CHARACTERIZATION OF SMALLHOLDER PINEAPPLE PRODUCTION SYSTEMS IN GHANA AND EXPERT-BASED PERSPECTIVE ON VALUE CHAIN DEVELOPMENTS

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CHARACTERIZATION OF SMALLHOLDER PINEAPPLE PRODUCTION SYSTEMS IN GHANA AND EXPERT-BASED PERSPECTIVE ON VALUE CHAIN DEVELOPMENTS

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Preface

This is a final report in fulfilment of a master of science thesis research carried out in Ghana with support from Wageningen University. This research has been commissioned by Farming System Ecology Group, department of Plant Science of Wageningen University in The Netherlands. This research was conducted in Ghana on smallholder pineapple farms in characterization of their production systems and expert-based perspective on value chain developments.

I will like to thank my supervisor Johannes Scholberg for his diligent support on this work. Furthermore, thanks to Stephanie Alvarez for the assistance in analysing the field data and Hennie Halm in analysing the soil samples.

I acknowledge the help of all individuals and companies that helped with this study by providing relevant information, especially Mawuli Agboka, regional and district directors, and field extension staff of Ministry of Food and Agriculture. Many thanks also goes to institutions such as Agro-Eco Louis Bolk Institute Ghana, Sea-Freight Pineapple Exporters of Ghana (SPEG), Gold Coast Fruits Limited Ghana, HPW Fresh and Dry Limited Ghana, Blue Skies Ghana, PEELCO Limited Ghana, and smallholder farmer cooperatives for their support in making this project a success.

Executive summary

Pineapples in Ghana are mainly cultivated by smallholder farmers. Its export was estimated to have contributed to more than sixty percent of the value of Ghana's non-traditional exports thus generating approximately twenty thousand jobs. Current trend in production indicates a decline in number of smallholder farmers cultivating pineapple, yield and exports. The aim of this research is to characterise smallholder farms and identify the main reasons for decline in pineapple production and marketing in Ghana. Three regions namely Central, Eastern and Volta were chosen for the study. Ninety smallholder pineapple farmers (thirty from each region) were randomly sampled using information provided by various pineapple cooperatives in each study location. Processing companies, staffs from both government and private companies were interviewed. Qualitative and quantitative approaches were used to generate data. Characterization of the existing smallholder pineapple farming systems in the field was based on quantitative assessment of the underlying components for biophysical and socio-economic factors. Monthly rainfall and temperature data for a period of 10 years were collected from the three regional meteorological stations. 30 composite soil samples weighing 300 g each for the top 30 cm of the soil profile from selected farms within the three regions were collected, air-dried and analysed for soil pH and percent organic matter at Wageningen University. To characterize the pineapple farming system diversity in the study area a farm typology was built using multivariate analysis, and in particular a Principal Component Analysis (PCA) followed by a Hierarchical Agglomerative Clustering (HAC). The climate conditions in the study areas indicated that pineapple production is suitable as the study areas recorded an average temperature range between 26^{o}C to 30^{o}C and annual rainfall between 593.4 to 1528.5 mm with Central region showing high variabilities in the rainfall pattern. Optimal soil pH for pineapple cultivation was obtained within all the study areas. Aside Akatsi north, soils from the rest of the study areas contain a reasonable amount of soil organic matter ranging between 2.5 to 3.5%. There were differences in marketing outlets and regional farm gate prices between the three production regions. For Volta region, 100% of pineapple produced was sold in the local market at a price of 40p per fruit. Eastern region, 34% of producers transport their fruits to the local market whiles 66% supply to fruit processors at an average price of 50 and 57p, respectively. In Central region, fruits are sold in all destination points, with the export market taking 43% of the production volume at an average farm gate price of 48p. The local market and fruit processors on the other hand accounted for the remaining 28 and 29% with a corresponding price per fruit of 51 and 50p respectively. In terms of technical support and training, the Ministry of Food and Agriculture (MOFA) contributes to both capacities building by providing either technical support or management trainings. A total of 27% of farmers in the Central region had access to credit compared to 23% in the Eastern region while only 3% for Volta region. The first three Principal Component (PC) resulting from the (PCA) collectively explained about 63% of the total variability of the pineapple farming systems of the study area. The results of the (HAC) grouped the farms into five types: Type 1, farms with a high resources endowment and a high investment in

production; Type 2, farms with a medium+ resource endowment with low use of the fertilizer and fungicide; Type 3, farms with a medium resource endowment, high experience in pineapple and high labour cost; Type 4, farms with a medium-resource endowment, and quite intense use of fertilizer and fungicide but high level of postharvest losses ; and Type 5, farms with a the smallest resources endowment, a low investment in production but a high level of postharvest losses. The study also showed that, the declined in national production of pineapples was basically as a result of the global market wanting none of smooth cayenne variety but all of 'MD2' variety. Consequently, the patent rights place by Del Monte on the 'MD2' variety affected Ghana quest to replace the smooth cayenne with MD2 leading to slow progress of the industry. Other constraints affecting the industry includes loss of vigour of planting materials, effect of abiotic factors like intensity of radiation from the sun on fruits, and lack of laboratory facility for analysis of soil and pulp quality. Channels of support can be provided by stakeholders in a form of input provision, acquisition of GLOBAL GAP and FAIRTRADE certificates, establishment of quality control standards. The key factors governing the decline of production among the analysed farm types includes, high input cost for production especially for 'MD2' variety, high postharvest losses of fruits and lack of transport and distributions services to reach out to both local and global market. Access to credit and unfair price of fruits especially at the local market are also contributing factors to decline in production. This work also established that, farm types differ among smallholder farms, in areas of production inputs, production condition and gross income. Resource use and management by the various farm types depends on type of crop under cultivation, existing local conditions in terms of access to credit and market opportunities. Government policy on service provision to the smallholder falls short on regulations and certification.

1. INTRODUCTION

1.1 Pineapple (Historic, Botanical, and nutritional aspects)

Pineapple (*Ananas comosus* L.) originated from southern Brazil and Paraguay and was domesticated by the Indians who carried it through Central America to Mexico and the West Indies long before the arrival of the Europeans (Morton, 1987). In the early 16th Century, the Spaniards introduced the fruit to the Philippines. In 1548, the fruit spread to India and the East and West coasts of Africa through trading activities of the Portuguese (Morton, 1987).

Pineapple is a tropical crop which belongs to the family Bromeliaceae. It is an herbaceous perennial plant that can measure up to 1.8 m high and 1.5 m in diameter. The leaves are sessile and whorled around the stem and can number up to 80. Its length reaches up to 100 cm and a diameter of 7 cm. The leaves tapers towards the tip and end in a sharp point (Crane, 2009). The stem is short and thick with maximum length of 35 cm. its diameter range between 5.5 – 7 cm and it is completely concealed by the leaves. It has two sets of adventitious roots; one is underground and the other is aerial (Morton, 1987). When developing fruit, it produces 200 flowers and even more for some cultivars. The flowers joined together as fruit which develops on a peduncle. It shoots are in different forms such as suckers, hapa, slips and crowns (Crane, 2009).

Pineapples are consumed as fresh cuts, cooked, juiced and dried (Jennylynd and Tipvanna, 2010). Fresh pineapple is an excellent source of antioxidant vitamin; vitamin C. 100 g fruit contains 47.8 or 80% of this vitamin and 50 calories which is equivalent to apples. Regular consumption of foods rich in vitamin C helps the body protect from scurvy; develop resistance against infectious agents (boosts immunity) and scavenge harmful, pro-inflammatory free radicals from the body. It also contains small amount Vitamin A (provides 58 IU per 100 g) and beta-carotene levels. Vitamin A is also required maintaining healthy mucus membranes, skin and essential for vision www.nutrition-and-you.com

1.2 Pineapple production in Ghana

According to Maxwell et al., (1998), pineapples have been grown for a long time in Samsam, mostly on a very small-scale basis, using traditional methods. Samsam is a small village in the Greater Accra region believed by many as the first to commence production of the crop. Commercial production of the crop started in the 1980s. Ghana‘s pineapple industry was largely supported by small-scale production systems (Danielou and Ravry, 2005). Its establishment served two main purposes – first, to complement the nations export portfolio which was facing declines in revenue generation; and secondly, to improve on the livelihood of rural farmers. Daniel and Ravry, (2005), noted that the success of Ghana‘s pineapple industry in the early 1990s was as a result of comparative advantages the local industry had over its major competitors. The market position and comparatively low airfreight cost were the advantages. Until the introduction of the ‘MD2’, smallholders were the main suppliers of

pineapples to the export market (Takane, 2004). The switch, by European consumers and supermarket chains undermined the cost advantage and competiveness of Ghana's smooth cayenne, thus resulting in declines in pineapple exports. Takane, (2004), indicated in his report that, the most affected players in the industry were the small-scale farmers who were the majority and largest suppliers of smooth cayenne to the export market.

1.2.1 Production trends

The pineapple industry has been the most developed horticultural sector in Ghana and is mostly concentrated in the Greater Accra, Eastern, Central, Western and Volta regions (Dadzie, 2008). As indicated by circles and arrow in Fig.1.

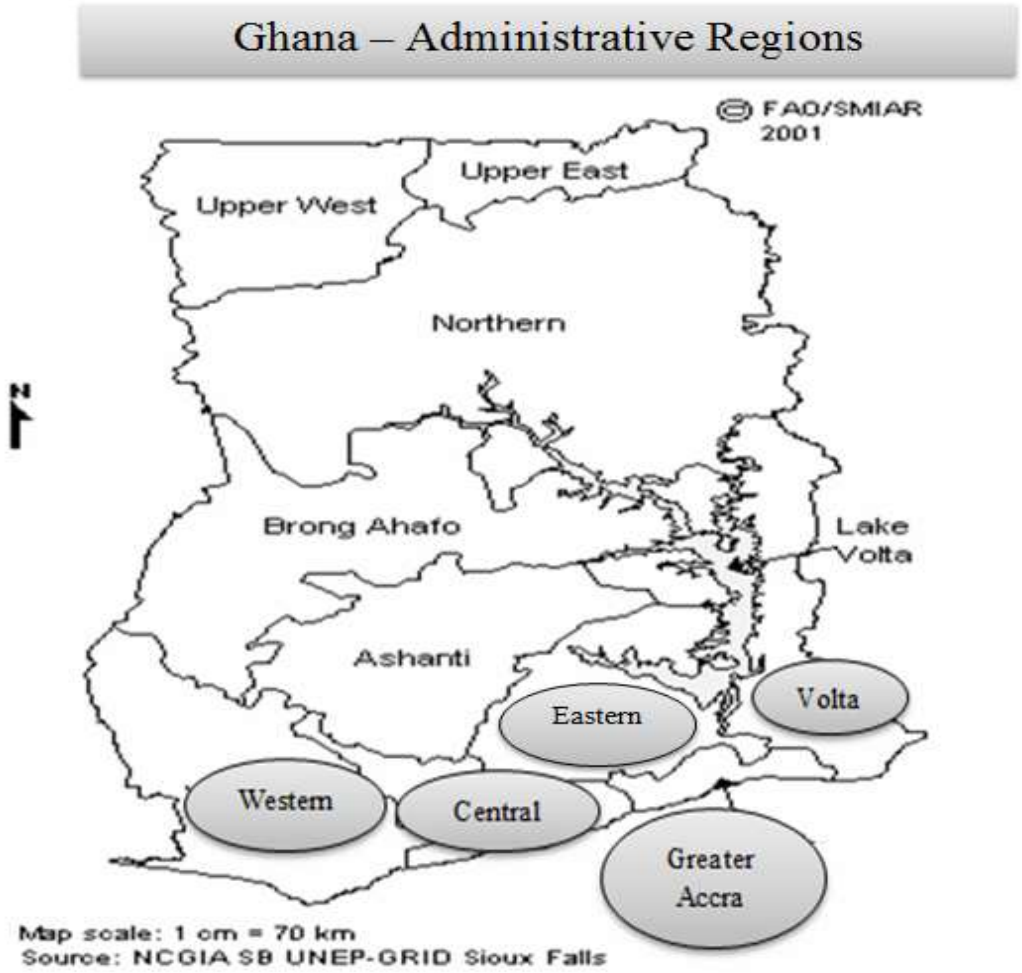

Figure 1: Pineapple producing regions in Ghana

In 2004, pineapple export was estimated to have contributed to more than 60% of the value of Ghana's non-traditional exports thus generating approximately 20,000 jobs and an estimated rural income of US$ 3.3 million thereby supporting 2,500 households in rural

communities (Kuwornu et al., 2013). In 2004, the total volume of pineapple imported into the European Union (EU) was about 400,000 tonnes, a 54% increase from 1997 while Ghana's export to EU accounted only for 70,000 tonnes (Danielou and Ravry, 2005). Pineapples in Ghana are mainly cultivated by smallholder farmers that cultivate less than 5 ha (Danielou and Ravry, 2005; Murray, 2010). According to Ghana Living Standards Survey, in 2009 a total of 170,627 households, which translates to 2% of all households in Ghana, produce pineapple. Ghana's pineapple production is estimated between 120,000 - 150,000 tons annually. Currently, the country only exports about 35,000 tons of pineapple per year http://agricinghana.com

Globally 'MD2' has become the predominant pineapple cultivar for most pineapple farmers producing for fresh export markets worldwide. Costa Rica is one of the most important producers and exporters of 'MD2', and many growers in this country have switched to this cultivar (FAO- Statistics, 2010; U.S. Department of Agriculture, 2008). The market for fruits in Europe is mainly defined by the supermarkets and retailers, which have huge leverage and influence over what is being produced and sold. Tesco, Marks and Spencer and the other food chains in Europe have been demanding 'MD2', which is the most important variety for export production in Costa Rica. This variety has completely displaced smooth cayenne, which was historically commonly grown in Ghana and many other regions. As a result, pineapple producers in most commercial production regions were forced to cultivate 'MD2' in order to be able to meet the export market (developeconomies.com). Also in Ghana, 'MD2' was introduced in the country in the late 1990s. However after its introduction many producers (mainly smallholders) were unable to successfully shift to 'MD2' production due to lack of access to financial resources needed for external inputs such as planting materials, agrochemicals and fertilizers moreover, most farmers lacked technical training on appropriate use of such new agricultural practices. This market-impose transition to intensified production had a negative impact on the overall pineapple production system in Ghana. As a result, starting 2004 the export volumes of pineapple produced in Ghana started to decline (Fig. 2). This was attributed to 'MD2' being more costly to produce and being poorly adapted to local pedoclimatic conditions in Ghana thus requiring higher external inputs. For smallholders and commercial farmers alike, it is more expensive to cultivate 'MD2' than it is of smooth cayenne and sugar loaf. However, it is unclear why there was also a decline in production of the traditionally grown pineapple cultivars in Ghana. Further characterisation of smallholder farms in aspects of production and marketing dynamics has not much been exploited. From a policy perspective, there is a lack of understanding regarding what measures may be needed to reverse this trend to increase market share of Ghana and its contribution to global pineapple production.

