

Research Article

Sustainable production of afforestation and reforestation to salvage land degradation in Asunafo District, Ghana

Kenneth Peprah*

University for Development Studies, Faculty of Integrated Development Studies, Wa Campus, P. O. Box 520, Wa, Upper West Region, Ghana. W/Africa

* kpeprah@uds.edu.gh

Received 01 August 2017, Accepted 30 August 2017

Abstract: Savannazation and marshy areas are common features of once evergreen and deciduous forest of Ghana. Attempts to salvage such degraded lands have considered replacement with closed tree canopy. This study aims at examining efforts at Asunafo forest area to use tree planting of different species to remedy land degradation in a swamp area colonized by shrubs and grasses. Study methods include the use of field visits and transect walk, photography, archival data, key informant interview, community meeting and socio-economic survey for sourcing primary data for analysis. The results indicate that where the swamp is vegetated by shrubs of different kinds, afforestation shows rapid success. And, where the swamp is dominated by grass species, afforestation success is slow. *Terminalia ivorensis*, *Triplochiton scleroxylon* and *Ceiba pentandra* registered quick impacts in height growth, stem development, canopy formation where the degraded land was originally covered with shrubs. Trees grow well when weed competition for essential resources is reduced through weed control. The study concludes that tree planting in swamp area is sustainable land management practice to redeem land degradation. Also, environmental benefits are imperatives but host communities derived near to zero social and economic benefits because such projects happen outside clean development mechanisms' arrangement.

Keywords: afforestation, Asunafo forest, land degradation, reforestation, swamp, savanna land

To cite this article: Peprah, K. 2017. Sustainable production of afforestation and reforestation to salvage land degradation in Asunafo District, Ghana. *J. Degrade. Min. Land Manage.* 5(1): 955-964, DOI: 10.15243/jdmlm.2017.051.955.

Introduction

The challenge posed by land degradation is daunting; the desire to achieve land degradation neutral world is rife; and, the prospects offered by afforestation and reforestation as strategies to neutralize the menace is encouraging and viable (UNFCCC, 2013, Welton et al., 2014, Orr et al., 2017). In the process, degraded lands release carbon to the atmosphere, while planted trees sequester substantial amounts of atmospheric carbon (Unruh, 2008 citing UNFCCC definition, Zomer et al., 2008). Afforestation and reforestation are considered as carbon sink projects in clean development mechanism (CDM) to reduce carbon emission from degraded lands and achieve global benefit of climate change

mitigation (UNEP, n.d.). At the smallholder farmers and rural communities' level, tree planting in afforestation, agroforestry plus soil and water conservation practices ensure food security enhancement and sustainability of land dependent livelihoods, subsequently, combating land degradation (Zomer et al., 2008). Afforestation reduces pressure on the natural forest through provision of forest resources such fuel, fruits, fodder and rafters (Dongre, 2011). At the global scale, afforestation and reforestation are bridges between developed and developing countries under clean development mechanism to ensure mutual benefits as climate change mitigation measure; subsequently, contributing to achievement of UNCBD and UNCCD (IUCN, 2004). Where the developed countries win carbon

credits, the developing countries benefit by stemming degraded and degrading land below forest threshold, grazing and fuel wood collection (Haupt and von Lupke, 2007). Already, 95 developing countries are benefitting from 7,500 emission reduction projects in which local communities' resilience to climate change are improving and contributing to attainment of UNFCCC, UNCCD and UNCBD (UNFCCC, 2013).

This study aims at examining efforts at Asunafo forest area to use tree planting of different species to remedy land degradation in a swamp area colonized by shrubs and grasses. Ghana is one of the seven countries found to be integrating with success agricultural productivity, food security of the population and halting and/or reversing deforestation (FAO, 2016). The West African country, vests naturally occurring trees in the President. However, forest are owned by chiefdoms and clans (public) but controlled by the government. The Forestry Commission manages forest reserves and national parks. Community Resource Management Areas abound under community supported by Non-Governmental Organizations and government arrangements. There is improvement in tree tenure in the off-forest reserves as regarding farmers' ownership of trees planted in the farm. Commercial plantation is supported by Forest Plantation Development Fund. REDD+ programmes are underway in the forest zone such as climate smart agriculture funded by Rockefeller Foundation and climate smart cocoa working group funded by UK's Department for International Development (DFID) geared towards reducing drivers of deforestation, forest degradation and carbon emissions (Asare, 2015). Yet, agriculture expansion contributing 50%, timber exploitation (35%), urban sprawl and infrastructure development (10%) and mining and mineral extraction (5%) continue to exacerbate land degradation (MLNR, 2012, FAO, 2016). Ghana's closed forest is being destroyed at a rate of 2% about 135,000 ha per annum (MLNR, 2012). In addition, the threat posed by savannazation is imminent in the forest areas of Ghana. Grasses of different kinds out-compete the mosaic of protected forest reserves, secondary forests and, biodiverse cocoa and food crop agroforestry. Such areas are described by farmers as degraded. Several measures are used to get rid of the grass in the forest mosaic. In some areas, such as Tanoso, oil palm was used initially but to no avail; now, afforestation is done as well as in the next door Dantano. The efforts require assessment after some years of implementation. Relevance of the study is drawn from the specific response to

