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Strategic Management for Systems Archetypes in the Piggery Industry of Ghana—A Systems Thinking Perspective

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Abstract: Ghana is predominantly an agricultural country with a clear majority of its population depending partly or fully on agriculture for their livelihoods. Pork consumption in Ghana is on the increase and the livestock industry is a key sector of alternative agri-business for farmers looking for profitable business ventures and household income. The growth of Ghana's domestic piggery industry has been impeded by several constraints such as inadequate information, lack of improved breeding stock, land limitations, rising feed cost and water availability. In this research, systems models provide an understanding of the interconnectedness and relationships present within the piggery industry of Ghana. The Industry's problems were pooled together and key factors identified, whose behavior over time causes problems by developing various individual two-loop system archetypes coupled with a list of sustainable management strategies. Also, the individual variables affecting the industry were consolidated to obtain a causal loop structure and behavior-over-time graph of the piggery industry. The system archetype developed here is generic enough to explain any productivity decline and business rivalry behavior of any agribusiness industry. The proposed archetype can also help farm managers and producers to make various decisions. The system archetypes contribute effectively to understanding the root cause of challenges rather than providing quick fixes 'now' which gives rise to a much bigger problem to fix 'later'. Application of CLDs models and system archetypes can help farmers and policy makers understand the behaviour of the entire complex piggery systems that will aid in more clarity and consistency in decisions and policy objectives. This will close the gap of inadequate information both to farmers and policy makers and governance. Through the archetypes and the CLDs, it has been identified that using a systemic approach in addressing the problems could lead to the provision of adequate data and management strategies for effective decision making for improving the piggery/livestock industry.

Keywords: systems thinking; piggery industry; piggery management; livestock management; pork consumption; Ketu Pig Farmers; BNARI piggery

1. Introduction

Approximately sixty percent of rural households in developing countries are partially or fully dependent on livestock for their livelihoods [1]. Livestock rearing provides the household with a wide range of benefits, such as cash income, food, manure, draft power and hauling services, savings and insurance, and social status [2]. The livestock farming sector, including piggery remains critically important for millions of people in developing countries including Ghana and developments within this sector are most important in terms of attaining the sustainable development goals (SDGs), goals of no poverty [3,4].

In Ghana, the Agriculture sector growth rates declined from 4.6 percent in 2014 to 0.0 percent in 2015. Of all the agriculture activities the livestock subsector recorded the highest growth of 9.3 percent in 2015 [5]. The piggery sector which contributes to household income, is one of the fast growing sectors of the livestock industry because of increase in pork consumption [6,7]. Pork production rose from 11,173 MT in 1999 to 17,512 MT in 2009 with pork production index ranging from 98 to 154 within the same period. Pork import in Ghana rose from 358.1 MT in 2000 to its peak of 13,290.5MT in 2006 and dropped to 3150.2 MT in 2009 [8]. Piggery represents a form of cash security of the livelihood strategies of many farmers and plays a central role in their socio-economic and cultural identity, and is a source of food, employment, food security and also assets for store or trade [6]. Livestock and crop production contribute 66.8% to agricultural GDP in Ghana [8]. The multiple roles of pig rearing and other indigenous livestock breeds are significantly acknowledged in different farming systems of Ghana including the intensive, semi-intensive and free range systems. The growth of Ghana's domestic piggery industry has been impeded by several constraints such as lack of improved breeding stock, the balance between the limitations and availability of land and water, rapid urbanisation processes, pollution and lack of managerial skills [7,9]. The industry is also affected by diseases caused by the PRRS virus, PCVD virus, Classical Swine Fever (CSF) Viral diarrhoea in piglets, Aujeszky's Disease virus or pseudorabies, Foot-and-Mouth Disease (FMD) virus, and of secondary importance, bacterial diseases [10–12]. As a result, pig production in Ghana is reflected in numerous research and development (R&D) projects, a vast number of grants, research projects and other activities developed by the government to support the piggery industry [13–15]. Their contribution to household food security and income as well as their social roles is well known; however, improvement of their productivity through crossbreeding, improved health and nutritional management are also concerns of many livestock development plans through national and international programmes [16–18]. Pig production, therefore is an integral part of Ghana's agri-business activities and a major source of livelihood for many entrepreneurs seeking an alternative source of profitable business ventures [6,7,16]. However, most Ghanaian entrepreneurs enter this business based on a survival driven motive without adequate knowledge and a business plan leading to subsequent business failure.

Apart from the question of competition for human staples, pigs are generally more efficient than ruminants as converters of food into flesh. A high proportion of Ghana's pork, up to 95%, is raised by farmers in small-scale (20–100 pigs) commercial operations and backyard outfits involving a handful (1–20) of pigs [6,19]. Large-scale private pig enterprises involve several hundreds of pigs with varieties of breeding stocks but with the Danish large white dominating. These farmers are acutely sensitive to the movements in price that determine their profit or loss margins. The two most important variables: the price of pork (the output) to the price of corn (the input) ratio of 6:1 is enough for pig farmers to break even [6,20]. Within the food industry, pork prices are particularly volatile [21–23]. In March 2009, the increase in pig population rose by 35% from 332,000 in 1999, with the pig population index rising from 96 to 150 within the same period [8,24]. During peak prices, farmers take advantage by slaughtering sows out of the breeding herd for the meat which in the short term results in unintended consequences of pork shortage and higher prices [24].

The major and biggest challenges for entrepreneur farmers in Ghana is the attitude that they must have hands-on control of all aspects of their business; from management, accounting systems, sales and decisions making; leading to business failure in both short or long run [25]. Delegation or outsourcing a particular task in the livestock sector is vital for effective production; however, this can sometimes be a major challenge for pig farm owners who take delight in having control of all aspects of the business. These owners are more concerned about giving up control at a cost than incurring the cost of training or building up the capacity of low standard employees. Nevertheless most pig owners, according to the survey results, lack the technical know-how in pig management (feed formulation, heat detection, identifying and curing poor and sick animals, pricing, marketing, and drug administration). Employing qualified or trained staff is essential to economic progress because it allows specialized people to deliver in their capacity. This specialization makes workers more efficient and effectively reduces the total cost of producing the pigs. The basic infrastructure required for pig farming including water source, proper feed formulation and ration, proper supervision and market access, with appropriately qualified staff is sometimes lacking [26,27]. Also, common arrangement found in pig farms are unskilled labourers who clean and water the animals, with the rest of the activities which do not require physical strength, managed by the owner. Thus, productivity and profit are highly influenced by poor infrastructure and lack of technical skills leading to unsustainable business. Because of the complexity of many agri-business issues, where numerous interacting variables need to be accounted for and multiple interventions and groups bring different values and concerns to bear, it is not uncommon for people to call for a holistic Systems Thinking approach.

1.1. The Major Gap of the Livestock Industry

The piggery sector, and the role that animals play in the household economy in Ghana, are anticipated to change rapidly in the coming decades. Consumers are increasingly demanding high-value agricultural products including pork products. In this fast-changing context, good-quality livestock data are needed for designing and implementing policies and investments that promote the sector's social and sustainable development [28]. Available livestock data, and the derived statistics or indicators, however, are largely considered inadequate for effective decision making. Ruling governments, agriculture advocates and livestock stakeholders including farmers have neither adequate facts nor the essential tools essential to analyse the performance and investment decisions affecting the agricultural sectors [29]. Governments and research scientists are under increasing pressure to implement the right management decisions in the face of a dynamic political and socioeconomic landscape. The domestic and worldwide challenges currently fronting the livestock sector in Africa (including Ghana) are highly complex in nature [29,30]

This research gap regarding inadequate information is likely to continue for these several reasons: inadequate support for research, high inflation, administrative complacency, and the use of the traditional approach to addressing livestock challenges often undermine the success of its sustainability. History suggests that these problems cannot be solved with the traditional approach in isolation and with single-dimensional mindsets and tools. Livestock sustainability may benefit from a systemic approach to interventions and capacity-building based on systems thinking and complexity management to address challenges holistically in order to deliver the desired sustainable outcomes.

1.2. Factors Affecting Pork in Ghana

Many factors affect pork production and price in Ghana; however, these factors are related [31]. There have been many initiatives to address and modernize the agriculture sector, including the pig industry in Ghana by the Government but with a limited success [3,6,29,32]. It is clear from the earlier discussion that the challenges in Ghana's piggery industry are complex [3]. To help address these, there is the need to equip policy makers, researchers and all relevant stakeholders with a new way of 'thinking' beyond the traditional 'linear' approach to solving problems, to a holistic systems approach that focuses on the root causes and provide a holistic view between various components of

an industry [3]. Thus, this research explored these issues using systems thinking to reveal how these components affect each other and to recommend the way forward. This paper explores the application of system archetypes to serve as effective tools for gaining insights into patterns of behavior of the piggery industry of Ghana and how it interacts to affect the survival of this industry. These models can be used to assess many dimensions of the piggery industry, from pig production dynamics to economic policies designed to support the production venture. Identifying and understanding the various system archetype in the piggery industry is crucial to building a robust and integrated production activity that can be managed under different production scenarios [30,33].

The trend of increasing piggery productivity in tropical and subtropical regions and an increasing pressure on tropical and subtropical livestock systems to produce food, to feed livestock, and to produce energy crops warrants the development of systemic models to address issues such as the economic importance of piggery.

In this research, systems archetypes are developed to provide an understanding of the dynamics, interconnectedness and relationships present within the piggery industry. The research is conducted using a systems thinking approach and tools such as causal loop diagrams (CLDs) to demonstrate its application in effectively addressing complex sustainability issues affecting the agriculture sector. This research seeks to address the agricultural system's complexity by gathering the 'mental models' of various stakeholders involved in the piggery sector in Ghana. The results and approach will help livestock farmers, decision makers, scientists, and managers to anticipate the long-term consequences of their decisions and actions, as well as significant unintended consequences of decisions and strategies, and avoid the danger of 'silo mentality' and 'organisational myopia'. The process aims to provide a common language for diverse stakeholders, such as pig farmers, labourers, policymakers, and researchers, for deep dialogue and consensus building. This will help build research capacity in areas needed to improve and modernize peri urban pig production and make it more efficient and profitable with a view to eradicating poverty and promoting the health and welfare of the people and the animals. Using a case study approach, data were collected from El-Capitano Piggery Farm at Agona-Duakwa in the Central Region of Ghana, Ketu Pig Farmers association (involving 60 smallholder typical pig farmers) in the Volta Region and the Biotechnology and Nuclear Agriculture Research Institute (BNARI) Farm Complex at Kwabenya in the Greater Accra Region.

1.3. Systems Thinking

The systems thinking approach is a transdisciplinary 'framework' that addresses the root causes of challenges by viewing 'problems' as parts of an overall system [29]. Currently, it is unusual to go through a single day without hearing the words "sustainability" or "green" applied to anything from Apple products to Zinfandels [34]. Resolving today's challenges requires moving from a "linear" way of thinking to a "systems" perspective that brings thought and behaviour in line with the natural laws of sustainability [29,35]. Systems thinking is a trans-disciplinary "framework for seeing interrelationships rather than things, for seeing patterns of change rather than static snapshots" [36]. Systems thinking helps one develop new ways of thinking and enables one to grasp and manage situations of complexity and uncertainty in which there are no simple answers. It is a way of 'learning your way towards effective action' by looking at connected wholes rather than individual component parts [37]. The piggery industry and its sustainability may benefit from a systems thinking approach to interventions and capacity building, to address challenges holistically and deliver the desirable sustainable outcomes. This is in contrast to the linear approach of identifying 'quick fixes' to specific parts which leads to the danger of 'silo mentality' in which a fix 'here' simply shifts the problem to 'there' and 'organizational myopia' in which a fix 'now' gives rise to a much bigger problem to fix 'later' [29,38,39]. The application of systems thinking to manage complexities has generated a broad array of tools including system archetypes and causal loop modelling.

1.4. Systems Archetypes

An archetype is a well-defined structure, which exhibits distinct behavior over time, and has well-defined strategies for dealing with the underlying structure of the system being studied [40]. The system archetypes do not describe any one problem specifically. They describe a spiral of problems generically [40]. Their value comes from the insights that they offer into the dynamic interaction of complex systems. This approach illustrates one's understanding of a particular system's structure and behaviour, which foster communication and identification of high leverage interventions for problematic complex system behaviour. The system archetypes exposed insights into the livestock system structure that already exist to anticipate potential problems and the problem symptoms. As part of a suite of tools, they are extremely valuable in developing broad understandings about the livestock industries and their environments and contribute to more effectively understanding the root cause of challenges rather than a fix 'now' giving rise to a much bigger problem to fix 'later' [38].

1.5. Causal Loop Diagrams

A causal loop diagram (CLD) is the first-step practical approach to modelling and simply converting the complex components into a simple easily understandable structure [30]. CLDs are variables connected by key causal relationships to represent reality used to display the behavior of cause and effect from a system standpoint [41]. The model is a framework for seeing interrelationships between components in livestock systems and sustainability rather than isolated features that impacts the productivity of the livestock sector. The word 'causal' refers to causes-and-effects relationships, and 'loop' allies with closed chain of causality that link back to each variable [42]. CLDs are variables connected by key causal relationships to represent reality used to display the behavior of cause and effect from a system standpoint [41]. Causal loop diagram is simply a diagram of 'words and arrows' in which the 'words' represent variables (factors) in the systems and the 'arrows' show causal connections between the variables [43]. A variable can be a condition, a situation, an action or a decision which can influence and also be influenced by others variable (factors) [44]. Variables can be quantitative or qualitative. Quantitative variables are the factors that can be measured such as the value of average air temperature, levels of rainfall, cost of feed sources and animal population; while qualitative variables refer to soft factors, for example, traditional culture, belief, moral and reputation [42].

1.6. Aims and Objective

In this paper, the piggery industry's past behavior has been analyzed using a systems thinking approach, and the structure of the piggery industry in the form of a system archetype has been developed, which explains the behavior of the industry. The system archetype developed here is generic enough to explain any productivity decline and business rivalry behavior of an agribusiness industry. The proposed archetype can also help the farm managers and producers to make various decisions.

In the following sections, the four levels of thinking model framework were used to explain the past behavior of the piggery industry and the development of the underlying structure causing the behaviour, to generate a list of sustainable management strategies for the industry. The industry's problems were pooled together, and key factors whose behavior over time caused problems were identified. Thereafter, we explain the past behavior of the industry by developing various individual two-loop system archetypes. Later, the individual variables affecting the industry were consolidated to obtain a causal loop structure and a behavior-over-time graph of the piggery industry.

2. Research Methods

Data are drawn from a variety of national data sources including: the Biotechnology and Nuclear Agriculture Research Institute (BNARI) and Ministry of Food and Agriculture Directorate. These qualitative and quantitative data are collected from participants' farm records, documents (historical and statistical records, media reports, policy documents, previous studies and publications), stakeholder's interview, focus group discussions, and observations through participatory research approach. Data obtained from farm records include birth and death rate, sales, treatment, feed formulations, weaning, etc. Discussions were held with stakeholders individually and in groups with the aid of structured and open ended questionnaires and checklists. Discussions that centred on farmers' views on the on-farm performance of pig production and the factors affecting performance, including benefits accrued from keeping these animals, were ascertained. The researchers' link datasets from the three study locations (Central, Greater Accra and Volta Region) thus increases the richness of information available in a study. The data were analysed using Excel spreadsheet and the Ventana Software developed in USA. The various data obtained were consolidated to obtain the system archetypes, a causal loop structure, and a behaviour-over-time graph of the piggery industry.

The combination of data obtained from the study areas through literature reviews, farm data, interviews, and focus group discussions regarding the use of the four levels of thinking model (Figure 1) provide an overview of the current structure and effect of management strategies on an agriculture system containing multiple feedback loops. Data collection started by gathering the mental models of all stakeholders involved in the piggery industry in Ghana during a workshop with pig farmers to analyse the systems' barriers and drivers to piggery sustainability.

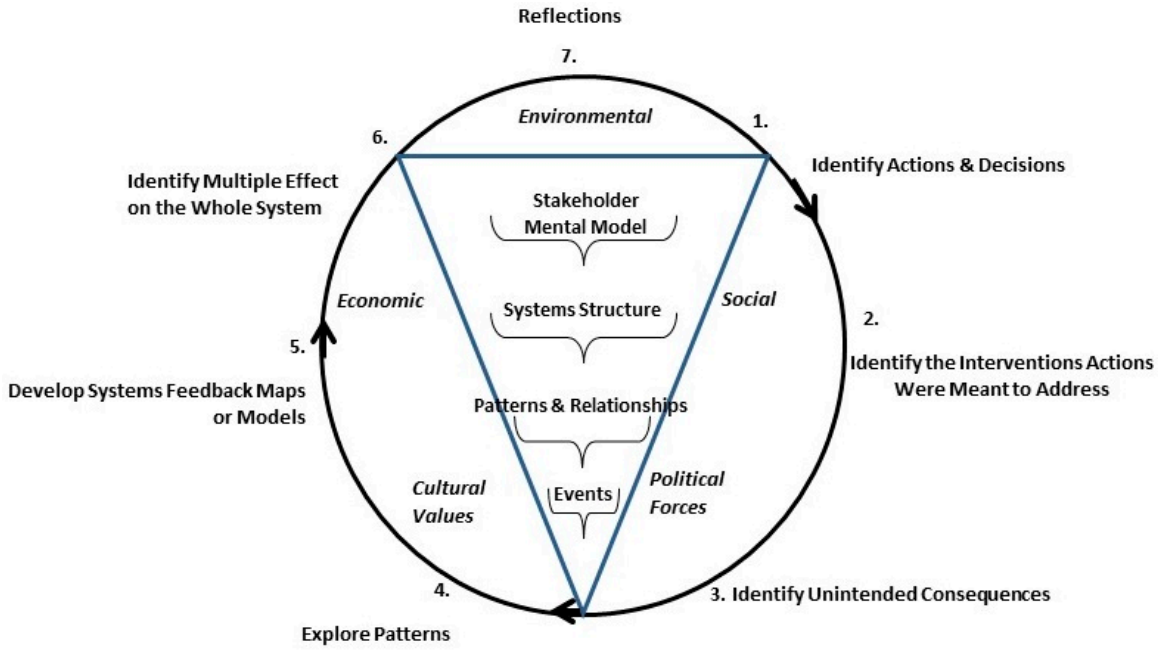

Figure 1. Feedback learning laboratory [30].

The model which starts at the 'first level of thinking', involves a series of literature reviews and interviews with experts in the field. Data on stakeholder opinions and perceptions of how the livestock system works, the barriers to success, the system drivers and the possible strategies (solutions) to overcome these problems were obtained through focus group discussions with a group of agricultural experts (e.g., agricultural scientists and extension officers and pig farmers) to obtain their mental models of the piggery sector under deliberation. A 2-day workshop organized in "Ketu" (Volta Region) and "Agona Duakwa" (Central Region) helped identify the core issues and high leverage interventions for problematic complex system behaviour in the piggery system. Several key variables in the livestock

sector were identified through the focus group (65 smallholders; 5 research scientist, 4 extension officers, 3 large scale farmers, 3 Ministry of Food and Agriculture agents, 5 input dealers) discussions and an in-depth review of literature. All farmers were males ranging from 32 to 73 years in age. Key leaders of heads of departments and some of the staff of these respondents were also interviewed. These variables are processed into loops using CLD modelling approach with the VENSIM Software program (Ventana Systems UK) for the development of the CLD of the issues under consideration. A researcher of BNARI, who has a rich experience and knowledge of the livestock industry in Ghana, provided the context and issues related to piggery to participants of the workshop. Some of the 85 workshop participants also had prior experience working in several piggery projects in Ghana. Researchers used key variables identified and integrated the different mental models into the causal-loop model using Vensim software. The outcomes of the actions and decisions that have been implemented by policymakers were also reflected upon to determine their effect and identify significant unintended consequences and new barriers generated. The research adopted an approach 'teaching to transfer' the art of interconnected thinking with stakeholders during the workshop, and these respondents are also involved in policy revision and formulation in Ghana. These 85 stakeholders were familiarised with and educated about the art of interconnected thinking. Research scientists and extension agents were also present. It is believed that these groups will be the facilitators of the art of interconnected thinking in policy formulations including some of the authors in Ghana who are also stakeholder of policy formulation at governmental level.

Once the unintended consequences and new barriers have been identified, the 'second level of thinking' is used to interpret and explore patterns and their interconnected components, and to analyse the kind of feedback loops, reinforcing loops and balancing loops that were generated.

This is followed by step three, which is the 'third level of thinking', in which the literature review was used to identify what pre-existing system archetypes were influencing the piggery industry. System archetypes are used to develop an understanding of interdependency and analyse the implemented strategies and/or policies that led to the intervention effect. The Vensim software program (Ventana Systems UK) was used for the development of the systems archetypes of the issues under consideration. A CLD is the first step to modelling and simply converting the complex elements into a simple, easy-to-understand structure. CLDs are variables that are connected by key causal relationships to represent the reality used to display the behaviour of cause and effect from the system's standpoint [41].

Finally, the 'fourth level of thinking' highlights the strategies needed to overcome the issues and challenges facing the entire complex agricultural system. Archetypes are useful for gaining insights into the 'nature' of the underlying problem and for offering a basic structure or foundation upon which a model can be further developed and constructed. Thus, Systems theory provides a framework for taming complexity, in other words, providing systems concepts and tools to unravel the complexity of any system under consideration [29].

The research method used focuses on the application of the Evolutionary Learning Laboratory (ELLab) and CLDs as knowledge integration tools in sustainable agricultural management and decision-making [39]. The ELLab is designed to equip policy makers, researchers and all relevant stakeholders with a new way of 'thinking' beyond the traditional 'linear' approach of solving problems, to a holistic systems approach that focuses on dealing with the root causes and interconnectedness between various components of the agricultural system. The process involves setting management objectives, abstract modelling to explore the effect of decisions on these objectives, identifying preferred management interventions and monitoring to track the success of implemented management intervention.

The purpose of this approach is for decision support, policy assessment and prioritisation of management interventions.

2.1. Systems Thinking Approach

'Systems thinking' approach highlights and addresses complex problems using integrated approaches and demonstrates how to translate complex ideas into potent management tools for change [45]. The systems analysis is guided by different levels of thinking. Generally, researchers do analysis based on the symptoms and patterns; however, this research focuses on the systemic structures that underlie the patterns of behaviour over time to anticipate the problem in the piggery industry and accommodate them [46–48]. This allows altering the source of the problem rather than just dealing with the symptoms.

The underlining systemic structures were shown using systems archetypes identified from the Causal Loop Diagram (CLD) to unravel the complexity of the piggery industry, where greatest leverage lies in solving problems. The CLDs have proven to be effective to unravel complexity and dynamics within a system [3,39,49]. Systems thinking approach also offers an opportunity for creating informal learning spaces for managing complex issues [39].

Systems archetypes and CLD modelling are key processes of using a systems approach to understanding the systems and identifying systemic intervention. The basic elements of any causal loop model or diagram are variables (factors) and links [29,46,50]. A "variable" is a condition, situation, action or decision that can influence and can be influenced by other variables. A variable can be quantitative (measurable) such as profit, productivity, or it can be qualitative (soft data) such as motivation, trust, morale, burnout and reputation. Qualitative variables do not generally lend themselves to direct measurement. One of the strengths of causal loop methodology is its ability to incorporate qualitative variables into the systems thinking approach [48]. System archetypes provide a systemic structure and storyline that can be used to diagnose or make sense of a situation [51]. The relationships between these variables, represented by arrows can be labelled as positive or negative. A link indicates a causal association between two variables or a change in the state of these variables of which "S" indicates a change in the same direction and an "O" indicates a change in an opposite direction [49]. Variables and links can form loops indicating feedbacks, either reinforce (R) or balance (B). Reinforcing feedback is when changes in elements of the system are fed back and result in an amplification of the change. Balancing feedback is when changes in elements of the system are fed back opposing the original change resulting in a counteracting effect [3]. The delay mark (⫫) on the causal arrows indicate that it will take time before the effect starts to play out.

The combination of loops can form systems archetypes which are generic systems models that represent a wide range of situations [47,52]. Systems archetypes can provide valuable indications of potential systemic interventions, normally referred to as leverages, which means actions or interventions that can have lasting impacts on the system in terms of reversing a trend or breaking a vicious cycle [51].

The increasingly complex nature of the Ghana piggery industry and other agribusiness has necessitated the use of a systemic research approach in solving operational problems. This assumes a significant role in the formulation of economic policy for both governments and businesses. The piggery industry sustainability may benefit from a systemic approach to interventions and capacity building, based on systems thinking and complexity management to address challenges holistically and deliver the desirable sustainable outcomes.

Eighty five respondents participated in the focus group discussions and all participants own or are involved in piggery businesses, from farmers, processors, wholesalers to retailers. Focus group discussion participants were asked to give their views about the problems of the piggery industry and their impact on economics in their livelihood. The mental models of participants, which included past observations and experience, were then analysed by the research team using the "four levels of thinking" model.

The research used focus study to gather the mental models of stakeholders. Given the growing complexity dynamism and instability of the pork markets, all businesses and economic factors that might influence the piggery industry were considered.

The research commenced on 23 August 2016 and involved a series of on-site visits. During the first phases of the visits, quick fixes were applied to address challenges encountered at the piggery (population capacity of over 3500 pigs at EL-Capitano Farm) which reduced its mortality rate from average of 14 per day as a result of thirst, hunger, filth, and poor leadership to average of one due to crushing of piglets by sows spanning over a period of three months. The study of the archetypes and factors affecting pig production and performance at Agona-Duakwa, Ketu and BNARI farm complex were carried out during the period August 2016–July 2017. The study adopted systemic interventions approach to address and revamp management issues encountered during this period.

The on-site review was completed using farm records data, information from the interview and focus group discussions with key individuals who are stakeholders. An audit-based methodology was applied to examine the key components of the organization and operations of the piggery. The data gathering process was both quantitative in examining records, reports and documented information (forms the basis of graphs) as well as qualitative through interviews and focus group discussions conducted in Agona-Duakwa in the Central Region, Ketu in the Volta Region and the Greater Accra Region and marketing survey through telephone interviews. The major areas analyzed included farm structures, feed formulation and measurement, weaning and sorting pigs into various sizes, employment, division of labour, access to water, breeding (identifying heat and crossing), training workers and market research for pigs. The analysis considered the unique geographic operating environment in which the farms operates, while fully understanding the needed balance of specializations, and operational performance associated with competent and effective management delivery.

Many calls have been made for a systemic intervention to farm management [29,36,53,54]. The approach of this research offers a methodology for systemic intervention that (1) emphasizes the need to explore stakeholder values and boundaries for analysis, (2) challenges marginalization, and (3) draws upon a wide range of methods (from the systems literature and beyond) to create a flexible and responsive systems practice.

The key objective of this study is to identify, reduce and eliminate threat to engaging in a piggery venture as a profitable business entity.

2.2. Participatory Research Process

Some of the researchers from BNARI were employed as consultants to address the piggery challenges during data collection at one of the larger scale commercial pig farms. These scientists launched the Maslow theory of motivation in the work place to produce the drive needed to motivate staff to satisfy the need to revamp the whole piggery sections [55]. The workforce comprehended the objectives stated above and most proposed ways forward through the focus group discussions. Division of labour was employed and members of staff who were 'randomly' assigned to any pen and also those managing two pens per day (each pen contain 100–150 pigs) in the absence of water flow were made to manage a pen per staff. This eliminated the poor cleaning and maintenance culture and gave them a sort of ownership of the blocks and ensured their animals are well cared for. The organizational interrelatedness of staff optimizes the delivery efficiency of labour productivity to some degree.

The Challenge Encountered

There are a lot of challenges to improving labour productivity. Insufficient and inefficient working tools led to delays and reduced labour productivity. Also, lack of consistent water supply led to fetching water from nearby ponds to both clean and water animals. This source of water means pigs must also be treated frequently with de-wormers. These entire challenges reduced labour efficiency and increased the motivational needs of workers. Some quit the job while those remaining lost interest in the work. All these challenges made supervision difficult and worked against productivity.

3. Results and Discussion

3.1. Development of Alternative Agribusiness: 'Shifting the Burden' Systems Piggery Archetype

Development of alternative agribusiness among farmers in Ghana is mainly because of failure to realise the economic benefits of their former business. Ghana's pork production and demand exhibits distinct continuous phenomenon which influences pork availability. Since domestic production cannot keep up with the demand for pork, Ghana imports processed pork to meet domestic demand as shown in Figure 2. Most crop farmers are shifting to piggery because of its fecundity and economic benefits. As domestic pig production increase, Ghana's pork import volume remained at a low level (Figure 2).

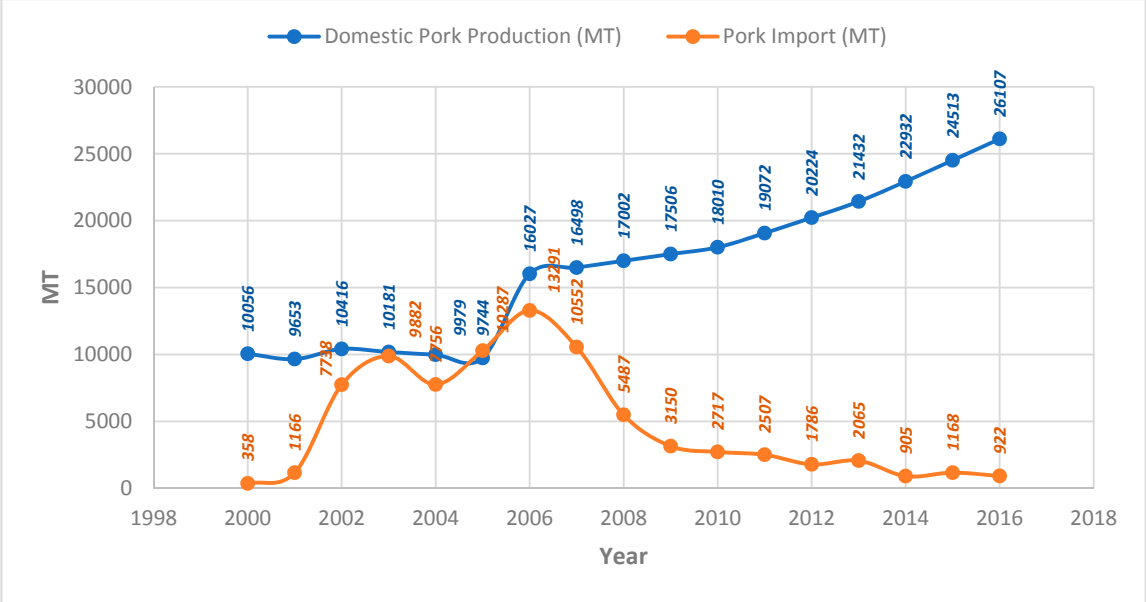

Figure 2. Pork Production and Imports into Ghana: 2000–2016 in metric tonnes (Source MOFA).

However, it is widely discovered that these shifts based on survival driven motives have more negative impacts on profit in overall socioeconomic and household developments among these farmers as a result of lack of business plan and inadequate information in pig production [6]. The development of alternative agribusiness in Ghana and its long-term impact have been described here as an example of 'shifting the burden' system archetype as shown in Figure 3.

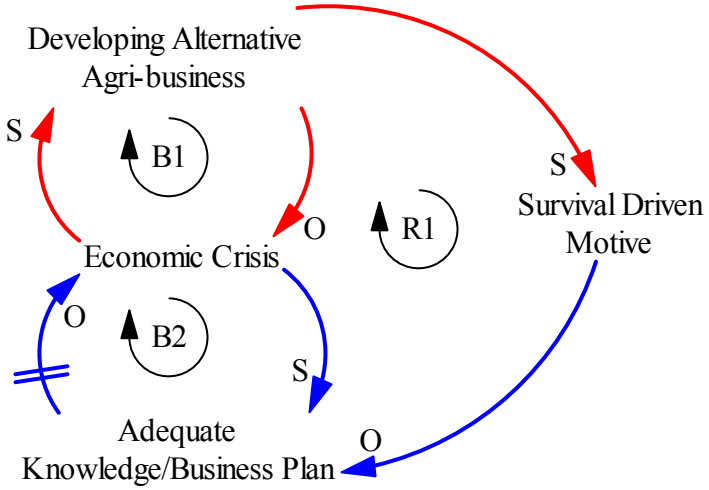

Figure 3. 'Shifting the Burden' System Archetype.

Findings reveal that the "Development of alternative agribusiness has taken deep root to the psyche of most entrepreneur farmers and business men without proper investigation of the cause of business failure of the former business" [6,56,57]. Some African farmers have received much more financial assistance in comparison to GDP than any other developing areas but they have grown much slower than the other parts of the world [2,29,58,59]. If they had focused on mobilizing adequate information on their own business rather than depending on finding alternatives, the countries would be independent and could develop in a faster pace and get rid of economic crisis and survival driven motive businesses. This is a case of 'shifting the burden' in which most market-oriented farmers opt to depend upon the development of alternative business rather than mobilizing adequate information and business plan during the financial crisis, which in long run, was unable to solve the problem of economic crisis (Figure 3). Nearby crop farmers seeing the initial progress of the piggery business of their competing neighbours also adopt this business, leading to escalation.

Effective Strategies

Focus on the fundamental solution. If necessary, use the symptomatic solution only to gain time while working on the fundamental solution. When dealing with the development of alternative agribusiness based on survival driven motive, a manager must ask himself whether he is treating the economic crises problem or addressing the root cause of the previous business failure. Often, out of expediency, the development of alternative agribusiness as a solution is essential. The most effective strategy for dealing with a Shifting the Burden structure is an employment of the alternative agribusiness and development of a business plan or acquiring adequate knowledge of that business. Thus, one resolves the immediate problem and works to ensure that it does not return.

3.2. Escalating Piggery Archetype

In the escalation of the piggery archetype, actions taken by one farmer influence actions others take, but unlike physics—where every action produces an equal and opposite reaction—farmers' actions are amplified with each round, leading to a phenomenon known as an escalation. It hypothesises that the two balancing loops will create a reinforcing Figure 8 effect, resulting in threatening actions by both parties that grow exponentially over time [60].

If left unchecked, the escalation dynamic can spiral out of control, going far beyond what either party may have intended. The expression, "keeping up with the Joneses" comes to mind-if the Joneses buy a new car, the Smiths feel compelled to replace their old vehicle with the latest model [46]. In this case, escalation occurs when farmers equate many alternative business establishments with success. Smith, believe they are merely "keeping up" when they buy their new car, they may choose one with bells and whistles that the Joneses do not have, triggering another round of escalating conspicuous consumption. Escalation dynamics is erupting in the agriculture industry of Ghana leading to rivalry. Delay in information access by new entrepreneurs into the piggery industry contributes to distortions flowing between the new and existing parties. Once delay occurs, information gets distorted along every link of the system, which leads to overestimation of the impact of its rival's activities. In Figure 4, Farmer A seeks piggery as an alternative business because of low profitability of sales from vegetables or crop farming. The results of these activities do not show up immediately in higher profits (B1 in "the structure of Escalation Dynamics"). This delay contributes to escalation dynamics because Farmer B then perceives that Farmer A's business alternative is more profitable. Farmer B responds by setting up a piggery as well. Eventually, the results of Farmer A's actions do become visible, but because of the delay between relative results and feelings of being threatened, Farmer B remains complacent about its level of activity relative to Farmer A. In both cases, farmers were previously caught off-guard because of delay. The problem is that each farmer's actions were based on extrapolations usually inflated by the other's activities. The challenges encountered compel the farmers to adopt quick fixes such as promotion, value addition, etc. which worsen the situation and lead to business failure.

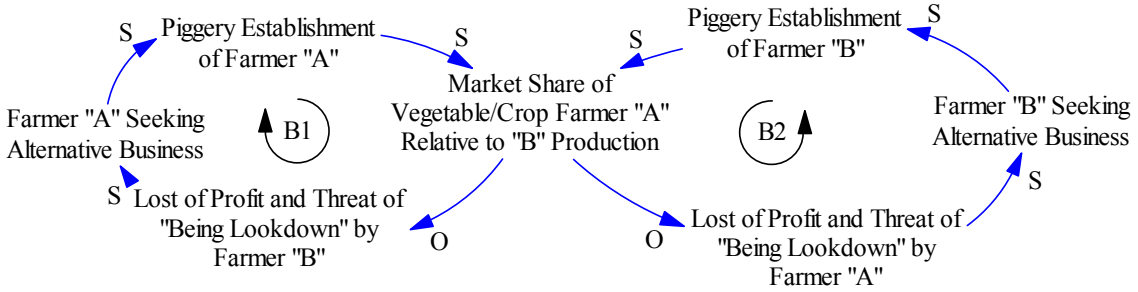

Figure 4. Escalating Archetype (Fear of Mockery).

Managing the Structure

Nothing comes without a cost and there is a limit to the results that one can generate. In this archetype, "Farmer A" and "Farmer B" are on a mutually destructive course. A point must be reached where the structure can grow no more because nothing grows forever. There are two effective strategies for dealing with this structure.

- One approach is to disconnect the two loops so "Farmer A" and "Farmer B" are no longer competing with each other but competing with themselves (Figure 5). This produces two reinforcing loops.

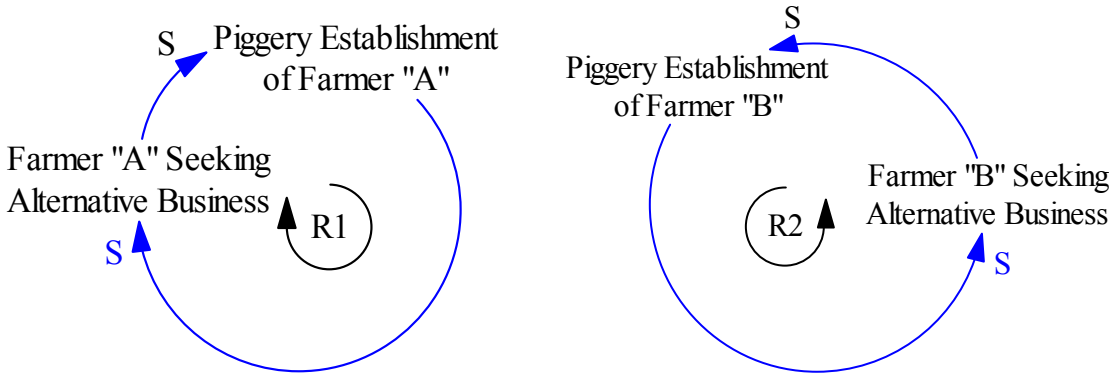

Figure 5. Disconnecting the two loops.

- The second approach is to begin evaluating the composite of "Farmer A" and "Farmer B's" actions rather than their individual actions (Figure 6). In this way, they begin to see the value of cooperation rather than competition and the structure turns into two synergistic reinforcing loops.

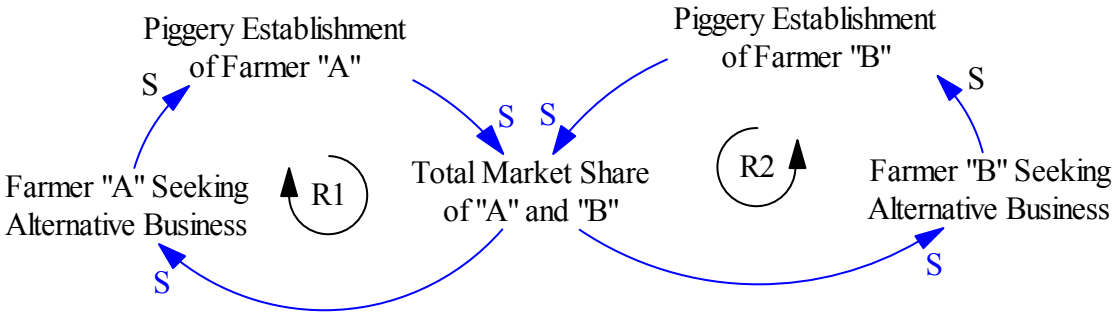

Figure 6. Evaluating the composite.

Areas of Concern

As the escalation structure is equivalent to a single reinforcing loop the same concerns apply to this overall structure. The most likely situation to develop is that "Farmer A" and "Farmer B" will cease to compete and begin to cooperate.

3.3. "Fixes that Fail" Archetype

There is a paradox that asks, why don't people have time to do things right in the first place, but have time to fix them over and over again? The fixes that fail archetype as shown in Figure 7, highlights how one can get caught up in a dynamic that reinforces the need to continually implement quick fixes to address the problem.

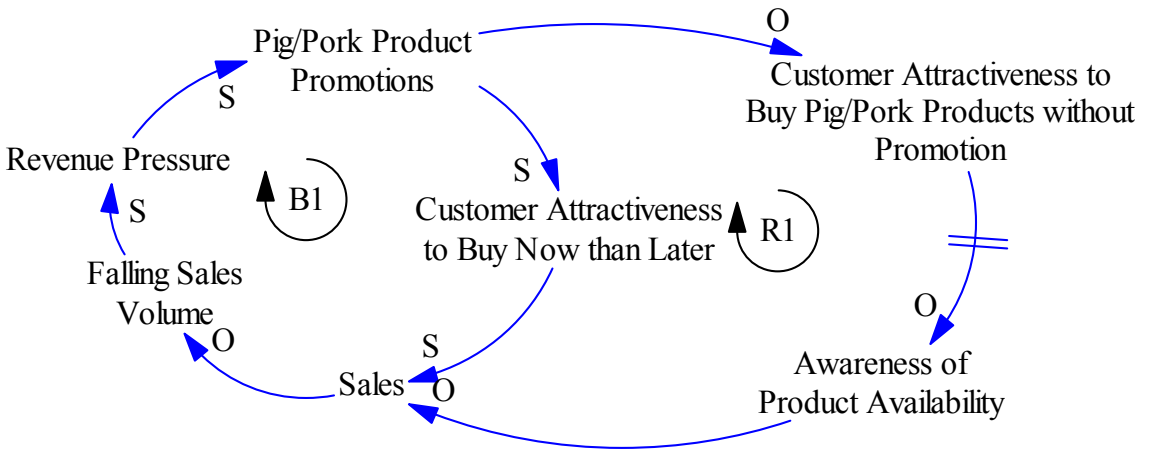

Figure 7. "Fixes that Fail" Archetype.

In this structure, a problem symptom gets bad enough that it captures attention: for example, a slump in pig or pork sales leads to the implementation of a quick fix (a marketing promotion) that makes the symptoms go away (pig sales improved). However, that action triggers unintended consequences that make the original symptom reappear after some delay—often worse than before—thus limiting business development and growth. The systems thinking approach is a transdisciplinary 'framework' that addresses the root causes of challenges by viewing 'problems' as part of an overall system, in contrast to the linear approach of identifying 'quick fixes' to specific parts. 'Quick Fixes' lead to the danger of 'silo mentality' in which a fix 'here' simply shifts the problem to 'there' and 'organizational myopia' in which a fix 'now' gives rise to a much bigger problem to fix 'later' [38]. Therefore, a systems thinker frames a problem in terms of seeing the whole forest, instead of focusing on a particular part. They see beyond the details to the context of relationships in which they are embedded. Today, it is widely used by academics and practitioners alike to address sustainability challenges.

Effective Strategies

A "fixes that fail" structure is often part of a more elaborate structure in which the fixes that fail structure simply represents dealing with the symptoms rather than the root cause underlying the real problem. A "fixes that fail" structure often results in becoming dependent on the fix, thus applying it over and over.

The most effective strategy for dealing with this structure is advance planning. Since one can never do just one thing, as everything affects everything else, before taking action to change the current state, one has to think about what else that action is apt to affect and what the impact will be. Sometimes the unexpected consequences may be several affects away, so one does not have to

stop at just one. Essentially what one seeks to do is to identify the unexpected, which means it is no longer unexpected.

A less effective strategy would be to figure out how to disconnect the unexpected consequence from influencing the current state in time. Of course, then it would not be a consequence.

3.4. "Limit to Market Growth" Archetype

In the Limit to Growth Archetype displayed in Figure 8, certain actions initially lead to growth, encouraging the company to engage in even more of those same efforts. Overtime; however, the system encounters limit that slow improvements in results. As performance declines, the company tends to focus even more on implementing the actions that initially led to growth. In the Limit to Growth Archetype, marketing is a common engine of growth. In the piggery industry, farmers allocate a certain percentage of the budget to pig or pork marketing and engage in various marketing activities that generate sales. More sales lead to increased revenue and a corresponding rise in marketing budget (R1). However, as pork sales grow, the customer base naturally expands, along with following up calls to build customer relationship marketing (B1). If the company marketing support capacity does not increase fast enough to meet the growing demand, the adequacy of that capacity begins to drop. This trend leads to lower customer satisfaction and downwards pressure on pig or pork sales. Farmers begin to seek alternative business or reduce investment in the piggery for other sectors.

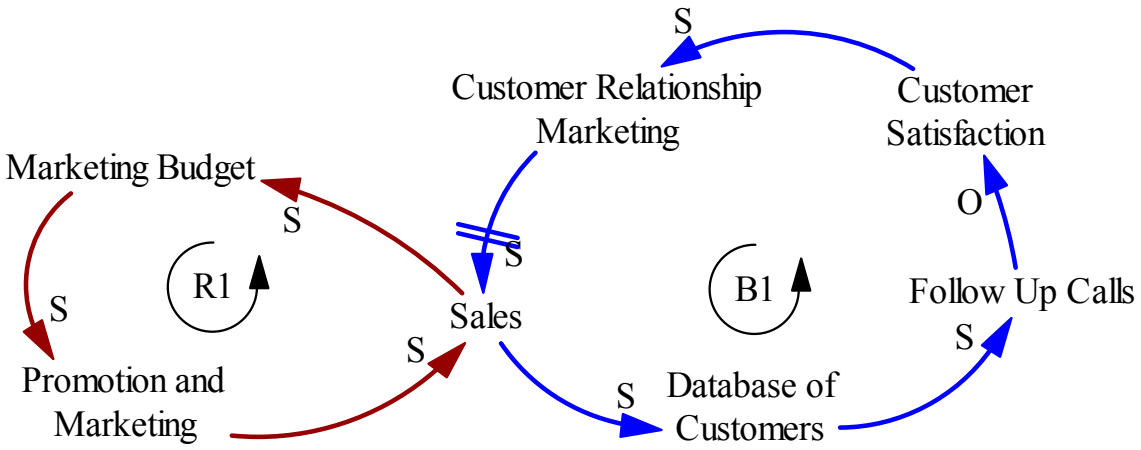

Figure 8. "Limit to Market Growth" Archetype.

Effective Strategies

1. The best defense is a good offense. As defined in the effective strategies for the Reinforcing Loop, if there is a Reinforcing Loop operating, start looking for what is going to become a limiting factor and remove it before it even has a chance to create a substantial impact on results.
2. If the structure is already at a stage where the limiting factor is interacting with results to limit them the options are the following:

    1. Alter the limiting factor in such a way that it no longer interacts with the results to create a slowing action.
    2. Find a way to disconnect the results from the slowing action so it no longer exists.
    3. Disconnect the slowing action from the results so it can have no effect on results.

Areas of Concern

1. There are often multiple limits to deal with which leads to an Attractiveness Principle.
2. It is possible that limited shared resources are the source of the limiting factor leading to a Tragedy of the Commons.
3. The limit may be insufficient capacity which leads to Growth and Underinvestment with a Fixed Standard.

3.5. "Success to Successful" Archetype

In the Success to successful Archetype in Figure 9, the demand made by another project in comparison to the piggery for a common resource such as funds, labour, time, etc. are linked by two reinforcing loops. As the resources dedicated to 'Project A' and 'Project 'A's success both increase, the resources invested in 'piggery' and in turn 'piggery's success decline. As resources are devoted to 'Project A' (which represents the more favoured project) for some time with no visible success in the beginning, the net returns for 'Project A' are low or even negative.

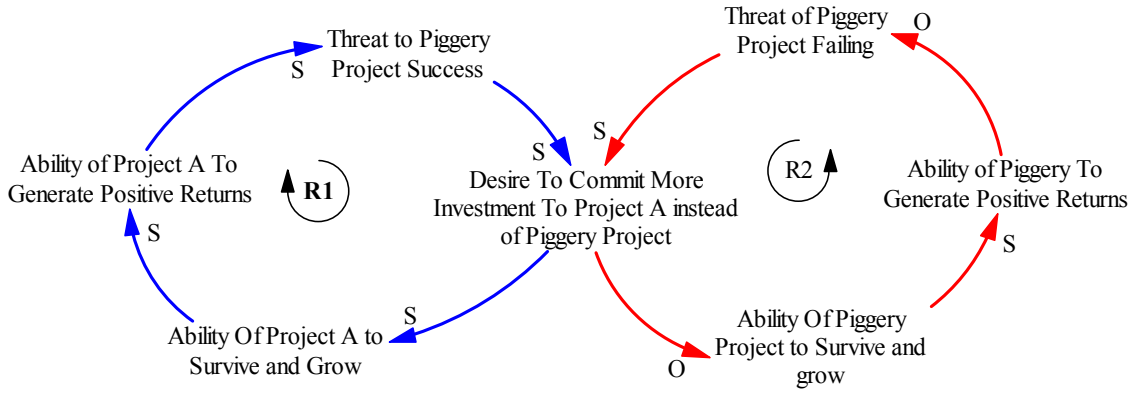

Figure 9. "Success to Successful" Archetype.

However, sustained investment leads to 'Project A"s success. The key here is that, if the investment is sustained in 'Project A' beyond a critical point, 'Project A' begins to generate positive returns. Beyond this critical threshold of positive returns, 'Project A's success is likely to be self-sustaining because continued investment brings ongoing positive net returns. In the case of 'piggery', we start by making the same initial investments as for 'Project A' but, for whatever reasons (inadequate knowledge, poor timing, external forces, lack of a business plan, etc.) 'piggery' takes longer than 'Project A' to become successful. In many cases, the reason for 'Project A' comparative success is that it had a head start in and is already beyond the critical threshold of positive returns. Thus, 'piggery's net returns stay low or negative longer than 'Project A', and 'piggery' begins to look less attractive as an alternative. Thus, less and less is invested in 'piggery', which delays 'piggery' achievement of success even further. At a certain point, resources, such as people, equipment, etc. is even taken away from 'piggery' because we do not want to waste resources on a "lost cause". In turn, 'piggery's performance only declines further. Finally, 'piggery' will be considered a failed project and abandoned.

Effective Strategies

1. Investigate Historical Origins of Competencies

One warning signal that the "Success to the Successful" archetype is at work is if you hear yourself validating decisions by saying, "Project A is a good way to go, because it is clear by the progress to date that it outshines the piggery alternatives." The Project A system has become entrenched because of the "Success to the Successful" loops and is difficult to dislodge because of the "competency trap" phenomena.

2. Identify Competency Traps

Competency traps lock us into a way of doing things simply because we are already skilled at doing it that way. Suppose, for example, you are good at managing Project A skillfully and profitably. When a new alternative business such as the piggery emerges, everyone raves and says it is superior to the first. However, you think, "I already know how to manage this one, so I'm just going to keep using it." Each time you use it, you invest more of your time and resources to get to know it better, without gaining any skills in the alternative piggery business. Over time, your competency "traps" you into continuing to manage Project A.

Such competency traps can turn your business into a corporate dinosaur, because they disconnect you from the current progress of piggery alternatives and engender the belief that you have the way, the best way, or the only way. Even if your favored method is currently superior, once you get caught in the "Success to the Successful" loops, you will not realize it when progress passes you by.

3. Evaluate Current Measurement Systems

The measurement systems you use can perpetuate your competency traps by making current Project A successes look good and Piggery alternatives appear less favorable than they actually are. Is your current system weighing too heavily the costs that have already been invested? Does it overly discount the opportunity costs of not switching or not scanning for other possibilities? If you think your system may be skewed in one direction, you may need to question the assumptions behind your current measurement systems and perhaps change them if necessary.

4. Map Internal View of Market Success

When you are successful in a market for a long time, you often begin to believe that your internal view of success is the same as the market's view. The internal success loop can thus blind you to shifts in the competitive environment that are obvious to less successful players. Mapping your internal view of success will make the operating assumptions explicit and clear.

5. Obtain External Views of Market Success

To complete the picture, you need to obtain external views of market success. This usually requires getting an assessment from a true "outsider" to the industry. Internal attempts to map the external view run the danger of looking too similar to the internal view.

6. Assess Effects on the Innovative Spirit

Competency traps and inaccurate views of the marketplace indicate how the "Success to the Successful" archetype can erode the innovative spirit of the organization. This trap is characterized by the old management adage, "If it ain't broke, don't fix it." Instead of allowing one successful way to predominate, use the archetype to question how you think and perceive. The challenge here is to always entertain alternatives in a highly innovative spirit.

7. Be Your Best Competitor

By nurturing an innovative spirit and continually scanning for new alternatives, you can become your own best competitor. With this mindset, you become the most critical of your own success, continually looking for gaps and areas for improvement. For example, Proctor & Gamble's approach of having multiple brands compete with each other helped the company become and remain the industry leader in many markets. By viewing your successes as if you were another company, you can find ways to create a competing product or service that may be better or more successful.

"Success to the Successful" is one of the toughest structures an organization has to overcome because many choices are often made subconsciously, influenced by the momentum of past actions. It is easy to become trapped in your success by continuing to learn how to do the same thing better.

Applying the archetype can hopefully help you design your successes to be a product of continual learning rather than the inertia of past achievements.

There are other strategies for dealing with a Success to the Successful situation.

1. Identify the resource(s) being unequally distributed and balance the distribution.
2. Disconnect the two reinforcing structures so they are not dependent on the allocation of shared resource(s).

3.6. "Tragedy of the Commons" Archetype

The tragedy of the commons structure of Figure 10 discovers that both projects can benefit from using a common resource without having to pay much, if anything, in terms of direct costs. The Tragedy of the Commons structure represents a situation where two or more reinforcing structures are contingent on some limited common resource. The more they use the resource, the more they gain from activity (Loops R1 and R2). Therefore, to maximise their individual benefit, they continue to take advantage of the commons as much as they want.

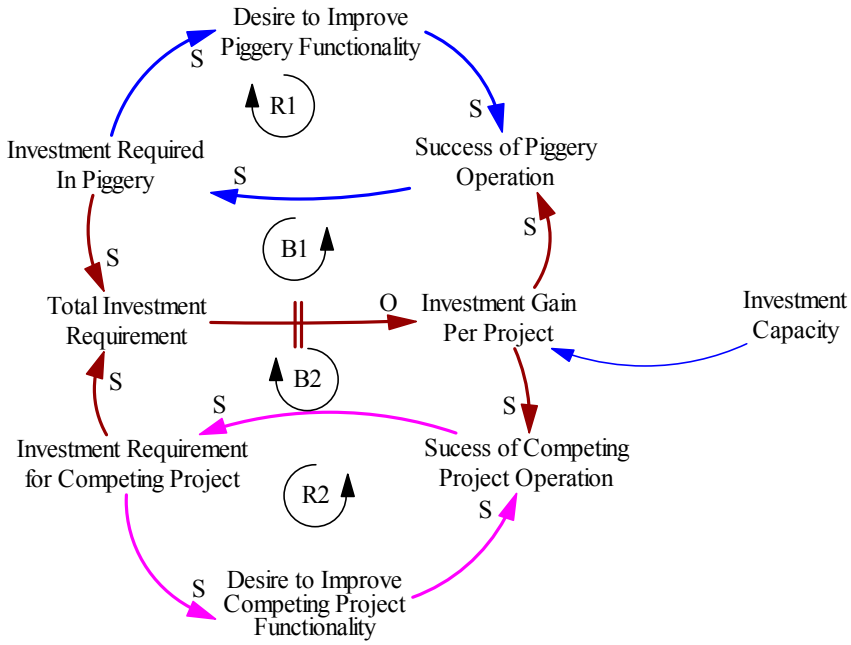

Figure 10. "Tragedy of the commons" Archetype.

The commons in the case of the piggery and vegetable production in Ghana is a resource (people, materials, space, tools, etc.) that is simultaneously made available to multiple people and/or teams. The initial rationale for creating the commons is typically economies of scale. As each person or team claims their "share" of the commons, within the context of the goals and objectives that they have set for themselves, they regard the commons as being uniquely available for their own purposes. Initially using the resource contributes to each reinforcing loops results. After some time the total activity of the reinforcing structures exceed the capacity of the resource which results in a reduction of the growing action for each of the reinforcing structures. As the Total Activity approaches the Resource Limit it begins to limit the Gain Per Individual essentially limiting the gain of both reinforcing structures. In the case of commons such as people, tools, materials or space, there is no conscious awareness of increased demand, but the concrete, physical limitations have no elasticity, and the satisfaction of people or teams placing demands on the commons erodes [60]. As aggregate performance of the commons slides, several consequences can be felt in the agribusiness. Individual or team performance declines as the erosion of the commons affects their ability to meet individual goals and objectives which in turn

erodes agribusiness goals and performance. It is assumed that if the total usage of a common resource becomes too great for the system to support, the commons will become overloaded or depleted and everyone will experience diminished benefits. As long as the total activities or total draw on the resource from all players stay within the carrying capacity or limits of the commons, everything is fine. The Tragedy never gets triggered, and the players keep doing what they are doing. When consumption begins to exceed the resource's ability to replenish itself; however, gains per individual effort will start to decline. When this happens, participants often respond by redoubling their efforts (B2 and B1). They may try to get the commons faster, initiate more request for the commons, or just outright grab more of the commons before others get to it. Of course, these kinds of tactics are quickly copied by everyone else, which further accelerates the depletion of the commons. Left unmanaged, these kinds of actions will eventually bring on the collapse of the commons. In this case, there will be no more gains for the participants, so their activities will finally cease or be greatly curtailed

Effective Strategies

This structure repeatedly appears in organizational contexts where a service organization supports the success of multiple departments who fail to support the service organization in return. There are two strategies for dealing with this structure, one being more effective than the other.

- The most effective strategy for dealing with this structure is to wire in feedback paths from the success of piggery operation and success of competing for project operation to the investment capacity so that piggery and competing for project use resources their results promotes for the availability of additional resources.
- The alternative, and less effective, strategy for dealing with this structure is to add an additional resource to control the use of resources by piggery and competing project. This strategy limits the overall potential results of the structure to the pre-defined resource limit. It also adds additional resource to the equation and probably results in endless disputes as to the fairness associated with the allocation of resources. While not really the most appropriate strategy, this is the one most often used (out of ignorance).

4. The Current State of the Respondent's Piggery

Death loss of growing pigs averaged about 50 pigs per week (at Agona Duakwa). Among these, preweaning mortality contributed about 60% which is attributed to lack of iron, hunger and thirst (as a result of lactating sow starvation), poor hygienic pens, and poor supervision. Other possible causes of preweaning death were small piglets' susceptibility to cold, making them lie more closely to the dam to avoid hypothermia and resulting in them dying as a result of crushing. Unlike many mammals, piglets do not possess brown adipose tissue, a type of fat that enables newborn animals to generate a great deal of heat to maintain body temperature [61]. Wean-to-finish mortality was mainly due to starvation, thirst and unhygienic pen and environment.

Figure 11 shows the conceptual model, which was developed at the workshop to broadly describe the current situation in the piggery. The model explains the sources of complexity that has given rise to pig productivity predicament. From the model it is apparent that the relationships between the key variables are far from simple or linear [62]. An inspection of this model revealed that the current adverse outcomes (pressure on management, high mortality rate and poor pen maintenance) could be traced back to the lack of integrated planning or decision making which affects productivity and in turn leads to business failure [63]. Ad-hoc cleaning of the pen by staff without taking charge or ownership of a block contributed mostly to these challenges as shown in Figure 11. This, in turn, increases the mortality rate and affects productivity, increasing work load and pressure on management.

The strategic management which curbs these deaths were assigning staff to take charge of the block, assigning new experienced manager and introduce new feed formulation to over-come malnutrition. The most important action implemented to decrease preweaning mortality was to install a manager during farrowing. Concern and vigilance during this time ensure that struggling piglets find the udder and can consume adequate colostrum. In addition, piglets that would be crushed can be placed in a safe spot until they can manoeuvre well and compete for a teat. However, the required tools (Measuring cups, shovels, wheelbarrows, cleaning brushes and brooms) to enable effectiveness were unavailable. Other challenges were workers not paid on time (sometimes almost 3 weeks over scheduled date), leading to disrespect to management instruction and putting more pressure on managers affecting the quality of work desired as shown in Figure 11.

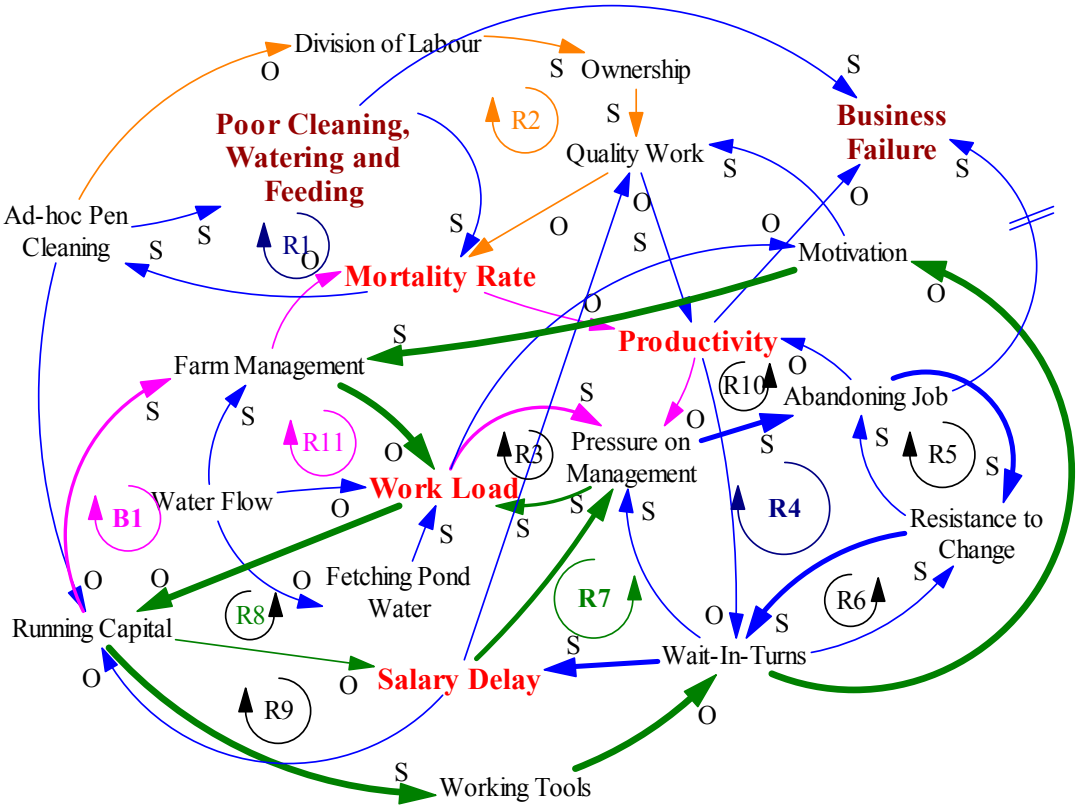

Figure 11. Causal Loop Diagram (CLD) of interacting factors.

This approach increased the number of pigs as shown in Figure 12 and reduced death rate as shown in Figure 13 within a period of 3 months. The increase in number resulted from new birth recorded per week (Figure 12).

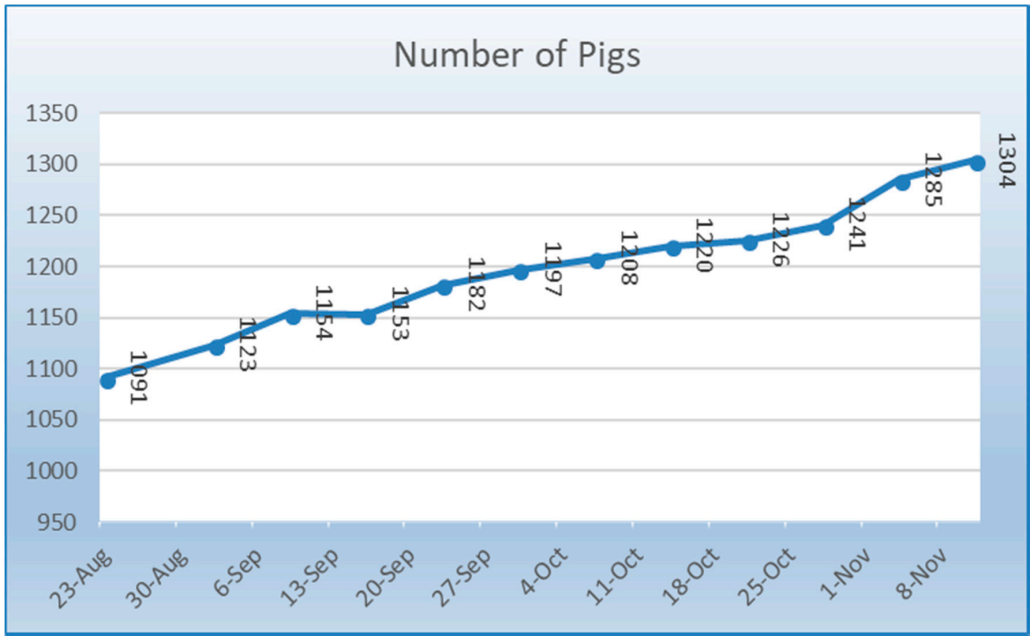

Figure 12. Number of pigs produced per week. (Source: data obtained from Agona Duakwa—August 2016—completed).

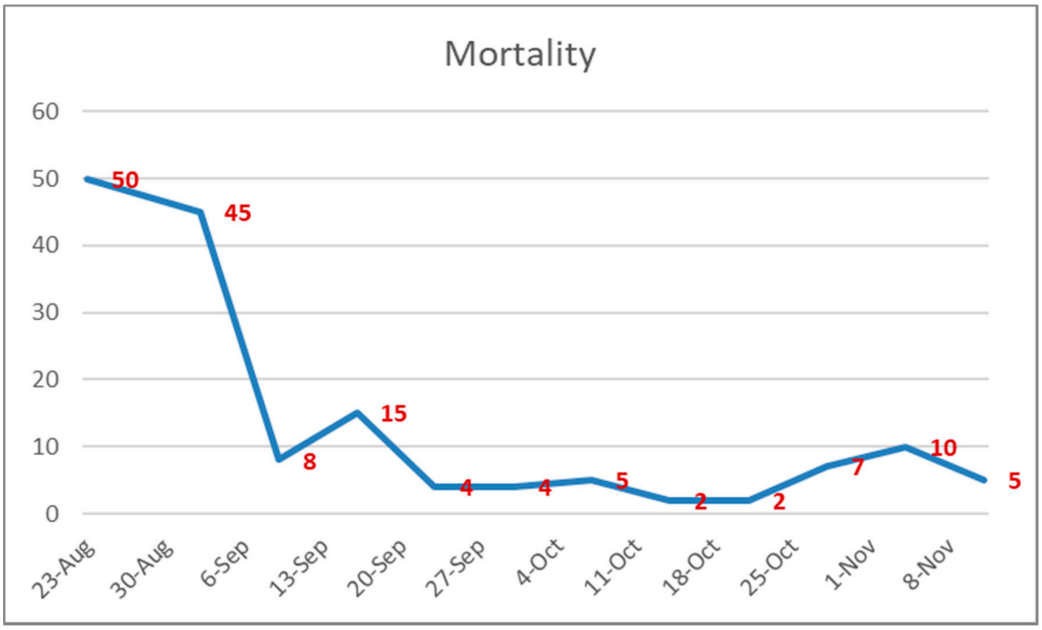

Figure 13. Mortality rate of pigs. (Source: data obtained from Agona Duakwa—August 2016—completed).

Other challenges encountered leading to rising death rate within the period of November were re-allocation and mixing of weaned piglets to different pens as a result of counter instruction by the farm owner leading to fighting to death among piglets. However, the overall achievement in the face of all these challenges was enormous as within a period of 3 months, 70 sows were crossed and 220 weaned piglets castrated.

4.1. Breeding Management Adopted in Pig production

Accurate heat detection is essential for the correct timing of crossing [64]. Poor heat detection leads to higher production cost and reduced herd size as shown in the limit to growth archetype (Figure 14). This affects pork production and profit. Sows and gilts are non-seasonal and polyoestrous, with the oestrous cycle lasting 18–24 (average 21) days [65]. Sows are behaviourally anoestrous during pregnancy. Ovulatory oestrus usually is not seen during lactation except under conditions of group rearing, high feed levels, or boar contact. Partial weaning or gonadotropin treatment can induce oestrus during lactation, but the results are inconsistent and not economical [66]. Normal uterine physiology is re-established by 20–25 days postpartum. Most sows exhibit oestrus 3–7 days after weaning [67]. Oestrus lasts ~36–48 h in gilts and ≥48–72 h in sows [68]. Time to oestrus after weaning and duration of oestrus in sows can be influenced by the length of lactation, nutrition, body condition, genetics, and other management practices. Oestrus is characterized by behavioural (e.g., mounting, fence walking, vocalizing, tilted ears, kyphosis) and sometimes physical (e.g., vulvar swelling, vaginal discharge) changes. Ovulation generally occurs in mid to late oestrus. During ovulation, 15–24 ova are released over a 1 to 4-h period. Ovulation rate increases over the first four parities, so that the fourth to sixth litters tend to be the largest in number. Ovulation rate can decrease when gilts or sows are undernourished. Most gilts are on full feed, thereby averting the adverse effects of undernourishment on early reproductive performance. In circumstances in which gilts are not routinely provided with a full feed, increasing energy intake for 10 days before oestrus (i.e., "flushing") is performed. This has optimized ovulation rate under these circumstances. To prevent undernourishment in recently weaned sows, an energy-dense diet should be fed until after oestrus and breeding.

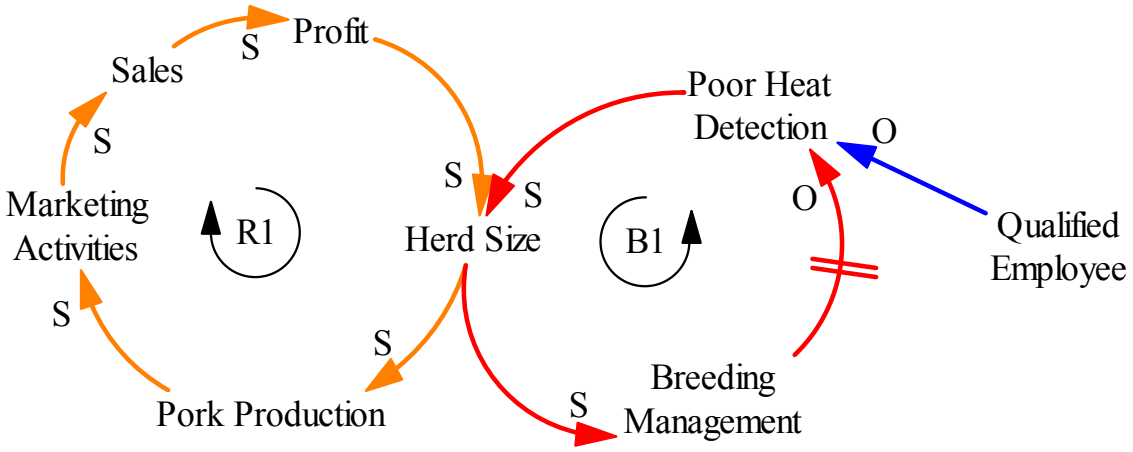

Figure 14. "Limit to Growth" Archetype.

Behavioural changes are most pronounced when the sow or gilt is exposed directly to the sight, sound, odour, and attention (nuzzling and grunting) of a mature boar [69]. A sow or gilt in standing heat normally assumes a rigid, immobile, receptive stance when exposed to a boar. Physical changes such as vulvar swelling and discharge are often unreliable; they do, however, appear to be more marked in gilts than sows and commonly develop 2–3 days before oestrus. The ultimate criterion of oestrus is either standing to the boar or a positive response to the "riding test" (an attendant applies pressure with the hands in the loin area, then gently sits on the pig's back to elicit the standing reaction); this test is best conducted in the presence of a boar (e.g., in an adjacent pen) or, as an alternative, after exposing the sow to a synthetic boar-odour aerosol or taint rag.

4.1.1. Diseases

Atrophic rhinitis, Actinobacillus pleuropneumonia, Transmissible gastroenteritis, mange and salmonellosis were major health issues encountered. The manager was trained to administer injections and detect symptoms.

4.1.2. Feed Formulation

The ingredients included in per ton of formulated feed on the farm are 10 bags of 50 kg maize, 20 bags of 25 kg wheat bran, 3 bags of 50 kg soy meal, 10 kg salts, 25 kg oyster shells, 1 kg lysine, 1 kg broiler premix, 1 kg Methionine, and 1 kg "Top 3". However, this feed formula is not being adhered to as a result of lack of missing ingredients leading to maize dominated feed without soybean, shells, premix, etc. This has impacted negatively on the health and nutrition of pigs but better than before the previous state.

5. Summary and Conclusions

Ghana is predominantly an agricultural country with a clear majority of its population depending partly or fully on agriculture for their livelihoods. Piggery productivity in Ghana is low by regional standards and the industry faces several challenges. The latest challenge is the rising cost of maize and corn, which are essential components in the feed formulation for pig diets as a result of the fall armyworm (Spodoptera frugiperda) infestation in Africa. In this paper, the piggery industry's past behavior has been analyzed using a systems thinking approach and the structure of the piggery industry in the form of a system archetype has been developed, which explains the complex behavior of the industry. The four levels of thinking model framework were used to explain the past behavior of the piggery industry, develop the underlying structure causing the behavior, and generate a list of sustainable management strategies for the industry. The industry's problems were pooled together and the key factors whose behavior over time manifests the problems by developing various individual two-loop system archetypes were identified. Furthermore, the individual variables affecting the industry were consolidated to obtain a causal loop structure and a behavior-over-time graph of the piggery Industry, with the help of which a list of sustainable strategies for the industry were developed. The system archetype developed here is generic enough to explain any productivity decline and business rivalry behavior of any organization or agribusiness industry. The proposed archetype can also help farm managers and producers to make various decisions. The system archetypes revealed insights into the livestock structure that already exist to anticipate potential problems and the problem symptoms. In this research, systems models provide an understanding of the interconnectedness and relationships present within the piggery industry of Ghana. The system archetypes contribute to effectively understanding the root cause of challenges rather than a fix 'now' giving rise to a much bigger problem to fix 'later'. Application of CLDs and system archetypes can help farmers and policy makers understand the behaviour of the entire complex agricultural systems that will aid in more clarity of consistency in policy objectives. This will close the gap of inadequate information both to farmers and policy makers and governance. Through the archetypes and the CLDs, it has been identified that better linear solutions do not solve the problems, but better systemic approach to the problems could lead to the provision of the right management strategies

Inclusive of stakeholders and their knowledge, using systemic interventions can increase the chances of innovation adoption and thus improve the agricultural supply chain. Farmers must evaluate the existing archetypes in their industry as well as evaluate its resource needs to assure that it will deliver profitable agribusiness in the most efficacious manner possible.

The same data will be validated involving same respondents and the outcomes will be refined into system dynamics simulation model, which will constitute an integrated master plan with orderly defined goals and strategies (systemic interventions). To operationalize the master plan, Bayesian belief network (BBN) modelling will be used to determine the requirements for implementation of the

management strategies, the factors that could affect the expected outcomes and the order in which activities should be carried out to ensure cost-effectiveness and to maximize impact.

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