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Land Use Trajectories, Forest Cover Change and the Consequential Land Degradation of the Asunafo Forest, Ghana

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Abstract: *The paper examines causative factors of land cover change of the Asunafo forest in Ghana. And, investigate whether the replacement of dense forest by crop land and other opportunistic covers has resulted in land degradation. It is suggested that settlement expansion, smallholder farming, timber extraction, wood carving, bushfires and harvesting of non-timber forest products are causal factors of the land cover change. Based on census records, population increase could be considered as ultimate cause of the land cover change, particularly the activities of the proliferating smallholder cocoa farmers. However, timber extraction, which does not relate to population increase and bushfires which showed inverse relationship with population increase are proximate causes. The paper concludes that weed invasion, reduction in native flora and declined in resource base of non-timber forest products are indicative of occurrence of biological land degradation.*

Keywords*: Land, degradation, land use, land cover, Forest,*

1. Introduction:

Environmental degradation has often been blamed on increase in human population over a period of time in a given area. The quintessential question often asked is, does land degradation results from just the sheer number of people using the land or the activities they are engaged in at any given time? Land degradation refers to progressive loss of the intrinsic or natural quality of the land [1:18]. When it occurs in the tropical forest, it reduces the capacity of the inhabitants to manage the natural environment sustainably [2]. Hence, there are attempts to explore optimal ways to avoid land degradation in forest ecosystems [3]. Wardell et al. [4] reproduced the debate in which deforestation is considered as an aspect of the broader land or environmental degradation. Again the authors raised the issue of cause-effect linkages between population increase and environmental degradation which are assumed rather than observed and verified. This paper contributes to the debate by investigating or providing verification of the causative factors of land cover changes of Asunafo area, Ghana. The study further shows how the trajectories of land use lead to land cover changes from dense forest to cultivated land and other opportunistic land covers, commonly associated with degradation lands.

Much of the discourse of population increase and environmental degradation is derived from the Malthusian argument that the power of population to grow is indefinitely greater than the power in the land to produce subsistence for human beings [5:13]. According to this thesis, the disequilibrium between population increase and food supply would lead to unsustainable exploitation of land resources and eventually cause land degradation. This would inevitably affect political economy, family life, prosperity, good citizenry and marriage life. Subsequently, living standards, disease, famine, infant mortality, mob action and political dictatorship would increase resulting in misery, vices and for some moral restraint [6: 5-19]. According to Stiles [7] this scenario would result in shortened fallow period, farmland expansion, agricultural intensification, overgrazing by livestock and overexploitation of fuel wood and constructional material. Subsequently, land degradation would manifest through deforestation, water scarcity, low crop yield and poverty. Poverty makes farmers vulnerable to land degradation, makes them dependent on foreign assistance in the form of food aid and makes them migrate in the long run or starve to death [7].

On the contrary, Boserup [8] posited that instead of land degradation, the increases in population would bring about sustainable land management (SLM) through agricultural

intensification and rise in cropping frequency. The SLM would be occasioned by increased agricultural technology which would help to expand agricultural productivity to cater for the needs of the increased population. According to Stiles [7], agricultural technologies such as farm mechanization, increasing skilled labour, ploughing, fertilizer application and irrigation would occur with increased population growth. Consequently, agricultural productivity would increase. As this happens, market prices, substitutes, inventions and government policies would control land degradation. However, failure of market economy and policies to efficiently manage, develop and allocate land resources would exacerbate land degradation.

According to Wardell et al. [4] the present land use and land cover change in West Africa have their antecedence in imposition of British and French colonial policies and practice. These imposing policies bore relevance to resource base of the river basins in which forest reserves were created. Resource poor areas were converted to labour pools for naturally endowed colonies. The then land use was driven by changing economic opportunities and accessibility to natural resource as determined by colonial laws. Again colonial laws determines data used in quantification of land and its economic value. However, the deficient quantitative data and the models based on such data reproduced inflated or deflated land cover values which often underestimate local situations. The authors advocated for local case studies because such studies highlight important features missed by the quantitative models. Therefore, land use and land cover change represent interaction of social, economic and ecological process which operate at different levels and change over time. It is therefore argued that to base the drivers of land use and cover change on increase in population figures in a relationship where population increase causes land degradation is oversimplification.

2. Materials And Methods:

The study area, Asunafo, occupies land surface of 2,187.5 km^2, lies between latitude $6^o27'$ and $7^o00'$N and longitude $2^o23'$and $2^o52'$W. The climate is wet semi equatorial type with an average temperature ranging between of 17.2 ^oC and 34.3 ^oC. The recorded rainfall values ranges from 1,200 mm – 1,500 mm while relative humidity is 47% – 77% [9; 10]. The vegetation of the area is mainly moist-semi deciduous forest supported by edaphic features categorized as Acrisols, Nitisols and Fluvisols [11].

The land cover analysis was based on Landsat TM5 1986 and Landsat TM5 2003 of the path/row 195/55 and subsetted with upper left coordinates of 501,605 m, 780,225 m and lower right coordinates of 571,605 m, 711,615 m. The image acquisition dates fell within the dry season: 1st January 1986 and 14th March 2003. These dates are appropriate since the phonological changes are likely to be minimal due to the general absence of rainfall within the time period. Pre-processing activities performed on the images include geometric calibration and atmospheric correction. The atmospheric calibration included assigning proper dates of acquisition and sun elevation as well as conversion from digital numbers to sensor radiance and conversion to surface reflectance. In addition the reflectance image was converted to an integer with the use of calibrated coefficient of 10,000 of the surface reflectance image. The images were processed through supervised classification under four cover types: forest reserve, secondary forest, grassland and settlement.

Process of validation included overlaying of mapped Global Positioning Points (GPS) and also comparison with the images on the 2012 Google Earth map of Ghana [12]. All the locations particularly boundaries of the forest reserves were accurately matched.

3. Results:

Figure 1 shows the 1921 forest cover map of Ghana and the red outline box depicts Asunafo area. The map shows evergreen forest, deciduous forest and transition savanna. Trees of the evergreen forest measured 20 to 150 feet or more in height linked together by many wood lianas and herbaceous climbers. The amount of shrubs on the forest floor depended on allowable penetration of sunlight [13:14]. The deciduous forest displayed upper layer of dominant trees that showed single crowns. Underneath the upper layer are the crowns of the middle layer trees forming a closed canopy. The forest floor contained shrubs, lianas, climbers and herbaceous cover depending on the amount of sunshine received. Trees, especially, the dominant ones shed their leaves during the dry season [13:17].

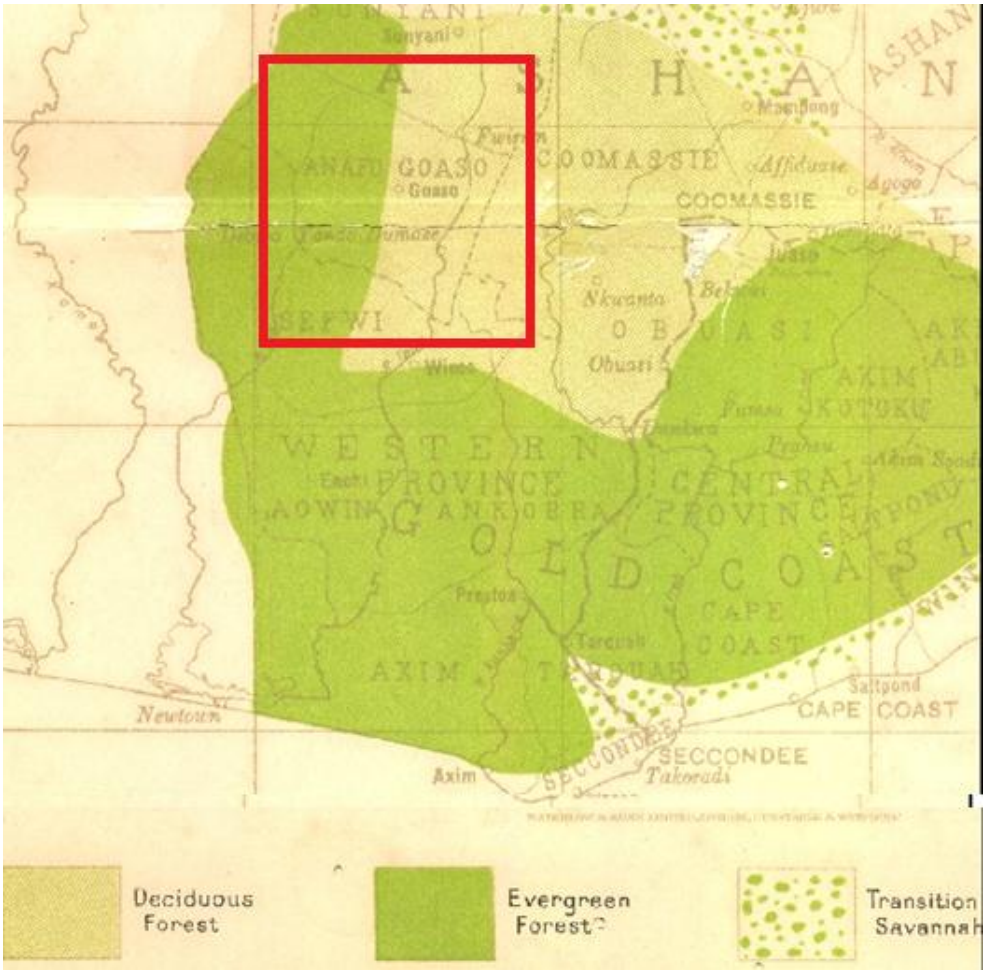

Figure 1: Forest Vegetation Map of Ghana in 1921

Source: Chipp [13]

Figure 2 shows land use and land cover types of Asunafo in 1986. Four land use/cover classes are involved namely: settlement, secondary forest, forest reserve and grassland (grass).

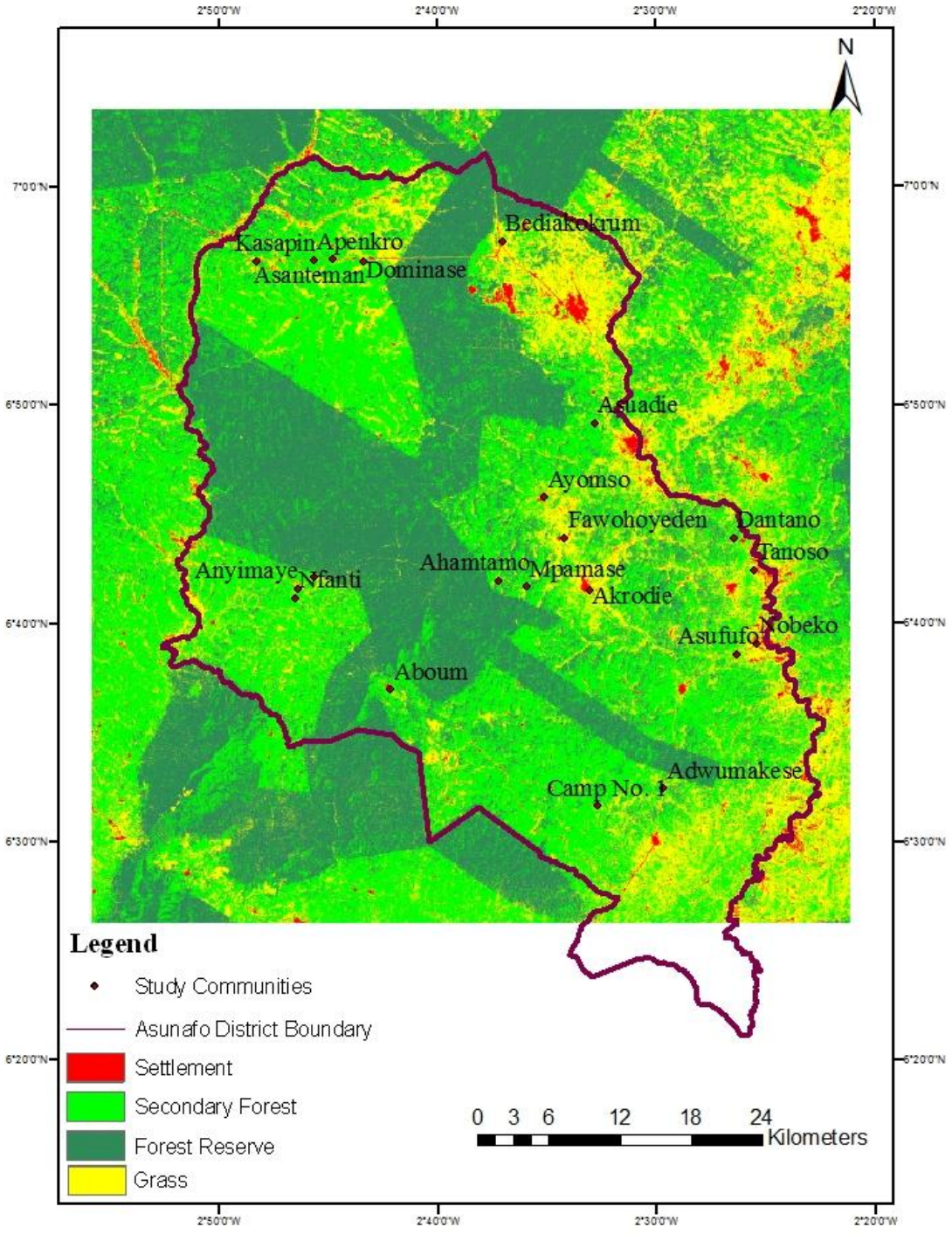

Figure 2: Land cover classes of Asunafo in 1986

Source: Processed by Yiran

Figure 3 shows land use and land cover types of Asunafo in 2003. The same land use/cover classification is used: settlement, secondary forest, forest reserve and grassland (grass).

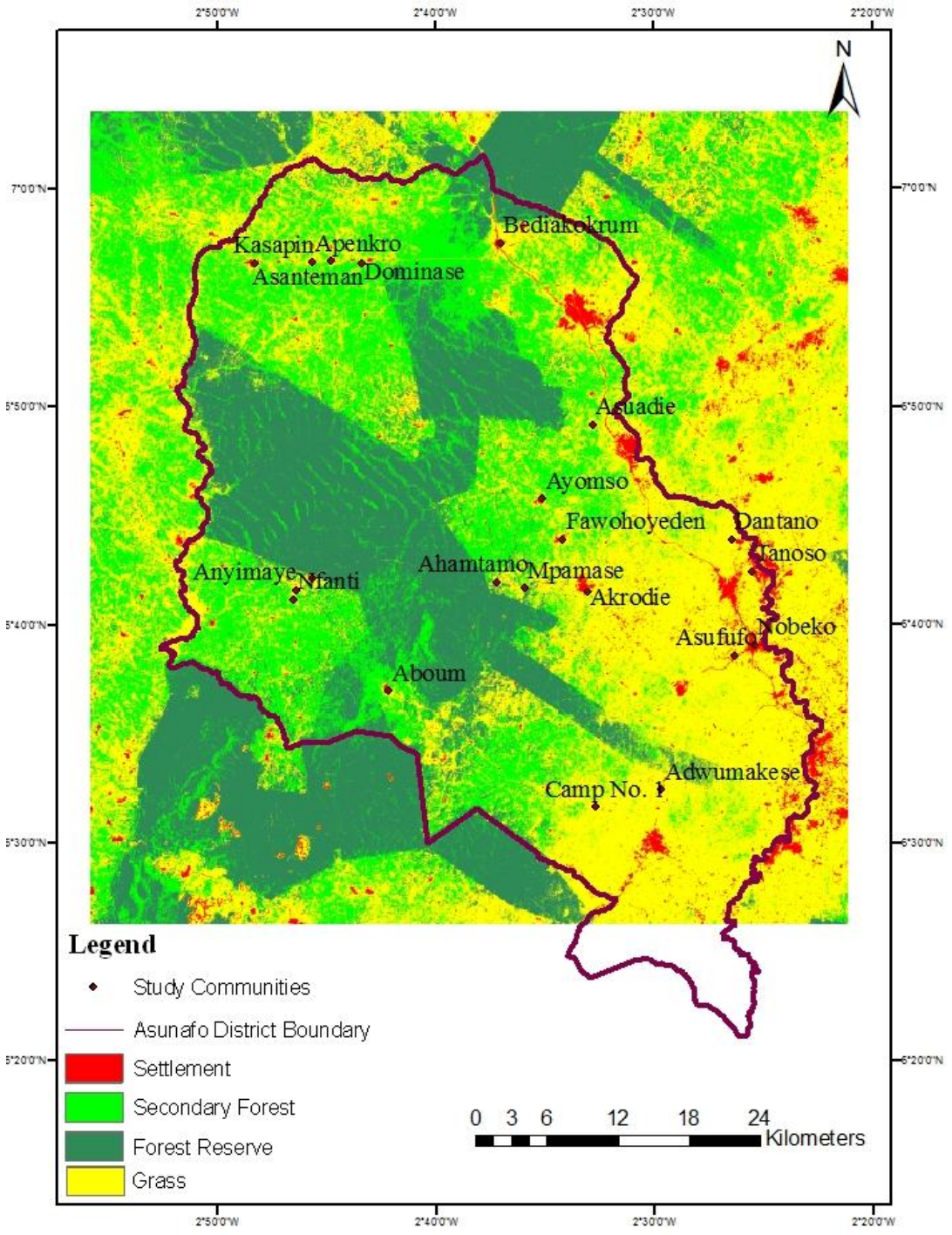

Figure 3: Land cover classes of Asunafo in 2003

Source: Processed by Yiran

The forest reserves were established during colonial rule in 1939 as protected areas barred from farming and other human activities involving cutting but often portions are offered as

timber concession. However, no form of mining activity is permitted to take place within the forest reserve [14]. The secondary forest consisted of a mosaic of fallowed forest and cocoa agroforestry farms. The grassland (represented as grass in the figures) comprised of cropland (maize and cassava) as well as several grass varieties; the most dominant were *Pennisetum purpureum*, *Panicum maximum* and *Rottboellia cochinchinensis*. Settlements consisted of human habitations such as towns, villages and farm cottages.

Table 1 shows the distribution of various cover types in Asunafo. In 1986, the largest proportion of land cover was secondary forest (41%). After 17 years; 1986 to 2003, grassland (44%) became the biggest land cover type. Forest Reserve reduced from 35.9% to 26.4%, secondary forest also reduced from 41.1% to 26.9% while grassland and settlements increased from 21.2% to 44% and 1.8% to 2.8% respectively.

	Forest Reserve	**Secondary Forest**	**Grassland**	**Settlement**
1986	1,576.4 km^2 (35.9%)	1,803.7 km^2 (41.1%)	929.2 km^2 (21.2%)	80.9 km^2 (1.8%)
2003	1,158.5 km^2 (26.4%)	1,179.1 km^2 (26.9%)	1,930.7 km^2 (44%)	121.9 km^2 (2.8%)

Source: Authors

Table 1: Values of land cover classes in Asunafo 1986 and 2003

Table 2 depicts transfer of one land cover type to the other from 1986 to 2003. Settlement showed the highest class change of about 62.3%. However, the largest image difference was shown by grassland in one fold (107.8%). Again, grassland recorded the highest gain in the land cover transfers (71.6%).

	Initial stage image 1986					
Final stage image 2003	**Land cover class**	**Forest Reserve (Area km^2)**	**Secondary Forest (Area km^2)**	**Grassland (Area km^2)**	**Settlement (Area km^2)**	**Class total (Area km^2)**
	Forest Reserve	938,553.3 (59.5%)	182,406.6	37,368	217.8	1,158,545.7
	Secondary Forest	320,511.6	689,047.2 (38.2%)	165,744	3,754.8	1,179,057.6
	Grass	310,267.8	908,782.2	665,249.4 (71.6%)	46,411.2	1,930,710.6
	Settlement	7,052.4	23,452.2	60,841.8	30,554.1 (37.8%)	121,900.5

	Class total	1,576,385.1	1,803,688.2	929,203.2	80,937.9	
	Class change	637,831.8 (40.5%)	1,114,641 (61.8%)	263,953.8 (28.4)	50,383.8 (62.3%)	
	Image difference	-417,839.4 (-26.5%)	-624,630.6 (-34.6)	1,001,507.4 (107.8%)	40,962.6 (50.6%)	

Source: Authors

Table 2: Land cover matrix of 1986 and 2003 for Asunafo in square kilometers

Table 3 depicts types of land use responsible for the land cover changes. Asunafo started as hunter camps, trails and trade routes. Between 1750 and 1777 hunter villages have grown to become towns. Farming in the area rather dates back to 1500 and 1800 AD for various food crops. Cash crops essentially oil palm began in 1807 to 1850. Cocoa became popular in the 1920s, export lumbering in the 1940s and wood carving particular canoe making declined in the 1970. Bush fires recurred in the 1960s, 1970s and the 1980s.

Land use type	**Records**	**Reference**
Settlement	Hunters' villages Towns 1750 and 1777 AD Population: 48,043 in 1960, 82,275 in 1970, 121,973 in 1984 and 174,026 in 2000	[15; 16; 17; 18]
Farming	1500 and 1800 AD plantain (*Musa ABB*), banana (*Musa Sapient*), yam (*Dioscorea guineensis*), rice (*Oryza sativa*), corn/maize (*Zea mays*), cassava (*Manioc*), vegetables (tomatoes, onion and garden eggs), mango varieties, avocado pear and citrus fruits 1807 and 1850 AD oil palm 1921 and 1931 cocoa, also 70% increase in human population	[15; 19; 20]
Timber/logging	1947 Mim Timber Company at Mim 1948 Gliksten West Africa Limited a bush station at Kwapong Two foreign companies exported 80% of timber output 2001 17 timber species were very scarce	[21; 22; 23; 24; 25]
Canoe carving	1970s three groups of carvers: Fantis (7 members) and Ga-Dangmes (Group 1, 13 members and Group 2, 16 members)	[26]

Wild fires	1960s Brong Ahafo Regional House of Chiefs requested the Minister of Agriculture to provide directives to the use of fire for farming in the region. 1970s Department of Forestry in Brong-Ahafo Region suffered widespread forest destruction by fire. 1980s Uncontrollable bushfires destroyed estimated 50% of vegetation and 35% of standing crops country-wide	[27; 28; 29; 30]
Harvesting of non-timber forest product	Dwindling resource base of anwonomo, canes and raphia palm; nsokordua *Garcinia spp* is extinct.	[25]

