Reducing Environmental Hazards through Reverse Supply Chain Model

Mohammad Shamsuddoha, Mohammed Quaddus, Desmond Klass

Abstract

Environmental hazards transpire when industrial wastages are dumped illegally into vacant lands, rivers or low-lying areas. This is a major problem in developing, and less-developed countries where environmental regulations are not (or cannot be) strictly enforced. Researchers around the globe are conducting research to find various ways to minimize or eliminate industrial hazards. In this paper, we take a supply-chain approach and show how the concept of the reverse supply chain can be used to recycle industrial wastage into useful by-products. Our problem domain is poultry industry in Bangladesh. Using Simul8, a simulation model of reverse supply chain is developed for a large poultry plant in Bangladesh where poultry wastes are modelled to turn into various by-products. We use primary and secondary data to run the simulation model. Our results show that poultry wastes can indeed be processed to turn into various by products as bakery products, biogas, artificial charcoal, etc. The management of the poultry plant can use our results to develop policies to reduce poultry hazards and thus save the environment. We touch on research and managerial implications of our results.

Field of Research: Environment, Reverse Supply Chain, Poultry, Bangladesh

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1. Introduction

Social, economic and environment performances are the key to attain organizational sustainability (Elkington, 2004). Among these, environment sustainability is the burning issue for poor economically performed and natural disaster prone countries. The issue of waste management in the agriculture sector is important as waste can be turned into by-products that could be used in home and industries. Improved methods of waste management are prerequisite to better resources utilization (Boyazoglu, 2002). Manufacturing procedures also often cause environmental and social hazards primarily during the production process (Corbett and Kleindorfer, 2003, Seuring and Muller, 2008). This paper focuses on reducing environmental hazards through the reverse supply chain concept in poultry industry in Bangladesh. Reverse supply chain deals with product return, recycle, reuse, and thus keep the surrounding environment waste free (Shamsuddoha, 2011a). Bangladesh is considered one of the most appropriate countries in the world for poultry rearing (Shamsuddoha and Sohel, 2008). In Bangladesh, poultry farms have developed mostly through private ownership and effort. However, poultry produces huge wastes, which does not get proper attention to manage to make further resources for the society. Poultry entrepreneurs do not have sufficient knowledge on reverse supply chain and waste management for environment sustainability. Applications of modern technology and overseas help in poultry can reduce environmental hazards, which are very essential for a country like Bangladesh. Agreeably, poultry entrepreneurs in Bangladesh are learning fast by the help of poultry-developed countries like USA, Canada, France, China, Malaysia, Thailand, among others. Research on poultry waste management is being increasingly reported in the literature. This kind of research will help the poultry stakeholders to undertake appropriate actions to reduce environmental hazards by way of applying reverse supply chain process within their existing operations. This paper reports such an application of reverse verse supply chain to manage wastes in a large poultry firm in Bangladesh. We present a Simul 8 based reverse supply chain model of the production process. The results and implications are then presented.

2. Literature

Stable environment is treated as natural capital that improves human lifestyles. Most environmental sustainability is achieved through transition to renewable energy. Environment needs to be protected from unfettered industrial expansion (Mill, 1848) as researchers also arisen from a question n regarding the wisdom of infinite throughput growth on a finite earth (Daly, 1999). "The Limits to Growth" (Meadows et al., 1972) and "Beyond the Limits" (Meadows et al., 1992) also highlighted the same. They have suspected environmental intactness in the flow of technological boost. Animal science and technology linked and dealt with the society's benefits, optimum use of resources, ecological balances and economically efficient production systems (Boyazoglu, 2002). Spotlight on supply chains is a step towards the sustainability since it considers the product from initial processing of raw materials headed for delivery to the customer. Nevertheless, sustainability must integrate issues and flows

that extend beyond the core of supply-chain management: manufacturing by-products, product life extension and recovery processes (Linton et al., 2007, Guide and Van, 2002).

