A VENSIM BASED ANALYSIS FOR SUPPLY CHAIN MODEL

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Abstract

The emphasis on supply chain has increased in recent years among academic and industry circles. In this paper, a supply chain model will be developed based on a case study of the poultry industry under the Vensim environment. System dynamics, supply chain, design science and case method under positivist and quantitative paradigm will be studied to develop a simulation model. The objectives of this paper are to review literature, develop a Vensim based simulation supply chain model, and examine the model qualitatively and quantitatively. The model will be also briefly discussed in relation of among forward, reverse and mainstream supply chain of the case.

Key words: *simulation; poultry industry; supply chain model; Vensim.*

JEL Classification: *L60; O10; Q01; Q56; Q57*

I. INTRODUCTION

Bangladesh Poultry sub-sector is contributing vibrant way to economy and society in light of self-employment opportunities, cheap sources of protein supply, and livelihood for millions of people. Afterward, this industry failed to adapt modern business concepts with latest technology for poultry supply chain, procurement and processing. This industry needs a structured supply chain model that must be tagged of sustainability, efficient forward and reverse supply chain process, environmental issues, profitability, and optimality concepts. This research focuses on how supply chain practices can carry out better profitability with maximum utilization of resources. A noteworthy research gap exists in the implementation of proper supply chain theory to this particular industry and its operations. This research proposes a poultry model, which includes the concept of supply chains which can create by-products from poultry wastages, generate more employments and so on. This approach has the potential of creating new windows of creating small and medium enterprises (SMEs) that will contribute towards society, economy and environment.

II. LITERATURE

Supply chain process starts from initial raw materials to the ultimate consumption of the finished product linking across suppliers, user companies; and within and outside a company (Cox, Blackstone, & Spencer, 1995). It is also a step towards the wider acceptance and development of sustainability that integrates disposal, recycling, reconditioning, and remanufacturing of used products (Gungor & Gupta, 1999; Kocabasoglu, Prahinski, & Klassen, 2007; Srinivas, 2007). Such things includes the product design, re-design, manufacturing by-products, by-products produced during product use, product life extension, product end-of-life, and recovery processes at end-of-life (Linton, Klassen, & Jayaraman, 2007). Dynamic concept of reverse supply chain (RSC), which is related to the concept of recycle, reuse and reduce (3R) as it may be applied to waste management. RSC refers to the series of activities necessary to retrieve a used product (or a product waste) from a customer and either dispose of it or recover value from it (Guide & Van, 2002; Prahinski & Kocabasoglu, 2006). However, the dynamic supply chain perspective have received little attention. Hence, this paper has taken account of such research gap on the issues related to poultry and its supply chain.

III. METHODS

This study covers a literature review on reverse supply chain, and Bangladesh poultry industry. This study adopted positivist ontology, empirical epistemology, and quantitative methodology based on case studies of a real poultry case. The design science methodology and case study method chosen for this study. Design science is concerned with "devising artefacts to attain goals (Hevner & Chatterjee, 2010; Simon, 1969). Design science is based on "build and evaluate" an artefact of a model (March & Smith, 1995; Venable, 2010). On the other hand, a Case study is observing the descriptions of particular instance of an occurrence (Yin, 1994). Both primary and secondary information used in this study. Primary information collected from December 2011 to January 2012, mainly through in-depth interviews with the respondents. This paper used in-depth interviews and observation tool to gain insights supply chain processes to understand and develop a sustainable environment friendly simulation model on poultry. The case industry is one of the biggest and reputed farms in Bangladesh. They have multiple firm locations and researcher has chosen one particular flock which is producing around 150,000 day old chicks per week having nearly 100,000 initial eggs and 150 employees. The total respondents was the Managing Director from the case industry. The respondents nominated for open-ended questions relating to understands required process based on their widespread knowledge and experiences. The in-depth interview long last for more than an hour for each respondents and information's relating to production, process and waste management discussed. Secondary information collected from different published documents such as referral books, journals, and conference papers, statistical yearbooks and company record and reports. Besides that, existing industry database used to get different distribution pattern for various simulation artefacts. All these calculations are nearly average value of mentioned period. The simulation package Vensim (version 5.11a) used to develop poultry supply chain model and conduct trivial analyses of existing poultry processes in order to investigate the research objectives.

