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Is mango farming sustainable? An integrated analysis of remote sensing techniques and smallholder farmers' perception in mango farming communities in Ghana

Gerald A. B. Yiran[1*], Austin D. Ablo[1] and Freda Elikplim Asem[2]

Abstract

In sub-Sahara Africa, sustainable agricultural sector has been trumpeted as the surest way for livelihood transformation through poverty reduction and ensuring food and nutritional security. Using mango farming as a case study, the paper determines how sustainable agriculture can be achieved by examining the environmental, social and economic impacts of mango farms in a rural setting. Qualitative and quantitative approaches were used to collect primary data from 400 respondents from the Shai Osu-Doku and Yilo-Krobo Districts of the Greater Accra and Eastern Regions respectively of Ghana. Secondary data, especially Landsat images between 2000 and 2020 were acquired and analysed. The quantitative data were analysed using descriptive statistics and cross-tabulations, while the qualitative data were analysed using thematic analysis and quotations from respondents. The findings show some positive outlook socioeconomically and environmentally. Socioeconomically, mango farming has led to an increase in incomes for farmers, reduced out-migration of the youth, ensured food security, and provided enough money to take of children's' education, health, and other social needs of the families. Environmentally, there is an improvement in the vegetal cover which has a positive impact on carbon sequestration, air filtering and soil conservation. The study confirms the sustainability of mango production as it is a viable business, provides good incomes and ensures access to food. To ensure sustainability and livelihood transformation, we recommend policies and measures to put in place to reduce the challenges that smallholder mango producers face to sustain and promote mango production.

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1 Department of Geography and Resource Development, University of Ghana
2 Department of Agricultural Economics & Agribusiness, University of Ghana
***Corresponding author:** Department of Geography & Resource Development, University of Ghana, Legon, Ghana
Email: gyiran@ug.edu.gh

Introduction

The development and growth of the agricultural sector are essential for poverty reduction and ensuring food and nutritional security (Christiaensen et al., 2011). For many developing countries, the United Nations Sustainable Development Goals (SDGs) attainment depends on the sustainable growth of their agricultural sectors. In sub-Saharan Africa (SSA), agriculture accounts for about 65% of the continent's employment and 75% of its domestic trade (Imara Africa, 2012). Agriculture development is central to GDP and industrial growth and job creation, and the overall enhancement of quality of life (Adenle et al., 2018; Diao et al., 2010; New Partnership For Africa's Development (NEPAD), 2013; Salehe, 2018). It is the primary source of livelihood for many of the poorest households in many countries. It employs more than half of the total workforce in Sub-Saharan African (SSA) countries (OECD-FAO, 2016).

Despite the role of agriculture in sub-Saharan African economies, the sector is mainly rain-fed and subsistence-based, with rudimentary technology used to produce about 80 percent of the total output (Barnett & Srivastava, 2017). Subsistence agriculture plays a crucial role in ensuring livelihood and food security, especially for rural folks in Africa (Poulsen et al., 2015). The crop sector remains dominant, accounting averagely for about 85% of the production value in SSA (OECD-FAO, 2016). Even though total food production has been growing, the growth rate is very slow, resulting in poverty and food insecurity in SSA (Chauvin et al., 2012). This is because the farming systems face many challenges from environmental, climate change and soil management (Altieri et al., 2015; Gashu et al., 2019). These challenges have led to low agricultural production, increasing the number of people in abject poverty.

To improve incomes, food security, and sustain people's livelihoods, agricultural transformation through the inclusion of non-ruminant livestock and cash crop production has been pursued (Waha et al., 2018). Cash crop production and fruit production have gained roots in many African countries. These fruit crops are largely grown for the export market because of their higher market prices than traditional cereals (Temu & Temu, 2005) and thus more profitable than cereals. Thus, their integration into the farming system is seen as a livelihood transformation and poverty alleviation strategy (Poulton & Poole, 2001). Fruit crops are also increasingly consumed locally due partly to dietary diversification and urbanisation (Van Melle & Buschmann, 2013) and this can contribute to reducing food insecurity. However, most SSA farmers cultivating fruit crops are smallholder farmers (Jamnadass et al., 2011) and this number is rising probably due to the cultivation of diverse cash crops and their higher returns.

Studies show that fruit production stagnated between 2010 and 2011 and then took a nosedive to about 2013, after which it began to pick up again (see Mensah, 2014). One such crop that has seen increased activity in recent times is mango production, which are mainly cultivated in the tropics (Yusuf & Salau, 2007). In West Africa, mango production has become an important livelihood activity where all 15 countries in the subregion are

involved in its production (ECOWAS-TEN, Undated). The subregion is the seventh producer of mango globally, producing about 3.8% of the global output, with exports standing at about 2.7% of global exports (ECOWAS-TEN, Undated). Mango production offers many livelihood opportunities along its value chain, with people engaged in the nursing of seedlings, transplanting, farm management, spraying, and picking of fruits. Some others also engage in its transportation, production of juice, retailing to local consumers and exporting. As a result, mango production provides a lot of income to many households and earns foreign exchange for countries (Banson & Egyir-Yawson, 2014; Mensah & Brummer, 2016; Mkenda, 2011).

Studies have shown that Land use Land Cover (LULC) changes, especially that driven by urbanisation have led to a reduction in land available for agriculture (Ablo et al., 2020; Sulemana & Yiran, 2019; Yiran, 2020). Most urban centres are surrounded by the most productive agricultural lands. The rapid growth of these centres due to population increase, means more areas around them are converted into settlements, at the expense of agriculture. Although mango production in the Eastern region is fast becoming a thriving business, the increasing population or urbanisation in this part of the country is becoming rapid and may consume the land used for mango production. This notion of the impact of urbanisation on agriculture has largely been the focus of research, neglecting other effects such as access to markets and demand for diverse foods. This is rightly so because the concentration has been on farmers at the peripheries of cities. But it is equally important to note that urbanisation will lead to increase demand for food which will afford farmers in other areas the opportunity to increase production. Thus, urbanisation may promote food production, but the seemingly less attention paid to that has created a knowledge gap on the full impacts of urbanisation on agriculture. Other studies have also shown that urbanisation coupled with agriculture has led to a reduction of vegetative cover which influences climate change (Majeed et al., 2021; Palafox-Juárez et al., 2021; Pongratz et al., 2021). Climate change in turn affects agriculture through a reduction in production resulting from changes in rainfall and temperature (Kogo et al., 2021; Tarfa et al., 2019). These challenges enumerated above are more stressful for smallholder farmers in rural communities who are very vulnerable (Harvey et al., 2014; Nyamadzawo et al., 2013). In the face of all these challenges, the call for agriculture sustainability is even louder. In this study, we seek to find answers to the following: 1) Is mango farming by smallholder farmers sustainable? 2) What constraints stand in the way of mango production? 3) Is urbanisation a threat to mango production? and 4) Can mango production transform the livelihoods of the smallholder farmer? Understanding these will aid in deploying strategies to boost mango output in Ghana. We try to answer these questions by investigating the sustainability of agriculture of smallholder mango farmers in rural communities in Ghana.

