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Ghana's pineapple innovation history: An account from stakeholders in Nsawam Adoagyiri Municipal Assembly

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Despite the pineapple fruit contributing significantly towards Ghana's non-traditional export, the empirical space deficiently accounts for innovations within the sector. This article addresses prime questions that beg answering such as: the origin of innovations, when, how, what conditions facilitate adoption intensity or otherwise, what type of innovations are systematically associated with pineapple production. This study fills this lacuna by chronicling the main pineapple innovations using innovation history methodology embedded in an agricultural innovation system conceptual framing. Relying on a qualitative approach, the findings showed the emergence of two varieties – smooth cayenne and sugar loaf, overtaken by the MD2 variety. Degreening, forcing, and global Good Agricultural Practices (GAP) dominate. The Millennium Development Authority programme consolidated business plan development, efficient marketing, record keeping, and farming as a business. Successes were recorded in some instances with the transfer of technology extension model, but this article argues that the agricultural innovation system can be prioritized given the plurality of actors. The innovation history is trivialized, but it is essential for learning and co-learning in building stronger partnerships. This article underscores a radical use of innovation history both as a methodological tool and means of documenting innovations, particularly in the global south, where copious record-keeping remains rare.

Keywords: innovation history, pineapple, smallholder farmers, agricultural innovation system, Ghana

Introduction

Agricultural innovation, and how it can be nurtured and up-scaled continue to receive attention in the agrarian change and innovation literature (Molina-Maturano, Speelman, and De Steur 2019; Leonardo et al. 2020). Klerkx and Begemann (2020) summarized innovation as the successful application of new ideas, products, and processes. Rogers, Singhal, and Quinlan (2019) viewed innovation as anything new successfully integrated into an economic or social process. This presupposes that innovation is not simply about trying new things but the successful integration of a new idea or product into a process that integrates social, technical, and economic components. Innovation can be described as neither technology nor science but the successful application of varied knowledge to achieve expected economic and social outcomes (Klerkx and Begemann 2020; Pigford, Hickey, and Klerkx 2018; Alaie 2020). Pound and Conroy (2017) underscored that innovation goes beyond global novelty, often stressing local ingenuity. In these definitions of innovation, it can be deduced that an end user's final application of a new idea remains prime. New ideas are generated and facilitated by various agents in an economic, social, technical, policy, institutional, and political context (Seguin et al. 2021). Innovation can be a product measured as adoption rates (Rogers, Singhal, and Quinlan 2019). Alternatively, it can be viewed as a process involving new process(es) in generating new ideas (Alaie 2020) or new ways of doing things and people adjusting to situations (Schut, Leeuwis, and Thiele 2020).

The Agricultural Innovation System (AIS)¹ serve as a framework for analyzing agriculture's technological, institutional, and economic change (Hornum and Bolwig 2021; Pigford, Hickey, and Klerkx 2018;

Schnebelin, Labarthe, and Touzard 2021). An innovation system can also be seen as a process in which accumulated knowledge is applied by several heterogeneous actors in a complex interaction that hinges on social and economic institutions (Alaie 2020; Pound and Conroy 2017). Pigford, Hickey, and Klerkx (2018) described AIS as not just a single aggregation of organizations but a group of agents that interact in a learning process in which the agents or enterprises interact with each other. This happens in an environment supported by organizations and institutions which play the principal role in facilitating and advancing novel products, processes, and new forms of organizations into economic and social use. The AIS encompasses a far broader set of actors than the traditional agricultural research, education agencies, and extension. Innovation is more holistic in that it takes place throughout the whole economy and emphasizes that not all innovations come from formal science and technology (Klerkx and Begemann 2020; Pound and Conroy 2017). This study takes inspiration from two frameworks – innovation history and AIS in conceptualizing and analyzing pineapple innovations. Combining these two frameworks provides rigour in documenting pineapple innovation within suitable conceptual and theoretical frameworks.

A vibrant innovation ecosystem is considered essential in a fast-evolving food system characterized by urbanization, technological advancement, and globalization (Pigford, Hickey, and Klerkx 2018; Alaie 2020). This phenomenon affects agricultural and rural development, particularly in most developing countries whose economies are agriculture-driven. Indeed, a prominent feature of modern agri-food systems is the occurrence of high rates of innovation. The innovations taking place are

manifest along the entire value chain of specific agricultural commodities.

In Ghana, the pineapple fruit constitutes one of the most developed non-traditional export crops. Consequently, its production has witnessed significant growth over the past six decades (Krumbiegel, Maertens, and Wollni 2020). The pineapple fruit has many innovations associated with its production, processing, marketing, and export. The export requirement imposes a lot of stringent international standards that need to be observed in its production.

Innovation is one of the core goals of research and development. The realization of this goal requires a firm understanding of how innovation happens or has happened. The innovation history proffers a solution to this by aiding in documenting innovation chronologically and systematically. This notwithstanding, innovation histories are rarely written and used. An innovation history captures a method for documenting and reflecting on an innovation process. This involves individuals who jointly construct a written account of innovation based on the recall of documents available (Douthwaite and Ashby 2005; Temple, Chiffolleau, and Touzard 2018; Alston and Pardey 2020).

Whitfield (2017) used oral firm histories to provide a limited account of Ghana's pineapple innovation. Amati, Munson, and Scholnick (2019) applied event histories to understand cultural traits in society. Becker et al. (2013) applied it in a workshop to understand solar home systems technology uptake in Kenya. The dedicated literature on innovation history in the global south remains scanty and limited. Many authors (Kleemann, Abdulai, and Buss 2014; Williams et al. 2017; Krumbiegel, Maertens, and Wollni 2020) have examined the pineapple business in Ghana, but limited studies exist on the pineapple innovation history. Such a history is particularly important because it allows stakeholders involved in the innovation processes to reflect on their actions and evaluate how their actions and other stakeholders contribute to better outcomes. Secondly, they allow external stakeholders to learn by examining experiences involving an individual or a collection of cases. Despite the plethora of innovations associated with pineapple production in Ghana, there are still limited accounts (Fold and Gough 2008; Kleemann, Abdulai, and Buss 2014; Danielou and Ravry 2005) of innovation history in Ghana's pineapple industry. The accounts that exist remain largely outdated. Vagneron, Faure, and Loillet (2009) presented the historical dynamics involved in fresh pineapple value chains, including Ghana.

Recent studies on pineapple production in Ghana have largely failed to implicitly examine pineapple innovations but rather examined other aspects of production such as technical efficiency and productivity (Ofori-Appiah, Onumah, and Asem 2021), pineapple value chains (Kolavalli 2019; Asante-Poku 2017), use of participatory budgeting in gross margin analysis in pineapple production (Ankrah, Boakye, and Agyei-Holmes 2021a), determinants of choice of climate change adaptation practices (Antwi-Agyei et al. 2021; Wuepper, Zilberman, and Sauer 2020), role of Fairtrade in pineapple workers' job

satisfaction (Krumbiegel, Maertens, and Wollni 2018), contribution of pineapple production to female empowerment (Krumbiegel, Maertens, and Wollni 2020), benefit cost analysis of climate adaptation practices among pineapple farmers (Williams et al. 2020), determinants of farmers production system choices (Badu-Gyan et al. 2019), climate variability impacts on pineapple production (Williams et al. 2017), welfare effects of pineapple adoption (Harou, Walker, and Barrett 2017), organic production of pineapples (Kleemann 2016; Gbedemah, Swatson-Oppong, and Adanu 2021), pineapple supply chain (Alexander, Anin, and Sarpong 2016), global good agricultural practices compliance (Annor, Mensah-Bonsu, and Jatoo 2016; Annor 2018), pineapple juice processing (Akonor 2020), contract preferences (Fischer and Wollni 2018; Wuepper and Sauer 2016), determinants of MD2 pineapple variety adoption, technology gaps and technical efficiency (Mensah and Brummer 2015). The implicit evidence that chronicles Ghana's pineapple innovation history in chronological order remains principally anecdotal and outdated even though innovations in the agricultural food systems keep evolving even more quickly. This negligence of the pineapple innovation literature can lead to current vital innovations going undocumented in the empirical space. This is similar to the extinction of indigenous knowledge regarding weather patterns, even though Ankrah, Kwapong, and Boateng (2021b) advocated integrating indigenous knowledge predictors in complementing science-based predictors in daily weather forecasting. Two pertinent research questions arise. First, what implicit systematic innovation history is associated with Ghana's pineapple production that presents an updated account? Second, to what extent can innovation history contribute as a methodological tool in the agrarian change literature?

In essence, this study bridges the gap in knowledge in four ways. First, it contributes to mitigating the dearth of literature on pineapple innovation history, particularly in the global south, where copious record-keeping remains a challenge, by chronicling the trajectories associated with pineapple production.