IV. A SIMULATION BASED SUPPLY CHAIN POULTRY MODEL

World's largest companies like Wal-Mart and Nokia have accepted dynamic supply chain concepts. For example, Wal-Mart processing centre are maintaining reverse logistic aspects of repairs, replacement part return to customers, inspection, salvage, disposal and reworking like upgrades (Krumwiedea & Sheub, 2002). This research examined the supply chain within the existing poultry process based on simulation modelling. The in-depth interviews with farm executives, the researcher clearly identified a lack of usage of existing poultry wastes. The lack of poultry waste management practices turn into environment pollution as the wastes dumps onto vacant land and rivers. Apparently, forward supply chain is contributing a lot to the society in terms of employment generation and creating promising entrepreneurs.

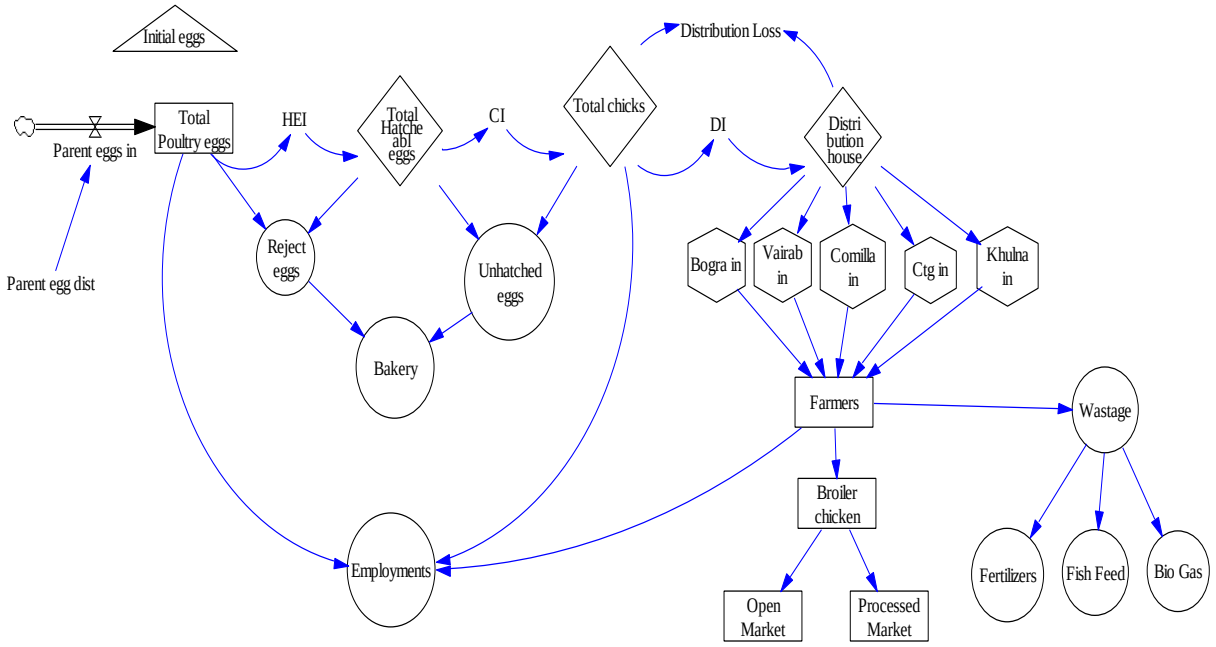

Figure 1: Vensim based Simulation Supply Chain Model

The participant farm already adopts latest technology in their production process which perhaps helps them to remain free from diseases and allows them to achieve economic success (Shamsuddoha, 2011b; Shamsuddoha,

Klass, & Quaddus, 2011). In this production process, it generates poultry wastes of litter, feed waste, feathers, broken and rejected eggs and intestines. Poultry litter can be used for making fertilizer, bio gas, charcoal and fish feed; feathers can be used as raw materials for the bed industry; reject eggs can be used for the bakery industry; and broken eggs and intestines can be used for fish feed (Shamsuddoha, 2011a; Shamsuddoha & Nasir, 2013).

