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Research Article

Farm Level Tree Planting in Ghana: Potential for Reducing Vulnerability and Mitigating Climate Change

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Abstract
Improvement in tree tenure and benefit sharing mechanisms has encouraged farmers with or without land to invest in economic tree planting in Ghana. This has been influenced by a policy reform which gives right of ownership to individuals who engage in tree planting coupled with a national reforestation programme. However, little is known regarding the contributions of small-scale tree planting in mitigating climate change at farm level. This study therefore explores the views of smallholder farmers in six villages in the Sefwi Wiaso, Asankrangwa and Offinso Forest Districts on how tree planting at farm level can reduce vulnerability and mitigate climate change. The study employed a household survey among 106 smallholder farmers, interviews of informants and validation meeting. Results revealed that farmers involved in tree planting have adopted agroforestry models that have the potential to generate significant carbon stores. The study also revealed that institutional partnership and benefit sharing mechanism are crucial for the success of farm level tree planting. The paper concludes by recommending public actor partnership with wide range of stakeholders to make small scaled farm level tree planting a reality in reducing vulnerability and mitigating climate change as well as serving as financial incentive to famers.

Keywords
afforestation — climate change — mitigation — agroforestry — partnership — tenure

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Introduction

Climate change is considered to be one of the major threats to sustainable development because of its effects on health, infrastructure, settlements, agriculture and food security and forest ecosystems [10]. Thus, climate change has indirect effect on the wellbeing of society especially the forest fringe communities whose livelihoods fully or partially depend on forest resources. Paradoxically, forestry activities including afforestation and reforestation offer an important potential for reducing Green House Gas (GHG) emissions and increasing carbon sequestration [20]. Mitigation aims at activities of reducing greenhouse gas emissions and / or removal of CO_2 from the atmosphere with the aim of stabilizing CO_2 concentrations [19]. Forest thus contributes to the mitigation of climate change through: (i) Maintaining or increasing forest area through afforestation and reforestation, reduction of deforestation and forest degradation; (ii) Maintaining or increasing landscape-level carbon density through improvement of forest management, such as fire control; and (iii) Increasing off-site carbon stocks in wood products and enhancing product and fuel substitution through sustainable biofuel plantations [15; 10]. Similarly, conserving natural forest, planting new forests, rehabilitating degraded forests, enriching existing forests and eliminating agricultural practices that contribute to the deterioration of carbon reservoirs are effective ways of mitigating GHG emissions and their effects [14]. The mitigation potential of tree planting in off-reserve areas is highly dependent on variables such as improvement in governance of forest resources, clarification of forest and tenure, as well as use rights

in favour of local forest-dependent communities [20]. Vulnerability to climate change on the other hand is the degree to which geophysical, biological and socio-economic system are susceptible to, and unable to cope with, adverse impacts of climate change, including climate variability and extremes [10]. There are different ways in which the forest sector can reduce vulnerability to climate change and these include: i) rehabilitation by development of more resilient agroforestry systems; ii) undertaking tree plantations with selection of appropriate species and management practices; and iii) conservation practices including creation of fire barriers [20]. Thus, sustainable forest management (SFM) has been envisaged to contribute significantly towards the reduction of climate change [19].

Ghana's Forest and Wildlife Policy of 1994 encourage economic tree planting [5]. Ghana intensified efforts in restoring its dwindling forests by launching the National Forest Plantation Development Programme (NFPDP) in 2001with an overarching strategy that centre on government-community-private sector partnership in reforestation programmes in degraded forest reserves. Under this overall strategy, are sub-strategies of i) promoting government –community partnership with schemes such as the modified taungya system; ii) government–private sector partnership (i.e. Commercial plantation scheme) and iii) government hired labour scheme. These approaches have significantly driven the process of reclaiming Ghana's degraded forests through the reforestation schemes as well as enhanced forest community livelihoods [17]. Even though the NFPDP scope was towards reforestation in on-reserve forests, however, the programme also promoted tree planting at off-reserve areas. In addition, the national initiatives were complemented by private companies and non-governmental organisations to boost up tree planting amongst small-holder farmers in off-reserve areas. This was further strengthened during policy reform in 2002 that resulted in the amendment of the Timber Resource Management Act 547 to Act 617.The amended Act 617 makes provision for granting ownership rights to individuals who plant timber trees on farmlands.

