forest belts and major river basins in Ghana.

Table 1: Classified land use and land cover classes (ha) in the Offin river basin (1986-2015)

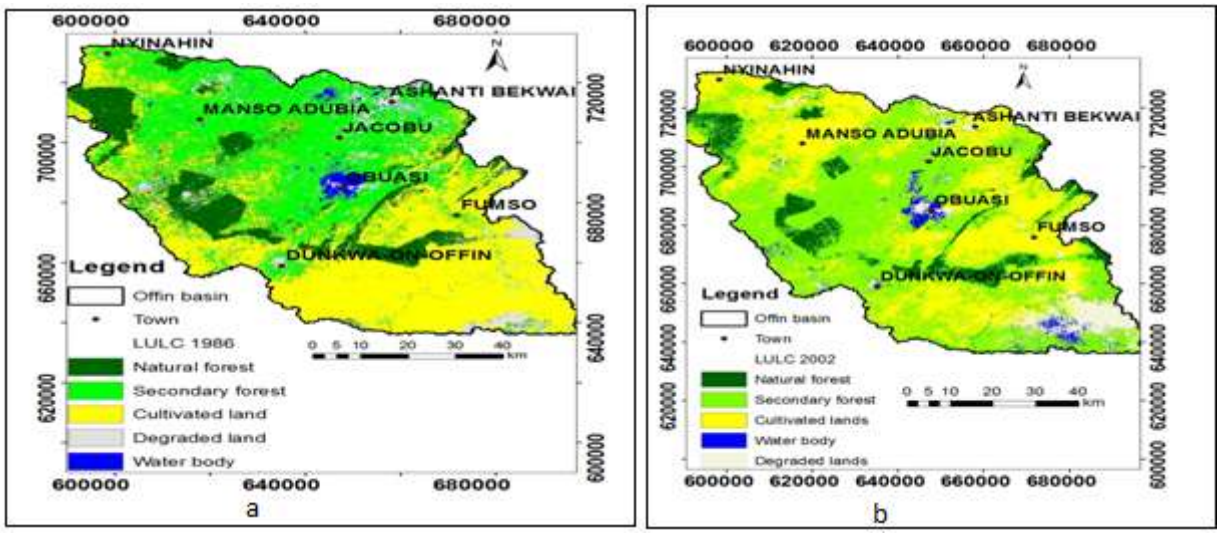
Land use and land cover classes	Land use and cover classes (ha)			
	1986	2002	2008	2015
Natural forest	91,168(13.88)	54,040(8.23)	55,726(8.49)	41,907(6.38)
Secondary forest	239,194(36.43)	315,908(48.11)	209,035(31.84)	215,118(32.76)
Cultivated land	265,409(40.42)	227,171(34.60)	306,638(46.70)	299,087(45.55)
Water bodies	10,656(1.62)	13,664(2.08)	11,030(1.68)	2,280(0.35)
Degraded land	50,187(7.64)	45,831(6.98)	74,185(11.30)	98,222(14.96)
Total	656,614(100)	656,614(100)	656,614(100)	656,614(100)

*Values in bracket are the percentages (%)

Table 2: Changes in land use and land cover classes (ha) in the Offin river basin (1986-2015)

Land use and land cover classes	Land use and land cover classes (ha)			
	1986-2002	2002-2008	2008-2015	1986-2015
Natural forest	-37,128(-41)	1,686(3)	-13,819(-15)	-49,261(-54)
Secondary forest	76,714(32)	-106,873(-34)	6,083(3)	-24,076(-10)
Cultivated land	-38,238(-14)	79,467(35)	-7,551(-3)	33,678(13)
Water bodies	3,008(28)	-2,634(-19)	-8,750 (-82)	-8,376(-79)
Degraded land	-4,356(-9)	28,354(62)	24,037(48)	48,035(96)

*Values in bracket are percentage of LULC changes (%), (+) indicate increase change, (-) indicate decrease change