Figure one exhibits a simple poultry process model, which modelled using Vensim – a simulation and system dynamics software package. The model consists of different phases of mainstream, forward, and reverse supply chain of poultry industry in Bangladesh. The Mainstream component includes the general supply chain of the poultry industry that starts from parent (mother of chicks) and ends up with the finished product of meat. The forward supply chain component of this simulation model consists of distributors, farmers, and intermediaries of processed and mature birds. This is the potential area of generating employment and achieving other socio-economic benefits based on volume of bird transacted or reared. The reverse supply chain phase consists of managing poultry wastes of broken and un-hatched eggs, poultry litter, poultry feather etc. that is the main focal point of this research.

This research demonstrates and understands how poultry wastes provide the input (raw materials) to other by-product processing plant in the same industry. The simulation model is able to assess the volume of wastes that can use as the input of by-products. Industrialist can simulate the different distributions in various work centres like parents, hatchery, broiler, and other processing centres to gain a better understanding of potential outcomes and to gain insight with respect to potential opportunities. The model will also able to use real life data through MS Excel input and allow the researcher to run the model based on historic data from the case industry. The model can be easily customized as par individual farm requirement.

Table 1: Simple average data entered into Vensim based simulation poultry model

Bio Gas= 0.6*Wastage	Processed Market= Broiler chicken*0.2
Unhatched eggs= Total Hatcheable eggs- Total chicks	Reject eggs= Total Poultry eggs- Total Hatcheable eggs
CI (Chicks in)= 0.8*Total Hatcheable eggs	Total Poultry eggs= INTEG (Parent eggs in, Initial eggs)
Comilla in= 0.25*Distribution house	Bogra in= 0.1*Distribution house
Ctg in= Distribution house*0.4	Vairab in= 0.2*Distribution house
DI (distribution in)= 0.995*Total chicks	Wastage= 0.1*Farmers
Distribution Loss= Total chicks-Distribution house	Processed Market= Broiler chicken*0.2
Employments= (Farmers + Total chicks+ Total Poultry eggs)*0.001	Farmers= Bogra in + Comilla in + Ctg in + Khulna in + Vairab in
Fish Feed= 0.1*Wastage	HEI (Hatcheable eggs in)= 0.95*Total Poultry eggs
Fertilizers= Wastage*0.15	Open Market= Broiler chicken*0.8
Final time = 25, Units: Week	Khulna in= 0.05*Distribution house
Initial eggs= 100000	**Ctg, Comilla,Vairab, Bogra and Khulna are the name of distribution house of Chicks
Parent egg dist = WITH LOOKUP (RANDOM UNIFORM(0, 1, 50000), ([(0,144000)- (1,154000)], (0.0550459,145491),(0.06,145000), (0.250765,145404),(0.28,147000),(0.492355,147114), (0.504587,151456),(0.587156,151325),(0.605505,151500),(0.782875,151456),(0.792049,153167), (0.874618,153079), (0.995,153000)))	

V. V.MODEL IN REAL LIFE ENVIRONMENT

The researchers collected historic data from the case farm, which provided parameters for the model and used as different level, auxiliary and constant variable in the Vensim software. For example, "total poultry eggs" is a level variable where eggs enter and go out for hatching. This level variable depends on other auxiliary and constant input. All the data used as average format by taking real data. The exception is only "parent eggs dist" auxiliary variable where lookup method used as a graphical presentation through real data. Eggs supply varied from 144,000 to 160,000. The system will pick the number randomly based on seed and also will added up with the initial eggs of 100,000. The model runs for 25 week having time step 1 though time step can be used as low as 0.03125 to see what is happening every small fraction of time.
The process includes hatchery divisions to hatch those eggs, twenty-one days needed to hatch the eggs that produced broiler chicks which are called day old chicks (DOC). The DOC then goes to distributors for distribution to the different regions. After 25-35 days, the DOC becomes mature chickens and is ready to sell in open market, restaurants, and processing centres. The rejected eggs, feathers, culled birds, and litter are generating after a certain interval. All these aspects maintained in individual supply chains to produce different by-products. There are also different technology and methods used to recycle, reuse, and reduce the poultry wastes.

