POULTRY WASTES REUSE THROUGH REVERSE SUPPLY CHAIN PROCESS TO ACHIEVE ENVIRONMENTAL SUSTAINABILITY

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Abstract

Environmental sustainability is well known for the livestock industry to manage resources to gain additional profit. Poultry livestock farms generate tons of wastage, which can be reused to transform economically valuable by-products. This quantitative study investigates reuse of poultry wastage to reduce environmental hazards. The model was developed under system dynamics simulation environment using design science methodology. The objectives of this paper are twofold. First, it develops a poultry process model considering reusing of poultry wastes in light of achieving environmental sustainability. Second, it develops causal loop diagram and stock and flow model to test the model under simulation environments. The paper ultimately focused on environmental sustainability along with reverse supply chain process in the hub of poultry industry in Bangladesh.

Keywords**:** *Environmental Sustainability, Reverse Supply Chain, Poultry Industry, Poultry Wastes, Bangladesh*

INTRODUCTION

Production procedures are often complicated as it deals with environment, social and economic issues during different stages of production (Corbett and Kleindorfer, 2003, Seuring and Muller, 2008). To maintain an intact environment for the subsequent generation, it is always important to maintain optimal productions based on monitoring environmental impacts. It is complicated for a business to integrate environmental sustainability with their production supply chain process (Shamsuddoha, 2010). Reversing wastes in another chain or forward flows are comparatively new idea in supply chain concepts as it deals with product return, recycle, reuse to keep intact of surrounding environment and internal Waste Management (Shamsuddoha, 2011a). Bangladesh is considered one of the most appropriate countries around the world for poultry rearing (Shamsuddoha and Sohel, 2008). The appropriateness is justified via to employment creation, entrepreneur development and social and economic changes in rural, urban and sub-urban areas. Realistically, poultry entrepreneurs do not have sufficient knowledge on reversing wastes through reverse or forward chain to maintain environment sustainability.

Now-a-days, we witness a bunch of young poultry farmers are motivated to take up poultry farming as a main profession due to high competition in the corporate job market (Shamsuddoha et al., 2011). These young educated people are trying their best to apply scientific knowledge on reverse supply chain and environment sustainability to build sustainable farming. Applications of such dynamic concepts an easily guide them toward more scientific farming with better profitability and sustainability. The entrepreneurs are picking up skills and good practices through the help of other poultry practices from developed countries like USA, Canada, France, China, Malaysia, and Thailand.

There is a scarcity of research works on such environmental issues, including reverse chains. This study will help them to understand how to achieve environmental sustainability and how to apply the reverse supply chain process within their existing operations. Unfortunately, these wastes are thrown into vacant land and rivers, which cause severe environmental damage (Shamsuddoha, 2011a, Shamsuddoha, 2011b). As Bangladesh is a relatively small country compared to its population, such dumped wastes creates environmental problems. Environmental problems contribute to the spreading diseases, polluting drinkeable water by contaminating river or canal water, spread odour in human localities. This research aims at the quantity of poultry wastes that could be reused in making by-products. It is argued that these by-products achieve social, economic and environmental benefits to the society.

The first task of this research was to develop a reverse supply chain model to sketch the real life practices in current poultry operation in Bangladesh. The causal/qualitative and quantitative model being developed based on real life and standard practices informations/data from poultry experts and executives. Finally, the model was used to simulate various scenarioos using the given data and various inout parameters to see the changes of behavior of the variable over time. These modeled changes of behavior over time is important for the industry as it provides policy makers or poultry entreprenuers with information with respect to optimality, sustainability and profitability. Future projected data is also observed in this stage.

LITERATURE

Sustainability is focused on the natural environment with implicit recognition of social and economic responsibilities (Jennings and Zandbergen, 1995). The environment needs to be protected from unrestrained expansion if we are to preserve human welfare before diminishing returns set in (Mill, 1848). Sustainability denotes 'meeting the needs of the present without compromising the ability of future generations to meet their own needs'(WCED, 1987). In reality, animal science and technology must be linked and deals with the society's benefits, optimum use of resources, being sensitive to environments with complex ecological balances and economically efficient production systems (Boyazoglu, 2002). However, sustainability must also integrate issues and flows that extend beyond the core of supply chain management: product design, manufacturing by-products, by-products produced during product use, product life extension, product end-of-life, and recovery processes at end-of-life. In this process, reverse supply chain refers to the series of activities necessary to retrieve a product from a customer and either dispose of it or recover value (Prahinski and Kocabasoglu, 2006, Linton et al., 2007). Again, the reverse chain process potentially can reduce negative environmental impacts of extracting virgin raw materials and waste disposal (Kocabasoglu et al., 2007). For instance, Wal-Mart has dedicated redistribution or processing centers for reverse logistic aspects of repairs, replacement part return to customers, inspection, salvage, disposal and reworks such as upgrades