Second, it contributes to the methodological use of innovation history in Ghana's pineapple industry and, by extension, sub-Saharan Africa (SSA), which can be extended and used for food, cash crops, livestock, and even the non-agricultural sector. For instance, Becker et al. (2013) applied the innovation history method in a solar home system uptake workshop in Kenya.

Third, it adds to contextual relevance in applying innovation histories in Ghana, hence re-igniting the conversation on the recognition and radical use of innovation histories in the global south. This study improves previous studies (Douthwaite and Ashby 2005; Dorward, Galpin, and Shepherd 2003; Whitfield 2017; Whitfield 2012) that have remained limited, skewed, and sparse (Douthwaite and Ashby 2005).

Finally, it provides evidence that can help actors in the pineapple industry to co-learn through either studying single cases or comparing past experiences with a shared vision that propels a mechanism for agrarian change as supported in earlier work (Douthwaite et al.

2006). This article aims to chronicle Ghana's pineapple innovation history from a diverse stakeholders' perspective. Specifically, it contributes to using innovation histories as a methodological tool and a medium of documenting innovations by chronicling innovations associated with pineapple production, which appears to be the most developed horticultural crop in Ghana. However, it ironically possesses limited, incoherent, and rare innovation history. From a multi-stakeholder perspective, the study validates, triangulates, enriches, and presents robust results in the less-threaded empirical space. This study essentially contributes to the pineapple innovation history and agrarian change literature and seeks to open further avenues for more innovative research in different agricultural commodity value chains.

Methodology

Research design

The study employed a qualitative research design involving Focus Group Discussions (FGDs) and Key Informant Interviews (KIIs). Lewis (2015) underscored that qualitative research enquiry allows researchers to investigate a given phenomenon in greater depth by understanding meanings, processes, and basically the 'why', 'by who', 'how', etc. An exploratory survey was conducted from January to March, 2012. The main study was undertaken between April and October 2012. This was complemented with triangulation of data in March, 2016 and February, 2021. The exploratory survey involved a reconnaissance study to identify the pineapple production innovations and other innovations associated with maize, pawpaw, and cassava. The main actors involved in the cultivation of these crops were identified and engaged in FGDs and KIIs.

The exploratory survey was undertaken in the Nsawam Adoagyiri Municipal and Effutu District based in the Eastern Region and Central Region of Ghana, respectively. The exploratory findings showed that pineapple was the only crop with diversified innovations compared with the other crops cultivated at the two study sites. Therefore, the Nsawam Adoagyiri Municipal Assembly was subsequently selected because of its rich history of pineapple production, which dates back to the early 1970s. The study particularly engaged a broad segment of actors in a systematic storyline approach on innovations surrounding pineapple. Filimonau, Beer, and Ermolaev (2021) indicated that this approach provides content validity, increases salience, innovation, creativity, and horizontal consistency. Additionally, it reduces unplanned biases associated with individual background, preferences, interests, and knowledge (Ernst et al. 2018). This study, therefore, ensured broad stakeholder engagement in covering many actors who represented different parts of the pineapple value chain.

The study was conducted in Pokrom (5°49'N 0°19'W), Fotobi (5°48'N 0°16'W), Nsawam (05°48'00"N 00°21'00"W), Dobro (5.78001,- 0.34106) and Ahodjo (5.8061 -.316), towns in the Nsawam Adoagyiri Municipal Assembly, which lies between latitude 5.45°N and 5.58°N and longitude 0.07°W and 0.27°W. The study

drew responses from farmers in farmer-based organizations (FBOs) that benefited from the Millennium Development Authority (MiDA) intervention and farmers that did not (non-MiDA). This was deliberately done to assess spill-over effects of innovation on non-beneficiary groups and afford a more balanced perspective of innovation from different categories of farmers. The MiDA FBOs were located in Pokrom, Nsawam, Dobro, and Fotobi, while the two non-MiDA FBOs were located in Fotobi and Ahodjo.

The study involved a total of seven FGDs made up of a minimum of six farmers. This was done to collect information on pineapple innovation history from farmers. Purposive sampling was used to select five MiDA FBOs from the existing 14 based on the criteria of adequate knowledge about past and current pineapple innovations, fair representation of the young (25–32 years) – 25%, middle-aged (33–59 years) – 25%, with the majority (50%) being older farmers (>60 years). The gender mix ensured 30% inclusion of women. Two FGDs were conducted involving two non-MiDA FBOs bringing the total number of 42 farmers for both categories of FBOs. The use of random sampling afforded an equal chance of selection and reduced selection bias. The second level was to randomly select six farmers through a lottery system within each FBO. The FGDs were used to document innovation history associated with pineapple production. A semi-structured interview guide was used to guide discussions on pineapple inputs, where inputs (pineapple varieties, fertilizers, weedicides, agro-chemicals, tractors) originated from, source of the innovation (whether it was self-started or introduced by an external source), motivation/factors that facilitated the innovation, year of the introduction of the innovation, innovations associated with land preparation activities, planting, agronomic activities, harvesting, transportation, fertilizer application, weed control, storage, processing, exports, and policy regulatory frameworks. Participants were made to collectively engage in actor-network mapping using flip charts to identify actors, establish relationships and flow of resources provided. A conscious effort was made to encourage participants to express themselves freely and to ensure that not only a few participants dominated the discussions. In line with this, the researcher moderated the discussions and was assisted by a reporter who recorded proceedings.

A total of 30 key informants were drawn from the MiDA, Central Management Consultants (CMCs), Technical Training Service Providers (TTSPs), Blue Skies Ghana Ltd, Ministry of Food and Agriculture (MoFA), Department of Agriculture, Combined Farmers Ltd, membership of MiDA, and non-MiDA FBOs (see Table 1).

The selection of the key informants was based on identified individuals with a good wealth of knowledge concerning the issues under investigation. Variables captured under the key informant guide included a narration of the emergence of the pineapple varieties, how and why an actor got involved in a specific task, how tasks were undertaken – whether in isolation or collaboration with other actors – the strength of such associations, challenges existing among actors, how and where inputs were

Table 1 : Summary of key informant interviews.

Institution of key informants	Number	Profile of Key Informants
MiDA	2	Agricultural Support Officer & Research Economist.
Central Management Consultants (CMCs)	1	A Central Management Consultant responsible for drafting the training manuals for the MiDA programme.
Technical Training Service Providers (TTSPs)	3	Two senior lecturers with the Department of Agricultural Economics and Agribusiness of the University of Ghana who acted as a consultant for ACDI/VOCA and an agricultural Officer with ACDI/VOCA.
Blue Skies Ghana Ltd	2	Agronomist and an Assistant Agronomist with Blue Skies Ghana Ltd.
MoFA/DoA	6	Three Agricultural Extension Officers & a Management Information Systems (MIS) Officer with the Department of Agriculture – Nsawam Adoagyiri Municipal Assembly. Farm manager & a Farm-hand at Combine Farmers Ltd.
Combined Farmers Ltd	2	
MiDA FBOs		
Adonten	2	A member of Adonten FBO as well as a chief of Pokrom village and a chairperson of Adonten FBO.
Nsabah	2	A chairperson and a member of Nsabah FBO.
Fotobi	2	A chairperson and a member of Fotobi FBO.
Apesika	2	A secretary and a member of Apesika FBO.
Pokrom Patriotic	2	A chairperson and a member of Pokrom FBO.
Non-MiDA FBOs		
Oman Vegetables	2	A chairperson and a member of Oman FBO.
Enkakyi	2	A chairperson, secretary, and a member of Enkakyi FBO.
Total	30	

Source: Ankrah and Freeman (2021) Fieldwork, 2012, 2016 & 2021

acquired for pineapple production, as well as type of fertilizers and timing of fertilizers, weedicides, agro-chemicals, tractors, and source of the innovation (whether it was self-started or introduced by an external source). Motivation/factors that facilitated the innovation, adoption intensity, year of the introduction of the innovation, innovations associated with land preparatory activities, planting, agronomic activities, harvesting, transportation, fertilizer application, weed control, storage, processing, sucker production, exports, and policy regulatory frameworks were also included. These variables were embedded in the agricultural innovation system and innovation history frameworks. Participants engaged in actor mapping using flip charts provided.

Key informants were therefore purposively selected in a participatory manner. At the end of every focus group discussion, participants were made to nominate individuals from their group or institution, individuals who they believed possessed the requisite knowledge in pineapple innovation trajectories. These individuals had between 10–30 years' experience in pineapple production and policy implementation. Therefore, the focus group shaped the selection of the key informants (see the summary in Table 1). Policy actors identified through the focus group interviews were followed-up. A deliberate attempt was made to have varied opinions within and across institutions, actors, gender, executives, and ordinary members. The main study in 2012 yielded 25 key informants. Further triangulation and studies in 2016 and 2021, led to 5 additional key informants who brought in new and different perspectives to the issue under investigation. The total number of 30 key informants was guided by theme saturation, i.e., once no new themes emerged from the issue under investigation, the researcher found no basis to engage additional key informants in the interviews. The total key informants cut across gender that intersected with class, seniority, age, ethnicity, and religion. Institutions, policy actors, FBOs

with varied expertise, skills, and opinions were interviewed (see Table 1).

