CHAPTER ONE

INTRODUCTION

1.1 Background to the study

Waste is broadly divided into four key categories-solid, liquid, agrochemicals and others. Poor waste disposal is associated with diseases and adverse environmental effects. Continuing population growth and urbanisation in developing countries the cause increase in waste and making the provision of urban environmental services very difficult. The greatest challenge many cities in the developing world face in relation to environmental health services is proper management of solid waste. Solid waste is the residue of consumption and production activities and poses environmental health risks. According to Mistra and Pandy (2005), a material becomes waste when it is discarded without the expectation of being compensated for its inherent value. In the agriculture sector, farm animals generate a lot of solid waste. The need for effective management of such waste is critical, considering the adverse health and environmental effects of poor waste management.

Next to the arable-crop subsector, the livestock subsector is the second largest agricultural subsector in the Nigerian economy, contributing about 10% of the agricultural gross domestic product (GDP) (CBN, 2008). Livestock contribute about 3% to Nigeria's GDP (NBS, 2006c). According to the Federal Department of Livestock (FDL, 2010), livestock estimates in Nigeria as at 2009 stood at 16.43 million cattle, 34.69 million sheep, 55.15 million goats, 7.18 million pigs and 183.16 million birds. The poultry subsector is the most commercialised of all subsectors in Nigeria's agriculture and represented approximately 6.2% of the total livestock contribution to the agricultural GDP in 2012 (CBN, 2012). Birds commonly reared in Nigeria are chickens, ducks, guinea fowls, turkeys, pigeons and, more recently, ostriches. Those that are of commercial importance, given the trade in poultry, however, are chickens, guinea fowls and turkeys, among which chickens predominate (Adene and Oguntade, 2006, Akanni et al,. 2014). The main poultry products from the Nigerian poultry sub-sector are parents stocks, commercial day-old chicks, frozen chicken, and table birds and eggs (Akanni et al., 2014). Poultry is the second widely eaten meat in the world accounting for 30% meat production in the world, after pork 38% (Wikipedia, 2012). Poultry is one of the world major and fastest growing sources of meat representing over 22% of the meat production in 1989 (Ekunwe and Alufohai, 2009). It is a well known fact that poultry is a very good converter of ingredients, especially those of plant origin into animal protein.

The poultry sector is a major source of income in Nigeria. It offers the quickest returns on investment outlays in the livestock enterprise by virtue of the short gestation period of chickens enterprise their high feed conversion ratio as well as their being one of the cheapest, commonest and best sources of animal protein in the country (Ojo, 2002). In Nigeria, production of eggs and poultry birds occupies a prime position in improving animal protein consumption by both rural and urban households. However, the emergence and activities involved in their production also give rise to human health concerns elements, compounds (including veterinary pharmaceuticals), vectors for insects and vermin and pathogenic microorganisms.

Chicken waste can be defined as any residue that is of no use in its current status. The poultry industry produces large amounts of solid and liquid waste. The solid waste consists of bedding materials, manure, feed, feathers, intestines, culled birds, hatchery waste (empty shells, infertile eggs, dead embryos and late hatchlings), shells, sludge and abattoir waste (offal, blood, and carcasses). In Botswana, ashes which result from the use of coal for chick brooding are also produced in large quantities on chicken farms, especially in medium and large scale operations. Poultry waste needs to be disposed of (Moreki and Chiripasi, 2011).

Dead birds and hatchery waste are high in protein. They contain substantial amounts of calcium and phosphorus due to the high level of material supplements in the diet. The approximate percentage of each element nutrient intake excreted by poultry are Nitrogen (65%), Phosphorus (68.5%) and Potassium (83.5%). These elements enhance soil fertility and increase crop production (Olumayowa and Abiodun, 2011). Chicken excreta is, therefore, potentially useful.

There are several ways of disposing of chicken excreta; these include burying, rendering, incinerating, composting and using it as livestock feed, fertilizer or source of energy. The predominant waste disposal method in Nigeria is burying in landfills. Waste disposal methods also include conversion of chicken excreta to energy for treatment of heavy-metal contaminated water. Poultry feathers can serve as raw materials in the bed industry; broken eggs can be used in bakeries while intestines can be used as feed in fish farms (Shamsuddoha, 2011b).

Moreki and Chiiripasi (2011) state that energy recovery is a promising form of waste disposal which works by having some forms of waste recycled into a source of fuel for heating, cooking and powering turbines. There is a huge quantity of various forms of poultry waste generated from poultry operations. Unfortunately, in some countries, these are dumped on vacant lands and into rivers and cause severe environmental damage (Shamsuddoha, 2011a;, 2011b). Neglected waste creates environmental problems which, in turn, spread various diseases, contaminate rivers or canal water and spread odour to homes (Gupta and Charkles, 1999). It is, therefore, important to approach poultry waste management in an innovative manner since the selection of the best device and practice in each stage depends on a variety of specific circumstances peculiar to the city under consideration.

In Nigeria, like in any developing nation, there is a rapid expansion of small and medium scale poultry farms with the attendant effect of huge chicken excreta generation. The magnitude of generated chicken excreta has given rise to improper disposal methods and improper timing of application resulting in soil, water and air pollution. Modern management methods for chicken excreta such as green disposal, gasification and production of organic fertilizer have not gained prominence in Nigeria probably due to level of awareness, lack of strict regulation from government in respect of chicken excreta disposal and the care-free attitude of farm owners *(Adeoye, et al.*, 2004).

Most farm owners in Nigeria do not utilise poultry waste for further by-product generation. Farmers do not re-use the waste they generate probably for lack of knowledge on its benefits to do with System Dynamics, involving simulations, is a tool that can be used to forecast the viability of waste disposal through by-products generation.

1.2 Statement of Problem

Worldwide, the poultry industry is growing rapidly and contributing to achieving key national development goals such as improving the standard of living of people through poverty alleviation and job creation (Agblevor, *et al.*, 2010). However, Roeper, *et al.* (2005) contended that a problem associated with poultry production is the waste that needs to be disposed off since it can become hazardous to humans.

Available statistics show that there has been a steady increase in the population of chickens in Nigeria, from 122 million in 1994 to 137.6 million in 2003 (FAO, 2004). The Nigerian poultry industry is estimated at ₦80 billion ($600 million) and comprises of approximately 165 million birds, which produced 650,000 MT of eggs and 290,000 MT of poultry meat in 2013. From a market size perspective, Nigeria's egg production is the largest in Africa (South Africa is the next largest at 540,000 MT of eggs) and it has the second largest chicken population after South Africa's 200 million birds (Sahel, 2015). Although the volume of waste has increased due to the increase in bird population, appropriate waste management processes have not been employed or designed. The increase in the quantity of solid waste, in particular, chicken excreta, is emerging as a major environmental problem in developing countries. The Nigerian poultry sector is extremely fragmented with most of the chicken raised in 'backyards' or on poultry farms with less than 1,000 birds. However, there are a number of large commercial players in the sector most of which are located in Southwestern Nigeria, especially areas in close proximity to Lagos and its large market of 17.5 million people. Some of these large commercial farms are presented in Table 1

TABLE 1: Selected large commercial poultry farms in Southwestern Nigeria

COMPANY NAME	**ESTABLISHED**	**PRODUCTS**
Animal Care	1979	Table eggs and hatchery
Amo Byng Nig. Ltd.	2003	Broiler, table eggs and hatchery
Ajanla (CHI)	1987	Broiler and hatchery
Obasanjo Farms	1979	Broiler, table eggs and hatchery
Zartech Agric Ltd	1983	Broiler, table eggs and hatchery

Source: Sahel, 2015

WHO (1992) reported that about 90% of the diseases occurring in developing countries result from sanitary problems. Livestock waste produces gases such as ammonia, carbon dioxide, methane, ozone, nitrous oxide and other free gases which affect the world's atmosphere by contributing about 5% to 10% to global warming (Bouwman *et al.*, 1995 , USEPA. 1995). In Nigeria, according to Adebayo (2012), chicken excreta is poorly collected, packaged and transported, thus contributing to environmental pollution. There is therefore, the need for a more effective waste disposal system.

Animal manure has been a key ingredient in maintaining the productivity of continuously farmed land for over five millennia (Beaton, 2003). Manure such as poultry litter is commonly referred to as animal waste (Parker, 2004), a derogative term that incorrectly conveys the idea that this by-product has no value (Gollehon, Caswell, Riboudo, Kellogg, Lander and Letson, 2001). The intrinsic worth of litter consists of its content of nutrients and other materials. Specifically, the results of many studies show that poultry litter is valuable, given its nitrogen and phosphorus content. (Jones and D'Souza 2001).

Most of the manure and litter produced by the poultry industry is currently applied to agricultural land. When managed correctly, land application is a way of recycling nutrients such as nitrogen (N), phosphorus (P) and potassium (K) in manure. Historically, poultry litter was an added source of income for growers. One year's poultry litter production from Benton and Washington was valued at approximately $16 million, going by the July, 2005 commercial fertilizer (N-P-K) prices (Goodwin and Carreira, 2005). However, pollution and nuisance problems can occur when manure is applied under environmental conditions that do not favour agronomic utilisation of the manure-borne nutrients (Sharplay *et al.,* 1998; Cosley *et al.,* 2006; Kaiser *et al.,* 2009). For instance, odour from poultry farms is caused by a large number of contributing compounds (VCOs) and hydrogen sulphide (H_2S). This adversely affects people living in the vicinity (Maheswari, 2013).

Since neglected waste or poor waste disposal creates environmental problems, which, in turn, spread various diseases, contaminate rivers or canal water and spread odours to homes, it is vital to approach chicken waste management in an innovative manner. This is because the best devices and practice in each stage depends on a variety of specific circumstances peculiar to the area under consideration.

The study, therefore, aims at assessing chicken excreta management and its perceived environmental effects in southwestern Nigeria. This is with a view to determining the perceived environmental effects of chicken excreta disposal, as well as the viability and profitability of using chicken excreta in the production of organic fertilizer.

This study, therefore attempted, to answer the following research questions:

1. What are the methods of chicken excreta management in the study area?
2. What are the perceived environmental effects of chicken excreta disposal.
3. What are the determinants of poultry farmers Willingness-to-Pay (WTP) for chicken excreta management

4. Is chicken excreta generated in sufficient quantities to make the production of organic fertilizer profitable?

1.3 Objectives of the Study

The main objective of the study is to assess chicken excreta management methods and the perceived environmental effects by farmers and residents in south western Nigeria.

Specific Objectives are to:

- examine the existing methods of chicken excreta management in the study area.
- evaluate the perceived environmental effects of chicken excreta disposal.
- examine the determinants of willingness to pay for chicken excreta management.
- estimate the viability of using chicken excreta as a key ingredient in producing organic fertilizers, using system dynamics.

1.4 Justification of the Study

The poultry industry is one of the largest and fastest growing agro-based industries in the world. The increasing demand for poultry meat is mainly due to its acceptance by most societies and its relatively low cholesterol content. However, the industry is currently creating a number of environmental problems through the large amount of waste , especially chicken excreta, it generates (Powers and Dick, 2000; Kellcher *et al.,* 2002; Sharplay *et al., 2007).* Existing methods of chicken excreta disposal have, however not been effective. Some of these are dumping on vacant lands, burying, and use as manure. Ineffective management of chicken excreta results in such environment problems as air, water and soil pollution which adversely affect chicken farmers as well as residents around the farm. However, effective disposal of chicken excreta, through using it as the main ingredient in organic fertilizer production, will improve the quality of the environment. The organic fertilizer is a better and much cheaper substitute for inorganic fertilizer. Also, at a time when the cost of natural gas is rising, use of organic fertilizer will reduce the demand for natural gas, a key ingredient in inorganic fertilizer production. Besides, if found profitable, it should it generate employment and income.

The collection of solid waste in many Nigerian cities was, until recently, dominated by government agencies. It was therefore, assumed that it is the responsibility of government to solve the problem of waste collection, as part of its obligations to the citizens(Salifu,2001). As a result the government has not been getting the cooperation of most of its citizens in this regard. However, the possibility of using chicken excreta in organic fertilizer production, stakeholders will be willing to pay for its disposal. This will improve environmental health as well as creates jobs

The justification for this study therefore derives from the imperativeness imposed by the growing concern over the health hazards resulting from environmental pollution through increasingly high chicken excreta generation. Also, the willingness or otherwise of chicken farms to pay for chicken excreta management and the viability of processing chicken excreta into organic fertilizer need to be determined. While studies have highlighted health hazards of chicken excreta, the current trend in its generation as a result of the geometric increase in poultry production requires an update. This research investigated the new direction in chicken excreta management and the viability of converting it to organic fertilizer

1.5 Plan of the Study.

The rest of this thesis is divided into four chapters. Chapter two contains the review of relevant literature and the theoretical and conceptual frameworks on which the research was based. The study methodology, comprising areas of study, sources of data, sampling technique and method of data analysis, is in chapter three. Chapter four describes the socio-economic characteristics of chicken farmers in Southwest and residents around the farms, perceived environmental effects of chicken excreta, types of chicken waste generated in both states, methods of chicken excreta disposal by chicken farmers, factors influencing environmental effects of chicken excreta and factors influencing WTP among chicken farmers. Chapter five concludes the thesis with the summary of findings, conclusion, policy recommendations, contribution to knowledge and suggestion for further studies.

CHAPTER TWO

THEORETICAL/CONCEPTUAL FRAMEWORK AND LITERATURE REVIEW

This chapter presents the theoretical and conceptual frameworks as well as methodological and empirical review of literature.

2.1 Theoretical Review

2.1.1. Utility Theory

This theory has to do with externality effects, in this case, of chicken waste. Externality is a situation where one or more of the variables in the consumption function of an individual or production function of a firm fall under the control of another economic agent. Externality can be positive or negative. Positive externality occurs when one economic agent benefits from the action of another economic agent whereas negative externality decreases the utility or production of another economic agent. Disposing of poultry waste on streets or into rivers is an example of negative externality.

Cropper and Oates (1992) characterise pollution as a public “bad” that results from “waste discharges” associated with the production and consumption of various goods and services. This was explained using the utility function of a representative consumer, which is given as:

$$U = u(X, Q) \qquad (1)$$

where:

X = a vector of private goods, and

Q = level of pollution.

In equation (1), $\delta u/\delta x$ is positive. If a unit increase in X increases the utility of the consumer. $\delta u/\delta Q$, is negative, implying that the level of pollution is inversely related to the utility of the individual.

Hence, the production of X and Q is given as:

$$X = x(L, E, Q) \qquad (2)$$

$$Q = q(E) \qquad (3)$$

where:

L includes a vector of inputs used in the production of X, such as labour and capital, and

E stands for the quantity of poultry discharges.

In this production function, $\delta x/\delta L$ is assumed to be positive when $\delta x/\delta E$ and $\delta x/\delta Q$ are expected to be negative. Poultry waste (E) is treated as an input determining the level of

X. This is because the attempts at emission reduction will require the reduction in the level of other inputs employed in the production of X and reduction in X. This means that a reduction in E will decrease X. Q also affects the production of X; this is the case when farms are the victims of pollution. For instance, the production of X can decrease as a result of absenteeism of workers due to illness, an unclean environment or the discharge of untreated poultry waste from a poultry farm which can adversely affect fish production somewhere else.

Equation (3) shows emission (E) as determining the level of pollution; in this model, $^{\delta Q}/\delta E$ is positive. For instance, increased disposal of solid waste in an open space would pollute the environment more, keeping other factors constant. But victims can protect themselves against pollution by taking various measures such as paying for proper management of poultry waste. This can be represented as:

$$F \quad = \quad f\,(L,\, Q) \ldots\ldots\ldots\ldots\ldots\ldots \quad (4)$$

and shows that the level of pollution to which the individual actually is exposed (F) depends on the level of inputs employed in protective activities (L) and the level of the pollution itself, Q. Substituting Eq. 4 into Eq. 1, we have the utility function of the individual as:

$$U \quad = \quad u\,[X,\, f\,(L,\, Q)] \ldots\ldots\ldots\ldots\ldots\ldots (5)$$

$$U \quad = \quad f\;[X,\, f(L,\, Q)] + \lambda(Y - P_x X - P_L L) \ldots\ldots\ldots\ldots (6)$$

From Eq.6, it can be seen that the individual will maximize his/ her utility, given the unit prices of Px and P_L and budget constraint (Y). This maximisation process will satisfy the first-order conditions for pareto-efficiency. This means the individual will allocate his/her limited income between X and L so that the marginal amount spent yields the same marginal utility, whether it is spent on *X or L*. Since eliciting the farm's willingness to pay for an improved poultry waste management service implies its willingness to contribute to the protective activities, L is supported by basic environmental economic theories.

2.1.2 Environmental Perception

Environmental perception is understood as the relationship human beings have with the environment. The relationship determines the attitude of the people in favour of or against the environment (Leund and Rice, 2002). Taboade-Ganzailer *et al,* (2011). The analysis of environmental perception has been approached by means of environmental behavio ur (Corraliza and Berenguer, 2000) and environmental beliefs or values (Stern, 1992). Regarding the analysis of environmental behaviour, variables such as the altruistic behaviour have been used i.e recycling/ saving energy and other activities based on personal rules and feelings of mind obligations (Brehmond and Eisenhoue 2006, Thon *et al.*, 2012).

Therefore, it is important to understand which factors promote or inhibit environmental behaviour, for example, values and beliefs. (Bordi and Schratz, 2003, Degroot and Steg 2007; Snelgor, 2006). Cultural values (Deny *et al*; 2006), environmental activitism (Dono *et al*, 2010, Fielding *et al*; 2008).

2.1.3 Investment Appraisal (IA)

Investment appraisal is a process of assessing whether it is worthwhile to invest funds in a project. The project may be replacement of an existing asset, acquiring on additional asset, introducing a new product or opening a new branch.

Funds invested in a project may include additional working capital as well as expenditure on non-current assets. The capital investment appraisal techniques used to measure capital investment of a business project include:-

Discounting Count Flow

- Net Present Value (NPV)
- Internal Rate of Return (IRR)
- Accounting Rate of Return (ARR)
- Modified Internal Rate of Return (MIRR)
- Adjusted Project Value (APV)
- Profitability Index (PI)
- Equivalent Amenity (EA)
- Payback period (PP)

These techniques are designed to assess the quality of projects, benefits arising from them and degrees of risk involved.

Only ARR is concerned with profitability; the others are based on cash flows. The NPV and Internal Rate of Returns take the value of money into account. They are all based on additional benefits and costs which will arise from the project. These are referred to as incremental profits and cash flows.

2.1.4 Accounting Rate of Return (ARR)

This compares the profits you expects to make from on investment to the amount you need for investment. The ARR is normally calculated as the average amount of profit you expect over the life of an investment project, compared with the average amount of capital investment.

Payback Period

This is a simple technique for assessing an investment by the length of time it would take to repay it. It is usually the defaults technique for smaller business and focuses on cash flow, not profit.

Discounting Count flow

This applies to the discount rate to work out the present day equivalent of a future cash flow. There are two types of discounting methods of appraisal the Net Profit Value (NPV) and Internal Rate of Returns (IRR).

Investment risk and sensitivity analytic assessment of risks is essential. In practice, the biggest risk for many investments is the distraction they can cause.

2.1.5. Theoretical foundations of system dynamics

A host of natural features (no artifact nor process in your list) such as estuaries, trees, volcanoes and birds are dynamic systems. The same is true of man-made structures such as processes and artifacts: airplanes, banks, political parties and cities.

The simplest and most obvious way to integrate a differential equation is in seven steps:

- set time to its initial value,
- select a value for each segment of time (TIME STEP),
- initialize the level at time = initial time,
- compute the rate of change of the level at the current time,
- compute the value of the level at time = time + TIME STEP using equation (7) b

$\text{Level}_{\text{time + TIME STEP}} = \text{level}_{\text{time}} + (\text{TIME STEP} * \text{Rate}_{\text{time}})$ .... (7)

- add TIME STEP to time,
- repeat steps 4 to 6 until time = final time.

The simplest possible formulation in the case of a single rate changing a single level is:

$\text{Rate}_{\text{time}} = \text{level}_{\text{time}} * \text{change fraction}$ ....(8)

Change fraction = constant ....(9)

Equations (7) to (9) describe a simple accumulation process which system dynamics represents in figure 1:

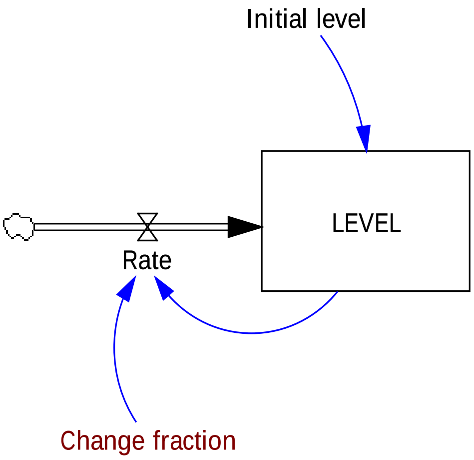


Fig 1: Simple accumulation process
Source: Author, 2015

After 10 years, with an assumed net change fraction of 2 % per year, level population has accumulated as shown in Figure 2. The accumulation of the simple model of fig 1 is described in Table 2 . Changes in Data reflects the improvement in model accuracy.

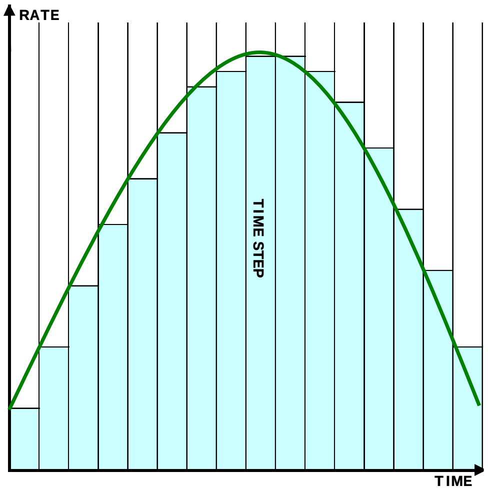


Fig 2: Graphical representation of simple accumulation process
Source: Author, 2015

Fig 2 is an illustration of the integration error that occurs when integration is performed with the Euler method. (There is no data behind it).

Each number in column Time represents a point in time. Therefore, the range between two successive points in time is a time period. Levels are defined at the beginning of time periods while rates are defined over time periods. Population is 1,000 at time = 0 while net number of births is 20 over the first period from time = 0, the beginning of period 1, to time = 1, the beginning of period 2 (or the end of period 1).

Table 2: Time Step Accuracy

TIME STEP = 1			TIME STEP =.5		TIME STEP = .25		TIME STEP = .125	
Time	LEVEL	Rate	LEVEL	Rate	LEVEL	Rate	LEVEL	Rate
0	1000	20	1000	20	1000	20	1000	20
1	1020	20.4	1020.1	20.4	1020.1	20.4	1020.2	20.4
2	1040.4	20.8	1040.6	20.8	1040.7	20.8	1040.8	20.8
3	1061.2	21.2	1061.5	21.2	1061.7	21.2	1061.8	21.2
4	1082.4	21.6	1082.9	21.7	1083.1	21.7	1083.2	21.7
5	1104.1	22.1	1104.6	22.1	1104.9	22.1	1105.0	22.1
6	1126.2	22.5	1126.8	22.5	1127.2	22.5	1127.3	22.5
7	1148.7	23.0	1149.5	23.0	1149.9	23.0	1150.1	23.0
8	1171.7	23.4	1172.6	23.5	1173.0	23.5	1173.3	23.5
9	1195.1	23.9	1196.1	23.9	1196.7	23.9	1197.0	23.9
10	1219.0	24.4	1220.2	24.4	1220.8	24.4	1221.1	24.4

Source: Author 2015

Table 2 shows that accuracy is improved as the size of TIME STEP is reduced. This is because the integration method used, the Euler integration, assumes that rates computed at a given time are constant over the time interval TIME STEP (which is not often correct).