(Krumwiedea and Sheub, 2002). In poultry, Wimex, Europe's largest producer of broiler hatching eggs and owner of Cobb Germany, has developed a biogas plant based on mostly chicken manure (Ranson, 2009). Over the last decade, reverse logistics has had a significant social, economic and environmental impact on industry as well as society. Companies that receive items back from the customer and not appreciate the significance of reverse logistics do missed out on profit-making opportunities (Krumwiedea and Sheub, 2002). Reverse logistics with end-of-life (EOL) products embraces many different characteristics of environmentally conscious manufacturing, including disassembly, reuse (Edwards and Daniel, 1992), recycling and remanufacturing (Gungor and Gupta, 1999). There is a disagreement whether poultry waste reuse and recycling can be called as reverse logistics or not. This study is argued that recycle and reusing of poultry wastes somehow follows the reverse logistics. For example, poultry is consumes huge feed intake and supplies wastes to the producers. Again, poultry litter can be used for making biogas and create further wastes which can be used in making fertilizers. It may flow in the forward or reverse flow of the main process.

There are four different kind of poultry wastes, namely, litter (Burak Aksoy, 2008), manure/compost (combination of poultry litter) (Rivera-Cruz et al., 2008), feathers (Shih, 1993), broken eggs and intestines (Burns and Stickney, 1980). Poultry litter can be the source of fertilizer (Gupta and Charles, 1999), bio gas (Bala, 1991), charcoal and fish feed (Burns and Stickney, 1980); feathers can be raw materials for the Bed industry (Shamsuddoha, 2011a), broken eggs for the bakery and intestines for the fish farms (Shamsuddoha, 2011a). The literature review identifies a few number of studies have been conducted on environmental sustainability and reverse supply chain process. Research gaps remain in the theory and practice of the poultry industry. No evidence was found on reversing poultry wastes in a supply chain being considered in Bangladesh context. This research gap motivated the researchers to conduct research that focused on this area.

POULTRY, ENVIRONMENT SUSTAINABILITY AND REVERSING WASTES

Over 73% people lives in the rural areas and are highly dependent on agriculture and livestock system in Bangladesh. The contribution of the livestock sub-sector to GDP and the agriculture sector as a whole is currently 3.2% and 10.11% respectively (Discovery_Bangladesh, 2009). The poultry industry is one of the major industries among the livestock sub-sector. Approximately 20% of the protein consumed in Bangladesh originates from poultry. Among poultry species, the chicken population is dominant over others, at almost 90%, followed by ducks (8%) and a small number of quail, pigeons and geese (Das et al., 2008). To implement reverse supply chain concepts in Bangladesh poultry industry, there is little opportunities for product retrieval, return or reconditioning due to the nature of the product, as most chicken products are perishable. However, there are immense opportunities to reuse or recycle poultry wastage. By reusing poultry wastage, industries can make valuable products like fertilizers, bio-gas, pillows, charcoal, and bakery items. This kind of wastage conversion will help to maintain our environment and will add value at the customer end of the product cycle (Shamsuddoha, 2011a). Sustainability, Environment and RSC in the poultry industry have not yet received proper consideration by the researcher. There are an opportunities to conduct researches aimed at developing existing poultry operations so achieve an organized supply chain, sustainability, and profitability.

METHODOLOGY

At first, Forrester (1961) defined system approach and its complexities related to dealing with supply chains in the mid-1900s. Afterward, system dynamic modelling implemented in the automobile industry (Sterman, 2000), and paper recycling industry (Spengler and Schröter, 2003), and poultry industry (Shamsuddoha et al., 2011). Forrester's (1961) famous ''Beer Game'' (Sterman, 1989) and Meadows's ''hog cycle'' (Meadows, 1970) were developed on the basis of supply chains. Most studies were focused on the forward supply chain with only a few researches focusing on reverse chains (Aghalaya et al., 2012). Systems dynamic modelling is a suitable approach to analyse or observe the dynamic behaviour in particular supply chains. Methodologically, system dynamics has ability to deal with complex dynamics systems. That is, due to multiple factors and non-linear behaviour among variables these dynamic complex systems are difficult to predict based on a description of their static structure.