Yet again, supply-chain management must expand to explicitly address the disposal, recycling, reconditioning and remanufacturing from used/reject products and wastage (Kocabasoglu et al., 2007). In this process, reverse supply chain refers to the series of activities necessary to retrieve products from customers and either dispose of it or recover value (Linton et al., 2007, Prahinski and Kocabasoglu, 2006). Over again, the reverse supply chain process potentially can reduce negative environmental impacts by extracting virgin raw materials and waste disposal (Kocabasoglu et al., 2007). It also carry out five key processes of product acquisition, reverse logistics, inspection and disposition, remanufacturing or refurbishment and marketing (Blackburn et al., 2004). For instance, Wal-Mart has dedicated processing centres for reverse logistic aspects of repairs, replacement, inspection, salvage, disposal and reworks such as upgrades (Krumwiedea and Sheub, 2002). Over the last decade, reverse logistics had a significant social, economic and environmental impact on industry as well as the society. Companies that receive product back from customers and failed to realize the significance of profit-making opportunities through reverse logistics (Cottrill, 2000). Reverse chains with end-of-life (EOL) products embraces many different characteristics of environmentally conscious manufacturing, including disassembly and reuse (Edwards and Daniel, 1992), recycling and remanufacturing (Gungor and Gupta, 1999). The current research examines the reverse supply chain process as the supplement of environment sustainability within the existing poultry processes of recycle, reuse and reprocess.

There are four different poultry wastes: litter (Burak Aksoy, 2008), manure (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). All these areas have been great potential to meet social, economic and environmental aspects that will make the industry and society more sustainable. Thus, literature review shown that a few numbers of research have been conducted on reducing environmental hazards through reusing wastage and reverse supply chain process. No evidence was found of reverse supply chain issues being considered in the light of the poultry industry. This research gap motivated the researchers to undertake this study on Bangladeshi poultry industry for the sake of reducing environmental hazards.

3. Data and methodology

The study covers literature review on environmental issue along with reverse supply chains of poultry industry. This paper used observation tool to develop and draw a reverse supply chain model for Bangladesh poultry in light of reusing poultry wastes. Both primary and secondary information have used in this study. Primary information collected from January 2011, mainly through in-depth telephone interviews with the respondents. The Managing Director and Executive Director of the case poultry industry have interviewed. Both respondents nominated based on their extensive knowledge and vast experiences in this particular industry and its operation. Information regarding volume of productions, wastages, distributions, inputs and outputs has discussed in the interview. Relevant literature collected from different published referral journals and conference proceedings, statistical yearbooks and industry report. This study followed a research paradigm of positivist ontology, empirical epistemology and quantitative methodology. Design science methodology preferred for this study as it is concern with "devising artefact to attain goals (Simon, 1969). Design science research (DSR) has two main activities: firstly, building an artefact and evaluating it. Secondly, design science products are four types: constructs, models, methods, and implementation (March and Smith, 1995). In this research, different artefacts have used in simulation modelling. Here, an artefact means design and develops soft or hard objects that can meet specific purpose and goal (Venable, 2006b, Venable, 2006a). A simulation based software of SIMUL8 used as a tool to analyse existing poultry processes in order to investigate the research objectives. Simulation as a research tool is used by various disciplines as diverse as cognitive science to develop models on emotion, cognition and social behaviour; economics to model people's economic behaviour; sociology to model social life and interactions among individuals within a particular society (Macal and North, 2005). Simulation is an appropriate tool that can give the optimality of the sample process, so it has used to estimate the environmental benefits from the existing poultry model based on case industry.

4. Environment and Bangladesh poultry

Environment and Bangladesh poultry has strong relationship as poultry wastes damages the natural environment through contaminating soil, water and air. Until late nineties, poultry farmers used to dump poultry wastage into nearer rivers, low lands or vacant lands, which causes air, soil and water pollution. Moreover, it causes of disseminating diseases and harming cultivable lands. Still, Bangladesh poultry did not able to overcome the situation, though there are many ways to reuse wastes. Poultry wastes have great potential to generate useful by-products for household and small industry. To achieve environmental success in the poultry industry of Bangladesh, the researcher split up the poultry process into three part of mainstream, forward and reverse phase. Internationally, there are numerous large companies applying reverse supply chain concept for the sake of reducing environmental hazards. These kinds of practices are not always non-profit oriented. In other words, there can be a profit motive to occupy reverse supply chain solutions. In the poultry industry, there are small chances of product retrieval, return or reconditioning in the

usual sense, 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, biogas, pillows, charcoal, and bakery items. This kind of waste conversion will help to eliminate environment hazard (Shamsuddoha, 2011a). In this way, environment can be protected for present and future generation.

