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HAND POLLINATION EXERCISE AND COCOA FARMERS' PERCEIVED CHANGE IN LIVELIHOOD: IMPLICATIONS FOR EXTENSION PRACTICE IN GHANA

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ABSTRACT

Using data collected from 384 cocoa farmers through the multi-stage sampling technique, the study assessed the hand pollination exercise and its perceived influence on cocoa farmers' livelihood. Descriptive and inferential statistics such as frequencies, percentages, means, standard deviation and paired sample t-test were used to analyse the data. The results show that majority of the cocoa farmers agreed that the hand pollination exercise was a good programme. Adoption of hand pollination significantly improved the production and income of cocoa farmers. Cocoa farmers perceived that their livelihoods had improved as a result of participating in the hand pollination exercise. The highest perceived livelihood change was observed in financial capital. Majority of the cocoa farmers were affected by the lack of rain during hand pollination periods. The study recommends that apart from the financial capital of cocoa farmers, extension agents should expand their efforts to encourage the practice of hand pollination in cocoa in order to improve the other essential livelihood capitals of cocoa farmers.

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INTRODUCTION

Cocoa is one of the most important tree crops grown in developing countries. The industry has been the main stay of Ghana's economy after it was introduced into Ghana, then Gold Coast by Tetteh Quarshie in 1879 from Fernando Po. It was first cultivated in both Central America and the Indians, which they believe to be of divine origin. Cote d'Ivoire, Ghana, Nigeria and Cameroon are the major producers in Western Africa. The Ghana government earns most of its revenue from exporting Cocoa (World Bank Group, 2018). Gold Coast was producing about 50% of the world's output of cocoa beans and remained the world's leading producer of cocoa until 1977 when she was overtaken by Brazil and later by Cote d'Ivoire in 1979. In Ghana, cocoa offers livelihoods for over 700,000 farmers in the Southern belt of the country (Anthonio and Aikins, 2009; Afrifa *et al.*, 2006).

According to Kassie *et al.* (2009), despite the importance of cocoa as a major cash crop of the tropics, the pollination biology of cocoa remains neglected. One of the ways cocoa can reproduce its kind is through the fertilization of matured pollen grains. Pollination is the act of transferring matured pollen grains from the anther of a flower to the stigma. Hand pollination is the process of manually transferring pollen grains to the pollen receptor part (the stigma, down to the ovary) for fertilization (Breisinger *et al.*, 2008). Thus, the same land

size can produce more than twice the tonnage produced (Bosompem *et al.*, 2011; COCOBOD, 2018).

Pollination rates are generally poor for cocoa and inconsistent across the year but recent evidence indicates that improving pollination can improve yield. For example, hand pollination of cocoa has been shown to increase fruit set, the number of mature pods and the number of seeds per pod (Adjaloo, 2012; Dormon *et al.*, 2004). In Ghana, the Cocoa Research Institute of Ghana (CRIG) at Tafo employs supplementary hand (artificial) pollination to increase yield and also breed new varieties of cocoa (Adjaloo, 2012; COCOBOD, 2018). This is to achieve maximum pollination which is very critical for optimum yield in crop production, this will enable bounty harvesting thus increasing in exports of cocoa beans which will stimulate farmers to increase production in the country (COCOBOD, 2018; Afrifa *et al.*, 2006).

Due to lack of systematic dissemination of information on pollination, farmers and extension workers are less informed of the value of cocoa hand pollinators. This has led to lack of proper management of pollinators in cocoa production and methods for monitoring cocoa hand pollinators are both limited and inefficient. To help arrest the decline and boost Ghana's cocoa production, the government initiated several programmes which was named as "Productivity and Enhancement Programmes (PEP)". These programmes were made up of hand pollination of cocoa farms, irrigation of cocoa farms, rehabilitation of Cocoa Swollen Shoot Virus Disease (CSSVD) infested farms, rehabilitation of moribund cocoa farms, increasing and improving warehousing capacity, creation of an integrated farmer database, promotion of domestic processing and promotion of local consumption (COCOBOD, 2018). Despite these efforts, cocoa production in the country is still low as compared to countries such as Cote d'Ivoire and Indonesia (Cobbina, 2014). According to Frimpong-Anin *et al.* (2014), a scarcity of information on farmers' knowledge on the hand pollination and pollinator conservation was indicated. This prompted a survey of farmers' and agricultural agents' awareness on pollination and possible impact of farm practices on cocoa pollination. It was realized that, cocoa famers had not intentionally developed pollinator management practices, although some of their practices were pollinator-friendly. Though extension officers had a good understanding of pollination, its relevance was downplayed by farmers and they did not know the identity of cocoa pollinators. There are also increasing reports of declining pollinator populations although the Government is still continuing its effects in that direction. Inadequate midge population therefore results in insufficient pollination, and this insufficiency has been reported as a major cause of low fruit set in some cocoa plantations (Anim-Kwapong and Frimpong, 2004; Klein *et al.*, 2003).

