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INVENTORY OF EXISTING AND EXPLOITABLE KNOWLEDGE AND TECHNOLOGIES ON COCOA IN GHANA

[1*]Agyei-Ohemeng, J., [2]Opare, P., [3]Obeng-Ofori, D.

[1, 2, 3] University of Energy and Natural Resources, Sunyani
[*]Corresponding Author Email Id: james.agyei-ohemeng@uenr.edu.gh

Abstract: **Under a project on Strengthening Innovations and Technology Dissemination for Sustainable Development in Cereals, Cocoa and Coffee Value Chains in Western and Eastern Africa implemented in Ghana, a baseline survey was conducted to provide an inventory of existing and potentially exploitable knowledge and technologies in the cocoa production value chain in the Brong Ahafo and Ashanti Regions of Ghana. The aim was to improve cocoa production and strengthen human resource and knowledge exchange on best practices and procedures in sustainable cocoa production along the value chain. Two research methodologies were used, first, literature search on reports, journal articles and books was conducted to determine the range of technologies that had been reported and secondly, interactions with staff of MoFA, COCOBOD and CRIG, and research scientists, farmers, and other stakeholders in the cocoa production value chain to ascertain the scope of technology development and application in cocoa farming in Goaso, Tepa, Maabang and Bechem cocoa areas. A stakeholder workshop was organized to validate the results obtained from the desk review and field interviews. Proven technological protocols identified by all stakeholders during the study to increase the productivity of the crop in Ghana were the use hybrid seeds, good husbandry practices, disease and pest control, harvesting and postharvest management. However, as a result of the prevailing economic, educational, socio-cultural, institutional and infrastructural constraints, many smallholder farmers in the rural communities were unable to take advantage of these novel technologies and innovations to increase cocoa production in the country.**

Keywords: **Innovation, proven technologies, inventory, dissemination, baseline survey.**

1. INTRODUCTION

Cocoa is the dominant tree crop in Ghana and the main agricultural export commodity of Ghana and employs about 60% of the national agricultural labour force (Ntiamoah and Afrane, 2008). Cocoa is produced in six regions of Ghana namely: Western, Ashanti, Eastern, Central, Volta and Brong Ahafo. The Dutch missionaries planted cocoa in the coastal areas of the then Gold Coast (now Ghana) in 1815 and in 1857, the Basel missionaries planted cocoa at Aburi on small scale (Tweneboah, 2000; GRI, 2007). In 1876 Tetteh Quarshie, a Ghanaian, arrived from Fernando Po with the Amelonado type of cocoa and started his farm at Mampong Akwapim in the Eastern Region of Ghana. His farm turned into nursery for all pioneering cocoa farms in Ghana. In 1886/87, the then governor of Gold Coast, Sir William Brandon Griffiths supported the cocoa industry by obtaining cocoa pods from Sao Tome and distributed seedlings to various farmers in the Akwapim area from a botanical garden he helped to establish near Aburi (Tweneboah, 2000).

The first export of 36.30 kg of cocoa beans from the Gold Coast was made in 1891 and by 1900, exports had increased to 540 tonnes (Tweneboah, 2000). By 1911, the Gold Coast was the leading cocoa producing nation in the world with 41,000 tonnes. The volume increased to 165,000 tonnes and at that time, Ghana accounted for 40% of world production (GRI, 2007). From 1930 to 1933 cocoa prices fell sharply which led to the imposition of a ban on further cocoa planting in some areas by local chiefs. There was a hold-up of cocoa sales for over six months by farmers during the 1937/38 main crop season and the burning of cocoa beans in some areas in protest against low prices (Tweneboah, 2000). However,

there was a sharp rise in the producer price after 1947 but the cocoa swollen shoot virus which had been identified in the country in 1936 devastated several cocoa farms. The government then instituted a disease control programme in 1946 where the affected cocoa trees were felled.