5. Poultry industry in Bangladesh in light of the environment restoration

As an important sub-sector of livestock production, the poultry industry of Bangladesh plays a significant role in economic growth and employment generation (Shamsuddoha and Sohel, 2008). Poultry plays a key role in the country's economy through direct and indirect involvement of 73% of people who are living in the rural areas. Bangladesh has long history of poultry rearing under traditional backyard farming practices (Reneta, 2005). Poultry rearing is dominated by backyard local chickens (Desi or local), which mostly live through a natural scavenger system (Nielsen, 2007). In the early nineties, a number of private parent stock and breeder farms shifted their operations to produce commercial day-old broiler and layer chicks (Reneta, 2005). Thousands of poultry farms have grown up through private ownership without getting adequate scientific knowledge on it. Lots of poultry owners practice the triple bottom line framework of sustainability (social, economic and environment) but not in an organized way (Shamsuddoha, 2010). Poultry is an alternative income generating activities for the rural and urban poor people in Bangladesh (Shamsuddoha and Sohel, 2004). It is also supplying the nation with a cheap source of good quality nutritious animal protein in terms of meat and eggs (Shamsuddoha, 2010). This industry does significantly contribute to the society in terms of economic, employment generation, and protein supply.

Importantly, various by-products can be made from poultry wastages for home and industry use that is socially, economically and environmentally viable for Bangladesh perspective. This approach has the potentials of creating opportunities to establish small and medium enterprises (SME) that will reduce unemployment rate and environmental disorder (Shamsuddoha, 2011b). Poultry owners are currently integrating foreign technology and breed in their commercial farms for the sake of more productivity, profitability and achieving sustainability. Increasing production level is generating more and more wastes, which can be used as raw material for further y-products generation. This is why, poultry rearing along with reverse supply chain and environment concepts can play a noteworthy role in keeping the environment intact, empowering rural people, fulfilling nutritional needs, providing food and protein security (Shamsuddoha, 2011b). Specifically, it helps to maintain standard quality of water, air and soil by not dumping poultry wastes in vacant land or riverside/water. In this way, poultry farmers can escape from common and rare poultry diseases that may protect their investments, farms, improve soil, water and air condition and restoring environmental damages.

6. Reverse supply chain model for the poultry industry

Companies are now building different supply chain model to accommodate sustainability, 3R, triple bottom line, forward and reverse supply chain in their existing operation. These concepts are being implemented due to sustainability concern, environmental recovery, customer satisfaction and government pressure (Shamsuddoha, 2011b). The researchers developed a simulation-based model that accommodates forward and reverse supply chain in light of sustainability and triple bottom line theory. Figure one shows three different wings of conventional, forward and reverse supply chain in the case industry, which was modelled using Simul8 – a simulation-modelling package. The Mainstream component includes the general supply chain of the poultry industry that starts from a parent (mother of chicks) and ends up with the finished product of meat and eggs. The forward supply chain component of this simulation model consists of distributor, farmers, and intermediaries of processed and mature birds and eggs. This is where employment and other socio-economic benefits can be achieved based on the volume of bird transacted or reared. Then again, the reverse supply chain consist of managing poultry wastes, as it is evident that different poultry wastes, including litter, feed waste, feathers, broken and rejected eggs and intestines are available. Among those, poultry litter can be used for artificial charcoal, fertilizer, bio gas, and fish feed; feathers can be used as raw materials for the bed industry; broken eggs and intestines can be used for the bakery and fish industry respectively (Shamsuddoha, 2011a). This aspect of waste conversions helps to maintain sustainable an environment in a profitable way (Shamsuddoha, 2011a, Shamsuddoha, 2011c). The participating farm adopts a range of environmental practices that help the farm remain free from diseases and allow it to achieve environmental success over pollution. The simulation model is efficient enough to calculate the volume of by-products from the existing and potential quantity of wastes. Industrialist can simulate the different distributions in various work centres like parents, hatchery, broiler, distributors, farmers and other processing centres to gain a better understanding of potential outcomes and to gain insight with respect to potential opportunities.

7. Model in a real farm environment

The researchers collected historic data (input and output of work items such as volume of chicks, eggs, wastes etc.) from case farm and input into the different objects or artefacts in the simulation model. Historic data helps the researchers to generate different distribution for various artefacts. Such artefacts designed as work entry, storage as queue, work centre, tank and work exit. In this model, breeder chicks' artefact used as work entry that produces hatcheable eggs, which grow as matured poultry parents. Matured parents provided on an average of 36,000 hatcheable eggs in 90 days. These eggs directly go to the queue for hatch in a hatchery. There are 40 incubators available to hatch queued eggs by rotation. Twenty-one days needed to hatch the eggs then produce broiler chicks. Day old broiler chicks are called day old chicks (DOC). Immediately, DOC inspect for regular grading based on standard weight, colour, strength etc. DOC then supplied to the

root level distributors to distribute to different sales centres all over the country. Numbers of sub-distributors are employing under each distributor house, and each sub-distributor has attached with a bunch of ultimate farmers. These farmers rear day-old chicks (DOC) period to grow it up as mature bird. After 25-35 days, DOC becomes mature broiler chickens, which are ready for supply to the open market, restaurants and processing centres. Within this period to grow up as mature broiler, a lot of poultry wastage generates for further processing. This hatching process creating lots of waste eggs, which is called unhatched eggs, and under graded chicks. These two kinds of wastes ultimately flow towards reverse chain process as raw materials of bakery and fish products.