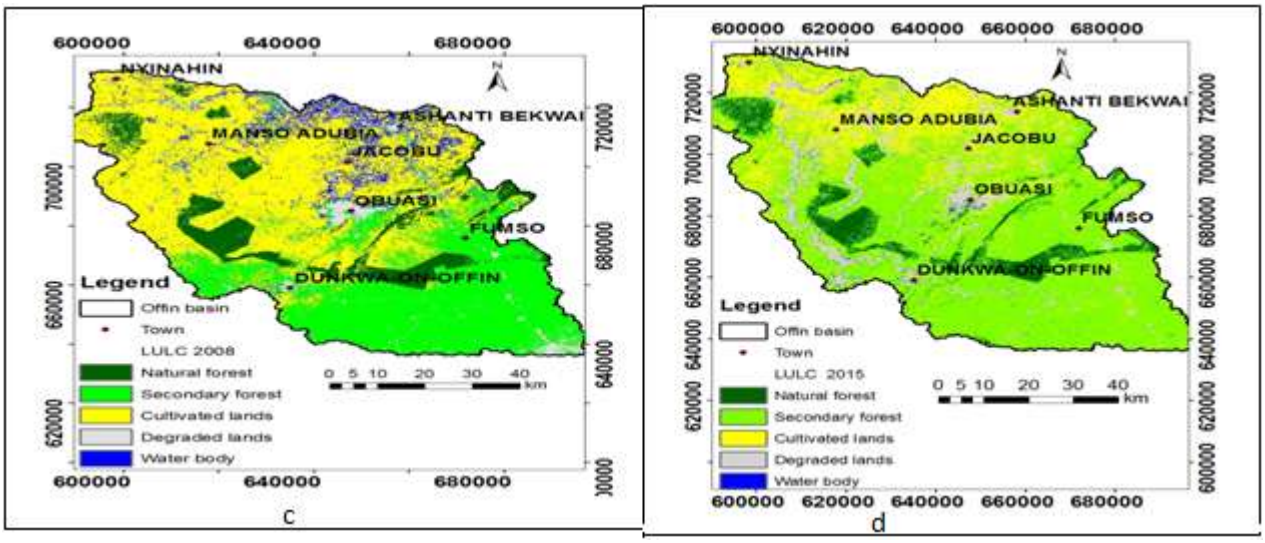


Figure 1: Land use and land cover classes (a) 1986, (b) 2002, (c) 2008 and (d) 2015

3.2 Farmland Distribution in Offin River Basin

Three hundred and eight nine farmlands in the basin were mapped and the result presented in the Table 3. The results revealed that about 53.27 % of farmers had cropland size less than 1 hectare for food crop cultivation. In addition, 70.10 % of farmers had total agricultural land less than 2 hectares for food crops, cash crop (cocoa, oil palm, citrus) and vegetables cultivation. The implications are that the majority of farmers have access to small farmlands for food production and these are attributed to the severe land degradation. The small farmland size constrains agricultural productivity and consequently rising food insecurity and poverty among smallholder farmers.

Table 3: Farmland distribution in the Offin river basin

Farmland	Farm size class (ha)	Offin basin n =398	Town			
			Nyinahin n=100	Manso n =88	Jacobu n=84	Dunkwa n=126
Croplands	Less than 1 ha	212 (53.27)	57(57)	31(35.23)	53(63.10)	71(42.06)
	Between 1 and 2 ha	170 (42.71)	31(31)	57(64.77)	29(34.52)	53(42.06)
	More than 2ha	16(4.02)	12(12)	0(0.00)	2(2.38)	2(42.06)
Agricultural landholding (food crops, cash crop and vegetables)	Less than 2ha	279(70.10)	61(61)	54(61.36)	59(72.62)	105(83.33)
	Between 2 and 5 ha	85 (21.36)	37(37)	27(30.68)	19(44.05)	19(15.08)
	More than 5ha	34(8.54)	2(2)	7(7.95)	6 (2.38)	2(1.59)

n = total number of sample size
Values in bracket are the percentages (%)

3.3 Production Level of Food Crops in the Basin

The results showed that the production level of the main food crops cultivated in the basin has declined with time (Table 4). Between 2004 and 2014, the production of maize, plantain, cassava, cocoyam and rice has reduced by 50.55, 65.68, 39.70, 88.34 and 88.50 % respectively. The declined in major food crop output could be attributed to the accelerated land and water resources degradation through the adapted land use and land cover change activities in the basin.