The conceptual framework underpinning the study

The debate about sustainable agriculture emerged in the 1950s and 1960s with the introduction of the green revolution (Siebrecht, 2020). At the time of the green revolution, the focus was on improving crop yield leading to the development of improved varieties, and the use of external inputs such as fertilizers, biocides, and modified land management practices (Ariga et al., 2019). Regrettably, these developments brought huge environmental consequences such as water and air pollution, soil degradation, and biodiversity loss (Horrigan et al., 2002). Consequently, alternative methods to traditional agriculture which were seen as sustainable were pursued and that was when the concept of sustainable agriculture emerged (Siebrecht, 2020). The concept of sustainable agriculture is not a well-defined concept that can be simply applied correctly due to the inconclusive debates surrounding it (Tenaw & Beyene, 2021). This has made actors, both practitioners and researchers, develop their various understanding of the concept based on their background leading to the emergence of several conceptions of sustainable agriculture. In this paper, sustainable agriculture is conceptualised as a goal-oriented concept where the emphasis is on achieving the ecological, economic, and social goals of present generations without compromising that of future generations (Deytieux et al., 2016; Farrell & Hart, 1998). This means that sustainable agriculture systems must meet the demands of multifunctionality, satisfying a varied set of goals, and should continue into the future (Bouma et al., 2021; Hansen, 1996 cited in Siebrecht, 2020).

The implementation of the definition as given above can only be achieved at the farm level where actual management can be adapted and decisions changed to enable sustainable development (Sabiha et al., 2016). This is because it is only farmers who can avoid unsustainable practices and employ methods that will guarantee the attainment of the diverse requirements of sustainable development (Carof et al., 2013). Farmers and their choices are very important for sustainable development as their practices and decisions have implications on natural resources. This calls for agricultural goods and services to be produced by farmers for consumers while protecting the environment and taking other societal demands into account. Farms are complex socio-economic-environmental systems where all pillars of sustainable development meet and interact. When the interaction takes place without any adverse effects on any of the pillars, sustainable agriculture is achieved. This conception of sustainable agriculture makes it easy to assess.

However, there is still some complexity in its implementation as the indicators used for assessing the pillars are diverse and varied. Nonetheless, it is worth assessing the sustainability of agriculture as it borders on human welfare. We thus assessed the sustainability of mango farming based on the indicators that could be gathered from the farmers' perspective. It is expected that this will highlight other indicators for future investigations and assessments.

Methods

Research setting

The study was conducted in two Districts: the Yilo Krobo District in the Eastern Region and Shai Osu Doku District in the Greater Accra Region of Ghana. The study area is specifically located between Latitudes 5˚50'00"N and 6˚05'00"N and Longitudes 0˚00'24"W and 0˚02'00"W. It is found along the Eastern foot of the Akwapim range in the northeastern part of the Greater Accra Region and the southeastern part of the Eastern Region (MoFA, 2013 cited in Emmanuel & John, 2017). Mango production is performing well in this part of the country with a bimodal production system (MoFA, 2013 cited in Emmanuel & John, 2017), giving Ghana a comparative advantage over its neighbouring countries which harvest only once a year (Van Melle & Buschmann, 2013). The area has both smallholder and large-scale farmers engaged in mango production. Mango is exported as well as consumed locally as fresh fruits or processed into other foods like jam, dry fruits, juices, and flavours (Leakey, 1999 cited in Abirami et al., 2020; Banson & Egyir-Yawson, 2014; Bekele et al., 2020).

Mango production in the area has faced many challenges including pest and disease infestation, low soil nutrients, lack of access to capital and markets, and post-harvest losses (Kibira et al., 2015; Kshirsagar et al., 2019; Mohammed et al., 2018; Rendon & Enkerlin, 2021; Shresthaa et al., 2021). Due to the various socio-economic benefits of mango production, several interventions have been provided to farmers, particularly technical and logistic support, by the Ministry of Food and Agriculture (MoFA), in collaboration with institutions such as Adventist Development and Relief Agency (ADRA) and Millennium Development Authority (MiDA) (MoFA, 2013). Despite the economic prospects and the various private and public interventions in mango production, the output of mango farmers in the study area is still low, with an average of about 8,000kg/hectare, which is far below the expected output of about 12,000kg/hectare (MoFA, 2014).

Research design and sample

The study adopted a cross-sectional design involving both primary and secondary data. The data were collected using both qualitative and quantitative approaches, which were chosen because they are complementary and produce more robust results than just using one of them (Teye, 2012). Three communities/villages, one in the Shai Osu Doku District and two in the Yilo-Krobo District. In selecting the communities/villages, the mango-producing communities in each district were written on paper, folded, and placed in a hat. Then after thorough mixing, the required number in each district was drawn without replacement. Because almost all commercial farmers do not reside in the area (noted from our pilot survey) and based on the objective of the study, we considered only small-scale farmers in the survey.