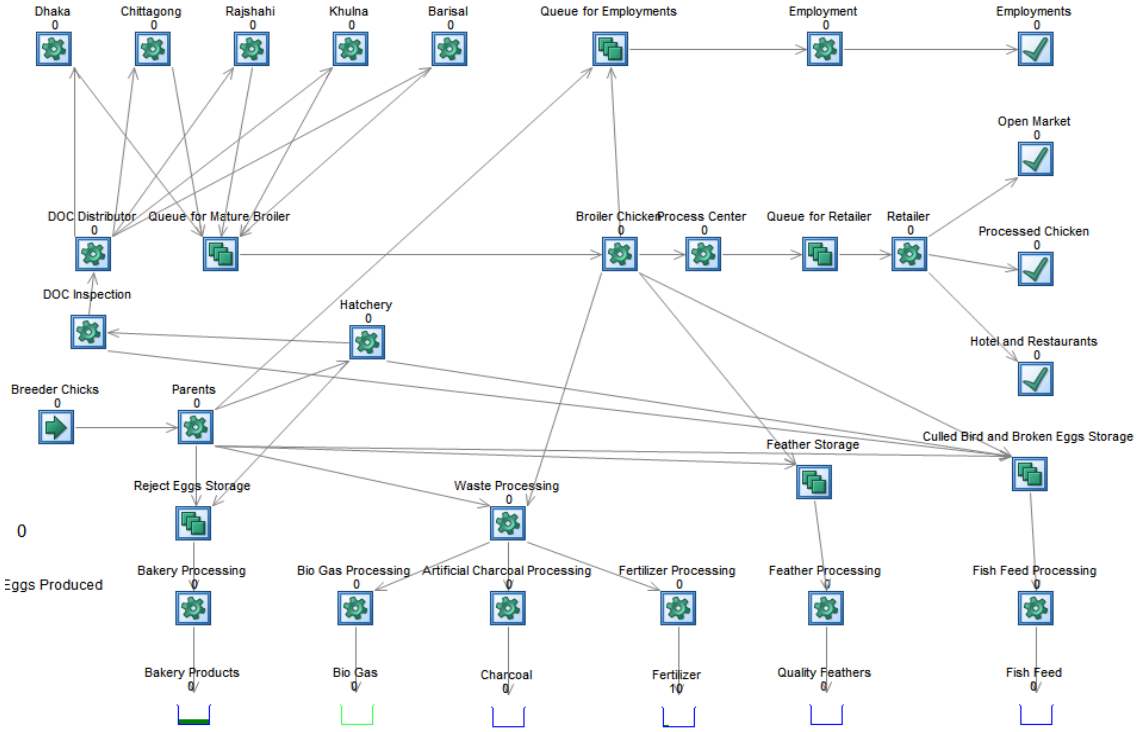

Fig 1: Reverse supply chain process model for reducing poultry waste

Broken and unbroken reject eggs, feathers, dead and culled birds and litter are accumulating after a certain period in the poultry process. All these wastes followed an individual supply chain to produce different useful by-products. In the below line of the simulation model, poultry wastes gathers in different storage or process centre for further processing or supply as raw materials for generating by-products. The participant farms procure and process several by-products of poultry litter, broken and damaged eggs and culled birds. Biogas, artificial charcoal and fertilizer generate from poultry litter. Different foreign and indigenous technologies are using to recycle, reuse and reduce the various poultry wastes. Such kind of practice easily reduces environment hazards.

8. Findings and Discussion

There are so many KPIs in the result area of simul8 package. In this paper, the researchers included only few of them to understand the variations in different trials.