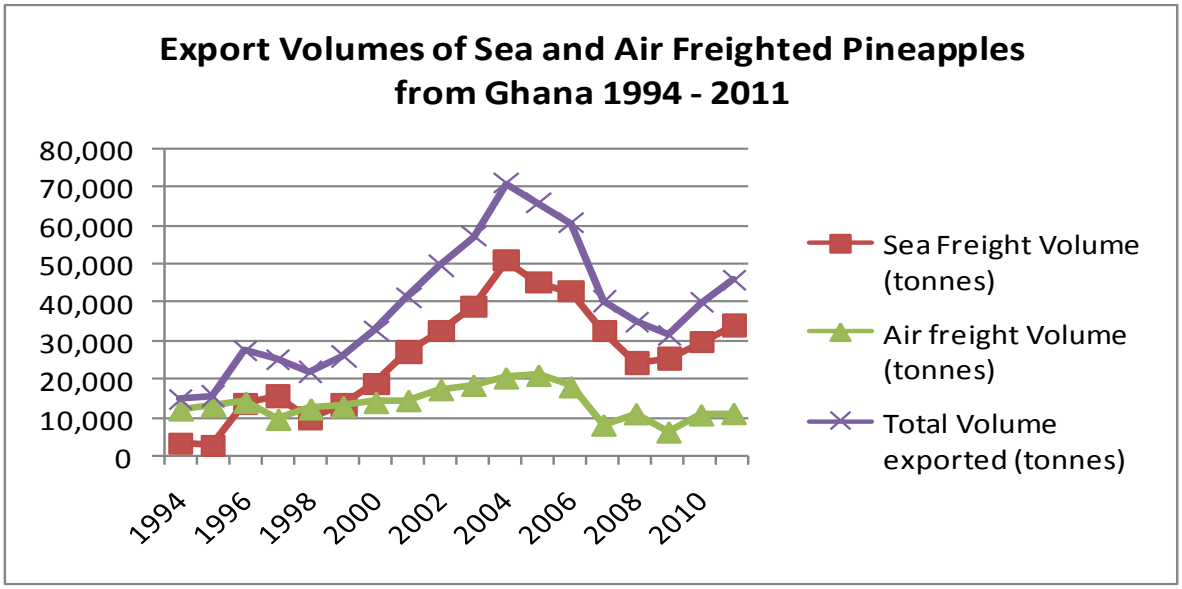

Figure 2: Export trend of pineapples produced in Ghana (SPEG, 2012).

1.2.2 Agronomic aspects

There are three main types of pineapple grown in Ghana. Sugarloaf (SL) is conical in shape and very sweet, and only sold in the local market. Smooth cayenne (SC) is a sweet, juicy variety that lacks bright yellow colour. It initially had high export value but is now only sold at the local market and processing factories. 'MD2' is a variety that was introduced by Del Monte in Costa Rica, and, though not the best for making juice, it is aesthetically-pleasing (more yellow than smooth cayenne), and complies better with consumers preferences in the United Kingdom (Fold and Gough, 2008). Also, it is a little more square-shaped than smooth cayenne, so it sits on the supermarket shelf better, as compared to the other cultivars, making it more suitable for the export market (developeconomies.com). Better shelf-life, due to its low acidity, is another favourable attribute of the 'MD2' variety (SPEG, 2012). Table 1 provides general descriptive characteristics of major pineapple cultivars produced in Ghana.

Table1: Characteristics of major pineapple cultivars produced in Ghana

Characteristics	*'MD2'*	*Smooth Cayenne (SC)*	*Sugar Loaf (SL)*
Leave	Spineless	Spineless except at base and tip	Leaves are smooth
Leave colour	Yellow-green with reddish tip	Dark green	Dark green
Suitable soil	Well drain loam soil	Well drain loam soil	Sand-clay-loam soil
Soil pH	5 – 6.5	5 – 6.5	5 – 6.5
Planting dist. (cm)	30*25*90	30*25*90	30*25*90
Major disease	Phytophthora	Wilt	Wilt
Fruit Wt. (Kg)	1.3 - 2.5	2.3 - 4	2.3 – 2.7
Shape	Cylindrical	Ovoid shape	Conical
Colour of Skin	Orange yellow	Yellow	Green
Colour of Flesh	Gold/yellow	Pale yellow	Cream white
Taste (Brix %)	15 - 17 with high sugar and low acidity	13 - 19 with high sugar and acid	15 – 17 with high sugar and low acidity

Source: Adapted from Siddiq, 2012

1.3 Research scope

1.3.1 General goals and program structure

The aim of this research is to characterise smallholder farms and contribute to sustainable production of pineapple through enhanced understanding of factors governing production and marketing of pineapples produced by smallholder farmers in Ghana. Additionally it is expected to generate knowledge that can help support local development and increase the market share of Ghana to global market demands for pineapple. This research focused on community profiling of major and potential pineapple cultivating areas in Ghana. Biophysical factors such as climatic data, soil conditions, farming systems characteristics at the study locations served as parameters to describe the existing smallholder farming system. Socio-economic drivers and its effects on livelihood, including marketing of produce both on local and global scale, local policies and institutional safety nets (interventions by private organizations) was also described. A farm survey targeting the main production regions aimed to capture resource endowment and prevailing management practices. This information was used to develop farming system typology based on farm size, use of external inputs, production levels, and marketing mechanisms within the pineapple belt in Ghana. The outcome provided more in-depth perspective on existing smallholder farming systems and a more detailed assessment of sustainability of specific farms as related to resource management practices. Exploring existing Farmer Base Organisation (FBO) impacts

on production, capacity building, quality control, standards for marketing and processing for both local and export market enhanced local production and addressed regional and global market requirements. A schematic diagram was used to structure a conceptual framework similar to DEED approach (Giller et al., 2008) as shown in Fig. 3. This approach helped in understanding the trend in resource use and management by smallholder farms. It provided a clear and predictive knowledge about the functioning of smallholder pineapple production systems that would allow for rational policy interventions. It also ensured more interactive ways of working with smallholder pineapple farmers.

The main focus of this thesis was on the ''DESCRIBE'' component with special reference to development of a farm typology, local policies as part of an initial market analysis based on interviews of key informants and local experts.

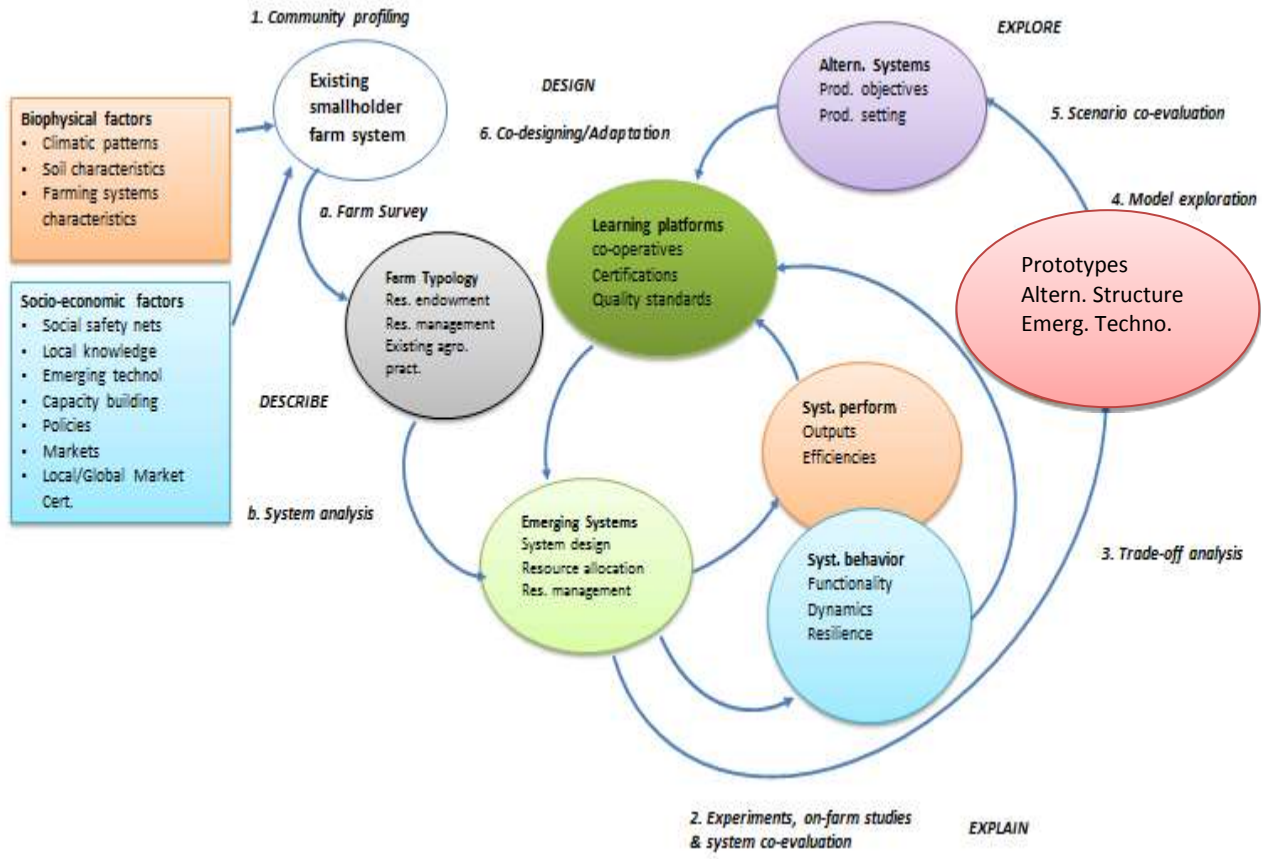

Figure 3. Conceptual framework

1.3.2 Research Objectives

The overall research objective was to characterise smallholder farms and to identify the key factors governing the decline in pineapple production as related to production and marketing components of the value chain. In addition to this, the study also assessed the extent at which Ghana Agricultural policy affects smallholder pineapple production.

1.3.3 Research Questions

This research addresses the following questions.

1. What are the characteristics of current pineapple production systems in Ghana?
2. What are the main difference in agronomic practices, input requirements and cropping system performance between 'MD2' and other cultivars?
3. What are the main production constraints that different farm types face?
4. What are the production and marketing niches for pineapple produced in Ghana?
5. What technical, policy and marketing interventions are needed to increase pineapple production and utilization?

1.3.4 Research hypothesis

- There are differences between smallholder farming systems based on land tenure system and access to capital.
- Required production inputs and production condition differ among farm types while actual production conditions govern yield variability and system performance.
- (S)low acceptance of 'MD2' variety during its introduction couple with changing global market demands cause declined national production.
- This decline in national production may have resulted from required change from smooth cayenne to 'MD2' driven by market demands coinciding with lack of required support.

1.5 Structure of the Thesis

This research consists of six chapters. Chapter one includes a brief introduction and background of the problem making clear the need to carry out this work including knowledge gaps, research scope, research questions and corresponding hypothesis. Chapter two also provides a detailed overview of materials and methods employed to address the research questions and test hypothesis. Chapter three presents the outcome of the farm characterisation which also includes basic soil and climatic characteristics along with a farm typology for pineapple-based smallholder farming systems. The impact of local and global agricultural policy and governing market forces are being outlined in chapter four. Chapter five includes a general discussion and puts the research in perspective of other related report and ends with a synthesis aiming to integrate key system components. The last chapter contains overall conclusions drawn from the research and provides recommendations for future studies and/or projects.

2. MATERIALS AND METHODS

2.1 Study location

Three regions namely Central, Eastern and Volta were chosen for the study. The choice of these regions was based on their principal involvement in pineapple production in Ghana and the potential for Volta region to increase its production of pineapples. Specifically, smallholder farmers were interviewed for the survey from the following districts; Gomoa East, Ewutu-Senya all in Central region, Akwapim South in Eastern region, Akatsi North and Kpando districts from the Volta region. In these locations respondents were either directly or indirectly involved in pineapple production except Kpando district which has other smallholder farmers engaged in other intensive farming activities like vegetable production. Each of these districts also has processing factories. However, Kingdom fruits limited a processing factory in Kpando district was not actively engaged in pineapple processing during the period of study.

2.2 Sampling size

Although a large percentage of the inhabitants in selected districts from the study location were smallholder pineapple farmers, a total of 90 smallholder pineapple farmers (30) from each region were randomly sampled using information provided by various pineapple cooperatives in each study location. Sampling of the farmers was done to have adequate representation of farms from various farmer cooperative groups to avoid bias. Three processing companies namely HPW Fresh and Dry Limited, PEELCO Limited and Blue Skies Ghana and seven staff members from government and private companies including Sea-Freight Pineapple Exporters of Ghana (SPEG), Ministry of Food and Agriculture (MOFA), Gold Coast Fruits Limited Ghana, and some large-scale companies were interviewed. The names, positions, company details and duration of interviews can be found in appendix III. Gold coast fruits were included because it is a model farm that undertakes similar agronomic procedures and practices as in Costa Rica.