A sample size of 400 was chosen based on Ahmad and Halim's (2017) view that for a population of more than 10,000 at a 5% level of significance, 95% confidence interval, and proportion of 0.5, a sample of 370 can be used. Though the number of people engaged in mango production is unknown, it was estimated to be more than 10,000 in the two districts, and thus, a sample of 400 was a good estimate for the study. The number of respondents, though arbitrarily, was based on the relative numbers engaged in mango gathered from perception of opinion leaders during a reconnaissance survey. Thus, Akorley had 173 respondents, with Trom 137 and Ayenya 90. To select the households, we listed more than 500 farmers in each community who agreed to participate in the survey during the reconnaissance. Telephone numbers of these people were taken and written on pieces of paper, folded, mixed, and selected randomly without replacement until the number for each community was attained. The selected numbers were then called and scheduled a time within the research timeframe for questioning. For the qualitative data, one focus group discussion was conducted at Trom. This involved 8 people consisting of three males and three females who are engaged in the mango business and two non-mango-related farmers. These people were selected after holding an initial discussion with a youth leader in the community and consisted of people who do different activities in the mango production chain. These people also cut across all the age groups above 18 years. Also, seven in-depth interviews were conducted with key opinion leaders (Some of whom were commercial farmers) in each of the communities, summing up to 21 interviews. This was considered enough as the minimum sample size for the qualitative interviews is 13 (see Vasileiou et al., 2018).

Data collection and analysis

The primary quantitative data were collected using a questionnaire. Two satellite images from path 194 row 056 for 2002 and 2020 were downloaded from the United States Geological Survey website. This period was chosen because mango farming became brisk after 2002 (MOFA, 2014). Both images were taken in December, which met the less than 10% cloud cover criteria (see Yiran et al., 2020). The images were calibrated, and bands 4, 3, and 2 were stacked to form a false colour composite. This band combination was selected because of its ability to discriminate vegetation. An interview guide was used for the qualitative data collection. Personal observations of the environment were done and combined with google earth to explain the results. The satellite images were classified using the Random Forest classifier. The initial classes that were used for the training samples were ten, but less separable classes were combined into one. Thus, the final classes were waterbodies/burnt scars/shadows, settlement/bare land, dense vegetation, and exposed soils/farms/grassland. The training samples were collected by combining field visits and google earth images. It should be noted that this broad classification did not affect the results as mango farms with young trees, especially those managed by smallholder farmers, were still being intercropped with other food crops until the

canopies were fully established. Thus, young mango farms will be classified as farms, but where canopies are fully established, they will be classified as dense vegetation. This is because our field observation indicated that when the canopies are fully developed, the farms look like a forest.

The quantitative data was analysed using descriptive statistics and inferential statistics. The descriptive statistics included frequencies and cross-tabulations presented in tables and charts, while the inferential statistics included multiple regression. Change detection was performed to assess changes in land use, especially the encroachment of built-up on mango farms resulting from urbanisation. Thematic analysis as well as Vignettes were used for the qualitative data.

Results and Discussion

Mango farming requires land, which is the base of the environment. Thus, we begin by assessing the contribution of mango farming to environmental changes by assessing land use land cover changes in the area and other environmental attributes that might change due to mango farming. Following Yiran et al. (2012) recommendation that better information about the environment can be attained through the integration of local knowledge with scientific knowledge, we start with assessing land use/land cover change from farmers and then use that to classify satellite imagery. We then turn to assess the benefits of mango production, the effects of urbanisation, and other challenges, after which we draw our conclusion on the sustainability of mango farming.

Assessing land-use change from farmers' perspective

In the focus group discussion in Trom, the participants identified four land use types: Natural Vegetation (dense vegetation and grassland), Settlement, Agriculture (farmlands), and Waterbodies. According to them, the dense vegetation which they refer to as forest represents areas with a high tree population (i.e., where there are many trees sometimes with interlocking canopies) while the grassland refers to areas occupied largely by grass and shrubs with scattered trees. Fortunately, the meeting ground was close to the community cemetery where the trees were not disturbed, and they used that as an example of a forest. In the interviews with opinion leaders in the other communities, they confirmed these broad land use types. Our observations were similar to their classifications, so we thus proceeded according to these classes. It was unanimously agreed that the natural vegetation is reducing in size and an increase in farming was given as the major cause of the reduction. Two types of farming; cash crop farming largely mango and food crop farming were largely practiced in the area. These types of farming practices were responsible for the land use and land cover changes in the area.

To examine the land use change patterns due to these farming practices, farmers were asked to indicate the use of the land before and after they acquired or started using it. This was a multiple-choice question as smallholder farmers did not have their lands in

the same place. The responses seemed similar and were later recorded into the options shown in Figure 1. As can be seen in Figure 1, the largest land use before the acquisition in all communities was either natural vegetation or food crops.

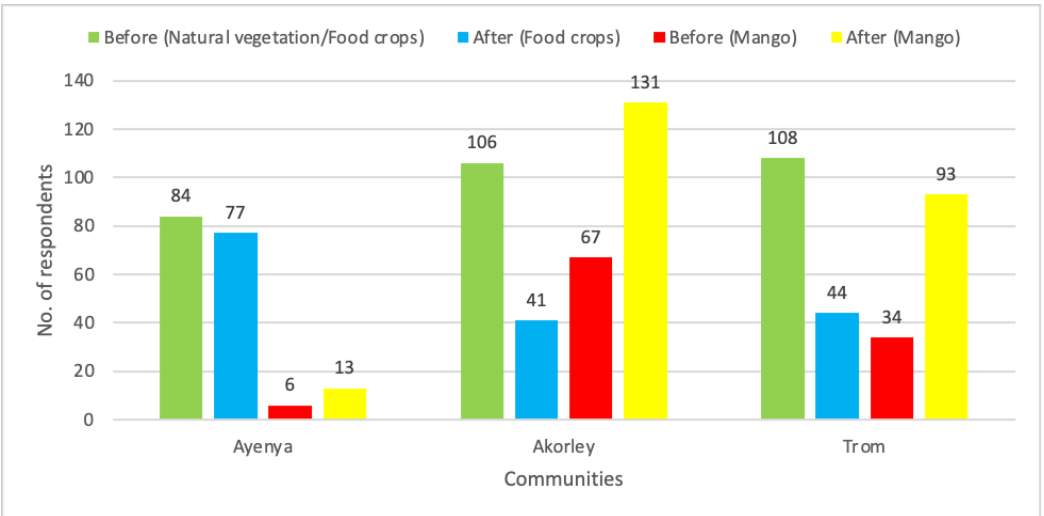

Figure 1: Community perception of change in land use (Source: Fieldwork)

But, after the acquisitions, the land was put into either food crops or mango farming. That is, either farmers continued to produce foods on the land they have acquired, switched from food crops to mango farming, or converted the natural vegetation to food crops or mango farming. This is not surprising because these are rural communities and therefore, the reason for land acquisition in these areas by smallholder farmers will be for farming. However, analysis of the in-depth interviews points to more conversion of both vegetation and food crops to mango farming as can be seen from this typical response from a respondent in Akorley: "*my mango farm was a grassland but the main reason for acquiring that land was to cultivate mangoes and I put it straight into it*".