Innovation histories

Innovation history is a method in which people involved in an innovation jointly reflect on and record detailed written accounts of an innovation process (Douthwaite and Ashby 2005). This method was the best-suited method because it allowed the researcher to compare experiences and accounts on innovation across different FBOs involving several cases. It also allowed the researcher to study an individual innovation in detail. Spielman, Ekboir, and Davis (2009) postulated that innovation history is a valuable method that captures important events. Detailed accounts of pineapple innovations were solicited from farmers belonging to both MiDA and non-MiDA FBOs, agri-business, MoFA, and a commercial farm present in the study area. A total of seven innovation histories were conducted through FGDs with five MiDA and two non-MiDA FBOs. The innovation histories obtained from the FGDs were further triangulated from representatives from Blue Skies Ghana Ltd (an agri-business), MoFA, and Combined Farmers Ltd in the study area.

Analysis of data

The analysis of data was done with the Nvivo² 12 software. Based on a thematic analysis approach, a coding system was generated in grouping themes as major or sub-themes. This was after an initial familiarization was done on the data captured in Nvivo. This helped categorize major and sub-themes based on an inductive approach, as suggested by Kayapinar (2014). Information was captured in Nvivo as nodes underpinned in the agricultural innovation system and innovation timeline conceptualization. Whenever a new theme emerged, it was captured as a new node in Nvivo. The first level of coding involved elemental coding techniques entailing descriptive,

structural, and Nvivo coding (Saldaña and Omasta 2016). This resulted in major themes such as pineapple variety emergence and source, policy and regulatory frameworks, agribusinesses formation, collapse and their roles, FBOs and their roles, input sources, land preparatory activities, weed control measures, fertilizer application, agronomic practices, farm mechanization/tractor usage, harvesting, storage, processing, post-harvest handling activities including cooling, adoption intensity or otherwise, sucker multiplication, production, etc. Overlapping codes were merged as a single code. This process was followed until other sub-themes emerged, and finally, no new themes emerged: theme saturation. Thematic analysis was conducted, and statements illustrative of themes were quoted in the results and discussions.

Results and discussions

Table 2 gives an account of the innovation timeline associated with pineapple production in Ghana. Various innovations have evolved with the production of pineapples in the study area emanating from different sources. The innovation history method and the AIS are used to foreground the discussions conceptually. The AIS particularly permits an analysis among actors involved in innovations, how innovations have emanated over time, processes of adoption or non-adoption coupled with factors accounting for adoption or otherwise. Reflective processes are involved in innovation generation, use and exchange, farmers' participation in the innovation processes and use, etc. The actors in the pineapple value chain include exporters who doubled as farms/producers (Bomarts Farms Ltd, Koranco Farms Ltd, Golden Exotics Ltd, Greenspan Farms Ltd, Chartered Impex Ltd, Combined Farmers Ltd,³ Jei-River Farms, Farmapine Ltd),⁴ a trade association notably, the Sea-Freight Pineapple Exporters of Ghana (SPEG), government ministries – Ministry of Food and Agriculture, Ministry of Trade and Industry (MoTI) – agribusinesses (Nsawam Canneries Ltd, Blue Skies Ghana Ltd), processors (HPW Fresh and Dry Ghana Ltd, Blue Skies Ghana Ltd, PEELCO Ltd), Ghana Export Promotion Council/ Ghana Export Promotion Authority responsible for regulatory and policy issues, Agricultural input companies (Weinco Ltd, Chemico Ltd, Agrimat). The agro-input companies were responsible for supplying agricultural inputs (fertilizers, weedicides, chemicals for forcing, dipping, and drenching) to farms.

The innovations associated with pineapple production include grading, dipping, drenching, removal of basal leaves, decrowning, forcing, plot labelling, diversification of farm business, development of business plan, value chain approach, drying of pineapple fruits, green label certification, planting MD2 without the use of plastic mulch but cover crops and mulch. Generally, an observation was made about the domination of pineapple production by males. A plausible reason could be differential access to productive resources such as land, as corroborated by Ankrah, Freeman, and Afful (2020). Krumbiegel, Maertens, and Wollni (2020), however, observed that female employment in the pineapple industry had a statistically significant and positive effect on

household income in Ghana. It will be useful if deliberate efforts are made to address women's differential access. Additionally, most farmers possessed farm sizes that can be characterized as small-scale (less than 5 hectares), but there is a current transitioning of smallholder farmers into medium-scale (5–10 hectares). Kwapong et al. (2021) give credence to this finding in their study on maize and cassava in Ghana.

In the 1960s, two pineapple varieties emerged – the smooth cayenne and the sugar loaf. These two varieties were brought into Ghana from Hawaii by Dr W. S. Abutiate, a researcher who worked with the Crop Research Institute. Dr Abutiate facilitated the commercial multiplication of these two pineapple varieties for commercial farms belonging to the Nsawam Canneries Ltd,⁵ and Kokobin Farms. The researcher was instrumental in lots of field trials in the commercial multiplication of the two varieties. The trials were carried out in Mampong-Ashanti, Wenchi, Ohawu, and Pokuase. In a focus group discussion, farmers indicated that:

In the 1960s, the smooth cayenne and sugar loaf pineapple varieties were introduced to us by Dr W. S. Abutiate. Most smallholders got these two varieties from Nsawam Canneries Ltd and Kokobin farms. Gradually, all smallholders got suckers to plant. (Pokrom Patriotic FBO, FGD/22nd/04/2012)

The smooth cayenne remains prominent in the Nsawam Municipal Assembly. Indeed Krumbiegel, Maertens, and Wollni (2018) showed that smooth cayenne was a dominant variety. The variety was introduced to the assembly from a small town (Samsu) along the Accra to Nsawam highway. Danielou and Ravry (2005) indicated that the smooth cayenne was introduced into Ghana during the early 1960s. The sugar loaf features prominently in Effutu and Awutu districts in the Central Region of Ghana. The sugar loaf is locally christened as *fante-fante*⁶ because it came from the Central Region. A key informant from the Department of Agriculture (DoA) reported that:

The smooth cayenne came to our municipal from Effutu and Awutu districts in the Central Region, even till now the Central Region remains a dominant producer of the smooth cayenne. (DoA KII, 8th/02/2012)

The rapid multiplication of the pineapple suckers and the subsequent production of the pineapple fruit was led by Dr W. S. Abutiate of the Crop Research Institute (CRI), giving credence to the vital role research institutes play in agricultural development. The full adoption and upscaling of the two pineapple varieties was sustained by the external demand in the American and European markets. Implicitly higher profit margins were obtained from pineapple production, hence the characterization as a high-value crop. This incentivized more smallholder farmers to get involved in pineapple production. The local market ironically had a minimal role to play in shaping the direction and requirements in the industry. This was because the pineapple produced targeted the export market. Pineapple fruits that did not meet the export market requirement found their way on the local market. This birthed the institution, the Ghana Export

Table 2: Pineapple innovation timeline from stakeholders in the Nsawam Adoagyire Municipal Assembly

Year of innovation	Type of innovation	Origin	Key Actors involved	Adoption intensity/success
1950	The emergence of the Smooth Cayenne and Sugar Loaf pineapple varieties by Dr. W.S. Abutiate, a researcher with Crop Research Institute. He brought the varieties from Hawaii. The two pineapple varieties were made available to commercial farms such as Combined Farmers Ltd, Koranco Farms Ltd, Nsawam Canneries Farms Ltd and Kokobin Farms.	Hawaii	Researcher - Dr. W.S. Abutiate – (Crop Research Institute), Combined Farms Ltd, Koranco Farms Ltd, Nsawam Canneries Ltd Farms, Kokobin Farms	Fully Adopted
1960	Forcing pineapples with the use of calcium carbide. MoFA introduced this and commercial farms such as Nsawam Canneries Farms Ltd. Dr. W.S. Abutiate was also very instrumental in the training of farmers on forcing.	MoFA	Independent Researcher – Dr. W.S. Abutiate (Crop Research Institute), Nsawam Canneries Ltd, MoFA	Fully Adopted
1980	Planting of pineapple in rows. This was introduced by Nsawam Canneries. Mr. Toluchi was very active in training farmers on planting in rows.	MoFA	Nsawam Canneries Ltd, Independent Consultant – Mr. Toluchi	Fully Adopted
1980/1985	Use of tractor for ploughing and harrowing. This was introduced by Combined Farmers Ltd. The use of tractors during this period was not widespread among farmers.	Combined Farmers Ltd	Combined Farmers Ltd, MoFA	Partially Adopted
1986	Degreening. This was introduced by exporters and commercial farms.	Exporters	High-end European Supermarkets (Tesco and Marks & Spencer), Exporters	Fully Adopted
1987–1990	The institution of the Pineapple Production Expansion programme led by the Ministry of Trade and Industry (MoTI) and the Ghana Export Promotion Council (GEPC).	Ghana	MoTI, GEPC	Successful
1990	Fertilizer and Agro-chemical usage. The use of fertilizer was introduced by MoFA and commercial farms like Combined Farmers Ltd, Nsawam Canneries Ltd, and Kokobin Farms Ltd.	MoFA	MoFA, Combined Farmers Ltd, Nsawam Canneries, Kokobin Farms	Fully Adopted
1990	<i>Nnobia</i>	Farmer-led	Farmer-led, NGOs	Partially Adopted
1991–1999	Agriculture Diversification Programme – Horticulture Development Component led by GEPC and MoFA (\$16.5 million)	GEPC & MoFA	GEPC, MoFA, World Bank,	Successful
1993–1998	Introduction of the Trade and Investment Programme (TIP) by USAID	USAID, AMEX International	USAID, AMEX International	Successful
1998–2004	The continuation of TIP with a Trade and Investment Reform Programme by AMEX International, Technoserve, Care International funded by USAID (\$60 million)	USAID	USAID, AMEX International, Technoserve, Care International	Successful
1994	Dipping and Drenching. MoFA introduced this.	MoFA	MoFA, Department of Agriculture	Fully Adopted
1994	The establishment of the sea freight for export of pineapples known as Sea-Freight Pineapple Exporters of Ghana (SPEG)	USAID Trade and Investment Programme led by AMEX International	USAID, AMEX International	Successful
1994	Sea freight of pineapples commenced	SPEG, USAID, AMEX International	SPEG, USAID, AMEX International	Successful
1995	Decrowning. Exporters introduced this as a way of encouraging large fruit sizes and also meeting customer specifications.	Exporters	High-end European Supermarkets, Exporters	Fully Adopted
1997	Use of liquid fertilizer. This was introduced largely by farmers and MoFA supported it.	Farmer-led, MoFA	MoFA, Department of Agriculture, Farmer-led	Fully Adopted

(Continued)

Table 2: Continued.

Year of innovation	Type of innovation	Origin	Key Actors involved	Adoption intensity/success
1997	Use of Neem tree leaves (<i>Azadirachta Indica</i>) as an insecticide. This is a farmer-led innovation. It is a case of an individual farmer using this type of innovation. It is not widespread among farmers.	Farmer-led	Smallholder farmers	Discarded
1997/1998	Establishment of Blue Skies Ghana Limited – an agribusiness firm that processes fresh fruit cuts for export and domestic market.	United Kingdom (UK)	Blue Skies Ghana Ltd, Ghana Free Zones	Successful
1999	The establishment of Farmapine Ghana Limited – a farmer-owned company composed of five FBOs and two producers and exporter companies (Gabrho Ltd and Kokobin Farms) funded by the World Bank.	MoFA, World Bank, Government of Ghana, Ministry of Finance, FBOs	World Bank, MoFA, Ministry of Finance and Economic Planning, FBOs, Gabrho Ltd, Kokobin Farms.	Discarded/ Collapsed
1999	Grading. This involves the categorization of pineapple suckers into sizes, i.e., small, medium, and large. Farmers and MoFA introduced this.	MoFA	MoFA	Fully Adopted
1999	Use of recommended planting distance for cultivating pineapple. This was introduced by MoFA and also commercial farms.	MoFA, CRI	MoFA, CRI	Fully Adopted
1999	Planting pineapple suckers based on the gradient of the land. This involves planting big suckers at the apex of the slope, medium suckers at the mid base of the slope, and small suckers at the base of the slope. This is an innovation introduced by farmers.	MoFA, CRI, FBOs	MoFA, CRI, FBOs	Fully Adopted
1999	Global GAP Certification. Blue Skies Company Ltd was the first to introduce GLOBAL GAP certification to farmers. MoFA and NGOs such as TECHNOSERVE, care International, GTZ/GIZ, and Farmapine Ghana Limited vigorously trained farmers to become GLOBAL GAP certified.	GiZ, MoFA	MoFA, GiZ, European Supermarkets (Marks & Spencer, Tesco)	Fully Adopted
1999	Use of plastic mulch for cultivating MD2 pineapple variety. This was used on a small scale by very few farmers'.	MoFA, GAEC, Bomarts Farms Ltd	MoFA, GAEC, Bomarts Farms Ltd	Fully Adopted
1999	There was the introduction of the queen pineapple variety by Jei River Farms.	Jei River Farms	Jei River Farms	Discarded
1999–2005	Fairtrade certification by George Field Farms, Prudent Exports, Milani Ltd, Bomarts Farms Ltd, Jei River Farms, Volta River Estates Ltd, Gold Coast Fruits, Bio Exotica Co. Ltd.	European Supermarkets	George Field Farms, Prudent Exports, Milani Ltd, Bomarts Farms Ltd, Jei River Farms, Volta River Estates Ltd, Gold Coast Fruits, Bio Exotica Co. Ltd	Fully Adopted
2000	The establishment of the Export Development Agriculture and Investment Funds (EDAIF).	Government of Ghana	Government of Ghana	Successful
2000–2007	Establishment of the Cotonou Agreement that permitted the export of fresh fruit pineapples to Europe duty-free.	Government of Ghana, European Union	Government of Ghana, European Union (EU)	Successful
2002/2005	The introduction of MD2 by Del Monte from Costa Rica. MoFA imported large quantities for farmers and institutions like the Ghana Atomic Energy Commission (GAEC) and Bomarts Farms Ltd for multiplication.	MoFA, GAEC, Bomarts Farms Ltd	MoFA, GAEC, Bomarts Farms Ltd	Fully Adopted
2004/2005	Gouging by TIPCEE, GiZ, MoFA.	USAID-TIPCEE, GiZ, MoFA	USAID-TIPCEE, GiZ, MoFA	Fully Adopted
2002/2005	Bed making for the cultivation of the MD2. This was introduced by MoFA.	MoFA	MoFA	Fully Adopted

(Continued)

Table 2: Continued.

Year of innovation	Type of innovation	Origin	Key Actors involved	Adoption intensity/success
2004/2005	Use of cooling vans in transporting fresh pineapples to ports by Koranco Farms Ltd, Blue Skies Ghana Ltd, HPW, George Fields.	Koranco Farms Ltd, Blue Skies Ghana Ltd, HPW, George Fields	Koranco Farms Ltd, Blue Skies Ghana Ltd, HPW, George Fields	Partially Adopted
2006	Use of cassava peels as weedicide. This was introduced by an individual farmer. The innovation is not widely practiced among farmers.	Farmer-led	Farmer-led	Low
2007	The expiration of the Cotonou Agreement was continued with the Economic Partnership Agreement between Ghana and the European Union.	Government of Ghana	Government of Ghana	Successful
2008	Efficient marketing through the formation of marketing sub-groups within FBOs. Securing the market for produce even before the commencement of production. Better bargaining power within FBOs and fixing a common price for pineapple fruits within FBOs. This also involves comparing prices for agricultural inputs from different agri-inputs outlets before the purchase of inputs. MiDA introduced this.	MiDA	MiDA	Fully Adopted
2008/2012	Diversification of farm activities. MoFA introduced this.	MoFA, MiDA	MoFA, MiDA	Fully Adopted
2008/2012	Development of business plans. MiDA introduced this.	MiDA	MiDA	Partially Adopted
2008/2012	Value chain approach. MiDA introduced this.	MiDA	MiDA	Partially Adopted
2008/2012	Provision of packhouses for storage of pineapple fruits	MiDA	MiDA	Discarded
2013/2014	Drying of pineapple fruits by HPW, Bomarts Farms Ltd.	HPW, Bomarts Farms Ltd	HPW, Bomarts Farms Ltd	Partially Adopted
2016/2018	Green Label Certification. MoFA, GIZ/Hortifresh introduced this.	MoFA, GIZ/Hortifresh	MoFA, GIZ/Hortifresh	Fully Adopted
2019	Planting MD2 without plastic mulch but using cover crops and weeds as mulch	Prof. Kofi Boah/GIZ	Prof. Kofi Boah, GiZ	Partially Adopted

Source: Fieldwork, 2012/2016/2021.

Promotion Council in 1969, an autonomous institution that promoted the non-traditional export crops. The capacity of the CRI was strengthened in sucker multiplication and pineapple production. The initial approach used aligned with the Transfer of Technology (ToT) model, where a national research institute (CRI) took the lead in the technology development and subsequent transfer to farmers. There was full adoption by farmers, given the novelty of the crop and the lack of experience by farmers in the production. This shows that if innovation is new but profitable, coupled with farmers limited experience, it can probably enhance full adoption. Within the AIS⁷ lens, there was a strong relationship between research, farmers, and the limited actors in the chain that allowed an effective collaboration and networking among the actors. There is strength in numbers, but it often complicates relationships among actors. Effective coordination of actors in a chain is essential.

The long gestation period for the maturity of the pineapple fruits led to further research to reduce the gestation period. An innovation known as forcing came into practice in the 1960s. Forcing is the inducement of pineapple

plants to ripe uniformly using ethylene/calcium carbide (Espinosa et al. 2017). The forcing innovation was a collaborative research effort between Dr Abutiante, and the Ministry of Food and Agriculture (MoFA). Nsawam Canneries Farms Ltd contracted MoFA to undertake various studies into best agronomic practices associated with the production of pineapples. The output of this research work resulted in innovations such as planting in rows, use of recommended planting distance, and fertilizer usage. Planting in rows and recommended planting distance, was introduced by Nsawam Canneries Farms Ltd, MoFA, Dr Abutiante and an individual researcher – Mr Toluchi in 1999. Planting in rows was initially introduced to commercial farms and later to small-scale farmers. The initial planting distance was 1.2 metres by 1.2 metres, with an estimated plant population of 6800 per hectare. Given that most pineapples produced were meant for the export market, best practices formed a strong foundation for the production practices. Private sector actors, therefore, invested in public partnership with MoFA, Crop Research Institute, in determining the recommended planting distance required for optimum pineapple fruiting.

The Transfer of Technology (ToT) was the sole medium of technology dissemination. Consequently, national research institutions led supported by big commercial farms. Farmers, therefore, remained at the receiving end. However, innovations such as forcing, planting in rows remained fully adopted. The strict export requirement and the private sector financial investment into the sector could explain this. Additionally, the industry was relatively new, therefore farmers lacked adequate knowledge and experience in the sector and had to oblige with the best scientific practices. Innovations that appear novel tend to work with the ToT, but usually, when farmers get more experienced, the systems thinking could be helpful in dealing with the multiplicity of actors involved. In a focus group discussion with Fotobi FBO, they indicated that:

We remember that the pioneers in pineapple cultivation told us that they learned about sowing in rows from the big commercial farms in the municipal, some farmers who also worked as labourers on the big commercial farms learned how to sow in rows and the recommended planting distance. They simply transferred this information to other farmers. (Fotobi FBO, FGD/ 8th/02/2012)

From 1980 to 1985, Combined Farmers Ltd pioneered the use of farm tractors for ploughing and harrowing. The use of tractors during this period was not widespread among commercial farms. Generally, its adoption remained relatively low or partial but popular among the commercial farms. Factors accounting for the low adoption included the high financial capital needed for purchases of tractors. The government, in bridging this gap launched input subsidies on tractor purchases and the establishment of agricultural mechanization centres (Diao and Takeshima 2020). The affordability of technology significantly affects the adoption of a given technology, and a useful lesson is to consider simple and affordable technologies. The use of systems thinking can pick up such valuable information from key actors in reflective processes that could probably generate cheaper and simple tractors that properly address smallholder needs. Farmers in a focus group discussion reported that:

We did not have the money, and even for the few who had money to purchase tractors, they did not know where to purchase the tractor. More so, we could not operate a tractor even if we did purchase one. It was Combined Farmers Ltd that first brought tractor into our community, so the workers that they employ to work on the tractor taught us how to operate tractors over time. (Apesika FBO, FGD/ 12th/02/2012)

Another milestone that featured in 1986, was the innovation of degreening. The quest to attain uniform ripening led to inducing uniform ripening of the pineapple fruits with ethylene known as degreening. This innovation originated from exporters and high-end European supermarkets (e.g., Tesco and Marks & Spencer), and both commercial farms and smallholder farmers implemented it. This innovation was not a requirement for the domestic market. However, fruits that did not find their way on the export market had to be diverted to the local market even though such a technology did not readily serve the needs of the local market. The export market drove the

pineapple industry and continues to influence the domestic market in the present day time. This has not completely departed from Ghana's agricultural food system influenced by colonialization and the liberalized market system. Degreening was fully adopted because it was an export market requirement. Non-compliance meant low prices for pineapple fruits because of the non-competitive prices offered by the local market. At the time, few processing companies existed, so basically, value addition was not an option. Most commercial farmers and smallholder farmers produced fresh fruits for the export market. A useful lesson is to develop the domestic market to absorb rejected pineapple fruits that do not meet the export market. This can offer competitive prices similar to what the exporters offer. This implies creating domestic demand for pineapple juice. Actors in the pineapple value chain need to interact in a reflective manner (systems thinking) on how best to harness the optimum domestic benefits from pineapple production through processing to offer competition.

In 1987, the Pineapple Production Expansion programme was established led by the Ministry of Trade and Industry (MoTI) and the Ghana Export Promotion Council (GEPC) with the main objective of scaling up pineapple production. This remained successful in providing the needed regulatory framework.

Farming in rural areas is characterized by communal living. The communal living arrangements influenced an innovation known as *Nnobia*.⁸ This practice gained prominence in the 1990s. The *Nnobia* practice was widely reported among the MiDA FBOs. This observation can be attributed to the importance that the MiDA programme placed on the *Nnobia* practice during the farmers training programme. Interestingly, *Nnobia* innovation was pioneered by farmers, indicating that farmers self-innovate. This resonates with findings (Ankrah and Freeman 2021; Ankrah 2014) that showed that farmers self-innovate. The *Nnobia* practice gained less traction partly because agriculture is recognized as a business involving heavy reliance on hired labour. It was reported in an interview with a representative from the Department of Agriculture that:

Nnobia practice is less dominant among farmers' because farming has witnessed a transformation to the level where farmers approach farming as a business. Pineapple produced in the districts goes to supermarkets hence, farmers have seen the need to approach it as a business. Additionally, farmers involved in pineapple production are better off than food crop farmers. Therefore, they can afford the services of hired labour. (DoA KII, 8th/02/2012)

In a focus group discussion, farmers corroborated that: *Nnobia practice has diminished from our system gradually. In the 1990s it was widely practiced among farmers, and it saved us labour costs. Currently, most farmers prefer to use the services of hired labour on our farms. Sometimes, most farmers produce generally around the same time, so relying on peer farmers as labourers on farms does not appear convenient. (Apesika FBO, FGD/ 12th/02/2012)*

This phenomenon, to some extent, increases production cost because labour cost, which would have otherwise been free, has to be paid. Conversely, other farmers who

work as labourers make economic gains through their services as hired labourers. This innovation was fully adopted in the 1990s, but it became partially adopted in the 2000s when the pineapple industry became more profitable, hence farmers could easily afford the services of hired labourers. The MiDA programme later on (2008) re-ignited the implementation of *Nnobia* among the MiDA FBOs. This innovation is however, received partial adoption. The *Nnobia* was partially adopted, implying that farmer-led innovation does not necessarily lead to full adoption even among farmers. A complex set of factors intersects to influence adoption, and efficient networking, and collaboration among actors help with the success or otherwise of innovation. System thinking appears useful in facilitating innovation.

In the 1990s, there was increased production of pineapples in the study area which led to the MoFA and commercial farms like Combined Farmers Ltd, Nsawam Canneries Ltd, and Kokobin Farms to introduce the use of fertilizers and various agrochemicals. Fertilizers during this period were not used in substantial quantities since most farmlands were fertile. Given the commercial nature of pineapple production, the need to meeting export demand obliges the intensive use of agrochemicals. This was led by MoFA/DoA, Combined Farmers Ltd, Nsawam Canneries Ltd, Kokobin Farms Ltd. This was fully adopted by most farmers due to the knowledge given by national research institutes about the best agronomic practices. Farmers had no issues with the export rejection of the pineapples fruits. This bolstered the confidence in the use of agro-chemicals. The innovation was fully adopted.

In 1991–1999 the Ghana Export Promotion Council spearheaded the agriculture diversification programme – horticulture development component with a World Bank, IDA \$16.5 million credit facility that targeted horticulture development. A horticulture unit was established under MoFA that ensured the implementation of horticultural sector development programmes. The project achieved success in promoting the horticultural sector.

1993–1998 also witnessed the introduction of the Trade and Investment Programme (TIP) funded by USAID but implemented by AMEX International. It targeted export industries, horticultural crops, and provisioning of finance for value chain actors. The programme was successful and led to a continuation of the Trade and Investment Reform Programme.