2.3 Administering of questionnaires and data collection

This research used both qualitative and quantitative approaches to generate data from the three major pineapple producing regions in Ghana. For smallholder pineapple farmers, a semi-structured survey questionnaires (Appendix I) was complemented with mixed (closed and open-ended) questions were administered using standard interview methods. All the responses from farmers recorded and converted to a digital format. Where necessary, focus group discussion methods were also used and responses recorded appropriately. In terms of interviews of local expert, representatives from processing companies, government agencies and private sector, were interviewed using structured open questions. The questions were relating to marketing, resource supporting services and policy measures and responses recorded with a digital recorder and further transcribed. Selected statements from the interviews were used to answer specific research questions and or hypothesis.

Characterization of the existing smallholder pineapple farming systems in the field was based on quantitative assessment of the underlying components for biophysical and socio-economic factors. For biophysical factors (soil organic matter content and soil pH), 30 composite soil samples weighing 300 g each for the top 30 cm of the soil profile from selected farms within the three regions were collected, air-dried and taken to Wageningen University for subsequent processing and laboratory analysis. The samples collected were taken from representative farms with one sample representing three (1-3) neighbouring fields of selected small farms that had similar soils. Hence soil samples taken from these farms represent 30 micro-regions for the entire smallholder farm population of 90 farmers that were interviewed.

Monthly rainfall and temperature data for a period of 10 years were collected from the three regional meteorological stations. However, average monthly temperature values for the Eastern region were not available. Rainfall and temperature data was analysed using excel spreadsheet and averaged values were used to generate Figures. This presented an overview of biophysical factors influencing the farming systems in the study area.

In terms of socio-economic factors, the market destination of pineapples and its corresponding farm-gate prices, access to credit and frequency of technical and management training pertaining to pineapple production was assessed. This took place through individual farm interviews conducted as part of the overall farm survey. Quantitative variables included in this survey were also used to develop a farm typology of study locations (cf. session 2.5).

For each farm the main cultivated cultivar was recorded, cultivar performance and perceived production constraints for cultivation of 'MD2', smooth cayenne and sugar loaf was being determined based on input use (e.g. labour, fertilizer, agrochemicals and other inputs) vs farm outputs.

The impacts of different production practices, marketing strategies and policy instruments from both governmental agencies and the private sector on smallholder pineapple farmer were assessed through semi-structured open question interviews of local experts and government officials.

2.4 Soil analysis

For soil pH analysis, a total of 12.0 g of air-dried soil was weighed and placed in glass containers to which 30 mls of distilled water was added. Samples were placed in a mechanical shaker for 2 hours. The samples were allowed to settle and the pH measured from the suspension using a pH meter (Brand: WTW inoLab, Type: pH/cond Level 1, electrode used: pH electrode Sen Tix 81, manufactured in Weilheim Germany). Determination of organic matter of the soil samples was based on the Loss on Ignition (LOI) method by gravimetrically weight losses after dry combustion of the organic material in a furnace at 500-550 °C. The observed loss in the weight gave an indication of the content of

organic matter in the sample. A crucible was heated for 1 hour in a drying oven at 105 °C. The hot empty crucible was weighed with an accuracy of 1 µg (A). Then precisely 5 g soil was weighed in the crucible (W). The crucible with soils samples were placed into the drying oven at 105 °C, for at least 8 hours. Then the hot crucible with the dried soil sample was weighed (B). After that the weighed crucibles were put in the furnace and the raise temperature gradually from room temperature to 550 °C. This temperature was maintained for at least 3 hours. Then the furnace was cooled off to about 150 °C. The crucible was placed in the drying oven at 105 °C for about 1 hour before being weighed to determine the weight losses due to combustion of carbon which is closely linked to total soil organic matter (C).

The dry matter content of the soil samples was calculated in % using the following formula:

$$\frac{W-B}{B-A} * 100\%$$

The % organic carbon content of the soil samples was calculated with the formula:

$$\frac{B-C}{B-A} * 100\%$$

2.5 Multivariate analysis and typology

In order to characterize the pineapple farming system diversity in the study area a farm typology was built using multivariate analysis, and in particular a Principal Component Analysis (PCA) followed by a Hierarchical Agglomerative Clustering (HAC). The PCA is used to analyze “interrelationships among a large number of variables and to explain these variables in terms of their common underlying dimensions” (i.e. principal components or PC). Thus PCA allowed to reduce the information contained in a large number of variables into a smaller set of variables (the first principal components) “with a minimal loss of information” (Hair et al., 2010). Data quality was assessed: missing values and potential errors or outliers were removed from the dataset for the PCA. The selected quantitative variables for the PCA are listed in Table 2. Information included was: size of pineapple fields, income, postharvest losses, and total cost of production, pineapple cultivation experience, and fraction of total production cost related to fertilizer, pesticide, fungicide and labour inputs. The data used to develop the farm typology was derived from interviews of the sampled farmers.

Table 2: Definition of variables used to develop a typology of smallholder pineapple farmers in Ghana

Variable	Variable code	Definition	Units
Land area for pineapple	psize	Area of land cultivated with pineapple	Acres
Years of cultivating pineapple	pexp	Pineapple cultivation experience	Years
Gross income	income	Gross income realised after pineapple production	Cedi
Postharvest losses	losses	Postharvest losses incurred after pineapple production	%
Total cost	totcost	Total production cost of producing an acre of pineapple	Cedi
Fertilizer cost ratio	fertratio	Share of the total production costs allocated to the fertilizer cost	-
Pesticide cost ratio	pestratio	Fraction of cost of pesticide and total production cost	-
Fungicide cost ratio	fungratio	Fraction of cost of fungicide and total production cost	-
Labour cost ratio	labouratio	Fraction of cost of Labour and total production cost	-

Source: From the survey

Subsequently, the farms were grouped into farm types using a Hierarchical Agglomerative Clustering (HAC), in which the first principal components of the PCA were used as input variables. The HAC progressively grouped the farms according to their resemblance, via a dissimilarity index called Height (Fig. 6). "At each step, the algorithm grouped the farms into pairs by selecting the individuals with minimum dissimilarity" (Blazy et al., 2009). Categorisation of farms although provides means of comparisons, its main challenge is related to the complexity of socio-economic component. The Ward's minimum-variance method was used on the HAC to aggregate the farms together. The interpretation of the farm types was based on the PCA results (Figure 7) and supported by the mean and standard error calculations (Table 6 and Fig. 8.) for each group of farms. A total of 76 farms were used in the analysis. The statistical analyses were performed with the software R version 3.0 (R Development Core Team, 2008) using the multivariate analysis package ade4.

3. RESULTS AND DISCUSSION

This section is structured in four major components. The first outlines the biophysical production factors governing pineapple production. The second part focuses on key socioeconomic driver factors which are followed by a typology of the key farm types in the study region. In the last section the impact of policies and global markets on pineapple value are being described.

3.1 The biophysical factors affecting pineapple production in the study area

3.1.1 Local climate: rainfall and temperature

Temperature and rainfall patterns for the three pineapple production regions are presented in Fig. 4 and 5. Based on these Figures the highest air temperatures occurred during the driest months (November to February). Maximum average air temperatures were recorded in February for Central and Volta region. In terms of average monthly rainfall amounts, values in June were highest (195 mm) whereas in January, the average rainfall amount was only 11 mm (Fig. 4). Considering the rainfall pattern and distribution, Volta and Eastern region had a reasonable even distribution of rainfall within the year while the Central region showed greater variability (Fig. 4). The limitation of using monthly rainfall pattern to make inform decisions in aspects of trends on rainfall amount is further explained in Fig. 5.

The effect of climate conditions such as temperature and rainfall on pineapple production especially in the tropics is very significant as a temperature range of 18 ^{o}C to 32 ^{o}C has been considered to be the most favourable for the cultivation of pineapple (Bartholomew et al., 2003). In addition to this, an ideal annual rainfall range of 1000 to 1500 mm is usually required for pineapple cultivation in the tropics especially under rain-fed conditions. The climate conditions in the study area therefore indicate that pineapple production in all the study areas seems suitable as the study area had a temperature range of 26 ^{o}C to 30 ^{o}C. Again it is considered that tropical countries are most suitable for pineapple cultivation especially in regions with adequate water availability. Even though there were variations in rainfall pattern especially in Central region as shown in Fig. 5, the rainfall distribution in all the study areas could support the cultivation of pineapple. However this rainfall irregularity in the regions may produce a delay in some phenological stages of the pineapple plant which may result in the reduction of fruit production (Bartholomew et al., 2003). It is therefore important for farmers to start considering the incorporation of appropriate irrigation practice to the production system of pineapple in the study areas.

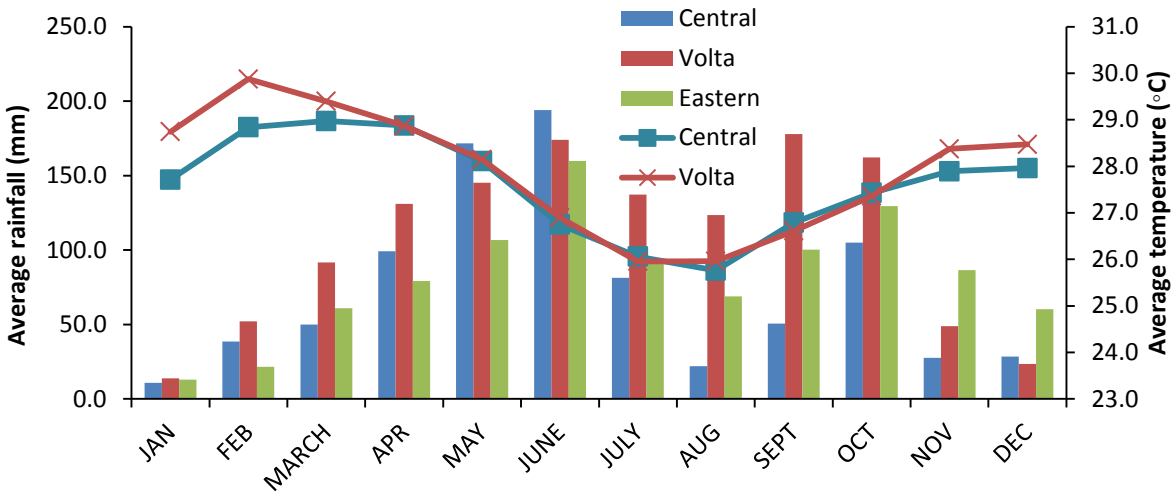

Figure 4. Average monthly rainfall and mean temperature distributions in the study area (Central, Volta and Eastern regions) in Ghana. The bar graphs represent average rainfall distributions in all the regions and line graphs represent the mean air temperature for two regions (Central and Volta regions). Mean air temperatures for Eastern region were not available**.**

Cumulative rainfall pattern over the last 10 years in the central region have shown a decline beginning from 2011. The lowest amount of rain (593.4 mm) was recorded in 2013. Although all the other regions experienced a decline within that same year, the drop in rainfall amount in the Central and Volta region was more pronounced compared to Eastern region. Subsequently, the rainfall trend among the three regions was not evenly distributed within the 10 year period with central region showing the highest variability as shown in Fig. 5. Although climate conditions seem suitable, it is also important to consider soil and other input requirements during cultivation to obtain better yield.

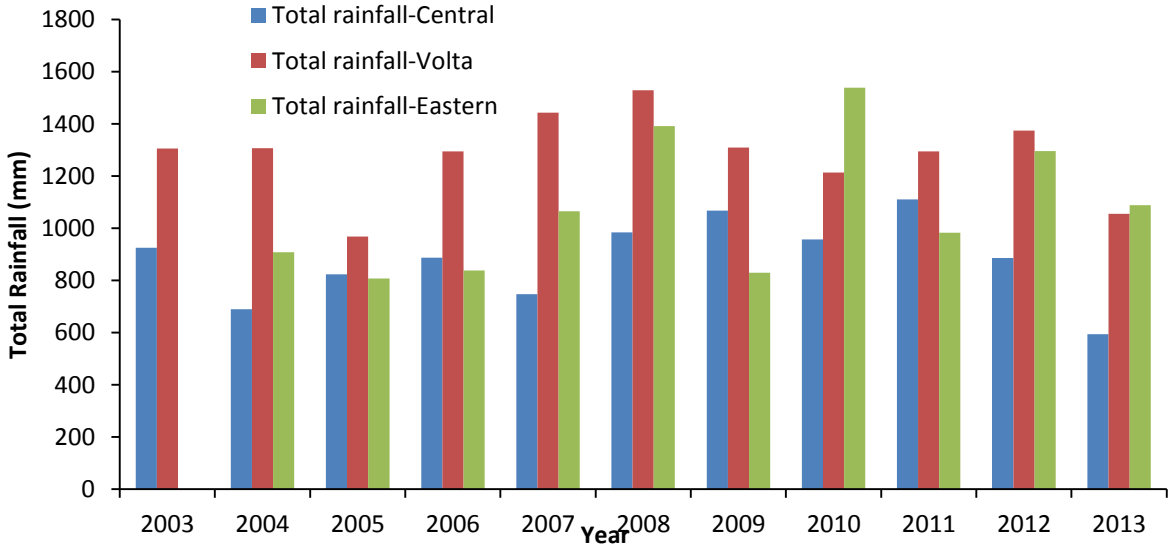

Figure 5. Cumulative rainfall amounts for a 10 years period within the study areas.

3.1.2 Soil characteristics for the study area

Soil organic matter content in the study area showed that organic matter content for soils in Kpando district was the highest (3.5%) with Akatsi North having the lowest organic matter content of 1.6%. Soils from Eastern and Central region recorded organic matter content of 2.5 and 2.9% respectively (Table 3). Soil pH for the study area ranged from 4.9 to 6.6 as depicted in Table 3.