If a rate is not constant, as displayed on Figure 3, the accuracy of integration improves as TIME STEP is reduced. TIME STEP is a parameter of the computation process not a parameter of models (Forrester, 1968). TIME STEP is selected by the model builder subject to the constraint:

$0 < \text{TIME STEP} < \quad = \quad 1$

Euler integration is not a good technique to get accurate solutions to differential equations in cases where a model describes a truly continuous phenomenon. However, in many social and economic processes, continuity coexists with discontinuity. The distinction between difference and differential equations is therefore imprecise and Euler integration is appropriate.

In many cases difference equations are sufficient to picture social or economic processes with acceptable accuracy. TIME STEP can then be set to 1 and differential equation (7) becomes difference equation (11) below:

$\text{Level}_{\text{time}+1} = \text{level}_{\text{time}} + \text{Rate}_{\text{time}}$ ....(11)

So that:

$\text{Level}_{\text{Final time}} = \sum \text{Rate}_{\text{time}}$ .... (12)

If a system dynamics model requires better accuracy, the Runge-Kutta integration method is available and can be used.

The process of growth that is pictured in Figures 1 and 2 directly results from the structure of the simple model which Figure 1 describes. The growth of LEVEL results from the accumulation of increasingly larger values of Rate, themselves the result of a growing LEVEL. This is a positive feedback loop. Feedback loops are common structural components of system dynamics models. Positive feedback loops are explosive. Explosions are dynamic processes that cannot ultimately be controlled. They are therefore unsustainable. In contrast, negative feedback loops are balancing and tend to prevent processes driven by positive feedbacks to explode (Yamaguchi, 2013). Continuing with the population example above, Figure 3 shows how the negative feedback loop of deaths balances the explosion of the positive feedback loop of births.

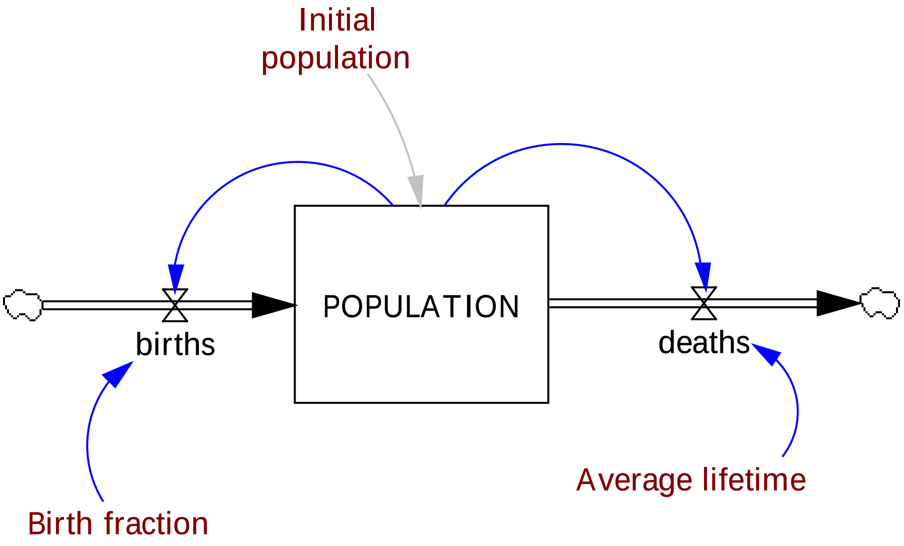


Figure 3 Feedback Loop of Population growth
Source: Author, 2015

In equation form, this diagram translates as follows:

$\text{POPULATION}_{\text{time + 1}} = \text{POPULATION}_{\text{time}} + \text{births}_{\text{time}} - \text{deaths}_{\text{time}}$ ....(13)

$\text{births}_{\text{time}} = \text{POPULATION}_{\text{time}} * \text{Birth fraction}$ ....(14)

Birth fraction = constant ....(15)

$\text{deaths}_{\text{time}} = \text{POPULATION}_{\text{time}} / \text{Average lifetime}$ ....(16)

Average lifetime = constant ....(17)

A feedback loop is positive if an increase/decrease in any component of the loop results by feedback in an increase/decrease in this same component. A feedback loop is negative if an increase/decrease in any component of the loop results by feedback in a decrease/increase in this same component. Good system dynamics models require consistent use of units of measurement. Levels are measured in specific units (people, money, weight, volume, items, etc) while rates are measured in units per time period. Parameters which connect a rate to a level (as change fraction above) are measured in percent per time period. A percentage is a ratio between two quantities of the same unit. Therefore:

percent per time period = quantity / quantity / time period = 1 / time period..............(18)

Parameters which connect two rates or two levels do no require that a time dimension be introduced and are dimensionless. If the population model above is a yearly model the unit for population is people, the unit for births and deaths is people /year, the unit for Birth fraction is 1 / year and the unit for average lifetime is year.

A common feature of many system dynamics model is to be target driven (Forrester, 1996). The model in Figure 4 is an example of the simplest possible feedback system driven by a target.

It includes a level, a rate and two policy constants. The level is an accumulator of recurrent flows. The rate is a flow that changes the amount in the level over time. The two policy constants define the value the rate takes depending upon:

- a comparison between the level and a goal, and the time required to adjust what exists to what is desired.

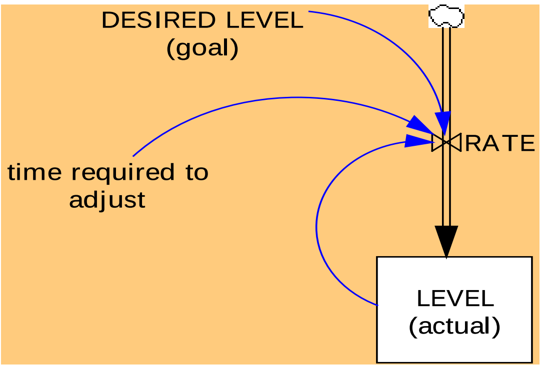


Figure: 4 Feedback System Driven by a Target.
Source: Author. 2015

The actual level may be material or information but the target or desired level is always information. Information is a critical component of feedback loops. Without information being collected, processed and acted upon, many feedback processes would not exist.

Assuming time starts at time = p and ends at time = P, level is initialised at time = p. In equation form, the sketch of Figure 3 can be written:

Rate in the course of period p = (desired level – level at the start of period p) / time required to adjust………………………………………………………………………….(19)

Level at the start of period p +1 = level at the start of period p + rate in the course of period p……………………………………………………………………………. (20).

Equation (19) allows the computation of Rate in the course of period p + 1 which itself allows the computation of Level at the start of period p + 2 so that the process can continue until time = P.

2.1.6. System Dynamics Modelling

Dynamic systems are organised sets of interacting elements which evolve through time to achieve a purpose (Meadows, 2009). System dynamics is a modeling and simulation tool which enables the user to understand and anticipate how such systems are likely to change as time passes. It has, therefore, a broad area of application (Forrester, 1961, 1968, 1996).

To understand how dynamic systems change through time, their structure must be known or correctly assumed. Key elements of structure are those which define the dynamics of systems. They are called levels. Levels are accumulators. The value taken by a level at any point in time depends upon its past value and the value of the variables that change it. Variables that directly change levels are rates. The dynamics of a system is therefore the process by which the rates that directly change the system's levels either build them up, deplete them or both (Forrester, 1968).

Mathematically, a continuous change through time is noted as d/dt. If a continuous change through time of a level is caused by a single rate, this change can be written as

$$\frac{d}{dt} level_t = rate_t \qquad \text{..(21)}$$

Or:

$$level_t = \int_0^T rate_t dt \qquad \text{..(22)}$$

Equation (21) is a differential equation while equation (22) is an integral equation. Both describe the same accumulation process but from a different time perspective. Equation (22) looks at the entire time period while equation (21) describes what happens in each segment of time.

Table 3: Level-rate relationship

	FLOW IN	**LEVEL/STOCK**	**FLOW OUT**
	Orders received	Orders to be met	Orders delivered
INFORMATION	Credit sales	Trade Debtors	Payment
	Credit purchases	Trade creditors	Payment
	Goods produced	Goods in stock	Goods supplied
MATERIAL	Investment	Capital	Depreciation
	Planting	Trees in Forest	Harvesting
	Hiring	Workforce	Retirement
PEOPLE	Births	Population	Deaths
	Income	Bank Account	Expenses
MONEY	Interest	Savings	Inflation
	Good things done	Reputation	Bad things done
INTANGIBLE	Skills & experience acquired	Competence	Skills forgotten

Source: Author, 2015

Table 3 provides some examples of level – rate connections in various areas of relevance to economists.

System dynamics models are therefore built connecting levels and rates in structures which may also include delays and non-linear relationships and may vary from the simplest to the most complex design. A recurrent characteristic of complex dynamic systems is their ability to exhibit counter-intuitive behaviours (Forrester, 1995): failure when success is expected or instability when equilibrium is anticipated.

The first system dynamics model that attracted the world's attention was built in 1972 (Meadows, Meadows, Randers and Behrens III, 1972) and consists of some 300 equations while a system dynamics model of the American economy developed at the Massachusetts Institute of Technology (MIT) includes about 250 levels and 3,000 equations (Sterman, 1984). But modeling is an art which should be appraised less by the quantity of equations involved than by the quality of the explanation it provides of real-world dynamic processes.

2.2: Methodological Review

2.2.1 The Contingent Valuation Method (CVM)

Environmental valuation methods are used to collect some of the data to be fed into the system dynamics model. They help to estimate the value people attach to environmental amenities or services, that is, how much better or worse off individuals are or would be as a result of a change in environmental quality. Since there are no existing markets for environmental goods, people's valuation of these kinds of goods will have to be derived from "hidden" or implicit markets by looking at the consumption of related private goods (e.g. Hedonic Pricing Methods and Travel Cost Methods, or by constructing artificial markets where people are asked to reveal their preferences as in the Contingent Valuation Method (CVM). The valuation method this study adopted is the CVM. One reason for using this method is its superiority over other valuation methods, owing to its ability to capture both use and non-use values. Using other valuation methods such as Hedonic Pricing and Travel Cost Method will underestimate the benefits people get from poultry solid waste management since they measure use values only. The other reason for using CVM is its ease of use in data collection compared to other valuation methods. The CVM is the best valuation method available for measuring the total value people attach to improved waste management in south western Nigeria.

CVM is an environmental valuation method which involves the use of an artificial market to measure consumer preferences by directly asking them questions. If correctly applied, the CVM will enable researchers capture the total value of the goods (both use and non-use values). Its flexibility facilitates valuation of a wide range of non-market goods. As a result, the method is becoming the most preferred valuation method at present (Mitchell and Carson, 1989). In most CVM applications, the major steps are designing and administering the CV survey, analysing of the responses, estimating and aggregating benefits (WTP and / Or WTA) and the total revenue and evaluating the CVM exercise (Validation Tests).

Designing and administering the CV survey is a very critical step in obtaining satisfactory results from CV surveys. The question and the description of the hypothetical market should be put in a way respondents will easily understand, so that biases in the survey can be minimised. One way of minimizing biases in CVM exercises is to undertake pilot surveys that will help generate starting values, if the Bidding Game or Closed-Encoded Elicitation techniques are to be used in the main survey. A contingent valuation survey covers three basic parts (Mitchell and Carson, 1989): first, a hypothetical description of the condition under which the goods or services are to be offered as presented to respondents, second, questions which elicit the respondents' willingness to pay for the goods being valued are presented and third, questions on socio-economic and demographic characteristics and their use of the goods or services under consideration are given to the respondents.

2.3 Conceptual Framework

2.3.1 Concept of Welfare Measures in Waste Management.

The relevant measures for quality changes in improving chicken excreta management are Compensating Surplus (CS) and Equivalent Surplus (ES).To derive these welfare measures, we follow Freeman (1993), and consider a utility maximisation problem [Max $U= U (X, Q)$] subjected to a budget constraint, where X is a vector of quantity for market goods and Q is the status of a non-market environmental good such as chicken excreta management. The solution to this problem will be a set of Marshalian (uncompensated) demands and the indirect utility function, $V (P, Q, Y)$, where P is a vector of market prices for market good X and Y is the level of income of the individual.

Assuming there are two possibilities for Q, Q^o is the initial level of Q while $Q1$ is the new (improved) level of Q, which is expected to improve the welfare of the individual. Then compensating surplus (CS) will be defined as:

$$V (P, Q^1, Y- CS) = V (P, Q^0, Y)=U^0 \qquad \text{.......................(23)}$$

and equivalent surplus (ES) will be:

$$V (P, Q^0, Y+ES)= V (P, Q^1, Y)= U^1 \qquad \text{.......................(24)}$$

The welfare measures of CS and ES can also be represented as integral to the Hecksian (compensated) demand curves. This is done by taking the dual of the minimisation problem. The first order condition of this maximisation problem gives the Hecksian (compensated) demand function as:

$$\bar{X} = (P, Q, \bar{U}) \qquad \text{.......................(25)}$$

Then the indirect expenditure function can be obtained as:

$$e(P, Q, \hat{U}) = P.X(P,Q, \hat{U}) \qquad \text{...(26)}$$

CS and ES can be defined respectively as:

$$CS=e(P, Q^0, U^0) - e(P, Q^1, U^0) \qquad \text{..(27)}$$

$$ES=e(P, Q^0, U^1)- e(P, Q^1, U^1) \qquad \text{..(28)}$$

In terms of the area under the Hecksian demand curves, CS and ES are given as follows

$$CS = \int_{Q_0^0}^{Q_1^0} \bar{X}(P, Q^0, U^0)\,dQ$$

and

$$ES = \int_{Q_0^1}^{Q_1^1} \bar{X}(P, Q^1, U^1)\,dQ \qquad \text{……......................................(29)}$$

In the absence of property rights, willingness to pay refers to the maximum amount of money an individual is willing to give up in order to secure a welfare improvement or to prevent a welfare decline. Then willingness to pay will be given as CS.

$$WTP = CS = e(p, Q^0, U^0) - e(P, Q^0) = \int_{Q_0}^{Q^1} \ddot{X}(P, Q^0, U^0)\,d\,Q \text{ ………………….(30)}$$

But if the individual has property rights over the good, then willingness to accept compensation refers to the minimum amount of money the individual is willing to accept for forgoing welfare improvement or welfare deterioration. Then willingness to accept will be given as ES.

$$WTA = ES = e(P, Q^0, U^1) - e(P, Q^{01}U^1) = \int_{Q_0^1}^{Q_1^1} \ddot{X}(P, Q^1, U^1)\,d\,Q \text{ ……………..(31)}$$

As noted earlier, the CVM can measure both willingness-to-accept and willingness-to-pay. But in this study, willingness to pay will be measured since, in general, willingness to accept is used in cases of deprivation while willingness-to-pay is used in cases involving the improvement of the current state, such as the improvement in chicken excreta management in south-western, Nigeria. Therefore, a reference utility level of U^0 (the existing utility level, Freeman 1993) and households responses to willingness-to-pay questions will directly give us the Compensating Surplus (CS), an estimate of the total value households in southwestern Nigeria place on the proposed improved chicken excreta management.

2.3.2 Waste: Environmental and Health Effects

Unwanted materials or substances left after something has been used constitute waste (Longman Dictionary of Contemporary English). It is the inevitable by-product of our use of natural resources. In any given area, the quantity and type of waste generated depends on such factors as population, economic prosperity, time of year, type of housing and methods of waste disposal (Defra, 2004). The four main categories of waste are solid waste, liquid waste, agrochemical waste and other forms of waste. Each of these forms of waste has significant environmental and health effects (UNEP, 1987).

The main emissions to air from waste are methane and carbon dioxide. Others are benzene, nitrogen dioxide and cadmium. Some of these substances are emitted before the waste decomposes while some are emitted after its decomposition. The global warming effects of methane is twenty times more powerful than that of carbon dioxide which is also one of the main contributors. Benzene can cause cancer; nitrogen dioxide affects air quality in urban areas while cadmium is associated with cancer of the lungs, throat and kidney diseases (Defra, 2004).

Waste can also produce emissions to groundwater and surface water. Emissions to water is mainly from landfills. Some of these are nitrogen and organo-tin compounds. While nitrogen can promote growth of unwanted algae, organo-tin compounds can affect fish and shellfish. Waste management practices can also have adverse environmental and health effects. Several possible ones are noise, odour, dust, visual intrusion, damage to plants and animals, damage to soils, pollution of air, emission of global warming gases and damage to buildings from acidic gas (Table 4) (Defra, 2004). The foregoing underscores the need for waste management techniques that will enhance the wealth-creating potential of waste while remaining as environment friendly as possible.

Table 4: Summary of key environmental issues

Activity	Noise	Odour	Dust	Flora/ Fauna	Soils	Water Quantity/ Flow	Air quality	Climate	Building Damage
Materials recycling facility	X	X	X	X	X	XX	XX	-	-
Composting	XX	XXX	XX	✓	X✓	XX	XXX	X	-
Incineration with pre-sorting	XX	XX	XXX	XX	XX	XX	XXX	X	X
Incineration	XX	XX	XXX	XXX	XXX	XXX	XXX	X	X
Landfill	XXX	XXX	XX	XXX	XXX	XXX	XXX	XXXX	X

Source: Adapted from Review of environmental and Health Effects of Waste Management, 2004

Category	Meaning
✓	Direct and indirect benefit
-	No effect
X	Unlikely to be significant
XX	Potentially significant impact in some cases, but can be controlled
XXX	Impact can normally be controlled, but an issue at sites if design engineering or operation falls below best practice
XXXX	An issue at all sites

Adapted from Review of Environmental and Health Effects of Waste Management, 2004

2.3.3 Waste Management Methods

Waste management constitutes all the activities and actions required to manage waste from its inception to it final disposal (Glossary of Environment Statistics,1997) This includes amongst other things, collection and disposal of waste together with monitoring and regulation.

It also encompasses the legal and regulatory framework that relates to waste management, encompassing guidance on recycling. The term normally relates to all kinds of waste, whether generated during the extraction of raw materials, the processing of raw materials into intermediate and finals products, or other human activities. Waste management is intended to reduce adverse effects of waste on health, the environment or aesthetics.

The waste management hierarchy refer to the 3Rs reduce, reuse and recycle which classify waste management strategies according to their desirability. Waste management methods include the following :anaerobic digestion, gasification, biodegradation and recycling. Among these, composting dumping on vacant lands and landfills and application to agricultural land are some the commonly used methods of chicken-excreta management in South western Nigeria. Recycling of chicken excreta is rare.

Composting is a form of waste disposal where organic substances decompose naturally under oxygen-rich conditions. It is the rotting down of plant and animal remains in heap before the residue, the compost, is applied to the soil (Akinsanmi 1988) biodegradation is involved in compositing. Despite its several advantages, an unpleasant odour results from the disintegration of the organic materials by bacteria during compositing. The odour persists for quite some time, given the fact that compost is not expected to be used immediately after it is made. It should be "left in a heap for, at least, one month, or better still, a year…" besides since plant and animal remains are involved in composting, it cannot be applied to chicken management because plant, and not animal remains constitute the bulk of what is used in composting.

Dumping waste on vacant lands, no matter where constitutes a healthy hazard. Although such waste will eventually enrich the land for agricultural use when it decomposes it still has adverse effects on the environment it can also contaminate surface water.

Landfills are special areas of land where waste is deposited. Dumping waste in landfill appears to be one of the most commonly used methods of waste management in developing countries. Dumping in landfills is much better than on vacant lands. Waste dumped in landfills does not constitute as much of a nuisance as that dumped on vacant land. It fills up land and increases the fertility of the soil around it. However, it still impacts negatively on the environment as well as on underground water.

Applying waste, especially animal waste, on agricultural land is a common waste management practice. This is because animal manure is a key ingredient in maintaining soil fertility owing to its nitrogen, phosphorus and potassium contents. However, despite its advantages, applying animal waste such as chicken excreta on agricultural land produces pollution and nuisance problems.

Recycling has many advantages such as conserving energy, and, in the case of paper, reducing the felling of trees for paper making. It helps in mitigating global warming and reducing pollution. It minimises waste and can help save money. Although recycling some materials has some disadvantages, it can be said that recycling organic materials such as chicken excreta, is the least disadvantageous of other methods of chicken excreta management.

The environmental and health effects of waste justify the need for its management, especially considering the rapidly increasing human population. This must have informed the observation of Eliot Morley, Minister of State for Environment and Agro-environment of United Kingdom, that "the growing amount of waste we produce" must be disposed of (Defra, 2004, Foreword). The need for not "wasting" waste in the course of its management is also stressed in the Prime Minister's Strategy Unit Report titled "Waste not, want not: a strategy for tackling the waste problem in England". Common waste management techniques include composting, incineration with pre-sorting, incineration, using landfills, re-using and recycling.

Composting involves the breaking down of organic waste by micro-organisms in the presence of air. It can be done in the open air. In developed countries, in-vessel composting systems are used. Since these are automated, it is much easier to control any emissions. Composting is beneficial to flora/fauna and soils. However, its adverse effect on soils is not likely to be significant. Incineration of pre-sorted waste is another waste-management technique. It involves the burning of waste after sorting. Incineration can also be done without sorting. This is generally done to reduce the volume of solids in the waste. More flora and fauna are destroyed and the soil is more adversely affected when incineration is done without pre-sorting (Table 4). Another poor management method of disposing of poultry waste that has gained prominence in Nigeria is open burning after waste has been subjected to sun drying (Adeoye *et al., 2014)* to reduce the moisture content and, thereby, raising the calorific value. The open drying itself releases excessive ammonia and other greenhouse gas emissions capable of creating climate change (Akinbile, 2012).

Landfills are special areas of land where waste is deposited. The volume of waste reduces when its biodegradable part decomposes. Dumping waste in landfills appears to be one of the most commonly-used method of waste management, especially in developing countries. In developed countries, such as the United Kingdom, a landfill is a specially engineered land area where waste is deposited. Each section of the landfill is sealed with a permanent cap when it is full (Defra, 2004). About three quarters of the U.K’s municipal solid waste is disposed of directly to landfill. Socially, the costs incurred by illegal dumping of waste is much higher than what is incurred by efficiently operating a landfill (Choe and Fraser, 1998). It is the most economically viable waste management option in Australia. Waste can also be re-used. For instance, reusable products such as returnable milk bottles can be taken from waste, cleaned up and re-used. Waste can also be recycled, in which case, new products are produced. This will reduce the need to use natural resources directly, and may reduce emissions from extraction and processing of raw materials. (Defra, 2004).

2.3.4 Chicken Excreta Management: Some Challenges

Chicken excreta constitute a large proportion of the organic waste used in the production of organic fertilizers through recycling. The combination of other organic materials and chicken excreta is in the ratio 3: 1. Chicken excreta contributes so much to the quality of the organic fertilizers, hence the emphasis on it. The tremendous expansion in chicken production is the result of the demand for low-cholesterol meat. In 2009, the estimate of the number of chickens in Nigeria stood at 183.16 million (FDC, 2010). However, this has caused increasing concern about the disposal of the resulting large quantity of chicken excreta. (Moore, Daniel, Sharpley and Wood). (year 2016) Poultry waste includes bedding materials, feed, manure, intestines, feathers, hatchery waste (empty shells, infertile eggs, dead embryos and late hatchings), culled birds, shells, sludge and abattoir waste. Waste generated in poultry production according to (6) includes waste food, animal waste or faeces, carcasses, sediments and sludge from on-site waste water treatment facilities, various kinds of packaging for feed and pesticides, used ventilation filters, unused/spoilt medications and used cleaning materials.

The three forms of waste of primary concern in poultry production are the excreta from laying operations (involving hens and pullets), litter associated with broiler production and dead birds (Edwards and Daniel, 1992). The composition of manure can enhance crop production because of their capacity to supply nutrients and increase soil quality. Broiler litter has relatively low moisture and high macronutrient content, which in why it is generally regarded as the most valuable animal manure for use as fertilizers (Wilkinson, 1979). It also contains significant amounts of secondary plant nutrients and micronutrients. This explains why a major way chicken excreta is disposed of is through its use on agricultural farms.