Against this background, many landowning farmers in Ghana's high forest zone, taking inspiration from the policy reforms and incentives from the private, governmental and non-governmental institutions adopted different agroforestry models over the years [9]. Thus, afforestation and reforestation are currently the only forest management practices that contribute to the mitigation of climate change for which developing countries can be rewarded [20].

The objective of this paper therefore is to provide insights into the governance arrangement and potentials of small-scale tree planting at farm level in reducing vulnerability and mitigating climate change. From the above objective, three research questions are addressed:

1. To what extent does governance arrangements (i.e. institutional, benefit sharing etc) favour farm level tree planting?

2. What factors stimulate small–scale farmers to engage in farm level tree planting?

3. How does small scale tree planting at farm level contribute to reducing vulnerability and mitigating climate change and challenges thereof?

1. Materials and Methods

1.1 Study area and rationale for selection of sites

The study was conducted in three forest districts (i.e. Sefwi Wiawso, Asankrangwa and Offinso) in the high forest zone of Ghana. In each of these forest districts, two villages engaged in farm level tree planting were selected. The choice of the villages (i.e. Oda-Kotoamso and Akyekyere) in the Asankrangwa Forest District was based on their involvement in a private tree planting programme, i.e. a company-community partnership, under which a timber company supports farmers in its concession area to undertake farm level tree planting. It does so as a strategy towards increasing the stock of timber in the concession area while contributing to improving the living standard of the participating farmers. The villages of Sefwi Abrabra and Bopa in the Sefwi Wiawso Forest District were purposively selected because of being active among 59 villages in the Sefwi Wiawso Forest District that were supported by Ricerca e' Corporazione (RC), an Italian NGO, which stimulated tree planting on farmlands from 2000 to 2004. This allowed the inclusion of an NGO-facilitated agroforestry and reforestation programme aimed at addressing deforestation in Southern Ghana while improving the livelihoods of the local beneficiary communities. The two villages (i.e. Nkwankwaa and Nkenkaasu) in the Offinso Forest District were selected because they were among the ten villages in this district where a number of farmers have adopted farm level tree planting as a forest-based livelihood strategy through their own efforts, with some support from organisations like the Forest Services Division (FSD) of the Ghana Forestry Commission (FC) (see Table 1)

1.2 Selection of respondents, data collection and analysis

Data for this study was largely obtained through household survey, field observations and interviews with key informants and validation meetings in the villages. The household survey involved 106 respondents engaged in smallholder farm level tree planting in all the study villages (Table 1). In each village, the household respondents were selected using simple random sampling among the smallholders with the help of farmer leaders. Key informants purposively selected and interviewed included:

- Chiefs and queen mothers' (n = 4)
- Project officers affiliated with supporting organisations (n = 3).
- FSD officers (n = 3).

- Farm level tree planting association/Steering Committee leaders (n = 2).

The data collection issues centred on i) Governance issues of relevance to farm level tree planting; ii) Factors influencing farmers' engagement in farm level tree planting and iii) Strategies in reducing vulnerability and mitigating climate change at farm level and challenges. The Statistical Package for Social Scientist (SPSS) was used to analyse quantitative data by presenting frequency and cross-tabulation tables from data already put into the system. With the assistance of the Microsoft Excel data drawn from the SPSS were presented in percentages and tables.

2. Results

2.1 Governance arrangements

Interview with the key informant revealed the different governance arrangements such as Institutional framework, tenure security, marketing of harvested trees, benefits sharing and alternative livelihoods are key factors identified to enhance: i) industry-farmers; ii) NGO-farmers and iii) self-initiated partnerships in tree planting at the three study forest districts.