Another observation is a decline in the number of respondents who used their land for food crop production while those using it for mango production increased. It can also be seen that the more significant shifts in land use from food crops such as maize and cassava to mango farming are in the Yilo Krobo communities, that is, Akorley and Trom. About 64 and 59 more farmers in Akorley and Trom respectively had converted their land from natural vegetation/food crop production to mango. These communities already had a higher number of farmers practicing mango farming and therefore, the corresponding increases suggest that the community members observed/heard of the success stories of mango farming and are also going into it. Farmers attempted to quantify the gains obtained from mango farming and, in some cases, estimated over 70% returns from mango as compared to food crop farming. It is therefore not surprising that farmers attributed these switches to the higher profitability of mango farming and found it to have higher returns than food crop production. In the in-depth interview with the female farmer at Trom, she said:

> *"my husband and I are into full-time mango production and even in bad years, we can get enough to balance our cost of production and still get something for upkeep. This, we could not have done if we remained in food crop farming as the weather and soil conditions keep changing and deteriorating".*

This statement implies that mango farming is more rewarding economically than food production for smallholder farmers, no matter the challenges. Thus, the shift from food crop production to mango farming. It also points to the fact that the land might be deteriorating, with declining soil fertility for one crop but suitable for another. This means that land deterioration or loss of fertility depends on the use or crop grown. This is a positive effect on the soil as according to Page et al. (2020), different crops may have distinct effects on the cyclicity of carbon stock which modifies the soil in many ways and improves the quality of the soil. More organic matter from mango tree droppings and dead weeds also protects the soil from agents of erosion and improves soil micronutrients (Dhaliwal et al., 2019). This suggests that the switch to mango farming is a form of conservation agriculture with a high potential positive effect on soil organic carbon (SOC) values.

Even though we did not assess the SOC in the soil, we observed that there was a lot of organic matter in the soil resulting from the droppings of the mango leaves/twigs and other dead plants which are not burnt due to the presence of the mango plants. Farmers explained that once they plant the seedlings, they protect the land from fire. This ensures that all organic matter decomposes into the soil and enriches the soil with SOC. High SOC is said to improve the productivity of the soil as it controls the properties (physical, chemical, and biological) of the soil (Owoade et al., 2021). Most respondents indicated they intercrop with food crops when their mango plants are young until the canopy is fully established. According to them, they observed an increase in yield when intercropped and attributed the increase to nutrients from the dead organic materials. This means that mango farming is helping to maintain the fertility of the soil and this has been observed by many scientists as a positive sign of intercropping (Kishore et al., 2021; Owoade et al., 2021; Wahab et al., 2020).

Assessing land use/land cover change due to mango farming from satellite imagery

From the farmers' perception as discussed above, it can be inferred that the major land-use change will be land changing from natural vegetation/food crop production to mango plantation. To verify the changes in land use as deduced above, we classified Landsat images of 2002 and 2020 (Figure 2). As shown in Figure 2, the 2002 image has more deep green (dense vegetation), but that had reduced and has become more fragmented in 2020. The dense vegetation thus changed to farms/grassland in 2020. This means that the native dense vegetation prevalent in the area in 2002 is changing largely to mango plantations. Although monoculture has been shown to have environmental impacts,

including biodiversity loss, soil degradation, and pest infestation (Iezzi et al., 2018; Niether et al., 2020), the intercropping, no/reduce tillage and no burning help some attributes of the ecosystem. Another visible change is that many red spots (settlement/bare lands), especially those far away from the settlements in the 2002 image in Figure 3, have been replaced by light green in the 2020 image. The red spots in the 2002 image are also found amidst dense vegetation, indicating that these could be cleared lands prepared for farming or bare lands. We verified from Google Earth images and can confirm that those red spots far from the settlements were bare lands (i.e., land cleared of vegetation) which are now farms or have been converted to grassland in 2020. This means these were native vegetation cleared for farming, either mango or food crop production, or have been left fallow to regrow. Our examination of the Google Earth image of the area (Figure 3) shows intense mango farming in this area. As shown in Figure 3, almost the entire land in the image has been converted to mango plantations.