When mixed with grains, chicken excreta have been used to successfully feed cattle. About 4% of the poultry manure produced in the U.S. is fed to cattle (Carpenter, 1992). It is also sold to nurseries and to garden stores and may also be used to produce electricity. But the quantity used in these areas is negligible, hence the need for its use on a larger scale, for instance in organic fertilizer production.

Applying chicken excreta on soil affects soil properties. It provides nutrients for crop production and builds up soil organic reserves. It is generally considered the most valuable animal manure for use as a fertilizer, due mainly to its low water content (Moore *et al.,* 1996). Poultry manure contains large amounts of N, P and K and secondary and trace elements. It also ameliorates the effect of salt in salt-affected soils. According to Miller *et al* (1991), rice yields in eastern Arkansas increased as much as 286% with poultry additions.

Solid poultry manure, also referred to as broiler litter or poultry litter, results from most broiler operations. It contains more than 150g dry matter per kg, which is why it is amenable to solid waste handling systems (Miner and Hazen, 1977). In the US, solid manure that is wetter than normal is dried using static aeration or by mixing it with drier materials. This is done to reduce its weight or for ease or spreading on farms. Dry manures are easier to transport long distances since the cost of moving poultry litter from the poultry farm to crop farms is "a major obstacle" (Daniel *et al.*, 1992). The obstacle can be surmounted if chicken excreta is recycled into organic fertilizers, which will be easier to transport.

According to Carpenter (1992), over 90% of poultry litter in the U.S. is applied to agricultural land, usually a few miles from where the litter is produced. This implies that many agricultural lands may not benefit from the manure. The result is that, in the major poultry producing states, the amounts of nutrients produced by the manure exceed crop requirements (Daniel *et al*, 1992). For instance, the amount of phosphorus produced annually from poultry litter is more than what is required by the three major crops in several poultry producing states in the U.S. (National Agricultural Statistics Service, 1989). Excessive poultry manure application results in nitrate leaching into the groundwater. Samples of well water on poultry farms in Tennessee USA showed that 43% of the well sampled contained fecal coliform bacteria while 8% of the wells contained water which exceeded $10mgNO_3\text{-}NL^{-1}$ (Green and Burcham, 1992). The researchers found that well location was an important factor in respect of contamination and recommended that wells should be at least 15.2m from poultry farms. Apart from poultry manure containing many pathogens which can contaminate both surface and ground water, it also contains viruses which are a greater threat to water resources than bacteria (Daniel *et al.*, 1992). Poultry litter applications also cause odour problems, which constituted the main complaints against poultry farmers received by the state and federal environmental regulatory agencies in the U.S. (Williams, 1992). If such problems exist in a developed country such as the U.S., it is obvious that the problem will likely be worse for Nigeria, considering the expansion of its chicken industry. This is another justification for the making of organic fertilizers from poultry litter through recycling.

In the light of the problems caused by chicken excreta and its management practices, there is need for the best management practice (BMP). Such BMP must relate directly to water quality and must be cost effective. It must be acceptable to chicken farmers and must provide them with economic returns (Daniel *et al.*, 1992). Recycling chicken excreta into organic fertilizers appears to meet these requirements of the BMP, hence the need for this study.

2.3.5. ADDING VALUE TO CHICKEN EXCRETA: CONCEPT OF A GENERIC SYSTEM DYNAMICS MODEL

Overview

This study is to design a generic structure to assess the viability of using chicken excreta as the main input in the profitable production of useful products (e.g. organic fertilizers) and if feasible, such projects would enhance economic linkages, employment, environmental sustainability and pollution control.

Figure 5 shows the skeleton of the generic management structure common to many businesses.

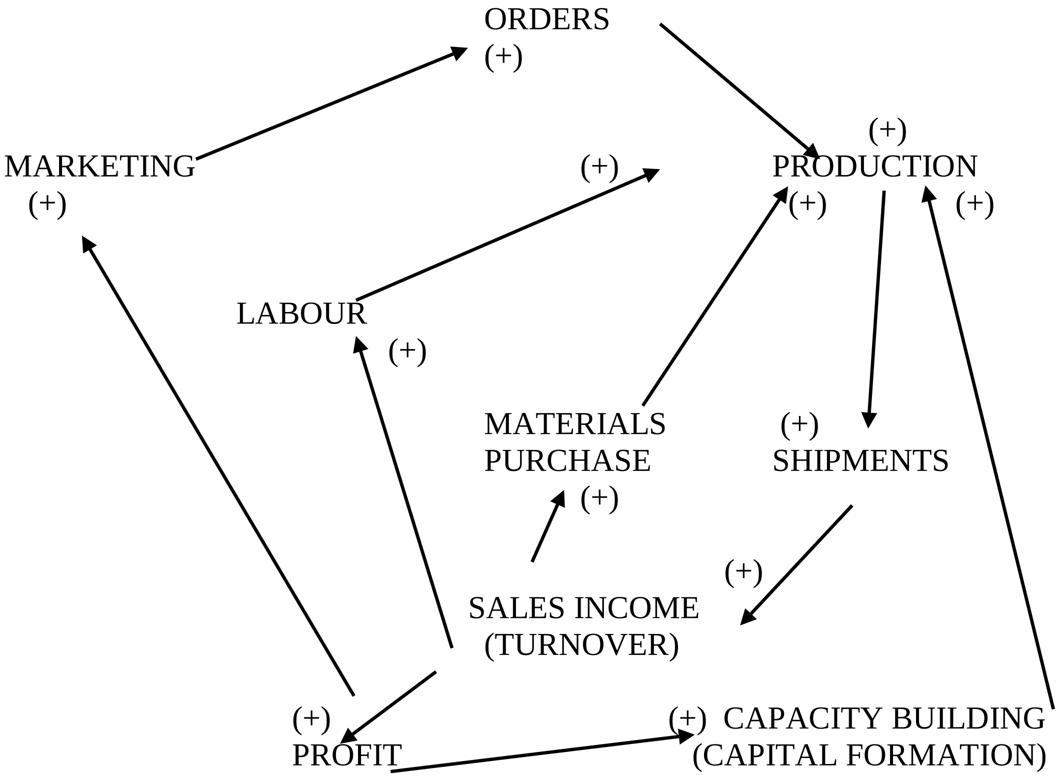


Figure 5: Generic Management Structure. (Arrows indicate causality.)

It is because there are demands for the goods offered for sale that production takes place and shipments are made. Supply of goods generate sales income with which the factors of production-labour and material are procured. Sales income also pays for marketing which generates orders. Profit results from sales income and finance investment to increase production capacity and production.

Figure 6 is a network of four positive feedback loops. All cause-effect relations between variables are positive (reinforcing): an increase in the cause results in an increase in the effect.

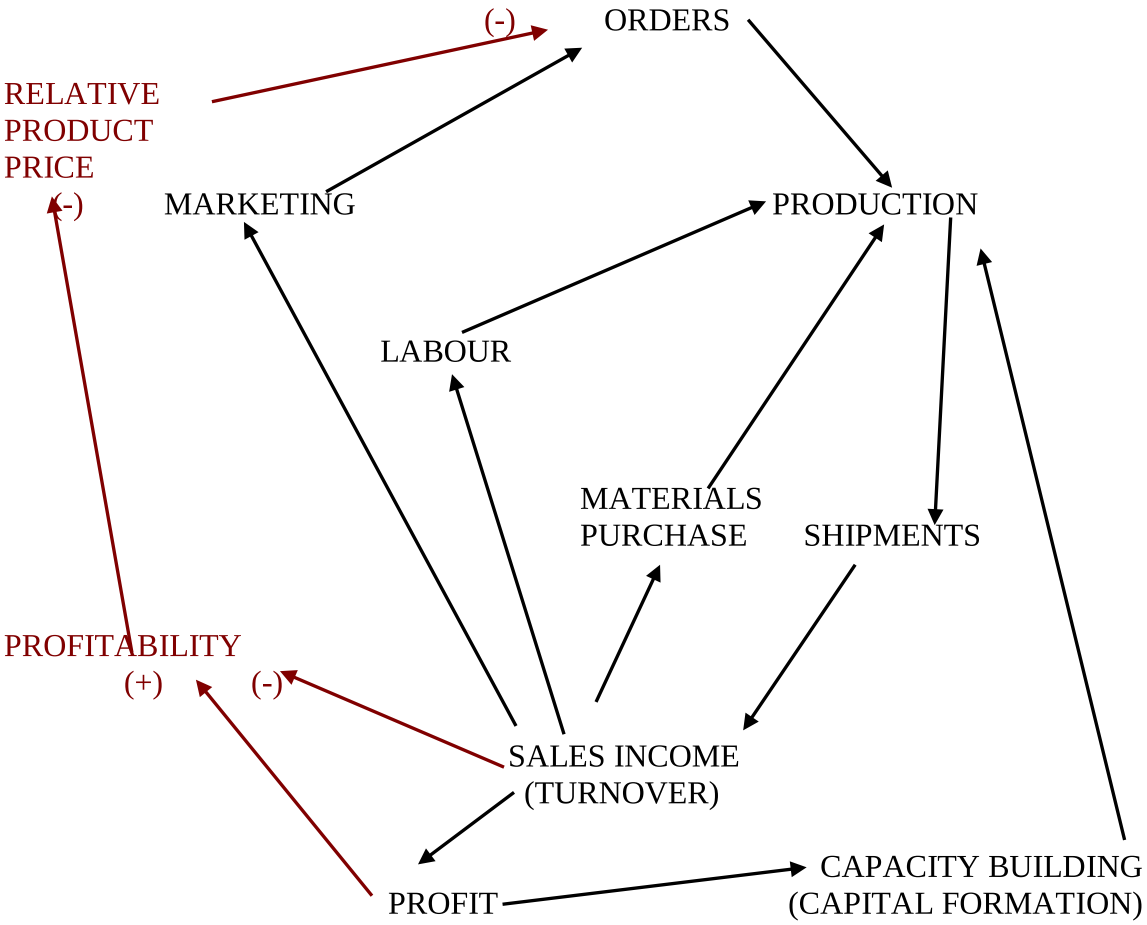


Figure 6: Balancing (negative) loop

But as Figure 6 shows, there is an important balancing (negative) loop, the major component of which is product price. The relative product price on Figure 6 reflects business competitiveness. The price of the good supplied, relative to the price of the same good offered by competitors, has an important impact on demand. A relative product price greater than 1 indicates a loss of competitiveness. Which is expected to reduce orders. A relative product price below 1 indicates a gain in competitiveness and is expected to boost orders and sales. As its name suggests relative product price is the result of the actions of both a business and its competitors. Assuming there is no change in competitors' situation, it is reasonable to expect a firm's pricing policy to be guided by profitability. As profit increases, product price may fall so as to increase orders. As profit decreases, product price may increase so as to maintain profitability. Transforming this basic generic structure into a system dynamics model involves five successive steps.

Step 1 in model construction: level identification

Model construction begins with the identification of all relevant levels. Levels are the system’s accumulation processes. There are at least five of them: order backlog, product inventory, workforce, sales force and raw material stock (more than one level, if more than one raw material is used).

Step 2 in model construction: rate identification and the construction of levels’ basic dynamics

This is equivalent to defining the set of differential equations which characterises the system’s basic dynamics. System dynamics represents differential equations either in graphic form, as shown in Figure 8 or written out as equations

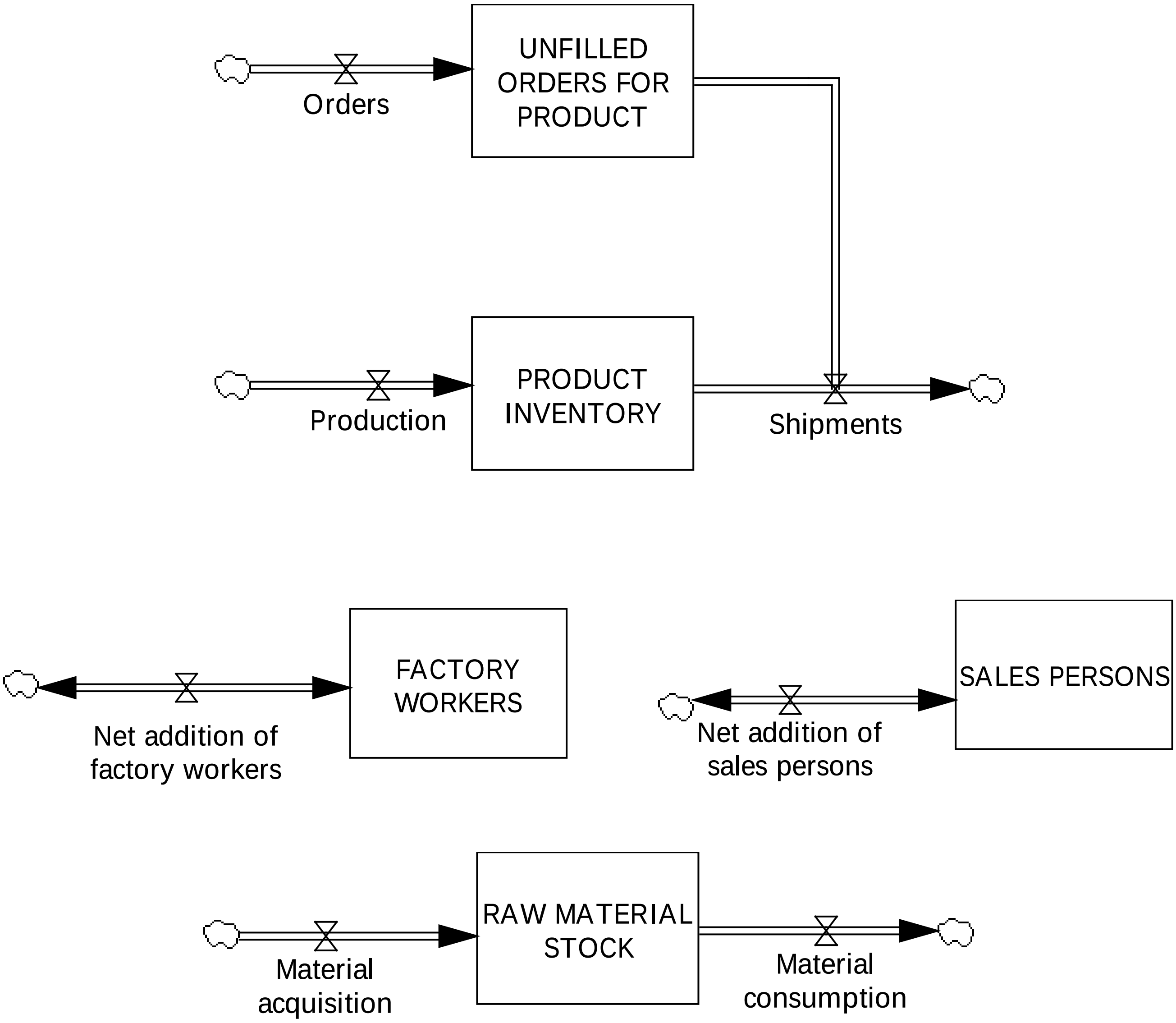


Figure 7: Graphical Representation of System Dynamics.

The above relationship can be expressed in equation form as follows:

UNFILLED ORDERS FOR PRODUCT = INTEG (Orders – Shipments, Initial unfilled orders for product)

PRODUCT INVENTORY = INTEG (Production – Shipments, Initial product inventory)

FACTORY WORKERS = INTEG (Net addition of factory workers, Initial factory workers)

SALES PERSONS = INTEG (Net addition of sales persons, Initial sales persons)

RAW MATERIAL STOCK = INTEG (Material acquisition – Material consumption, Initial raw material stock)

INTEG is a system dynamics keyword which refers to a built-in function which returns the integral of the rate. This is added to the level's initial value (set or calculated) and previous integrations (if any).

Step 3 in model construction: model networking and causal linkage of rates

The causal linkage of rates is most likely to require the introduction of three additional elements of structure: auxiliary variables (used to break down rates into explicit components), delays and non-linear relationships.

Auxiliary variables are important components of system dynamics models. A system dynamics model is basically a network of relationships between levels and rates: rates determine levels which, in turn, determine rates. But causal links between levels and rates are often indirect and complex. Making them explicit requires the introduction of intermediate or auxiliary variables. For example rate *Material acquisition* depends upon level *Unfilled orders for product* through the following causal chain:
Material acquisition = (Desired raw material stock – raw material stock) / Time to adjust material stock Desired raw material stock = Desired product inventory * Input output ratio * Material stock coverage**.** Desired product inventory = SMOOTH (Unfilled orders for product, Smoothing factor) * Product inventory coverage. This is presented in graphic form in figure 8.

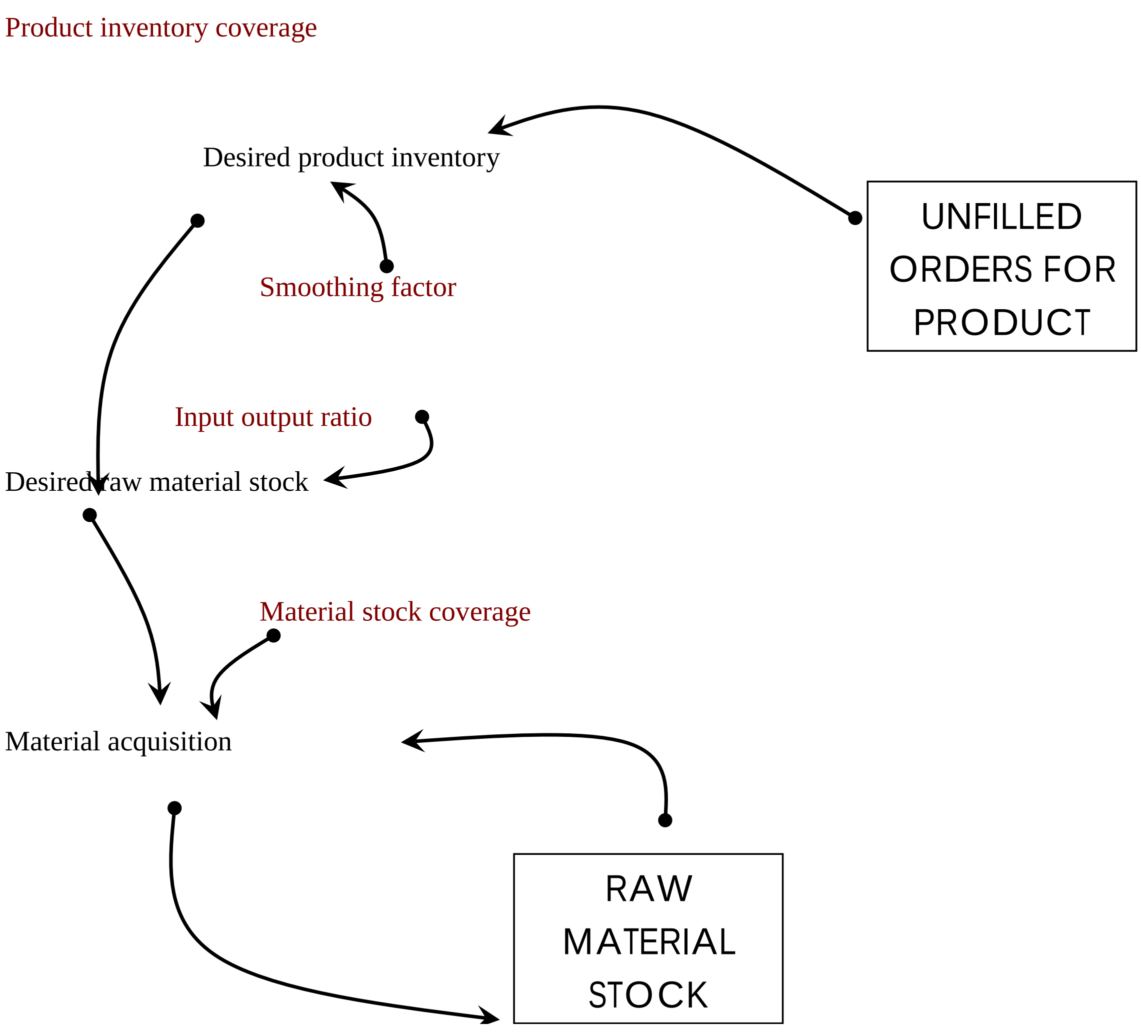


Figure 8: Product Inventory Coverage

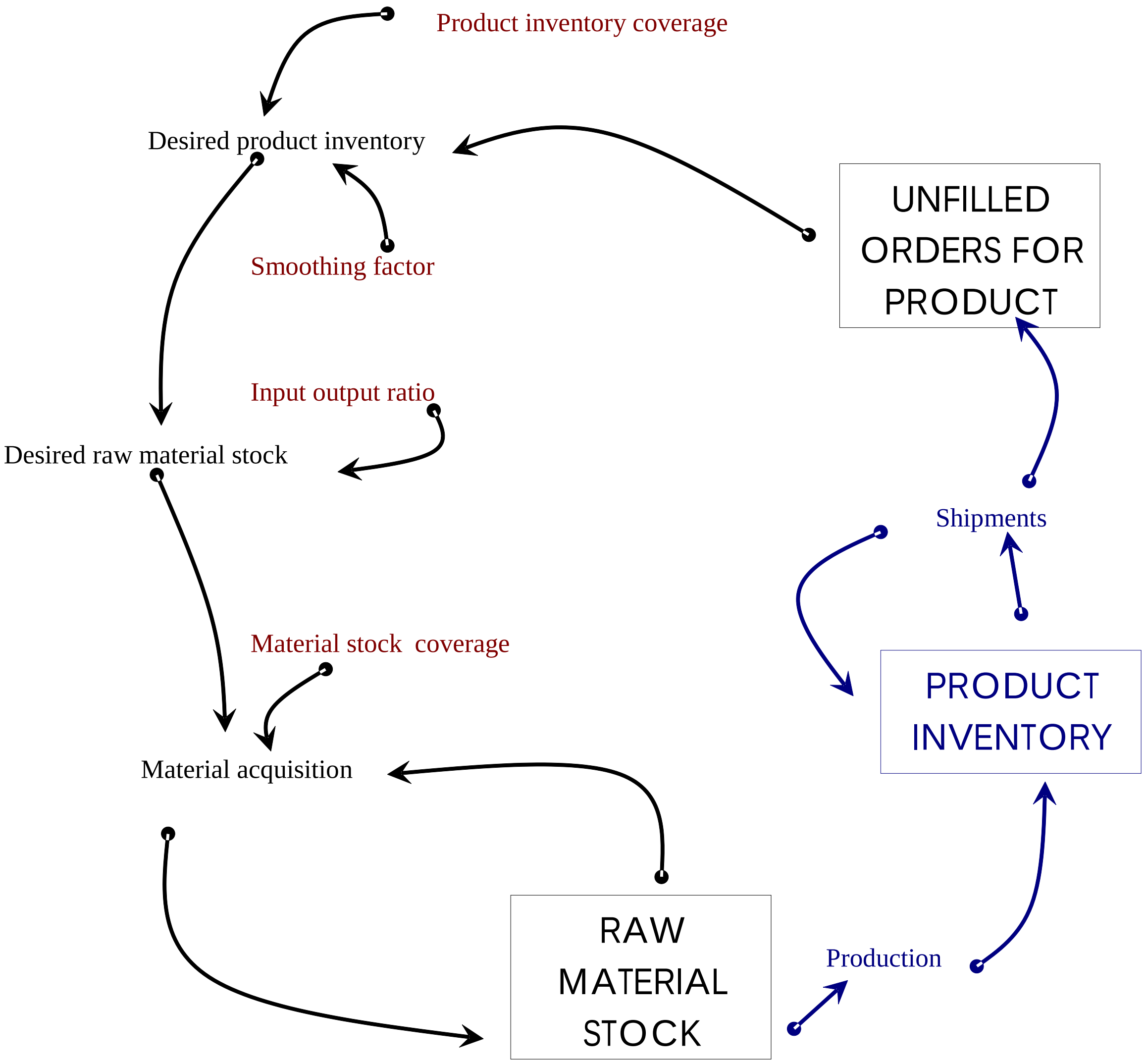


Figure 9: Product inventory to rate shipment

The only causal link in Figure 9 which requires explanation is that from level *Product inventory* to rate *Shipments*. The causal link from rate *Shipments* to level *Product inventory* is clear: shipments decrease inventory. But the level of inventory also influences the flow of shipments as an increase in inventory improves the coverage of unfilled orders by existing inventory and therefore allows more shipments.

