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Agroforestry Adaptation for Climate Resilient Economy in Lowland Rainforest Ecological Zone of Delta State, Nigeria

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A R T I C L E I NFO

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ABSTRACT

Forest ecosystems provide ecological services as sink for environmental wastes and greenhouse gases while supplying agriculture with essential nutrient-rich soil and biodiversity to support growth. Unfortunately, the skewed management approach to bias indicator for either economic or environmental development often results in conflict and bane to thwart full realization of well-articulated policy framework in the environmental and agricultural sectors. Agroforestry types as a multiple land use mechanism, integrates critical trade-offs in both sectors to achieve sustained yield management objective in forest management and sustainable food production. Forest litters and agricultural component residues in the agroforestry system interact to reduce influx of in-organic chemicals at source fertilization and disposals as sequestered carbon as well as other GHGs in the environment. This paper examined the potential benefit in developing policy thrust from practical approach of Taungya (agricultural crops and trees) as agroforestry tool for stemming further forest degradation, food insecurity and enrolment in carbon credit schemes for climate change mitigation and adaption in the lowland rainforest zone to resuscitate forest regeneration and short-term incomes from annual agricultural crops.

INTRODUCTION

Climate change in the last two decades has significantly led to critical cross cutting issues globally, with Nigeria at the brink of serious socio-economic and ecological challenge due to inadvertently tried inept approaches, especially deforestation and forest degradation for myriad land-based ecosystem-dependent agricultural programs in different ecological zones. Increasing temperature and precipitation with attendant pests, diseases, frequent rainfalls and floods have accounted for decline in agricultural productivity, rural household income and erosions (Mujeed and Sylvia, 2017; Peter and Elizabeth, 2015; Ogboi, 2011).

Agroforestry presents an inverse practice of shifting cultivation, as systemic interphase between agriculture and forestry, for enhanced multiple land-use services, to accommodate environmental, social and economic needs (Sale and Olujobi, 2013; Ordonez *et al*, 2010). Varying models as scattered farm trees, Taungya farming (crops and trees), shelterbelts, alley cropping, live fence,

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agrosilvopastoral (crops, pasture and trees) and aquaforestry reportedly by interaction between components of agroforestry ameliorate temperature, raise groundwater, moisture content for enhanced productivity as well as influence micro-climates to reduce the incidences of drought and diseases (Fischlin *et al*, 2007; Carrol *et al*, 2004). Thus, multiple alternatives and opportunities of agroforestry in improving farm production and income for sustainable livelihood enhance significant potential for food security, environmental conservation, employment and income opportunities (Tiwari *et al*, 2017).

The choice of forest ecosystem for establishment of land-based agriculture has been linked to the rich soil resource associated with forest litters decomposition to supply nutrients for early growth and development of agricultural crops. Even in aqua-forestry, agricultural crops rely significantly on inter planted forest trees species in the watershed to pull water, in addition to the upper forest floor moisture, to support crop growth in scattered tree farms and agro-silvo-pastoral systems, especially in drought situations. Therefore, agroforestry models create readily available buffer for an improved income stream which could serve as attraction for the poor interest in private forest development due to long gestation period.

However, the conflict between forest conservation and utilization for agriculture has continued to impinge on sustainable use, especially in the face of global warming, climate change and food insecurity (Melissa *et al*, 2017). The vast forest resources naturally bequeathed developing nations are potentials for industrial growth for economic development that encompasses green utilitarian values. But poor perception of conservation and utilization as both sides of the same coin has denied developmental feats by erecting almost irreconcilable frictions between these critical sectors of the economy.

Consequently, programs that have been outlined to benefit most third world countries with relatively intact forest ecosystems have eluded Nigeria. The nature-for-debt exchange program by UNDP/UNEP was conceived as a panacea to manage the inability of enrolled third world nations in the tropics to balance forest resources exploitation for quick-fix economic measures at the expense of environmental resources. This increased carbon sink capacities and microclimatic contribution to the overall global pursuit of benign climate. Recently, the carbon credit scheme was initiated as a more robust and all-inclusive program to globally pursue carbon decapitalization in view of global warming vis-à-vis climate change using the standing forest (Law and Williams, 2021).

Delta State was unable to qualify in the last forest assessment conducted for selected States for the carbon credit scheme due to the high fragmentation of available forest across three-quarter of the ecological zones as a result of ill-integrated agricultural practices that accounted for over 70% forest loss. The scenario has not changed as the conflict in the past one decade has accounted for approximately 100% (323ha) de-reservation of Iyiocha Forest Reserve without appropriate legislation to cultivate *Elaeis guineensis* (Palm) plantation while over 60% of Ogwashi-Uku Forest Reserve for agriculture.

The competition between agriculture and conservation for forest land still undermine strategic programs and policies which portends a great challenge in the face of current global climate change. The situation is more precarious in Delta State as a littoral State and much more for low-lying regions in the lowland rainforest ecological zones that could be more prone to emergent climate challenge of flood from irregular rainfalls and sea-level rise. This paper therefore articulates agroforestry as an *ad hoc* adaptation approach to compliment forest sink mitigation while aggressively providing support for rural households through income generation and employment in this critical ecological zone of Delta State.

Lowland rainforest ecological zone

Delta State is a low-lying land area that stretches parallel to the Atlantic Sea and have been edaphically fortified with wide range of indigenous forest trees species upland, to act against various forms of degradation, in the lowland rainforest ecological zone. These ecological features of the zone which occupies the northern half of Delta State, with the remnant forest found in forest reserves and riparian environment not very suitable for agriculture (Table 1).