Sustainable Development Goal (SDG) 15, specifically, target 15.2: by 2020 promote the implementation of sustainable management of all types of forest, halt deforestation, restore degraded forests, and increase afforestation and reforestation by x% globally. Target 15.2 is reinforced by 15b: mobilize significant resources from all sources and at all levels to finance sustainable forest management, and provide adequate incentives to developing countries to advance sustainable forest management, including for conservation and reforestation (Brack, 2014). By doing so, target 15.3 stands to show the results: 'by 2020, combat desertification, and restore degraded land and soil, including land affected by desertification, drought and floods, and strive to achieve a land-degradation neutral world' (Orr et al., 2017).

The paper is divided into six sections. The introduction shows the importance of using afforestation and reforestation to stem land degradation. An elaboration on the aim of the study and guided sections of the paper ends the first section. The next section discusses the conceptual basis of the paper founded on the triad of sustainable development as including environment, social and economic processes with specific reference to afforestation and reforestation. The third section reviews existing knowledge on the prospects of afforestation. Study methods spell out laid down procedure in carrying out this study and the description of the study area. The subsequent section catalogues results of the study interwoven with discussion bringing out the various nuances. Lessons learnt and conclusion are drawn using environmental, social and economic sustainability benefits discussed in section two. Environmental sustainability is the main outcome with difficulties bringing out social and economic benefits due to the community level scale of the demonstration site.

Conceptual Framework

The study adopts sustainability triad of environment, social and economic pillars after Olsen and Fenhann (2008). The authors used the three sustainability components to discuss benefits accruing from clean development mechanism projects as involving afforestation and reforestation. The qualitatively measurable indicators include environmental components as air (quality by reducing pollution), land (stem degradation and improve quality), water (quality by decreasing pollution) and conservation (landscape protection and management). Social aspect involves employment, health, learning and welfare. Economic feature, taken at country level,

includes growth, energy and balance of payments. Sustainability tax and corporate social responsibility were measured as other benefits. Watson and Frankhauser (2009) takes sustainable development from a triple bottom line approach. The authors follow Hamilton et al. (2004) and considered the three dimensional concept as capital translating into physical capital (economic benefits dealing with building, machines and infrastructure assets); social capital (social benefits as people's ability to draw meaning and incentives from social interactions); and, natural capital (environmental benefits as involving life-support services derived from ecological systems' goods and services). The UNFCCC(2011) categorizes benefits accruing from CDM into economic (direct/indirect financial benefits to the economy, employment, development/diffusion of imported technology, investment in infrastructure); environment (efficient utilization of natural resources, reduction in noise, odour, pollutants or dust, improvement/protection of natural resources, available utilities and promotion of renewable energy); and, social (labour condition and human rights, promotion of education, health and safety, poverty reduction, empowerment of local people and empowerment of women, care for children and frail). The study adopts the triad benefits as analytical framework to qualitatively indicate benefits in terms of lessons learnt from the current study. This is carried out based on the background that agenda 2030 in seeking to achieve sustainable development for the world invokes simultaneous integration of all 17 goals against the backdrop of the three pillars (FAO, 2016).