The government and cocoa farmers were concerned about the decreasing yields per hectare. Previously, most cocoa farmers in Ghana relied on natural pollination for higher cocoa yields, which as well contributed to the lower yields. Discouraging price in production, difficulty in getting areas or lands for cultivation, non-compliance with standard farm practices, the incidence of pests and diseases and low yield per hectare, were some of the challenges faced by the cocoa farmer (Frimpong-Anin *et al.*, 2014). Some of the considered threats which led to low cocoa yields are old aged trees (cocoa farms that aged over 30 years old), predominance of low yielding traditional varieties (limited use of hybrids), smaller farm sizes due to fragmentation from land tenure arrangements, non-adherence to good agricultural practices, limited and irrational use of agro-inputs such as fertilizers, fungicides, herbicides and insecticides, use of unapproved agrochemicals in cocoa production by some farmers (Anthony *et al.*, 2014).

The occurrence of cocoa swollen shoot viral disease and other factors like high rainfall which leads to the abortion of already pollinated flowers and low rainfall leading to insufficient moisture content were also identified as factors that cause yield decline in cocoa (COCOBOD, 2000). Natural pollination has been inefficient due to the abuse of insecticides and pesticides, which kill both the harmful and beneficial bugs of cocoa, resulting in low cocoa yield productivity, which has impacted cocoa farmers' lives. The Ghana Cocoa Board (COCOBOD) implemented hand pollination of cocoa in Ghana in 2017 due to inefficiencies in natural pollination (Appiah, 2004).

Hand pollination of cocoa kicked off the process of enhancing Ghana's cocoa productivity in order to improve their earnings and living conditions (Badu, 2019). Although there are numerous studies conducted on hand pollination, there is minimal empirical research in Ghana. For instance, Frimpong-Anin *et al.* (2014) conducted a study on cocoa farmers' awareness of

pollination and its implication for pollinator-friendly practices. This study only addressed perceptions and knowledge on the subject matter. Wongnaa *et al.* (2021) conducted a study on the impact of adoption of artificial pollination technology in cocoa production. Again, Wongnaa *et al.* (2021) studied the perceptions and adoption of artificial pollination technology in cocoa production. All these previous studies have proved to be useful. However, a crucial gap needs to be filled. This present study compares the perceived changes in production, income and livelihoods of farmers who practiced both natural pollination and hand pollination. The research objectives are to ascertain the perceptions of cocoa farmers on the hand pollination exercise, analyse the level of change in production, analyse the resultant change in income, assess farmers' perception of change in their livelihood and identify the challenges faced by cocoa farmers during hand pollination.

MATERIALS AND METHODS

The research design adopted for this study was a descriptive survey design. This was done because the descriptive survey design allows a researcher to gain knowledge to make informed decisions. It also helps to collect and analyse quantifiable data of the population sample for statistical analysis. The population of the study included all cocoa farmers in Ghana. The multi-stage sampling procedure was used to identify the individual respondents. First of all, the simple random sampling technique was used to select two Cocoa Regions in Ghana, thus, the Eastern and Central Regions were selected. Secondly, the Nkawkaw Cocoa District (Eastern Region) and Breman Asikuma District (Central Region) were the districts selected through the simple random sampling technique (balloting method). In the third stage, five communities were selected out of each of the Cocoa Districts using the simple random sampling procedure (balloting method). In the fourth stage, a list of the registered cocoa farmers within the selected communities was obtained from their respective Cocoa Health and Extension Division (CHED) offices. The proportionate sampling technique was used to assign the relative sample sizes to the districts; thus, in the Nkawkaw Cocoa District (Eastern Region), 200 respondents were selected while in the Breman Asikuma Cocoa District (Central Region), 185 respondents were selected. Out of the list obtained, a simple random sampling technique (balloting method) was used to select the individual farmers from the list.