Diagrams such as those shown on Figure 9 are called stock and flow diagrams. They are ways of representing the structure of a system emphasising the movement of people, material, money or information. Stock and flow diagrams are the most common first steps in building system dynamics models. Figures 4 and 5 are called causal loop diagrams. They are ways of representing the structure of a system emphasising causal relationships between the elements in the system. Causal loop diagrams are helpful, even if no simulation is conducted, in conceptualising structures and understanding dynamics.

On Figures 8 and 9 *Desired raw material stock* and *Desired product inventory* are auxiliary variables. *Time to adjust material stock, Material stock coverage, Smoothing factor* and *Product inventory coverage* are policy parameters while *Input output ratio* is a technical parameter.

Information delays. SMOOTH is a system dynamics keyword which refers to a built-in function comparable to a moving average. This function represents an information delay: information is cumulated and processed before a decision is made.

Figure 10 shows the function structure. A hidden level is created (*SMOOTHED QUANTITY*), the initial value of which is the first value of *Actual quantity*. The successive differences between *Actual quantity* and *SMOOTHED QUANTITY* divided by a *Smoothing factor* accumulate into the hidden level (the result of the smoothing operation).

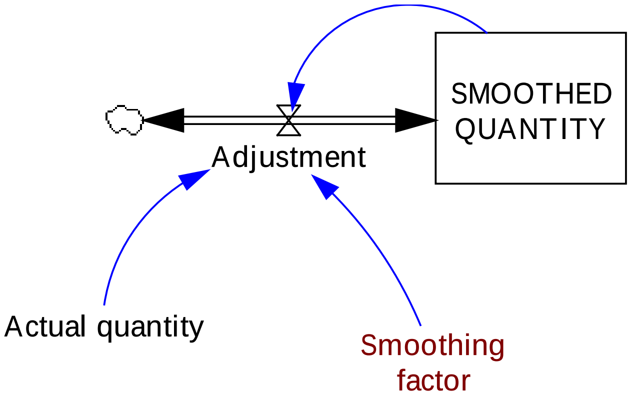


Figure 10: Function Structure

The smoothing factor is equivalent to the adjustment time of a material delay and can be compared to the number of periods used to smoothen a trend. The equations are:

SMOOTHED QUANTITY = INTEG (Adjustment, Actual quantity)

$$Adjustment = \frac{Actual\ Quantity - Smoothed\ Quantity}{Smoothing\ Factor}$$

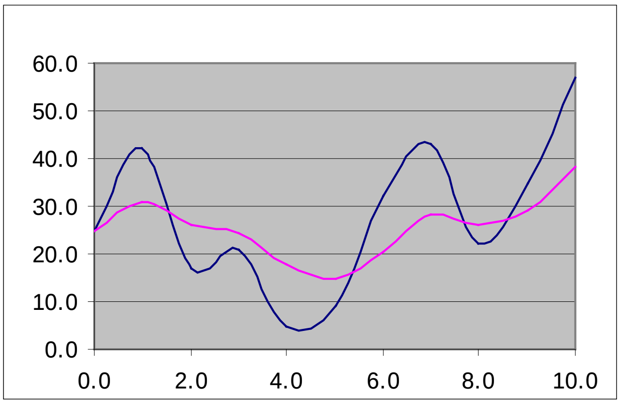
Smoothing factor = constant

If the actual quantity remains constant after a given step increase, the adjustment progressively reduces to reach zero. In such a case, the smoothed quantity becomes equal to the actual quantity after a period of time approximately equal to three times the smoothing factor (rule of thumb). If the actual quantity oscillates as in the example in Figure 11, the smoothed quantity also oscillates but with a lag and a reduced amplitude. The lag reflects the delay in obtaining information and the reduced amplitude, the process of eliminating random ups and downs in the actual quantity. Figure 11 illustrates the computation process.

NUMERICAL EXAMPLE:

The blue line on the graph is a.. hypothetical data series. Smoothed with a delay time of 3 periods, it produces the pink line. It is on the basis of the information carried by the pink line that decisions are made.

	DATA SERIES		
TIME	BLUE	PINK	GAP
0	25	25	0
1	42	30.7	5.7
2	17	26.1	-4.6
3	21	24.4	-1.7
4	5	17.9	-6.5
5	9	15	-3
6	32	20.6	5.7
7	43	28.1	7.5
8	22	26.1	-2
9	35	29	3
10	57	38.4	9.3



At time 0, PINK = BLUE = 25

At time 1, PINK = 25 + [(42 - 25)/3] = 30.7

At time 2, PINK = 30.7 + [(17 - 30.7)/3] = 26.1

At time 3, PINK = 26.1 + [(21 - 26.1)/3] = 24.4, etc

Figure 11: Hypothetical values of function structures.

Material delays. Function SMOOTH is used in many system dynamics models to represent information delay. Its material counterpart, also widely used, is the function DELAY1 which is used to represent material delays.

Function DELAY1 is illustrated in Figure 11. It pictures the fact that raw materials (here chicken excreta) must be collected and transported from poultry farms to processing centres. The delay between material requirement and material acquisition is graphically represented by a double-crossed arrow. This graphic symbol reflects the time required for waste collection and transport to factories. Desired raw material stock.

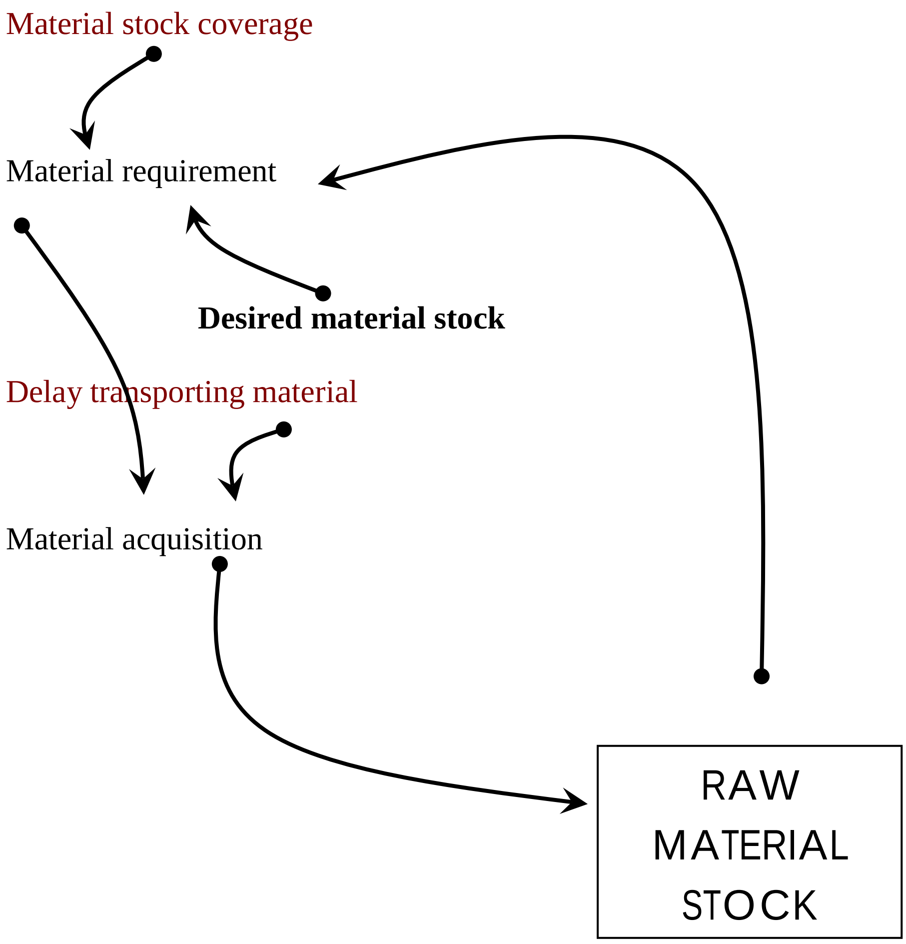


Fig 12: Material Acquisition

In a system dynamics model, the equation for *Material acquisition* would simply be written:

Material acquisition = DELAY1 (material requirement, delay transporting material)

Delay transporting material = constant

But the keyword, DELAY1, triggers a built-in procedure diagrammed in Figure 12.

The material delay creates a delayed flow by accumulating an input rate (in this case auxiliary variable *Material requirement*) into a hidden level which is drained over a given time period until its input is fully returned.

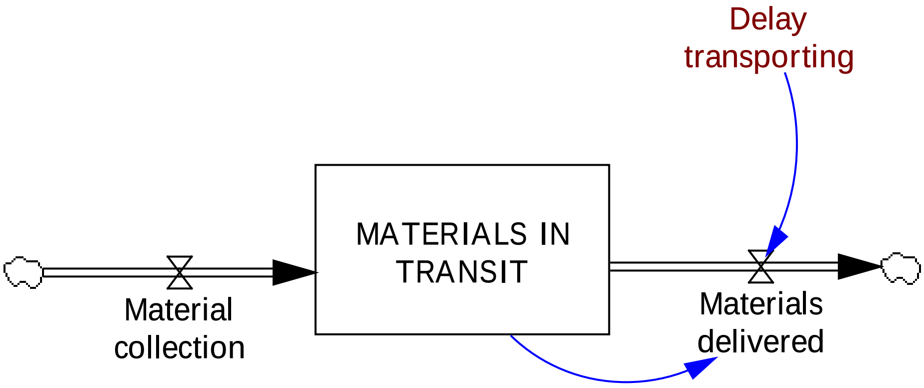


Fig 13: Materials in transit

The equations are:

MATERIALS IN TRANSIT = INTEG (Material collection – Materials delivered, Material collection * Delay transporting)

Materials delivered = MATERIALS IN TRANSIT / Delay transporting

Material collection = Material requirement

The major difference between information and material delays is that material delays return the totality of their input while information delays do not.(Figure 13)

Non-linear relationships. Another important element of structure commonly found in system dynamics models is the lookup or table function. Lookup or table functions are used to model non-linearity, a frequent occurrence in real-world dynamic systems.

Lookup functions may be regarded as an extension of a concept well known to economists, that of elasticity. For example, to analyse the impact of price on demand, economists use a measure of price elasticity. The price elasticity of demand is an important economic and ecological concept. It is the principal parameter through which exponential processes can be broken and sustainability created.

The price elasticity of demand is the ratio between the relative or percentage change in demand and the relative or percentage change in price:

$$\text{price elasticity of demand} = \frac{\frac{\Delta D}{D}}{\frac{\Delta P}{P}} = \frac{\%\ \text{change in demand}}{\%\ \text{change in price}}$$

Demand is price elastic when the absolute value of the ratio is 1 or greater than 1. This is the case of goods which can easily be substituted for. Demand is price inelastic when the absolute value of the ratio is less than 1. This is the case of basic goods which cannot easily be substituted for. A significant advantage of elastics is that they are independent of scale and units of measure. System dynamics extends the concept of elasticity by introducing a user-defined functional relationship (the lookup or table function):

% change in demand = lookup (% change in price)

Or, more generally:

% change in *Y* = lookup (% change in *X*)

Referring to Figure 14 and the relationship between profitability *(X*) and relative product price *(Y*), the following lookup function may be created:

Relative product price = lookup (profitability)

Note that both relative product price and profitability are already percentage changes and do not need to be normalised. Relative product price is the firm's product price relative to the price of competitors; profitability is the firm's profit relative to its turnover.

INDEPENDENT X PROFITABILITY	DEPENDENT Y RELATIVE PRICE
0.3	0.8
0.2	0.85
0.1	0.9
0	1
-0.1	1.15
-0.2	1.4
-0.3	1.7

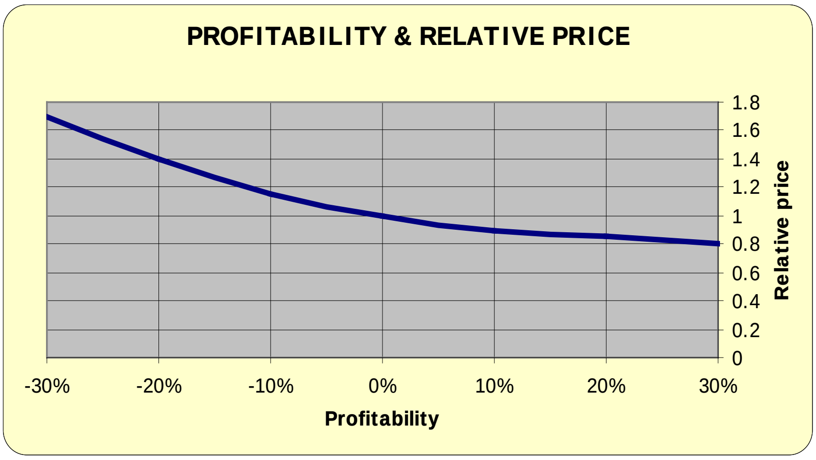


Fig 14: Relationship between profitability and relative price

Numerical values for the non-linear relationship are entered as shown on figure 15 and are based either on statistical data or on estimates or on both. The software calculates intermediate points by linear interpolation.

Step 4 in model construction: Model initialisation

This is the step just before model simulation. It is concerned with the initialisation of all levels and the definition and estimate of all relevant technical, behavioural and policy parameters. The model must include all relevant material and financial flows. It should also include the mechanism by which competition influences pricing and determines market shares. In this case, an additional level, PRODUCT PRICE, is introduced.

Step 5: Model simulation

Model simulations for each category of waste inputs and its associated output help determine which vectors of realistic parameters would lead to economic viability.

Model diagramming, coding and simulations are supported by VENSIM, the leading software support for system dynamics models.

2.4 Empirical Studies on Waste Management and System Dynamics

Alta and Deshazo (1996) disproved the conventional presumption that households give low priority to solid waste management compared to other urban services and are unwilling to pay for it. Using the bidding game format, they concluded that 82% of the households were interested in improved solid waste services and 80% were willing to pay. Out of those households who were interested in the service but were unwilling to pay anything for it, 84% said it was the responsibility of the government to give that kind of service. Out of the total households who said they were not interested in the service (18% of the total), 62% said that it was the government’s responsibility to collect and dispose of solid waste while 29% said that they were satisfied with the existing services. The OLS results showed that WTP for solid waste management in Gujarwala was positively and significantly correlated with disposable income, education and property, indicating that waste management is a normal economic good. The mean willingness-to-pay amount was found to be Rs. 9.80 per month, indicating a prospect for cost recovery.

A huge quantity of waste is generated from poultry operations. Unfortunately, the waste is dumped on vacant lands or into rivers. Shamsuddoha and Quaddus (2013) used a system dynamics approach in poultry operations to achieve additional benefits in the city of Chittagoing, Bangladesh. The poultry model, grounded in system dynamics was used to determine the interaction among factors in the system using a software package, Vensim. The result showed that poultry generates various kinds of waste such as litter, reject and broken eggs, intestines, waste feeds, feather and culled birds. Most of the farm owners do not utilise the waste for further by-product generation. Without profitability, farmers do not reuse their waste. System dynamics, along with simulations is a tool that can be used to forecast the feasibility of waste and by-products generation from waste.

Shamsuddoha, (2011) examined incorporating the reverse supply chain (RSC) in the poultry process in Bangladesh. The author made use of quantitative design science and case study methods. The outcome of the research shows how to achieve environmental sustainability using the reverse supply chain within the main stream poultry process. It is now feasible, through the model, to manage poultry waste by applying the RSC.

In Bangladesh, Klass *et al* (2011) worked on reducing environmental hazards through the RSC model using simul8, a simulation model of RSC developed for large poultry plants where various forms of poultry waste are modelled into various by-products. They used primary and secondary data to run the simulation model. The results show that poultry waste can indeed be processed into various by-products such as bakery products, biogas and artificial charcoal. These research results can be used to develop policies to reduce poultry-waste hazards and thus keep the environment safe.

Ahamad (2006) used a system dynamics modelling of a municipal solid waste management system in New Delhi, India. A system dynamics (SD) computer model has been used to predict the generation, collection, disposal, recycling and capacity for treatment of municipal solid waste (MSW), to estimate the electricity generated from MSW and to predict the fund required for MSW in New Delhi between 2006 and 2024. The projected result shows that the per capita generation rate will be 0.61kg/day and the compost product rate will be 342000 tons in 2024. The electrical energy generation potential from various MSW treatment methods will be 302275.3 MW and the projection revenue produced from different facilities will be 2068.6 million RS. Thus, the revenue can cover all the cost required for these facilities in 2024.

Adebayo (2012) examined the existing chicken excreta management and utilisation techniques in urban agriculture and its implication in Lagos, Nigeria. A table of random numbers was employed to determine the number of copies of the questionnaire that were administered in the study locations. The questionnaire consisted of both open and close ended questions that gave respondents the opportunity to express their views about integration of poultry waste management into urban agricultural activities. Qualitative information was obtained from key government officials through face-to-face interviews. A socio-economic survey was carried out to determine the relationship between economic characteristics of the farmers and poultry waste management while field experimentation and estimation were done to determine poultry waste production input and crop yield. The result revealed that poultry waste was poorly collected, packed and transported. Effective synthetic fertilizers and their prices were among other factors which determine poultry waste utilisation. Exotic vegetables require more poultry waste than indigenous ones and soil characteristics play a strong role in influencing poultry waste input and yield of vegetable crops. The result also showed that at $p>0.05$, there was significant differences among poultry waste utilisation, crop yield and revenue in the study area.

Moreki and Chiriposi (2011) examined chicken excreta management in Botswana. The people used the direct methods of disposing poultry waste in landfills, applying it as fertilizer in gardens or farms and burning manure or litter to raise the fertility status of the soil, which appears to be appropriate, since the soils in Botswana are generally poor in plant nutrients, especially phosphorus. Given the high feed costs in Botswana, the authors suggested that the use of poultry manure as livestock feed should be considered in areas where foot and mouth disease (FMD) was endemic.

Tao and Manel (2008) estimated daily manure production by a broiler and a laying hen to be 0.09kg and 0.18kg, respectively. Factors that influence manure production include type of chicken, age and breed, stocking density, feed conversion, kind and amount of feed, type and amount of litter, moisture content of litter, type of floor, and even climatic conditions during accumulation (Perkins *et al.,* 2006). On the other hand, factors affecting composition of litter or manure are type of birds, feed nutrient density, bedding materials and amount, time in use and other management factors (Ritz and Merka, 2009).

Ahmad (2012) used a system dynamics model to analyse the existing (2001-2006) and the proposed scenario (2006-2024) of municipal solid waste management systems (MSWMS) in Delhi. The result from this model showed that the generation of MSW in Delhi would increase from 2006-2024 with increased population at the annual rate of 4.28%. There would be an increase in the rate of MSW collected and recycled while MSW disposed of in landfill would decrease by up to 56.6% in 2024(of the MSW generated with an increase in the rate of MSW treated.

The per capita generation rate would be 0.61kg/day in 2024 and the compost production rate will be 342000 tons in 2024. The electrical energy generation potential from various MSW treatment methods would increase from 0 in 2001 to 58379.5 MWh in 2007 and 302275.3 MWh in 2024. The projection revenue produced from different facilities will increase from 0 in 2001 to 334.42 million Rs in 2007 and 2068.6 million Rs in 2024. This revenue would positively affect the budget required for MSW disposal and treatment facilities since it can cover the costs required for these facilities in 2024. In the final analysis the system dynamics can therefore be used to assess the benefit of recycling poultry waste and such study can be applied to Nigeria.

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Adebayo (2012) examined the existing chicken excreta management and utilisation techniques in urban agriculture and its implication in Lagos, Nigeria. A table of random numbers was employed to select respondent using simple random sampling technique. The questionnaire consisted of both open and close ended questions that gave respondents the opportunity to express their views about integration of chicken excreta management into urban agricultural activities. Qualitative information was obtained from face-to-face interviews of key government officials. A socio-economic survey was carried out to determine relationship between the economic characteristics of the farmers and chicken excreta management while field experimentation and estimation were done to determine poultry waste production input and crop yield.

The result revealed that chicken excreta poultry waste was poorly collected, packed and transported. Effective synthetic fertilizers and their prices were among other factors that determine poultry waste utilization. Exotic vegetables require more chicken excreta than indigenous ones and, soil characteristics play a strong role in influencing chicken excreta input and yield of vegetable crops. The result also showed that at $p>0.05$, there was significant differences among poultry waste utilization, crop yield and revenue in the study area.

Total environmental concern was heightened for issues related to pollution control, extinction and the wise use of natural resources, while the students perception of the government's ability to prevent or control environmental problems significantly diminished. These results are consistent with those presented by Benton (1993) who found that concerns for pollution related issue substantially increase in college-aged business major (MBA) following 10 weeks of environmental management course.

Similarly, Smith-Sebasto (1995) found that an environmental studies course could promoted environmentally responsible behaviours and an increased perception of their personal environmental knowledge. This is supported by significant increases in the post test responses to ECS questions, which indicated students would be willing to accept $100/year increase in family expenses, if they promoted the wise use of natural resources.

A relationship between a student's self-reported grade point average (GPA) and total environmental concern was also identified. Those student's with a GPA, or below 2.0 had a decrease total environmental concern following the class, whereas students with GPA of 3.5 or higher showed significant increase in regarding environmental concern.

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2.5. Commercial Poultry Production Systems in Nigeria

Poultry farming is the practice of raising domesticated birds such as chickens, turkeys, ducks, and geese, as a subcategory of animal husbandry, for the purpose of producing meat or eggs for food. Virtually all Nigerian commercial poultry farms are devoted to rearing chickens and most of them rear layers. Recently, however, a few ostrich farms have emerged in the north of the country while other species reared include guinea fowls, pigeons, ducks and turkeys, almost exclusively reared in backyards and in the traditional sector. In addition, a few geese and peacocks are reared as ornamental birds (Paolo *et al.,* 2008).

FAO (2004) classified commercial poultry into three sectors: industrial commercial farms (sector 1), large commercial farms (sector 2) and small commercial farms (sector 3). Industrial commercial farms (sector 1) are those with very high production capacity, up to 250,000 birds and very high processing technology. They are few and are mainly found in southern Nigeria. Sector 1 farms constitute a significant share of the poultry sub-sector in the country. They form the apex of Nigeria's livestock sub-sector, supplying mainly poultry inputs (day old chicks) to large commercial farms (sector 2), as well as providing various services such as equipment hire. The sector is well organised, with each of the (industrial) integrated farms having its own feed mill and a significant staff strength covering areas such as farm administration, health and safety, veterinary control, quality control and quality assurance, engineering, stock control and marketing. Such an organisational structure can also be found in large commercial farms.

Large commercial farms of operation capacity within 5,000 and 100,000 birds dominate the medium-scale sector. Many farms with lower production capacities are widely spread in Lagos, Osun, Ogun, Oyo, Ekiti, Ondo, Delta, Edo, eastern states and the northern states. However, the primary economic objective of many large commercial farmers is the production of eggs and rearing of day old chicks to table birds to meet substantial demands from many corporate firms in the food processing industry.

Small commercial poultry farms with a flock size ranging from 1000-4999 birds are unevenly located across the six geopolitical zones in Nigeria. Available evidence reveals that many of these farms grew from the backyard production scale. Therefore, such a scale of production represents the intermediate level between free-range non-commercial farms and the integrated commercial farms in the country. This sector focuses primarily on egg production, with some farmers also simultaneously engaged in broiler meat production. The majority of small scale farms are located in the southern part of Nigeria. Available data also show that most of these small scale farms are located in Lagos and Ogun state and surrounding areas. This could be due to the fact that Lagos and Ogun states are the major entry points into Nigeria for imported poultry inputs such as vaccines and drugs. In addition, the market for poultry products (especially eggs) in Lagos and other southern States is huge.

Gaseous, liquid and solid waste, usually called ‘emissions’, are the unavoidable and “unfortunate” consequences of human activities. If chicken excreta is not properly dealt with, it can cause tremendous damage to consumers, farm, residents and the nation at large since most poultry waste have externality effects.

2.6. Recycling Organic Waste in Southwestern Nigeria

In Nigeria, it is estimated that waste is generated at the rate of 0.43kg/head per day and that 60% to 80% of such waste is organic waste (Sridhar, 2006; Ogwueleke, 2009). Markets in Nigeria generate such biodegradable waste as corn cobs, vegetable waste and packaging materials. The foregoing suggests that generating enough waste for recycling plants should not be a problem in urban centres in Nigeria, provided access to waste and collection is guaranteed.

Attempts at converting waste to wealth have been made in southwestern Nigeria through projects initiated by the University of Ibadan. This resulted in the design and fabrication of recycling machines for biodegradable and non-biodegradable waste. Made entirely from locally sourced materials, the machines were deployed in different parts of southwestern Nigeria.

In 1998, a 10 - ton - daily - capacity, pace- setter organo - mineral fertilizer plant was designed, built and deployed at Bodija Market, Ibadan. In 2002, another plant of half the capacity of the first was built for Ayeye Community, Ibadan. In Orita - Aperin, also in Ibadan, a 10 - ton per day capacity plant, designed and built for the Oyo State Government, was installed. A plastic recycling plant and a scrap - metal plant were also installed in the same location. A 5 - ton per day organic fertilizer plant was also installed at the Aleshinloye market; it is currently owned and managed by the Traders' Association (Sridhar and Hammeed 2014). Similar plants exist in Ogun and Ondo states.

Poultry meat and eggs provide affordable, quality food products that are consumed by most ethnic populations worldwide. Advances in knowledge and technology over recent decades favour the growth and intensification of poultry production in developing countries where there are increasing human populations and economic constraints. Issues related to the environment, human health and the quality of life for people living near to and far from poultry production operations make waste management a critical consideration for the long-term growth and sustainability of poultry production in larger bird facilities located near urban and peri-urban areas, as well as for smaller commercial systems associated with live bird markets, and for village and backyard flocks located in rural areas. These foregoing primarily has to do with medium-sized to large, intensive poultry production units, but many of the principles apply to smaller operations, including small, family scavenging flocks. Fundamental knowledge of the environmental and health issues associated with poultry waste management will serve both small and large poultry producers now and in the future, as the intensification of poultry production continues to gain favour globally.

This study is conceptualised as shown in figure 15; the rapid growth in population will lead to demand for more chicken meat and eggs .This will continue because of the acceptability of poultry products that cut across all barriers of tribal and religious inclinations. As the number of chicken farms increases, more chicken excreta is generated and this has adverse environmental effects if not properly disposed of. The willingness to pay for its disposal becomes an issue.

The chicken excreta generated can be used for the production of organic fertilizers, using system dynamics. The waste can be collected from farmers that are willing to pay for disposal of waste or from farmers willing to sell their chicken excreta to organic fertilizer plants. Some of it can be used by other users. However, using the system dynamics approach to ascertain the feasibility of converting chicken excreta to organic fertilizers resulted in profit generation, more investments and employment creation and shows that recycling chicken excreta to produce organic fertilizer is feasible, environmental-friendly and sustainable. Besides, organic fertilizers are better alternatives to inorganic fertilizers.

CONCEPTUAL FRAMEWORK

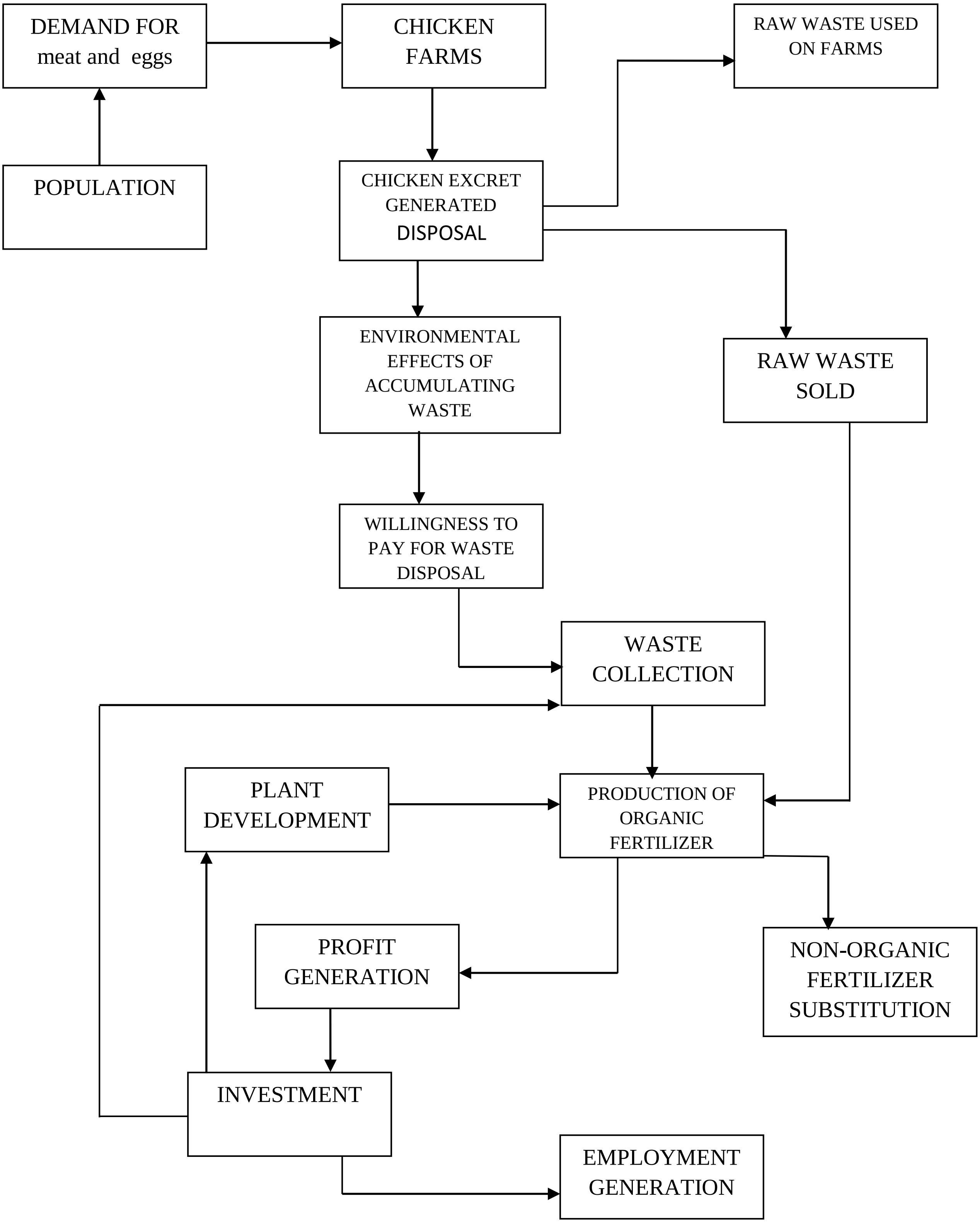


Fig 15: Conceptual Framework

***Source:* Author (2015)**

CHAPTER THREE

METHODOLOGY

3.1 Study Area

The study was carried out in southwestern Nigeria, which comprises Oyo, Ogun, Osun, Ekiti, Ondo and Lagos states. (Figure16). It is one of the six geo-political zones in Nigeria and falls on latitude 6^0 North and latitude 4^0 South and is marked by longitude 4^0 (to the) West and 6^0 (to the) East. It is bounded in the north by Kogi and Kwara states, in the east by Edo and Delta states, in the south by the Atlantic Ocean and in the west by the Republic of Benin. The zone is characterised by a tropical climate with a distinct dry season between November and March and a wet season between April and October. The mean annual rainfall is 1480mm while the mean monthly temperature ranges between 18^0C and 24^0C during the rainy season and 30^0C and 35^0Cduring the dry season. The zone covers an area of about 114,271 km^2 and has a population of 27,581,992, which is predominantly agrarian. Major food crops grown in the area include cassava, cowpea and yam (NPC, 2006). The people are predominantly farmers as well as lovers of education and they are also given to hospitality. According to Adene and Oguntade (2006), most commercial poultry farms with moderate to high bio-security systems are located in southwestern Nigeria, especially in the states nearer to Lagos, the industrial capital of Nigeria. It is estimated that over 65% of Nigeria's commercial poultry farms are located in Lagos, Ogun, Oyo, Osun and Ondo states while another 25% are located in the south-south and south-east geo-political zones. The balance of 10% or less of Nigeria's commercial poultry farms are in the north-central, north-west and north-east zones (Adene and Oguntade, 2006).

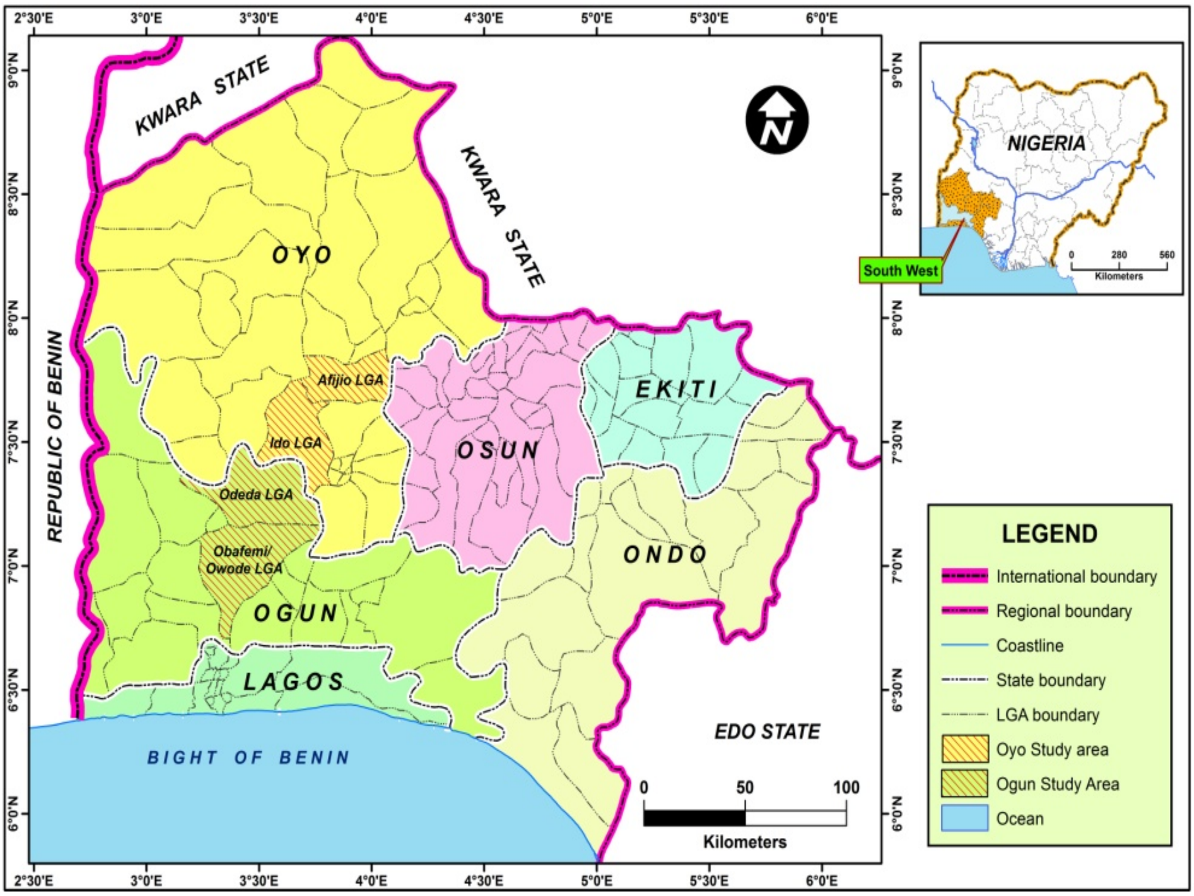


Fig 16: Map of southwestern Nigeria indicating sampled states. Inset Map of Nigeria indicating location of southwestern Nigeria.

Source: Dept. of Geography, University of Ibadan (2015)

Ogun and Oyo states were purposively selected for the study. Ogun State (Fig. 17) has a land area of 16,409.26 km^2 and is bounded in the west by Lagos State and the Atlantic Ocean, in the east by Ondo State and in the north by Oyo and Osun states. It is situated between latitude 6.2º N and 7.8º N and longitude 3ºE and 5ºE. The state has 20 local government areas (LGAs), with an estimated population of 3.7 million (NPC, 2006).

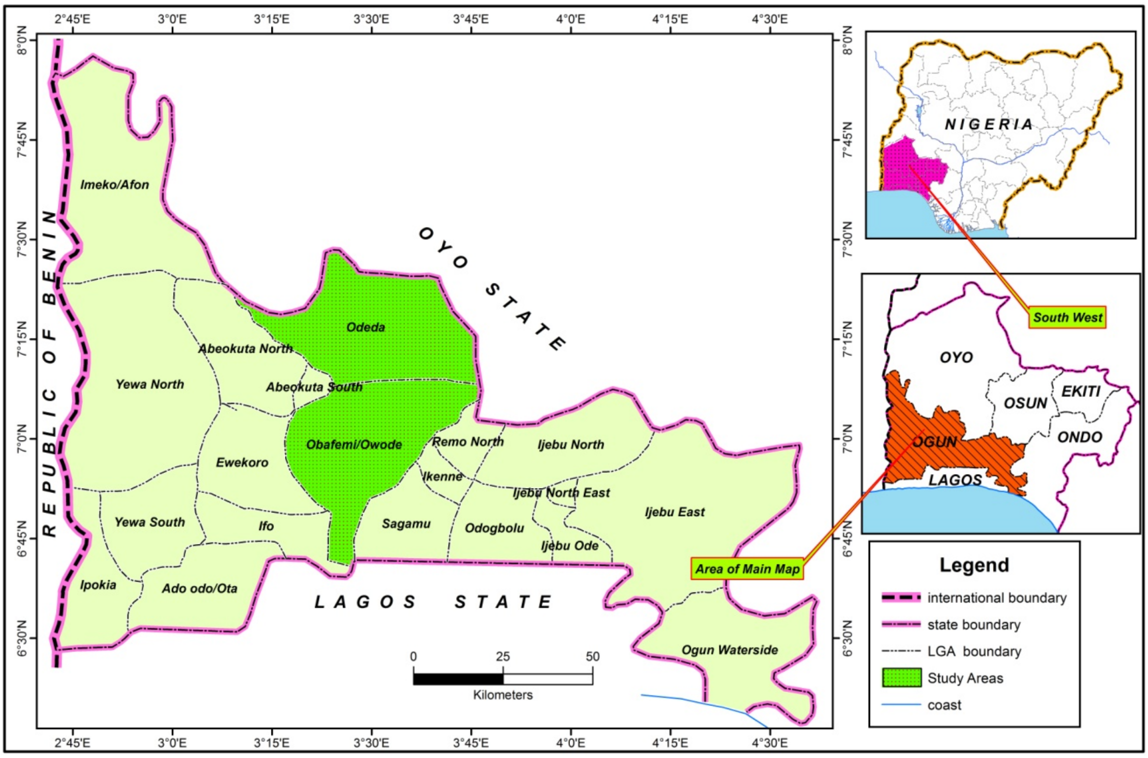


Fig 17: Map of Ogun state indicating sampled Local Government Areas (LGAs) and inset map of Nigeria indicating the Southwest and inset, indicating location of Ogun State.

Source: Dept. of Geography University of Ibadan (2015)

Oyo State has 33 local government areas with an estimated population of 5.6million (NPC,2006) and a land area of 35,743 km^2 it is located within latitude 3º N and 5ºN and longititude 7º E and 9.3º E (Figure 18). It is bounded in the south by Ogun State, in the North by Kwara State, in the west, partly by Ogun State and partly by the Republic of Benin, and in the east by Osun State. Agriculture is a dominant economic activity and the main source of employment in the region .The people are predominantly farmers; most of the women engage in food processing and trading. Large commercial livestock farms operate on intensive and semi-intensive scales while small-holder farms rear animals on the extensive system as backyard practices.

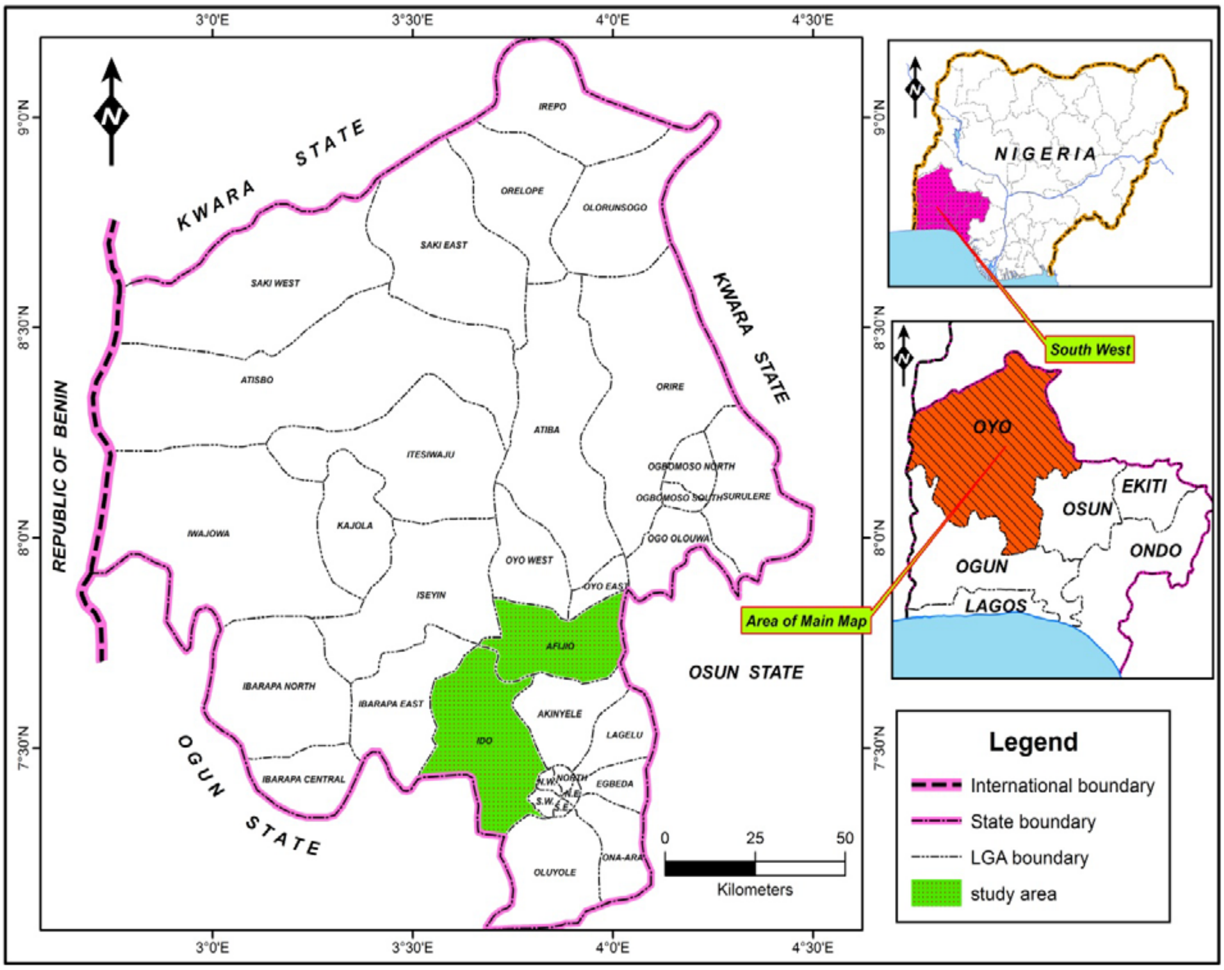


Fig 18: Map of Oyo State indicating sampled Local Government Areas (LGAs); Inset: Map of Nigeria indicating the southwest.

Source: Dept. of Geography University of Ibadan (2015)

3.2: Sampling Technique, Sample Size and Sources of Data

Primary and secondary data were used for this study. Oyo and Ogun states were purposively selected based on the fact that poultry business is very popular among the farmers of the states and there is a ready market for poultry products. Available records (PAN Lagos, 2003) show that Ogun State has the highest number of poultry farms while both Oyo and Ogun states, have the highest numbers of chicken farms per household in Nigeria (Adene,2006). The sample was obtained using a multistage sampling technique. In the first stage, two states, Oyo and Ogun were selected. In the second stage, four local government areas were purposively selected from the two states: Afijio and Iddo in Oyo state and Odeda and Obafemi Owode in Ogun State. This was due to the high concentration of poultry farms in these local government areas. The third stage involved the random selection of poultry farmers in each of the selected LGAs, proportionate to the number of poultry farms in each state. Based on this, 68 farmers were sampled in Oyo, and 80 in Ogun States. Residents around the selected farms were also sampled for the study. A total of 73 residents were randomly selected from the two states.

Two structured questionnaires were administered: one on the farmers and the other on residents around the farms. The questionnaire administered on the farmers sought for data on their socio-economic and demographic characteristics, chicken excreta disposal methods and willingness to pay (WTP) for chicken excreta disposal. The questionnaire administered on the residents was to elicit data on their socio-economic characteristics and the perceived environmental effects of chicken excreta among others.

3.3: Methods of Data Analysis.

3.3.1 Descriptive statistics

Descriptive statistics, involving frequency distribution tables mean and standard deviation, were used to analyse the socio-economic characteristics of the respondents, techniques of poultry waste disposal and types of waste generated by poultry farmers in southwestern.

3.3.2 Ordered-Probit Regression for Environmental Effects (EE) of chicken excreta.

A widely used approach in estimating models of this type is an ordered response model, which almost always employs the probit link function. This model is thus often referred to as the ‘‘ordered probit’’ model. Like many models for qualitative dependent variables, this model has its origin in bio-statistics (Aitchison and Silvey, 1957) but was brought into the social sciences by two political scientists, McKelvey and Zavoina (1975).

The ordered probit model is widely used (approach) in estimating models of ordered types. There is a latent continuous matrix underlying the ordinal responses observed by the analyst. The latent continuous variable Y, is a linear combination of some predictors, x, plus a disturbance term that has a standard normal distribution (equation 32).

$$Yt \quad = \quad Xi\,B + e \text{ ……………………. ....(32)}$$

In equation 33, the latent variable, *Yi* exhibits itself in ordinal categories, which could be coded as *0,1,2 ……k.* The response of category *k* is thus observed when the underlying

continuous response falls in the *k-th* interval as $Y^* = 0$ *if* $Y^* \leq \delta o$ $Y^* = 1$ *if* $\delta o \leq Y * \delta 1$ $Y^* = 2$ *if* $\delta 1 \leq Y * \delta 2$ ……………………………………………… ……….............… (33)
where Y^* $(i = 0, 1, 2)$ are the unobservable threshold parameters that will be estimated together with other parameters in the model. When an intercept coefficient is included in the model, Y^*iB is normalised to a zero value (Green, 2000) and hence, only *k-1* additional parameters are estimated with *Xs.* Like the models for binary data, the probabilities for each of the observed ordinal responses (which in this study had 3 responses 0,1,2) will be given as presented in equation 34
$Prob\ (Y = 0) = P\ (Y^* = 0) = P(BiXi + ei = 0) = Ø(Bixi)$ $Prob\ (Y = 1) = Ø(\delta i - BiXi) - Ø\ (BiXi)$ $Prob\ (Y = 2) = 1 - Ø\ (\delta i - BiX)$…………………...…(34)
where, $0 < Y^*i < Y^*i < Y^*i = 1,2 \ldots\ldots\ldots n$ is the cumulative normal distribution function such that the sum total of the above probabilities is equal to 1.

Among the most common methods employed to elicit environmental concerns according to the Organization for Economic Co-operation and Development (OECD) (2008) and adopted in this study, is the direct elicitation of environmental concerns with single questions/statements usually based on the Likert Scale.