Although Ghana was the world's largest cocoa producer in the early 1960s, by the early 1980s Ghanaian production had dwindled almost to the point of insignificance. The drop from an average of more than 450,000 tonnes per year to a low of 159,000 tonnes in 1983-84 was attributed to aging trees, widespread pests and disease attack, bad weather, and low producer prices. In addition, bush fires in 1983 destroyed some 60,000 hectares of cocoa farms, so that the 1983-84 crops were barely 28% of the 557,000 tonnes recorded in 1964-65. Due to rapid expansion in cultivation, production reached 700,000 tonnes in 2011 increasing to a record 879,384 tonnes in 2012. Production fell sharply to 835,466 tonnes in 2013 and increased to 858,720 tonnes in 2016. A number of factors have contributed to the success of Ghana's cocoa sector: a favorable price regime, both in terms of the share price passed on to producers and the real price received by farmers, Gockowski, J. (2007)

Cocoa is the dominant tree crop in Ghana and the mainstay of the Ghanaian economy that accounts for 30% of Ghana's export earnings (ICCO AR, 2007) and employs about 60% of the national agricultural labour force. Cocoa production employs about 800,000 farm families spread over six of the 10 regions of Ghana and contributes about 70-100% of the annual household incomes of the Ghanaian cocoa farmers (Appiah, 2004; Ntiamoah and Afrane, 2008). In terms of agricultural Gross Domestic Product (GDP), cocoa contributed 11.24% and 11.50% in 2008 and 2009, respectively (MOFA SRID, 2010). Cocoa beans and products exported in Ghana from 2005 to 2009 seasons generated US$ 908.40 million to an estimated amount of US$ 1,865.98 million (ISSER, 2010).

It is a major source of taxation to the government and over the years, cocoa has provided money for infrastructural development and for the education of the mass of the people. . Cocoa beans are used to make chocolate biscuits, cake and confectionary. In preparing cocoa powder, excess fat known as cocoa butter is expressed which is used in chocolate manufacture and other industrial processes such as in confectionary, margarine making and perfumery. COCOBOD offers a lot of social incentives to Ghanaians through programmes like construction of feeder roads, the scholarship scheme, pest and disease control, supply of subsidized fertilizers, provision of solar bore holes and solar street lights and the recent pension and housing scheme for cocoa farmers among others (COCOBOD News, 2010).

Cocoa also has important health benefits to consumers. The Mayans and the Aztecs thought of cocoa of having medicinal properties (Wood and Lass, 1985). In recognition of its multiple health benefits, they maintained its ancient Olmec name 'kakawa' meaning 'God Food' (Little, 1998; Addai, 2009). Natural cocoa powder contains the highest antioxidants and procyanidins compared to Dutch processed cocoa powder, unsweetened baking chocolate, semi-sweet chocolate baking chips, dark and milk chocolate (Addai, 2009). Cocoa beans contain a large number of phytochemicals which help the body cells resist damage and also inhibit the oxidation of the low density lipoprotein associated with heart disease. Consumption of cocoa which is a rich source of polyphenolic compounds is associated with a reduced risk of diabetes mellitus (Grassi et al., 2006), dementias strokes and end-stage renal disease (Hollenberg, 2006). There is also reduced frequency of malaria illness in people who drink hot natural cocoa powder (Addai, 2009). Unlike tea and coffee, cocoa contains little caffeine which has little effect on the central nervous system and as such can be given to children without fear of sleeplessness (Weisburger, 2001). The moderate consumption of cocoa can prevent or cure a sickness like the plaque of the guts (Wood and Lass, 1985).

The government of Ghana has attempted to restructure cocoa production through market reforms (liberalization of domestic marketing of cocoa), improved seed and nursery development, improved cocoa varieties, better disease and pest control, integrated nutrient management and other measures like road construction and provision of social amenities in cocoa growing areas. Until the early 1990s, an estimated 40 hectares continued to be added to the total area of 800,000 hectares under cocoa production each year. In addition, a major programme to upgrade existing roads and to construct 3,000 kilometres of new feeder roads was launched to ease the transportation and marketing of cocoa from some of the more neglected but very fertile growing areas on the border with Ivory Coast. Furthermore, the government tried to increase Ghana's productivity from 300 kilograms per hectare. New emphasis was placed on efficient and effective extension services, development of technologies such as early maturing cocoa varieties, improved pest and disease management, improved agronomic practices, nutrient management etc. by the Cocoa Research Institute of Ghana (CRIG). These measures resulted in increased cocoa production to its highest level of 1 million tonnes in 2006 (CRIG, 2010), although this production level was not sustained.