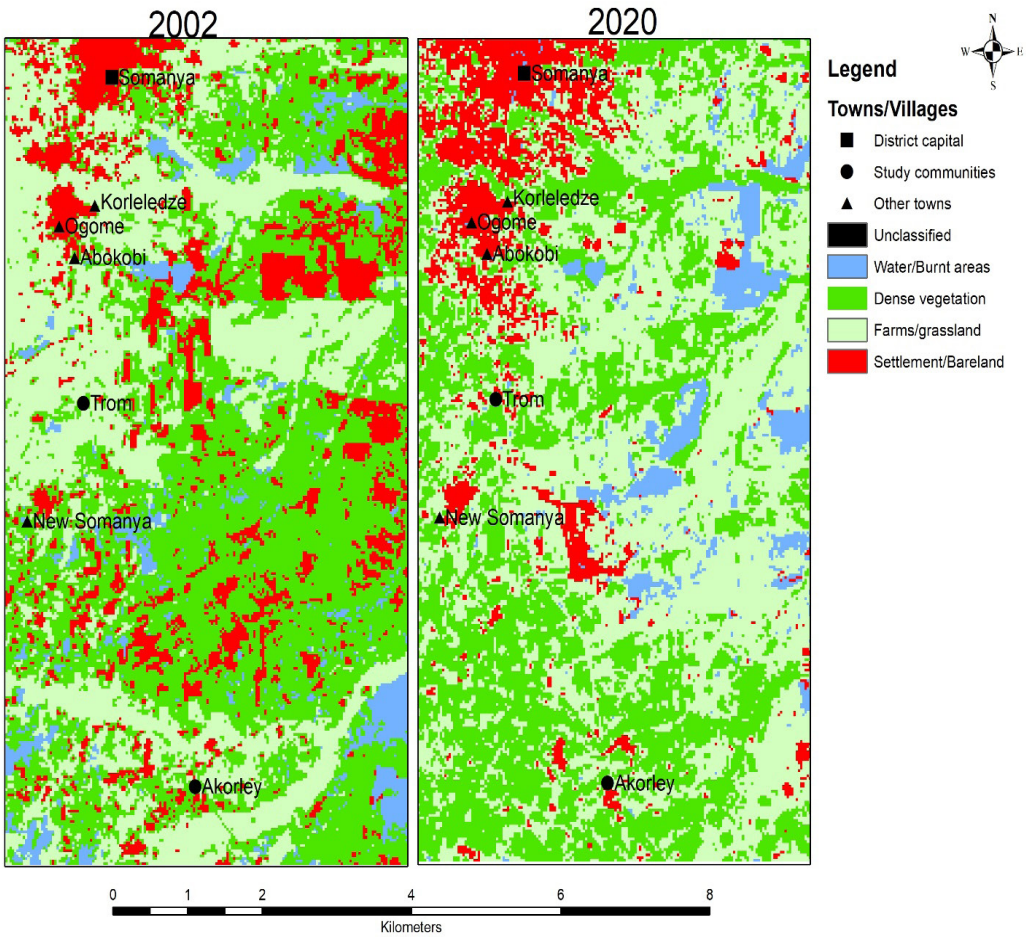

Figure 2: Land use/land cover change between 2002 and 2020 (Source: Authors' construct, 2020)

This means that some of the areas classified as farms/grassland could actually have young mango plants or had just been prepared for mango farming. Over the years, some of these young mango plants have matured into full tress and, therefore, assume the signature of dense vegetation. An energetic male farmer at Akorley mentioned that one of his mango farms is more than 15 years old. This means his mango farm at the time of the image capture (2002) could have been bare land (prepared/cleared for plantation) or had young mango plants on it. Thus, our analysis shows mango plantations as the largest land consumer in the area. Several studies have similarly shown agriculture as one of the largest consumers of natural vegetation (Jayathilake et al., 2021; Marques, 2021; Yiran, 2020).

A statistical examination of the changes that occurred between 2002 and 2020 reveals that the largest class changes from dense vegetation (17.69 km^2) and settlements/bare lands (4.01 km^2) went into farms/grasslands (Table 1). The total loss from dense vegetation is 4.45 Km^2.

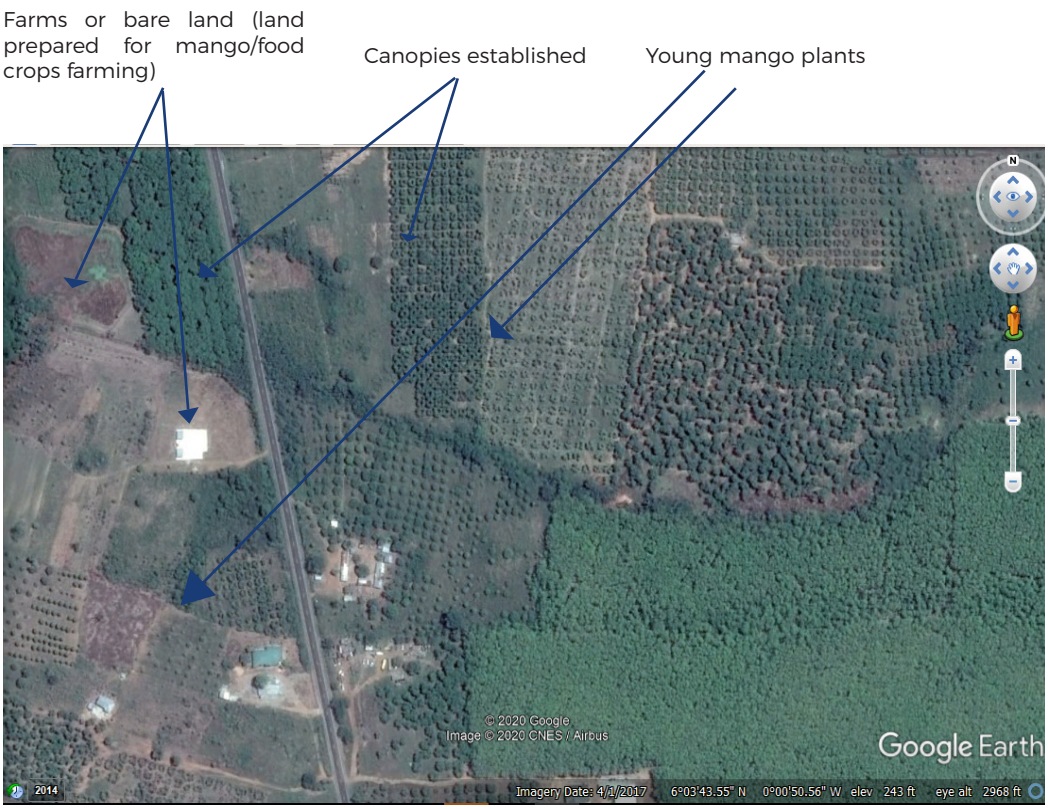

Figure 3: Mango Plantations in the Eastern Region of Ghana (Source: Google Earth, July 2020)

Table 1: Changes in land use/land cover[3] (in Km^2) between 2002 and 2020

		2002				
	Classes	**Water/Burnt scars**	**Dense vegetation**	**Farms/ grasslands**	**Settlement/ bareland**	**Class Total**
2020	Water/Burnt cars	0.38	1.98	0.22	1.27	3.85
	Dense vegetation	1.34	8.46	13.73	2.01	25.55
	Farms/grasslands	2.36	17.69	9.26	4.01	33.33
	Settlement/bareland	0.17	1.86	2.33	2.95	7.32
	Class Total	4.26	29.99	25.54	10.25	0
	Class Changes	3.87	21.53	16.28	7.29	0
	Image Difference	-0.41	-4.45	7.78	-2.93	0

The loss from Water/burnt scars (0.45 Km^2) signifies that most of the areas were burnt which later were covered by grass or crops as a larger portion (2.36 Km^2) of that cover type went into farms/grassland in the latter date. Similarly, Settlement/bare land had lost largely to farms/grassland (4.01 Km^2) and dense vegetation (2.01 Km^2). These changes indicate that these areas were prepared for crop production or mango farming. Our observation indicates that most of these areas are mango plantations signifying that mango plantations have taken a majority of the land. The large change from settlement/bare land to farms/grasslands also confirms our belief that most of that class were bare.