The methodological approach of this study is based on the Systems modelling methodology (Maani and Cavana, 2007). The two phases of this methodology used in this study follow a qualitative approach through depicting causal relationship among variables (Sterman, 2000), as shown in Table 1 in the appendix. In the first phase, the complex problem related to product returns in the poultry industry was structured systemically. For structuring the problem systemically, a behaviour-over-time data/information and chart was developed. In the second phase, a causal loop model was developed using a rigorous simulation package of Vensim DSS 6.01b. Both primary and secondary information was used in this study. Primary information was collected in September 2012 mainly through in-depth interviews with the sample respondents from the poultry case industry. The in-depth interviews and observations were used to gain insights and develop a case poultry supply chain model. The total respondents included the top ten executives in the industry. Secondary information was collected from various books, referral journals, conference papers, statistical yearbooks and company record and reports. This study adopted positivist ontology, empirical epistemology, and quantitative methodology based on real supply chain cases of poultry processes. The design science methodology was chosen for this study as it helped to developing models with relevant variables to attain goals (Simon, 1969) that could be hard and/or soft to meet particular objectives (Venable, 2006a, Venable, 2006b). A simulation package of Vensim DSS 6.01b was used as a tool to analyse the reverse process of poultry wastes in order to investigate the research objectives.

PROBLEM STRUCTURING

In the problem structuring phase, historical behaviour-over-time graph (BOT) was developed for the case industry. Developing a historical trend graph is one of the important tools used in systems thinking (Aghalaya et al., 2012, Borshchev and Filippov, 2004). Such graph shows the real-life trend of the key variables in a system. More historical data can be used to provide a proper impression of future tendency. Such behavior shows the growth, decline, oscillations, or a combination thereof. The important elements captured by a graph are the overall trends, directions and variations and not the numerical value of the variable (Aghalaya et al., 2012). In this study, reference graphs were drawn (figure 1) to capture the historical output (behaviour) of key variables of fertilizer, fish feed and biogas. The data input for the graph covered a total of two years (104 weeks) with weekly informations.

QUALITATIVE MODEL BUILDING

Causal loop diagramming or qualitative modelling (Sterman, 2000) is an important part of system dynamics modeling. Positive and negative feedback loops indicate the dynamic relationship among or between the key variables (Richardson, 1986). A causal loop diagram also helps with the visualizing of how interrelated variables affect one another. The diagram consists of a set of nodes representing the variables connected together (Aghalaya et al., 2012, Maani and Cavana, 2007). The relationships between variables, represented by arrows, can be labelled as positive or negative. For example, if an increase in the causal variable caused a decrease in the affected variable, a negative (-) sign was placed in the head of the arrow (Aghalaya et al., 2012).

The figure 2 in appendix is shown the relationships or links between/among key variables that are modeled to depict reality. The key variables of the poultry process were identified through in-depth interview and observation's techniques in the case industry. This model only depicts partial reality and only key variables are used to study the changes over time having calamities, policy changes and observe influential variables and its impacts. According to Figure 2, there are numbers of loops in this qualitative/causal model. A couple of loops are discussed below:

Negative Feedback loop ‘Poultry Litter and ‘Biogas’: If poultry litter supplies increases, then biogas production will increase as well. However, when biogas production escalates, litter will be a decrease for the time being.

Positive feedback loop ‘Poultry Litter’ and ‘Fish Feed’: If poultry litter supplies increases, then fish feed production will increase as well. Even so, when fish feed production intensifies, litter will be a decrease for the time being.

QUANTITATIVE/CAUSAL SIMULATION MODEL

The model (Figure 3) was developed based the causal diagram (Figure 2), and the relationship found among or between variables. This simulation model incorporates only the mainstream supply chain line along with reverse supply chain where poultry waste is recalled for reuse in the by-product production. The model also consists of a number of reference variables and excels look up to compare and contrast with the real-life outputs which are shown in a different graph in the appendix. Different calamities like disease, natural disaster and political unrest have been used in the model. The values of these calamities are between -1 to +1, here +1 and -1 indicate as no calamities and fully sink on calamities respectively. Like calamities, there is some policy variable (over/under production, government policy, competitor's action and market demand assess) were also needed as input. The value of these policy variables varies between +1 to -1. The model starts from the “Broiler Chicks Lookup” variable where policy maker/farmers decide how many breeder's chicks can be reared in their whole process as a flock. This breeder chicks look up is the only real-life information inputted to the system. Rest of the information is based on standard, assumption and experience of the farmers. Figure 4 shows the synthesim mode of the same simulation model where constant variables can be seen and adjusted. The frame of time used as the model depends on researcher or policymaker to help them decide how many years they do want to forecast their operation to help them gain insight into their operation.