Optimal soil pH for pineapple cultivation was obtained within all the study areas justifying their continuous cultivation of the crop till present. According to Goldstein and Udry, (1999), pineapples are planted on soils which are acidic, and perhaps on soils with a lower content of organic matter. However, soils from the Akatsi north in the Volta region recorded very low organic matter content which may require appropriate fertilization methods to improve yields and quality of pineapple in the district. Aside Akatsi north, soils from the rest of the study areas seems to contain a reasonable or an ideal amount of soil organic matter ranging from 2.5 to 3.5% which could support the cultivation of pineapple. The lower amounts of soil organic matter content in the Akatsi north may be attributed to the fact that the soils in the area are mainly sandy soils while inputs of organic materials for soil fertility improvements by farmers in the district are limited. Further, the textural class of sandy loam, sandy loam with clay at valley bottom and sand-clay loam for soils in Kpando, Akwapim South and Gomoa East respectively could be the reason which these regions had higher organic matter percentage (http://mofa.gov.gh). It has been observed that soil organic matter tends to increase with the percentage of clay fraction as it becomes protected against microbial degradation (Six et al., 2002).

Although the response of pineapples vary with locality, soil and climate, Abutiate and Eyeson, (1973), did a study with smooth cayenne and reported a high yield of pineapples for nitrogen and potassium applications while excessive nitrogen reduced the total soluble solids. It is therefore appropriate that for a higher yield of pineapple in Ghana, farmers need to use the required level of plant nutrients per each locality. Alternatively farmers in Akatsi could focus on the cultivation less nutrient requirement varieties like sugar loaf and smooth cayenne as to 'MD2'. As yield variability in this context is been govern by soil condition and or characteristics.

Table 3: Mean percentage organic matter and soil pH of study locations at district level with means followed by standard error values (n=30)

Soil characteristics	*Volta region*		*Eastern region*	*Central region*
	Akatsi North	*Kpando*	*Akwapim South*	*Gomoa East*
Soil organic matter (%)	1.6 ± 0.02	3.5 ± 0.03	2.5 ± 0.03	2.9 ± 0.06
Soil pH	5.6 ± 0.08	5.8 ± 0.03	4.9 ± 0.18	6.6 ± 0.21

Source: From the survey

3.2 Key socioeconomic factors governing pineapple production.

Differences in marketing outlets and regional farm gate prices between the three production regions are outlined in Table 4. There were key differences in terms of destination of pineapples. In the Volta region, 100% of the locally produced pineapple was sold in the local market at a price of 40p per fruit. However, in the Eastern region 34% of the producers transported their fruits to the local market and 66% supplied their produce to fruit processors at an average price of 50 and 57p, respectively. In Central region, fruits are sold in all destination points, with the export market taking 43% of the production volume at an average farm gate price of 48p. The local market and fruit processors on the other hand accounted for the remaining 28 and 29% with a corresponding price per fruit of 51 and 50p, respectively (Table 4).

The lack of processing factories and exporters in the Volta region could be the reason for limited marketing opportunities for smallholder farmers in the region which could also cause lower profit margins for farmers. A strategic study on horticultural exports from Ghana by the World Bank in 2011 showed that smallholder access to domestic market opportunities could be improved if grades and standards of fruit quality are adopted as this could easily influence prices of fruits at the farm gate and retailing in general. Although fresh pineapple fruit exporters exist in Eastern region, their level of dependence for fruits from smallholders in study locations surveyed is low. Therefore, the majority of farmers are depending on fruit processors and local market. This could be due to the low price that is being offered by fruits exporters. Again the only fruit exporting company for smallholder farmers called FARMAPINE is no longer in operation hence allowing them to shift their produce to fruit processors and local market which offer quite fair price for fruits produced.

In the case of Central region there is a ready market for exporting of fruits although prices tend to be low, this could be because farmers receive support for external inputs to facilitate production. However, fruit price for local market and processing industry is much better. This goes to strengthen the argument that a well-structured local market can improve the smallholder farmers' level income.

Table 4: Shows fruits destination and average price per fruit in study regions with means followed by standard error values (n=30)

Socio-economic factors	*Volta region*	*Eastern region*		*Central region*		
Destination	*LM*	*LM*	*P*	*LM*	*P*	*E*
% Destination of Fruits	100 ± 0.0	34 ± 6.10	66 ± 6.20	28 ± 0.10	29 ± 0.10	43 ± 0.10
Average price per fruit (pesewas (p))	40 ± 0.02	50 ± 2.1	57 ± 0.70	51 ± 0.00	50 ± 0.00	48 ± 0.00

LM = Local Market; P =Fruit Processor; E = Fruit Exporter

Source: From the survey

In terms of technical support and training, the Ministry of Food and Agriculture (MOFA) contributes to both capacities building in terms of providing both technical support or management trainings. It was observed that 93% of farmers received some form of training in the Eastern and Central region compared to 87% of famers in the Volta region. However, access to farm credit in all the three regions was low. A total of 27% of farmers in the Central region had access to credit compared to 23% in the Eastern region while only 3% of the interviewed farmers in the Volta region had access to farm credit (Table 5).

Training for Smallholder farmers in Central and Eastern region were high because, commercialisation of pineapple began much earlier in these areas compared to Volta region which was only identified as a potential region for pineapple cultivation rather recent. Similarly, access to credit is low in the Volta region because the majority of the farmers have small land sizes under cultivation and the banks see it as higher risk without any security for re-payment of loans if fruits are loss. Secondly, most farmers access loans as individuals and have low production levels so it will be better if they could access the loans as groups since this can encourage the provision of better loan facility. Access to credit will help increase land area under cultivation, encouraging farm maintenance leading to improve crop productivity and subsequently improve fruit quality.

Much effort by MOFA has been spent on providing smallholder farmers with training and agronomic advices as this could translate into improvement production. However, these trainings do not include on topics such as enforcement of regulations, certification standards and research on improving the existing planting materials and establishment of laboratories for soil analysis, pulp analysis and 'D' leaf analysis.

Table 5: Institutional support for smallholder pineapple farmers in study regions with means followed by standard error values (n=30).

	Volta region		***Eastern region***		***Central region***	
Responses	Yes	No	Yes	No	Yes	No
Training %	87 ± 0.06	13 ± 0.06	93 ± 0.00	7 ± 0.00	93 ± 0.00	7 ± 0.00
Access to credit %	3 ± 0.03	97 ± 0.03	23 ± 7.90	77 ± 7.90	27 ± 0.10	73 ± 0.10

Source: From the survey

3.3 Typology results

Based on the results of the Hierarchical Agglomerative Clustering (HAC) there appears to be five main farm types or cluster (Fig. 6). The outcome showed that type 3 and 4 branched out further at a slightly lower level of dissimilarity (Fig. 6). Types 3 and 4 are more similar to each other compared to types 1, 2 and 5. Farm type 1 and 5 within the cluster stands out the most whereas types 2 and 3 are also somewhat similar. From the results, the majority of the smallholder farmers in farm type 3 and 4 share similar production characteristics for all the variables tested while Farm type 1 and 5 have distinctively less chance of sharing common production characteristics. This also implies that some key factors affecting the decline in production and its related marketing components among all the farm types should fall within similarity groups. As quoted by Vanwindekens, (2014), "the complexity of the social components of farming systems taken into account by functional typologies is usually limited to issues, such as farmers' general objectives, strategic choices and farm history". Invariably categorisation of farms although providing means of comparisons across farm types, the main challenge is related to the complexity of socio-economic components which are influenced by the choices and objectives of the farmer.

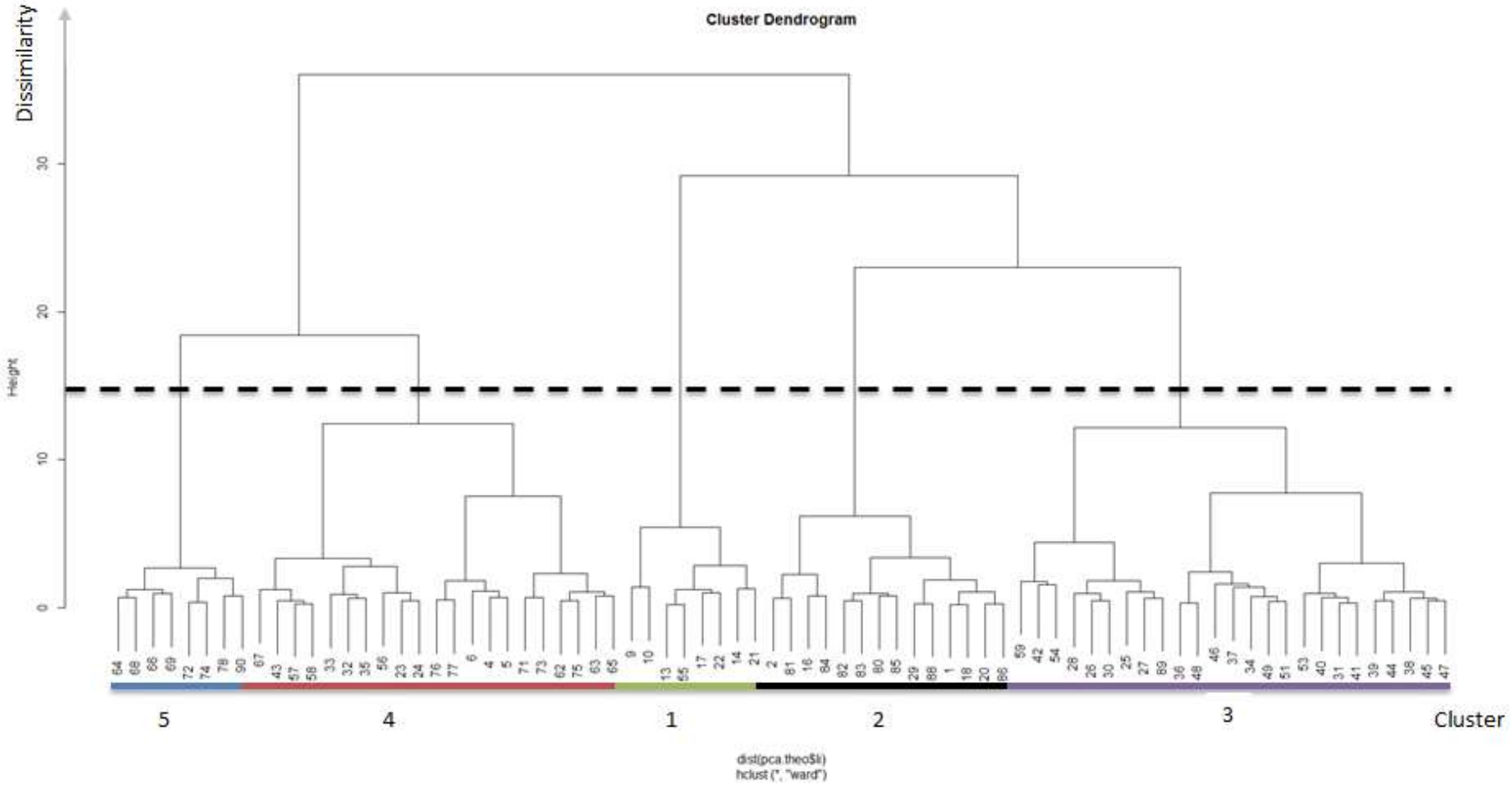

Figure 6: Classification tree or dendrogram of farm types obtained from the Hierarchical Agglomerative Clustering; the black line (Height about 15 here) shows the potential cutting point resulting in five distinct clusters.

3.3.1 Principal Component Analysis results: variables correlations

The Principal Component Analysis (PCA) allowed us to select the first three principal components (PC) of the PCA, which collectively explained about 63% (Fig. 7a and b) of the total variability of the dataset. The plane defined by the first two principal components (PC1 and PC2) explained about 47% of the variability of pineapple farming system of the study areas (Fig. 7a). The correlation circles in Fig. 7 are showing relationships among significant variables analyzed and their underlying dimensions is described below.

- a negative correlation of the area cultivated to pineapple (*psize*), the gross income (*income*), the total cost (*totcost*) with the first principal component, PC1 (x-axis);
- a positive correlation on postharvest losses (*losses*) with PC1;
- a positive correlation of the share of labour in the total cost (*labouratio*) and pineapple cultivation experience (*pexp*) with PC2 (y-axis in Fig. 7a);
- a negative correlation of the use of fungicide (*fungratio*) and the use fertilizer (*fertratio*) with PC3 (y-axis in Fig. 7b);

This implies that PC1 categorised the structural aspects and resource endowment of the farms (cultivated area, income, total cost). The negative correlation between size of land cultivated with pineapple and the postharvest losses makes sense as large farms, with improved postharvest technology, experience lower fruit losses. Additionally, the correlation between total cost and gross income could mean that high resource investment farms invest more in the production (fertilizer, fungicide, plastic mulch, stumping, etc.) but they benefit also of a higher gross margin after production; so this investment seems sound since it generates adequate profits.

The positive correlation between the extent of cultivation experience and the share of labour in the total cost signifies that the more experience farmer tends to make more use of hired labour. This situation could arise in context of farms cultivating more than one type of pineapple variety.

Fungicide and fertilizer usage in cultivation of pineapple is strongly influence by the variety of pineapple under cultivation and their applications move in tandem with each other. Moreover, inputs requirements differ among cultivars. The ‘MD2’ cultivars requires higher fungicide and fertilizer applications whiles Smooth Cayenne and Sugar Loaf requires low resources investment on fungicide and fertilizer to produce quality fruits.