Table 4: Production level of six major food crops cultivated in the Offin river basin

Major food crop in the basin	Food Production level (Mt/ha)				Change in Production (Mt/ha)	
	2004	2008	2010	2014	2004 - 2014	%
Maize	43475.37	23697.37	22537.36	21496.74	-21978.63	-50.55
Plantain	302972.7	170615.50	111407.5	103974.70	-198998	-65.68
Cassava	283964.4	22802.72	221350.3	171221.00	-112743.4	-39.70
Cocoyam	108601.6	23786.00	21872.07	12660.00	-95941.6	-88.34
Rice	1390.116	301.60	183.74	159.90	-1230.22	-88.50
Total	740404.1	444,203.20	380,519.60	309,512.4	-430891	-58.20

3.4 Driving forces of land use land cover changes

The surface mining, sand winning, water extraction and deforestation were identified as the major driving forces behind land use and land cover change (Table 5). These drivers of land use and land cover change have translated into soil degradation, drying of water bodies, low crop yield, rising food prices, flooding, declining soil fertility and loss of human lives (Figure 2). Similar findings have been reported by Akabzaa *et al.* (2005), Kumah (2006) and Schueler *et al.* (2011) in Ghana that conversion of agricultural lands into mining around river basin in Ghana

constituted the major driving force towards soil degradation, dwindling of water bodies and declining soil fertility.

Table 5: Response of farmers on causes of land use and cover change in the basin.

Factors	Offin river basin n=398	Town			
		Nyinahin n=100	Manso Adubia n=88	Jacobu n=84	Dunkwa-on-Offin n=126
Settlement	213(54)	59(59)	56(64)	41(49)	57(45)
Bush fires	32(8)	12(12)	5(6)	10(12)	5(4)
Mining	385(96)	100(100)	85(97)	81(96)	117(93)
Farming practices	223(56)	52(52)	58(66)	56(67)	57(45)
Sand winning	309(78)	75(75)	69(78)	79(94)	86(68)
Deforestation	252(63)	59(59)	49(56)	71(84)	73(58)
Waste disposal	70(18)	10(10)	12(14)	22(26)	26(21)
Water extraction	271(68)	56(56)	70(80)	59(70)	86(68)