VALIDITY AND RELIABILITY

Validity and reliability tests are the requisites to build confidence in system dynamics models (Barlas, 1996, Forrester and Senge, 1980). The formal principles of validation and realiability set by Barlas (1996) and Forrester and Senge (1980), which involved three major stages: structure validity; behaviour validity and tests of policy implications. Principally, structure validity tests resolve at assessing model structure and parameters without examining relationships between structure and behaviour. Structure validity comprises a structure-verification test, extreme-condition test, dimensional consistency test (Barlas, 1996). Structure validity has been checked by “Check Model” and “Check Units” option from the research tools. Figure 5 reveals the simulated output of three main variables in the poultry industry. The blue lines are marked as simulated result and red line marked as real-life data. It is observed that both the lines (red and blue) lines are almost matched with each other having around ten percent fluctuation. The simulation has been run for 156 weeks (three years) whereas real data available was for 104 weeks only. This means, that the simulation was used to predict an additional years’s result/output based on a historical business wave. Policymakers or researcher can use this model to see as far as they want to be predicted. Predicted results that are not similar to real-life output can still help producers, and policymakers get an idea about what measures they need to take in what stages as the model will provide some idea about the relationship between variables. This research compared real-life data and model output data. In figure 5, it clearly displays both the real and simulated data matchings closely enough to justify its validity.

EXTREME CONDITION TEST

Validity of a model under extreme conditions resulting values beyond the projection/anticipation of what would happen under a similar condition in real life (Forrester and Senge, 1980). This model has been tested in various ways of changing policy and constant variable, but it behaves as par expectation and trends. Finally, the model has been tested on the policy implications by the policy makers. For example, policy makers want to assess the growth for next year based on 20% instead of 10% due to demand an increase. The option in the 'synthesim mode' of the research tool allowed the researcher to change the value and option to study the effect to this change in another variable in the model. Figure 6 in appendix demonstrates the extreme condition test of the simulation model. So far, the results fluctuates based on extreme conditions (such as 14% decrease of government support, 16% decrease for disease, 25% increase for market demand, 23 % for competition, 8% decrease of natural disaster) are not showing abnormality of them model behavior. The model behaves perfectly based on changes of policy and constant variable.

MODEL RESULT AND DISCUSSION

Bangladesh is a densely populated country with inadequate land facilities and resources. In this circumstance, these poultry wastes can be vital resources for Bangladesh people. Number of by-products can be produced from poultry wastes through reversing poultry wastage to the same industry or third party small-medium industry. A model (Figure 3) in appendix shows that how poultry wastes can be managed for making economically valuable by-products of biogas, fish feed and fertilizers. The reverse poultry supply-chain model was modelled based on real-life practices in Bangladesh. By conducting in-depth interviews with large poultry farm executives, the researchers identified that there is a lack of use of poultry wastes. This lack of usage of poultry wastes pollutes the environment as it throws into river water and vacant land. The participant industry is adapted environmental practices, which helped them to remain free from poultry disease and generate some extra economic benefits by creating by-products from wastes (Shamsuddoha, 2011a). Appropriate poultry Waste Management can help to alleviate environmental hazards. The economic and social aspects of the reverse chain are exceptionally vivid. Reverse supply chain process applied to individual waste could help to build new businesses. These businesses can easily commercialize their products for both home and industrial users in Bangladesh.

Figure 3 shows that the poultry model that was developed into a simulation model using Vensim package. This model contains two different part of the forward and reverse supply chain in the poultry industry. This research has concentrated on poultry waste reversing to the by-product processing unit. Reverse supply chain process shown in the bottom of the simulation model of figure 2 and 3, consists of managing poultry wastes of broken and un-hatched eggs, poultry litter, poultry feather, intestines, and fish feed. This study reveals how poultry wastes can be used as input for other by-product industries or additional economic potential for the existing industry. In this simulation model, production personnel can easily work out the volume of wastes based on its farm input. This model can determine the volume of final output of eggs and meat, employment, wastes, by-products, based on its input. These results can be examined and compared one after another to compare with the standard or read life data to see its acceptability. There is always the option to change the value in individual variable's equation so that total impacts can be viewed a right way. The research tool can instantly show the results based on change of value of a particular or multiple variables' Policy/decision makers or entrepreneurs can easily test different scenarios on the model. The model will allow poultry entrepreneurs to save time by conducting experiments in the simulation environment rather doing it in the real life. Real-life experiments are expensive and time consuming. This simulation model can simulate outcomes from historical or imaginary data to determine the suitability of individual farm strategies and decisions.

CONCLUSIONS

The idea of the reversing poultry wastes in a supply-chain process is effective enough to help decision-makers to determine strategies to protect the environment and achieve sustainability. It provides practical ideas for the poultry entrepreneurs to focus on and utilize their poultry wastes by making economically viable by-products. This kind of process not only utilizes poultry wastes but also preserves the environment to the future generations. The model will help to identify viable practices to create more employment opportunities, shield for poverty, empowering poor people, creating small and medium businesses. Future research opportunities could focus on testing the entire process model to realize meticulous particulars of the total industry operation and its optimality.