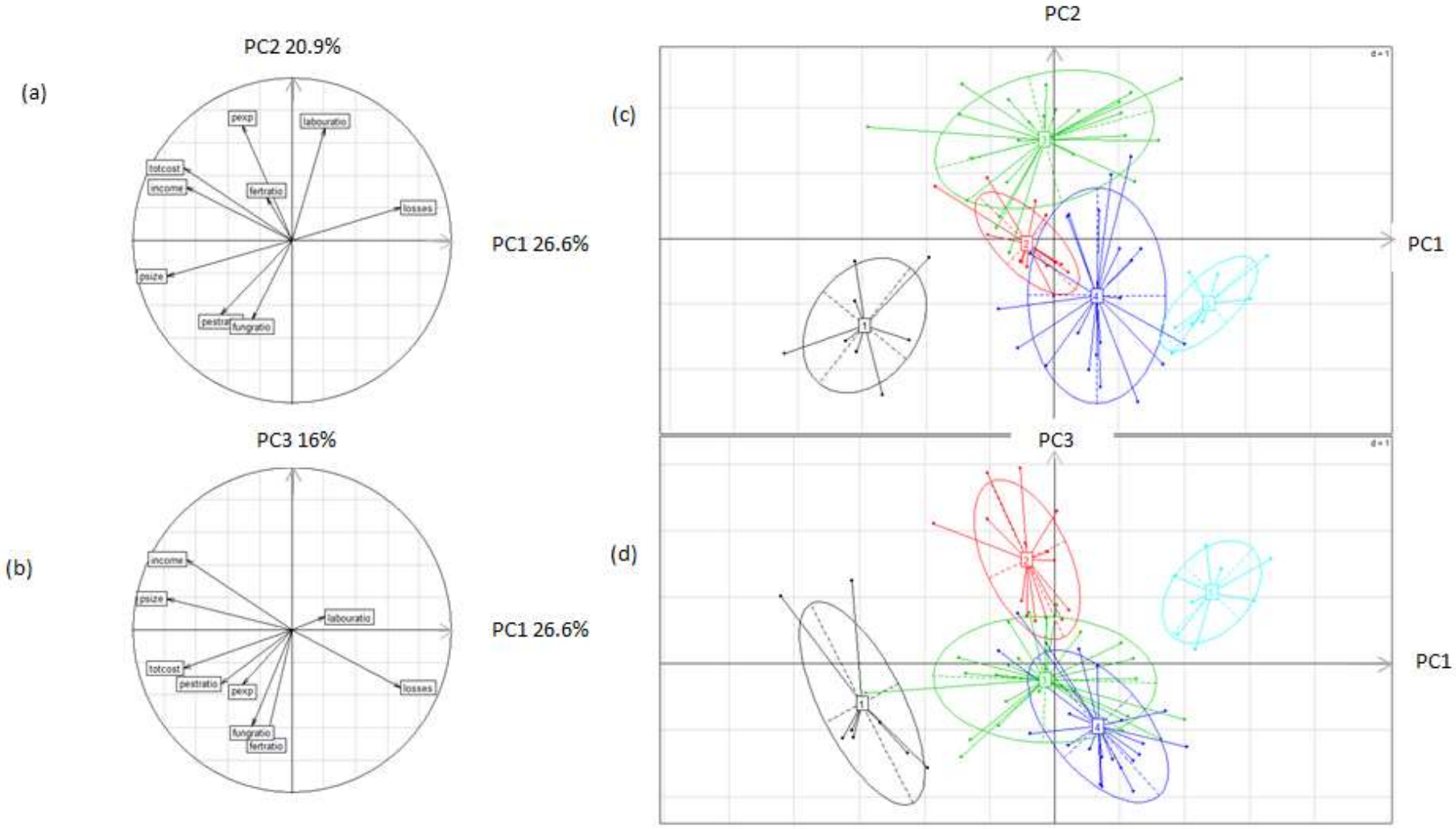

Figure 7(a and b): Correlation circles: projection of the variables on the plane of the first three principal components (plane PC1-PC2, and PC1-PC3); (c and d). Projections of the farms types in the plane PC1-PC2 and PC1-PC3

3.3.2 Classification results: farm types description

The projection of the five farm types resulting from the HAC in the planes PC1-PC2 and PC1-PC3 (Fig. 7 c and d) results in gradient from Type 1 to Type 5 on the axis PC1, i.e. following structural and resource endowment proprieties. Thus Type 1 and Type 5 seem to be the two extreme farms. Resource availability, input requirement and crop performance could be best described using this categorization and specific values for the different farm types are outlined in Table 6 and Fig. 8. A narrative pertaining to a brief characterization of each type is provided below as well.

Table 6: Farm types and main characteristics (land size, gross margin, cultivation experience, cost components and postharvest losses)

Type	Pineapple area	Gross income per acre	Production Experience	Total cost per acre	Fertilizer ratio	Fungicide ratio	Labour ratio	Postharvest losses (%)
	Mean ±SE *(acres)*	Mean ±SE *(G. cedi/acre)*	Mean ±SE *(years)*	Mean ±SE *(G. cedi/acre)*	Mean ±SE *(-)*	Mean ±SE *(-)*	Mean ±SE *(-)*	Mean ±SE *(%)*
1	11.4 ±1.3	4480 ±574	9 ±2.7	4178 ±77	0.19 ±0.01	0.02 ±0.00	0.15 ±0.01	4 ±0.5
2	4.5 ±0.8	5485 ±377	6 ±1.5	3020 ±58	0.15 ±0.01	0.00 ±0.00	0.20 ±0.00	6 ±0.9
3	2.2 ±0.2	4297 ±259	14 ±1.0	3906 ±158	0.18 ±0.00	0.00 ±0.00	0.27 ±0.01	17 ±2.6
4	1.7 ±0.3	2738 ±358	6 ±1.2	2860 ±86	0.20 ±0.00	0.02 ±0.00	0.20 ±0.00	22 ±2.0
5	1.0 ±0.1	1195 ±277	3 ±0.6	2156 ±72	0.10 ±0.03	0.00 ±0.00	0.11 ±0.04	22 ±2.5

Source: From the survey; SE: Standard Error; G. cedi: Ghana cedi

Farm type 1: it represents large farms (n= 8, i.e. 11% of the sample) with large land areas allocated for pineapple production (about 11 acres). Farms feature high gross income after production (mean about 4,480 Ghana cedi) and also a high investment resulting in high total cost of production (Figure 7c and d, Figure 8 and Table 6). Moreover, these farms had the lowest postharvest losses (about 4%) and the lowest share of the labour cost in the total cost (about 15%). Further, the share of the fertilizer and fungicide costs in terms of total cost is quite high also for these farms, respectively 19% and 2%. Thus Farm type 1 tends to be larger farms with high endowment of resources and high production costs related to extensive use of external inputs.

Farms type 2: Type 2 (n=14, i.e. 18% of the sample) could be characterized as having a medium^{+} resource endowment with low use of the fertilizer and fungicide (Figure 7c and d, Figure 8 and Table 6). Indeed these farms have smaller land area cultivated for pineapple (about 4.5 acres) compared to the first cluster yet they have the highest total gross income (Table 6). Thus it seems that this medium resource endowed Farm type 2, more efficiently manage the few input used thereby being able to generate quite high income.

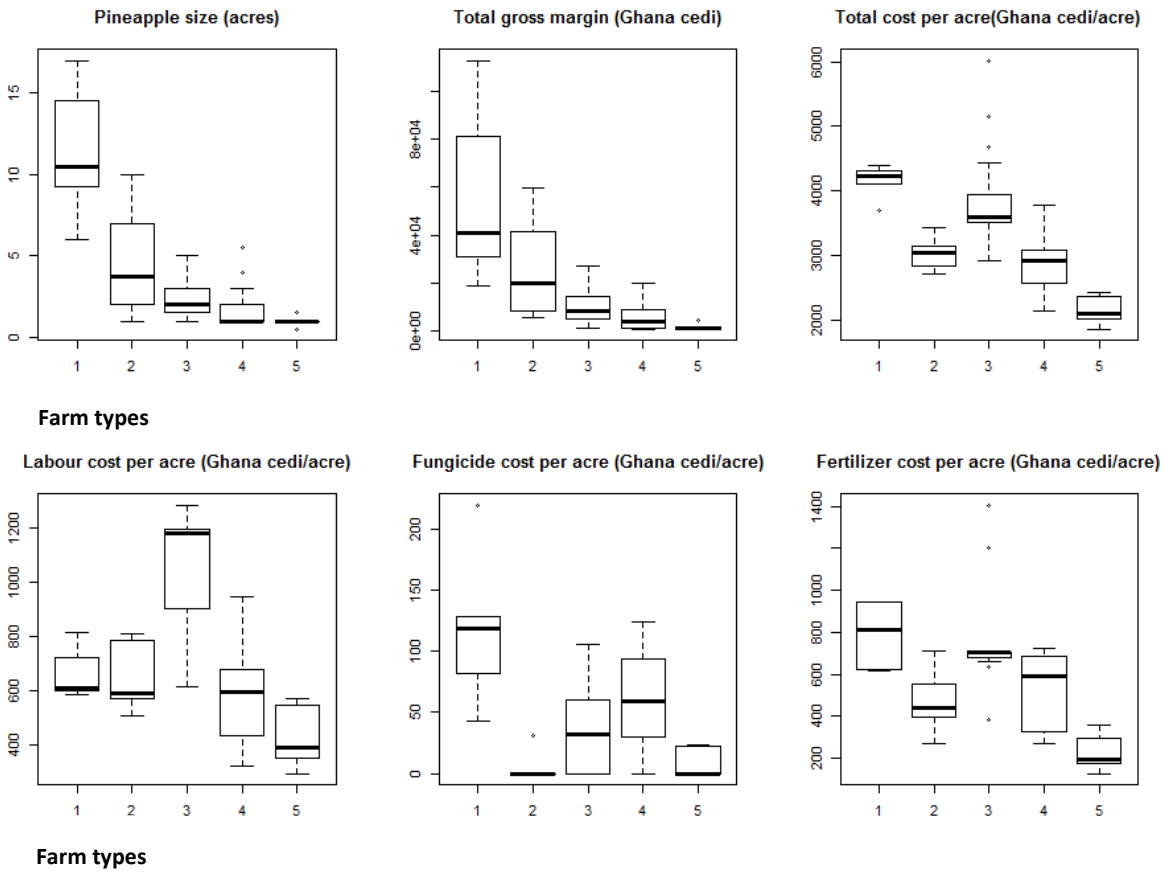

Figure 8: Variability between and within Farm types - boxplot of the pineapple size, the total gross margin, the total cost, the labour cost, fungicide cost for each of the five types.

Farm type 3: This represents a relatively large group of farms (n= 25, i.e. 33% of the sample) with also average resource endowment but with extensive experience in pineapple cultivation and relatively high labour cost (Figure 7c and d, Figure 8 and Table 6). Farmers within this cluster tend to spend more on labour compared to capital investments related to fertilizers and fungicides. They also have extensive production experience (about 14 years). Farm type 3 forms the largest group sampled) and had a quite large variability within the group (Figure 7 and Figure 8).

Farm type 4: These farms (n= 21, i.e. 27% of the sample) are characterised by average resource endowment (pineapple acreage is about 2 acres and the corresponding gross margin are about 2738 Ghana cedi/acre). These farms are quite intensive in terms the use of fertilizer and fungicide. However, they also had one of the highest levels of postharvest losses (Figure 7c and d, Figure 8 and Table 6).

Farm type 5: Farmers within this group (n= 8, i.e. 11% of the sample) were the smallest in terms of land sizes (about 1 acre), had lowest total gross margin (about 1200 Ghana cedi/acre) and also featured relatively high postharvest losses percentage (about 22%). However, they also present the lowest total production costs (about 2160 Ghana cedi/acre) due to the limited use of fertilizer and fungicide (Figure 7 c and d, Figure 8 and Table 6).

These farms, belonging mainly to the Volta region (Figure 9) they tend also to be less endowed with resources in terms of soil quality (Table 6). As the total costs are higher than the gross margin, gross income generated after production would not be enough by itself to further expand production.

In summary:

- **Type 1** groups farms with a high resources endowment and a high investment in the production;
- **Type 2** groups farms with a medium^{+} resource endowment with low use of the fertilizer and fungicide;
- **Type 3** groups farms with a medium resource endowment, high experience in pineapple and high labour cost;
- **Type 4** groups farms with a medium^{-} resource endowment, a quite intense use of fertilizer and fungicide but high level of postharvest losses;
- **Type 5** groups farms with smallest resources endowment, a low investment in production but a high level of postharvest losses.

Identifying production differences within smallholder farmers allowed to clearly distinguished between farm types. This puts them in the context for specific management practices and resource endowment conditions prevailing within each farm types and this in turn may have ramifications in terms of cost incurred and corresponding output efficiencies. Which in turn are crucial components in resource management and economic farm performance. The required production conditions in terms of costs differ among the farm types and this could be as a result of (input differences) on cultivars under production by these farm types. Fungicide ratio could best be informed by the cultivar under cultivation. Taniguchi, (2007), reported that, 'MD2' variety is highly susceptible to Phytophthora spp. and heart rot disease compared to Smooth Cayenne variety. Successful production thus requires adequate investments and frequent application of fungicides which in turn would increase the production cost invested in fungicides.

The size of farm is quite good indicator in predicting the total gross margin of farm types (Figure 8). Gross margin per acre could give an information on the efficiency of the available resources management and the input costs per acre (as the fertilizer, fungicide and pesticide cost) is indicative of the level of intensification of the production. Comparing total cost and gross margin, Farm types 1, 2 and 3 have a high opportunity to expand their farms during the next production season whiles 4 and 5 do not generate enough income to justify subsequent production cycles (Table 6). This could be due to high postharvest losses. Even though Farm type 3 has a high rate of fruit loss after harvest despite the highest experience in production; it appears that farmers may require more training specifically on techniques to reduce postharvest losses. As confirmed by Jasper (2010), the change in market demands from Smooth Cayenne pineapples to 'MD2' required rapid investment in post-harvest technologies and in-depth knowledge and expertise for an efficient output.