Temperature and humidity of lowland zone is often variable compared to the other ecological zone due to high deforestation that has taken place in the region. NiMet (2016) reported a critical three banded temperature ranges for the zone due to high rate of forest loss in the region.

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Table 1: Ecological and socioeconomic characteristics of Lowland rainforest zone of Delta State

Population	
- Males	85,305
- Females	86,583
Elevation	>200m
Average temperature	
- Maximum	30.0°C
- Minimum	23.0°C
Predicted average temperature change	+0.0226°C/year
Average rainfall	2762mm/annum
Predicted aggregate rainfall change	+ 4mm/day
Proximity to River Niger/ other rivers (<10km) Level of vulnerability	59.8% Moderate vulnerability
Land-use in communities	
– Farming	68.5%
– Housing	55.0%
– Forest reserves	12.3%
– Fishing	1.70%
Presence of crude oil facilities (wells, flow-stations, pipeline)	54.5%

Source: Climate Change Department, Delta State Ministry of Environment (2017).

Impact of agroforestry on crop productivity

Forest soils have been reported as the bait for consistent influx of farming practice in high forest zones of the tropics. High yield on de-forested land used for agriculture was observed in clear felled forest areas but diminished with time due to harvest of matured agricultural crops as nutrient mining overtime.

However, in agroforestry systems, the standing forest tree species act as systemic source of nutrients, reduction of precipitation and percolation throughout the various stages of growth and development to result in better yield as well as productivity. Egwunatum (2016) reported higher yield of cassava, plantain and yam obtained for three years from farmlands under Taungya as agroforestry and non-agroforestry sites in Akehie forest community in Aniocha South LGA of Delta State showed higher productivity for the agroforestry farmland (Table 2). The yields in the agroforestry farmlands increased with years unlike the non-agroforestry sites that declined with time due nutrient resource exhaustion. This incremental yield equally implied increase in income as demonstrated by the internally generated revenue and farmers income profiles of the lowland agroforestry centres in Delta State from 2001-2017 (Table 4). The internally generated revenue (IGR) from the issuance of permits for farming and thinning of forest produce in agroforestry system was expectedly lower than the profits accruable to the farmers from sales of farm produce alongside employment generation.

Table 2: Agricultural crop yield under agroforestry plots in Akehie

Period (Taungya year)	Land-use Types	Cassava (Bags/ha)	Plantain (Bunches/ha)	Yam (Kg/ha)
2013	Taungya Non-Taungya	4.86 2.10	49 35	180 155
2014	Taungya Non-Taungya	5.13 2.30	65 40	215 165
2015	Taungya Non-Taungya	5.83 2.34	70 43	226 169

Source: Egwunatum (2016)

Comparative assessment of agroforestry system on carbon mitigation

The means of soil organic carbon under agroforestry were significantly different ($p < 0.05$) for all the agronomic crops (Table 3). Forest ecosystems have the capacity to mitigate carbon even when integrated with agricultural crops. The plantain agroforestry site recorded highest soil organic carbon mean compared to cassava and yam. This could minimize the rate of deforestation by crop intensification on such agroforestry plots since less area will be required to grow agricultural crop and together be employed in the pursue of carbon credit scheme by the same farmer. Consequently, the agroforestry system invariably qualifies the rural farmer for inclusion in the global carbon decapitalization scheme, especially with the absence of in-organic fertilization approach on the farm environment.

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Table 3: Effect of Agroforestry system on soil organic carbon (SOC) accumulation in Akehie

Crop Type	Land-use type	Mean SOC (g/kg)	T-value	P	Statistical Remarks
Cassava	Taungya Non-Taungya	106.20 65.12	2.31	0.02	significant
Plantain	Taungya Non-Taungya	1146.29 75.86	3.62	0.01	significant
Yam	Taungya Non-Taungya	93.43 45.33	1.23	0.04	significant

Source: Egwunatum (2016)

Table 4: Income stream from Lowland Agroforestry Centres in Delta State

Agroforestry Centre	No. of Centres	Period (Years)	Average Income (N)		Total Income (N)
			IGR	Farmer	
Akehie	30	2001-2015	386,280	6,851,870	7,238,150.00
Iyiocha	22	2006-2017	634,930	4,510,450	5,145,380.00
Ogwashi-Uku	18	2003-2017	487,850	3,262,300	3,750,150.00

Source: Delta State Ministry of Environment (2017)

Policy framework for agroforestry

Government must be at the fore front by developing tools and approaches that combine agriculture and improve forest ecosystem conservation with livelihood opportunities.

Tools include:

1. Remote sensing maps of parchment forests to accommodate agriculture
2. Comparative analysis of compatible tree species cum agricultural crops
3. Rotational route services to manage nutrient-use and carbon-sequestration efficiencies

Approaches include:

1. Programs to leverage support services to existing farmers
2. Erect temporal nursery schemes at households and community levels to provide seedlings
3. Review existing Forest laws on Taungya to include more agricultural crop species as well as quantity per hectare in reserves
4. Drive public private partnership to lowland rainforest reserves

Furthermore, policy of agricultural credit scheme should be all encompassing by integrating conservation framework to accommodate forest related issues that indirectly influence agriculture.

CONCLUSION

Agroforestry practice is an efficient land-based mechanism that can engage agriculture and conservation at the same time with series of benefits. Its potential during climate change remains unique as it combats food insecurity, soil thermal problems that affect root-tubers, microclimate to moderate incidences of wind throw and flooding while mitigating carbon. The need to effectively establish agroforestry conurbations in the already degraded lowland ecological zone of the Delta State cannot be overemphasized in view of a resilient climate economy.

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