Although the other classes have lost some land to farms/grassland, the highest gain of 73% (17.69 Km^2) is from dense vegetation. On the other hand, 80% (13.73 Km^2) of the gains into dense vegetation came from farms/grassland. These changes show that major conversions are between farms/grassland and dense vegetation. As explained earlier, the conversion of dense vegetation to farms/grassland is largely for farming purposes, while farms into dense vegetation are mango plantations that now have fully established canopies. The mango plantations in Figure 3 are at different stages of growth, from bare land (cleared/prepared) to fully grown plantations. In an in-depth interview with a leader of the farmers' association, he indicated that some of the large-scale mango farmers converted natural vegetation areas because they have access to bulldozers. This assertion was confirmed by our observation during the fieldwork as new farms were being cleared. This could explain why conversion of natural vegetation was an issue in the survey. When the mango trees fully establish canopies, then they resemble dense vegetation, the reason for the large change from farms/grassland to vegetation.

As is the case in many settlements, especially cities or urban areas, buildings and related constructions displace agriculture, but this was not apparent in our study as the communities are yet to experience any massive urbanisation. However, 9% of the respondents from Akorley and Trom, reported that mango farms are being cut down to make way for residential buildings. Unlike many land-use change studies which report

3 The images used for this Table only considered the portion of the Yilo Krobo district that contained the study communities and Somanya, the district capital as Ayenya is still rural and far from any urban centre.

a change in land use from agriculture to urban/built-up (Ablo et al., 2020; Guzha et al., 2018; Sibanda & Ahmed, 2021), our study found a change in land use largely from food crops (cassava/maize) and natural vegetation to mango production. This means that the type/nature of land-use change is most likely dependent on location (rural or urban), further strengthening the rural-urban divide thesis (van Noorloos et al., 2019; Wu & Keil, 2020).

Though land conversion from natural vegetation to other land uses is most often seen as negative as it leads to environmental degradation and/or biodiversity loss, the change from natural vegetation to mango farming, in the long run, will benefit the environment to some extent. This is because the mango trees, when fully grown, can cover the land and protect it from erosion and sequester carbon better than the natural grasses and shrubs. The protection of the farms from bushfires also ensures the growth of other microbial organisms in the soil which would have been destroyed by the perennial bushfires (Mataix-Solera et al., 2009; Verma & Jayakumar, 2012). The conversion from farmlands to mango farms does not make farmers worse off as the respondents to the questionnaire indicated that they intercrop with food crops (cassava/maize) until mango fully establish canopies. Growing food crops among young mango plants was strongly stressed as a common practice in the focus group discussion. Thus, mango farming does not only improve the soil quality but also the quality of the vegetal cover and other microorganisms in the soil which can maintain or improve biodiversity.

Land tenure system

As land uses change, one of the socioeconomic variables that are responsive to the change in land tenure system. We, therefore, present an analysis of the land tenure system. The results as presented in Figure 4 below reveal a variation in landownership or means of land acquisition for farming in the mango-producing zone.

Whereas the popular means of land acquisition in Akorley is by inheritance (60) followed by family (40), in Trom it is family (44) followed by lease (35) while in Ayenya it is largely by leasehold (48) and shared tenancy (22). Leasehold and purchases are becoming popular in Trom because it is beginning to be urbanised. In the case of Ayenya, it is because that community is in the Greater Accra Region where land acquisition is largely by leases or purchases (see Ubink, 2008). The family land and the inherited land acquisition types can be regarded as the same and grouped as inheritance. However, the type of inheritance system practiced in Ghana where the land is divided among descendants of the owner results in land fragmentation (Yiran et al., 2012), leading to smaller landholdings. This kind of land ownership might affect mango farming as it can result in the land being infinitesimally small and insecure, potentially making mango farming unprofitable. Land fragmentation has resulted in a reduction in agriculture outputs as it affects farm size and the distance between plots, thus increasing the cost of production (Danquah et al., 2019; Lu et al., 2018). The two districts, Yilo Krobo and Shai

Osudoku, are in different regions, and the variations in land ownership systems (Figure 4) reflect the regional land tenure systems. The large mix of land ownership for farming in the Yilo Krobo area could be attributed to the co-existence of land tenure arrangements which dates back to the colonial days when commercial agriculture (palm cultivation) was thriving in the area (Kene Bedele, 1993). The findings reinforce the regional and ethnic variations in Ghana's land tenure systems and land holdings (Lands, 2003).

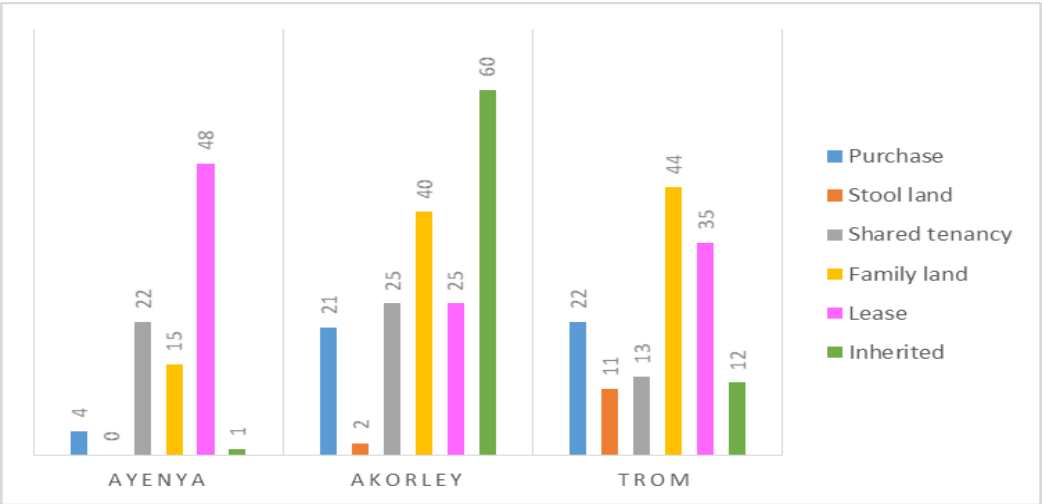

Figure 4: Types of Land Ownership (Source: Fieldwork)