3.3.4 Linkage of farm types and study regions

Identification of the farm types (Fig. 9a), according to PC1 and PC2 to the study regions (Fig. 9b), showed that majority of farmers in farm type 1 are from the Central and Eastern regional part of Ghana. This study location is one of the major and largest producers of pineapple in Ghana. They have good access to all the three market destinations, with quiet suitable soil and climatic conditions for cultivation of pineapple. However current rainfall trend in Central region poses a treat for future pineapple sustainability. Farm type 2 shares common characteristics with type 1, with farmers stemming also from the Central, Eastern and a few from Volta region. Possible reason for the survival of most smallholder farms in these regions is because they enjoy input support from big companies that source extra fruits from them during exports and processing. This ensures reliability of market after production. For farms in the Volta region, the cultivation of sugar loaf variety ensures their survival as depicted in Table 7. Farm type 3 are mainly farms from the Eastern region, they also really on the local market and fruit processors for sales of their fruits with little to no exporters. Many smallholder farms from these regions are folding-up because the major export group for smallholder farmers is no longer in existence. However, soil and climatic conditions are suitable for pineapple cultivation. Farm type 4 is well presented in all the three regions. Farm type 5 is predominantly dominated by farms from Volta region where rainfall and temperature are conducive for pineapple production. However, soil quality improvement strategies are required especially in Akatsi North district. The destination of fruits from this region only ends up in the local market and features low pricing. Finally access to capital from local banks for production is extremely low for farms within this region (Table 5).

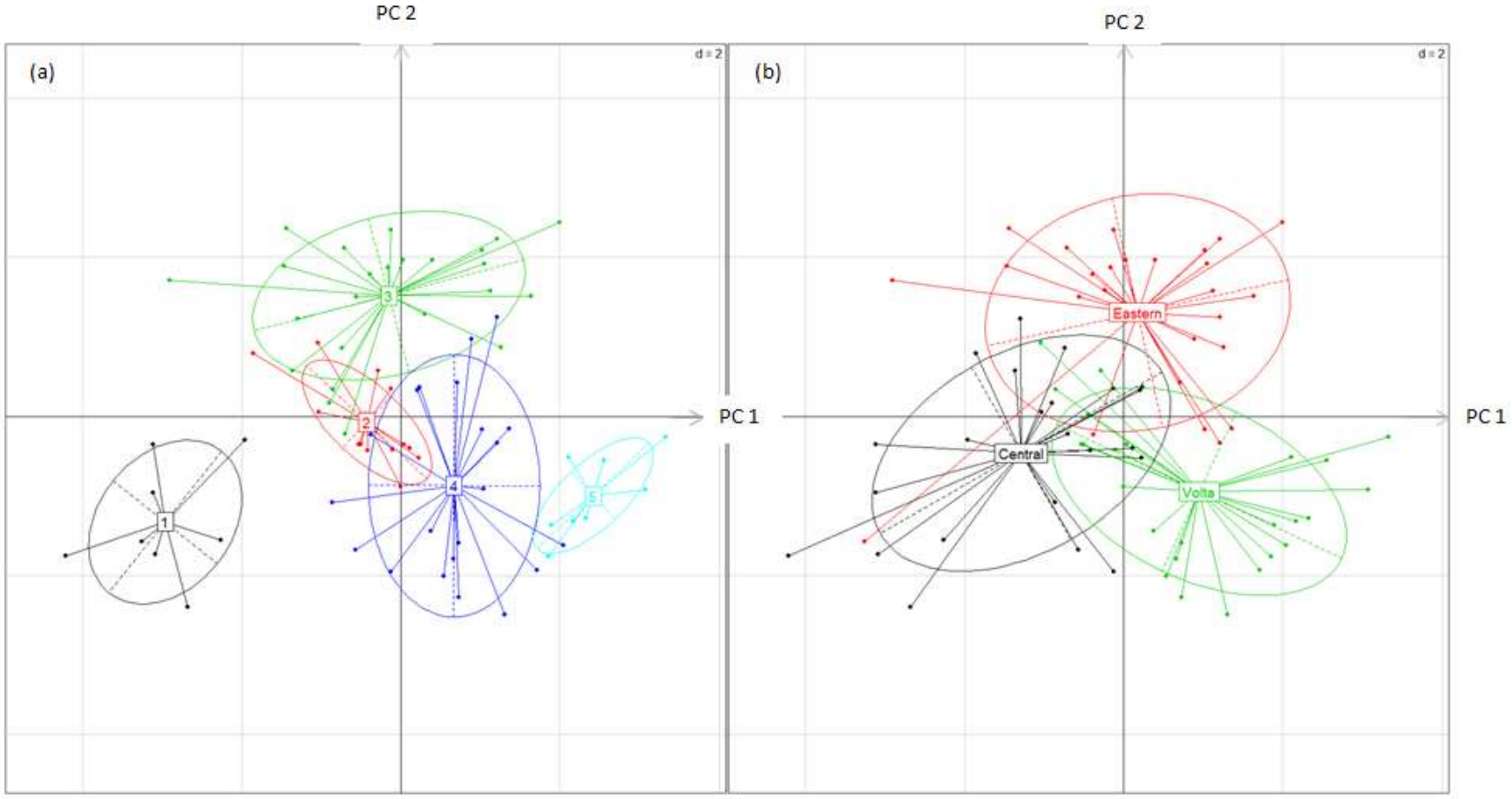

Figure 9 (a and b): Projections of the farms types in the plane PC1-PC2 and plane PC1-PC3 and their corresponding regional study locations.

3.3.5 Linkage of Farm types and varieties under cultivation

Dominating varieties under cultivation for each farm types, showed that farm type 1 mainly cultivate two or more varieties with 50% and 37.5% cultivating either 'MD2' and Sugar Loaf (SL) or 'MD2', Smooth Cayenne (SC) and Sugar Loaf (SL). Whiles 12.5% cultivate only 'MD2'. Farm type 2 has 85.8% of the smallholders cultivating only SL whiles 7.1% cultivate more than one variety. Farm types 3 and 4 at least cultivates all the varieties but with varying percentages. Further, farm type 5 has 62.5% dominating in the production of SL, with 'MD2' only and 'MD2' and SL combination representing 25 and 12.5%, respectively (Table. 9). The choice of cultivating a particular variety could principally be based on access to market both local and global and presence of processing factories. 'MD2' and SL dominated in farm type 1 due to available market for export and local market. The local market absorbs more supplies of SL than 'MD2' because the 'MD2' is the most preferred variety for export and this farm type is mainly found in the Central region (Table 4 and Fig. 8). Farm type 2 which has farms in Eastern, Central and a few from Volta region mainly cultivating SL this could be because the SL variety requires less input to cultivate and is more drought resistant. So it may serve more or less like a security crop in that when the 'MD2' fails then the farmer can really on SL which is a hardier crop. Farm type 3 is primarily dominated by farms in Eastern region which has some farms cultivating SC. According to the farmers, after the required switch from SC to 'MD2' lots of planting materials for SC was burnt resulting in a decline of farms cultivating only SC or its combination with other cultivar. Farm type 4 also has virtually all the varieties been cropped and this is because majority of the farms surveyed in this area cultivates all the varieties because they have access to all the marketing destinations. That SL is the dominant variety under cultivation for farm type 5 is to be expected because of poor soil organic matter level except farms in Kpando district. They require a variety with less input during cultivation. Fruits produced are mainly focus on local market due to lack of exporters and fruit processing factories.

Table 7: Farm types with percentage variety under cultivation

FARM TYPE	'MD2'	SL	SC	'MD2' & SL	'MD2' & SC	SC & SL	'MD2', SC & SL	TOTAL
1	12.5	0	0	50	0	0	37.5	100
2	0	85.8	0	7.1	0	7.1	0	100
3	16	0	4	12	16	24	28	100
4	47.6	19.0	4.8	0	14.3	9.5	4.8	100
5	25	62.5	0	12.5	0	0	0	100

Source: From the survey. SL= Sugar Loaf, SC= Smooth Cayenne

4. IMPACT OF GOVERNMENT POLICY and GLOBAL MARKETS ON LOCAL PRODUCTION

This section considers the effects of Ghana Agricultural policy effects on smallholder pineapple production. Here the impact of local and global agricultural policy and governing market forces is put in perspective based on interviews of local stakeholders and experts. Further, the factors governing the decline in pineapple production and related solutions to production and marketing components of the value chain is also being described.

The decline in national production may have resulted from required change from Smooth Cayenne (SC) to MD2 driven by market demands coinciding with lack of required support.

''During 2005, the pineapple business collapsed because the global market wanted none of Smooth Cayenne (SC) but all of 'MD2', so a lot of farmers and exporters abandoned their fields and trade, leading to lots of smallholders getting out of business. So out of that they also abandoned their fields because they have a product that nobody was willing to buy. However, some of them still tried to cultivate the 'MD2'. This was the main reason that created a decline or shortage, because nobody really wanted SC in the export market. Also, the local market was not paying that much and if the local market was that good I am sure farmers would have still been in business. But the local market was their third preferred market because; the price offered was not good enough. So their major target was the export market. Additionally the small growers were not directly exporting to Europe but were exporting through third parties like an exporter or cooperative which were not reliable'' ***(Mawuli Agboka Director Horticultural Exports Industry Initiative (HEII) (MOFA).***

(S)low acceptance of MD2 variety during its introduction couple with changing global market demands cause declined national production.

''The situation was that; Smooth Cayenne (SC) was the preferred commercial variety for over 60 years in the export market both for canning and fresh produce. So by the time 'MD2' variety was introduced, Del Monte in Costa Rica tried to fend everyone else off by saying that they have patented the 'MD2' variety. We knew because we had intelligence from the market that this 'MD2' variety is coming in waves but we did not know exactly when it will hit and hit really hard. So actually by 2004 I together with three other people were sent by the government of Ghana to go to Costa Rica and look for source of materials but even at that time it was still under patent. The few that we brought, the small farmers had to start with as small as 0.5 of an acre, they harvest and sell, and re-expand to 1 acre, they re-invest and expand to 2 acres → 4 acres → 8 acres so it has been re-investing and re-investing before the situation changed in 2010 and most of the investment support for planting materials also fizzled out. Further, in 2005 the production in Costa Rica has reached a high level and they were now pushing it to the European market which was our main market, initially their focus was on the US market but then they have started producing huge quantities and everybody admired the beauty of the fruit. Other reasons why it succeeded probably were because we were also part of the problem. When we started fresh air freighted pineapples Ghana's quality could be the best but unfortunately we couldn't

manage the quality issues very well that is we were also harvesting immature fruits. So there was no consistency in the quality and consumers buy pineapples which look yellow because it's sprayed with ethephon but when eaten sometimes the taste is good and other time it taste sour. That is one of the reasons the 'MD2' succeeded because for me, a good quality smooth cayenne is as good if not better than 'MD2', the only other advantage 'MD2' had was good marketing strategy adopted by Del Monte'' ***(Mawuli Agboka Director Horticultural Exports Industry Initiative (HEII) (MOFA).***

Policy measures to improve production

''Ministry of Food and Agriculture (MOFA) Policy for smallholders operates under three main section; infrastructure, technical provision and technical support. For Infrastructure support, MOFA realised that the lack of infrastructure is detrimental to the production of horticultural crops for export in general. So together with Millennium development Authority, it established packing houses at Vakpo in the Volta region, another at Pepawani and Somanya all in the Eastern region. These packing houses can be used as a tool to develop or encourage other people to establish their nucleus farms. It can further encourage out-grower schemes in these areas. The other thing that MOFA has done is to also improve access to feeder roads. It has constructed about 200 km access roads under the Export Marketing and Quality Awareness Project (EMQAP) with the believe that farms develop, when you have good accessibility.

Marketing is not really MOFAs mandate but the realisation is that MOFA needs to look at issues from the market perspective as well. Generally, the Ministry of Trade is the mandated organisation. For market facilitation, institution such as Ghana export promotion council and MOFA see this aspect as the most crucial aspect if the country wants to develop the industry in the future because we are lacking in that aspect of trade. But MOFA makes some effort to link some smallholders with other marketers. For global market, the EMQAP project facilitates market access requirements such as organic certification GLOBAL GAP and FAIRTRADE, without these access tools your produce will not get to the global market. There should be a unit within the ministry that focus on training farmers on activities such as quality standards and certification procedures so that the farmers can be taken through. That will put them in a good step to access the market'' ***(Mawuli Agboka Director Horticultural Exports Industry Initiative (HEII) (MOFA).***

Private organisational support for smallholder pineapple farmers

''Gesellschaft für Internationale Zusammenarbeit (GIZ) improvement on sustainable smallholder pineapple farms in Ghana we use the value chain approach. By bringing all the stakeholders together to ensure constant flow of information. We established a Value chain committee which includes processors, input dealers, producers and marketers. However, the issue of trust for business partner is important for sustainability. During production the organisation provides training, for GLOBAL GAP certification and also pays for farmer groups 100% in the first year, 50% in the second year and by third year it should be sustainable for

*the group to pay by itself GLOBAL GAP certificate. GLOBAL GAP certification requires training on Global Positioning Systems (GPS) and GIZ has a team that trains farmers on that. First aid training, planning and record keeping are also part of our training activities for smallholder farmers. Market for export of mangoes is easier compared to pineapple. Going in to a contract agreement with local buyers will be ideal solution of having a fair price on the market for pineapples'' (**GIZ representative Peter Reiner in Ho).***

Possible interventions to revive the pineapple industry

*''Providing financial support will help encourage smallholder farmers since this will afford them to buy the inputs required for production. Smallholder farmers are already aware of standard production practices so financial support can boost smallholder farms to bounce back into production. There is market for pineapples but we do not have the resources to meet the request from Europe. Also delay in payment of sold produce by exporters is a course of low boost of pineapple. Price uncertainty in Europe for produce is also a factor due to the world economic crisis. For some farmers the local market is better. So the decline in production is as a result of poor market, less alternatives and unsustainable local market. Possibilities of expanding our trade to neighbouring countries like Burkina Faso and Nigeria could be a solution'' **(Kweku-Amanfo Yeboah, Operations manager with Sea-Freight Pineapple Exporters of Ghana (SPEG)).***