*Values in bracket are the percentages (%); n= total number of sample

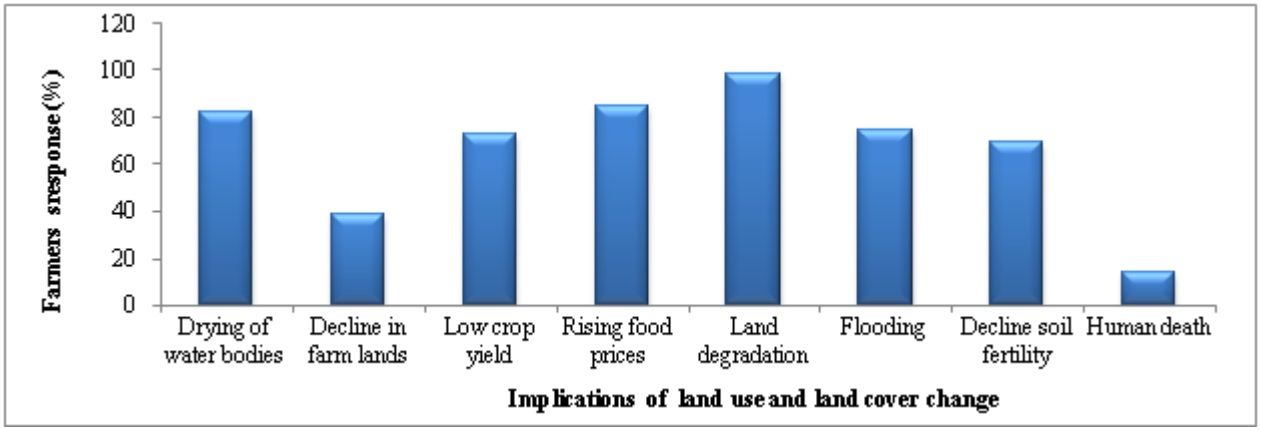


Figure 2: Response of farmers on the implications of land use and land cover change in the Offin river basin

4. Conclusions

Land use and land cover change (LUCC) in the basin has had negative impacts on land and water resources with the illegal surface mining, sand winning, water extraction and deforestation being the major drivers behind the deterioration of productive farmland. In inclusion, land use land cover change has exposed the basin to massive soil degradation, dwindling of streams and rivers, destruction of wetland resources, recurrent flooding, poor soil fertility and low crop yield. Thus threaten food production and food security among the smallholder farmers in the basin.

5. Policy recommendation

- Restoration of degraded farmlands through reforestation, afforestation and investment in physical soil and water conservation would help ameliorate soil degradation and erosion
- Implement effective and efficient adaptation measures to motivate smallholder farmers to rehabilitate their degraded farmlands such as provision of free tree seedlings and effective forest plantation extension services.

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References

[1] Adu-Poko, I., Drummond, J., and Li, Z., (2012). Land-cover change monitoring in Obuasi, Ghana: an integration of earth observation, geoinformation systems and stochastic modelling. Journal of Earth Science and Engineering, 2 (5). 1-14 http://eprints.gla.ac.uk/64272

[2] Agarwal, C., Green, G. M., Grove, J. M., Evans, T. P., and Schweik, C. M., (2002). A Review and Assessment of Land-Use Change Models: Dynamics of Space, Time, and Human Choice. General Technical Report NE-297. Newtown Square, Pennsylvania: U.S. Department of Agriculture, Forest Service, Northeastern Research Station. 61 pp.

[3] Ahmed, K.F., (2016). Climate Change Impact on Agricultural Land Use in West Africa and Its Implication on Regional Climate Projection *Doctoral. Dissertations.* Paper 1018.

[4] Akabzaa, T.M., Banoeng-Yakubo, B.K. and Seyire, J.S., (2005). Impact of Mining Activities on Water in the Vicinity of the Obuasi Mine. 79, 377-379.

[5] Boakye, E., Odai, A. and Annor, F. O., (2008). Landsat images for assessment of the impact of land use and land cover changes on the Barekese catchment in Ghana. European Journal of Scientific Research. 22(2): 269–278.

[6] Krause, P. (2002). Quantifying the impact of land use changes on the water balance of large catchments using the J2000 model. *Phys. Chem. Earth*, *27*, 663–673.

[7] Kumah, A., (2006). Sustainability and gold mining in the developing world. Journal of Cleaner Production. 14(3–4):315–323. doi: 10.1016/j.jclepro.2004.08.007
[8] Lambin, E.F., Rounsevell, M.D.A. and Geist, H.J., (2000). Are agricultural land-use models able to predict changes in land-use intensity? Agric. Ecosys. Environ. 82, 321 – 331.
[9] Sanchez, P.A. (2002). Soil Fertility and Hunger in Africa. *Scienc*, 295, 2019 – 2020.
[10] Schueler, V., Kuemmerle, T. and Schröder, H., (2011). Impacts of Surface Gold Mining on Land Use Systems in Western Ghana. Published online 2011 March 18. doi: