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Motivating cocoa farmers to adopt agroforestry practices for mitigating climate change

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Abstract

With the adverse effects of climate change becoming more prominent, more effective strategies for reducing the increase in atmospheric CO_2 levels are required for mitigating further climate change. Increasing use of renewable energy by farmers motivated to practice agroforestry is one natural solution for reducing those climate change impacts. Unfortunately, climate change mitigation through agroforestry has been inhibited by a lack of scientific validation. In this paper, we ascertain factors that motivate African cocoa farmers to use agroforestry practices for enhancing food production as well as for mitigating climate change. We analyzed data collected from 120 farmers from the Oyo state of Nigeria through descriptive and regression analysis statistical tools. We found that access to information ($\beta = 0.23$, $t = 2.18$) and extension service ($\beta = 0.23$, $t = 2.27$) was associated with greater willingness of farmers to participate in agroforestry whereas negative attitudes ($\beta = -0.29$, $t = -3.21$) were associated with a lower involvement of cocoa farmers in agroforestry practices. We conclude that effective climate change mitigation programs need to do more to motivate farmers to adopt agroforestry practices by increasing their understanding of the benefits to be derived from carbon markets and by providing them with the necessary tools for employing these practices for climate change mitigation and more sustainable food production.

Introduction

The impacts of climate change are being felt in various economic sectors, in particular the agricultural sector (Nyong *et al*., 2020). To date the mitigation measures used to reduce greenhouse gas emissions that are causing climate change have not been effective at achieving climate change resilience (Nyong *et al*., 2020). These measures include using renewable energy sources, such as solar panels for water extraction and irrigation systems (Zou *et al*., 2016). In developing countries, most renewable energy sources have been insufficiently harnessed or developed to achieve the desired objectives, such as hunger eradication, global food security, nutrition improvement and sustainable agriculture under Sustainable Development Goals (Sidaa *et al*., 2018; Baya *et al*., 2019). More effective strategies for climate change mitigation are needed as CO_2 emissions and high-end climate change continue to occur (Taylor *et al*., 2020). Future climate change due to increased greenhouse gas emissions is likely to result in more intensive rainfall patterns (Nyadzia *et al*., 2018) and more global warming consequences. To overcome the challenge of global warming, major changes in production and consumption patterns are needed. One of the strategies for reducing CO_2 emissions is to motivate farmers to adopt agroforestry practices. Although many agricultural programs in developing countries have paid much attention to adoption of farmers, they have not adequately addressed the question of how to motivate farmers to be innovative (Meijer *et al*., 2015; Novlloyd *et al*., 2019).

According to Badubi (2017), motivation plays a key role in driving personal and organizational goals of employees, and, to a certain extent, national development and growth. In the context of agricultural programs, a low socio-economic status of smallholder farmers often presents challenges to adopting agroforestry practices (Novlloyd *et al*., 2019). In this instance, motivating smallholder farmers to adopt agroforestry would require effective communication, demonstrated results, application of appropriate technology and supportive farm visits, as well as enabling them to be able to see other benefits from agroforestry (Ragasa *et al*., 2016).

Other factors influencing technology dissemination and climate change mitigation are documented in the literature (Apata, 2011; Arimi, 2014; Olorunfemi *et al*., 2018; Dang *et al*., 2019). Olorunfemi *et al*. (2018) found that contact with extension service agents who interact and freely share information with farmers and years of experience of those agents are key factors responsible for better managing climate change mitigation strategies/initiatives and adoption of organic agricultural practices (including minimum tillage, crop rotation, cover cropping, mulching and composting). These are relevant in helping to mitigate the adverse impacts of climate change through effective soil, water, air and landscape management. Besides the role of extension agents in climate change mitigation, Arimi (2014) found that age, gender, educational level, sources of information and working experience were significant determining factors affecting the ability of farmers to change practices to adapt to climate change. However, agroforestry practices are considered novel in reducing carbon emissions.