Table 1 above shows the data or information placed in different variable. Most of the data used as average; average data calculated from real life data for particular period. And table 2 reveals KPI's of different variable of simulation model including various constants, levels and auxiliary. There are many ways to compare, contrast, and display the results of the simulation, for example, using graphs, pie charts, bar chart, compare runs, sensitivity analysis and so on. In this study, the model ran for 25 time step and table 2 represents the results of first, fifth, tenth, fifteenth, twentieth, twenty-fifth time step result. This kind of results allows the decision maker to adopt effective and quick decision to save time, money, and energy.

Table 2 : Model results for different time step

Time (Week)	**1**	**5**	**10**	**15**	**20**	**24**	**25**
Variables Runs:							
Bakery	24000	168306	346384	527246	704415	845795	882146
Bio Gas	4537.2	31818.2	65484	99675.8	133170	159898	166770
Bogra in	7562	53030.3	109140	166126	221949	266496	277950
Broiler chicken	75620	530303	1.09E+06	1.66E+06	2.22E+06	2.66E+06	2.78E+06
CI (Chicks in)	76000	532968	1.10E+06	1.67E+06	2.23E+06	2.68E+06	2.79E+06
Comilla in	18905	132576	272850	415316	554874	666240	694874
Ctg in	30248	212121	436560	664505	887798	1.07E+06	1.11E+06
DI (Distribution in)	75620	530303	1.09E+06	1.66E+06	2.22E+06	2.66E+06	2.78E+06
Distribution house	75620	530303	1.09E+06	1.66E+06	2.22E+06	2.66E+06	2.78E+06
Distribution Loss	380	2664.81	5484.38	8348	11153.3	13391.8	13967.3
Employments	327.24	2294.85	4722.95	7188.99	9604.7	11532.4	12028.1
Farmers	75620	530303	1.09E+06	1.66E+06	2.22E+06	2.66E+06	2.78E+06
Fertilizers	1134.3	7954.55	16371	24918.9	33292.4	39974.4	41692.4
Fish Feed	756.2	5303.03	10914	16612.6	22194.9	26649.6	27795
HEI (Hatch eggs in)	95000	666210	1.37E+06	2.09E+06	2.79E+06	3.35E+06	3.49E+06
Initial eggs	100000						
Khulna in	3781	26515.2	54570	83063.1	110975	133248	138975
Open Market	60496	424243	873120	1.33E+06	1.78E+06	2.13E+06	2.22E+06
Parent egg dist	151490	145247	151450	145491	145125	151462	151488
Parent eggs in	151490	145247	151450	145491	145125	151462	151488
Processed Market	15124	106061	218280	332253	443899	532992	555899
Reject eggs	5000	35063.7	72163.4	109843	146753	176207	183781
Total chicks	76000	532968	1.10E+06	1.67E+06	2.23E+06	2.68E+06	2.79E+06
Total Hatcheable eggs	95000	666210	1.37E+06	2.09E+06	2.79E+06	3.35E+06	3.49E+06
Total Poultry eggs	100000	701274	1.44E+06	2.20E+06	2.94E+06	3.52E+06	3.68E+06
Unhatched eggs	19000	133242	274221	417403	557662	669588	698366
Vairab in	15124	106061	218280	332253	443899	532992	555899
Wastage	7562	53030.3	109140	166126	221949	266496	277950

Numerous experiments and analyses can be done in the model environment by providing various inputs to find out optimum output. Synthesim mode of Vensim package can experiment more on changing constant variables to see what best results can be achieved. Eggs used as throughput of this model and mature chicken and wastage shown as output. Within the process, the model can able to assess volume of employment, wastage, by-products. Table 2 collected some results from simulation run that are displaying various output.