In the determination of the sample size, the Yamane (1967) provides a simplified formula to calculate sample sizes. This formula was used to calculate the sample size for this study. In this formula, a 95% confidence level and P = 0.5 are assumed. A sample size of 385 cocoa farmers was obtained after the calculation. Community Extension Agents (CEAs) assisted the researchers to identify the respondents to respond to the questionnaire. Data was collected from the individual farmers through the face-to-face method in July 2021. They were visited in their homes and farms to aid in the exercise. The results were analysed using descriptive (means, standard deviations, percentages and frequencies) and inferential statistics (paired sample t test, perception index). Perception index (means and standard deviation) was used to analyse the perceptions of the cocoa farmers on the hand pollination exercise and the perceived changes in their livelihoods. Perception index was used through a 3-point Likert scale; disagree (1), neutral (2) and agree (3). The paired sample t-test was used to assess changes in their production and income before and after the introduction of artificial pollination. The significance was tested at 5%. The challenges cocoa farmers face during hand pollination were explored descriptively.

RESULTS AND DISCUSSION

Socio economic characteristics of cocoa farmers

From Table 1, it can be observed that 49.09% of the cocoa farmers were below the age of 40 years. About 33.51% of the cocoa farmers were found to be between the ages of 41 and 60 years while 17.40% were above the age of 60 years. This clearly indicates that over 70% of the cocoa farmers are within the working class, although most of them were young. Cocoa farming in the study areas could be said to be dominated by people in the economically active population bracket age group (below 60 years). In terms of sex, the males were represented by 64.42% while the female population of cocoa farmers in the study areas were 35.58%. It is expected that female population in cocoa farming will increase over time because the numerous programmes and interventions by COCOBOD to encourage women to take farming as an occupation. In terms of marital status, cocoa farmers who were married were 70.65%, singles were 26.23%, divorced were 20.52% whiles widowed were 8.85%. The educational level of cocoa farmers was

categorized into four groups; no formal education (68.05%), primary school (27.27%), senior high (6.23%) and no tertiary (4.68%). This implies that majority of the cocoa farmers had very low level of education. Majority of the respondents (277) were Christians representing 71.95% of the sample. The others were Islam (20.52%), Traditionalist (5.71%) and Others (1.82%). In terms of ethnic affiliation, majority of the respondents (334) were Akans representing 86.75%. The others were Ga (3.17%), Ewe (2.08%) and Others (8.05%).

Table 1. Socio economic characteristics of cocoa farmers.

Variables	Category	Frequency	Percent (%)
Age	Below 40 years	189	49.09
	41 – 60 years	129	33.51
	Above 60 years	67	17.40
Sex	Male	248	64.42
	Female	137	35.58
Marital status	Single	101	26.23
	Married	272	70.65
	Divorced	79	20.52
	Widowed	34	8.83
Educational level	No formal education	262	68.05
	Primary school	105	27.27
	Senior high	24	6.23
	Tertiary	18	4.68
Religion	Christianity	277	71.95
	Islam	79	20.52
	Traditionalist	22	5.71
	Others	7	1.82
Ethnic affiliation	Akan	334	86.75
	Ga	12	3.17
	Ewe	8	2.08
	Others	31	8.05

Source: Field Survey, 2021

Table 2. Perception of Farmers on Hand Pollination Exercise.

Statements	Mean	Std. Dev.
Tools for hand pollination are expensive	1.81	0.47
Farm was weeded before the pollination exercise	1.95	0.65
Farm was pruned before the pollination exercise	1.97	0.28
Farm was sprayed with insecticides before the pollination exercise	1.99	0.11
Pollination intensity affects fruit set	2.06	0.24
Hand pollination is labour intensive	2.15	0.98
It enables me to identify farm solutions and develop plans	2.34	0.47
I implement solutions and plans without support from outside	2.34	0.49
Extension agents sensitize and educate farmers on pollination	2.39	0.49
Hand pollination has created more employment opportunities	2.45	0.00
Farmers are very cooperative with extension officers	2.49	0.00
Farm was fertilised before the pollination exercise	2.5	0.55
Hand pollination exercise enables farmers to plan on- farm activities	2.51	0.49
Extension service delivery on hand pollination is very effective	2.53	0.14
Hand pollination requires little or no skill	2.55	0.00
Pollinators use the appropriate pollinating PPEs	2.55	0.00
Hand pollination is easy to implement	2.55	0.50
Hand pollination enhances sharing and diffusing of knowledge	2.57	0.50
Hand pollination is time consuming	2.63	0.48
Pollinators pollinate a minimum 50 flowers on a tree & cover at least 17 cocoa trees per day	2.69	0.49