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APPENDIX

Table 1: Methodological Framework

Phases	Steps
Problem Structuring (Aghalaya et al., 2012, Maani and Cavana, 2007)	Behaviour over time graph development/ historical behaviour
Identify Variables (Aghalaya et al., 2012, Maani and Cavana, 2007)	In-depth interview
Causal Loop Modelling (Wolstenholme, 1990, Sterman, 2000)	Variable identification and Causal loop model development
Draw Quantitative Simulation Model with rate, level and constant variables (Wolstenholme, 1990, Sterman, 2000)	Sketch the model based on relationship among variables
Run Simulation	Entered real life data once with starting variable
Reliability and Validation (Barlas, 1996)	Examine structural validity and assess the data reliability in different phase
Extreme Condition Test (Barlas, 1996)	considerable Changes of key variable values to observe output reliability
Forecasting Future	Model run for 160 weeks whether it has only 104 weeks data to compare with the reality

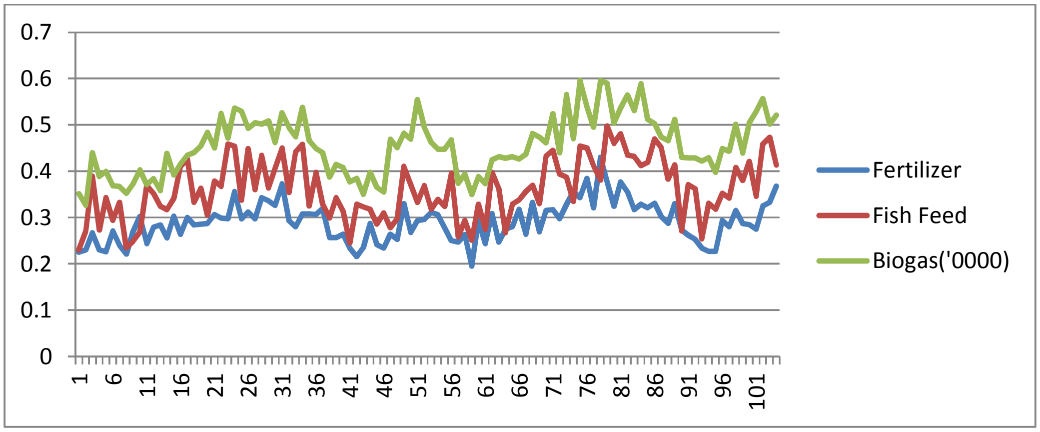

Figure 1: Historical graph of realistic data for key variable over time

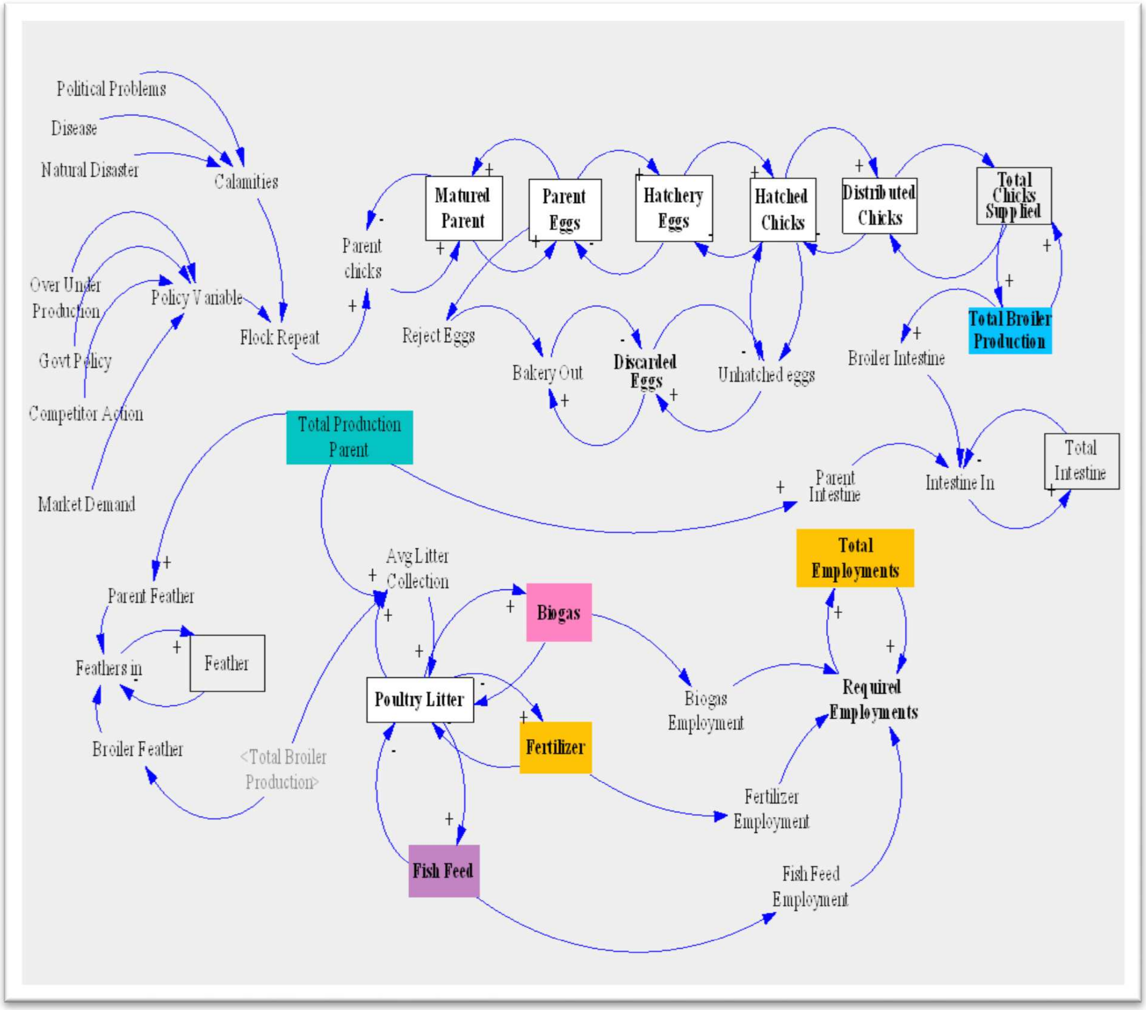