Dunlap and Beus (1992) determined the principal components of the overall attitude towards pesticides and found three factors: necessity of pesticide use (the “positive” attitude), safety of pesticide use (health and environmental concerns), and trust in the food industry, and correlated these factors with demographic variables using a Probit regression. In the same vein, environmental effects of chicken excreta such as odour, air pollution, water pollution, soil pollution and infectious diseases are identified as components and built into the Likert Scale to generate individual scores of poultry farmers and residents around the farm for their perceived effect of chicken excreta on the environment. An index of environmental effects was determined using the relationship in equation 35:

Strongly Agree (SA) = 5; Agree (A) =4; Undecided (UD) =3; Disagree (D) =2;
Strongly Disagree (SD) = 1

Table 5: Environmental Effects of chicken excreta

Perceived effect of chicken excreta disposal.	**SA**	**A**	**UD**	**D**	**SD**
Disposal of chicken excreta results in offensive odour in and around your farm					
Disposal of chicken excreta results in water pollution in and around your farm					
Infectious diseases outbreak from poor chicken disposal					
Air pollution results from poor chicken excreta disposal					
Poor chicken excreta disposal causes soil pollution.					

Source: Author's compilation, 2015

The total score from the Likert Scale was used to compute an index of respondents perception of environmental effects which was determined using the following relationship:

*HS - LS/no of EEC…………………………………………………………………(*35)

where: *HS* = Highest Score generated from the Likert scale

LS =Lowest Score generated from the Likert scale

EEC =Environmental Effect Category, which, in this study was divided into 5 sub-categories:

Severely Affected = 4

Highly Affected = 3

Moderately Affected = 2

Slightly Affected = 1

Least Affected = 0

The total score obtained for Oyo and Ogun respondents ranged between 0 and 25.The lowest and highest score obtainable are 0 and 25 for the respondent who do not score at all and those that gave the highest score of 5 for the five questions on the Likert Scale.

The Ordered Probit Model is built on a latent variable with the formulation in equation 36 for poultry farmers:

$$EE^* = X_i\beta + \varepsilon_i \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots(36)$$

where

EE = Environmental Effect

β = a vector of coefficients

X_i = vector of Independent Variables

$$EE = \beta_0 + \beta_1 Y + \beta_2 SR + \beta_3 AR + \beta_4 YER + \beta_5 MSR + \beta_6 QW + \beta_7 FE + \beta_8 HHZ + \varepsilon_i \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots(37)$$

where

Y = Income of the respondent

SR = Sex of the respondent

AR = Age of the respondent

YER = Education of the respondent

MSR = Marital status of the respondent

QW = Quantity of waste generated

FE = Farming experience

HHZ = Household size

$\beta 1 - \beta 8$ = are coefficients to be estimated and b0 is intercept or constant and

ε_i = error term

Definition of Variables and A priori Expectation

The environmental effects of chicken excreta are expected to be influenced by various factors. Some of these factors, with their expected signs, are defined as follows and summarised in Table 5.

Income (Y): This variable refers to the monthly monetary income of the household and includes the income from all sources of all the members of the household. There is a general agreement in the literature on environmental economics on the positive relationship between income and environmental effects. Therefore, we expect income to have a positive relationship with the effect of environment.

SR (Sex of Respondents is a dummy variable taking 1, if the respondent is male and 0, if otherwise. This study expects female respondents to be more conscious of the perceived effect of chicken excreta than men, since traditionally, it is the role of women to clean the house and dispose of waste.

AR (Age of Respondent) refers to the age of the respondent and is expected to affect perception of respondents on environmental effect because old people may consider waste collection as government’s responsibility and could be less willing to pay for it while the younger generation might be more familiar with the cost sharing that is involved in education, health, *etc* and could be more willing to pay.

Years of Education of Respondent (YER): This variable is meant to capture the level of understanding of the respondents about the desirability of proper management of chicken excreta. It is hypothesised that the higher the level of education, the more the respondent would understand the consequences of mishandling poultry waste and the more the value the individual would place on avoiding the risks posed by an unclean environment.

Marital Status of Respondent (MSR): Whether the respondent is currently single or not is expected to influence the value the individual places on the proposed change. MSR is a dummy variable, taking 1, if the respondent is married and 0, if otherwise;

it is expected to have a positive sign .A married person is likely to be more concerned in respect of efforts to keep the environment clean than a single person , because of his or her family, the married person faces higher risks than the unmarried one.

Quantity of Waste Generated (QW): This variable stands for the quantity of chicken excreta the farmer generates within a week. The unit of measurement used is a 50 kg fertilizer bag, which was commonly used by almost all respondents during the survey. The study hypothesised that environmental effect is positively related to the quantity of chicken excreta generated, since the more the quantity of waste generated, the more the problem chicken farmers face in keeping the waste for collection and the higher the hazards.

Household Size (HHs): To examine whether the number of family members has impact on an willingness to pay. The study expects that the higher the number of family members the more willing the family to pay for chicken excreta. This is because the members with large family, most especially children are likely to be more willing than family with small number .they are likely to be more conscious of out-break of diseases.

Farming Experience (FE): This refers to the number of years the chicken farmer has been in the business. The higher the number of years in the chicken business the more he would be willing to pay for chicken waste disposal, since he realises the consequences of chicken waste disposal on both the chickens and the environment.

Table: 6 A priori expectation for environmental effect of chicken excreta .

VARIABLE	**SIGN**	**LITERATURE**
AGE	+	Yusuf *et al*., 2007 ; Ekere *et al*., 2010), Bonya *et al*., 2011 ; Amiya 2002
SEX	+ (-)	Ekere *et al*., 2010, Adepoju and salimonu
MARITAL STATUS	+ (-)	
ANNUAL INCOME	+	Massito 2009, Rahji and Oloruntoba 2009; Khattack *et al* 2009, Ekere *et al* 2010, Banga et al, *2011*, Mahanta and Das *2011*, Amiya 2002.
FARMING EXPERIENCE	+ (_)	
WASTE GENERATED	+	Ekere *et al*., 2010, Amiya 2002
HOUSEHOLD SIZE	+ (-)	Yusuf *et al*., 2007; Massito 2009.
EDUCATION	+ (-)	Yusuf *et al*., 2007, Rahji and Oloruntoba 2009, Khattak *et al* 2009, Banga *et al* 2011, Amiya 2002

Sources: Author's compilation,2015

3.3.3 Determinants of Willingness to Pay (WTP) for Chicken Waste Management in Southwest

The Probit model was used to identify factors responsible for willingness to pay for improved management services. The model is used to identify factors that influence a household's willingness to pay decision. The dependent variable in this model was given a value of 1, if the poultry farmer gave a positive willingness-to-pay response for the suggested improvement and 0, if otherwise.

The Probit Model was built on a latent variable with the formulation in equation 38:

$$WTP^* = X_i\beta + \varepsilon_i \text{ . } \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots(38)$$

where

β = a vector of coefficients

X_i = vector of Independent Variables

Therefore, based on equation 39, the Probit model will be:

$$WTP = \beta_0 + \beta_1 YPF + \beta_2 SR + \beta_3 AR + \beta_4 ER + \beta_5 MSR + \beta_6 QW + \beta_7 FE + \beta_8 HHZ + \varepsilon_i \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots(39)$$

where $\beta 1 - \beta 8$ = Coefficients and ε_i = error term

YPF = Income of poultry farmers (Respondent)

SR = Sex of respondent

AR = Age of respondent

ER = Education of respondent

MSR = Marital status of respondent

QW = Quantity of waste generated

FE = Farming experience

HHZ = Household size

Definition of Variables and Apriori Expectation.

Improved chicken excreta management is expected to be affected by various factors. Some of these factors, with their expected signs, are defined as follows and summarised in table 7.

YPF (Income of the chicken farmers): This variable refers to the monthly monetary income of the household and includes the income of the head and all other members of the household from all sources. There is a general agreement in the literature on environmental economics on the positive relationship between income and demand for improvement in environmental quality. Therefore, it is expected that income will positively and significantly affect willingness to pay and the amount pay.

SR (Sex of Respondents): This is a dummy variable taking 1, if the respondent is male and 0, if otherwise. Female respondents are expected to be more willing to pay than male respondents, since traditionally, it is the role of women to clean the house and dispose of waste.

AR (Age of Respondents) refers to the age of the respondent and it is expected to affect willingness to pay. This is because old people may consider waste collection as government's responsibility and could be less willing to pay for it while the younger generation might be more familiar with cost sharing as in the case of education, health, etc and could be more willing to pay.

ER (Education of Respondent): This variable was meant to capture the level of understanding of the respondent about the desirability of proper management of poultry waste. It was hypothesised that the higher the level of education the more the respondent would understand the consequences of mishandling poultry waste and the more the value the individual would place on willingness to pay. Education is expected to have a positive and significant effect, with higher levels having higher effects on willingness to pay and the amount.

MSR (Marital Status of Respondent): Whether the respondent is currently single or not is expected to influence the value the individual places on the proposed change. MSR is a dummy variable taking 1, if the respondent is married and 0, if otherwise; it is expected to have a positive sign. Married people are likely to be more responsible in respect of efforts to keep the environment clean than single ones because married respondents are likely to have larger family sizes and hence face higher risks than those not married.

QW (Quantity of Waste Generated)-This variable stands for the quantity of waste the poultry farmer generates within a week. The unit of measurement used is a 50kg fertilizer bag, which was commonly used by almost all respondents during the survey. The study hypothesises that willingness to pay is positively related to the quantity of poultry waste generated, since the more the quantity of waste generated, the more the problem chicken farmers face in keeping the waste for collection. They will, therefore, be willing to pay more.

SRH (Status of Respondent in the Household): This variable is included to examine whether interviewing the household head rather than his or her representative has an impact on willingness to pay. It takes 1, if the respondent is the head of the household and 0, if otherwise. The study expects heads to be more willing than their representatives since the latter might not be courageous enough to offer a price on behalf of the head.

TABLE 7: A priori expectation for willingness to pay for chicken excreta disposal

VARABLES	**SIGN**	**LITERATURES**
AGE	+/-	Yusuf *et al*., 2007, Ekere *et al*., 2010, Bonya et al., 2011, Amiya 2002
SEX	+/-	Ekere *et al*., 2010, Adepoju and salimonu
MARITAL STATUS	+/-	
ANNUAL INCOME	+	Massito 2009, Rahji and Oloruntoba 2009, Khattack *et al* 2009, Ekere *et al* 2010, Banga *et al*,2011, Mahanta and Das 2011, Amiya 2002.
FARMING EXPERIENCE		
WASTE GENERATED	+	Ekere *et al*., 2010, Amiya 2002
HOUSEHOLD SIZE	+	Yusuf *et al*., 2007, Massito 2009.
EDUCATION	+	Yusuf *et al*., 2007, Rahji and Oloruntoba 2009, Khattak *et al* 2009, Banga *et al* 2011, Amiya 2002

Sources : Author's compilation 2015

3.3.4 Predicting the viability of using chicken excreta in organic fertilizer production, using the system dynamics approach.

The study investigated whether chicken excreta is generated in sufficient quantities to make downstream industries profitable and if so, what extent can it be recycled to reduce its adverse effects and cost of disposal and create business opportunities.

The fertilizer plant model was built to investigate the profitability of producing organic fertilizer from chicken excreta in an economically sustainable context characterised by the coexistence of some chicken farmers willing to pay for waste disposal and others willing to sell theirs or use it as farm input. The simulated fertilizer plant is assumed to first process inputs collected from farmers who are willing to pay for waste disposal. If required, the plant then pays to source additional inputs from farmers selling their chicken excreta.

The model, a weekly model simulated over a period of 5 years (260 weeks), includes *159 equations, 15 levels and 66 numerical assumptions* and is made up of seven inter-connected modules (i) waste collection and composting; (Fig.19) (ii) compost processing, (Fig.20) (iii) factory labour (Fig.21) (iv) electricity cost (Fig.22) (v) sales; (Fig.23) (vi) cumulative costs (Fig.24) and (vii) cash balance and sales budget (Fig 25).

The first module, waste collection and composting, shows waste collection and the process by which poultry waste is turned into dry compost, beginning at the *first week in season* and ending at the *last week in season*. The model operates on the basis of 52 weeks of 7 days in a year. If one assumes that the rainy season begins in April and ends in October, *first week in season* is set at 13 or 14 and *last week in season* at 41 or 42. As the model simulates over 5 years, the week when the season starts and the week when the season ends are calculated for each year. This is the purpose of the variables *Start week, End week* and *Sales season* (equations 120, 45 and 115 respectively)

3.4 Modelling chicken excreta utilisation using System Dynamics

The fertilizer plant model was built to investigate the profitability of producing organic fertilizer from chicken excreta in an economic context characterized by the coexistence of some poultry farmers willing to pay for waste disposal and others willing to sell their poultry waste or use it as farm input. The simulated fertilizer plant is assumed to first process inputs collected from farmers willing to pay for waste disposal. If required, the plant then pays to source additional inputs from farmers selling their poultry waste.

The model is a weekly model simulated over a period of 5 years (260 weeks) and includes 159 equations, 15 levels and 66 numerical assumptions. It is made up of seven inter-connected modules: 1. waste collection and composting (Fig 19), 2. compost processing, (Fig 20) 3. factory labour, (Fig 21), 4 electricity cost (Fig 22), 5 sales (Fig 23), 6 cumulative costs (Fig 24), and 7 cash balance and sales budget (Fig 25).

The first module, waste collection and composting, shows waste collection and the process by which chicken excreta is turned into dry compost.

Note that level RAW WASTE and level COMPOST are not connected by a single rate. This is because a transformation occurs in the composting process. What empties level RAW WASTE is not the same material as what fills level COMPOST. What empties level RAW WASTE is waste, what fills level COMPOST is wet compost. A major difference between the two levels is their weight. There are eight parameters driving this module (in red on the diagram). Initial values of levels are in green and shadow variables (variables originating from other modules) are enclosed in < >. Parameters in red and green require data input. These are supplied by the data obtained from the survey previously presented. Each model variable and parameter has a unit. Unit coherence is an essential requirement of system dynamics models. The relationships between the various components of raw waste is also represented in equation 40.

Model structure equations and assumptions

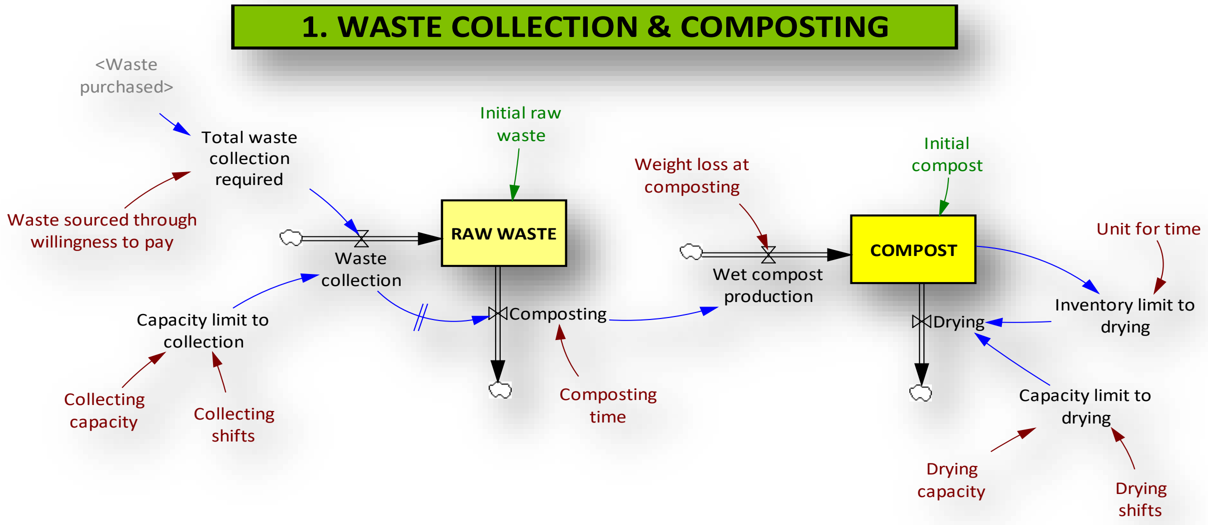


Figure 19: Waste Collection and Composting

RW$_t$ = $\int_0^T (WC - Com + Rw)$.......................................(40)

Where;

WC = Min (TWCrq + CL p)

Com = WC$_{t-k}$

Where k = compositing time

Therefore:

RW = $\int_0^T [Min(TWCrq + CLC) - (WC_{t-k}) + RW_0]$..................

.(41)

But, TWCrq = WSTWTP + WP where;

RW = Raw Waste

WC = Waste Collection

COM = Composting

TWCrg = Total Waste Collection required

WSTWTP = Waste Sourced Through Willingness to Pay

WP = Willingness to pay

CLC = Capacity Limit to Collection

CLp = Waste Collection possible

The second module, compost processing (Fig20), breaks down the fabrication of fertilizer from compost treatment to bagging. Each step, from waste collection to shipment of fertilizer bags, has its own capacity constraint. (Equation 41).

Constant *unit for time*, by definition equals 1 and with the time dimension, *week*, is used to transform a level (no time dimension) into a rate (time dimension) in the case when a level fully empties in the course of a single time period.

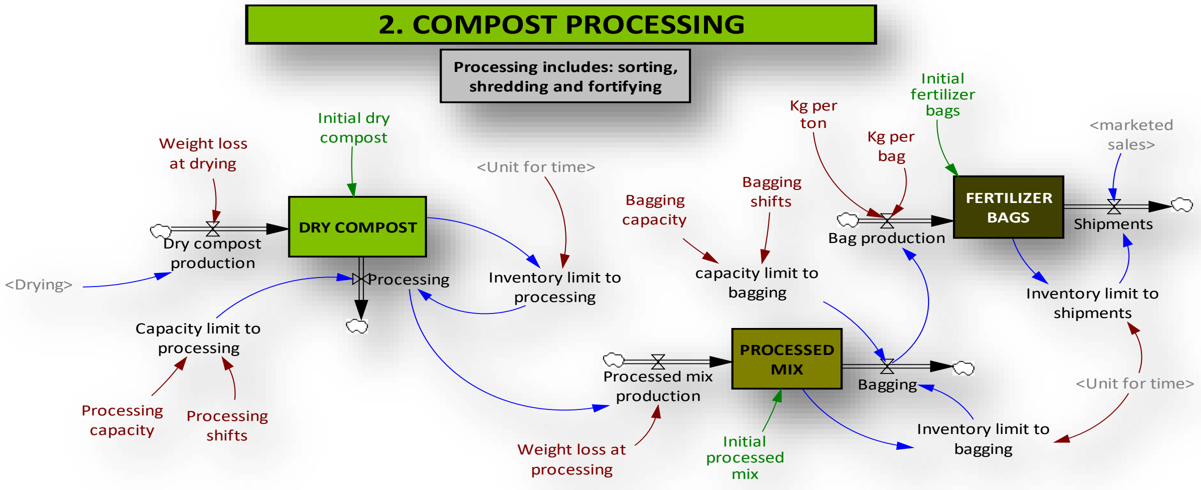


Figure 20 Compost Processing

C_t = $\int_0^T (WCP - Dg + IC_0)$……………………….................…..(42)

Where:

WCP = Com $(1 - WL\ Com)$

Dg = Min $(CLD_g + ILD_g)$

and CLD = D_gC * DS; ILD_g = CO/Unit time

C = $\int_0^T [Com\,(1 - WLC_{Om}) + Min\,(CLD_g + ILD_g) + IC_O]$…..(43)

DC = $\int_0^T (DCP - P_r + IDC_0)$ ……………….………………..(44)

Where:

DCP = $D_g * (1 - WLD)$

P_r = Min $(CLP + ILP)$

T/F DC = $\int_0^T [D_g * (1 - WLD) + Min\,(CLP + ILP) + IDC_O]$ ……….(45)

Ct = Compost

WCP = Wet Compost Production

Dg = Drying

ICo = Initial Compost

WLCom = Weight Loss at Composting

CLD = Capacity Limit to Drying

ILD = Inventory Limit to Drying

Dgc = Drying Capacity

DS = Drying Shift

DC = Dry Compost

DCP = Dry Compost Production

P_r = Processing

IDC_0 = Initial Dry Compost

D_g = Drying

WLD = Weight Loss at Drying

CLP = Capacity Limit to Processing

ILP = Inventory Limit to Processing

PROCESSED MIX

PM_E = $\int_0^T [PMP - B_G + PM_0]$ ……………………………..(46)

where:

PMP = P * (1 – WLP)

Bg = Min (CLB_g + ILB_g)

PM_0 = Constant

But:

P = Min $CLP_g + ILP_g$ ……………………………..(47)

and

CLP_g = P_gC * PS

ILP_g = DC/Unit of time

Also

CLB_g = B_gC * BS

ILB_g = PM/Unit of time

PM_t = $\int_0^T [Min\left(PC * PS + ILP_g\right) - Min\left(B_gC\ BS + ICB_g\right) + PM_0]$..(48)

PM - Processed Mix

PMP - Processed Mix Production

P - Processing

WLP - Weight Loss at Processing

B_g - Bagging

CLB_g - Capacity Limit to Bagging

ILB_g - Inventory Limit to Bagging

FERTILIZER BAGS

FB_t = $\int_0^T [BP - S_h + IFB]$……………………………………………..(49)

where:

BP = B_g * kg per ton/kg per bag

S_h = Min [MS + ILS]

IFB =

But:

MS = SP * BSP

ILS = FB/Unit of time

FB_t = $\int_0^T [B_g\ kg\ /\ t - Min\ (SP * BSP + ILS) + IFB_0]$……………………..(50)

FB_t = Fertilizer Bags

BP = Bag Production

S_h = Shipment

IFB_0 = Initial Fertilizer Bag

MS = Market Sales

ILS = Inventory Limit to Shipments

SP = Sales Person

BSP = Bag Sold per Sales Person

The third module, factory labour, calculates factory labour requirement (Figure 21). This is based on the quantities processed in each operation (collecting, composting, drying, processing and bagging) and the assumed labour productivity of the corresponding operation.

The general formula is:

Labour in operation, x = quantity in operation x / labour productivity in operation

(staff) *(ton/week)* *(ton/staff/week)*

(Equations 82 to 86).: appendix ii

Unit coherence check: *(ton/week) / (ton/staff/week) = (ton/week) * (ton/staff*week) = (ton/week) * (staff*week/ton) = staff*

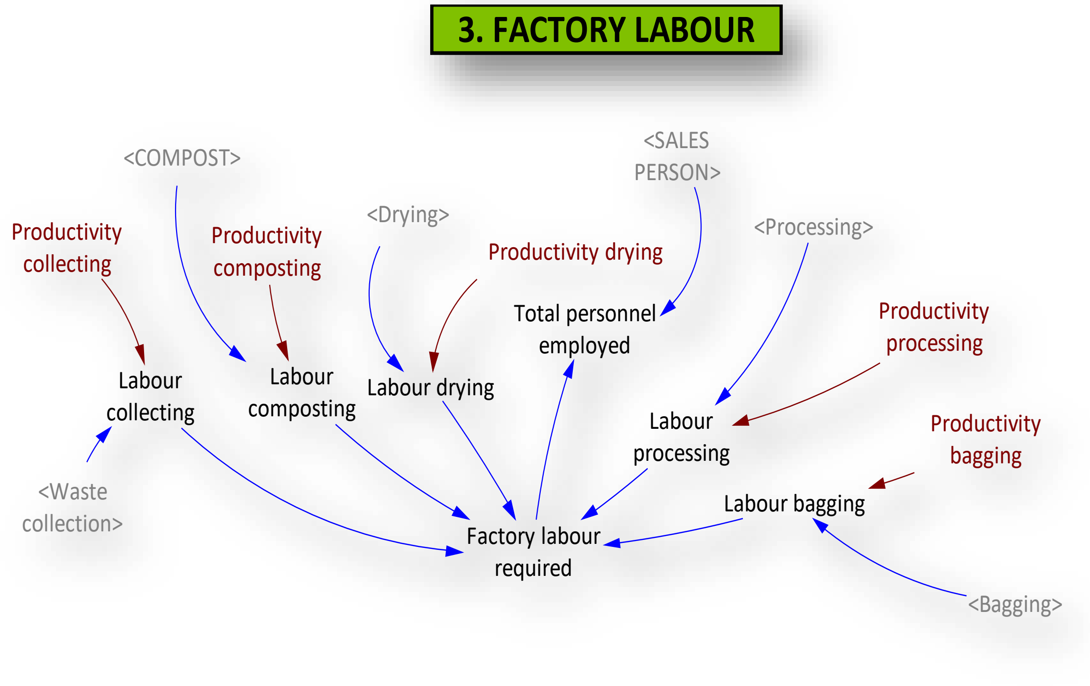


Figure 21: Factory Labour

FACTORY LABOUR

FLR = $LC + L_{Com} + LD + LP + LB$ …………………………….(51)

where:

LC = $^{WC}/_{PC}$

LCom = $^{Com}/_{PCom}$

LD = $^{Dg}/_{PDg}$

LP = $^{P}/_{Pp}$

LB = $^{B}/_{Pb}$

and

TPE = FLR + SP

FLR = Factory Labour Required

LC = Labour Collecting

LCom = Labour Composting

LD = Labour Drying

LP = Labour Processing

LB = Labour Bagging

TPE = Total Personnel Employed

SP = Sales Person

The fourth module (Fig. 22) electricity cost computes electricity costs assuming the plant backs up grid supply with a generator. An organic fertilizer plant is a large consumer of electricity. The generator’s hourly fuel consumption, grid kWh cost and number of hours of grid supply are important cost parameters.