In spite of this increase in production, Ghana's cocoa yield per hectare is still low by international standards. More importantly, only about 3% of cocoa farmers have adopted the full range of technologies developed by CRIG to increase productivity of cocoa. The study were conducted to find out the knowledge of existing technologies and to ascertain the scope of technology application in their cocoa farming practices in these cocoa communities namely Goaso, Tepa, Maabang and Bechem. The farmer field schools were also designed to encourage more widespread adoption of these technologies among the farmers.

2. MATERIALS AND METHODS

2.1 Project Areas:

The inventory field survey was carried out in Goaso, Tepa, Maabang and Bechem farming communities in the Brong Ahafo and Ashanti Regions of Ghana (Fig. 1).

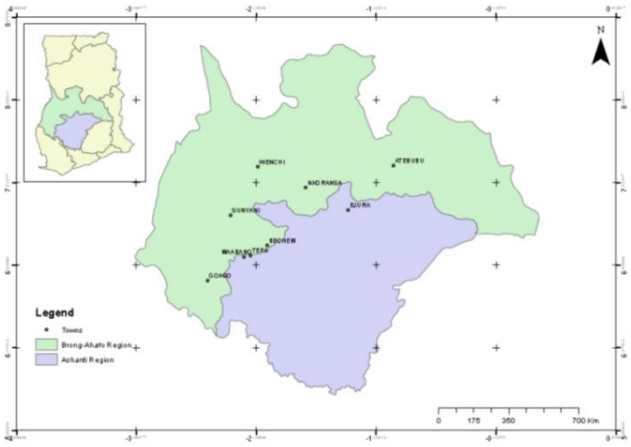

Figure 1: Map of Ghana showing project areas for field inventory survey

2.2 Inventory Survey:

Two main research methodologies were employed. First, a literature review of reports, journal articles and books was conducted to determine the range of technologies that have been developed and reported. In the literature review, searches were done seeking specific information about improved technologies, innovations, and practices that had been developed in order to increase cocoa productivity over the years. An analysis of research findings and publications, particularly by scientists of the CRIG and COCOBOD was conducted. Secondly, interviews with staff of MoFA, COCOBOD and CRIG and research scientists, farmers, and other stakeholders were conducted to find out their knowledge of existing technologies and to ascertain the scope of technology application in their cocoa farming practices in these cocoa communities namely Goaso, Tepa, Maabang and Bechem.

Armed with this information the various stakeholders were interviewed using mostly open-ended questions on technologies and innovations in the cocoa value chain. The open ended questions were broken down into the various cycles of crop production: land preparation, seed technologies, planting, and weed and pest control, harvesting and processing for market, and storage practices.

2.3 Validation workshop:

A validation workshop was organized at the University of Energy and Natural Resources, Sunyani for fifty (50) participants who are all the stakeholders in the cocoa production value chain. These included twenty (20) farmers, MoFA, CRIG staff, Cocoa Health Division and the Cocoa seedling unit of Cocobod, were invited to validate the inventory collected. Participatory approach method was used to prove the technologies identified and used in the cocoa production value chain. A visit to some farmers' farms in Goaso was also done to ascertain the validated technologies.

3. RESULTS, ANALYSIS AND DISCUSSIONS

3.1 Land preparation and planting technologies:

In cocoa plantation, land clearing is conducted between the months of December and February, leaving desirable trees to provide shade. According to current research finding and practices, cocoa seedlings are to be planted at a distance of 3 m

x 3 m for maximum yield. Plantain, cocoyam and cassava are planted to serve as temporary shades for the young cocoa plants, while in the forest regimes, 35-45 trees are left as shade trees per hectare (Table 1). This is further pruned to between 15-18 trees per hectare after the establishment of cocoa trees. The best time for planting cocoa is in May to July (the major rainy season). Seedlings should be watered a day before planting in rows of 3 m x 3 m, (10 ft. x 10 ft.) spacing. This gives 1,111 seedlings per ha or 435 seedlings per acre.

Table 1: Examples of desirable and undesirable trees in cocoa farms

Desirable shade trees	Local Name	Undesirable shade trees	Local Name
Terminalia ivorensis	Amire	*Ceiba pentandra*	Onyina
Terminalia superb	Ofram	*Cola gigantean*	Watapuo
Albizia coriaria	Awiemfuosamina	*Cola chlamydantha*	Krabise
Entandrophragma angolense	Adinam, cedar	*Adansonia digitata*	Odadee
Funtumia elastic	Ofuntum	*Blighia sapida*	Akyewobiri
Alstonia bonei	Nyamedua	*Canthium glabriflorum*	Gyapam
Pycnanthus angolensis	Otie	*Musanga cecropoides*	Odwuma
Milicia excels	Odum	*Carapa procera*	Kwakuobise
Spathodea campulata	Kukuoninsuo	*Lecaniodiscus cupanoides*	Dwindwera
Ficus exaperata	Nyankyeren	*Myrianthus arboresus*	Nyankuma

3.2. Seed technologies:

Seed technologies are developed in seed production units at Bechem and Goaso. There are four varieties of cocoa in Ghana, namely; Criollo, Amelonado, Trinitario and the Hybrid Seed. The hybrid seeds are recommended because they are disease resistant, drought resistant, and high yielding, easy to establish, with trees bearing in two years and high yielding.

3.3 Good husbandry technologies:

Improved methods of nursing seedlings, land preparation, transplanting of seedlings, planting patterns, mulching, weed control, and pruning are technologies applied to reduce losses and increase yield. Pruning is done on both young and mature cocoa trees. Young seedlings are pruned within the 3rd and 4th year of establishment. Pruning is important to minimize shape in the farm, control mistletoes, improve air circulation, reduce quantity and cost on chemicals and opens canopy for adequate sunlight.

3.4 Pest and disease technologies:

Disease and pest control methods have been developed, including the use of synthetic pesticides and plant based pesticides.

3.5. Soil fertility management technologies:

The application of fertilizers depends on the stage of plant growth, soil type and its fertility. Three types of fertilizers are recommended by the COCOBOD for cocoa as follows:

Conventional (inorganic) Fertilizers

i) Asaase Wura (NPK 0-22-18 +9CaO +7S + 6MgO)

ii) Cocofeed (NPK 0-30-20)

iii) Triple super phosphate (TSP; 46% P2O5) + Muriate of potash mixture (MOP; 60% K2O)

iv) Ammonium Sulphate (21%N).

Fertilizers are broadcast on the same plot for four consecutive years with 1-2 year break.

Foliar/Liquid fertilizers, these come in three formulations:

i) NP K 10:10:10 (balanced)

ii) NPK 20:2:4 (Nitrogen-rich) and

iii) NPK 6:0:20 (Potassium-rich)

These are applied at monthly intervals by way of broadcasting at the base of cocoa trees.

Mulching helps to conserve soil moisture, promote soil organic activities, reduce impact of rain drops and slow down run offs. Mulching materials include dry grass, pseudo stems of plants. In termite infested areas a synthetic insecticide, Confidor solution is applied with water to the mulch.

3.6 Harvesting technologies:

Harvesting and processing methods have also been developed for cocoa. These include such technologies as harvesters, pod-breakers, fermentation processes, drying technologies and bagging. The breaking of cocoa pods is normally done within 2-3 days after harvest. The pods can be broken using either a wooden club or cutlass. If not done with caution cutlasses may injure the cocoa beans inside the pods. Wooden clubs are therefore recommended for pod breaking to ensure bean quality.

3.7 Postharvest management technologies:

Cocoa fermentation is one of the stages in postharvest processing that defines the ultimate product quality. Methods of Fermentation include basket, box, tray and heap fermentation. Advantages of Fermentation

- More homogenous fermentation
- Better aeration – increased acetic acid concentration and lower levels of moulds
- Reduced loss of cocoa beans
- Better quality of the beans – higher price

Freshly fermented cocoa beans must be dried immediately to avoid being rotten. The moisture content of the freshly fermented beans is about 60% and must be reduced to at least 7.5% for safe storage and shipment to its ultimate destination. Drying reduces the bitterness and astringency of cocoa by oxidizing polyphenols to insoluble tannins and also developing the chocolate colour of well fermented cocoa beans.

Table 2: Summary of some of the technologies identified

Technologies	Purpose	Remarks
Seed technologies (There are four varieties of cocoa in Ghana, namely; Criollo, Amelonado, Trinitario and the Hybrid Seed)	Development of disease resistant, drought resistant, and high yielding varieties of both crops	Improved methods of nursing seedlings, land preparation, transplanting of seedlings, planting patterns, mulching, weed control, pruning, and fertilizer application to reduce losses and increase yield.
Better disease and pest control methods have been developed, including the use of synthetic pesticides and plant based pesticides	Advantages: • Easy to establish • Fruit bearing in two years • High yielding • Resistant to black pod and swollen shoot diseases • Resistant to capsids (akate) pest	
Best Agronomic Practices	Trees are left as shade trees pruned to between 15-18 trees per hectare after the establishment of cocoa trees	Pruning is done for both young and mature cocoa trees. Young seedlings are pruned within the 3rd and 4th year of establishment. Pruning is important for the following reasons; • To provide shape to the plant • Control mistletoes • Improve air circulation • Reduce quantity and cost on chemicals • Opens canopy for adequate sunlight
Fertilizer Application	The application of fertilizers depends on the stage of plant growth, soil type and its fertility. Three types of fertilizers are recommended by the COCOBOD for	

	cocoa as follows: Conventional (inorganic) Fertilizers i) Asaase Wura (NPK 0-22-18 +9CaO +7S + 6MgO) ii) Cocofeed (NPK 0-30-20) iii) Triple super phosphate (TSP; 46% P2O5) + Muriate of potash mixture (MOP; 60% K2O) iv) Ammonium Sulphate (21%N) Fertilizers are broadcast on the same plot for four consecutive years with 1-2 year break. Foliar/Liquid fertilizers These come in three formulations: i) NP K 10:10:10 (balanced) ii) NPK 20:2:4 (Nitrogen-rich) and iii) NPK 6:0:20 (Potassium-rich) These are applied at monthly intervals by way of broadcasting at the base of cocoa trees.	
Planting Methods a) Using nursed poly bags	Advantages • Better plant growth and establishment • Higher survival rate • Opportunity to establish healthy plant seedlings • Seedlings tolerate adverse climatic conditions.	
b) Using seedlings raised on beds	Advantages • Relatively high survival rate after transplanting • Better seeding growth • Reduce losses due to diseases • Opportunity to be selective in establishing farms • Minimize losses due to weeding • Lower transportation cost than poly bags.	
c) Planting at stake,	Advantages • More economical, requires no planting facility • Reduces transportation cost • Reduces transplanting shock • Seedlings can better tolerate adverse conditions since they develop in sit	
Harvesting and processing methods have also been developed for cocoa. These include such technologies as harvesters, pod-breakers, fermentation processes, drying technologies and bagging.	Two cocoa cropping seasons in a year in West Africa in particular, the main crop in October-March and the light-crop in May-August (CRIG, 2010). Harvesting is done every 2-4 weeks when the pods are ripe and yellow in color. However, for farmers who apply fertilizers, harvesting weekly or every two weeks is not uncommon. Regular harvesting ensures that pods of about the same level of maturity are harvested.	The breaking of cocoa pods is normally done within 2-3 days after harvest. The pods can be broken using either a wooden club or cutlass. If not done with caution cutlasses may injure the cocoa beans inside the pods. Wooden clubs are therefore recommended for pod breaking to ensure bean quality.
Cocoa fermentation is one of the stages in postharvest processing that defines the ultimate product quality. Methods of Fermentation	Advantages of Fermentation	

• Basket fermentation • Box fermentation • Tray fermentation • Heap fermentation	• More homogenous fermentation • Better aeration – increased acetic acid concentration and lower levels of moulds • Reduced loss of cocoa beans • Better quality of the beans – higher price
Drying of Cocoa Beans Freshly fermented cocoa beans must be dried immediately to avoid being rotten. The moisture content of the freshly fermented beans is about 60% and must be reduced to at least 7.5% for safe storage and shipment to its ultimate destination.	Drying reduces the bitterness and astringency of cocoa by oxidizing polyphenols to insoluble tannins and also developing the chocolate color of well fermented cocoa beans.
Quality control of beans	This is not done by farmers but by trained professional field staff of COCOBOD located in key cocoa producing regions in Ghana to provide services which include representative sampling for laboratory tests. Cocoa laboratory analysis includes the following: 1. Physical entomological assessment. 2. Chemical assessment for essential oils. 3. Moisture content to assess aflatoxin. 4. Microbiological assessment though pH of beans 5. Fat content and pesticide residue testing.

Table 3: Major Pests and Diseases of Cocoa and their control methods

Disease	**Control Method**
Swollen shoot	Cut down infected diseased trees and replant
Black pod	a. Pruning regularly to reduce shade. b. Using chemicals to spray in May/June every year to stop germination of fungal spots.
Thread blight, charcoal pod rot, root rot, cushion gall and mealy pod diseases are other minor diseases.	Using fungicides approved by COCOBOD.
Mistletoe	a. Providing shade trees b. Cutting infected branches. c. Chemicals are being tested.
Pests	**Control Method**
Cocoa capsids	Shade management, use of approved insecticides
Cocoa Mealy bugs	Cultural practices, use of approved insecticides
Shield bugs	Cultural practices, use of approved insecticides
Termites	Cultural practices, use of approved insecticides
Grasshoppers	Cultural practices, use of approved insecticides
Rodents	Cultural practices (e.g. trapping, weeding)

An effective method of controlling the key pests and diseases that attack cocoa is the application of synthetic pesticides. There are three approved insecticides for the control of pests and diseases in cocoa (Table 4).

Table 4: List of approved insecticides for cocoa by CRIG

Trade Name of insecticide	**Active ingredient**	**Dosage**
Akate Master	Bifenthrin	500 ml/ha
Actara	Thiomethoxam	85 ml/ha
Confidor	Imidacloprid (200 SL)	150 ml/ha

Table 5: Summary of Technologies in Cocoa

COCOA TECHNOLOGIES				
Seed	**Growing**	**Disease and pest control**	**Harvesting**	**Postharvest Management**
Improved cocoa varieties Nursery management	Land preparation. Transplanting. Planting patterns. Mulching. Weed control. Pruning. Fertilizers. -Inorganic -Organic	*Chemical* -Akate Master. -Actara. -Confidor. *Organic* -Neem tree extract	Sickles/harvesters for harvesting. Pod- breakers	Fermentation Drying Bagging

4. CONCLUSION

Cocoa is economically an important crop in Ghana for revenue generation and attainment of food security, respectively. Several proven technologies have been developed to increase the productivity of the crop in Ghana. However, as a result of the prevailing economic, educational, socio-cultural, institutional and infrastructural constraints, many smallholder farmers in the rural communities are unable to take advantage of novel technologies and innovations to increase production. The introduction, application and utilization of agricultural technologies in cocoa production should be a collaborative effort of the state and community actors who will be supported by capable and well-organized extension services and other service providers. Many novel and valuable agricultural innovations become lost to communities as a result of inadequate information, poor dissemination and application. It is of categorical imperative that a more effective and efficient technology dissemination platforms are developed to empower farmers to adopt these appropriate technologies to increase crop productivity and yields.

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REFERENCES

[1] Addai, F.K. (2009). Medical hypothesis. Natural cocoa as diet-mediated anti-malarial prophylaxis. University of Ghana Medical School, Accra Ghana, pp. 825-830.

[2] Addai, F. K., Nuamah, I. K. and Addo, J. (2002). Responses of saliva pH to ingestion of Golden tree chocolate and the effect of stick chewing. Journal of the Ghana Science Association 4 (1), 8-13.

[3] Appiah, M. R. (2004). Impact of cocoa research innovations on poverty alleviation in Ghana. Ghana Academy of Arts and Sciences Publication, 32 pp.

[4] Asase, A., Ofori-Frimpong, K. and Ekpe, P.K. 2009. Impact of cocoa farming on vegetation in an agricultural landscape in Ghana. African Journal of Ecology 48 (2), 338-346.

[5] Chamberlin, J. 2007. Defining smallholder agriculture in Ghana: Who are smallholders, what do they do and how are they linked with markets? GSSP background paper 6. Washington, DC: IFPRI.

[6] Clark, N. L. 1994. "Agriculture" A Country Study: Ghana.

[7] COCOBOD News. (2010). A publication of Ghana Cocoa Board, 16 (3), pp. 2-4

[8] Grassie, D., Desideri, G., Croce, G., Pasqualetti, P., Lippi, C. and Ferri, C. (2006). Cocoa and Cardiovascular health: the sweet heart protection. Chocolate Health Anno., pp 13-16.

[9] Ghana Review International. (2007). COCOBOD Anniversary edition Issue 123, Micromedia consultant Gh. Ltd, pp. 13-28.

[10] CRIG, 2010. Cocoa manual: Source book of Sustainable cocoa Production. CRIG, Tafo, Ghana.