Review of the Prospects of Afforestation

Afforestation entails effectiveness of tree planting to manage degraded land where the said land cannot be categorized as forest land. A similar term reforestation is used if the new trees are planted on a previously forested land (Woodfine, 2009). And, when trees are integrated with agricultural crops on the same land management unit where there is ecological and economic interaction between the trees and the crops, such a system is called agroforestry (Stocking et al., 1990). Afforestation takes place in areas that have not been forested before or at least for the past 50 years. Reforestation is done to redeem forest cover in historically forested area (IUCN, 2004: citing UNFCCC). Forest refers to an area of 0.05-1 ha, containing trees with average height of 2-5 m and canopy density of 20-30% (Haupt and von Lupke, 2007). Land, the basis for afforestation, reforestation or agroforestry is perceived variously as *terra firma* – solid portion of the

earth, terrestrial ecosystem – self-maintaining habitat of micro-organisms, plants as well as animals and the relationship with the biophysical environment or as a resource comprising of soil, water, vegetation, rocks, air, climate and relief (Safriel, 2007, Stocking and Murnaghan, 2001). Land is bare if it has no cover. Hence, bare rock or bare soil refers to the land itself and not the cover. The cover of the land is the observed biophysical protection overlaying the Earth's surface. It may be classified as biological if the land cover is made of vegetation or physical if the land cover consists of human-made or artificial features (Di Gregorio and Jansen, 1998).

In the history of land cover studies, particular emphasis has been focused on land cover change. Changes to the cover of the land may refer to alteration in land surface roughness and albedo (Zhan et al., 2002) or a shift from one cover type to another (Bradley and Mustard, 2005). Land cover change may occur as conversion, that is, long-term changes representing a complete replacement of one cover type by a different type or as modification, that is, short-term changes indicating partial changes within a particular cover type (Lambin, 1999). For instance, land cover change from forest to grassland represents conversion and land cover change from rain-fed cultivated area to irrigated cultivated area indicates modification (European Communities, 2001). Since AD 1700, human activity, particularly, agriculture has transformed much of the natural land cover to anthropogenically managed areas (Pongratz et al., 2008). In recent times, industrialization and urbanization are twin factors that have also caused large scale land cover change. Subsequently, there are many observable features resulting from land cover change such as loss of biodiversity, global warming as well as water, soil and air pollution. For instance, the conversion of forest to agricultural land immediately shows complete loss of forest species. Also, agricultural lands reduce carbon sequestration and increase emission of carbon dioxide into the atmosphere to warm the Earth through creation of greenhouse effects. In addition, phosphorus, nitrogen and sediments from farms are washed into rivers to cause sedimentation, turbidity and eutrophication. While agricultural burnings worsen the status of air quality (Ellis, 2013).

In sub-Saharan Africa, land cover change is observed from overgrazed fields, fuel wood shortages, degradation of once-pristine forest, soil erosion and depletion of natural resources. In this regard, the change to land cover is explained as human mismanagement of land in which the African is considered a victim as well as a causal

agent (Leach and Mearns, 1996). However, in the hilly Machakos region of Kenya, research shows that the African is an agent of natural environmental improvement (Tiffen et al., 1994). One of two cases demonstrated an earlier period where the African population was comparatively lower but suffered severe forms of soil erosion. The land cover was made up of large and small trees, shrub, herbs and grasses and the steep relief showed many rills and gullies. The second case showed a rather increased African population in which the people suffered less erosion in the same piece of land.

The increased population had been used to convert the shrub land cover, rills and gullies to cultivated hedges and terraced cropland. The researchers opined that fewer people severe soil erosion and more people less soil erosion (Tiffen et al., 1994). Similarly, this study uses two cases, one which shows the situation before where the land cover was swamp and savanna grassland to a second case which shows the situation after, represented by beautiful forest land cover. Unlike the Machakos example, the emphasis here is not on population increase and environment nexus, rather indigenous farmers' ability to change less productive land cover to more beneficial cover and aesthetical scenery. The trees apart from the possibility of serving as source of fuel wood can also provide shade, building rafters and other ecosystem goods and services (Leach and Mearns, 1996).

Methods of Study

The study began with a visit to the Brong Ahafo Regional archival records office in Sunyani to review history of afforestation with special reference to the Asunafo north and south districts, the then Ahafo District. The next step was a discussion with officials of relevant state institutions beginning from the Ghana Forestry Commission's regional office at Sunyani and District offices at Goaso for both Forest and Wildlife Divisions. Due to the prominence of cocoa in the study area, officials of Ghana Cocoa Board (Cocobod) at the national office in Accra and District office at Goaso were interviewed. The study then engaged primary land users basically smallholder cocoa farmers in meetings at 21 communities and attended by a total of 774 farmers. Other pertinent steps included questionnaire administration to a sample size of 264 (Israel, 2009); key informant interviews; and, focus group discussion with Akan Radio Discussion Group made up of five men. Analytical approaches comprised of SWOT (strengths, weaknesses, opportunities and threats) as well as trend using descriptive statistics. Figure 1 shows a map of Asunafo north and south districts with a total land surface area of 2,187.5 km² (Abagale et al., 2003).

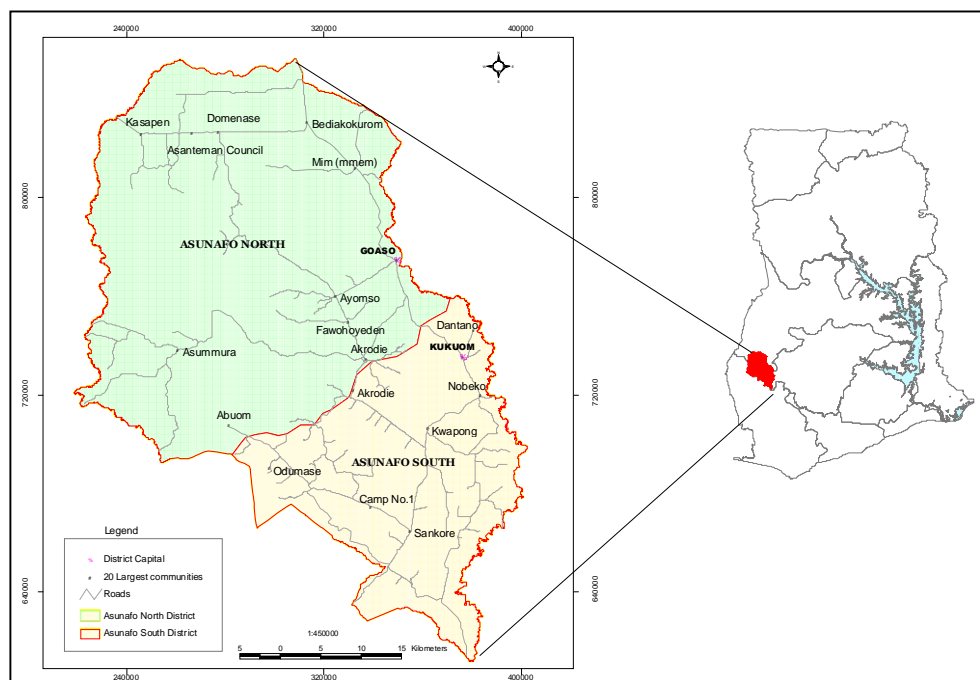


Figure 1: Map of Asunafo North Municipal and South Districts of Ghana
 Source: CERSGIS, Department of Geography and Resource Development, (2010)

The climate is wet-semi equatorial type with double maxima rainfall peaking in May-June and September-October with rainfall values between 1,250 – 1,750 mm and temperature ranging between 26°C and 30°C. The original land cover is classified as moist-semi deciduous forest. Some trees shed their leaves while others remain evergreen (Dickson and Benneh, 1988). Anthropogenic land management has resulted in conversion of much of the original forest to agriculture and settlement land uses with portion of the forest managed as forest reserve. Dickson and Benneh (1988) describe edaphic features as forest ochrosols while CERSGIS Department of Geography and Resource Development (2010) classified the soils as much of acrisols, nitisols only around Nobeko and Kwapong with fluvisols along revering areas on the district borders.

Results and Discussion

Archival records reveals that forest reserves in the area started in 1939; and, cocoa farming much earlier in the 1920s. In the 1960s, the Government of Ghana established agricultural extension stations at Goaso and Sankore to provide technical support for propagation of cocoa. The stations nursed cocoa seedlings and supplied to farmers for transplanting (District Commissioner, 1960). However, official tree planting in Asunafo can be traced back to the 1970s when the Forestry Commission introduced the *taungyas* system in which farmers integrated different crops with trees in a form of agroforestry in order to reclaim degraded forest reserves. Farming continued until such a time that the trees needed no tending. Between 1975 and 1977 a total land surface area of 1,445.93 ha of degraded forest reserve was restored in Asunafo. Table 1 provides details of land area put to *taungyas* activities as containing tree planting, beating up and tending.

Table 1. Land Surface Area (ha) put to Taungyas Activities 1975-1977

Date	Planting	Beating up	Tending
1975	445.00	45.00	570.00
1976	118.40	47.20	107.66
1977	29.37	39.06	44.24
Total	592.77	131.26	721.90

Source: Adapted from District Chief Executive, (1978)

Presently, farmers, particularly, at Nobeko are engaged in tree seedling nurseries on commercial basis for profit purposes. *Gliricidia sepium* is the

common nursery in the area as it possesses several qualities such as its usefulness in serving as livestock fodder, supporting yam cultivation as stalk and live fence for home gardens. Plate 1 shows a test case of swamp land covered by water loving shrubs planted to different healthy tree species' seedling guided by the split bamboo pegs. The swamp wetland is poorly drained, invaded by elephant ear plant species of the *Xanthosoma* family but both the leaves and the cormels are not edible. Farmers used machetes/cutlasses to slash the shrubs. A local practice, *proka*, was used; a slash and no burn, in which the slashed debri decomposed and replenish the soil with nutrients. Tree seedlings were transplanted as indicated by the split bamboo sticks as pegs for identification purposes. *Terminalia ivorensis* and *Triplochiton scleroxylon* seedlings were then planted. The elephant ear plants provided shade for the seedlings for some time before the weeds were slashed. The enlisted processes occurred in 2010.

In the Tanoso demonstration site, where the swamp is dominated by grass species, afforestation success is slow. The processes included slashed grass vegetation but no burning (*proka*) followed by planting of teak (*Tectona grandis*), *wawa* (*Triplochiton scleroxylon*), *emire* (*Terminalia ivorensis*), *esa* (*Celtis spp.*) and *oyina* (*Ceiba pentandra*). Herbicide (weedicide) application was carried out to suppress grass regrowth. Two tree species *Wawa* (*Triplochiton scleroxylon*) and *esa* (*Celtis spp.*) failed to survive in the swamp and savanna grassland. Three tree species teak (*Tectona grandis*), *emire* (*Terminalia ivorensis*) and *oyina* (*Ceiba pentandra*) are successfully growing. Although *Terminalia ivorensis* show larger diameter at breast height than teak, there were more teak trees surviving than *Terminalia ivorensis* and *Ceiba pentandra*. *Emire* (*Terminalia ivorensis*) and *oyina* (*Ceiba pentandra*) are sparsely populated in the field while teak has proven to be the most suitable for the purpose.

From the study, afforestation takes place as a result of farmers' efforts and government's persuasion. The study revealed that 100 farmers (38%) plant trees as a strategy to restore degraded land while 164 farmers (62%) do not plant trees at all. Although, trees naturally grow well at Asunafo, the need to supplement natural regeneration is felt by farmers. Tree planting as land degradation management strategy was subjected to various analyses including SWOT and trend analyses.



Plate 1: Demonstration site 1 – afforestation to recover swamp land at Dantano
Source: The Author 24th June, 2010.

Plate 2 portrays impacts of vegetative land cover conversion from swamp and invasive elephant ear plant to appreciable tree heights and well-developed tree canopy. The test looks successful although the elephant ears plant is not completely

eliminated. The effect of the weeds on the land is drastically reduced by the good performance of the trees in barely two years. Plate 3 shows the success story at Dantano for nearly seven years of implementation.



Plate 2. Two years later at demonstration site 1 – success story at Dantano
Source: The Author 27th September, 2012.