Figure 4 also indicates a spatial trend in the private ownership of land (lease and purchase) along the urban-rural gradient. Trom is urbanising and becoming part of Somanya, the district capital of the Yilo-Krobo District, while Akorley is still rural. This observation is evident in this statement by a female respondent in the in-depth interviews who doubles as a leader in the farmers' association:

> "*Our community (Trom) is becoming urban and with the problems associated with urban land use, the majority of the farmers are beginning to acquire or convert their interests in the land to leaseholds which possess some security of tenure*".

According to her, many leaseholders (mango farmers) have registered their interests with the land commission, which secures the land. Her thoughts were strongly echoed in the focus group discussion held with a section of the inhabitants of the community. This observation is very interesting as one would have expected the main reason behind smallholder farmers shifting to these secure tenancy arrangements to be the presence of large-scale commercial farmers who acquire their land through purchase and/or leasehold. This is because in areas where plantation/commercial agriculture dominates, land accessibility shifts from the traditional system of access to highly atronizeized land relations (Yaro et al., 2017). However, commercial agricultural leases are granted for 50 years (Republic of Ghana (1992).This means that the land can come under intense

pressure in some 10 to 50 years, especially with the expansion of settlements which usually outcompete agriculture for land closer to urban centres. The next section will discuss land-use changes, especially concerning mango farming in the short to medium term.

Benefits from mango production

In addition to environmental factors, economic factors drive the change from food crops to mango production. About 71% of respondents indicated that mango production had increased income, while 22% noted it is a lucrative/good business. Thus, more than 93% of respondents consider mango farming a more profitable venture than any other agricultural activity in the area. Others attributed the shift to mango farming to poor yield in food crop production and food scarcity. According to them, the yield from food crops is reducing, but with mango farming, they can earn enough income to buy more food than they would have produced and still have enough to cater to other family needs. A female who partners with her husband to farm mango stated that:

> *"since we started harvesting and selling our mango, we feel more secure financially than before because we make a lot of money from the sale of mango that can offset the cost of inputs, buy enough food to feed until the next harvest. We also can pay school fees and undertake/contribute to other social activities that require money. The returns from mango are several times better".*

This statement, which seems to be the view of many interviewees, is pregnant with a lot of positive socioeconomic implications.

Apart from direct income, mango production also offered employment opportunities to the respondents. The employment opportunities that were gleaned from the focus group discussion held in Trom included seedling nursing/production, water fetching, transplanting, spraying, pruning, farm security, picking, and weeding. Some people are also engaged in packaging, carting/transporting, and selling. Although some of these jobs are short-term, they stated that the jobs do not often occur simultaneously; therefore, there is something for them to do at any point in time. It was unanimously agreed that these opportunities have given almost every young person (both sexes) something to do and drastically reduced migration and some minor social vices in the area. In an in-depth interview with a 34-year-old seedlings producer, he stated that:

> *"after primary school, I could not further my education due to financial difficulties and got employed by an agribusiness man in his seedling's nursery as a farmhand. After diligently serving him, he set me up to do my nursery and now I also have five permanently employed staff and up to 13 casual workers. The number of casual workers engaged depends on requests. My workers are involved in different jobs such as filling seedling bags with soil, planting seeds, sorting seedlings, grafting, weeding, watering, and transplanting. The business is rewarding economically, even to my workers.*

It can be deduced from this statement that there are a lot of jobs created even at the nursery stage and thus, at every level of the mango farming chain, there are more jobs and these engage the youth and provide them with enough income to meet their households' financial needs.

Analysis of the survey data confirms that mango farming has been a good business as affirmed by more than 70% of respondents. According to them, they harvest twice a year and the amount spent on inputs is reduced. Even though mango farming is believed to be replacing food crop production, the respondents feel they have access to food. One farmer stated that

> *"though I produce less food now than before, I have not run out of food since I started harvesting mango because I earn enough money to buy foodstuffs from the market. Before I engaged in mango farming, I relied largely on foodstuffs produced from my farm which could not sustain my household throughout the year. Now, I can also buy many different types of foodstuffs which I could not do when I was engaged in food crop farming".*

Noteworthy from this statement is that mango farming affords people access to diverse food items. The focus group discussion in Trom and the in-depth interviews also indicated that their daily interaction with urban dwellers have led to a diversity of food eaten at home and, as a result, the number of people consuming mango products (both fruits and juice) has increased. This has provided a local market base for mangoes and has reduced postharvest losses to some extent. It is obvious from the findings that mango production has transformed the livelihoods of most of the smallholder mango farmers from poverty and food insecurity to self-sufficiency. Although mango production, as shown here, is doing well in the area, other factors also contribute positively or negatively, as discussed in the next section.

Socially, farmers can buy food and cater for other household needs such as education, health, and contributions to extended family activities from proceeds of mango production. It also empowers women as they are not seen as farmhands but partners and can contribute to decisions on the farm. Themes were gleaned from the in-depth interviews on the use of the of proceeds from mango and included: food purchases, children's education, healthcare, support for cultural activities like funerals, wedding, and other traditional activities. Our findings suggest that mango production is transforming the lives of smallholder farmers as they are earning more and thus, can support their children's education, healthcare, and other household needs. Through our observation and interactions with the farmers, the changes (from food crops to mango) are borne first and foremost out of their anxiety to get themselves out of poverty and change their economic narrative. As similar studies have found agriculture as a means for rural transformation (Hisano et al., 2018; Jayne & Sanchez, 2021), we emphasise the need to redirect focus of smallholder farmers, where applicable, to fruit crop production to achieve the desired rural transformation. This is because the farmers are already doing something to transform their livelihoods but only need a push.