In 1998–2004 based on the success of TIP, the Trade and Investment Reform Programme focused on the inclusion of private sector actors. This was led by Technoserve, AMEX International, and Care International with funding (\$60 million) from USAID. Provision of funding is an aspect that is usually neglected in most programmes. Production tends to be over-emphasized in government programmes. This programme, therefore, targeted micro-enterprises and smallholders into production and marketing targeted value chains for exports. From an AIS perspective, it was good integrating the private sector and financial components into the value chain, particularly in addressing marketing constraints. This programme was also successful.

MoFA's continuous engagement with farmers' led to the introduction of dipping and drenching in 1994. Dipping is done before the pineapple suckers are planted, whereas drenching is done after planting the pineapple suckers. Dipping involves placing the pineapple suckers into a mixture containing fungicide, while drenching involves placing the suckers in an insecticide to prevent insect damage to suckers. This is an innovation that emanated from formal science (National agricultural research systems – Crop Research Institute, Food Research Institute). MoFA implemented this, and it was fully adopted by farmers because it minimizes losses due to insects and fungicide attacks. Adoption, was however low among few low-resourced farmers. The cost associated with technologies is a valuable factor to consider in the introduction of a given innovation. This should be a useful starting point and lesson for future innovations within the remit of systems thinking.

In 1994, there was the establishment of the Sea-Freight Pineapple Exporters of Ghana (SPEG) tasked with the responsibility of the sea freight export of pineapples. Whitfield (2017) confirmed SPEG formation in 1994. The pioneering members of SPEG were John Lawrence Farms, Jei River Farms Ltd, Integral Farms Ltd, Combined Farmers Ltd, and Greentext Farms Ltd. The Horticulturists Association of Ghana (HAG) collaborated closely with SPEG since members of SPEG were incidentally members of HAG as well. This was led by SPEG and AMEX International with funding from USAID. SPEG achieved success which has been sustained till now. There is however, weak coordination with smallholder farmers. This needs addressing in improving actor networks and linkages in encouraging reflective thinking.

In 1995, decrowning was introduced. Decrowning involves removing the crowns of the pineapple fruits to induce bigger fruits and reduce crown sizes. Decrowning is performed with a gouging tool to remove crowns from the pineapple fruit. It emanated from exporters who conformed with the requirements from European retail outlets (supermarkets – Marks & Spencer, Tesco). The practice of decrowning was fully adopted among FBOs. The supermarkets ensured strict conformity to decrowning as an export requirement, failure to do so resulted in the rejection of pineapple fruits. This, therefore, obliged farmers to produce according to specification. This points to the direction that stringent export requirement is a factor that facilitates the adoption of innovation.

In 1997, the pineapple industry witnessed liquid fertilizer application. This was in response to boost the commercial production of pineapple in the Nsawam Municipal. Farmers became more innovative as a result of the high expenditures associated with the use of solid fertilizers. The liquid fertilizer came up as a way of minimizing fertilizer expenditure. It involves the mixing of solid fertilizer with an insecticide. The liquid fertilizer also constitutes a mixture of solid fertilizer and water. This affords the fertilizer or mixture to be applied to a larger area in smaller or appropriate quantities compared to solid fertilizer. This was a farmer-led innovation that had its efficacy confirmed by the MoFA and the Department of Agriculture – Nsawam Municipal Assembly

and subsequently approved. In a key informant interview with an officer with the Department of Agriculture, it was reported that:

Farmers informed us about a practice that they carried out by mixing solid and liquid fertilizer, as a department we carried out trials on a demonstration farm, and we have seen the merit in it, so we have approved for farmers to use. (DoA/ KII, 12th/02/2012)

The use of liquid fertilizer indicates how farmers self-innovate and collaborate with MoFA and DoA in facilitating innovation. More such collaborations are needed to confirm farmer-led innovations. This innovation, therefore, was fully adopted among FBOs. Farmer-led innovations usually receive full adoption, even though this is not given. This is seen in the next innovation (Neem tree leaves).

The use of Neem tree leaves as an insecticide came up in 1997 as well. This involves the grinding of Neem tree leaves and mixing with water. The use of Neem tree leaves was, however not widespread among FBOs. It constituted an isolated case of an individual farmer innovating. This confirms findings by (Ankrah, Freeman, and Afful 2020; Ankrah 2014; Ankrah and Freeman 2021) that indicated that farmers self-innovate. The low adoption of this innovation could be attributed to the ease of getting commercial quantities of the Neem tree leaves. This makes the innovation beneficial but not one that can easily be up-scaled. A useful lesson, is however to consider the commercial production of Neem trees to serve this purpose. Actors in the pineapple value chain need to reflect on this from an AIS perspective leading to the generation and use of innovation. The universities and research centres can undertake a benefit–cost analysis of this innovation relative to the inorganic insecticides. This is useful given the current drive for organic production.

In 1997/1998, Blue Skies Ghana Ltd was established as an agri-business company exporting fresh fruit cuts to the United Kingdom (UK). The agribusiness is still in existence and strongly shaping fresh fruit pineapple export and processing in Ghana. The company's success can partly be attributed to the private foreign and domestic partnership between a Ghanaian and British entrepreneur, i.e., it is entirely private-sector led and devoid of government direct control and leadership.

In 1999, there was the establishment of Farmapine Ghana Ltd. This was modelled around a farmer-owned company (cooperative-based); therefore, it was composed of 5 FBOs made up of 450 farmers, medium-scaled producer-export companies (Kokobin Farms Ltd & Gabrho Ltd). The Ministry of Finance secured a loan of \$1.5 million from the World Bank. Farmapine recorded growth and success from its humble beginnings. Indeed, between 1999–2004, the company accounted for a 23.5% market share of fresh pineapple exports in Ghana. It was the second- largest exporter of pineapples in the year 2000 (Kolavalli 2019). The success was, however not sustained due to bad governance, high operating costs, management challenges, diversion of fruits by FBO members, low input recovery from farmers, etc.

Perhaps, the Blue Skies Ghana Ltd model can be studied to provide valuable lessons on how the company managed to thrive throughout its inception. Such a useful lesson is what the innovation history seeks to document for the agrarian change and innovation literature.

The grading of pineapples was introduced in 1999 by MoFA. The grading of suckers involves the categorization of suckers into small, medium, and big suckers. Generally, both categories of farmers practice grading because it allows for the uniform growth of suckers. This eventually helps in the harvesting of the pineapple fruits at a uniform time. Farmers in 1999 brought up the innovation of planting pineapple suckers on the land area based on the gradient of the land surface. The bigger suckers are planted at the apex of a slope; the medium suckers are planted at the mid-base of a slope, with smaller suckers planted at the base of a slope. The rationale is that the smaller suckers use the soil nutrients that are leached to the base of the slope. This innovation was fully adopted among both the MiDA and non-MiDA FBOs. The topography of the land for pineapple cultivation coupled with the fact that farmers easily resonate with this innovation constituted some plausible reasons for the high adoption rate among FBOs. It came up from the FGDs that both FBOs practiced this innovation on their farms.

In a FGD with an FBO that did not benefit from the MiDA programme, farmers indicated that:

We learned how to grade pineapple suckers from Ata Mudzi Farms. News spread among us that small suckers have to be planted at the base where the farmland has a slope, the bigger suckers need to be planted at the apex of the slope. This is because, in the case of run-off leading to leaching, the smaller suckers at the base of the slope can benefit and catch up in growth with the bigger suckers planted at the apex of the slope. (Enkakyi Cooperative, FGD/6th/December/2011)

In another FGD with a MiDA FBO, farmers indicated that:

The Department of Agriculture around 1999 taught us that we needed to grade our pineapple suckers before planting. The rationale underlying grading was to plant smaller suckers at the base of slopes and the bigger suckers at the apex of the slope. (Nsabah FBO, FGD/ 8th/02/2012)

In 1999, farmers were introduced to the recommended planting distance based on trails led by Dr. Abutiati of CRI. Pineapple plants were spaced 60 cm between rows and 90 cm apart. A spacing of 45 cm was recommended within rows. This innovation was fully adopted, given its novelty and farmers' inexperience.