The approach of hand pollination delivery was effective	2.7	0.75
Hand pollination requires education	2.82	0.48
Hand pollination is very important	2.92	0.85
Pollinators take daily records of the number of flowers pollinated	2.95	0.67
The timing of hand pollination exercise was satisfactory	2.95	0.64
The implementation was participatory	2.97	0.59
Pollinators execute farm pollination (pollinate flowers on cocoa trees).	2.99	0.42
It enables me to diagnose farm problems	2.99	0.41
Hand pollination is better than natural pollination	2.99	0.38
Perception Index (Mean=2.52, SD=0.43)		

Perception of Farmers on Hand Pollination Exercise

In terms of the perception of the respondents on hand pollination, the three statements with the highest means are as follows; Hand pollination is better than natural pollination (Mean=2.99; SD=0.38), pollinators execute farm pollination (pollinate flowers on cocoa trees), (Mean=2.99; SD=0.42) and it enables me to diagnose farm problems (Mean=2.99; SD=0.41). The three statements with the lowest scores are as follows; Tools for hand pollination are expensive (Mean=1.81; SD=0.47), farm was weeded before the pollination exercise (Mean=1.95; SD=0.65) and farm was pruned before the pollination exercise (Mean=1.97; SD=0.28). A perception index of 2.52 shows that the cocoa farmers generally agree with majority of the statements on the hand pollination exercise. This means that they perceive that the hand pollination exercise is a good programme championed by the Government of Ghana through the COCOBOD. From all indications, cocoa farmers perceived hand pollination better than natural pollination. Wongnaa *et al.* (2021) who indicated that cocoa farmers have a positive perception towards adoption of artificial pollination technology.

The Level of Change in Production

Table 3 shows the difference in bags produced during the usage of natural pollination and the bags produced after the usage of the hand pollination method. Natural pollination yielded 123 bags maximum per year with a minimum of 8 bags while cocoa hand pollination yielded 175 bags maximum per year with a minimum of 10 bags. This shows that cocoa hand pollination yielded 52 bags more than natural pollination. This corroborates with COCOBOD strategically, using hand pollination to increase the yield and production of cocoa farmers from year to year (Bosompem *et al.*, 2011). The purpose of the hand pollination of cocoa was to enhance Ghana's cocoa productivity in order to improve their earnings and living conditions (Badu, 2019). The results above show that this is being achieved.

Table 3. The Level of Change in Production.

Natural Pollination vs Hand Pollination	Minimum	Maximum
Bags produced during the usage of natural pollination	8	123
Bags produced after the usage of hand pollination	10	175
Difference (Bags produced)	2	52

Source: Field Survey, 2021

Table 4. Paired Sample T-Test (Production).

		Paired Differences					t	Df	Sig. (2-tailed)
		Mean	Std. Dev.	Std. Error Mean	95% Confidence Interval of the Difference				
					Lower	Upper			
Pair	Bags produced during natural pollination - Bags produced during hand pollination	-0.67	0.99	0.15	-0.97	-0.38	-4.62	45	0.00

Source: Author's Construct, 2021 t test = 22.05; P < 0.05; Correlation = 0.93

A paired sample t-test was performed to compare yield (number of bags produced) obtained during natural pollination and artificial pollination. The mean difference in number of bags produced during natural pollination and hand pollination was 0.67 (SD=0.99) and a p value of 0.00. In essence, there is a statistically significant difference between the bags produced during natural pollination and the bags produced during hand pollination. This implies that hand pollination is a better option in terms of yield (cocoa bags produced) than the natural pollination. Following the introduction of hand pollination, the number of bags of cocoa produced has increased (Altshuler, 1999; Donald, 2004). Wongnaa *et al.* (2021) also showed that farmers recorded an increase in yield after they adopted cocoa hand pollination. The role of agricultural innovations in increasing overall farm production is not debatable. Artificial pollination is one of such innovations. Kassie *et al.* (2009) asserted that artificial pollination reduces production costs, improves environmental benefits and increases crop yield among others. According to Forbes *et al.* (2019), artificial pollination, regardless of the extent of adoption, leads to significant increase in the yield of cocoa. During the season where most trees display abundant flowers, artificial pollination results in a tremendous increase in the final fruit sets which resulted in higher yields and profits. This has implications for extension policy and practice. Extension agents must aggressively pursue the agenda of assisting farmers to adopt the practice and not decline with the perception that since it is a government policy, it is just a political ambition. In terms of practice, the extension office must also train cocoa farmers to be able to handle the practice by themselves, instead of waiting for pollinators. This can ensure the sustainability of the exercise among the cocoa farmers.

