A SYSTEMS THINKING APPROACH TO ADDRESS THE COMPLEXITY OF AGRIBUSINESS FOR SUSTAINABLE DEVELOPMENT IN AFRICA

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ABSTRACT

African countries have comparative advantages in terms of land and relatively cheap labour cost compared to western countries in the production and export of primary commodities. However, there are many challenges such as sustainability issues, and the danger of "silo mentality" (in which fixing one problem "here" simply shifts the problem "there") and "organizational myopia" (in which a short term fix "now" gives rise to a much bigger problem to fix "later") facing the agriculture sector. Since the democratic progresses of many African countries, there have been a number of interventions to overcome the challenges facing the agriculture industry but with little success. The problem still persists and many budgeted billions of dollars for the agriculture sector have already been spent. The agriculture industry is a complex system economically, socially, and environmentally thus dealing with problems in isolation fails to produce lasting results. A survey and literature reviews was conducted to gather the mental models of all stakeholders involved in addition to the challenges of the agricultural sectors within Africa. Their opinion concerning how the system works, barriers to success and the system drivers, and possible strategies (solutions) to overcome these problems was analysed. These results developed four system models for agribusiness sustainability using a "systems thinking" or integrated approach and tools such as casual loop diagrams and Bayesian Belief Network models. Casual loop modeling were used to determine the components and interactions between the policy, social, environmental and economic dimensions to provide insights into potential systems behavior and to facilitate leverage points and systemic intervention strategies that are required for sustainable development of the agriculture industry. The Bayesian Belief Network models reveal that farmer education, access to both seasonal production, access to information, quality seeds and cold storage facilities will help drive overall export performance by 8.2%, increasing market share by 11.7%, raising export volume by 22% and enhance farmer's profit by 13.1%. This approach will enable and assist farmers, policymakers, researchers and donors to successfully manage the agriculture and food systems so as to strengthen food security, enhance rural livelihoods, and improve environmental sustainability in the context of the challenges arising from agriculture production in Africa. These will also help stakeholders and governments to anticipate the long-term consequences of their decisions and actions, as well as the unintended consequences of policies and strategies and avoid "silo mentality" and "organizational myopia". This will further induce innovative agribusiness with an entrepreneurial approach and empower the youth to be successful agribusiness entrepreneurs through an innovative and systemic approach.

Keywords: systems thinking; agriculture; Africa; sustainable development; causal loop modelling; leverage points.

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1 INTRODUCTION

Increasing production and export of agricultural products in a sustainable manner can be an effective way of reducing poverty and enhancing economic growth in developing countries. Agriculture is emphatically the back bone of the economies of most African countries as well as have comparative advantages in the production and export of primary commodities in addition to timber, minerals and oil (Bates 2005; Nutsukpo et al. 2012). In addition to being an important source of household income, it also constitutes the core of raw materials for the manufacturing sector. Africa is populated with more than 900 million people and 70% of them are engaged in agriculture for full-time employment (Bationo, A & Waswa, BS 2011; Mahajan 2009; Ojukwu et al. 2010), 33% of national income and 40% of total export earnings (Bationo, A & Waswa, B 2011) and several others depend on agriculture for part of their household income. Due to the importance of the agricultural sector's to national economy and household income, accelerating agricultural growth is key for transforming Africa and also a must for reaching the middle income country (MIC) target (Bates 2005; Breisinger et al. 2008).

Despite the importance of agriculture in the African economy, it is characterized by low productivity, poor quality products, poor service quality, and high production and transaction costs (Eifert, Gelb & Ramachandran 2008; Kydd et al. 2004; Wiebe et al. 2003). It is also plagued by major environmental constraints such as competition, legal requirements and technology (Bationo, A & Waswa, B 2011; Nutsukpo et al. 2012; Ortmann 2000, 2005). An increase in agriculture production over the past 20 years at an average rate of 3.2% is due to an increase in land under cultivation rather than productivity increase. For example, a 229% increase in cultivated farmland accounted for 70% increase of productivity in regional production (Oxford Business Group 2010). Average agriculture growth rate in real terms has been stagnant at about 1.7 to 1.9 percent since 1965 (Cleaver 1993). According to Cleaver (1993), the agriculture growth rate is far less than the population growth rate which has increased from 2.7% per annum between 1965 to 1980 to 3.1% per annum since the 80s. These and other significant factors have exposed 200 million people in Africa to the vulnerability of food insecurity (Ojukwu et al. 2010). This is further demonstrated by food imports and aid which have increased from 4 to 7% per annum respectively since 1974 (Cleaver 1993) and have put more pressure on economic growth which has been held at 3% over the past 20 years (Ojukwu et al. 2010). Currently, it is estimated that Africa can feed less than half its population by 2015 (Ojukwu et al. 2010). Agricultural GDP per farmer over the last two decades has risen by less than 1% in Africa relative to 2 and 3% per annum in Asia and Latin America respectively (Nutsukpo et al. 2012; Ojukwu et al. 2010). According to Boko et al. (2007), there has been a 20 to 40% decline in rainfall in Africa over the past fifty years, this has resulted in a serious consequences for the savanna or dry land areas. Per-hectare yields for most crops are among the lowest in the world, only increasing by an average of 42% between 1980 and 2005, and accounting for just 30% of the increase in agricultural and food production (Bationo, A & Waswa, BS 2011).

There have been many initiatives to address and modernize the agriculture sector in African by the World Bank, FAO, governments, research institutions, NGOs etc. However, these initiatives have failed to modernize the sector. The reasons include, among others: the challenges in particular low agricultural productivity, abject poverty, food shortages, unequal income distribution, deforestation and unfair competition cited above are still predominant; therefore continue to hamper the development of the sector.

To help address the above challenges, this research considered a new approach that address the root causes of challenges by viewing "problems" as parts of an overall system, rather than a linear approach or quick fixes to specific parts which leads to the danger of “silo mentality” in which a fix “here” simply shift the problem to “there” and “organizational myopia” in which a fix “now” give rise to a much bigger problem to fix “later”. This paper used a systems thinking approach to address sustainability challenges in a holistic view, using systems models. “Systems thinking” is based on the belief that the component parts of a system of interest can be best understood in the context of its connectedness or linkages and relationship or interactions between the entities or elements that comprise the whole system, rather than in isolation (Sherwood 2002a). According to Sherwood (2002a) “Systems thinking” focuses on cyclical rather than linear cause and effect. “Systems thinking” admit that an alteration in an area of a system component can adversely affect another part of the system; thus, it promotes Self-organisation and emergence at all levels in order to avoid the silo effect.

1.1 *Aims and objectives of the study*

1.1.1 Aims

In this paper, systems models were developed for agribusiness sustainability, using an systems thinking approach and its associated tools such as casual loop diagrams and Bayesian Belief Network models to demonstrate its application to address effectively complex and sustainability issues affecting the agricultural sector. This addressed the system complexity by gathering the “mental models” of all stakeholders involved in addition to the challenges of the agricultural sectors in Africa. This provide a way for decision makers anticipate the long-term consequences of their decisions and actions, as well as avoid the unintended consequences of policies and strategies and also avoid the danger of “silo mentality” and “organisational myopia”.

1.1.2 Research questions

This study addresses the following problems:

- The pressing constraints and challenges facing stakeholders and performance of the agricultural sector in Africa.
- The opinions of stakeholders concerning how the agricultural system works, barriers to success and the system drivers
- The possible new strategies or solutions needed to be designed to overcome these challenges or problems in the agricultural sector
- How competitiveness can be increased through the formulation of management policies which will help in the proper allocation of a country's scarce resources

These questions were addressed within the context of literature and focus group discussions with African agricultural students studying at the University of Adelaide, Australia.

1.1.3 Objectives of the study

In addressing the questions identified, the research aims:

- To provide an understanding of the dynamics, interconnectedness and relationships present within the agricultural industry

- To identify leverage points and key research areas to help prioritize actions and understand the importance of addressing core issues rather than symptoms within the agricultural system to enact effective changes
- To reveal the simplicity underlying the complexity of management issues in agribusiness
- To develop a systems model to capture key forces and dynamics affecting the agricultural industry in Ghana
- To introduce and implement integrated approach in youth agribusiness development with participation of all stake holders and link them to the value chain

1.2 Justification for the research

African governments and agriculture proponents currently have neither adequate information, nor the necessary tools, to analyse the performance of policies affecting the food and agricultural sectors. They are under increasing pressure to make the right management decisions in the face of a continually changing political, socio-economic landscape and technological change. Local and global problems and challenges facing the agricultural sector of Africa today are highly complex in nature. These problems and challenges cannot be addressed and solved in isolation and with the single dimensional mindsets and tools of the past.

Therefore, agricultural sustainability management requires a systemic approach to interventions and capacity-building, based on systems thinking and complexity management to address challenges holistically and deliver the sustainable outcomes desired. The on-going Cat Ba Biosphere Reserve sustainability project in Vietnam by Nguyen and Bosch (2012) is a demonstration case for these approaches and has been adapted to the agricultural sector.

1.3 Significance to discipline

Systems thinking approach in applied economics in the context of a social, economic, environment or business is greatly increasing in modern times (Nguyen & Bosch 2012). The increasingly complex nature of government and business has raised the use of a systemic research approach in solving operational problems. This assumes a significant role in formulation of economic policy, for both the government and business. Systems thinking approach is a new concept of sustainable management and many fields of study are yet to be explored by this approach. Apart from that, its application to agricultural sustainability management is yet to be exploited by many researchers, managers and policy makers. Though other generalist thinking or traditional approaches to solving problems in isolation to sustainability managements have been attempted but with little success, this approach highlights and addresses problems in integrated or systemic approaches and demonstrates how to translate hitherto difficult ideas into potent management tools for change. The theory of this approach uses thoughtful, realistic examples to build policy makers and or managers understanding of not only when a more systemic solution is possible, but how to uncover that solution.

The results can be applied to such a wide range of situations because the approach is adaptable to different contexts and can deal with complexity as in the agricultural sector of African countries. The research would benefit not only several countries in Africa but also the world at large. First of all, this study would be able to benefit governments, managers, policy makers of the agricultural sectors, the World Bank, FAO, NGOs and other development agencies as the model can reveal the root cause of challenges and identify key leverage points. It can also serve as the basis of an economic system for all governments, and proponents of good policies for agribusiness sustainability. It can also be used as "simulation model" to develop and test alternative Government budget formulation and management policies which can helps in the proper allocation of a country's scarce resources. This can serve as a platform to tame the complexity of the challenges in natural resource management in addition to social, economic and environmental development in Africa. This research describes an approach to bridging the gap between dealing with problems in isolation to an integrated approach.

In this light, the results ("casual loop diagram") of this study reveal and foster integrated planning for sustainable development which is necessary in Africa and avoid disjointed government policies coupled with a lack of unity in fixing challenges among international agencies. This will also help decision makers anticipate the long-term consequences of their decisions and actions, as well as avoid the unintended consequences of policies and strategies. This will also help provide deep dialogue and consensus building with a common language for diverse stakeholders.

2 LITERATURE REVIEW

2.1 Some initiatives to modernize the African agricultural sector

According to Sandrey et al. (2008) and Vink, Tregurtha and Kirsten (2002), as cited in Economic Research Division (2011), the agriculture sector has undergone huge economic, social and political changes since the beginning of African democratic progress. This has increasingly impacted productivity and integration into world markets. Since 1972, there have been many interventions from the World Bank, to address the challenges facing the agriculture industries in developing countries through the Consultative Group for International Agricultural Research (CGIAR). In 1975, the World Bank published a design named "rural development in Africa" which was the centre piece for the bank to counter food shortages and unequal income distribution (World Bank 2013). In 1978 there was a further study by the World Bank to alleviate abject poverty and distribute benefits of growth to the poorest. In the same year the World Bank and International Fund for Agricultural Development (IFAD) signed an agreement to cooperate in the identification, preparation, appraisal and administration of agricultural development projects. In 1979, former president of the World Bank, McNamara warned that the growing trend of trade protectionism can undermine economic development, and proposed "structural adjustment" lending in an address to the United Nations Conference on Trade and Development in Manila, Philippines (World Bank 2013). In 1981, the World Bank focused on an agenda for action, also known as the "Berg Report" for accelerated development in sub-Saharan Africa. Then in 1995, the World Bank donates a grant of $3 million to the World Food Program for emergency food supplies to drought-stricken Sub-Saharan Africa which was the second donation within the space of a single year ($2 million was granted in April 1984).

This indicates that all its initial interventions could not fortify the sector. In 1986, the World Bank issued a statement on its forestry operations. The statement asserted that the Bank is deeply concerned about the destruction of tropical forests, and is intensifying efforts to effectively deal with the problem. In 1996, the World Bank released "Taking Action to Reduce Poverty in Sub-Saharan Africa", outlining specific actions that the Bank will take to improve results in poverty alleviation. In 1998, a meeting of African agricultural policymakers and researchers, organized by the World Bank and African Development Bank, was held in Abidjan, Ivory Coast to discuss food security and economic growth. Then in 1999 World Bank approved a program for policy-based guarantees, extending the Bank's existing partial credit guarantee instrument beyond projects to include sovereign borrowings in support of structural and social policies and reforms. Previous new lending instruments include Learning and Innovation Loans, Adaptable Program Loans, Programmatic Structural Adjustment Loans, and Special Structural Adjustment Loans have failed to deliver it promises (Havnevik et al. 2007).

In the 1990s, African heads of state, government and donors engaged in a lot of tentative initiatives to reverse the negative trends in and concerning agriculture in Sub-Saharan Africa (Zimmermann et al. 2009). In 2003, the New Partnership for Africa's Development (NEPAD) and its Comprehensive Africa Agriculture Development Program (CAADP), were launched to catalyze growth in agriculture in the region (Zimmermann et al. 2009). Furthermore, in 2003, African governments signed the Maputo Declaration committing to a minimum allocation of 10% of their national annual budgets to agriculture (African Union 2003). Recent political fora confirmed the urgent need to secure and increase basic food staples, these are the Sirte Conference on Water for Agriculture and Energy (December 2008), the FAO Summit of 2008, and the AU Summit (July 2009) on Investing in Agriculture for Economic Growth and Food Security (African Union 2009; FAO 2008). As an expression of their strong commitment to support agriculture in Africa, in July 2009, the G8 pledged to provide US$ 20 billion over the next three years to increase food production on the continent (Zimmermann et al. 2009). The L'Aquila Declaration which is centered on energy and climate further underscores the need for effective use of investments in the agriculture sector (Zimmermann et al. 2009).

2.2 Impact of interventions to date

However, these initiatives have failed to modernize the sector. The reasons include, among others: the challenges in particular low agricultural productivity, abject poverty, food shortages, unequal income distribution, deforestation and unfair competition cited above are still predominant; therefore continue to hamper the development of the sector. Furthermore, the sector is weak in responding to new challenges posed by development cooperation due to its multi-complexity. This is due to its openness and intense interactions with other sectors economically, socially, and environmentally. However, good agricultural strategies, programmes and policies are considered essential to prelaunch agriculture and attract donor's interest under the new aid modalities. There is a broadly shared consensus that, for African countries to turn the table of underdevelopment, they must succeed in calibrating their agricultural and eco-policies in a manner that not only diversifies output and boosts productivity but also promotes strong linkages with other economic sectors and serves broad social policy objectives. According to Nguyen and Bosch (2012), building human capacity and renewing a critical mass of domestic capacity for the design and implementation of sound agricultural policy in rapidly changing contexts is, therefore, absolutely a key leverage for sustainable economic, social and agricultural development in Africa.

2.3 "Systems thinking" approach to sustainable management

Currently, it is rare to go through a single day without hearing the words "sustainability" or "green" applied to anything from Apple products to Zinfandels (Kim 2012). Resolving today's challenges requires moving from a "linear" way of thinking to a "systems" perspective that brings thought and behaviour into line with the natural laws of sustainability. “Systems thinking” is a trans-disciplinary “framework for seeing interrelationships rather than things, for seeing patterns of change rather than static snapshots” (Nguyen & Bosch 2012). According to Nguyen and Bosch (2012) critical systems thinking is a way for development practitioners to conceptualize and act towards the integration of social, environment and economic dimensions of sustainability which support communities to address the challenges of improving both human and ecosystem well-being. Bosch et al. (2013) agree that, the use of systems thinking approach indeed helps to leverage management complexity relative to other approaches. The challenges of sustainability are complex and ever changing, and require the development of effective mental models in the face of rapid social, political, economic and technological changes that support adaptive transition to sustainability. Senge (1997) explains "Mental models as deep-rooted generalizations, or images that influence how we understand the world and how we take action". Mental models exist for families, organizations, the global market, the environment and of course, what sustainability is and how to achieve it (Soderquist & Overakker 2010). Mental models are used to assess what is happening, predict what might happen and choose how to influence our future through casual loop diagrams.

Causal loops diagrams are variables connected by key causal relationships to represent reality used to display the behaviour of cause and effect from systems standpoint (Toole 2005). Causal loop diagrams (CLD) simply convert the complex elements into simple easy understanding plan and often is the first step process approach to modelling. The relationships between these variables, represented by arrows, can be labelled as positive or negative. Everything start with a cause, a cause leads to effect, and the effect leads to another cause, another cause leads to another effects, and this things go on and on and on again. The symbol ‘+’ or ‘S’ is used to show the cause and effect that changes in the same direction. In contrast, if the cause and effect shows change in the opposite direction, the symbol ‘-’ or ‘O’ is used. Feedback loops describe the cause and effect relationships between the parts of a system (Bettis & Prahalad 1995). 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 result in a dampening effect.

For example plant processes photosynthesis (Figure 1), when it produce more photosynthesis, it grows better, so there will be a positive side, then when it grows better, it needs more photosynthesis to support it, so there will be another positive side and this shows reinforcing feedback.

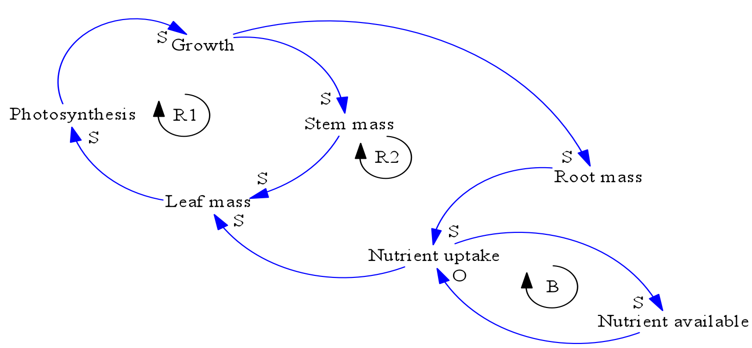

Figure 1: photosynthesis loop

Plant processes photosynthesis, more photosynthesis leads to a better growth. A better growth enhances stem mass and this also to leaf mass and this leads to more photosynthesis process this is the first reinforcing feedback. As the same process the plant grows, it enhances the root mass, this encourages more nutrients to be absorbed, the leaf mass get stronger and more photosynthesis is required, there is another reinforcing feedback. Next more nutrients was uptake means more available nutrients the more nutrient available means less nutrient uptake is needed, then there will be the balancing feedback.

3 RESEARCH APPROACH AND METHODS

This research work start with a detailed literature review on theoretical approaches on the concept of "Systems Thinking", the application of 'systems thinking to the agricultural sector of Africa and the identification of variables and different loops present within the agricultural sectors. Data collection for this paper was conducted through desktop survey and literature reviews to gather the mental models of all stakeholders involved in addition to the challenges of the agricultural sectors in Africa. The opinions of stakeholders concerning how the system works, barriers to success and the system drivers, an d possible strategies (solutions) to overcome these problems were analysed. Further study involving workshops and interviews with stakeholders will be conducted to validate the identified mental models obtained through desktop and literature review to refine the models. Further workshops will also be organised in Ghana and other African countries to refine the identified models.

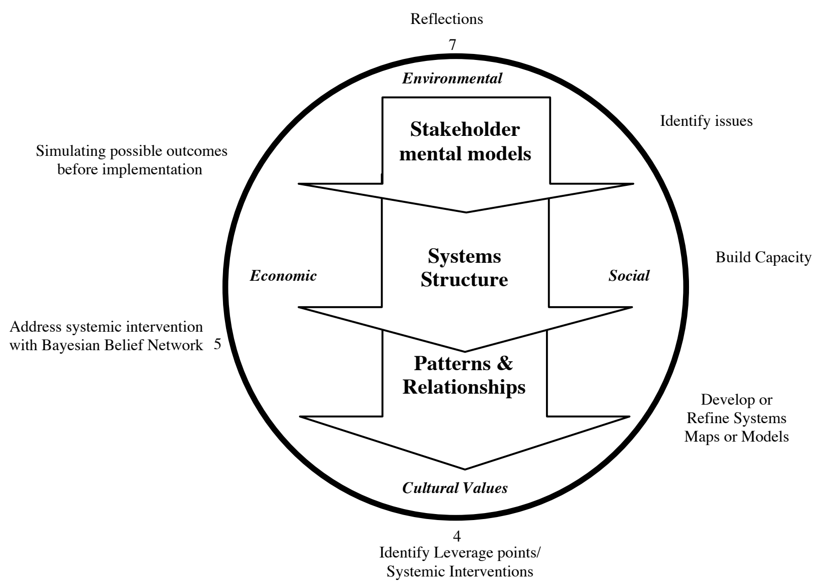

Figure 2: The basis of the systemic approach for managing complex issues

Adapted from Bosch et al. (2013)

Figure 2 demonstrates how stakeholders can deal with complex challenges in an unpredictable environment in the Africa context. This is a unique 'methodology' to integrate collaboratively and use existing and future knowledge to help manage complex issues. This approach has been used by Bosch et al. (2013) and Nguyen and Bosch (2012). It starts at the 'fourth level of thinking' which is the initial step to gather the mental models of all stakeholders involved in addition to the challenges under deliberation. Their opinion concerning how the system works, barriers to success and the system drivers, and possible strategies (solutions) to overcome these problems was analysed.

Step two; the ‘third level of thinking’ was done through follow-up capacity-building by involving agricultural PhD students of the University of Adelaide from African countries to integrate the various mental models to fit the systems structure. The Vensim software program (Ventana Systems UK) was used for the development of the causal loop diagram of the issue under consideration. The next step which is the ‘second level of thinking’ was completed by interpreting and exploring the model for patterns, their interconnected components, and analysed the kind of feedback loops, reinforcing loops and balancing loops which existed. These processes lead to step four, which is the identification of leverage points for systemic intervention. Leverage points are places within a complex system e.g. the agricultural industry or ecosystem where a small shift at a point can generate a bigger change in the system which can lead to significant lasting improvements’(Nguyen & Bosch 2012).

In step five, the outcomes were used to develop a refined systems model, which constitutes an integrated master plan with orderly defined goals and strategies (systemic interventions). As cited in Bosch et al. (2013), to operationalise, the master plan, Bayesian belief network (BBN) modelling (Cain, Batchelor & Waughray 1999; Smith, Felderhof & Bosch 2007) was 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 maximise impact.

The systems model can be used as a simulation model to test the possible outcomes of different systemic interventions by observing what will happen to the system as a whole when a particular strategy or combination of strategies is implemented: that is, before any time or money is invested in actual implementation. According to Bosch et al. (2013), this is a powerful way of determining where to invest time and resources, instead of having only a list of recommendations, without an understanding of how they are interconnected, which ones are the most important to invest in and in what order the strategies should be implemented to ensure an efficient and cost-effective plan of action.

In step six, once the systemic interventions have been identified and an operational plan has been developed, different interventions can be simulated to demonstrate possible outcomes before implementation. Step seven: because no systems model can ever be completely ‘correct’ in a complex and uncertain world, the only way to manage complexity is by reflecting at regular intervals on the outcomes of the actions and decisions that have been taken to determine how successful or unsuccessful the interventions are and to identify unintended consequences and new barriers that were previously unforeseen.

The iterative process serves as a valuable informal co-learning experience and leads to new levels of capability and performance. Working in this way as a coalition is the most effective way to deal with complex issues; because the methodologies and processes acknowledge that complex problems are multi-dimensional and have to involve all stakeholders mental model, they require cross-sectoral communication and collaborative approaches to resolve, and deal with many uncertainties that need adaptive management approaches as more knowledge becomes available through the iterative process of learning by doing.

4 RESULTS AND ANALYSES

4.1 Key identified variables of the agricultural sectors in Africa

Table 1 represent identified variables from literature and interview with agricultural experts doing their PhD at the University of Adelaide from Africa. Variables identification and choosing is a way of moving from the level of events or symptoms to the levels of patterns and structure as explained in the research approach. The table 1 include "Performance" measures variables such as costs, profit, GDP, etc., Causes and consequences of the performance or condition or symptom variables which mostly represent our "policies" or decisions and the actions of others that are a result of both problems and success. These variables are used to develop causal loop models in order to help understand the complex systemic structure of the Agricultural industry in Africa

Table 1: Key Identified variables of the agricultural sectors in Africa

MOFA	**QUALITY**	**EXPORT**	**Agribusiness**
Extension service	Cost	Regulations	Budget to Agriculture
Extension capacity	Produce quality	Market share	Profit
Training	Willingness to pay	Market size	R&D
Workload	Regulation	Exporter	Training
Strain on MOFA	Strain on export	Customer	Youth in agriculture
Cost	Exporter revenue	Farm scale	Migration
Ability to cope with farmers issues	Extension service quality	New farmers or exporters	Good Agricultural Practices
Extension officers head count	Exporter dissatisfaction	GDP	Environmental protection
Farmer population	Farmer revenue	Agronomic issues	Productivity
Farmer problems	Margin	Sales revenue	Savings
Farmer error	Resource	Profit	Seeds
Extension monitoring device	Frustration	Returns to investment	Yields
Farmer load	Migration	Investment	Storage facilities
Agriculture policy	Infrastructures	Competition	Value addition
Agricultural capacity	Storage facilities	Contract	Returns
Economic prosperity	Quality seed	Conflict	Deforestation
Education	Productivity	Employment	Co2 emission
Employment	Quality control	Growth rate	Pollution
Growth rate	Production cost	Farmer load	Health
Land reforms	Resource capacity	Price	Access to finance
Famine	Farmer load	Farm income	Climate change adaption
Food security	Pest	Hunger	Hunger
Agricultural development	Small holders	Exchange rate	Poverty
Adoption	Innovation	Economy of scale	Household
Farmer organisation	Farming system	Protectionism	Fuel
Information	Price	Irrigation	Expenditure
Sources (Anderson & Feder 2004; Barrows & Roth 1990; Bautista & Valdés 1993; Coulter & Onumah 2002; Delgado, Chrstopher L 1998; Delgado, Christopher L & Mellor 1984; Gibbon, Havnevik & Hermele 1993; Godfray et al. 2010; Haug 1999; Morris 1976; Pretty 1999; Pretty, Toulmin & Williams 2011; Raikes & Gibbon 2000; Viljoen 2005; Vlek 1990; Wu 2004)			

4.2 Developing Causal Loop Model

Agribusiness is the engine of economic growth, contributing a major portion of GDP, employment, and foreign exchange earnings in many developing countries as well as serving as the cornerstone of poverty reduction. In many African countries, cultivation and production of both crops and animals are produced by smallholder farms with limited mechanization and capacity, leading to high transaction cost and poor yields. Fragmented markets, price controls, and poor infrastructure also hamper production and development. Many of the agricultural products produced in the region, such as maize, rice, and palm oil, are not competitive globally or have low profit margins. The identified variables in the agricultural sectors of Africa lead to the formation of four different loops for the sector; The African agri-business industry loop, Ministry of Food and Agriculture (MOFA) loop, the quality loop, the export loop and the agribusiness loop. MOFA has great influences on food security, quality and training of famers, thus MOFA and Quality loops were combined to generate MOFA and Quality loop.

4.2.1 The African Agri-business industry loop

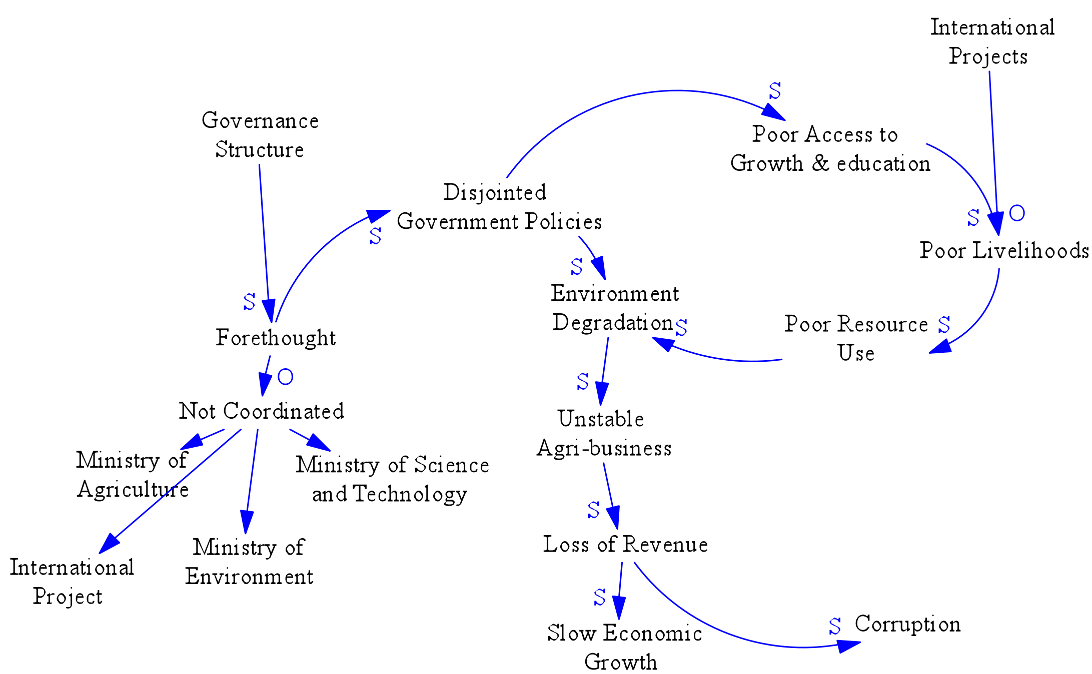

Figure 3: Africa's Agri-business governance structure

Governments and development agencies describe agri-business as an 'engine' for Africa's economic growth, and essential to establishing food security on the continent. However Figure 3 demonstrates the current governance plan in most African countries. There is lack of coordination in policy formation among the ministerial offices as shown in figure 3. The lack of coordination management plans in the governance structure has leads to disjointed government policies with unintended consequences such as environmental degradation, unstable agri-business and loss of revenue. These unintended consequences also lead to slow, no or sometimes negative growth and poor livelihood. This results in loss of jobs/employments which slow economic development and increase crime rates leading to high corruptions.

4.2.2 MOFA and Quality Loop

In most African countries, the ministry of agriculture controls and directs affairs of the agriculture industry. They are committed to agricultural research, technology development and technology transfer, and direct the optimisation of agriculture's role in the national growth and development. Agricultural extension services are part of the Ministry of Agriculture, with field extension officers at the bottom of the hierarchy and a minister at the top (FAO 1971).

Agricultural extension officers are a potent and critical force in the agricultural development process. Agricultural extension officers are intermediaries between research and farmers. They operate as facilitators and communicators, helping farmers in their decision-making and ensuring that appropriate knowledge is implemented to obtain the best results. They assist farmers through training activities in improving farming techniques, increasing production efficiency and income, bettering their levels of living, and lifting the social and educational standards of rural life (FAO 1989). According to Maunder (1973), they also communicate agricultural research findings and recommendations to farmers as well as bringing them useful information. However most small holder farming operations are typified by ad hoc, uncoordinated individual plantings where no authorisation is required from the relevant authorities, thus there is no record of the exact number of farmers cultivating in African countries (FAO 2004). This system has made it difficult to determine the number of extension officer to deploy in a particular region to help these farmers. Therefore the ability of an agricultural extension officer to assist farmer's problems in a particular location becomes an issue (FAO 1971). The key issue for farmers is reducing production cost and not compromising the qualities that get them buyers or customers. When the quality falls, buyers look elsewhere and for that matter, African farmers cannot be competitive on international market.

For an extension officer to make an impact efficiently, he should be able to assist with all the demand of the farmers in a timely manner: working with farmers to teach improved farming practices, new techniques, and more productive or more efficient technologies. Figure 4 demonstrate that the greater the ability to assist farmers, the better the service quality and productivity in general in the agricultural locality. Conversely, if the ability to assist is eroded, many things go wrong: only farmers who seek advice benefit and these tend to be large-scale wealthier farmers (FAO 1989), most smallholder farmers get stressed farming and make more mistakes which eventually affect quality and productivity.

Figure 4 shows within the centre, ability of extension officer to cope or assist farmers, linked to two other variables, extension service quality and farmer problem load. Each arrow indicates the cause and effect relationship and the symbols "S" and "O" indicate the way in which the cause and effect relationship work. According to the diagram, as the ability to cope increases, so does the service quality while the problem load of farmer decreases. As the ability of extension officer to assist goes down, farmers problems multiply, a possible consequence is, farmers get frustrated, do trial & error, and drop out of farming business and migrate to the cities which in general course productivity to go down. The direction of causality is such that, as the number of farmer's increases, extension ability to assist in field work goes down. Quite often supervisors and managers are drawn into the problem, collaborating with external organization to help address the issue. These put more strain on MOFA to sort farmer's problems out and increase the work load. The workload on the MOFA is driven by the number of farmers and the different types of agronomic problems to deal with. As the number of farmers and agronomic problems increase, so does the work load on MOFA and extension officers.

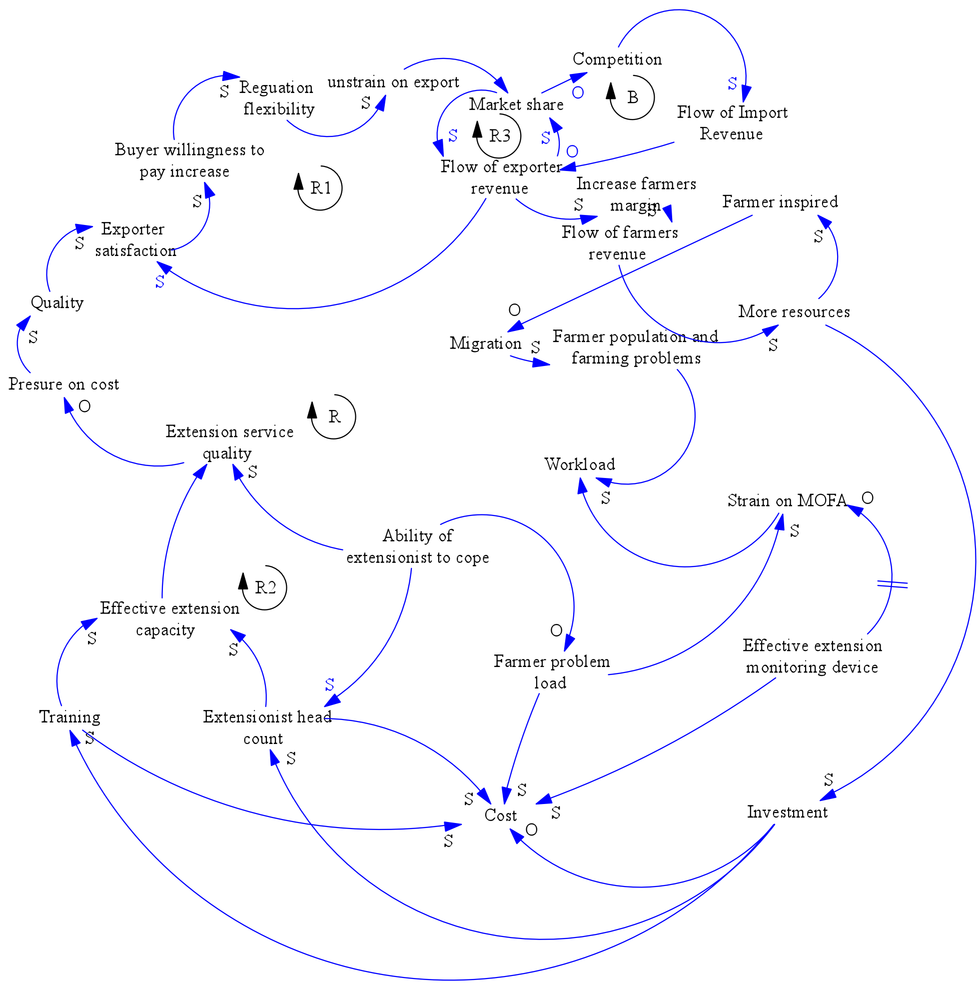

Figure 4: MOFA and Quality Loop

As the work load of MOFA increases, ability to cope decreases. For MOFA to reduce strain and increase farmer's productivity, the total number of farmers must be known, including a system in place to record new farmers or exporters who enter or exit the faming business. The right number of effective extension capacity and with good effective extension monitoring device must also be ensured. Effective extension capacity includes headcount and good training. The headcount, good training and monitoring system cost money. The "good" of optimising our ability to cope is therefore in direct conflict with the "good" of minimising cost. In many instances the budget to the agriculture sector is not enough, therefore, MOFA imposed headcount restrictions, minimise training, and the government divert resources to other sectors as in line with structural adjustment programs. However farmer's errors are expensive and include the cost of low productivity and the cost of losing international market to other competitors as well as cost for correcting the error through research and development. Conversely, if the government is able to meet the investment requirement of the sector, it will enhance productivity, reduce pressure on farmers cost and improve quality of agricultural produce. This will increase consumers' willingness to pay, putting less strain on export and increasing exporters and farmers revenue.

4.2.3 The Export Loop

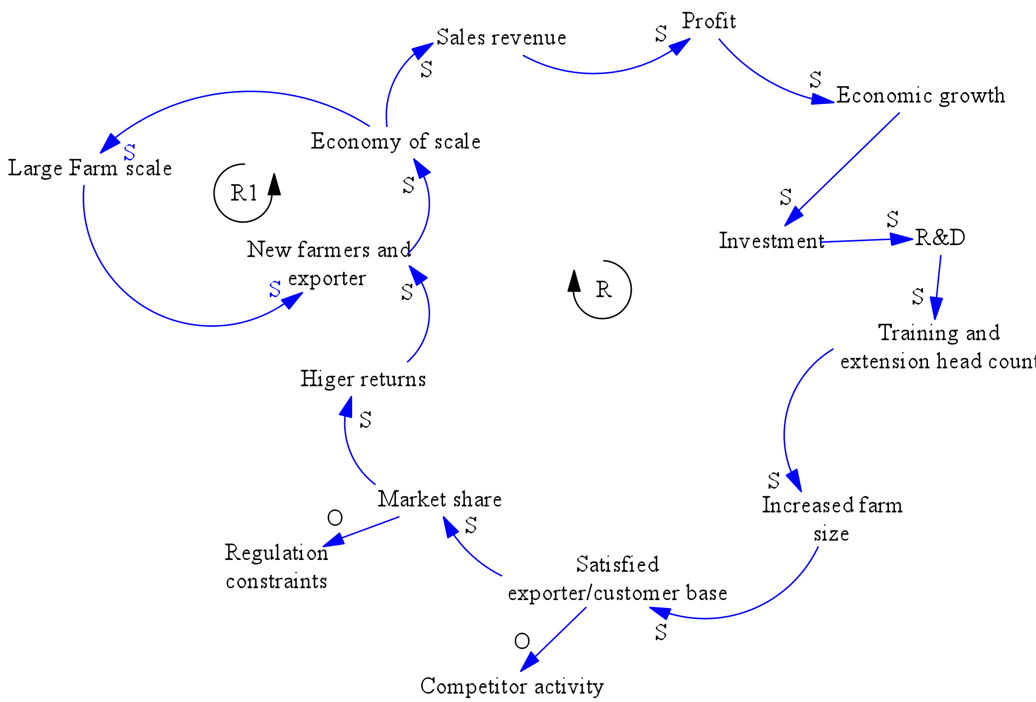

Figure 5: the export loop

The costs of compliance with international standards or related rules of Sanitary and Phytosanitary (SPS) of fresh produce exports from Africa is entirely born by the exporter despite the fact that their capacity for the compliance is limited. Indirectly if standard measures required by importing countries are not met, the exporting country would lose its market in those countries whether it is a member of WTO or not (Shafaeddin 2007). Exporters and farmers bear the cost of loss rejection of poor agricultural produce by importer at the border of an importing country, as well as the cost of reorganization of the supply chain; which often results in the lack of export expansion. However, the socio-economic cost of the lack of compliance is enormous. Agricultural exports represent one of the most important sources of foreign exchange that ease the pressure on the balance of payments and create employment opportunities for more than 80% of the workforce in Africa.

As shown in the Export Casual Loop Diagram in Figure 5, Government or exporters' investment to the agricultural sector enhance research and development. This enhances training farmers and extension officers with research outcomes which results in quality and efficient outputs and variably more investment in the sector. This leads to satisfied exporter and customer base which increase their competitiveness and market share abroad with less regulation constraints. The outcome is higher returns for the actors in the field and these attract new actors to the sector increasing the nation's economy of scale of the agriculture sector resulting in higher revenue, profit and economic development.

4.2.4 The agribusiness loop

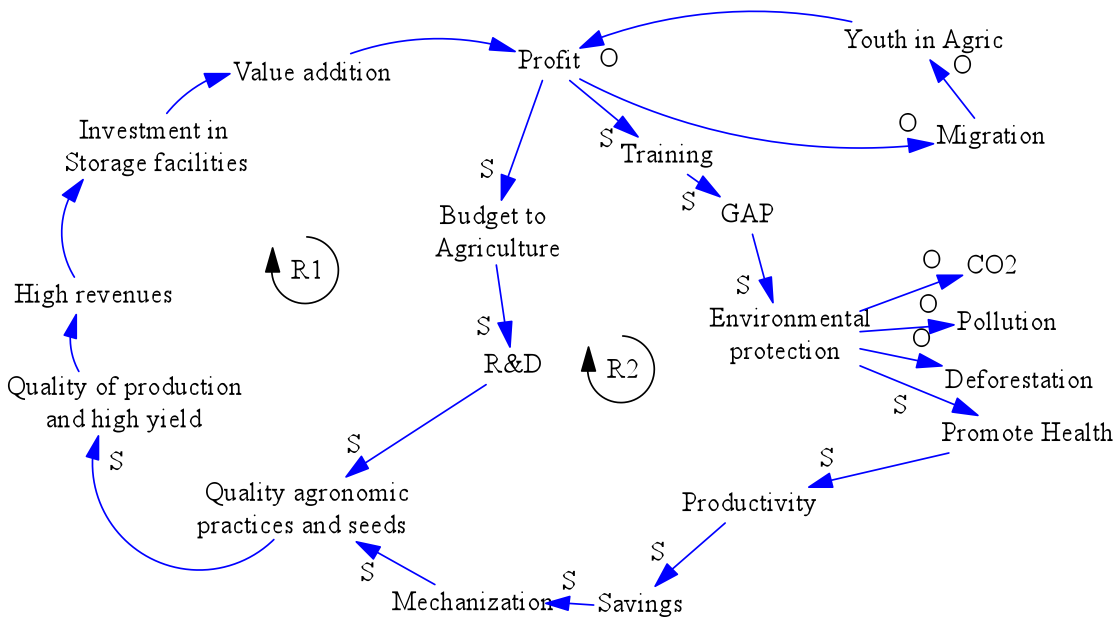

Figure 6: The agribusiness loop

The agribusiness casual loop, Figure 6 demonstrates that if government increase the budget to the agriculture sector, this will lift the research and development in the sector which in turn will lead to quality agronomic practices and quality seeds production. This will lead to more investment in the sector including investment in storage facilities and semi-processing as a result of higher revenues. This will as well lead to increased profit which can increase money circulating in the economy or investment in training by actors in the sector. This can also attract other stakeholders to the sector and will increase the attraction of the next generation of youth to the agricultural sector which will minimise youth migration from such sector because the sector will be more profitable. Training will lead to more Good Agricultural Practices (GAP) which will enhance environmental protection which in the long run promotes good health, which in turn increase productivity. This leads to more savings which can be invested in many areas including investment in mechanization which can also promote quality agronomic practices and feed into a reinforcement of investment and productivity.

4.2.5 Bayesian belief network (BBN) modelling for improving the quality of export produce

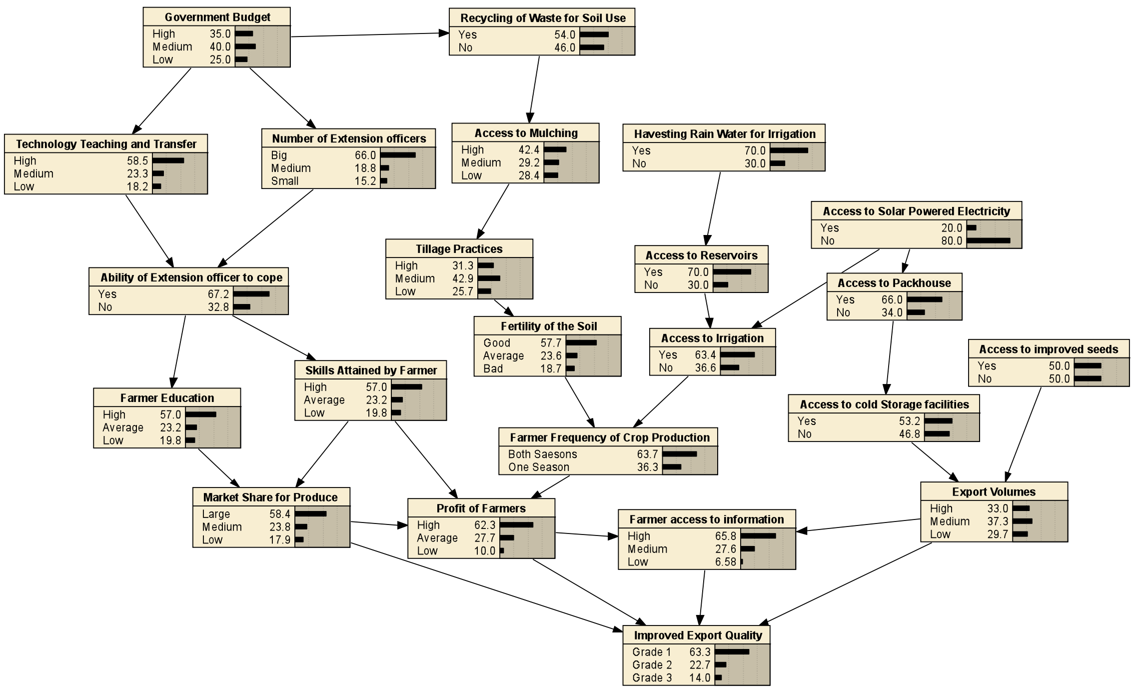

Figure7: BBN modelling for quality of export produce – current conditions

The leverage point identified in the MOFA and Quality loop in Figure 4 is to improve quality of agricultural produce for export. Most African farmers face challenges in terms of product quality and food safety from dramatically changed marketing chains that require African farmers to compete in the international markets.