Agroforestry is an important carbon sequestration strategy because of the carbon storage potential of the multiple plant and soil species involved, as well as its applicability to agricultural land and reforestation (Sikstus *et al*., 2020). With respect to crops such as cocoa, Hairiah *et al*. (2020) stated that proper management of cocoa planting practices in agroforestry can effectively sequester carbon (C). Montagnini and Nair (2004) observed that the extent of C sequestered depends on the quantities of C in standing biomass, of C in soil and of C in wood products. Generally, the average carbon storage potential from agroforestry practices is estimated to be 9, 21, 50 and 63 $\mathrm{Mg\,C\,ha^{-1}}$ in semi-arid, sub-humid, humid and temperate regions, respectively. For smallholder agroforestry systems in the tropics, the potential C sequestration rate ranges from 1.5 to 3.5 $\mathrm{Mg\,C\,ha^{-1}\,yr^{-1}}$ (Montagnini and Nair, 2004). Thus, adoption of agroforestry has been proposed as one solution to problems caused by climate change (Matocha *et al*., 2012), problems which pose a serious threat to food security in smallholder agriculture (Mbow *et al*., 2014; Sidaa *et al*., 2018). Restoring forests and improving forestry practices could cost-effectively remove 7 billion metric tons of carbon dioxide annually, which would be as much as eliminating 1.5 billion cars (Minnemeyer *et al*., 2017). As well as carbon sequestration benefits, agroforestry also reduces irrigation needs by providing cooling shade from vegetative covers and by improving soil moisture retention and rainfall distribution. Agroforestry is a widely used practice that also combats deforestation by providing both wood for energy and construction and food for human nutrition (Molua, 2005; Ifejika, 2010). The capacity of the earth to naturally absorb greenhouse gas emissions is declining (Carter *et al*., 2015) due to widespread deforestation resulting from annual cropping and the establishment of new industrial sites. With the great potential benefits from forestry, farmers should be motivated to participate in agroforestry and to derive benefits from carbon credit markets. One of the objectives of the Kyoto Protocol was to enable developed nations, which have profited from fossil energy intensive economic development, to economically assist developing nations, including through benefits from carbon credits (Reichle, 2020).

Carbon credits and carbon markets are components of national and international attempts to mitigate greenhouse gas concentrations in the atmosphere (Reichle, 2020). A carbon credit is a credit for greenhouse emissions that have been reduced or removed from the atmosphere by an emission-reduction project or agroforestry program. Family forest landowners and smallholder farmers can be important contributors to the carbon sequestration programs and carbon market credits generated from the growth of their forests (Miller *et al*., 2012). The features of forest carbon project participation include landowners enrolling as individuals or joining certified groups (such as with a participating consulting forester) and giving annual updates on any changes made to their forests that would alter the carbon stock (e.g., through timber harvesting, or losses from natural disturbances) (Dong-Ho *et al*., 2018). Participants of forest carbon projects are expected to gain attention in the carbon market, with financial benefits that will improve their socio-economic status (Miller *et al*., 2012). Recent developments have improved the transparency and credibility of voluntary carbon trading and forest carbon credit transactions have constituted more than half of trade volume (Dong-Ho *et al*., 2018). If farmers were aware of these benefits they would be likely to participate in forest carbon projects. Dollisso and Martin (2017) established that farmers could be motivated to participate in an extension program that was capable of improving their livelihoods. As such, agroforestry has the potential to mitigate climate change (Nyong *et al*., 2020) and provide additional income to participants.

Addressing climate change is important since it threatens agricultural production in Nigeria, and this has social and economic implications; among the threats is decline in the crop yield due to decreased rainfall and relative humidity and due to increased temperatures. Extremely low rainfall has also resulted in unfavorable crop growing conditions, resulting in limited water availability and crop failures. Changes in the degrees and intensities of rainfall are beyond what farmers know, or can cope with, to remain productive. Arimi (2020) also noted that for smallholder farmers mitigating the impact of climate change on production required the adoption of agroforestry as the most affordable measures to reduce carbon emissions for climate resilience and sustainable agricultural production. For instance, in cocoa-based agroforestry systems, which are credited for sequestering significant amounts of carbon, offer great potential for mitigating climate change. In several studies reported in the literature, carbon stocks under shaded agroforestry systems with perennial crops—such as coffee (*Coffea arabica* L.), rubber (*Hevea brasiliensis* (HBK) Muell.-Arg.) and cocoa—may vary between 12 and 228 $\mathrm{Mg\,ha^{-1}}$, amounts that are significant for mitigating climate change (Ofori-Frimpong *et al*., 2010; Somarribaa *et al*., 2013; Sikstus *et al*., 2020).