Civil society organizations, mainly Non-Governmental Organizations (NGOs), greatly influenced the commercial production of pineapples and the improvement in the livelihoods of the rural poor small-scale farmer. The quest to improve farmer livelihoods in the past triggered lots of capacity-building programmes. The training involved training in proper farm record-keeping, training in Global Good Agricultural Practices (GlobalGAP). In 1999, NGOs such as TECHNOSERVE, Care International, Gesellschaft für Internationale Zusammenarbeit (GTZ/GIZ) trained farmers' on record keeping and Global

GAP/EUREPGAP⁹ certification. Whitfield (2012) indicated that Global GAP strict compliance, however become more effective in 2005. Farmapine Company Limited,¹⁰ and MoFA also corroborated the efforts of these NGOs in their training programmes. Indeed, studies (Fold and Gough 2008; Kleemann, Abdulai, and Buss 2014; Krumbiegel, Maertens, and Wollni 2020) gives credence to this funding of capacity building by civil society. The Global GAP innovation was fully adopted among farmers against a background that it became a pre-requisite for exports of fresh pineapples. Farmers were therefore obliged to conform to the stringent standards. This points to the direction that, when strict measures are enforced, farmers conform. This can be a useful lesson in the innovation literature.

In 1999, few farmers were introduced to the cultivation of the MD2, even though the variety existed in 1961 through the invention by the Pineapple Research Institute (PRI) in Hawaii. The research institute was created by Maui Pineapple Company, Del Monte, and Dole. However, Del Monte Company patented and commercially produced the MD2 on the world market in 1996 (Paniagua-Molina and Solís-Rivera 2020). The creation of the MD2 signals the resolve of the private sector in innovation. The use of the MD2 during this period was not widespread among Ghanaian farmers'. The MD2 became more prominent in 2002/2004 due to the shift in consumer preference for this variety (See Table 2). MoFA imported commercial quantities of the MD2 pineapple suckers from Costa Rica and tasked institutions such as the Ghana Atomic Energy Commission (GAEC), Bomarts Farms for the commercial multiplication of the suckers. Farmers were also introduced to the construction of beds to cultivate MD2 in the same year (2002/2004). The MD2 was fully adopted because it became the preferred variety on the export market, hence farmers were compelled to produce. Taste and preference on the international market constitute a significant drive in shaping the pineapple innovation literature. It is helpful for new entrants to monitor international preferences and shifts to keep abreast with international demands. The systems thinking will permit early signals to be picked up for stakeholders to conform or contest.

In the year 2004/2005, there was the introduction of cooling car vans that cooled the fresh fruits pineapples up until the airport. Controlling respiration leads to maintaining good quality fruits. Higher temperatures influence the respiration process, therefore cooling minimizes the rate of respiration and prevents fruits deterioration (Behdani, Fan, and Bloemhof 2019). Cooling vans were implemented by well-endowed and established farms/producers, such as Koranco Farms Ltd, Blue Skies Ghana Ltd, HPW, and George Fields. The innovation was partially adopted since the innovation targeted a few high-end supermarkets in Europe. The cost and the unstable electricity supply contributed to making the innovation unpopular. These challenges need addressing from the system thinking perspective.

In 2004/2005, gouging was introduced. This involves forcing plantlets to develop through the destruction of the apical growing point (eye) of the vegetative plants with a

crow metal bar or iron rod to trigger the growth of lateral buds. This prevents the plant from bearing flowers and fruits but rather channels such nutrients into the formation of suckers (Muimba-Kankolongo 2018). This innovation increased significantly during the introduction of the MD2 when there was the need to multiply more planting materials. Ankrah, Boakye, and Agyei-Holmes (2021a) showed that the multiplication of pineapple suckers is a viable business that generates comparative farm profits even though it is neglected. This was introduced by GiZ, USAID Trade and Investment for a Competitive Export Economy (TIPCEE), and MoFA. This innovation was fully adopted, given the need to multiply more MD2 varieties. Demand for products is a major driver for innovation. It is therefore vital to create a sustained demand for products through systems thinking.

In 1999, Jei-River Farms introduced the queen pineapple variety. Different variants exist with the queen variety. For instance, Victoria (Queen) is prominent in Saint Pierre, Reunion Island, South America (Soler et al. 2021), Honey Queen is famous in Indonesia (Afifah 2020) and the Tripura Queen variety is prominent in north east India (Das et al. 2021). However, these varieties fizzled out quickly on the Ghanaian production sites because they appeared not to be a preferred variety in the export market destinations. The taste and preferences of consumers are important factors to consider according to the adoption literature. This innovation was therefore discarded based on a low consumer preference for the variety. The use of systems thinking would have otherwise have identified an apparent dislike of the variety in Ghana's export destinations. Weak linkages and coordination among actors need addressing.

In 1999–2005, Fairtrade certifications were introduced as a direct fall-out from the GLOBAL GAP/EURPGAP certifications. Fairtrade is a trading partnership based on mutual benefit and respect that seeks to ensure equity in countries where pineapples are produced through transparency in minimizing inequalities in North–South trade (Raynolds 2020). Actors along the value chain must be certified by Fairtrade Labelling Organizations International (FLO). This was led by George Field Farms, Prudent Exports, Milani Ltd, Bomarts Farms Ltd, Jei River Farms, Volta River Estates Ltd, Gold Coast Fruits, and Bio Exotica Co. Ltd. This helped to provide social amenities, such as toilet facilities, supply of books and computers to schools, and scholarship schemes that supported brilliant but needy children, etc., in the communities where production took place. Some challenges included meeting compliance, i.e., certification cost and how this translates into sustainable production without excessive spending on certification. This notwithstanding, the Fairtrade market offered higher prices than the conventional ones. This innovation was fully adopted given the higher prices offered, it attracted more farmers. Additionally, the money for community development incentivized farmers. Stakeholder incentives need to be given recognition within systems thinking in facilitating innovations.

In the year 2000, there was the establishment of the Export Development Agriculture and Investment Funds

(EDAIF) by the government of Ghana to provide dedicated finance to the pineapple sector players to make smallholder farmers more competitive. The EDAIF transformed into the Ghana EXIM Bank in 2016 with a mandate to position Ghana as an export-driven economy. Despite the EDAIF support for farmers, the export sector did not perform creditably against the benchmarks expected (Appiah et al. 2019). This signals an increased need for incorporating systems thinking into development programmes that allow for reflective thinking and remedial actions.

From 2000 to 2007, the establishment of the Cotonou Agreement permitted the export of fresh fruit pineapples to Europe duty-free. This agreement was facilitated between the government of Ghana and the European Union (EU). This was successful, and it enhanced increased exports to the EU. This agreement benefitted most exporters to increase exports to the European market. Weak linkages among the value chain actors did not allow other actors to have mutual benefits. There was an unbalanced benefit that advantaged the exporters. A useful lesson is to harness the full benefits of the value chain and allow for effective forward and backward linkages among the actors. In this direction, reflective learning processes are encouraged.

In 2006, farmers came up with an innovation of removing basal leaves of pineapple suckers before planting. This practice helps to hasten the growth of the pineapple suckers. A farmer introduced this innovation in 2006 but did not receive the needed patronage because of its laborious nature. It appears time-consuming to peel off the basal leaves for thousands of suckers. This innovation, therefore, was not fully adopted. Another farmer also introduced the use of cassava peelings to smother the growth of weeds on his farm. This innovation did not gain traction among farmers. The use of cassava peelings serves a dual purpose; first it helps smother weeds, and secondly helps to fertilize the soil. The practice involves spreading cassava peelings in rows to a thickness of one inch on the land surface. The cassava peelings are just left on top of the soil to decompose. The more the cassava peelings keep on decomposing, the more one has to keep on topping up to maintain the one-inch thickness. The use of cassava peelings helps one to harvest without weeding the farm. The use of cassava peelings also helps to trap water vapour which helps to conserve soil moisture. The use of cassava peelings could be done twice yearly. It is interesting to observe self-innovations put forth by farmers giving credence to the notion that they self-innovate, as confirmed by Ankrah and Freeman (2021). It is therefore imperative to consider farmers' innovation to be non-trivial in the design of technologies. Indeed, Kwabong et al. (2020), in their study, found peer-to-peer learning as an important source of agricultural extension. Some of the relevant literature (Ankrah 2014; Tambo et al. 2020; Shah, Grant, and Stockmayer 2016) shows that farmers self-innovate. Innovations that are laborious and time-consuming need addressing to facilitate innovation adoption.

The application of cassava peelings can be undertaken on a particular land for five years. In the subsequent years,

once the cassava peelings have been used, there is no need to apply chemicals to supplement the control of weeds on the farmland. The farmer who brought up the innovation explained that there is no known side effect using the cassava peelings as weedicide since he started using it. However, the farmer indicated that in swampy soils or muddy soils, the application of the cassava peelings could lead to the growth of maggots which can impede the successful use of the cassava peelings as a weedicide. The adoption of this innovation, however, was low among farmers because the municipal is not a major producer of cassava which brings into question the ease of accessing enough quantities of the cassava peels for upscaling. Access to commercial quantities of raw materials is an important consideration for innovation adoption and upscaling. Valuable lessons need to be drawn from this from the system thinking perspective.