Production constraints faced by smallholder pineapple farmer

*''Our planting materials that we have in Ghana is in its fifth decade and we need to change the entire planting materials that we have with new planting materials. Our planting materials are susceptible to lot of diseases and we need to change. Tissue culture for new planting materials will be a good initiative but that should come from government to set-up pineapple planting material multiplication sites across the pineapple growing areas. And the 'MD2' that we have now compared to what was brought initially has shown a big difference because 10 years ago, the colour, aroma were all perfect but now you harvest and even wonder whether is smooth cayenne or 'MD2'. So basically it has lost its quality and it is bad now. Without carefully monitoring and ensuring of standards we will lose it just like we lost Smooth Cayenne (SC). Bad agricultural practices, less monitoring and poor standards leads to loss of quality'' **(Ernest Ablorh Blue skies Ghana Farm manager).***

''Other production declining factors are environmentally related. The 'MD2' fruit is sensitive to intensity from the sun and during period of high intensity, it tends to affect the fruit formation. You may get fruits that are deformed and cannot be exported; problems of double or multiple crowns cannot also be exported. Apart from that you will also have small fruits from high intensity of the sun which will reduce yield. Radiation also affects the internal quality of the fruits especially if your fertilization is not fine-tuned, if you have too much urea and under very high radiation intensity you tend to have high translucent fruits which cannot be exported. Translucency is a term used to describe the level at which

pineapple picks-up water. For radiation we reduced its effect by having some nets over the beds to provide some form of shade we tried with some plots and compared to those without shade and the outcome was better for those under shade but was too expensive to continue. Phytopthera disease especially when you have moist conditions is another major production problem. It thrives very well under moist conditions and it can be so devastating that you will not pick a single fruit from a whole plot. To control phytopthera, ensure that your soil is well-drained'' ***(Sampson Ameyaw smallholder farmer).***

*''Ghana has limited laboratory facilities to perform analysis such as soil analysis, pulp analysis, D leaf analysis. The D leaf serves as a useful indicator for assessing when to force the plant by using the length of the leaf and the weight of the D leaf. The weight of the D leaf should be about 80-100 grams to carry-out forcing. Also when the D leaf is around 100-130 grams it is likely to get around 3 kilo fruit weight. The pulp analysis will help us do very good analysis on pesticide and insecticide usage, residual deposit and limits. Sometimes people come with claims after fruit purchase but if these laboratory facilities are established it will clear any doubts from supplier and retailer'' (****Patrick Alexes Gold Coast fruits limited).***

Impact of processing company in sustaining the pineapple industry

''HPW, a local trader has FAIRTRADE pineapple growers who are grouped in cooperatives and we support them to stay FAIRTRADE. Smallholder farmers under FAIRTRADE include Fotobi cooperative and Adonten pineapple grower cooperatives and they all supply to HPW. The varieties that we dry here are 'MD2', Smooth Cayenne (SC) and Queen Victoria. For sugar loaf there is too much water in it and drying process means taking the water out. Smooth cayenne is good for juice when is highly matured and smooth cayenne when dried, the colour does not change but with sugar loaf there is colour change it comes out a bit as off-white and then with time it deteriorates to brown and finally to black, because it contains much sugar. Export dried pineapple is not a big market now so we support it with other products especially mangoes. For us air freight is better than using shipping line because a container of dried fruits could be shipping 20 - 25 containers of fresh fruits, and the turnover is good because one container of dried fruit is more like 20 containers of fresh fruits in turnover. The local market for dried fruits is not yet catching up. But our observation for the past two years shows that it is more for a niche market. Another issue has to do with the price which might be very expensive for the locals 100 g of dried pineapple is about 1.6 kg of fresh pineapple which is 3.00 Ghana cedi. The few challenges that we have is our capacity in processing pineapple all year round'' ***(HPW James Obeng Production/Quality control manager)****.*

5. SYNTHESIS AND INTEGRATION OF KEY SYSTEM COMPONENTS

This section aims to integrate key system components with other related reports. It also assesses the research hypothesis. The outcome of clustering farms in relation to biophysical factors shows that climatic and soil conditions are favourable for pineapple cultivation at the various study location (Table 3 and Fig.4). Hence actual production conditions govern yield variability in the context of soil condition of the study locations. Although these locations largely have access to local market, processing factories and exporters; transport service to these centres is a challenge as some varieties like 'MD2' which is suitable for export requires continuous cold storage from the farm gate to its final destination. The establishment of pack houses at various locations within the pineapple belt has been done (Mawuli Agboka, 2014. interview), but what is lacking is continuous maintenance of a cold storage chain and improved management systems of the exportable variety. This statement is supported by Takane, (2004) identifying the disadvantages of smallholder production systems as small volume of fruits, quality control, and inability to comply with new customer requirements—this situation is also compounded by lack of proper packing facilities or cold chain management systems.

The production system of the smallholder farmer changed because of shift in demand of traditional Smooth Cayenne (SC) variety leading to decline in the production. Subsequently the recovery period of the smallholder farmer to adapt to the 'MD2' was slow because of high input requirement of the 'MD2' variety. Based on the farm types provided in Table 7 it is evident to have relatively few growers of Smooth Cayenne (SC) because no strategies were adopted to still maintain the variety while there is no longer any demand in the global market where 'MD2' has been prevailing. Additionally like other pineapple producers and exporters in Ghana, smallholder farmers suffered from the change in market demand from smooth cayenne to 'MD2' because their financial resources could not meet the input demand of the 'MD2' (Fold and Gough, 2008). The (S)low acceptance of 'MD2' variety during its introduction couple with changing global market demands cause declined national production. In this context lack of strategies to maintain and source planting materials to sustain the smallholder farmer to produce was the distinguishing factor for causing the decline. This was duly elaborated from the expert interviews; however this hypothesis could be overstated since it lacks quantitative assessment.

Although basic resources for production where available, postharvest losses was high and resource management strategies were not efficient thus reducing gross income. As a result, production is not profitable which hampers producers to continue its cultivation and/or to expand the land area under pineapple production. Required production inputs and production condition differ among farm types hence, linking of farm types to study locations provides measures in determining which cultivar is suitable and has a comparative advantage in production (Table 6). As shown in (Fig. 9), there are regional differences among farm types in terms of cultivating a particular variety. These differences are mainly based on

cost components required by a particular variety during production, access to market and soil characteristics at the various study location. Chamberlin, (2008) concluded that important variations are apparent in small farm attributes and therefore advocate for a basic distinction among small farms for easy implementation of policies. The classification tree and the hierarchical clustering of farm types provided a good measure in understanding production system dynamics in terms of resource use and management.

Characterisation of smallholder farms in Ghana is largely dependent on landholding size as the basic indicator (Ekboire et al., 2002). With increasing land scarcity, issues concerning access to land could be a major issue in the near future as estate developers and urbanisation are encroaching on agriculture lands and for that matter some of the study locations surveyed. Land ownership in Ghana can broadly be divided into three categories: customary ownership, state ownership and a partnership between the state and the customary owners (split ownership) (Maxwell et al., 1998). Most of the agricultural lands are rented land belonging to customary owners and they terminate agreements without following due process. Most smallholders are somewhat land constrained and more vulnerable to risk than larger farms. This provides an indication that land tenure system although not a crucial issue for smallholder farm types for now it could be a major issue in the near future in Ghana. The results from this survey did not show clear evidence of the effect of land tenure on farm characterisation but rather identified landholding size as the main indicator underlying indicator in showing differences between smallholder pineapple production systems.

Various ways can be used to help the smallholder farms to start or expand production and thereby strengthen the value chain. Channels of support can be provided by stakeholders in a form of input provision, acquisition of GLOBAL GAP and FAIRTRADE certificates, establishment of quality control standards and more extensive education on government policy to the smallholder farmer. The sequence by which pineapple fruits are produced within the value chain could serve as avenues for employment generation among the youth (Fig. 10). This can be achieved through the establishment of processing factories and transportation of fruits from site of production and further distribution to the final destination markets. This is key in the value chain and investments in logistics and infrastructure are required for smallholder farms to re-join the value chain and to ensure it subsequent sustainability. Training on quality standards is an important aspect for the smallholder to regain its lost glory of exporting pineapple to the global market. These notwithstanding, farmers will only adapt to these practices in context of existing livelihood situations (Chamberlin, 2008). Therefore identifying policy interventions which targets smallholders farmers should be to recognize their internal differences and production objectives as this will make problem solving easier. This situation is inimical to the growth and development of the pineapple sector in Ghana.

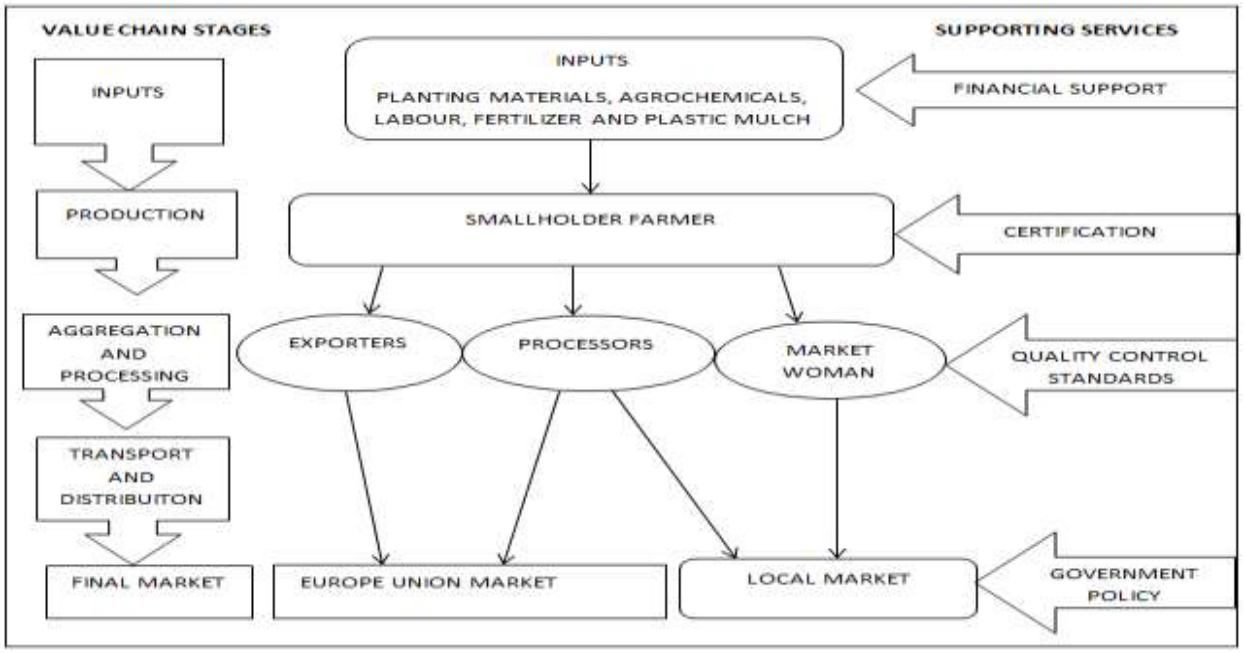

Figure 10: Smallholder pineapple farmer value chain frame work

6.0 CONCLUSION AND RECOMMENDATION

Carrying out this study in these three regions has been beneficial in understanding the current production systems and the characteristic differences of smallholder farms in Ghana. Also it has provided an overview of the potential for Volta region to pursue intensification of pineapple production systems since all the bio-physical parameters are favourable. However, irregular rainfall pattern at times which poses risks and is a treats for the pineapple production. The key factors governing the decline of production among the analysed farm types includes: high input cost for production especially 'MD2' variety, high postharvest losses of fruits and lack of transport and distributions services to reach both local and global markets. Access to credit and low price of fruits especially at the local market are also contributing factors to general decline in pineapple production. This work also established that, farm types differ among smallholder farmers, in terms of input used for production, production condition and gross income as related to prices and yields (input differences). Resource use and management by the various farm types depends on type of cultivar that is being cultivated, existing local conditions in terms of access to credit and market opportunities. Government policy on service provision to the smallholder falls short on regulations, certification and maintaining of standards.

Differences in soil organic matter level at the study locations and especially Akatsi north district will require improved soil management and use of organic amendments to ensure sustainable cultivation of pineapple. For the smallholder farmer to participate in production of export quality fresh pineapples, there should an exporting company whose sole interest will be to export produce from smallholder farms. Further research on plant vigour of plant materials for all cultivars is needed since it has been speculated by some farmers that loss of vigour has led to lower yield and difficulty in production. Also the setting up of laboratory to provide services in aspects of soil analysis, pulp analysis among others at the various pineapple cultivation areas is essential to enhance the sustainability of the pineapple industry in Ghana. Identifying potential European-based fruit juice manufacturers who might be interested in establishing strategic partnerships with Ghanaian processors to increase the cultivation of Smooth Cayenne is another required improvement to reinforce the value chain of pineapple production in Ghana. Characterization of farm types provided in this study may inform policy makers and help them to design sound policies that match specific characteristics of the major pineapple cultivation district. This is essential to ensure more rapid diffusion of production knowledge among farmers through policy interventions including increased support for capacity building, training and formation of cooperatives. Hence, government policy should be more focused on the smallholder farmer as majority of them are out of production due to the unsustainable situation in marketing and production channels. It is clear that comparative advantage in production was provided by the smallholder farmer in the past, therefore their integration into domestic and international markets provides advantages to Ghana to regain its position in global markets.