2.1.1 *Industry-farmers partnership in Asankrangwa Forest District*

In this District, the Samartex Timber & Plywood Co. Ltd. (Samartex in the rest of this paper) has established the Samartex Agroforestry Unit (SAU), which undertakes several activities to get the institutional arrangements functional and to make the tree planting scheme operational. According to the officials of Samartex, communities in the company's concession environs engaged in farm level tree planting are provided with agroforestry extension services; ii) free tree seedlings; iii) Capacity building training in tree planting techniques and alternative livelihood development. The partnership also extend collaborations with organisations such as local chiefs, the District Assembly, the Ministry of Food and Agriculture (MOFA), Forest Services Division (FSD), the Customary Land Secretariat of the regional Land Administration and NGOs. With respect to land tenure security, the Chiefs, elders and mostly the participating farmers have been sensitized on land rights and rules that regulate tree planting in off-reserve areas. In making an effort to grant property titles to the farmers, a total of 212 farm plots with trees had been mapped and were being processed for registration and documentation as at November 2010. Furthermore, it was ascertained that Samartex had negotiated with landowners to make land available to farmers who do not have land for tree planting. For such arrangements, benefit-sharing on timber trees are distributed as follows: 33% for the chief/landlord and 67% for the farmer but 100% of food crops are for the farmer. In the case of planting timber trees in cocoa farms under a sharecropping arrangement, benefit-sharing is based on the 'Abunu' sharing system (i.e 50% for the landlord and 50% for the tenant for both timber and crop benefits). In respect to marketing arrangement, Samartex has the first purchasing right to buy the harvested timber trees at prevailing market prices when harvested. Smartex is also exploring opportunities for farmers to engage in carbon credit schemes, through ongoing research to assess the carbon contents of planted trees. It was also revealed that the Company encouraged the farmers to integrate bee keeping in tree farms. Farmers involved in this scheme sell the filled comb honey at GHc1.70 per kg (US$1.20 as at November, 2010) to Samatex. Farmers who also incorporate Thaumatococcus daniellii, an understory herb locally known as 'aworomo', with the fruit are provided the opportunity to sell the *Thaumatococcus* fruits (locally, 'ego') at GHc0.70/kg (US$0.50) as at November, 2010).

2.1.2 *NGO-farmers partnership in Sefwi Wiawso Forest District*

In this district, Recerca e' Corporazione (RC), an Italian NGO from 2000 to 2004 facilitated on-farm timber tree planting in the selected communities. From this NGO-communities partnership, the three factors seen to play a role were i) capacity building; ii) benefit sharing and tenure security. Farmers were organised into tree-grower associations, provided with seedlings, technical advice and equipment (e.g. water tanks). Farmer-beneficiaries capacities were also built in tree planting techniques and alternative livelihood development. Farmers use individual or family/clan lands for tree planting thus are entitled to a 100% share of the food or cash crops and a 100% share of the tree benefits.

2.1.3 *Self-initiated projects in Offinso Forest District*

Farmers in the Offinso forest district were seen not to have external supporting institutions compared to the two preceding districts. However, it was revealed that majority (73%) of the respondents are members of the Offinso Teak Growers Association (OTGA) that is composed of on-farm tree farmers from ten villages in the Offinso Forest District. The rationale for joining such association according to the respondents is to expand their access to external support and provide a strong voice for the welfare of tree growers. The OTGA liaises with the district FSD office for the provision of technical advice and capacity building in tree planting techniques and tree seedlings production to its members. Tree-planting farmers in this district totally rely on their own or on hired experts to survey and to find a market for their mature timber. This was observed to be disadvantage for the farmers since adhoc and low prices are given by the buyers. Only farmers with own land or land inherited from parents are able to engage in on-farm tree planting, with few opportunities for migrants to participate in such schemes. Farmers use their own or family/clan lands for tree planting. Therefore, they receive 100% of the crop benefits (all types) and 100% of the tree benefits.

Table 1. Overview and characteristics of the study sites

Forest district (Region)	Study villages	No. of respondent	Administrative districts	Eco-zone
Asankrangwa (Western)	Oda-Kotoamso	16	Amanfi West	- Wet evergreen to moist evergreen forest
	Akyekyere	14		
SefwiWiawso (Western)	Sefwi Abrabra	32	Sefwi Wiawso/ Akontombra	- Moist evergreen to moist semi-deciduous forest
	Sefwi Bopa	21		
Offinso (Ashanti)	Nkwankwaa	9	Offinso	- Moist semi-deciduous, semi-evergreen forest
	Nkenkaasu	14		