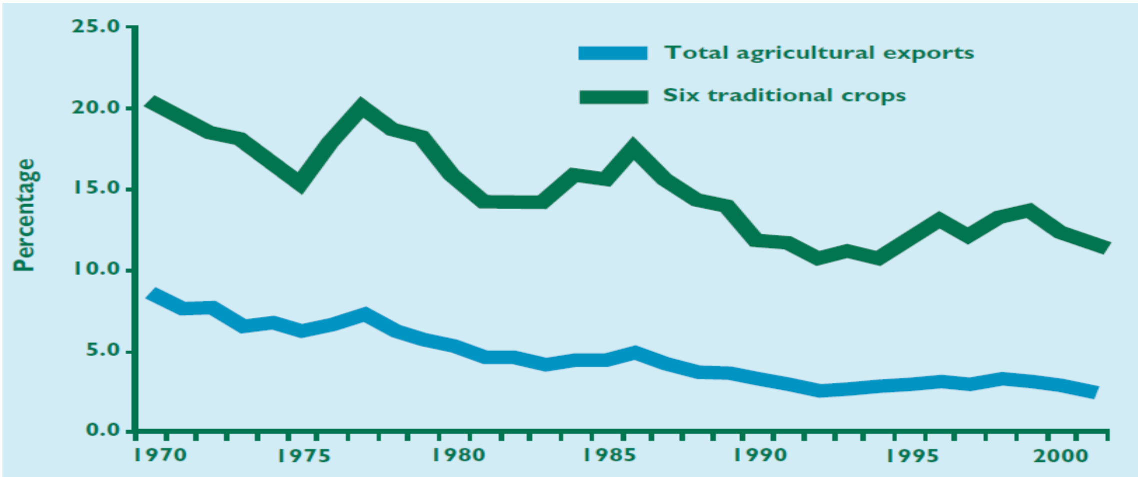

Figure 8: Sub Saharan share of agricultural exports 1970-2001.

Source: (Diao & Hazell 2004)

The challenge posed by world demand for agricultural produce is compounded by competition from many exporters in Asia and Latin America who have improved product differentiation and quality, features that satisfy importing countries increasing demand. According to Diao and Hazell (2004), Africa has lost its market share in the global marketplace since the past two decades for its agricultural exports (Figure 8). Africa's share of the total world market for agricultural exports has fallen from about 6 % in the 1970s to 3 % in 2013. The BBN model in Figure 7 indicates the current quality levels of agricultural produce termed as first class or grade one, second class or grade two and third class or grade three. Grade one quality are normally exported whereas grade two and three are sold in the local market and also used in the processing industries. The BBN model in Figure 7 shows the current grades as 63.3% grade one quality, followed by 22.7% and 14.0% of grade two and three respectively of agricultural produce of Africa.

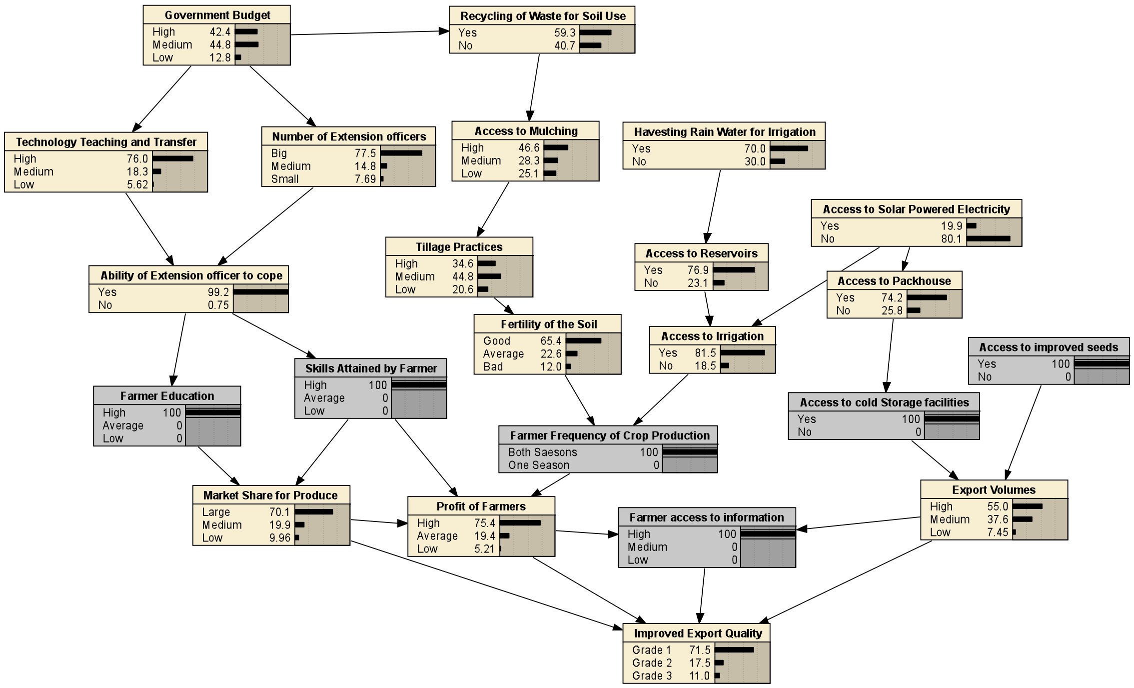

Figure 9: BBN simulated Model of improving quality

However, simulating farmer education, access to both wet and dry season production, access to information, quality seeds and cold storage facilities as shown in Figure 9, the performance of the export sector improved by 8.2%, increasing market share by 11.7%, raising export volume by 22% and enhance farmer's profit by 13.1%.

5 CONCLUDING REMARKS

This research presents four Causal Loop Diagrams for generic mental models of agricultural management system in Africa. While it is believed that the diagrams are more complete than found in previous literature, it will still be refined further and validated through focus group discussions and in-depth interviews with stakeholders in the agricultural industry in Ghana to include missing variables for all project management contexts.

As demonstrated in the above Causal Loop Diagrams with a systemic approach, agriculture will be the engine that develops and empowers the emerging and existing commercial agribusiness sectors and entrepreneurs/business people across Africa. This will also provide access to a system perspective of dealing with sustainability challenges in a resilience collaborative, integrated systemic holistic approach and gradually extinct the linear way of dealing with challenges. With systemic approach as demonstrated above, information on farming, agro-processing and the related agribusiness services, including the links between the commercial agribusiness opportunities on the continent to the necessary/required technology, inputs, resources and expertise will all be synchronised.

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