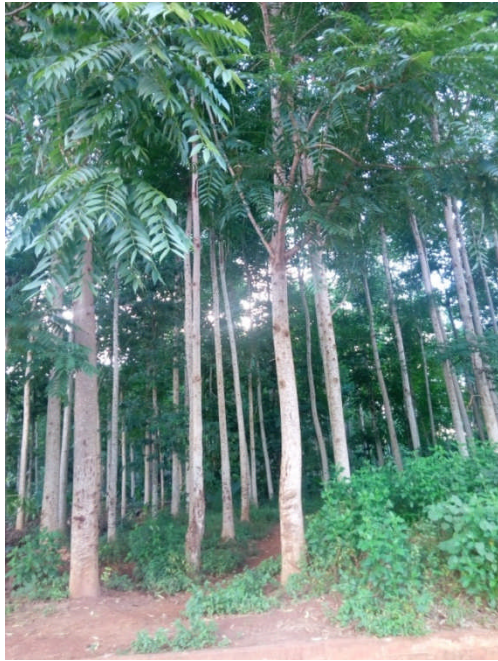
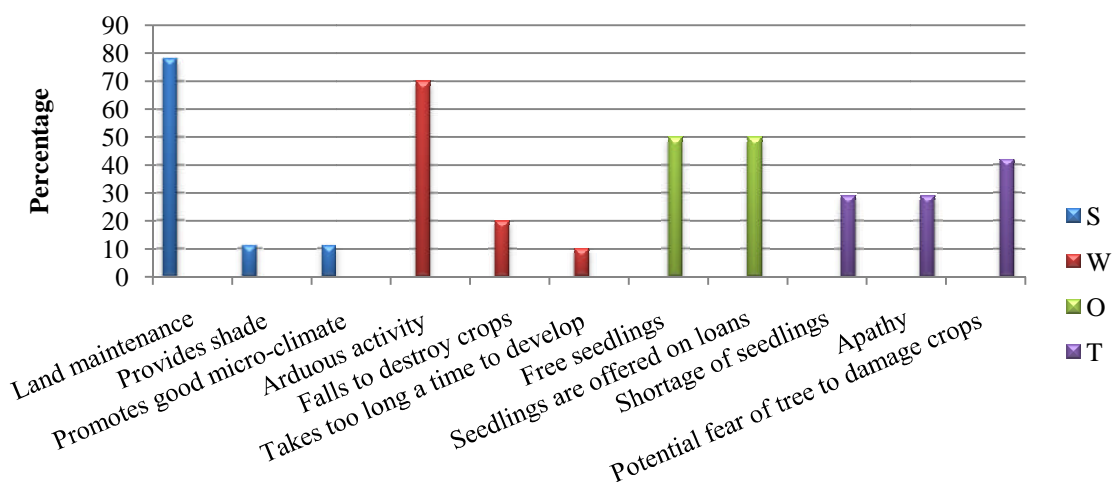


Plate 3. 2010 – 2017 at demonstration site 1 - at Dantano Source: Field assistant

Figure 2 indicates strengths, weaknesses, opportunities and threats (SWOT) analysis of tree planting. The main strengths of tree planting includes: trees grow and develop to provide shade for cocoa and plantain (*Musa ABB*) (11%), tree litter adds organic matter to the soil (78%) thereby contributing to the maintenance of soil fertility while a lot of the tree help create a conducive micro-climate for the general agricultural activities (11%). However, tree planting exhibits weaknesses such as arduous task demanded by

plant nursery, transportation of trees to the farm, actual planting, tending and beating up until the tree are left on their own (70%). During rain storms, branches of trees or sometimes the whole tree falls to destroy crops (20%). Otherwise there are opportunities such as low pricing of seedlings, sometimes free of charge or tree seedling are offered to farmers to be paid for at a later date. The threats to tree planting are associated with tree tenure in which timber species on farms are owned by government and the fear that one day the wood would be extracted and cause farm destruction without compensation to the farmer. Hence, farmers do not grow timber species on farm or allow naturally generated timber species to grow on farms. Since 2011, government policies on tree tenure are changing in favour of farmers' ownership of at least planted trees on farm.

Table 2 presents qualitative trend analysis of tree planting. Planting trees was not imperative in the past (during childhood period of the farmer-respondents) as trees grew naturally. Combination of characteristics such as presence of tree nurseries and increasing encouragement of farmers by government agencies to plant trees explain the success of afforestation presently. Moving to the desired future, farmers would want continuation of natural regeneration of trees. However, the obvious differences in soil would not permit natural regrowth of trees in the required quantities. Hence, attempts to recreate tree afforestation and reforestation appear tenable option in the likely future.



SWOT of tree planting

Figure 2. Results of the SWOT analysis of tree planting
Source: The Author

Table 2: Trend Analysis of Tree Planting

Land degradation management strategies	Past	Present	Desired future	Likely future
Tree planting in farm	natural growth	seedling nurseries averagely planted	natural growth	more trees planted