Table 2. Access rights to land for engagement in on-farm tree planting

Kind of access rights to land	Forest Districts							
	Asankrangwa (n=30*)		SefwiWiawso(n=53*)		Offinso(n=23*)		Total N=106	
	N	%	N	%	N	%	N	%
Had own land or farmland	18	81.8	43	95.6	18	94.4	79	91.8
Had land inherited from parents	2	9.1	2	4.4	1	5.6	5	5.8
Chief made land available	1	4.5	-	-	-	-	1	1.2
Access to land owned by spouse	1	4.5	-	-	-	-	1	1.2
Total	22	99.9	45	100	19	100	86	100

Source: Field Data, August 2009 – November 2010 * In all the study districts, not all the respondents responded to the issue

2.2 Factors influencing farmers' engagement

Using a household survey approach in the three study districts, farmers were asked to indicate the factors that facilitate their engagement in tree planting on farmlands.

2.2.1 *Access rights to land to engage in farm level tree planting*

According to the farmers in the three districts as shown in Table 2, land tenure security is a major factor influencing farmers' decisions to engage in tree planting. Majority (98%) of the respondents (including those who had inherited land) had own land available for tree planting or had own farmland with permanent crops with which timber tree planting could be integrated, though some of this group additionally took land from the chief, while others went into sharecropping arrangements. However, few (1%) of the respondents indicated that land provided by chiefs was the sole sources of land for tree planting.

2.2.2 *Farmers' reasons of investing in farm level tree planting*

Majority (77.2%) of the respondents across the three study forest districts indicated that the rationale of engaging in farm level tree planting was because of being owners of the planted trees which may serve as source of livelihoods and inheritance for their children as indicated in Table 3. Across the three districts, there were also those who indicated reasons such as opportunity to plant one's own choice of tree species as well as crops.

2.3 Farmers' views of strategies in reducing vulnerability and mitigating climate change at farm Level and challenges

2.3.1 *Farm level small scale tree planting contributions to reducing vulnerability to climate change*

- Farm level tree planting using Agroforestry system

The study revealed that farmers in Sefwi Wiawso and Asankrangwa forest districts had adopted typical agroforestry models in tree planting at the farm level by incorporating permanent agricultural crops (e.g. cocoa, black pepper and oil palm) in tree farms. This was reported by 85.4% and 88% of the respondents in SefwiWiawso and Asankrangwa forest districts respectively. On the contrary, none of the respondents from the Offinso FD indicated such planting arrangement with the reason being the frequent fire outbreaks in this area, which deters farmers from intercropping permanent agricultural crops with the timber trees. They however, prefer to invest in the planting of teak which is resistant to fire.

The type of agroforestry model adopted and the technique of planting is based partly on the advice given by the supporting institutions, and partly on the farmers' own intuition. In the two villages (Sefwi Bopa and Sefwi Abrabra) SefwiWiawso forest district, respondents and field observations revealed that farmers have planted exotic and indigenous timber trees together with cocoa or oil palm within 2m–5m spacing, but not in rows. Further discussions with the farmers' revealed that Recerca e' Corporazione gave the spacing type to farmers but did little demonstration on how to plant using the spacing given. There was a revelation that the close spacing for planting timber trees even in permanent crop farms was done with the aim of doing early thinning.

Similarly, under the Samartex farmer-supported agroforestry projects, discussions with Samartex Agroforestry officers and visits to eight tree farms in April 2009 and November 2010 at Akyekyere and Oda-Kotoamso respectively revealed that the farmers had been guided to plant timber trees using different spacing according to the kind of timber tree species. Thus, the following agroforestry models were adopted:

i Planting of indigenous trees in permanent crop (e.g. cocoa, black pepper, cola, oil palm and orange) farms, particularly when both agricultural and timber species are planted in the same year– 10m by 10m or 10m by 15m depending on crown of timber species.

ii Planting of indigenous timber trees in already established cocoa farms is done by putting the tree seedlings in open spaces in the cocoa farm where the sun's rays falls directly on the ground. In this case, the timber trees are not planted in rows as such.

iii Planting of exotic timber species at boundaries of permanent agricultural crop (cocoa, orange and oil palm) farms.