Resultant Change in Income

Table 5 shows the difference in income earned before and after the usage of the hand pollination method. Results of the analysis indicates that natural pollination earned a maximum of GH₵68,640 per year with a minimum of GH₵1,332 while cocoa hand pollination earned a maximum of GH₵118,800 per year with a minimum of GH₵6,600. This shows that cocoa hand pollination earned GH₵50,160 more than natural pollination (maximum). This shows that the income of cocoa farmers increased after the introduction of hand pollination, which is in line with a study that says the usage of hand pollination increased the yield of cocoa trees by 161% (Toledo-Hernández *et al.*, 2020). The introduction of hand pollination significant increases productivity, which eventually affects the income of beneficiary farmers.

Table 5. The level of change in income.

Natural Pollination vs Hand Pollination	Minimum (GH₵)	Maximum (GH₵)
Income obtained during the usage of natural pollination	1332	68640
Income obtained after the usage of hand pollination	6600	118800
Difference (Income obtained)	5268	50160

Source: Field Survey, 2021

Table 6. Paired Sample T-Test (Income).

		Paired Differences					t	Df	Sig. (2-tailed)
		Mean	Std. Dev.	Std. Error Mean	95% Confidence Interval of the Difference				
					Lower	Upper			
Pair	Income during natural pollination – Income during hand pollination	-0.24	0.60	0.09	-0.42	-0.06	-2.69	45	0.01

T test = 19.69; P < 0.05; Correlation = 0.70

The paired sample t-test was used since the mean profits before and after hand pollination were compared. In essence, there is a statistically significant difference between the income earned during natural pollination and the income earned during hand pollination (P<0.05). This implies that hand pollination is a better option in terms of income obtained than the natural pollination. Following the introduction of hand pollination, the

income received has increased. A study by Wongnaa *et al.* (2021) also showed that farming households who adopted artificial pollination had improvements in their income. It was also revealed that adopters earned between GH₵ 2756.84 to GH₵ 11074.38 more on average in terms of income. According to Gupta *et al.* (2017) total pollination of the entire tree also led to a 161% increase in net income. This has implications for extension practice. Money or financial returns is a good motivation for anyone embarking on any project. If this practice can significantly improve farmers' income, then extension agents must not relent in their efforts at disseminating the goodwill of the exercise to all and sundry, especially cocoa farmers. More farmers must be encouraged to adopt the practice. This is because there is empirical proof that the hand pollination exercise has the potential to improve cocoa farmers' income (Klein *et al.*, 2003).

Perceived Change in Livelihood

Five (5) different livelihood indicators were used to analyze the perceived in livelihood. In terms of human capital, the statement with the lowest mean score was "hand pollination has helped me expand my farm" (Mean=2.29, SD=0.11). This means that hand pollination has increased the respondents' enthusiasm in their work, allowing them to gain further information and abilities in cocoa production. The statement with the highest score was "I have learnt a lot through the training on cocoa hand pollination" (Mean=2.50, SD=0.53). This suggests that adopting hand pollination has helped boost their confidence as cocoa farmers. When they are trained to adopt hand pollination, it will help broaden their knowledge and view related to their work or profession as farmers. This agrees with a finding which says, training will reinforce individual farmer's level of competencies in conducting specific psychomotor skills (Danquah *et al.*, 2015).

In terms of physical capital, four (4) different perception statements were used to analyze the change in line with the farmers' asset acquisition. The statement with the lowest score was "I have my own farm land" (Mean=2.38, SD=0.11). The statement with the highest score was "I can purchase my own farm inputs" (Mean=2.85, SD=0.09). Majority of the respondents agreed to the statements in terms of asset acquisition. According to Bosompem *et al.* (2011) and Anthony *et al.* (2014), asset acquisition in a household has a bigger influence on the livelihood of farmers which is in line with the results. Also, the extent to which cocoa farmers diversify in livelihood also depends on asset acquisition. Danquah *et al.* (2015) also agrees that activities involved in livelihood needs a combination of asset to obtain a good result.