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Appendix I: Questionnaire Smallholder pineapple Producers (Survey)

DATE	
CROP	
VARIETY	
NAME OF FARMER	
AGE	
GENDER	
DISTRICT	
LAND AREA OF DISTRICT	
CONTACT DETEAILS (PHONE NO. ADDRESS, EMAIL)	
Do you belong to farmer base organisation FBO or Farm cooperatives?	
Total number of members in the organisation or cooperatives?	
Number of members certified?	
GLOBAL GAP	
ORGANIC	
FAIRTRADE	
OTHERS	

SECTION	CATEGORY	QUESTIONS	FARMERS RESPONSE
A	CURRENT CROPPING SYSYTEM	Land area of farm?	
		Type of land ownership? *Outright purchase, or Rented*	
		Type of farming system? *Intercrop or mono crop*	
		Intercropped with which tree crop? *Mango, Citrus , Passion fruits*	
		What is the area cultivated with pineapple?	
B	GENERAL AGRONOMIC PRACTICES	How long have you been cultivation this variety?	
		Name source of planting suckers?	
		Are the suckers easily available? *Yes or No*	`
		How do you transport it to your farm? Own transport, Hired transport,	
		How do you get supply of planting suckers? *Friends, Certified nurseries, MOFA, NGO's*	
		Distance from source of planting material to your farm?	
		How do you request for your planting suckers? *Direct supply to farm, Self-transport.*	
		Price of planting material per Ha in Ghana cedi?	
		Is the planting material always available or upon request by the farmer.	
		Do you get subsidy on planting	

		materials? Yes or No If yes how much subsidy?	
		Planting date for pineapple?	
		List the basic field operations from land preparation to harvesting?	
		Cost of land preparation?	
		Cost of fertilizer per Ha?	
		Cost of insecticides?	
		Cost of fungicides?	
		Labour cost for spraying?	
		Labour cost for fertilizer application?	
C	PRODUCTION AND MARKETING CONSTRAINTS	Indicate major problems in the following areas land preparation?	
		Planting?	
		Major weeds affecting yield?	
		Problems faced during Harvesting?	
		Source of nutrients used?	
		Indicate type of weed control measures used?	
		Name of important pests that reduces yield?	
		Name of important diseases that reduces yield?	
		Do you have storage infrastructure?	
D	YIELD	Harvest per year? (*tonnes*)	

		Total harvest by FBO per year? (*tonnes*)	
		Total harvest per year to GLOBALGAP Certified pineapple?	
		Total harvest for Organic?	
		Total harvest for FAIRTRADE?	
	B.YIELD ANALYSIS	TOTAL COST OF INPUTS (VARIABLE COST) per ha?	
		Total cost of labour?	
		Total of other cost (land lease per season) per ha?	
		Total production cost (variable cost + labour+ fixed cost) per ha?	
	C. Destination of market produce and price	Total volume of pineapple sold to local market (Kg/tonnes)?	
		Which local market do you sell to? Provide names?	
		Price per kilo (GH₵)?	
		Total volume of pineapple sold to processing companies (Kg/tonnes)?	
		Price per kilo (GH₵)?	
		Total volume sold for export (Kg/tonnes)?	
		Price per kilo (GH₵)?	
	D. Gross Income	Total sales – Cost of production? (For local market)	
		Total sales – Cost of production? (For Fruit	

		Processor)	
		Total sales – Cost of production? (For Export market)	
E	Resources/supporting services	Source of labour? *Family ,hired, communal*	
		Type of credit facility?	
		Source of credit?	
		Do you receive training for 'MD2' OR smooth cayenne production and improvement of training? Yes/No	
		Frequency of training? Once, twice or three times in year.	
F	Policy	Do you get support from the Ministry of food and Agriculture? Yes or No	
		What kind of support? Fertilizer subsidy, Planting material subsidy, Micro-Financing	
		Do you get support from NGO's? Yes or No	
		Name them?	
		What kind of support from NGO's? Fertilizer subsidy, Planting material subsidy, Micro-Financing	

Appendix II: Questionnaires for Pineapple Fruit Processing Company

DATE	
CROP	
VARIETY	
NAME OF COMPANY	
DISTRICT	
CONTACT DETEAILS (PHONE NO. ADDRESS, EMAIL)	

CATEGORY	**QUESTIONS**	**RESPONSE**
FRUIT PURCHASE	Source of supply of pineapples? Individual farmers, FBO'S, or Both	
	Name other sources if available?	
	Price per kilo (GH₵)?	
	Do you have premium price for fresh cut pineapples?	
QUALITY REQUIREMENTS	What quality standards do you buy from farmers? Colour, taste, brix content, appearance, shape?	
VARIETAL PREFERENCE	Most suitable variety for local market? (supermarkets)	
	Most suitable variety for export market?	
	In what form do you sell the final produce? Juice, dried, fresh.	
	Which form is more preferred for export?	
EXPORT STRENGTHS	What are your strengths in the export market?	
EXPORT WEAKNESS	What are your weaknesses in the export market?	

Appendix III: Names, positions, company details and duration of interviews

Name	Positions	Company details	Appx. duration of interview
Mr. Mawuli Agboka	Director	Horticultural Exports Industry Initiative (HEII) (MOFA).	1hr:30mins
Mr. Kwaku Amoafo-Yeboah	Operations manager	Sea-Freight Pineapple Exporters of Ghana (SPEG)	1hr
Mr. Kankam Biney	Operations manager	PEELCO Limited	1hr
Mr. James Obeng	Assistant Manager	HPW Fresh & Dry Ltd. Ghana	1hr
Mr. Patrick Alexes	Agronomist	Gold coast fruits Limited Ghana	1hr:30mins
Mr. Ameyaw Debrah	Smallholder Farmer	Nsawam	1hr: 15mins
Mr. Ernest Ablorh	Agronomist / Fruit quality inspector	Blue Skies Ghana.	1hr
Mr. Peter Reiner	Regional Rep - Ho	Gesellschaft für Internationale Zusammenarbeit (GIZ)	1hr.
Mrs. Cecilia Agboloo	District Director Kpando	Ministry of Food and Agriculture (MOFA)	1hr: 15mins
Mr. Kofi Aheto	Chairman	Vovoli Pineapple Producers Assoc. - Akatis North district	1hr: 30mins

Appendix IV: Correlation matrices

QUATITATIVE VARIABLE ANALYSED	PRINCIPAL COMPONENT 1	PRINCIPAL COMPONENT 2	PRINCIPAL COMPONENT 3
FARM SIZE	-0.78	-0.22	0.19
PROD. EXPERIENCE	-0.31	0.71	-0.34
GROSS INCOME	-0.66	0.33	0.43
POSTHARVEST LOSSES	0.69	0.20	-0.35
TOTAL COST	-0.68	0.45	-0.24
FERTILIZER RATIO	-0.16	0.26	-0.66
PESTICIDE RATIO	-0.45	-0.45	-0.33
FUNGICIDE RATIO	-0.25	-0.49	-0.60
LABOUR RATIO	0.21	0.69	0.08

Appendix V: Summary of the PCA:

> Summary (pca.theo)

Class: pca dudi

Total inertia: 9

Eigenvalues:

Ax1	Ax2	Ax3	Ax4	Ax5
2.3954	1.8822	1.4230	0.8305	0.7287

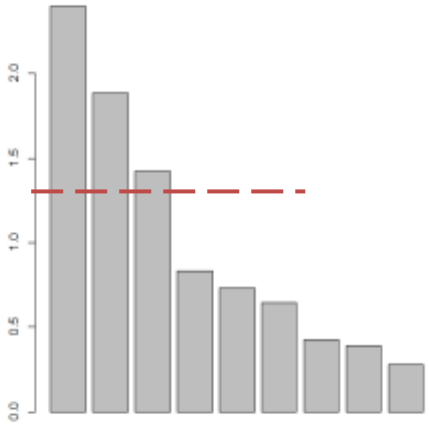
Projected inertia (%):

Ax1	Ax2	Ax3	Ax4	Ax5
26.615	20.913	15.811	9.228	8.097

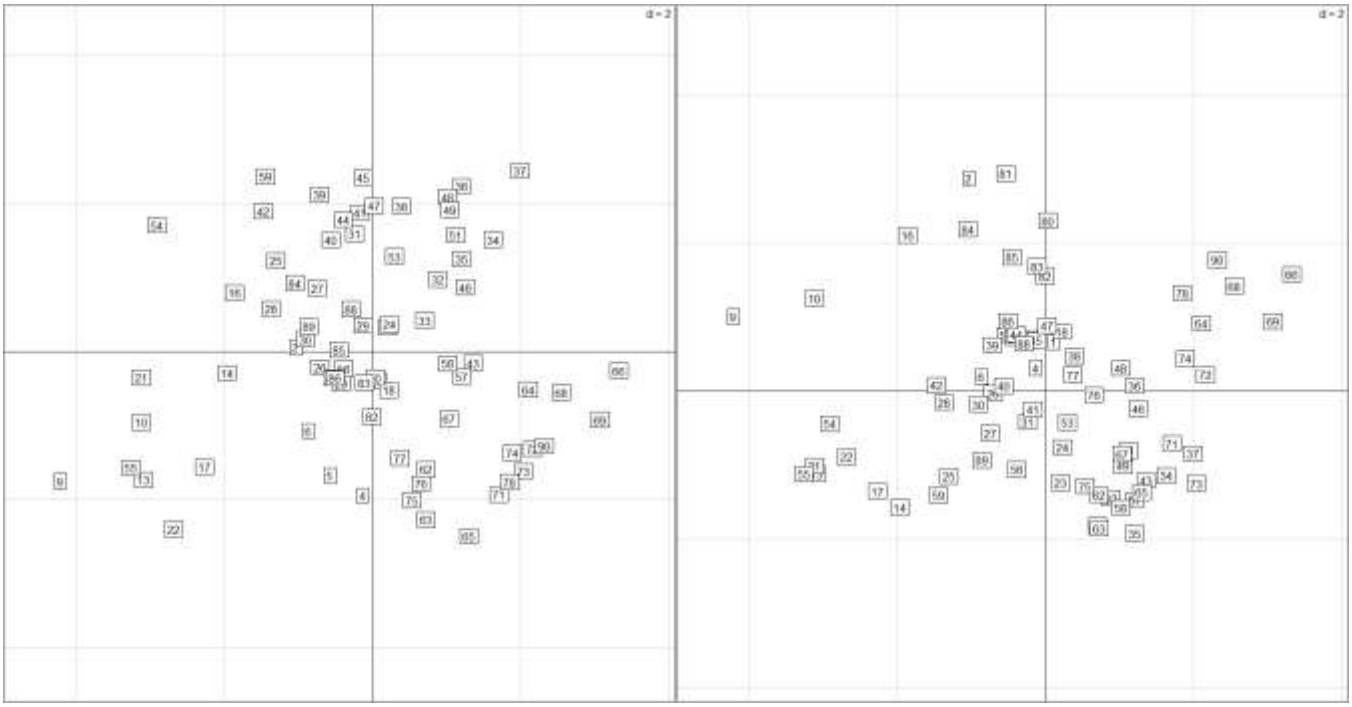
Cumulative projected inertia (%):

Ax1	Ax1:2	Ax1:3	Ax1:4	Ax1:5
26.62	47.53	63.34	72.57	80.66

(Only 5 dimensions (out of 9) are shown)



Appendix VII: Observations/farms in the planes PC1-PC2 and PC1-PC3:



Appendix IX: Output of quantitative variables analyzed.

	Farm size (Acres)			Labour ratio			Fertilizer ratio		
Type	Mean / SE	Min	Max	Mean / SE	Min	Max	Mean / SE	Min	Max
1	11.43 ± 1.27	6.0	17.0	0.15 ± 0.01	0.1	0.2	0.19 ± 0.01	0.1	0.2
2	4.5 ± 0.77	1.0	10.0	0.20 ± 0.00	0.2	0.3	0.15 ± 0.01	0.1	0.2
3	2.23 ± 0.23	1.0	5.0	0.27 ± 0.01	0.1	0.3	0.18 ± 0.00	0.1	0.3
4	1.76 ± 0.26	1.0	5.5	0.20 ± 0.00	0.1	0.2	0.20 ± 0.00	0.1	0.3
5	1 ± 0.09	0.5	1.5	0.11 ± 0.04	0.1	0.3	0.10 ± 0.03	0.1	0.2

	Income (Cedi) /acre			Pineapple cultivation experience (Years)			Fungicide ratio		
Type	Mean / SE	Min	Max	Mean / SE	Min	Max	Mean / SE	Min	Max
1	4480 ± 574.44	2910	6660	9.25 ± 2.73	3	25	0.02 ± 0.00	0.0	0.1
2	5485 ± 377.11	3100	7488	6 ± 1.46	1	23	0.00 ± 0.00	0.0	0.1
3	4297 ± 259.26	972	6100	14 ± 0.96	5	23	0.00 ± 0.00	0.0	0.0
4	2738 ± 358.42	480	4575	6 ± 1.22	1	20	0.02 ± 0.00	0.0	0.1
5	1195 ± 277.24	530	2858	3 ± 0.56	1	6	0.00 ± 0.00	0.0	0.0

	Total cost /cedi/ acre			Labour ratio		
Grp	Mean / SE	Min	Max	Mean / SE	Min	Max
1	4178 ± 77.12	3700	4390	0.15 ± 0.01	0.1	0.2
2	3020 ± 58.73	2712	3425	0.20 ± 0.00	0.2	0.3
3	3906 ± 158.09	2630	6021	0.27 ± 0.01	0.1	0.3
4	2860 ± 85.97	2135	3775	0.20 ± 0.00	0.1	0.2
5	2156 ± 72.43	1860	2420	0.11 ± 0.04	0.1	0.3

	Postharvest loss (%)			Pineapple cultivation experience (Years)		
Type	Mean / SE	Min	Max	Mean / SE	Min	Max
1	4 ± 0.49	2	5	9.25 ± 2.73	3	25
2	6 ± 0.94	1	15	6 ± 1.46	1	23
3	17 ± 2.63	1	40	14 ± 0.96	5	23
4	22 ± 2.02	10	40	6 ± 1.22	1	20
5	22 ± 2.48	12	30	3 ± 0.56	1	6