- *Using appropriate tree species and management practices*

At Sefwi Bopa, field observations in three oil palm farms mixed with *Cedrella odorata* and *Terminalia superba* (ofram); and cocoa farm with same timber species revealed that the timber species had fast growth rate, densely stocked but not planted in rows. These agroforestry (timber trees mixed with crops) farms, established during the period of 2000 to 2004 had not been thinned as at November 2010. Hence, the timber species had overshadowed the oil palm and cocoa trees that were planted together with the timber trees within the same year. However, a visit to an already established cocoa farm mixed with indigenous timber species (planted later) in open spaces in the farm, revealed that the timber trees had fast growth rate, well stocked (about 45 timber per 1 ha), and had no shade effect on the cocoa. Again a visit to a mixed agroforestry farm at revealed a well-designed mixture of black pepper and timber tree species, with pineapples as under crop, all planted in rows. This farm looked relatively well maintained with the black pepper farmer having a separate pure stand farms of *Cedrela odorata* and *Triplochiton scleroxylon* (wawa), and one with mixed *Cedrela odorata* and indigenous timber species; each of these farms planted at 3 m by 3 m spacing. The farmer had a number of bee hives set up under his timber tree farms some of which had been colonized with bees and producing honey as an Entomoforestry system. In the Asankrangwa Forest Districts, field observations at

Table 3. Farmers reasons of adopting on farm level tree planting

	Forest Districts							
	Sefwi Wiaso(n=46)		Asankrangwa(n=25)		Offinso(n=21)		Total(n=92)	
	n	%	n	%	n	%	n	%
Ownership right and 100% benefit-share of trees	43	93.5	23	92	5	23.8	71	77.2
Opportunity to plant any kind of crop	2	4.3	1	4	4	19	7	7.6
Government and others institutions have no share in the planted trees	1	2.2	0	0	6	6.5	7	7.6
Simultaneous benefits of food crops and tree	0	0	1	4	6	6.5	7	7.6

Source: Field Data, August 2009 – November 2010

already established cocoa farms at Akyekyere revealed a preserved and planted indigenous timber species in open spaces. The timber stands are relatively well maintained and stocked and had fast growth rate without casting shade on adjacent cocoa. Similarly, in Oda-Kotoamso village an orange farm showed alternate rows of orange stands and indigenous timber tree species [e.g. *Khaya ivorensis* (African mahogany), *Aningeria robusta* (Asanfena), *Tieghemella heckelii* (Bako), *Entandrophragma ivorensis* (Edinam)]. In these two districts, farmers were observed to practice tree preservation through regeneration of naturally growing trees in their cocoa, cola or black pepper farms. During land preparation some trees are felled and burnt. However, some are preserved with the initial purpose of using to protect the young growing cocoa, as shade trees. In this regard, farmers leave few trees during initial clearing of virgin forests; and also as the vegetation begins to regenerate and farmers begin to weed their growing cocoa trees, they deliberately leave economic tree species such as *Milicia excelsa* (Odum), *Khaya ivorensis* (Mahogany), *Ceiba pentandra* (Onyina) and *Tiegamella heckelii* (Bako) to serve as shade trees among the young cocoa trees. As the cocoa trees start bearing fruits, some of the preserved trees are cut away to give room for more sunlight to the cocoa, especially the modern hybrid species. Thus, a substantial number of economic trees are maintained throughout the fruit bearing period of the cocoa. The farmers had the understanding that once the trees are preserved among planted ones they will have ownership of them. Unfortunately, such arrangements were not observed in the Offinso Forest District.

- *Forests and tree farm conservation*

Much as farmers attach importance to the protection of their permanent agricultural crop farms against fire outbreak and theft, so do they protect planted trees and nearby forests. In all the study villages, views expressed by tree farmers show that planted trees are mixed with or share boundaries with some permanent agricultural crop (cocoa, oil palm, orange) farms. So, tree farm owners as well as adjacent crop farm owners are committed to the protection of both permanent crops and planted timber trees. With most people in the study communities being crop farmers, the protection of tree and crop farms generally becomes the concern of the whole community, headed by the Caretaker Chief ('Odikro'). Thus, from the month of November every year, the Chief / Odikro regularly reminds members of the community, through the beating of 'gong gong', on the need to refrain from sending fire to farms during the dry season (November to February).