The carbon-sequestering potential of cocoa-based agroforestry indicates that the conversion of agricultural lands to agroforestry management practices would likely be an effective strategy for storing sufficient quantities of carbon to mitigate climate change. However, despite the potential climate benefits of cocoa-based agroforestry practices, adoption of such practices has been slow due to the lack of motivating incentives for farmers. Moreover, practices that are capable of reducing greenhouse gas emissions using forest restoration processes have often been hindered by factors that have yet to be fully validated. Hence, our objective for undertaking this study is to identify key factors affecting adoption of agroforestry practices for mitigating climate change, as well as to understand factors that can motivate smallholder cocoa farmers to broad-based adoption of agroforestry practices in Nigeria.

Methodology

We conducted this study in the Oyo state of Nigeria, a hotspot of vulnerability to climatic change that affects agricultural production and the livelihoods of producers. Oyo is located between latitudes 8.1°N and 3.5°E. The farmers largely use traditional tools on the loamy soils that are good for tree crop production. The dominant soil type is the ultisols, which are deep and rich in nutrients (Adeoye and Adeoluwa, 2013).

We used a multi-stage sampling procedure. The Agricultural Development Program (ADP) divided the Oyo state into four agricultural zones, namely the Ibadan/Ibarapa zone, the Ogbomoso zone, the Saki zone and the Oyo zone. We chose the Ibadan/Ibarapa zone for this study because it is the zone with the most intense production of cocoa. Using the standard

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structure of ADP for extension services, the Ibadan/Ibarapa zone was classified into eight blocks from which three blocks were randomly chosen. Each block was further divided into eight cells. We then used a simple random sampling technique to select two of the eight cells from of the three blocks, ending up with a total of six cells. Each of these cells contained at least 140 cocoa members (namely Aba Agbo 302 farmers, Olubi 181 farmers, Owobale 240 farmers, Alugbo 161 farmers and Foworogu 182 farmers and Elese Erin 140 farmers). Ten percent of the farmers in each cell were randomly selected for a total sample size of 120. Replacement sampling was used to ensure that 10% of respondents were reached. Respondents who did not return or complete their questionnaire were replaced. Out of the 18 members originally selected from Foworogu, four farmers did not return their questionnaires on time. This cell had a total of 182 members. To make up the sample size, the four people were chosen at random out of the remaining 164 members.

Data were collected through structured interviews. We pretested the questionnaire outside of the study area with two sets of cocoa farmers in Ido village at the Ido Local Government Area to ascertain the consistency in the measuring instrument. A reliability coefficient of 0.71 was obtained from the pre-test. Items included in the questionnaire were attitudinal statements pertaining to the willingness of the respondents to practice agroforestry for climate change mitigation and food production; items with response categories of 'Agreed', 'Undecided' and 'Disagreed'. Responses to these items were coded with a score of 2, 0 and 1, respectively. The respondents were given a list of factors and asked to rank their influence on their willingness to adopt agroforestry practices to mitigate climate change. The rankings were coded on a 3-point scale of 'major' (scored as 2), minor (scored as 1) and not a factor (scored as 0). Data were collected on various socio-economic characteristics of the respondents, their willingness to adopt agroforestry, their attitudes toward participation in agroforestry for climate change mitigation and factors affecting their participation in climate mitigation agroforestry practices. The questionnaire was administered in the English language, but was interpreted to the respondents in their local language through trained enumerators who were fluent in the local languages. The data collected were analyzed using frequencies, percentages and regression analysis (Arimi, 2020) with the use of Statistical Package of the Social Sciences (SPSS).

Results and discussion

Demographically, most (60.0%) of the respondents were between 31 and 50-year-old (Table 1), which indicates that they were in their productive age. A large proportion of the respondents involved in the cocoa production business in the study area were male (70.0%) whereas 30.0% were female. Most of the respondents were married (54.2%) whereas 45.5% were single. Respondents engaged in the cocoa farming business to support their households. The majority (64.2%) of the respondents had households with five or fewer members. Farm work in the study area depended heavily on family labor for keeping financial outlays for production low. That may be the reason for why most of the respondents had relatively large households. Most (82.5%) respondents had formal education. The formal education system in Nigeria is from primary to the university. A high level of

Table 1. Socio-economic characteristics of the respondents ($n = 120$)