In terms of natural capital, three (3) different perception statements were used to analyze the change in line with the production. The statement with the lowest score was "Increment of cocoa yield increases from year to year" (Mean=2.29, SD=0.31). The statement with the highest score was "My output is now higher" (Mean=2.90, SD=0.55). According to the results, respondent agree to the fact that cocoa hand pollination has help improve upon productivity. This is in line with a study by Toledo-Toledo-Hernández *et al.* (2020) which says that manual pollination can triple farm yields and double farmers annual profit in the major producer countries by about 13%.

In terms of financial capital, four (4) different perception statements were used to analyze the change in line with the farmers' income and expenditure. The statement with the lowest score was "I have been able to pay all of my debts" (Mean=1.81, SD=0.01). The statement with the highest score was "I can now afford three square meals for my family" (Mean=2.82, SD=0.62). This suggests that majority of the respondents have not been able to pay all their debts but they are able to afford three square meals for their family. "I have been able to save money in the bank" (Mean=2.31, SD=0.04) was the second highest. Bosompem *et al.* (2011) also found that cocoa farmers in their study also had the option to save a portion of their income for future use. This is because they were able to access farm credit from banks and microfinance institutions.

In terms of social capital, five (5) different perception statement were used to analyze the change in line with the farmers' associations. The statement with the lowest score was "I attend political meetings" (Mean=1.98, SD=0.15). The statement with the highest score was "I attend funerals and weddings" (Mean=2.91, SD=0.99). This suggests that majority of the respondents have not been able to pay all their debts but they are able to afford three square meals for their family.

Table 7. The perception of change in livelihood.

Perception Statements	Mean	Std. Dev.
Profession (Human Capital)		
Hand pollination has helped expand my farm	2.29	0.11
My interest in cocoa farming has increased	2.40	0.19
I have learnt a lot through the training on cocoa hand pollination	2.50	0.53
Asset Acquisition (Physical Capital)		
I have been able to purchase new farm tools for my farm	2.81	0.54
I have purchased new household gargets	2.39	0.28
I have my own farm land	2.38	0.11
I can purchase my own farm inputs	2.85	0.09
Production (Natural Capital)		
Increment of cocoa yield increases from year to year	2.29	0.31
I am able to cultivate higher acreage of farm land	2.55	0.24
My output is now higher	2.90	0.55
Income and Expenditure (Financial Capital)		
I have been able to pay all of my debts	1.81	0.01
I can now pay my children's school fees	2.30	0.45
I can now afford three square meals for my family.	2.82	0.62
I have been able to save money in the bank	2.31	0.04
Associations (Social Capital)		
I attend religious programmes	2.65	0.67
I attend funerals and weddings	2.91	0.99
I attend political meetings	1.98	0.15
I engage in communal labour	2.81	0.97
I enjoy being a member of a farmers' association	2.70	0.38

Source: Field Survey, 2021

Table 8. Summary of Perception Index on Change in Livelihood.

Change in Livelihood	Mean Perception Index
Human Capital	2.40
Physical Capital	2.61
Natural Capital	2.58
Financial Capital	2.82
Social Capital	2.50
Overall Mean	2.58

Source: Author's Construct, 2021

An examination of the results in Table 8 shows that in terms of the perceived change in livelihood of cocoa farmers, this can be seen in their financial capital. This is followed by physical capital, natural capital, social capital and human capital. The least perceived change in livelihood can be seen in their human capital. The overall mean perception index of the change in livelihood was found to be 2.58. It could therefore be said that participation in the hand pollination has brought a high level of perceived impact on the livelihoods of the cocoa farmers. In another study by Tham-Agyekum *et al.* (2021) a comparison of the livelihood outcomes of the cocoa farmers who participated in an intervention and those who did not participate. In that study, the results showed that participants had better livelihood outcomes (3.07) than the non-participants (2.68) and this was statistically significant ($p<0.05$). Bosompem *et al.* (2011) in a study that looked at the impact of a programme on the livelihood of cocoa farmers found that the impact of the programme on their 'overall' livelihoods was 'average' (Mean=3.32, SD=0.66).