Source: Authors

Table 3: Determinants of land cover changes

4. Discussion:

4.1. Major Findings:

The broad objective of the study was to verify whether the conversion of dense forest cover to cultivated land and other opportunities covers have resulted in land degradation. Hence, this paper's interests in investigating trajectories of land cover changes and its determinants. The findings on the land cover changes are suggestive of land degradation. The dense forest in 1921, partly evergreen and deciduous has been converted to grassland vegetation. Grassland increased at 107.8% (1,001,507.4 km^2) between 1986 and 2003. The increase was at the expense of the forest reserve which was reduced by 417,839.4 km^2 (26.5%) and the secondary forest which also decreased by 624,630.6 km^2 (34.6%). Settlement showed the largest positive cover change (62.3%), whiles secondary forest showed the largest negative change (61.8%) followed by forest reserve (40.5%) negative with grassland increasing only by (28.4%). In terms of image differencing, grassland showed the highest gain from the land cover transfer between 1986 and 2003 (71.6%), forest reserve followed with 59.5%, secondary forest 38.3% and settlement 37.8%. The causal factors of the land cover change included population increase (70% population increase between 1921 and 1931) in terms of settlement creation and upsurge in the number of smallholder farmers. Other causative factors were operation of medium to large scale forest-dependent industries essentially foreign and local timber companies and proliferation of canoe carving as well as rampant wild fires.

4.2. Clarification Of Findings:

Explanations to the land cover changes have various dimensions. History reveals that Asunafo started as hunters' villages. It attracted large population because of the cheap prices of food, meat and other forest products (Robertson, 1973). Between 1750 and 1777, the population of the villages increased and converted a substantial portion of the dense forest cover to settlement. The dense forest provided space and constructional materials. However, chaos and insecurity occasioned by ethnic battles hampered rapid development [15:118-120]. Boahen [20] reproduced that the people were gatherers of forests products, hunters, traders and food farmers. Therefore, they slightly modified the dense forest cover. Minor deforestation was easily recovered during few years of fallow. Farming intensified after 1800 through the growing of indigenous crops.

The 1800s witnessed the abolishment of slave export trade, the British did so in 1802 and the Danes in 1807 with strict enforcement in their occupied territories. In the absence of slave trade, the Europeans promoted agricultural export trade. Initially, maize and cassava dominated until oil palm trade became the most prominent [15]. Later, cocoyam, cotton and coffee were introduced. Between 1807 and 1850 farming was more important due to the introduction of the export of palm oil to Europe. Ashanti resettled many of their slaves in Asunafo to do plantation farming for the stool [15:121]. Unfortunately, palm oil export did not reign for a long time since supply exceeded demand at the world market and expectedly, prices fell [19:100]. Furthermore, there were many ethnic wars at the time which disturbed the growth of palm oil export [15:145]. It was not until 1896 that Asunafo chiefs entered into a treaty with the British for protection against the Ashantis [31]. Although the nineteenth century witnessed great improvement in farming especially in the study area with the introduction of Ashanti slaves, the impact on the dense forest cover was still minimal.

Peace prevailed after the Yaa Asantewaa war of 1900. Asunafo came to be administered by a British District Commissioner. Human population grew significantly converting many villages into towns. Dickson [15:279] reported of 70% increase in the population of Ahafo [Asunafo] between 1921 and 1931. The impact was massive deforestation resulting from the creation of settlements and cocoa farms. In addition, the area was opened up with good roads particularly the triangular road which linked the Pamu forest to Goaso and Sunyani. The deforestation necessitated creation of protected areas as forest reserves in 1939 [14; 15:167].

Export of timber from Asunafo began with the establishment of Mim Timber Company at Mim in 1947 and Gliksten West Africa Limited bush station at Kwapong in 1948. The two firms exported about 80% of their log and veneer output [21:24; 22:29]. In addition to the two large-scale timber firms, many local small-scale timber merchants joined the lumbering business. The impact of lumbering activity on the dense forest was very devastating. The timber firms extracted logs from both forest reserves and off-reserve forests including cocoa-agroforestry farms [23]. By the 1960s, the over-exploitation of timber species from Asunafo's dense forest had resulted in shortages of timber logs [24].

In addition, wood carving particularly canoe making in the 1970s adversely affected the dense forest cover. Nfanti, a case study community located on latitude 06.41' N and longitude 002.46' W was reportedly established by Fanti canoe carvers. Sheves [26] reported of a decline in the industry due to scarcity of large timber logs at Asunafo.

Moreover, wild fires exacerbated degradation of the forest, in that, when fire passed through the forest, one could walk through the forest without the help of cutlass; soon after rainfall, the forest floor becomes colonized by plants which hitherto did not exist in the forest. The menace of fire in Asunafo and Brong Ahafo Region as a whole necessitated the Regional House of Chiefs to request the Minister of Agriculture to provide directives to the use of fire for land preparation in the region during the 1960s [27]. During the farming season most farmers cut the vegetation, leave it for approximately two weeks to allow it to dry and set fire of it to clear the land for cultivation, a typical farming practice known as the slash and burn. Although the Department of Forestry in Brong-Ahafo Region practiced early controlled burning in the forest reserves, uncontrolled bushfires still occurred and destroyed forest plants in the 1970s [28]. The country-wide bushfire of Ghana that occurred in 1982-1983 reportedly destroyed an estimated 50% of vegetation cover and 35% of standing crops, which Asunafo area was a major victim. In many cases the destruction of forest cover leads to vegetation succession where grass immediately takes over. There are other observations which show different ways that grasslands have emerged in the area.