Simulation Object	Performance Measure	Run 1	2	3	4	5	-95%	Av.	95%
Bio-Gas Processing	Waiting %	97.69	97.04	97.48	98.33	98.612	97.04	97.83	98.62
	Completed Jobs	13	12	10	7	6	5.81	9.60	13.38
	Average use	0.167	0.000	0.056	0.056	0.000	0.000	0.056	0.140
Artificial Charcoal Processing	Waiting %	97.43	96.54	93.33	96.42	93.26	92.96	95.40	97.83
	Working %	2.564	3.454	4.483	3.577	6.734	2.189	4.162	6.136
	Average use	0.000	0.000	0.111	0.111	0.111	0.000	0.067	0.142
Bakery Processing	Waiting %	26.69	25.99	23.67	20.78	28.71	21.39	25.17	28.95
	Working %	73.30	74.00	76.32	79.21	71.28	71.04	74.82	78.60
	Completed Jobs	70	66	67	71	64	64.02	67.60	71.17
	Average use	0.667	0.722	0.722	0.778	0.722	0.673	0.722	0.771
Broiler Chicken	Waiting %	43.44	44.82	46.48	50.53	44.71	42.57	46	49.42
	Blocked %	56.55	55.17	53.51	49.46	55.28	50.57	54	57.42
	Completed Jobs	9700	9700	8270	7760	9225	7842	8931	10019.9
Parents	Completed Jobs	37500	36500	37000	37000	36000	36092	36800	37507
	Average use	3.333	3.722	3.611	3.389	3.611	3.329	3.533	3.738
Process Centre	Waiting %	42.61	43.64	44.57	47.62	41.93	41.32	44.07	46.83
	Working %	57.38	56.35	55.43	52.37	58.06	53.166	55.92	58.67
Waste Processing	Completed Jobs	17	19	18	17	17	16.49	17.60	18.71
	Average use	0.944	0.944	0.944	0.944	0.944	0.944	0.944	0.944
Bakery Products	Average	347.5	421.2	998.4	1511	434.3	118.31	742.6	1367.07
	Maximum	670	1115	2065	2570	1075	521.1	1499	2476.8
Bio Gas	Average	33.75	33.88	28.05	17.36	13.33	13.51	25.27	37.03
	Maximum	65	60	50	35	30	29.07	48	66.93
Charcoal	Maximum	500	503	995	500	540	82.55	511	939.44
	Average	46.38	10.83	551.5	153.0	300.2	0	212.4	486.13
Fertilizer	Average	11.09	15.62	14.72	23.84	22.90	10.79	17.63	24.48
	Maximum	14.37	25.82	25.29	34.22	32.31	16.74	26.40	36.06
Quality Feathers	Average	68.56	64.20	55.49	65.93	60.74	56.70	62.98	69.26
	Maximum	182.9	172.3	159.8	178	174.07	162.74	173.45	184.15
Fish Feed	Average	8.611	9.44	9.44	7.77	10.55	7.87	9.16	10.45

Table1: Different KPI for various objects and artefacts

There are various ways to compare the objects/artefacts results and these includes graphs, pie charts, random runs, trial etc. This model runs through five random trials and table one represents the various results based on particular trial run and the average of all results. Trial runs give different results with variations that might be useful for the decision makers. The simulation model provides many indicators of

waiting, working, block and stop percentages of an object/artefact, standard deviation, average queue time, minimum and maximum queue time, completed jobs, blocked jobs, etc. Entrepreneurs or decision makers can use the information to find out where to adjust their industry by using the virtual model. This kind of model does not require real-life experiments. It is noted that researchers avoid actual travel time, monetary unit and individual measurement unit initially. Throughput of this model is number of eggs and mature broiler chickens and various by-products showed as output. Within the process, it assesses the number of employment generation and the unit of various by-products and its quantity of usage. The model simulated for three months (90 days) and units are measured based on throughput. All the tank storage denotes the output of by-products, which used poultry wastages to reduce environmental hazards. Entrepreneurs can easily find out by giving input of optimum throughput to see how the thing goes based on poultry wastes. It would be easy to develop customize farm model to find out the answer how much or what quantity by-products can be generated from stored poultry wastes.

9. Further direction and conclusions

Reverse supply chain process model in poultry is appropriate to gain social benefits and environment protection. It is enormously important for the farmers to know what dimensions and impacts are laying on their operations. The process model suggested not only utilizes poultry wastes but also helps our environment intact for the present and future generation. The improved and clean environment resulting from the implementation of the reverse supply chain concept will assist farmers in the prevention of common poultry diseases. The study did an initial investigation by using a small sample of historical data. The model can be extended based on future and individual needs. Future research can be absolute to test the entire process model to understand the workings of the total industry operation and its optimality. Thus, simulation model can able to simulate any kind of operation for the particular period by giving proper throughput. As a result, various try out can be done in the virtual model to find out required and optimum results on environmental hazards. This the way, industry can eliminate the entire environmental hazard by utilizing their own wastage in a profitable way.

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