The study again revealed that tree farmers at the village of Oda-Kotoamso in the Asankrangwa forest district formed a local steering committee with a representative from Samartex to engage in forest and tree conservation activities such as (i) mediating in encroachment and boundary disputes, (ii) monitoring illegal felling of timber trees from nearby forests and farmlands. In dealing with theft and illegal cases, respondents in the Asankrangwa forest district revealed that people

who attempt to steal crops or illegally fell timber trees from forest reserves and farmlands were arrested and sent to the chief and elders, and they were made to face the full rigors of the local law, which include payment of fines. Respondents at Nkwaankwaa and Nkenkaasu in the Offinso forest district assert that they do undertake activities such as planting of *Cassia siamea* (Cassia) as green fire belts around their tree farms to help in preventing fire.

2.3.2 *Farm level small scale tree planting contribution to mitigating climate change*

The study revealed that farmers plant trees in pure stands on land from which forest cover has been absent (afforestation) particularly in the Offinso Forest District, as well as areas which had forest but degraded (reforestation), as in the Sefwi Wiawso and Asankrangwa Forest Districts. In all these cases, where trees are planted in pure stand, the farmers inter-plant with food crops within the first three years. In this case, afforestation and reforestation can be considered as the direct human-induced conversion of non-forested land to forested land through planting.

At the Sefwi Wiawso Forest District, some of the farmers who could follow the planting instructions given by officials of RC planted mixed exotic and indigenous timber trees in pure stands, in rows at 3 m by 3 m spacing. At Akyekyere and Oda-Kotoamso in the Asankrangwa FD, the Samartex Agroforestry Unit guided the farmers to plant trees in pure stands using different spacing based on the species planted. For exotic species (*Tectona grandis* and *Cedrela odorata*) the spacing of 3 m by 3 m was used, while 5 m by 5 m was used for indigenous species e.g. African mahogany, ofram, emire. In the Offinso FD (at Nkwaankwaa and Nkenkaassu), farmers practiced afforestation by planting exotic timber trees, particularly teak, mostly in pure stand based on the technical advice from the district FSD. Observations in four tree farms visited here indicate that the dominantly planted teak tree is planted in rows at the spacing of 3m x 3m.

The study revealed that the implementation of the on-farm tree planting scheme can best be likened to the taungya system, whereby trees and wood production are mainly for commercial purpose. The study revealed that participants usually consider opportunity cost of the land use, and decides to invest in timber trees with their natural capital of land instead of using it for other farm based investment such as growing of permanent agricultural cops (e.g. cocoa). Participants in the Offinso Forest District for instance adopt this model by planting *Tectona grandis* (teak) which is fire resistant, because investment in permanent crops like cocoa and oil palm had since 1983 become risky and uneconomical as a result of frequent fire outbreaks in this zone. The sense of total ownership of planted timber trees based on the Timber Resource Management (Amendment) Act 2002 (Act 617) also becomes a source of motivation for the farmers' commitments in planting and maintaining tree plantations after canopy closure, despite no income from such plantations till trees mature.

The potential of tree planting either in pure stands or mixed with food crops when well established and maintained as shown in the different sites do have the potential to serve as carbon sequester in mitigating process. However, it was observed that on farm tree planting are confronted with challenges, some of which are presented in the subsequent sub-section.

2.3.3 *Farmers' perception of challenges in farm level tree planting*

Respondents were pessimistic about the stability of on-farm tree planting. This was based on perceived challenges as follows:

i Most farmers are inexperienced because on-farm timber tree planting is not based on farmers' traditional farming systems thus they must be trained before they can effectively integrate trees with crops.

ii Lack of funds for maintenance of tree farm especially after removal of food crops. This was reported by 63.0%, 22.2% and 8.7% of respondents from Offinso, Asankrangwa and Sefwi Wiawso Forest Districts respectively.

iii High labour and maintenance costs were mentioned by 45.7%, 18.5% and 5.3% of the respondents from Sefwi Wiawso, Asankrangwa and Offinso respectively.

iv In Offinso FD where farmers have being engaging in tree farming long enough to harvest some trees, 15.8% of the farmers reported of facing several bureaucratic hurdles during harvesting and marketing.

v Shade effect of trees on adjacent crops resulting in yield reduction, reported by 17.4% and 7.4% of respondents from Sefwi Wiawso and Asankrangwa Forest Districts respectively.