Seeds of grass were allegedly propagated by wheels of mobile timber equipment. As they traverse the forest, timber vehicles and skidders transport grass seeds even to the forest reserves. Hence, the grass invasion began along the timber tracks in the forest reserve and along major roads in Asunafo. Other lands often colonized by grass included areas that were continuously cropped and thus contained reduced tree cover and exhausted soil. Vegetation

of such lands was easily replaced by grass varieties such as *Pennisetum purpureum, Panicum maximum* and *Rottboellia cochinchinensis*.

4.3. Derivation Of Land Degradation:

The process of conversion of dense forest to cultivated land and other opportunistic covers caused severe decrease in biodiversity notably reduction in native species resulting in biological degradation of land [32]. The harvesting of forest products particularly timber was expected to increase the well-being of the people in Asunafo. However, foreign companies repatriated their profit and local timber firms failed to give back to the study area. Hence, the forest resource decline represented loss of human well-being and as such classified as land degradation. Similarly low returns from farming and low investment in land restoration practices have had negative effect of land including land exhaustion, erosion and loss of fertility [33].

5. Conclusion:

The foregoing clearly shows that population increase was a significant causative factor in the adverse land cover change and the resultant land degradation. The increase in the number of smallholder farmers meant a cumulative conversion of large tracts of forest to cropland. However, the deforestation resulting from timber extraction and canoe making could not be attributed to population increase. Moreover, there seemed to be more wildfires in the 1960s to the 1980s than there were in 1990s to date. It is implied that more bushfires occurred with less population and vice versa. The spread of invasive species were attributed to the wildfires and also movement of timber equipment. Hence, upsurge in the number of farmers (population increase), activities of two foreign timber companies (not attributed to population increase) and wildfire (also not caused by population increase) were causal factors behind land cover changes and the consequential land degradation.

Land use types that lead to land cover change may not necessarily relate to increases in human numbers rather the intensity and frequency of the land use activities. Hence, timber extraction holds great potential to degrade the forest reserves and must therefore be reconsidered in the light of sustainable land use ethics.

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References:

1. E.A. Gyasi, O. Karikari, G. Kranjac-Berisavljevic, and V.V. Vordzogbe, Study of Climate Change Vulnerability and Adaptation Assessment Relative to Land Management in Ghana, University of Ghana, Legon, Accra, 2006, pp. 1-91 http://www.nlcap.net/fileadmin/NCAP/Countries/Ghana.
2. J. Mayers, G. Birikorang, E.Y. Danso, K.S. Nketia, and M. Richards, Assessment of Potential Impacts in Ghana of a Voluntary Partnership Agreement with the EC on Forest Governance International Institute for Environment and Development, London, 2008, pp. 1-44.
3. B. Swallow, M. van Noordwijk, S. Dewi, D. Murdiyarso, D. White, J. Gockowski, G. Hyman, S. Budidarsono, V. Robiglio, V. Meadu, A. Ekadinata, F. Agus, K. Hairiah, P. Mbile, D.J. Sonwa, and S. Weise, Opportunities for Avoided Deforestation with Sustainable Benefits ASB Partnership for the Tropical Forest Margins, Nairobi, Kenya, 2007, pp. 1-52.
4. D.A. Wardell, A. Reenberg, and C. Tottrup, Historical footprints in contemporary land use systems: forest cover changes in savannah woodlands in the Sudano-Sahelian zone. Global Environmental Change 13 (2003) 235–254.
5. J. Bonar, First Essay on Population 1798, Sentry Press, New York, 1965.
6. M.P. Fogarty, An Essay on Population Volume One, Dent and Sons, London, 1958.
7. D. Stiles, Linkages between Dryland Degradation and Migration. Desertification Control Bulletin 30 (1997) 9-18.
8. E. Boserup, The Condition of Agricultural Growth: The Economics of Agrarian Change under Population Pressure, George Allen and Unwin Ltd, London, 1965.
9. F.K. Abagale, J. Addo, R. Adisenu-Doe, K.A. Mensah, S. Apana, A.E. Boateng, N.A. Owusu, and M. Parahoe, The Potential and Constraint of Agroforestry in Forest Fringe Communities of the Asunafo District-Ghana, Tropenbos International http://www.tropenbos.org/search?search, Amsterdam, 2003, pp. 1-60.
10. Ghana Meteorological Agency, Rainfall, Humidity and Temperature Data on Goaso Weather Station, Ghana Meteorological Agency Accra, 2010.
11. Survey Department, Ghana sheet 0603A1, 0603A2, 0603A3, 0603A4, 0603B1, 0603B3 and 0603D1, Ministry of Land and Mineral Resources, Accra, 1972.
12. A. Shalaby, and A. Gad, Urban Sprawl Impact Assessment on the Fertile Agricultural Land of Egypt Using Remote Sensing and Digital Soil Database, Case Study:

Qalubiya Governorate, US-Egypt Workshop on Space Technology and Geo-Information for Sustainable Development National Authority for Remote Sensing and Space Sciences, Egypt, Cairo, 2010, pp. 1-11.

13. T.F. Chipp, Forest Officers Handbook of the Gold Coast, Ashanti and the Northern Territories, Waterlow and Sons Ltd, London, 1921.
14. Environmental Protection Agency, National Action Programme to Combat Drought and Desertification. National Action Plan April 2002, Environmental Protection Agency, Accra, 2002.
15. K.B. Dickson, A Historical Geography of Ghana, Cambridge University Press, Cambridge, 1969.
16. A.F. Robertson, Histories and Political Opposition in Ahafo, Ghana. Africa: Journal of the International African Institute 43 (1973) 41-58.
17. Ghana Statistical Service, 1984 Population Census of Ghana: Demographic and Economic Characteristics Brong Ahafo Region, Ghana Statistical Service, Accra, 1987.
18. Ghana Statistical Service, 2000 Population and Housing Census: Special Report on 20 Largest Localities, Ghana Statistical Service, Accra, 2002.
19. N. Fold, Transnational Sourcing Practices in Ghana's Perennial Crop Sectors. Journal of Agrarian Change 8 (2008) 94-122.
20. A.A. Boahen, The States and Cultures of the Lower Guinea Coast. in: B.A. Ogot, (Ed.), General History of Africa: Volume V. Africa from the Sixteenth to the Eighteenth Century, Berkeley University Press/UNESCO http://books.google.com.gh/books, Berkeley, 1992, pp. 204-220.
21. S. Adei, Technology Transfer and Nationalization in Ghana, International Development Research Centre, Ottawa, 1987.
22. F.K. Odoom, Chain sawing in the Natural Forest of Ghana: An Assessment of the Socio-Economic Impacts of this Practice Forest Harvesting Case-Study FAO, Rome, 2005, pp. 1-69.
23. District Commissioner, Quarterly Report Brong Ahafo South Goaso District for the Quater Ending 31st March, 1960. Goaso: Goaso District No.1494/GBA.18 - GBA. 18/125, PRAAD, Sunyani, 1960.
24. Conservator of Forests, Ashanti/Brong-Ahafo Sub-Division Quaterly Progress Reports, PRAAD Brong-Ahafo Region, Sunyani, 1965.

25. Forestry Commission, 2001 - Multi Resource Inventory: The Status of Timber, Wildfire, and Non-Timber Forest Products in Brong Ahafo, Forestry Commission of Ghana, Kumasi, 2001.
26. G.T. Sheves, The Ghanaian Dug-out Canoe and the Canoe Carving Industry in Ghana, Integrated Development of Artisanal Fisheries FAO Subregional Workshop, FAO, Accra, 1991, pp. 1-119.
27. Brong-Ahafo Regional House of Chiefs, Preservation of Forests Brong-Ahafo Region, PRAAD, Sunyani, 1962.
28. Deputy Chief Conservator of forest, Ashanti/Brong Ahafo Division: Report for the Quarter Ended 31st March, 1977, PRAAD, Sunyani, 1977.
29. N.D. Namikat, Traditional Ecological Knowledge in Addressing Global Warming - The Ghana Situation, International Conference of the Society for Ecological Restoration, www.ser.org/iprn/earth-in-transition/eit-conference-proceedings, Zaragoza, 2005, pp. 1-23.
30. Ministry of Environment and Science, National Biodiversity Strategy for Ghana, Ministry of Environment and Science, Accra, 2002, pp. 1-62.
31. A.C. Commissioner, Petition of the Odikro of Goaso and Others, District Commissioner's Office No. 808/s.5/1931 (BRG. 28/2/32), Kumasi, 1932.
32. J.L. Rubio, and E. Bochet, Desertification Indicators as Diagnosis Criteria for Desertification Risk Assessment in Europe. Journal of Arid Environment 39 (1998) 113-120.
33. Millennium Ecosystem Assessment, Ecosystems and Human Well-being: Desertification Synthesis, Island Press, Washington, D. C., 2005.