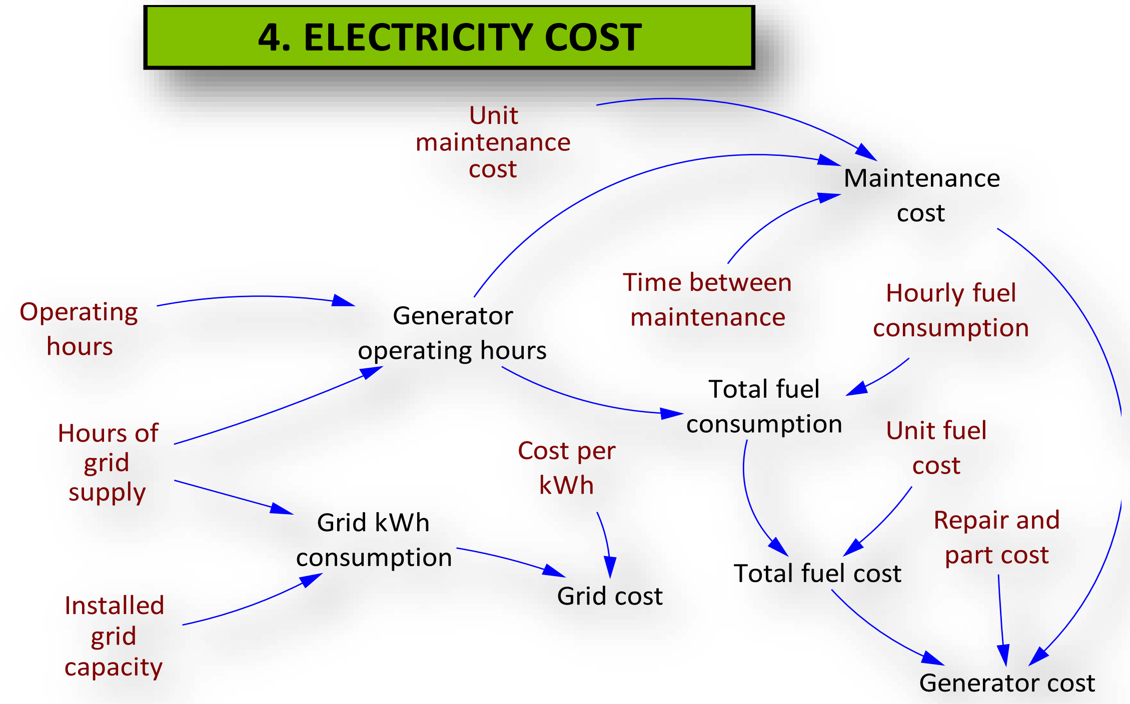


Figure 22: Electricity Cost

ELECTRICITY COST

GCon = $IGC * HGS$

But

GC = $GCon * Cost/kwh$

GC = $(IGC * HGS)\ Cost/kwh$

………………………………………...……(52)

GCon = Grid (kw/h) Composting

IGC = Installed Grid Capacity

HGS = Hours of Grid Supply

GC = Grid Cost

$G_{en}C$ = $TFC + MC + RPC$

where:

TFC = $TF_{Com} * UFC$

MC = $\left(\frac{GOH}{TBM}\right) * UMC$

RPC =

Also:

TFCom = $GOH * HFC$

Therefore:

$G_{en}C$ = $(GOH * HFC) + \left(\frac{GOH}{TBM}\right) * UMC + RPC$ …………………(53)

$G_{en}C$ = Generator Cost

TFC = Total Fuel Cost

MC = Maintenance Cost

RPC = Repair and Past Cost

TFCom = Total Fuel Consumption

UFC = Unit Fuel Cost

GOH = Generator Operating Hours

TBM = Time Between Maintenance

UMC = Unit Maintenance Cost

HFC = Hourly Fuel Consumption

The fifth module (Fig. 23) sales, is the driver of the model. While production is a year-long activity (the plant has a removal commitment to farmers paying for waste disposal), the model assumes that sales of organic fertilizers are seasonal and only occur during the rainy season, a period assumed to begin at *first week in season* and to end at *last week in* *season*. The model operates on the basis of 52 weeks of 7 days in a year. If one assumes that the rainy season begins in April and ends in October, *first week in season* is set at 13 or 14 and *last week in season* at 41 or 42. As the model simulates over 5 years, the week when the season starts and the week when the season ends are calculated for each year. This is the purpose of variables *Start week*, *End week* and *Sales season* (equations 120, 45 and 115 respectively- appendix ii.

Because sales are seasonal, sales workers are seasonal as well. They are recruited only for the period of the sales season. Variable *Firing* empties level SALES PERSON at the end of the sales season.

The number of sales people and their productivity determine the volume of sales which itself drives an adjustment process of waste collection to fertilizer demand. If desired waste collection exceeds the volume of waste sourced from farmers willing to pay for waste disposal, additional waste is purchased from farmers willing to sell poultry waste. The purchase price of waste is therefore an important determinant of profitability.

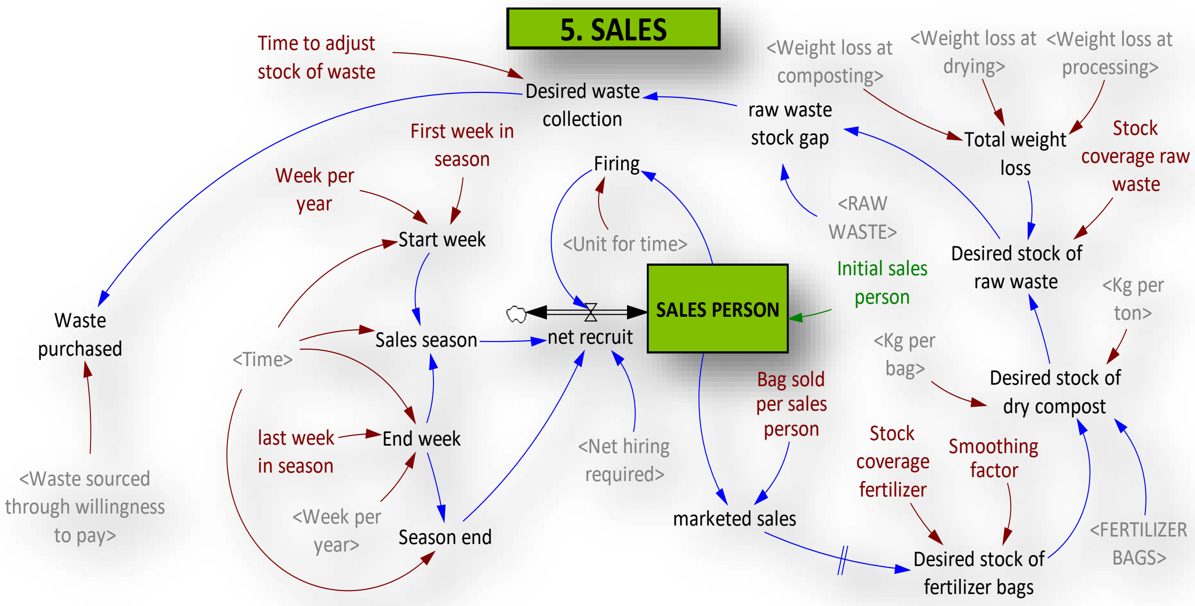


Figure 23: Sales

SALES

SP = $\int (NR + ISP)$

SP = $ISP + \int_0^t NR$

where:

SP = Sales Person

NR = Net Recruit

ISP = initial Sales Person

MS = Marketed Sales

MS = $SP * BSP$

DSF = $\int[S(MS + SF) * SCF]$

DSF = Desired Stock Fertilizer

S = Smooth

MS = Marketed Sales

SF = Smooth Factor

SCF = Stock Coverage Fertilizer

The corporate growth process was built into the sales model. An increase in the volume of sales enlarges the plant's turnover. As the plant's sales budget is assumed to depend upon its turnover. a larger turnover allows recruiting more sales people which, in turn, increases the turnover. More sales also trigger a request for a larger production of fertilizer bags and therefore, for more compost and more waste collection. In turn, a larger stock of fertilizer bags allows for more shipments. Business growth is, therefore, driven by two positive loops.

Increases in quantities of waste purchased, processed and sold, however, also imply increases, not only in revenues but also in costs. Therefore, the two feedback loops of corporate growth are not necessarily synonymous with increasing profits. The cost structure of the business is a critical element of profitability. Companies usually produce financial results on a yearly basis. The purpose of the model's sixth module is to accommodate this requirement.

Weekly costs are cumulated in four levels for five consecutive periods of 52 weeks, starting at time zero. At the end of each period of 52 weeks (each year), each level is emptied (cleared) so that a new cost accumulation can start for the next year (Fig. 24). The signal to empty a level is given by variable *is end of year?* (*equation* 79 - appendix ii).

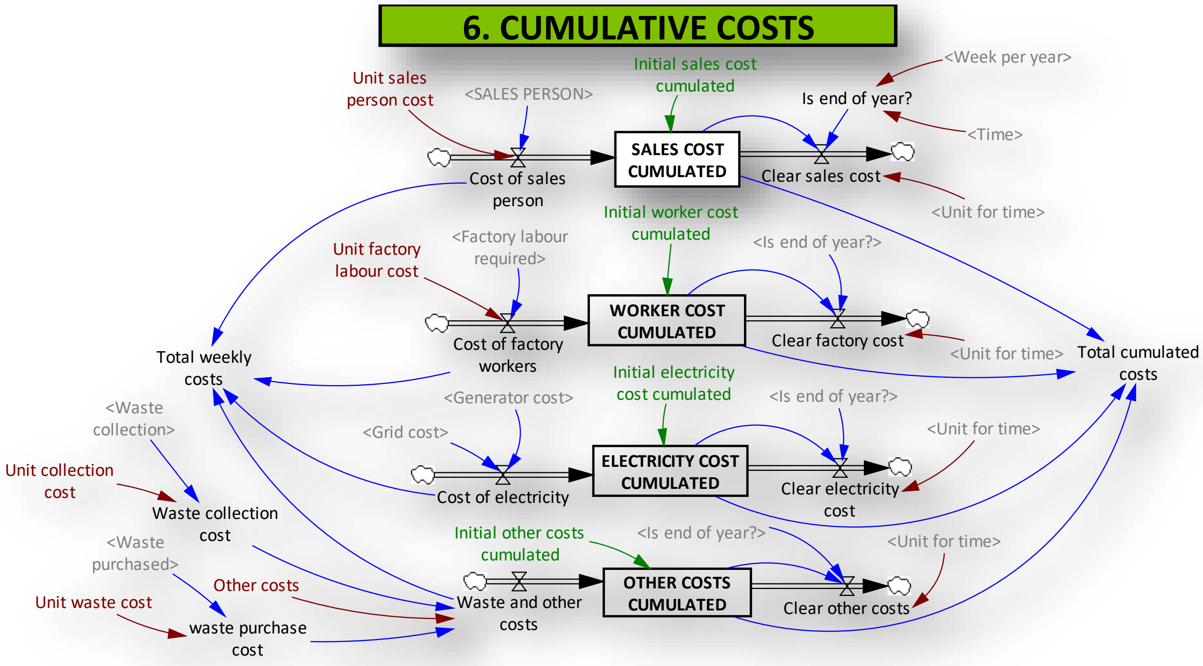


Fig 24: Cumulative cost

The seventh and last module (Figure 25) is the cash balance and sales budget It calculates the plant's turnover, margin and cash flow. It is also in this module that the funds needed to recruit additional sales people are calculated on the basis of the assumption that the sales budget is a given fraction of the plant's turnover. To keep simulations meaningful and realistic, most of these parameters, which are either structural or technically rigid, must remain constant. Only a few (policy parameters, some time delays) can be varied so as to select favourable management strategies.

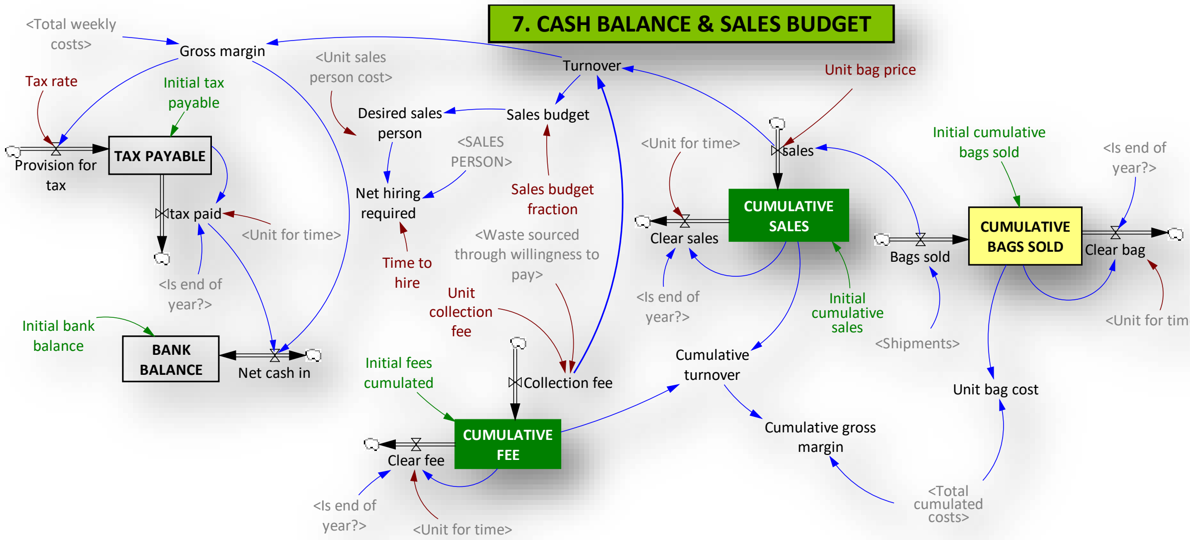


Fig 25: Cash balance and sales budget

The model has 159 equations and 66 numerical assumptions. It is not a large system dynamics model but it is not a small model either. It calculates 159 – 66 = 93 variables. As a substantial number of simulations must be performed to determine the conditions of profitability, a long time is needed to examine each one of the 93 variables for each simulation experiment. One therefore needs only a few benchmarks to be able to rapidly assess a simulation.

This is done using six graphs.

1. *Profit and loss*: plots on the same scale turnover, total cost and gross margin (Fig 26)
2. *Cost structure*: plots on the same scale, factory labour cost, sales peoples cost, electricity cost and waste cost (Fig. 27)
3. *Composition of turnover*: plots on the same scale sales and collection fees (Fig. 28)
4. *Stock of fertilizer bags* (Fig 29)
5. *Staff employed*: plots on the same scale factory workers and sales personnel (Fig 30)
6. *Bank balance* (Fig 31)

The purpose of the model is to assess the profitability of an organic fertilizer plant built to process poultry waste generated by poultry farms in Oyo and Ogun states. The assumption was that a plant has been built in Oyo State to recycle the waste generated in that state.

A survey conducted in Oyo State provided the following items of information:

- Waste that can be collected from farmers willing to pay for disposal amount to 450 ton/month (112.5 ton/week)
- Waste generated by farmers unwilling to pay for disposal amount to 151 ton/month (37.75 ton/week)
- Total is 601 ton/month (150.25 ton/week)
- The cost of waste sold and the amount farmers are willing to pay for waste disposal stand between ₦100 and ₦400 per 50kg bag.

Further research indicated that a 50kg bag of poultry droppings can be sold for ₦1,300.

3.5: Parameter Settings

The first parameters to define are the time parameters (Table 8). The model is simulated over a period of 5 years on a weekly basis. Financial results are aggregated on a yearly basis. The time unit of the model is, therefore, the week (w). The value 1 for TIME STEP indicates that the model is a system of difference rather than differential equations since great accuracy is not required.

There are 52 weeks in a year, so the model simulates until week 52 * 5 = 260. The value 0 for the model's initial time means that model simulation begins at the start of the first week (so that TIME = 1 indicates the end of the first week or the beginning of the second). Sales cover 7 months (28 weeks), starting in the first week of April (TIME = 12) and ending in the last week of October (TIME = 40).

Because the plant is a new plant, all initial values (except the business bank account) are set at zero (Table 9). The plant is assumed to start operating with a bank balance of ₦100 million. If the bank balance increases, the business grows; if it does not, the business declines and is eventually bound to disappear. Level BANK BALANCE is therefore a critical variable in the model.

The composting process and the production of electricity (an important input to the fertilizer plant) are driven by fixed technical coefficients (Table 10).

It is assumed that it takes 5 weeks to turn poultry waste into compost. There is a total weight loss of 75% from raw waste to fertilizer bagging. Technical coefficients relative to composting are likely to vary with the mix of waste collected (droppings, litter and city waste). The values shown in Table 10 may, therefore, change if the plant collects a different waste mix. But the difference is most likely to remain small.

The plant has an assumed installed grid (transformer) and generator capacity of 250 kW. Grid supply is available for an assumed 30 hours per week, the rest being provided by the plant's generator. It is assumed that the plant generator burns 8 litres of diesel fuel per hour.

The plant has a given fixed capacity for each of its four main operations (collecting, drying, processing and bagging). Capacity parameters are listed in Table 11. Capacities are potentials: they are abilities to deliver. Actual deliveries depend upon the rate at which capacities are used. Maximum potentials are given by capacity parameters while maximum deliveries are given by shift parameters. Shift parameters indicate how many times capacities are utilized in a given period. All capacities are assumed to be fully utilized. Thus, the model assumes that the plant can take a maximum of 100 * 2 = 200 tons of raw waste per week. It can also dry, process and bag a maximum of 20 * 6 = 120 tons per week of wet compost, dry compost and processed mix respectively.

Unit 1/w (also noted fraction/w) stands for a percentage per time period (quantity/quantity/week = 1/week).

Table 8: Time Parameters

INITIAL TIME	0	W
FINAL TIME	260	W
TIME STEP	1	W
Unit for time	1	W
Week per year	52	W
First week in season	12	W
last week in season	40	W

Sources : Author's compilation, 2015

Table 9: Initial values

Raw waste	0	Ton
Compost	0	Ton
Dry compost	0	Ton
Processed mix	0	Ton
Fertilizer bags	0	Bag
Sales person	0	Staff
Sales cost cumulated	0	Naira
Worker cost cumulated	0	Naira
Electricity cost cumulated	0	Naira
Other costs cumulated	0	Naira
Tax payable	0	Naira
Bank balance	100,000,000	Naira
Fees cumulated	0	Naira
Cumulative sales	0	Naira
Cumulative bags sold	0	Bag

Sources : Author's compilation, 2015

Table 10: Technical Coefficients

Composting time	5	W
Kg per bag	50	kg/bag
Kg per ton	1,000	kg/ton
Weight loss at composting	65.0%	Dmnl
Weight loss at drying	5.0%	Dmnl
Weight loss at processing	5.0%	Dmnl
Hourly fuel consumption	8	liter/hour
Hours of grid supply	30	hour/w
Installed grid capacity	250	kW

Sources : Author's compilation, 2015

(*) Dmnl = dimensionless (no dimension).

Capacity parameters are production related. Equally important is the plant productivity. Productivity parameters are listed in Table 12.

As no statistical data are available to back up the models productivity parameters, the values above are guess estimates. It is, therefore, appropriate to run alternative simulations with modified productivity parameters.

Table 11: Capacity Coefficients

Collecting capacity	100	Ton
Collecting shifts	2	1/w
Drying capacity	20	Ton
Drying shifts	6	1/w
Processing capacity	20	Ton
Processing shifts	6	1/w
Bagging capacity	20	Ton
Bagging shifts	6	1/w

Sources : Author's compilation, 2015

Table 12: Productivity Coefficients

Bag sold per sales person	60	bag/(w*staff)
Productivity collecting	4	ton/(staff*w)
Productivity composting	2	ton/staff
Productivity drying	2	ton/(staff*w)
Productivity processing	2	ton/(staff*w)
Productivity bagging	2	ton/(staff*w)

Sources : Author's compilation, 2015

This is the model of a dynamic system, that is, a system in which delays occur. Table 13 lists the time delays included in the model. The smoothing factor is the time period over which marketed sales are averaged to determine the stock of fertilizer bags the plant ought to maintain. The time between maintenance is the average number of hours between two successive generator maintenance operations. The time to adjust the stock of waste is the time period over which the plant adjusts its stock of waste to conform to the stock desired (equation 38 - Appendix ii). The time to hire reflects a similar adjustment process for sales persons (equation 91 in the model).

Table 13: Time Delay Coefficients

Smoothing factor	4	W
Time between maintenance	150	Hour
Time to adjust stock of waste	3	W
Time to hire	2	W
Grid cost per kWh	15	naira/kW/hour

Sources : Author's compilation, 2015

Table 14 lists the model’s cost parameters. As is the case for productivity parameters, several of these coefficients are reasonable guess estimates. Other cost estimates are based on survey data and/or the observation of currently incurred costs for similar operations. In line with survey results, the model assumes that the fee paid to the plant from farmers willing to pay for waste disposal equals the cost of waste purchased from farmers willing to sell their poultry waste. This is put at ₦200 per 50kg bag, (₦4,000 per ton).

Costs are obviously critical factors of profitability. It is, therefore, important to run alternative simulations with varying cost structures

Table 14: Cost Parameters

Other costs	0	naira/w
Repair and part cost	2,000	naira/w
Unit collection cost	1,000	naira/ton
Unit collection fee	4,000	naira/ton
Unit factory labour cost	10,000	naira/(w*staff)
Unit fuel cost	120	naira/litre
Unit maintenance cost	30,000	Naira
Unit sales person cost	12,500	naira/(w*staff)
Unit waste cost	4,000	naira/ton
Tax rate	25.0%	Dmnl

Sources : Author's compilation, 2015

Table 15: Policy Parameters

Operating hours	60	hour/w
Sales budget fraction	15.0%	Dmnl
Stock coverage fertilizer	3	W
Stock coverage raw waste	1	Dmnl
Unit bag price	1,300	naira/bag
Willingness to pay volume	112.5	ton/w

The last group of parameters is the policy parameters (Table 15). Three of them are particularly important. The first one is the sales budget fraction: the proportion of the plant's turnover allocated to sales financing (sales persons' recruiting). The second one, the unit bag price, is the price at which the plant's product is sold. The third one is the volume of waste that the fertilizer plant commits itself to lift weekly from farmers willing to pay for waste disposal (willingness to pay volume).