Factors affecting mango production

Urbanisation has often been seen to harm agriculture, especially in urban and peri-urban areas. However, in our study, though these areas are yet to experience urbanisation and its consequent effect of land consumption, they are surrounded by urban centres that serve as a marketplace for their produce. The non-farmer association members indicated that over 80% of their produce is sold in the local market (i.e., the urban centres in Ghana), with the urbanised areas in the Greater Accra Region consuming the largest. This is because they do not have the certificates like their counterparts in the associations and the commercial farmers. Their produce is bought by local juice producers and the urban dwellers who consume them as raw fruits. Due to the good roads, traders can get fresh produce to the market centres within and without the districts in good time. According to them, the species of mango grown have a longer shelf-life and taste nice; therefore, consumers can store them for long and eat them as fresh fruits. Fruit consumption is particularly becoming an integral part of the diets of many Africans as people are advised to take more fruits to avoid/minimize the risk of contracting some diseases (Tagoe & Dake, 2011). Thus, as urbanisation continues and the food basket of urban dwellers grow, mango farming will always be in business.

Despite its positive impacts, urbanisation has adverse effects on land prices. Most of the respondents (82.7%) stated that the price of land for urban development is so high that landowners lean towards selling their lands for urban development. They are afraid this might affect mango farming for smallholders in the near future as the majority of them do not have secure tenures (see Figure 1). Even those with leases might lose their farms to urbanisation as landowners will wait for the lease to expire and refuse to renew. Interestingly, about 8% of the respondents reported being displaced from their farmland due to urban expansion. According to these farmers, the rent they offered landowners were far less than what the urban developers offered. The fears of farmers are not farfetched as farmers in urban/peri-urban areas in other parts of the country and the subregion have experience a loss of land to urban development (Sulemana &Yiran, 2019).

In addition to urbanisation, other constraints were identified (Table 2). The four topmost constraints identified from the study were difficulty accessing skilled labour, lack of capital, difficulty in acquiring land and the incidence of pests and diseases. The rankings by farmers were tested for agreement among them, and the agreement of the results was statistically significant.

Table 2: Ranking of constraints to mango production

Constraint	Mean rank	Rank
Difficulty in accessing skilled labour	1.72	1
Lack of capital/credit	2.22	2
Difficulty in acquiring land	3.47	3
Incidence of pests and diseases	4.05	4
Difficulty in obtaining certification	4.81	5
Competition from imported fruits and juice	6.02	6
Limited storage facilities	6.95	7
High post-harvest losses	7.97	8
Limited access to market	8.69	9
Poor transport network	9.56	10
Poor yields	10.54	11

Skilled labour for certain agronomic activities such as pruning, spraying, and grafting was a significant issue for the farmers. Many people engaging in these activities do not have the requisite training, which greatly affects yield. All the constraints affect farmers' ability to expand, increase the shelf-life of produce, or access the external market, thereby reducing profitability. Another worrying development was competition from imported fruits and juice. As a result of trade liberalisation, Ghana is importing all kinds of fruits, including those with a competitive advantage such as mango. This most often results in low patronage for the local products leading to post-harvest losses.

Limitations of the study

The major limitation of the study was its narrow focus on smallholder farmers. Thus, while the overall findings speak to broader socioeconomic and ecological issues relating to tree crop production and the dynamics of agriculture in Ghana, the empirical context of the paper is limited in focus. Perspectives from medium size farms and large-scale mango producers are therefore not reflected in the study.

Conclusions and recommendations

The results from the study indicate there are land use and land cover changes with the changes mostly going into mango plantations. The changes are largely from natural vegetation to farms/grassland and vice versa. This is an indication that the changes are largely resulting from clearing land for mango farming. According to farmers, the changes they observe taking place are largely the replacement of food crops and forest lands by mango. Their observation corroborated well with the change detection from the satellite images. These cases indicate that mango is gradually becoming an essential crop. It also shows that the environment is becoming more greener than before. Farmers also

practice less tillage and no burning on the farms which improves organic matter content and soil structure also reduce exposure of the soil to agents of erosion. The net effect is an improvement in the environment.

Socioeconomically, there also some gains. We found that urban centres served as markets for farm produce resulting in good sales and incomes. Although we found urbanisation currently as a booster to mango farming as urban dwellers patronise the produce, farmers express fears they might lose their one day as the land tenure system is not secure. The land tenure, however, follows either regional practices or near urban-rural divide. That is, land acquisition in the Greater Accra Region is by leasehold while those in the Eastern Region are by inheritance, family, and shared tenancy. The rights in these tenancy arrangements are generally communal and are not secure. It can also be seen that Trom is becoming urbanised and tenancy there is becoming largely leases or purchases. A key finding is that mango production has increased smallholder farmers' income and enabled them to buy more food. This means mango production has led to a great reduction in poverty and food insecurity among smallholder farmers. It has also provided farmers with enough income to care for their children's education, healthcare, and other social needs. However, mango production is beset with some constraints, including difficulty in accessing skilled labour, lack of capital, difficulty acquiring land, and pests and diseases. Thus, mango farming has shown to protect the environment while providing socioeconomic benefits to farmers. We, therefore, conclude that mango production is sustainable based on the sustainable agriculture model and has a very high potential to transform the livelihoods of the smallholder farmers by moving out of poverty and ensuring food security.

It is recommended that interventions to boost mango production and reduce post-harvest losses should be strengthened by encouraging public-private partnerships and attracting the right kind of investment into the sector. Smallholder farmers should be encouraged to form groups to receive training and other extension services. This will enhance their chance of being certified and have accessibility to external markets. It is also recommended that farmers be encouraged to register their interests in the land to secure it against future encroachment.

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ORCID

Gerald A. B. Yiran https://orcid.org/0000-0003-4624-9701
Austin D. Ablo https://orcid.org/0000-0002-8240-4599
Freda E. Asem https://orcid.org/0000-0003-0331-2256

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