Source: The Author

Conclusion and Lessons Learnt

Environmental Sustainability of Afforestation

The purpose of the study was to assess effectiveness of farmer management strategies of land degradation particularly the performance of trees planted to recover swamp land. The findings confirm a strong case for conversion of swamp land by afforestation. The most successful processes included slash and no burning (*proka*) of the initial vegetation cover, the use of seedlings of different tree species, pegging for easy identification of seedlings and clearing of weeds regrowth with cutlass (hand weeding) or application of herbicides (weedicides). Embedded in indigenous farmer traditions and customs are the significance of trees, planting and caring for trees. For instance, the farming culture of commercial cocoa tree agroforestry dates back to the 1900s (Dickson, 1969). Above all, agrodiverse farming – integrated management of trees left *in-situ* in farm, biological species including crops and other land resources organization, utilization and sustainable management is a common farming practice (Gyasi, 2004). However, planting trees to restore degraded land through afforestation or reforestation began with the *taungya* system in the 1970s (District Chief Executive, 1978). Special qualities of selected tree species include fast growing in the case of *Terminalia ivorensis* and *Triplochiton scleroxylon*. *Tectona grandis* has high yielding and survival rate. *Ceiba pentandra* possesses fast growing and low incidence of pests (Odoom, 2002). Tree planting shows particular strength in producing litter to enrich the land, suggestive of the good performance of *Terminalia ivorensis* and *Triplochiton scleroxylon* at Dantano where the litter fell on the bare land. Instead of bare ground, tree litter at Tanoso fell on grass mat, a kind of carpet that hampered decomposition of leaves thereby preventing immediate enrichment of the soil with organic matter. Also, during the dry season the swamp still contained enough soil moisture which helped to ensure continuous tree growth. A further explanation has to do with the

ability of the indigenous people to manage and prevent the occurrence of wild bushfires.

Essentially the afforestation reduced the numerous plant species of no commercial value to basically few plants species made up of trees with economic significance, of the same age and on a tract of land or compartment (Odoom, 2002). Also, *Terminalia ivorensis* and *Triplochiton scleroxylon* with their broad leaves and closed canopy intercept raindrops and prevent the wetlands of swamp from further land degradation. In the sense that waterlogging, flooding and soil erosion were reduced and there was improvement in infiltration of rainwater as well as enhancement of soil moisture content as also found in (Woodfine, 2009). Weed control at pre-planting and post-planting of tree seedlings ensures effective utilization of light, moisture and nutrients. Reduction or elimination of weed competition for these essential resources ensured better growth of tree as also revealed by (Balneaves, 1982). Weeds constitute disturbing factor in agroforestry and forestry plantations due to tilling regimes, crop phenology and weed control systems (chemical in agroforestry and physical in forestry). If animals are integrated, birds roost on the trees and fertilize young trees while sheep weed the trees and occasionally manure the field (Dupraz, 1999). However, majority of farmers (62%) did not engaged in tree planting exercise indicative of the weakness of tree planting as an arduous strategy and in anticipation that economic trees managed under agroforestry would be extracted someday by timber merchants to destroy the very crops intended to be supported by the trees. Farmers indicate that crops do not grow well under *wawa* (*Triplochiton scleroxylon*). For this reason, farmers will not integrate the seedlings of *wawa* (*Triplochiton scleroxylon*) with crops in agroforestry. Hence, using *wawa* (*Triplochiton scleroxylon*) to stem land degradation is problematic since it does not make the land any better for arable farming purposes. Experience farmers will not plant *wawa* (*Triplochiton scleroxylon*) in the farm anyway. Instead of poorly drained wetland colonized by invasive

elephant ear plants, water loving and water craving weed, the afforestation ensures free overflow of water and provides trees that possessed economic and ecological significance. A further research is required to investigate the inability of *esa* (*Celtis spp.*) to survive the test.

Social Sustainability of Afforestation

For now, the social benefits include the ecosystem services such as provision of shade and improvement of air quality, particularly, in the Dantano case, where the demonstration site is close to the community. The impact on the micro-climate can only be inferred as there are no scientific instruments in close proximity to do such measurement.

Economic Sustainability of Afforestation

The contribution to carbon sequestration is not yet calculated. The small size of the demonstration site is an issue regarding the economic contribution. Employment generations is plausible but not in this particular case. Also, generation of fuel wood from the trees is likely in the future as well as the *wawa* (*Triplochiton scleroxylon*) potential for harvesting as timber. In the process of using afforestation to redeem land degradation, environmental sustainability is the imperative and inevitable outcome. Social and economic sustainability may not measure up to the same degree and intensity of benefits.

Acknowledgements

I am most grateful to Nelson Owusu Mandela, research assistant and the farmer respondents at Tanoso and Dantano. I am equally grateful to officials of relevant state institutions for the interviews.

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