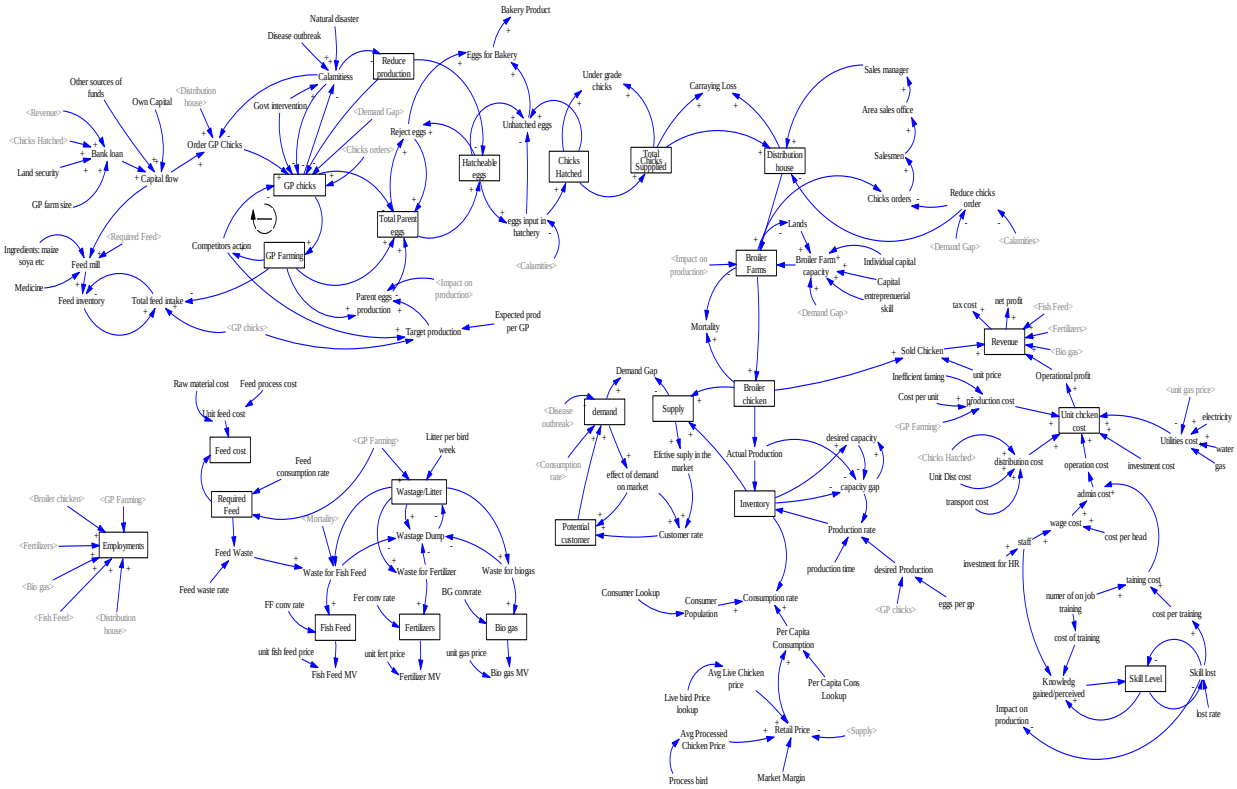

Figure 2: A Qualitative model for Future work based on current modelVI.CONCLUDING REMARKS

In this paper, researchers developed a simple and proposed an idea of a poultry simulation model incorporating mainstream, forward, and reverse supply chain. This model will help the entrepreneurs to compute general calculation of what numbers and quantities of chicken, chicks, wastage, by-products can be generated from a poultry process. Again, this is a very simple model to shown real dynamics in the practical arena. Later, a qualitative model displays to understand how this simple model could be more realistic and complex. This model consists of wastes, production, distributors, various process centre, and different outputs. In future, supply-demand, finance, calamities, government intervention, capital flows, bank issues etc. added in qualitative model. Obviously, it would be great challenge to work on it and give input of more and more realistic issues based on system dynamics and supply chain management. The model will also indicate that wastage can contribute towards the establishment of many small-medium enterprises (SMEs) with the potentials of creating more by-products, employments and income. This study can help poultry entrepreneurs to evaluate their waste subject to individual farm capacity to assess the quantity of by-products. The model can also be further extended, modified, or tuned up in several directions of forward and reverse which has shown in figure 2 in the above. For example, in practice, main operation and recycling matters hampers in the situation like heavy rainfall, flood, natural calamity similar to cyclones, droughts, poultry disease (bird-flue), alternative meat price, and some cultural influence etc. In these circumstances, the percentage of workflow shall be change as per situation. Future research could focus on testing the entire process model and variables to understand the total industry operations and its optimality.

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