	Frequency	Percentage
Age category		
21–30	22	18.3
31–40	45	37.5
41–50	27	22.5
51–60	17	14.2
61 and above	9	7.5
Total	120	100.0
Sex		
Male	84	70.0
Female	36	30.0
Total	120	100.0
Marital status		
Single	55	45.8
Married	65	54.2
Total	120	100.0
Household size		
0–5	77	64.2
6–10	40	33.3
11–15	3	2.5
Total	120	100.0
Educational status		
No formal education	21	17.5
Primary	18	15.0
Secondary	39	32.5
Tertiary	43	35.0
Total	120	100.0
Religion		
Muslim	45	37.5
Christian	68	56.7
Traditional	7	5.8
Total	120	100
Farming experience		
0–10	60	50.0
11–20	47	39.2
21–30	12	10.0
31–40	1	0.8
Total	120	100.0
Willingness to involve in agroforestry for climate change mitigation		
High willingness	67	55.8
Moderate willingness	53	44.2
Never willing	–	–
Total	120	100.0

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Table 2. Attitudes toward involvement in climate change mitigation activities and food production ($n = 120$)

Sl. no.	Attitudinal statements	Agree		Undecided		Disagree	
		F	%	*F*	%	*F*	%
1	It is possible to mitigate climate change	89	74.2	19	15.8	12	10.0
2	I always seek information that will enhance my climate change mitigation capacity	65	54.2	36	30.0	19	15.8
3	Adoption of adaptation strategy measures is costly	65	54.2	28	23.3	27	22.5
4	Nothing can change nature	30	25.0	37	30.8	53	44.2
5	Adoption of mitigation measures is a waste of time	35	29.2	22	18.3	65	52.5
6	Adaptation strategy measures are inefficient	31	25.8	24	20	65	54.2
7	Adoption of mitigation measures is time-consuming	46	38.3	23	19.2	51	42.5
8	Mitigation measures are the responsibility of government	36	30.0	31	25.8	53	44.2
9	A soft loan is always required for climate change mitigation	59	49.2	28	23.3	32	26.7
10	Access to carbon credit will facilitate my participation in the climate change mitigation program	69	57.5	30	25.0	21	17.5

Source: Field survey, 2019.

education usually facilitates better adoption of agroforestry practices due to acquisition of superior knowledge and information about mitigating climate change from being able to read and understand the conditions for participation and the benefits derivable from participation. Furthermore, religious affiliation and farming experience can have an impact on participation in agroforestry for income generation and food production.

Religion is a cultural universal because it serves several fundamental functions in human societies. Religion also has a significant impact on human behavior and participation in business activities. Our results for this study area show that Christians were more involved in the production of cocoa than were those who identified with other religions. The respondents varied in religious affiliation, including Christians (56.7%), Muslims (37.5%) and traditionalists (5.8%). The adoption of new practices by the farmers is influenced by their farming experience. Half (50.0%) of the respondents had at most 10 years of experience in the production of cocoa.

The attitudes of the farmers toward climate change events may influence their willingness to participate in programs designed to mitigate its effects. The distribution of respondents on their expressed willingness to adopt agroforestry for climate change mitigation shows that a majority of the respondents were very willing (55.8%) to participate in a climate change mitigation program. Although forest-related solutions are critical to climate change mitigation, climate solution intervention programs must balance responding to climate change with the need for increasing food production as population and incomes increase.

The majority (74.2%) of respondents agreed that the impact of climate change in the study area could be mitigated (Table 2). This belief may influence their behaviors toward adopting agroforestry with the goal of mitigating climate change. More than half (54.2%) of respondents indicated that they were always seeking information that would improve their capacity for adapting to climate change or participating in mitigation. Access to information is crucial to adaptation or mitigation of climate change. The majority of the respondents agreed that the adoption of climate change adaptation or mitigation measures would be costly and would, therefore, require financial assistance from the Climate Change Intervention Program. This implies that, if farmers were financially supported, they would be more likely to be involved in the agroforestry practices for mitigating climate change. More than half (52.5%) of the respondents agreed that their participation in the climate change mitigation program (agroforestry) would not be a waste of time.

Our results show that adoption of agroforestry practices to mitigate climate change is affected by incomes of the farmers, by their knowledge of the benefits of participating in the carbon reduction program, by the services provided by extension, by access to funding needed for adoption and by access to irrigation (Table 3). Income level significantly influenced the current participation of the farmers (76.8%) in the agroforestry for climate change mitigation. These findings suggest that intervention programs must ensure that farmers be adequately compensated for their participation in the agroforestry program. Compensation could be in the form of marketing premiums for more sustainably produced products. Many respondents (42.5%) rated the lack of knowledge on benefits to be obtained from participation in a climate change mitigation program as a major factor hindering their participation. Access to irrigation helps in coping with water shortages, whereas access to funding for participation in climate change mitigation program (59.2%) influenced the behavior of the farmers.