Challenges of cocoa hand pollination

Table 6 shows that about 48% of the cocoa farmers were challenged by lack of rains during cocoa hand pollination, 15% by the cost of cocoa hand pollination,

21% by the distance and location of their farms, 11% of the farmers indicated that hand pollination makes the cocoa flowers weak and 5% indicated that the practice takes time. This means that a high percentage of the cocoa farmers are affected by the lack of rain during hand pollination periods. The increasing negative impact of climate change on agriculture remains the major threat to cocoa hand pollination. For instance, erratic rainfall pattern (highlighted in this study), extreme temperatures and excessive rainfall are inimical to the success of cocoa hand pollination. The lack of rains during the pollination period or heavy downpours causes the young pods to drop prematurely. Likewise, when there is inadequate rain, the plants cannot bear flowers which are needed for the pollination exercise (Breisinger *et al.*, 2008).

COCOBOD (2000) agrees with this assertion that high rainfall which leads to the abortion of already pollinated flowers and low rainfall which also leads to insufficient moisture content are factors that cause yield decline in cocoa. This has implications for extension policy and practice. These challenges can go in a long way to reduce the progress made so far by the hand pollination exercise. They also have the potential of halting the exercise all together. In order to ensure the sustainability of the exercise, policy makers and all stakeholders must be involved to help curtail these apparent challenges.

Table 9. Challenges in hand pollination.

Challenges	Frequency	Percent
Lack of rain during hand pollination	184	47.91
Distances in location	79	20.57
Its costly	58	15.10
It makes the flower weak	43	11.20
It takes time	20	5.21
Total	384	100.0

Source: Field Survey, 2021

CONCLUSION AND RECOMMENDATIONS

Generally, cocoa farmers perceive that hand pollination is better than natural pollination. They also agree with most of the statements on the hand pollination exercise. This means that they find the hand pollination exercise as a good activity to engage themselves in. This has implications for the practice of extension in Ghana. If the perceptions of the cocoa farmers can translate into practice, then the exercise will be quickly disseminated among the farmers even with little effort from the extension agents. This will make it easier for the work of extension agents who need to train farmers on how to perform the activity on their own. Peer learning is highly encouraged among farmers since the extension-farmer ratio in Ghana (1:1200) is wide. Farmer groups should be encouraged to help convey or share pertinent knowledge among themselves, especially in places where extension personnel are scarce. This will aid the promotion of hand pollination in the country. Extension officers through the media can be encouraged to aid the promotion of agriculture, particularly innovative agricultural technologies such as the hand pollination because they can reorder information access to cocoa farmers. The hand pollination exercise resulted in a rise in cocoa yield when compared to natural pollination. Also, hand pollination caused a rise in the income of cocoa farmers. Participation in the hand pollination exercise has brought a high level of impact on the livelihoods of cocoa farmers, especially in relations to the financial assets of cocoa farmers. The implication is that, Government, in collaboration with COCOBOD should expand its effort to encourage the practice of hand pollination in cocoa in order to improve the other livelihood assets of cocoa farmers.

In cocoa plantations, pollinator population levels can be increased by augmenting the amount of hand pollinator breeding substrates. An introduction of such materials by extension agents among cocoa farmers will likely enhance pollinator breeding and subsequently their population levels.

Though training farmers to hand pollinate cocoa will add to their already overloaded time and resources, it is reasonable for extension agents to inform them about the impact of pollination on yield, in addition to agronomic inputs such as fertilizer and pesticides. Extension service agencies should provide agricultural

information to farmers, particularly in rural areas, in order to improve the livelihood of small-scale cocoa farmers by increasing crop productivity. Increased visitations by extension officers to farmers increases the likelihood of farmers using hand or artificial pollination. This shows a positive relationship between the availability of extension services and the likelihood of adopting hand pollination practices for cocoa, which accounts for the increase in yield and income. Extension officers can typically prepare demonstration plots to provide farmers with hands-on training and to assist farmers in experimenting with this exercise. This will provide employment opportunities for extension service personnel while also increasing farmer income.

Majority of cocoa farmers are affected by the lack of rain during hand pollination periods. Community extension agents in collaboration with irrigation scheme experts are encouraged to develop and train cocoa farmers on strategic irrigation practices that can be used for hand pollination especially during the dry season so that farmers can continuously engage in the practice.

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