3. Discussion

3.1 Governance arrangements

Organisations provide appropriate structures to foster projects like farm level tree planting schemes [18]. Hence, the support of both government and non-government organisations play key roles in stimulating smallholder farmers' tree planting at the farm level. From the study, three mode of farm level tree planting observed were industry-farmers partnership, NGO-Farmers partnership and Self-initiated project. In all these modes, the role of the public actor such as FSD and MOFA were found to be limited. However, public actor involvement in partnership approach based on cooperation between wide ranges of stakeholders is crucial for the success of tree planting and agroforestry schemes [9; 21]. The rationale being that public sector can create an enabling environment by providing extension services and improving road networks that enable efficient marketing of products. The prevailing innovations in governance arrangement in off-reserve areas could set the tone for public sector active involvement in tree planting to reduce vulnerability and mitigate climate change as well as enhance rural livelihood sources [9]. These include i)

Timber Resource Management (Amendment) Act 2002 (Act 617) recognising ownership rights to individuals who plant economic trees on farmlands, thus encouraging smallholder farmers to invest in establishing economic timber tree; and ii)Institutionalization of equitable benefit-sharing agreements in tree-planting schemes[9].

3.2 Factors influencing farmers' engagement

Secure land and tree tenure are also major factors in adopting on-farm tree planting in Africa [6; 3]. In Ghana, farmers with secure rights to land are more likely to plant trees on farmlands [22]. This is confirmed in this study, where majority (98%) of the respondents (with 63% of them being natives) were owners of the land on which trees are planted. Positively, this is an indication that afforestation or reforestation activities can be promoted by the government aiming at mitigating climate change. In contrast, this implies that the farm level tree planting favours natives with ownership rights of land more than migrants who can plant trees only through tenancy (sharecropping) agreements. The issue of people having no secure rights and tenure over the lands and resources affects the possibility of promoting activities in the forest sector that are aimed at mitigating climate change [20]. However, from the study it was realised Samartex has set a tone in facilitating land and tree tenure arrangements in the Asankrangwa Forest District with the chiefs to ensure effective implementation of on-farm tree planting by both native and migrant farmers.

3.3 Strategies in reducing vulnerability and mitigating climate change at farm level and challenges

From the study, it was observed that farm level tree planting contribute to reducing vulnerability to climate change through i) development of more resilient agroforestry systems; ii) using appropriate tree species and management practices and iii) conservation practices including creation of fire barriers. As confirmed in literature, cocoa agroforestry do meet ecological, biological and economic objectives as well as create forest-like habitats, which harbour tropical biodiversity in rapidly degrading landscapes while providing an economic crop for small-holder farmers [24;7; 1]. Furthermore, [14] asserted that conserving natural forest, planting new forests, rehabilitating degraded forests, enriching existing forests and eliminating agricultural practices that contribute to the deterioration of carbon reservoirs are effective ways of mitigating the GHG emissions and their effects. In this study, the potential of small scale on-farm tree planting in contributing to climate change mitigation is based on: maintaining or increasing forest area through afforestation and reforestation. Even though farmers' main purposes for involving in tree planting at off-reserve areas is for generating revenue from the harvested timber trees, some of the mode of tree planting like the pure stands as observed in the Offinso District have strong potential for climate change mitigation. In choosing to maintain or increase forest area through afforestation and reforestation activities, the efforts of the farmers in the study areas can strongly contribute to climate change mitigation. This is confirmed by the observation by authors such as [15; 10] who have reported that the forest sector contributes to the mitigation of climate change through management strategies which include afforestation and reforestation. Furthermore, it is reported that trees (particularly tree plantations in pure stands) act as long-term reservoirs, which lock up the carbon for decades, in the form of cellulose and lignin [20]. Therefore, such tree plantations have higher potential to enhance carbon sinks and reduce Greenhouse gas (GHG) emissions by contributing substantially to mitigating climate change and its effects on ecological and social systems [20].