The regression analysis revealed a negative significant relationship between willingness of farmers to practice agroforestry and their attitude toward participation in climate change mitigation activities. This suggests that some respondents were discouraged from implementing agroforestry practices. At the same time, we found a positive relationship between access to information and access to extension service and willingness of farmers to practice agroforestry (Table 4). The more farmers had access to information, the greater their willingness to practice agroforestry, so our results suggest that if farmers are to adopt new agroforestry practices for climate change mitigation, they need information on the benefits to be derived, for instance, information about the benefits from carbon credit markets. Provision of timely extension service provision, forming farmers into groups to collectively cultivate more hectares of land and linking farmers to the carbon market through extension activities should increase the motivation for farmers to participate in agroforestry and gain carbon market

Table 3. Factors influencing participation of farmers in agroforestry for climate change mitigation ($n = 120$)

		Level of effects					
		Major		Minor		Not a factor	
Sl. no.	Factors	*F*	%	*F*	%	*F*	%
1	Income	91	76.8	12	10.0	17	14.2
2	Knowledge of benefits to be derived from participation	51	42.5	49	40.8	20	16.7
3	Availability of fund	71	59.2	29	24.1	20	16.7
4	Provision of early warning information	29	24.2	44	36.7	47	39.2
5	Provision of Extension service	48	40.0	55	45.8	17	14.2
6	Availability of irrigation	43	35.8	41	34.2	36	30.0

Table 4. Regression analysis of factors influencing willingness of cocoa farmers to adopt agroforestry for mitigating climate change

	Unstandardized coefficients		Standardized coefficients		
Variables	*B*	Std. error	β	*T*	Sig.
(Constant)	16.67	3.24		5.15	0.01
Age	−0.02	0.04	−0.06	−0.55	0.59
Sex	−0.38	0.74	−0.09	−0.52	0.61
Marital status	0.21	0.19	0.18	1.13	0.26
Religion	0.39	0.56	0.06	0.70	0.48
Educational status	0.23	0.26	0.08	0.86	0.39
Household size	−0.11	0.16	−0.07	−0.68	0.50
Attitude toward participation in agroforestry	−0.36	0.11	−0.29	−3.21	0.01
Access to information	0.29	0.13	0.23	2.18	0.03
Income	0.80	0.64	0.15	1.24	0.22
Provision of extension service	1.22	0.54	0.23	2.27	0.03
R	0.55				
R^2	0.59				
Adjusted R^2	0.52				

benefits. This finding is supported by Olorunfemi *et al.* (2018) who observed that extension officers are important in increasing competency to manage climate change mitigation. This is because the degree of interaction with farmers depends to a large extent on the framework of extension agents. These agents in the field are highly appropriate for sharing information with farmers on appropriate agricultural practices (including hedge planting, minimum tillage, crop rotations, crop cultivation, mulching and composting). These agents can thus be relevant in helping to mitigate the adverse impacts of climate change through effective land, water, air and landscape management. Perhaps surprisingly, we found no statistically significant relationships between age, sex, educational status, farming experience, household size and willingness of farmers to practice agroforestry for the climate change mitigation.

Conclusion

As advancing global change consistently brings about climate-related problems for agricultural producers and others, there is a need to reduce the concentration of CO_2 in the atmosphere. Motivating farmers to adopt agroforestry strategies for increasing carbon sequestration can make a potentially significant contribution in this effort. Thus, adoption of cocoa-based agroforestry practices has potential to cost-effectively remove 7 billion metric tons of carbon dioxide annually. In cocoa-based agroforestry, practices that are capable of reducing greenhouse gas emissions through forest restoration have often been impeded by factors that we investigated in this study. Hence, in this study we identified key factors affecting adoption of agroforestry practices for mitigating climate change. One factor that has hindered willingness of some cocoa farmers to adopt agroforestry practices is negative attitudes stemming from a lack of adequate knowledge of derivable benefits from carbon markets. Therefore, climate change mitigation programs need both to emphasize the benefits to be derived from carbon markets and to provide necessary tools for agroforestry practice adoption if they are to motivate participation of farmers. In addition, participation of farmers in initiatives, such as the climate change mitigation programs, requires

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the availability of appropriate marketing information and links that can connect farmers to the carbon credit market information that could motivate them to participate in the climate change mitigation program.

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