In 2007, the Cotonou Agreement expired, and it was continued with the Economic Partnership Agreement (EPA) between Ghana and the European Union (Hurt 2020). This partnership was successful, but it primarily benefitted exporters at the expense of the value chain actors. Actors' interests need to be fairly managed and aligned with other actor interests in ensuring innovation adoption.

From 2008–2012, MiDA facilitated innovations such as efficient marketing, diversification of farming activities, the development of business plans, and the value chain approach among FBOs. Both MiDA and non-MiDA FBOs engaged in FGDs attributed the source of these innovations to be the intervention from the MiDA programme. This is corroborated in other studies (Abdul-Rahaman and Abdulai 2018; Ankrah and Freeman 2021). Efficient marketing involves forming a marketing sub-group to bargain for better and fairer prices for the fruits. MiDA FBOs were introduced to the idea of securing a market for their pineapple fruits even before the start of production. This involves signing a contractual agreement between the FBO member and the exporter or buyer to harvest agreed quantities of the pineapple fruits. MiDA FBOs, given their capacity building, compared prices of agri-inputs from different market outlets before making purchases.

Diversification of farm activities involves ploughing back profit from one farming activity into either a farm or non-farm activity. Funding for diversification could also be borrowed capital. This would help to secure diversified sources of income for the farmer. The development of a business plan involved production activities and the associated expenditures that need to be presented to a financial institution for a loan. FBOs did this innovation collectively but largely failed due to the inconsistencies between the requirement expected by the financial institutions and what the outcomes farmers achieved in the technical training they received from service providers (Ankrah and Freeman 2021). The value chain approach involved recognizing the various activities involved in pineapple production and how a farmer can be well positioned to add value to the various production segments involved in the chain (see Table 2). The value chain approach was partially adopted because of differential

actor interest, and inadequate money to facilitate strong linkages among actors and actors who do not mutually interact. The full or partial adoption of innovation needs to address challenges among actors, and the systems thinking affords a platform for reflecting thinking among actors in addressing bottlenecks.

In 2008–2012, MiDA facilitated the provision of packhouses to store pineapple fruits before export to the countries of destination. The location of the packhouses appeared inappropriate. This is because farmers preferred a location close to Accra, where fruits stored could easily be transported to the port or Accra for final distribution to destinations. This rendered the use of the packhouses non-effective in achieving its intended purpose. It is important to draw useful lessons in engaging value chain actors in reflective processes to have a broader consensus on deciding on the location of communal projects. Even though it is generally difficult to achieve consensus among stakeholders, it appears to be a helpful resort in innovation adoption. This innovation was not fully adopted/discarded.

In 2013–2014, HPW and Bomarts Ltd introduced the drying of pineapple fruits. This innovation was partially adopted. It was not fully adopted owing to the small market share of dried pineapple fruits. Consumers' taste and preference for fresh pineapples far outweighed their desire for dried ones. Drying, however preserves the pineapple fruit and improves shelf life. The integration of systems thinking can help upscale this technology adoption since this innovation provides a solution to the perishability associated with the fruit.

In 2016–2018, green label certification was introduced by MoFA, Hortifresh, Ghana Standards Authority, Trade Related Assistance and Quality Enabling Programme (TRAQUE) of the European Union, Christian Aid, Quin Organics, Agro Eco Louis Bolk Institute, and GiZ – Market Oriented Agriculture Programme (MOAP). This was intended to promote safe food production, distribution, and post-harvest handling through sustainable agricultural practices. This innovation is fully adopted and even gaining ground in the domestic market. This is because pineapple fruits that are green labelled certified have a better shelf-life. Unlike other innovations, the green label targets the local market as an entry point to reach out to the international market.

In 2019, Prof. Kofi Boah and GiZ introduced the planting of the MD2 variety without plastic mulch and raised beds. This innovation involves using natural cover crops such as *mucuna* and weeds to serve as mulch to smother weeds. This innovation is partially adopted (see Table 2). This is because most farmers are already used to planting the MD2 with plastic mulch and raising beds. With time given the cost-saving component, smallholders, in particular, are expected to adopt fully. Information asymmetry is affecting upscaling. This needs addressing from the systems thinking perspective.

Conclusion

Smooth cayenne and MD2 constitute the dominant pineapple varieties cultivated in commercial quantities in the

Nsawam Municipal Assembly. Main actors associated with pineapple innovations include agribusiness (Nsawam Canneries Ltd, Milani Ltd, Bomarts Farms, Gold Coast Fruits Ltd, and Blue Skies Ghana Company Limited), Crop Research Institute, exporters, the Ministry of Food and Agriculture, Ghana Export Promotion Council/Authority, Department of Agriculture under the decentralized Nsawam Municipal Assembly, commercial farms (Kokobin Farms, Prudent Farms, Georgefield Farms, Combined Farmers Ltd, Koranco) and NGOs (GiZ, Technoserve, Care International). Farmers were found to self-innovate as exemplified in innovations such as *Nnobo*, removal of the basal leaves of pineapple suckers, the use of Neem tree leaves as an insecticide, and cassava peelings in smothering weeds. The adoption of these innovations, even though farmer-led, did not result in full adoption. Getting adequate raw materials for commercial up-scaling is a major driver for innovation adoption. However, the recognition and harnessing of the ideas and knowledge of farmers remain essential, but it can potentially be lost unless a rigorous effort is made to document an innovation history that can guide actors in Ghana's pineapple value chain and, by extension, in sub-Saharan Africa. Given the system thinking framework, it is important to include all the multiple value chain actors in knowledge generation and use reflectively in facilitating agricultural innovations' adoption.

The MiDA programme consolidated innovations such as business plan development, efficient marketing, diversification of farming activities, and value chain approach to agriculture. Global Good Agricultural Practices (GAP) remained a dominant standardization requirement. The study finds a vacuum in pineapple innovation history even though pineapple constitutes one of the most developed non-traditional export crops in Ghana, thus Fold and Gough (2008), Kleemann, Abdulai, and Buss (2014), Krumbiegel, Maertens, and Wollni (2018) have attempted to document Ghana's pineapple history. However, their studies remained partial and non-coherent in systematically presenting a chronology of Ghana's pineapple innovation history. The use of innovation history affords rich documentation of origin, year of innovation, and all innovations in the pineapple value chain. Finally, the innovation history provides evidence that can help actors in the pineapple industry to co-learn by either studying single cases or comparing past experiences with a shared vision that can potentially propel a mechanism for change, as supported in the earlier work of Douthwaite et al. (2006). Even more compelling is embedding innovation history in an agricultural innovation system conceptual framework.

A recommendation is made that the innovation history methodology is used radically to help stakeholders in the pineapple value chain to document and co-learn, and to provide new entrants an opportunity to understand the industry, including challenges and how innovations emerged that can shape the future of the pineapple value chain (input supply, production, distribution, processing, marketing, and post-harvest technologies) and agrarian change. This is essential in the global south, where copious record-keeping is limited among smallholder

farmers and the broader value chain actors, thus emphasizing the need to embrace innovation history as a useful agricultural methodology in the global south. Beyond Ghana, African governments, smallholder farmers, national research institutes, policymakers, and all other pineapple stakeholders are encouraged to make deliberate efforts in a reflective manner that inclines towards the Agricultural Innovation System conceptual framing to promote profitable innovations that will inure particularly to smallholder farmers who often remain disadvantaged in the value chain.

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Notes

1. In this study, we consider the AIS, also known as systems thinking (the two terms are used interchangeably) to include all pineapple value chain actors. An examination is made about the type of relationships existing, the level of interaction among actors that leads to the generation and use of knowledge, processes involved in knowledge generation, who champions innovation, what influences innovation generation and use, the level of reflectivity involved in the processes leading to the generation and use of knowledge. Inferences are made about valuable lessons derived from the level of adoption or otherwise of varied pineapple innovations.
2. Nvivo is a software program used to analyze unstructured text, images, videos, and audio information within the qualitative research domain.
3. In the 1980 and 1990s, Combined Farmers Ltd was the largest producer, and exporter of fresh pineapples in Ghana.
4. Farmapine is no longer in operation.
5. Nsawam Canneries Ltd was a government-owned fruit processing company engaged in canning pineapple juice for the export and domestic market.
6. Fante is a local name meaning the local dialect for the people hailing from the Central Region.
7. The Agricultural Innovation System (AIS) is also known as systems thinking.
8. *Nnobia* is a group practice where individual farmers come together to constitute a group to weed each other's farm in an agreed successive arrangement.
9. GLOBALGAP constitutes a private standard established in 1997 as EurepGAP by a collection of European retailers. The standard has the sole aim to establish a universal standard for Good Agricultural Practices (GAP) (Kleemann, Abdulai, and Buss 2014).
10. Farmapine Company Limited was a farmer-owned company established in 1999 with funding from the World Bank (Fold and Gough 2008).

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