[11] Global Forum on Food Security and Nutrition, (2010).

[12] Ghana Living Standard Survey, (2000), Report of fourth round (GLSS 4), Ghana Statistical Statistical Service, Accra, 86 pp.

[13] Ghana Living Standard Survey (2008). Report of the fifth round (GLSS 5), Ghana Statistical Service, Accra, 131 pp.

[14] GMS, 2013. Ghana Meteorological Annual Report for 2013.

[15] Gockowski, J. (2007) "The Analysis of Policies, Productivity and Agricultural Transformation in the Cocoa-Producing, Rural Economies of West Africa." STCP Technical Report Executive Summary.

[16] Hollenberg, N. K. (2006).Vascular action of flavonols in humans: the root of the story. Journal of Cardiovascular Pharmacology 47: 119-121.

[17] ICCO. (2007). Annual Report 2005/2006. International Cocoa Organization. 22 Berners Street, London, pp. 13-15.

[18] ICCO. (2006). Annual Report 2004/2005. International Cocoa Organization, 23 pp.

[19] ICCO. (2009). Annual Report 2007/2008. International Cocoa Organization, 12 pp.

[20] ICCO. (2010). Annual Report 2008/2009. International Cocoa Organization, pp. 3-4

[21] ISSER. (2010). The State of the Ghanaian Economy in 2009. Institute of Statistical, Social and Economic Research, University of Ghana, Legon, 93 pp.

[22] ISSER, (2011). The State of the Ghanaian Economy, 2010. Institute of Statistical and Economic Research, University of Ghana, 123 pp.

[23] ISSER, (2012). The State of the Ghanaian Economy, 2011. Institute of Statistical and Economic Research, University of Ghana, 147 pp.

[24] Jonfia-Essien, W. A. (2004). Cocoa storage in Ghana. In: Hodges, R. J. and Farrell, G. (eds.). Crop Postharvest: Science and Technology, vol. 2. Durables, Blackwell Science Ltd, UK, 274 pp.

[25] Marcella, V. 2007. "Drivers of cocoa production growth in Ghana.

[26] MoFA, 2010. Production of major crops in Ghana, PPMED, Accra, 12 pp.

[27] MoFA, 2011. Ministry of Food and Agriculture Report, Accra, Ghana.

[28] Ntiamoah, A. and Afrane, G. (2008). Environmental impacts of cocoa production and processing in Ghana: life cycle assessment approach. Journal of Cleaner Production 16, 1735-1740.

[29] Obeng-Ofori, D. (2008). Major Stored Product Arthropod Pest In: Cornelius, E. W. and Obeng Ofori, D. (eds.). Post-Harvest Science and Technology, Smartline Publishing Limited, Accra, pp. 67-91.

[30] Obeng- Ofori, D. (2010). Residual insecticides, inert dusts and botanicals for the protection of durable stored products against pest infestation in developing countries. Proceedings of the 10th International Working Conference on Stored Product Protection, Portugal, pp.773-787.

[31] Panni, J. 2012. Some Post Harvest Issues in Ghana. Ministry of Food and Agriculture (MOFA) Ghana, Workshop Report, Accra, Ghana.

[32] Regional Director, COCOBOD, Sunyani, (Pers. Comm)

[33] SRID MOFA. (2010). Facts and Figures. Ministry of Food and Agriculture, Statistics, Research and Information Directorate 2009, pp. 14-37.

[34] Tweneboah, C. K. (2000). Modern Agriculture in the Tropics. Co-Wood Publishers, pp. 318-362.

[35] Weisburger, J. H. (2001). Chemo protective effects of cocoa polyphenols on chronic diseases. Experimental Biology and Medicine 226, 891-897.

[36] "Supply Chain Risk Assessment: Cocoa in Ghana". Forum for Agricultural Risk Management in Development. .https://www.agriskmanagementforum.org/doc/supply-chain-risk-assessment-cocoa-ghana

[37] http://www.cocoafarming.org.uk/ Cocoa_farming_bw_v8_uk.pdf

APPENDIX - 1

Pictures of Fermentation and drying of Cocoa:

Plate: 1. Heap of fresh beans on plantain leaves and covered heaps for fermentation

Plate 2: Basket fermentation

Plate 3: Examples of box fermentation

Plate 4: Tray fermentation

Plate 6: Sun drying of cocoa beans