Figure 2: Causal Diagram of Poultry Reverse Supply Chain

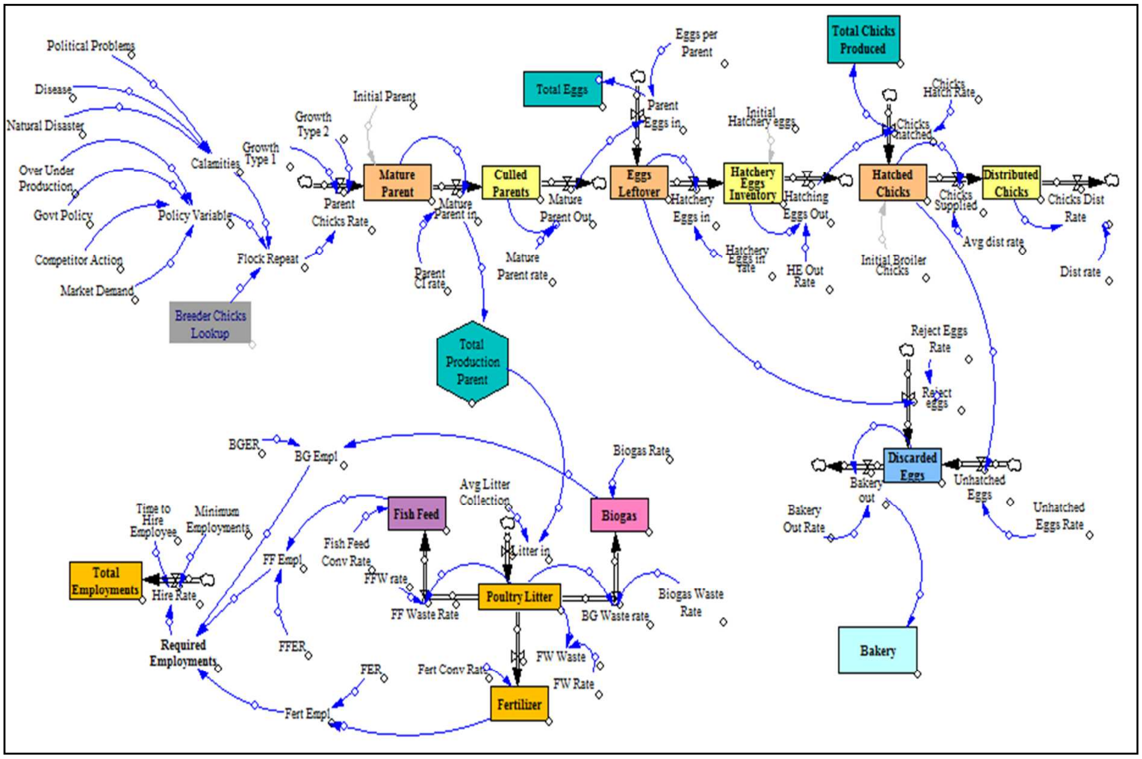

Figure 3: Poultry Reverse Supply Chain Simulation Model

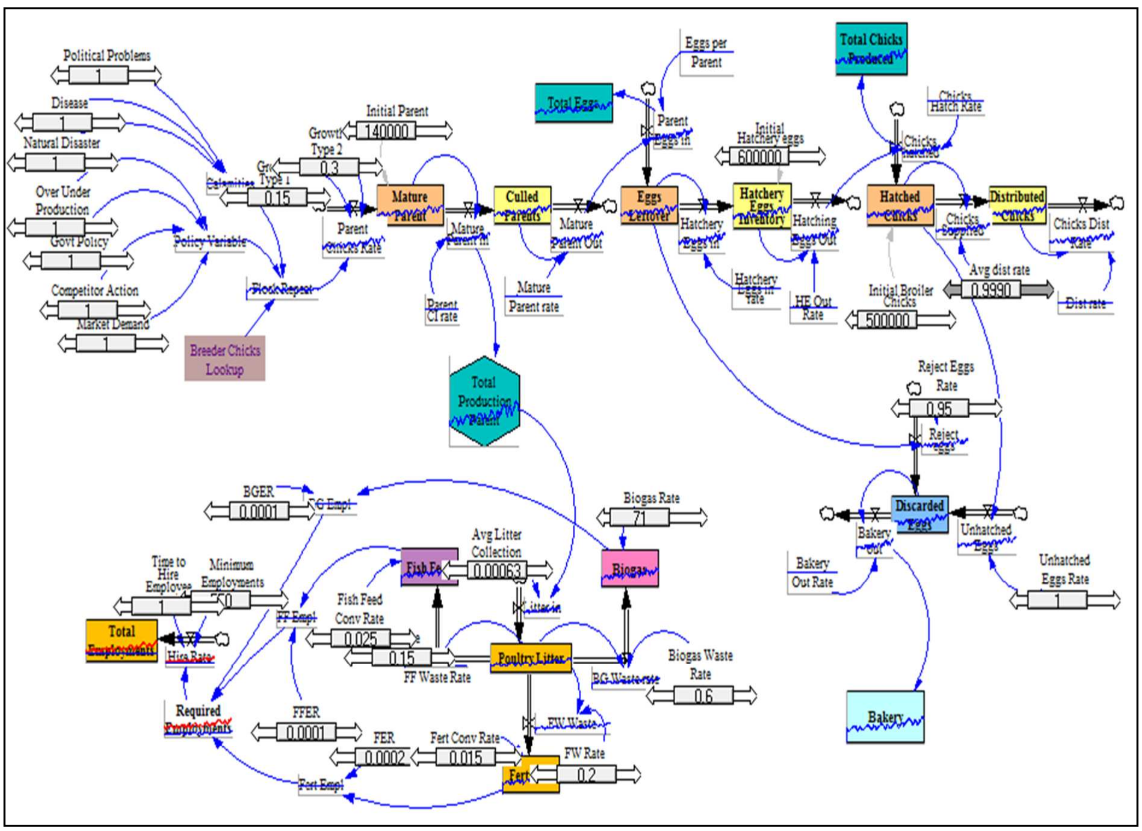

Figure 4: Synthesim Mode of Simulation Model

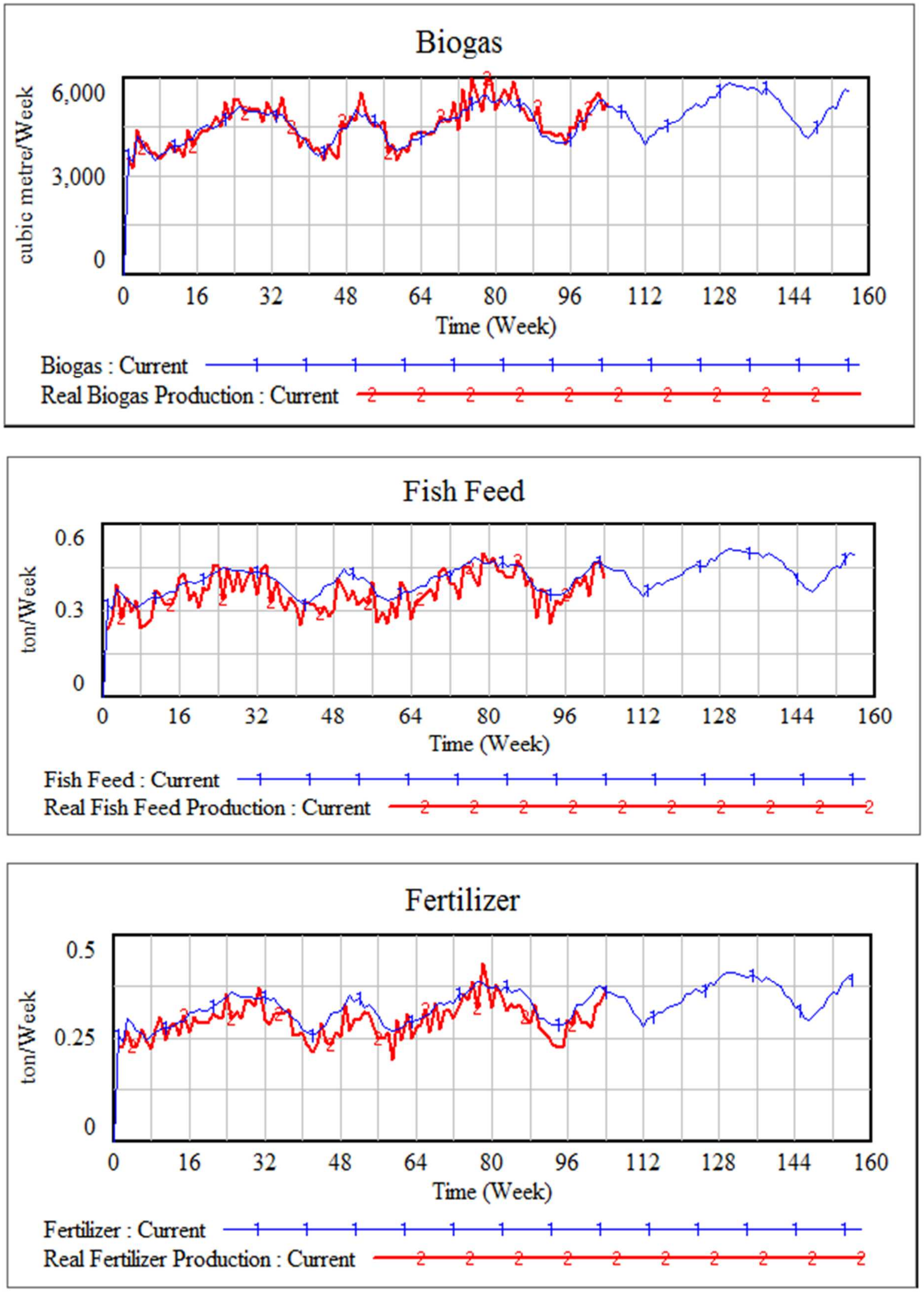

Figure 5: Few Tests for Reliability

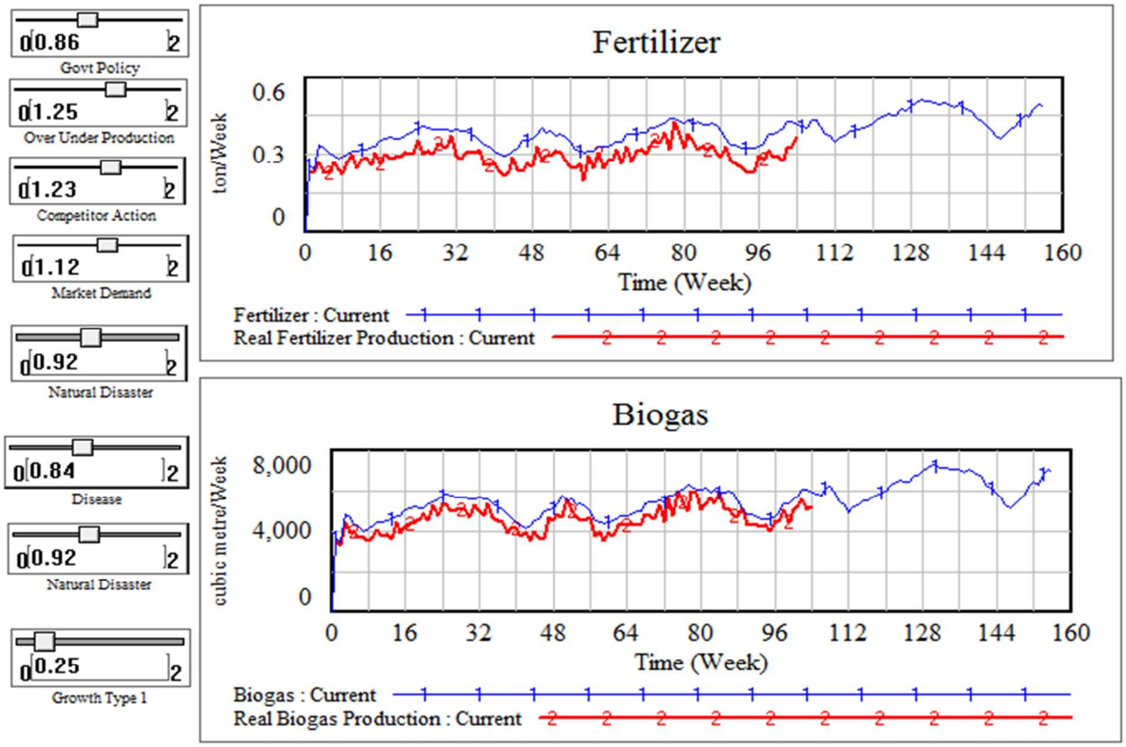

Figure 6: Extreme Condition Test of key Variables