On-farm tree planting has potential to become an important element of reducing vulnerability, mitigating climate change and enhancing rural livelihoods. However, several challenges adversely affect small scale tree farmers. The problem of inexperience can be overcome when farmers' capacities are built in the areas of technical-know-how and marketing skills in tree planting. Furthermore, government need to facilitate the institution of Payment for Environmental Services (PES) from which farmers involved in tree planting can benefit from, in order to overcome financial challenges and related high maintenance costs. Payment for Environmental Services (including Reducing Emission from Deforestation and forest Degradation plus (REDD+) schemes can therefore be considered as a financial incentives from government and other agencies to attract farmers in investing in tree planting as alternative land use ventures. In this vein, lessons can be drawn from Costa Rica where the forestry legislation includes incentives for the establishment and management of plantations and agroforestry systems, especially on abandoned pastures and other deforested lands [16]). Other private sector companies with relatively high turnover can be drawn into the scheme to contribute to the PES. Selective taxes on products from such companies including gasoline, gold nuts, and lumber, among others can contribute a lot in financing this incentive programmes as practiced in Costa Rica. Another option is for government and other supporting organizations to take advantage of the favourable conditions under climate change financial mechanisms and intensify the introduction of farmers into on-farm tree planting. The scheme can be linked to climate change mitigation programmes and carbon schemes under the non-Kyoto compliant voluntary carbon sequestration[1] projects. As noted by [13]) the Kyoto Protocol recognises carbon sequestration through forestry as a way of mitigating global warming. These financial options would help in achieving overall success of on-farm tree planting by smallholder farmers.

The procedures for obtaining harvesting and conveyance permits are lengthy leading to low prices being paid by timber companies to farmers. There is therefore the need for the state forestry agency to review its policy towards enabling local people involved to have secure rights to harvest products of planted trees [8; 23]. Nonetheless, farmers should also be guided to do

[1] Carbon sequestration has been defined as the process of removing excess carbon dioxide (CO_2) from the atmosphere (3.67 tons CO_2 = 1 ton sequestered carbon) [13].

selective harvesting, as means of encouraging keeping a good stand of the planted trees to provide environmental services. Finally, the problem of shade effect has a reflection on the quality of tree-crop mix design in an agroforestry system. It has been reported that "timber trees planted at a distance of 12m $\times$ 12m initially (which may be thinned to a spacing of 24m $\times$ 24m after sometime), in association with cocoa planted 3m $\times$ 3m will ensure good growth conditions for cocoa [1]. This is because although young cocoa trees need high level of shade, since they are more sensitive to light, maturing cocoa trees need substantial volume of light for optimal levels of cocoa productivity and sustainability [11].

4. Conclusion

This paper provides insight into the governance arrangement and potentials of small-scale tree planting at farm level landscape in mitigating climate change and the challenges thereof. The study revealed that in the implementation of the on-farm tree planting, the main forestry activities adopted that have the potential in mitigating climate change include development of resilient agroforestry systems, afforestation and reforestation using appropriate crop and tree species with forest management practices. These activities are however, primarily meant to restore the forest cover as well as serving as secure livelihoods sources for the local people involved.

Several challenges adversely affect participants' livelihoods and explain the mixed feelings among farmers about current livelihood outcomes from on-farm tree planting. The main challenges faced include: (i) the fact that farmers are inexperienced because on-farm timber Carbon sequestration has been defined as the process of removing excess carbon dioxide (CO_2) from the atmosphere (3.67 tons CO_2 = 1 ton sequestered carbon) [13]. tree planting is not based on farmers' traditional farming systems; (ii) financial challenges faced by farmers involved because of lack of income between canopy closure and timber harvesting; and (iii) shade effect of trees on adjacent crops resulting in yield reduction, especially in the Sefwi Wiawso Forest District.

To help improve the implementation of on-farm tree planting, it has been recommended that the public actor (government) need to be actively involved in partnership approach based on cooperation among a wide range of stakeholders. Furthermore, government need to facilitate the institution of financial mechanisms, particularly Payment for Environmental Services (PES) including REDD+ and CDM projects, from which farmers involved in tree planting can benefit. These steps will boost participating farmers' interest in using their land for investment in tree planting and ensuring the sustainability of the system. This means creation of good stock of carbon sink that has high potential in mitigating climate change, as well as serving as reliable source of livelihoods for farmers involved.

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