The volume of poultry waste lifted by the plant from farmers willing to pay for disposal is based a contractual agreement. It must be lifted, whether the plant needs input or not. It is, therefore, a significant policy parameter. If the plant requires a greater input volume it must procure it at the cost per ton charged by farmers willing to sell waste.

CHAPTER FOUR

RESULTS AND DISCUSSION

4.1: Socio-Economic Characteristics of Chicken Farmers in Southwestern Nigeria

This section presents results obtained from the analysis of the socio-economic characteristics of the poultry farmers in both Oyo and Ogun States using descriptive statistics (frequency distributions and statistic measure of central tendency (mean) and standard deviation).

Table 16 shows that 85.1% of the chicken farmers were male. This is consistent with the findings of Amao (2013) which showed that high proportion 92.3% of the chicken farmers in Saki West were male. The table also shows that 86.4% were married .This implies that chicken farming is a lucrative venture, which enabled them to take care of their families. While their average age was 41.0 ±10.8 years, their household size was 5.0 ±2.0 and their years of farming experience was 8.09 ±5.9 years. Most of the farmers had formal education: 8.78% had primary education,16.21% had secondary education and 56.08% had tertiary education. Those without formal education constituted 19.00%. This suggests that chicken farming in the study area was dominated by educated farmers, perhaps because of the technicalities involved in chicken farming. Most of the chicken farmers (55.40%) practised the intensive system, 30.47% practised the semi-intensive system while 10.13% practised the extensive system. Sonaiya (2005) had also observed that the dominant chicken management system in Nigeria is the intensive system.

Table 16: Socioeconomic Characteristics of Chicken Farmers in Southwestern Nigeria

Characteristics n=148	
Age	%
< 30	19.00
31 – 40	38.01
41 – 50	23.53
> 50	17.46
Mean	
Standard dev.	
Sex of poultry farmer	
Male	85.07
Female	14.93
Marital Status	
Single	13.57
Married	86.43
Household Size	
< 5	34.84
5-7	59.28
> 7	5.88
Mean	
Std. dev.	
Educational status	
No formal education	18.91
Primary	8.78
Secondary	16.21
Higher	56.08
Yrs of Experience	
< 5	28.96
5 -10	49.77
10 -15	15.84
> 15	5.43
Mean	
Std dev.	
Type of Poultry System	
Intensive	55.66
Extensive	10.41
Semi- Intensive	33.93

Source: Field Survey, 2015

Table 17 shows socio-economic characteristics for residents leaving around the farms, 59.00% of the selected residents around the farm were male while 41.00% were female. Their average age was 45±13, which shows that most them were in their active years While 27.39% had no formal education, 41.09%had primary education, 20.54% had secondary education and 10.98% had tertiary education. Residents who were single constituted 19.17% while those who were married made up 80.83%. Most of the residents had lived there for over 10 years .The main source of water was hand-dug wells with pumping machines attached, while 34.00% had their water from boreholes. Most of the residents (84.00%) own the houses they live in. This implies that they will not find it easy to relocate if they find the environment uncomfortable.

Table 17 Socio- demographic characteristics of residents around the farms

Characteristics	**Pooled. n = 73**
Age	%
≤ 30	13.69
31 – 40	38.35
41 – 50	36.98
> 50	10..98
Mean	
Standard dev.	
Sex of Residents	
Male	58.90
Female	41.10
Marital Status	
Single	19.17
Married	80.83
Household Size	
< 5	20.54
5-7	52.05
> 7	27.42
Mean	
Std. dev.	
Educational Status	
No formal education	27.39
Primary	41.09
Secondary	20.54
Higher	10.98
Period of Residence	
< 5	52.05
5 -10	31.50
10 -15	12.32
> 15	04.13
Mean	
Std dev.	
House Status	
Owned	83.56
Rented	16.44
Sources of water	
Bore Hole	34.24
Hand dug well	56.16
River/Stream	09.60

Source: Field Survey, 2015

4.2 Types of poultry waste generated in Southwestern Nigeria

Table 18 reveals that in the pooled data for Ogun and Oyo States most of the waste generated by chicken farmers were chicken excreta and litter. The majority (77.82%) generated waste from poultry droppings while 56.11% generated waste from poultry litter. The least generated waste item were offal and hatchery waste. Only 4.52% of the farmers generated offal as waste while 11.31% generated hatchery waste. Other waste generated include feathers (19.91%) and condemned carcasses (30.77%). The waste from processing consists mainly of feathers and a few visceral parts. In Ogun State, 80.83% generated chicken excreta, followed by poultry litter (56.66%) and condemned carcasses (34.16%). The least quantity of chicken excreta was generated from feathers, hatchery waste and offal at 20.06%, 10.83% and 5.00% respectively (Table19). In Oyo State, 74.26% and 55.45% of the farmers generated chicken excreta and poultry litter respectively. The least quantity of poultry waste generated in Oyo State, just as in Ogun State is, offal (3.96%) and hatchery waste (11.88%)..

Table 18: Types of Poultry Waste Generated in Southwestern Nigeria

Types	**Yes**	
	Frequency	**%**
Poultry droppings	115	77.82
Feathers	29	19.91
Hatchery waste	17	11.31
Carcass	46	30.77
Offals	07	4.52
Poultry Litter	83	56.11

Source: Field Survey, 2015

* Multiple responses were allowed

Table 19: Types of poultry waste generated in Ogun State n=80

Types of waste	Yes	
	Freq.	%
Poultry droppings	65	80.83
Feathers	16	20.06
Hatchery waste	09	10.83
Carcasses	27	34.16
Offal	04	5.00
Poultry litter	46	56.66

Source: Field Survey, 2015

* Multiple responses were allowed

Table 20: Types of poultry waste generated in Oyo State n=68

Types of waste	Yes	
	Freq.*	%
Chicken excreta	50	74.26
Feathers	13	19.80
Hatchery waste	08	11.88
Carcasses	18	26.73
Offal	3	3.96
Poultry litter	38	55.45

Source: Field Survey, 2015

* Multiple responses were allowed

4.3 Methods of chicken excreta disposal by chicken farmers

Table 21 reveals that most commonly used methods of poultry waste disposal by poultry farmers in the Southwestern were using it as manure on the farm and dumping it on vacant sites. The majority (46.61%) of poultry farmers in Southwestern dumped the waste on vacant lands while 50.67% used it as manure. Other methods used include collection by others (36.65%), selling (29.41%), being used as feed (23.98%), burying (19.46%), being used in compost making (4,%%) and dumping in landfills (4.07%).

Respondents who used chicken waste as manure constituted 50.00%.Those who dumped it on vacant lands constituted 47 .00%; 29.00% sold it while 19.46% buried it. The quantity collected by others was 36.65%, while 23.98% was used as fish feed, 4.52% was used in composting and 4.07% was dumped in landfills (Table 21).

In Oyo and Ogun states, (Tables 20 and 21) 54.17% and 40.59% converted their waste to manure respectively. This indicates that Ogun State had a higher proportion of farmers that converted their waste to manure. The least used methods were disposal in landfills (5.83%) and composting (7.50%). Only 4.07% disposed of their waste at landfills while 4.52% disposed of theirs by composting. In Ogun and Oyo states, 5.83% and 1.98% disposed of their waste in landfills while 7.50% and 0.99% disposed of theirs waste by composting respectively. The results indicate that Ogun State had a higher proportions of farmers that used the various waste collection methods cited in the study. Other methods of disposal were burying (19.46%), collection by others (36.65%), as fish feed (23.98) and sale to others (29.41%). All the methods of poultry waste disposal were not used by the poultry farmers in Oyo State as the farmers that put any of the methods into use were below average. However, 46.53% and 40.59% disposed of their waste as manure and by dumping respectively. (Table 23).

Table 21. Methods of chicken excreta disposal in Southwestern Nigeria Ogun (n=148)

	Yes	
Methods	Frequency	%
Burying	29	19.46
Dumping	69	47.00
Landfill	06	4.07
Use as manure	75	50.00
Composting	07	4.52
Collected by others	54	36.65
Fish feed	36	23.98
Sold	44	29.00

Source :Field Survey 2015

Table 22: Methods of chicken excreta disposal in Ogun State n=80

Methods	Yes	
	Freq.	%
Burying	18	22.50
Dumping on empty land	42	51.67
Landfill	05	5.83
Use as manure on farm	44	54.17
Composting	06	7.50
Collected by other users	32	40.00
Fish feed	23	28.33
Sale to others	23	28.33

Source: Field Survey, 2015

Table 23: Methods of Chicken excreta disposal in Oyo State n=68

Methods	Yes	
	Freq.	%
Burying	11	15.84
Dumping (empty on land)	28	40.59
Landfill	01	1.98
Use as manure on farm	32	46.53
Composting	1	0.99
Collected by other users	22	32.67
Fish feed	13	18.81
Sale to others	21	30.69

Source: Field Survey, 2015

4.4: Estimation of index of the perceived environmental effects.

Environmental effects of chicken excreta such as odour, air pollution, water pollution, soil pollution and infectious diseases were used as components and built into a Likert scale to generate individual scores of farmers and residents around the farm on the perceived effect of chicken excreta on the environment. The five items on the scale were generated from the effects identified. These had to do with odour, water pollution, outbreak of infectious diseases, air and soil pollution.

Table 24 shows the perceived environmental effects of chicken excreta on the chicken farmers and residents around the farm. While 6.3% of the farmers and 11.3% of residents were least affected, 5.8% and 11.3% respectively, were slightly affected and 34.3% and 26.4% respectively, moderately affected. Highly affected farmers and residents constituted 39.3% and 32.1% respectively while severely affected farmers and residents constituted 14.00% and 18.1% respectively. Generally, residents around chicken farms had a more adverse perception of the environmental effects of chicken excreta than the chicken farmers. This is to be expected, since chicken farmers are not likely to complain about the waste they generate.

Table 24: Distribution of Perceived Environmental Effects of Chicken Excreta in Southwestern Nigeria

Range	Sub-Categories	Farmers (n = 148) %	Residents (n = 73) %
1 – 5	Least Affected	6.3	11.3
6 – 10	Slightly Affected	5.8	11.3
11 - 15	Moderately Affected	34.3	26.4
16 – 20	Highly Affected	39.3	32.1
21 – 25	Severely Affected	14.0	18.1

Source: Field Survey, 2015

Furthermore, a mean score of respondents (farmers and respondents) perception of environmental effects was determined.

Table 25 shows that while the mean score from the Likert Scale in respect of farmers was 14.82, that of residents was 16.82. This implies that residents around the farm were more affected by the environmental effects of chicken excreta than the farmers.

Table 25: Mean Scores on Perception of Environmental Effects by Farmers and Residents

			Farmers n = 148		**Residents n = 73**	
Sub-category	**Range**	**Mean**	**F**	***fx***	**F**	***Fx***
Least affected	1-5	3	11	33	8	24
Slightly affected	6-10	8	10	80	8	64
Moderately affected	11-15	13	54	702	19	247
Highly affected	16-20	18	55	990	14	252
Severely affected	21-25	23	18	414	24	552
				2219		1139

Source: Field Survey,2015

$$\boldsymbol{{}^{\Sigma fx}/_{\Sigma f} = {}^{2219}/_{148} = 14.82}$$

Mean Score from the Likert Scale on perception of environmental effects by farmers = 14.82

$$\boldsymbol{{}^{\Sigma fx}/_{\Sigma f} = {}^{1139}/_{73} = 16.21}$$

Mean Score from the Likert Scale on perception of environmental effects by residents around the farm = 16.21

4.5 Factors influencing respondents perception of the environmental effects of chicken excreta

The relationship between some selected socio-economic factors and the perceived effect of chicken excreta on the environment is examined in this sub-section. Farming experience and education of chicken farmers (Southwest- Table 26) was found to be a significant factor ($p<0.01$) affecting the perceive effect of chicken excreta on the environment. A positive relationship shows that with a unit increase in farmers' farming experience and education level, their perceived effect of chicken excreta on the environment increases by 0.056 unit and 0.029 unit, respectively.

In Oyo State, (Table 26), a unit increase in farmers’ experience increased the perceived effect of chicken excreta on the environment by 0.919 unit ($p<0.05$), while it increased the level by 0.529 unit ($p<0.05$) in Ogun State (Table 27). The quantity of waste generated was also significant ($p<0.01$) and had a positive relationship with the perceived environmental effects of chicken excreta. Thus, a unit increase in the quantity of waste generated would lead to a 0.117 unit increase in the perceived level of environmental effect of chicken excreta for the Southwest. In Oyo State however, the perceived level of environmental effects of chicken excreta increased by 1.407 units ($p<0.05$) while it increased by 0.031 unit ($p< 0.10$) in Ogun State respectively for every unit increase in the quantity of waste generated.

Income had a significant ($p<0.01$) positive relationship with the environmental effect of chicken excreta. An increase in income would lead to a 1.213 unit increase in the perceived level of environmental effect of chicken excreta. In Oyo State, income increased the perception by 0.478 unit ($p<0.05$) while in Ogun state, it increased by 0.246 unit ($p<0.10$) with an increase in income. This indicates that income had a higher effect on the level of perception of the environmental effects of chicken excreta in Oyo State when compared to Ogun State. Age, sex and marital status did not have any significant effect on respondents' perception of the environmental effects of chicken excreta. Age and sex had positive relationships while education and marital status had negative relationships Education on the other hand had a positive relationship and was significant at 1%.

Table 26: Factors influencing respondents' perception of the environmental effects of chicken excreta in Oyo State

Variable	Coefficient	Standard error	Z stat
Age	-0.007	0.018	-0.38
Sex	0.565	0.513	1.10
Marital status	-0.086	0.712	-0.12
Education	0.605**	0.305	1.98
Income	0.478**	0.199	2.39
Farming experience	0.919**	0.488	1.88
Waste generated	1.407**	0.566	2.49
Cut1	0.504	1.821	0.27
Cut 2	2.328	1.861	1.25
Cut 3	4.407	1.932	2.28
Cut 4	6.312	3.125	2.02
LR chi^2	11.82**		
Pseudo R^2	0.144		
Log likelihood	-35.267		

Source: Field Survey, 2015 *** $P < 0.01$ ** $P < 0.05$ *$P < 0.1$

Table 27: Factors influencing respondents' perception of the environmental effects of chicken excreta in Ogun State

	Coefficient	Standard error	Z stat
Age	0.105	0.130	-0.80
Sex	0.209	0.284	0.74
Marital status	-1.467	3.760	-0.39
Education	0.029	0.064	-0.46
Income	0.246*	0.143	1.72
Farming experience	0.529**	0.212	2.49
Waste generated	0.031*	0.015	2.12
Cut1	-1.639	0.874	1.87
Cut 2	-0.577	0.869	0.66
Cut 3	1.027	0.866	1.18
Cut 4	2.102	1.067	1.97
LR chi^2	13.98**		
Pseudo R^2	0.158		
Log likelihood	-37.501		

Source: Field Survey, 2015. *** $P < 0.01$ ** $P < 0.05$ *$P < 0.1$

Table 28: Factors influencing respondents' perception of the environmental effects of chicken excreta in South western

	Coefficient	**Standard error**	**Z stat**
Age	0.109	0.21	-0.50
Sex	0.416	0.396	0.1.05
Marital status	-1.467	3.760	-0.39
Education	0.140	0.164	0.85
Income	1.213***	0.185	5.07
Farming experience	0.056***	0.013	4.31
Waste generated	0.117***	0.034	3.48
Cut1	-1.639	0.874	1.87
Cut 2	-0.577	0.869	0.66
Cut 3	1.027	0.866	1.18
Cut 4	2.270	0.910	2.49
LR chi^2	25.01***		
Pseudo R^2	0.084		
Log likelihood	-136.47		

Source: Field Survey, 2015. *** $P < 0.01$ ** $P < 0.05$ *$P < 0.1$

The result of marginal effects reveals that all the variables, except marital status, had the highest marginal effects on respondents that were severely affected by environmental effects of chicken excreta when compared to other categories of respondents Table 21 shows that age and gender had marginal effects of 0.105 and 0.209, respectively but were not significant. Education and waste generated had a marginal effect of 0.029 and 0.117 respectively, and were significant at 10% and 5% respectively. The marginal effects for income and farming experience were 1.213 and 0.056 respectively and were significant at 10%.Therfore, education, quantity of waste generated, income and farming experience of the respondents significantly affect the perceived effect of chicken excreta on the environment. Marital status on the other hand, had the highest value of 0.039 for the highly and moderately affected respondents.

Table 29: Marginal effects of factors affecting perception of environment effects in Southwestern Nigeria

	Severely Affected	Highly Affected	Moderately Affected	Slightly Affected	Least Affected
Age	0.105	0.001	0.001	0.001	0.001
Sex	0.209	0.021	0.020	0.019	0.014
Marital status	-1.407	0.039	0.039	0.037	0.026
Education	0.029*	0.004	0.003	0.003	-0.002
Income	1.213***	0.002	0.002	0.002	0.001
Farm exp	0.056***	0.002	0.002	0.002	0.001
Waste gen	0.117**	0.003	0.003	0.003	0.002

Source: Field survey, 2015. *** $P < 0.01$ ** $P < 0.05$ *$P < 0.1$

Table 30 reveals that income and farming experience had marginal effects of 0.043 and 0. 001 respectively and were significant at 5% for the category of respondents that were moderately affected by chicken excreta. Education and age were significant at 1% and had marginal effects of 0.006 and 0.01 respectively for respondents that were least affected. All variables, were found to be negative, meaning that an increase in age, farming experience and education lead to a decrease in the effect of chicken excreta on the environment.

Table 31 shows the result of marginal effects in Ogun State. Farming experience and waste generated had marginal effects of 0.002 and 0.003 respectively and were significant at 5% for respondents that were moderately affected. Age was significant at 1% for respondents that were slightly affected and had a marginal effect of 0.001.The marginal effect of education was 0.002 and was significant at 1% for respondents that were least affected. The result, therefore, reveals that an increase in the farming experience of respondents reduces the effects of chicken excreta on the environment.

Table 30: Marginal effect of factors affecting perception of environmental effects in Oyo State

	Severely Affected	Highly Affected	Moderately Affected	Slightly Affected	Least Affected
Age	-0.007	-0.001	-0.001	-0.001	-0.001***
Sex	0.565	0.002	0.002	0.003	0.001
M. stat	-0.086	0.015	-0.013	-0.016	-0.004
Education	-0.605	0.041	-0.004	-0.005	-0.006**
Income	0.478	0.047	0.043**	0.051	0.014
Farm exp	0.919	0.001	0.001**	0.002	0.003
Waste gen	1.407	0.003	0.003	0.004	0.001

Source :Field Survey, 2015. *** P < 0.01 ** P < 0.05 *P < 0.1

Table 31: Marginal effects of factors affecting perception of environmental Effects in Ogun State

	Severely Affected	Highly Affected	Moderately Affected	Slightly Affected	Least Affected
Age	0.105	0.001	0.001	0.001	0.001
Sex	0.209	0.022	0.022	0.019	0.015
M.sta.	-1.467	0.014	0.014	0.012	0.009
Education	-0.029	0.002	0.002	0.002	0.002***
Income	0.246	0.002	0.002	0.001	0.001
Farm exp	0.529	0.001	0.002**	0.001	0.001
Waste gen	0.031	0.002	0.003**	0.002	0.001

Source: Field Survey,2015. *** P < 0.01 ** P < 0.05 *P < 0.1

4.6 Factors influencing willingness to pay for chicken excreta disposal among Poultry farmers

The analysis of the result of willingness to pay revealed that 65.0% of the poultry farmers were willing to pay for chicken excreta disposal while the remaining 35.0% were not.

Age had a significant (p<0.01) positive relationship with willingness to pay for chicken excreta disposal by the respondents (Table 34) poultry farmers in. Thus, as age of poultry farmers increases by 1 unit, their willingness to pay for chicken excreta disposal also increases by 0.014 unit. A similar result was obtained for Oyo State (Table 32). A unit increase in the age of poultry farmers also increased the willingness to pay for chicken excreta disposal by 0.027 unit (p<0.01). Though not significant (Table 33), age also had a positive relationship with the willingness to pay of farmers in Ogun State. Total income generated by farmers also had a significant (p<0.10) positive relationship with the willingness to pay for waste disposal among poultry farmers. A unit increase in the income generated by farmers would lead to an increase in their willingness to pay by 0.142 units. In Oyo State, income increased the willingness to pay by 0.123 (p<0.10) while it increased it by 0.123 (p <0.05) in Ogun State. This indicates that total income had the same influence on the willingness to pay of farmers in both states. Total waste generated also had a significant (p<0.05) positive relationship with the willingness to pay for chicken excreta disposal among poultry farmers. An increase in total waste would lead to an increase in the willingness to pay of farmers by 0.058 unit. Total waste generated increased the willingness to pay by 0.453 percentage points (p<0.01) in Oyo State and by 0.138 percentage points (p< 0.01) in Ogun State. The results reveal that total waste generated had a higher influence on the willingness to pay of farmers in Oyo State than those in Ogun State. This could, however, be attributed to the larger quantities of waste generated in Oyo State.

Farming experience had a significant (0.10) negative relationship with willingness to pay. An increase in farming experience would lead to a 0.008 unit decrease in the willingness to pay of poultry farmers.

Education had a significant (p<0.01) positive relationship with willingness to pay for chicken excreta disposal among poultry farmers in Oyo and Ogun states. Thus, as the education of poultry farmers increases by 1 unit, their willingness to pay for poultry waste disposal also increases by 0.011 unit. A similar result was obtained for Oyo State: a unit increase in the educational level of poultry farmers also increased the willingness to pay for waste disposal by 0.027 unit ($p<0.01$). Though not significant, educational level had a positive relationship with the willingness to pay of farmers in Ogun State.

Table 32: Factors influencing willingness to pay for chicken excreta disposal among chicken farmers in Oyo State

Factors	Coefficient	Standard error	Zstat	Marginal effect
Age	0.073***	0.019	3.78	0.027
Sex	-0.046	0.375	-0.12	-0.017
Marital status	0.205	0.530	0.39	0.076
Household size	-0.146	0.303	-0.48	-0.053
Farming experience	-0.027	0.035	-0.81	-0.011
Income	0.334*	0.177	1.89	0.123
Waste generated	1.232***	0.435	2.83	0.453
LR chi^2	29.65***			
Pseudo R^2	0.2201			
Log likelihood	-52.542			

Source: Field Survey, 2015 *** $P < 0.01$ ** $P < 0.05$ *$P < 0.1$

Table 33: Factors influencing willingness to pay for chicken excreta disposal among chicken farmers in Ogun State

Factors	**Coefficient**	**Standard error**	**Zstat**	**Marginal effect**
Age	0.017	0.012	1.46	0.027
Sex	-0.345	0.334	-1.03	-0.134
Marital status	0.196	0.392	0.50	0.077
Education	0.091	0.076	1.20	0.036
Household size	-0.022	0.022	-1.02	-0.053
Farming experience	-0.027	0.035	-0.81	-0.011
Income	0.261***	0.044	5.94	0.123
Waste generated	0.354**	0.156	2.27	0.138
LR chi^2	14.360*			
Pseudo R^2	0.088			
Log likelihood	-74.325			

Source: Field Survey, 2015. *** $P < 0.01$ ** $P < 0.05$ *$P < 0.1$

Table 34: Factors influencing willingness to pay for chicken excreta disposal among chicken farmers in Southwestern Nigeria

Factors	**Coefficient**	**Standard error**	**Zstat**	**Marginal effect**
Age	0.037***	0.011	3.61	0.014
Sex	-0.345	0.334	-1.03	-0.105
Marital status	0.196	0.392	0.50	0.053
Education	0.091	0.076	1.20	0.011
Household size	-0.022	0.022	-1.02	-0.095
Farming experience	-0.055*	0.033	-1.71	-0.008
Income	0.184***	0.054	3.40	0.142
Waste generated	0.359**	0.152	2.35	0.058
LR chi^2	25.01***			
Pseudo R^2	0.084			
Log likelihood	-136.468			

Source: Filed survey, 2015. *** $P < 0.01$ ** $P < 0.05$ *$P < 0.1$

4.7 Simulation Scenarios

An important component of system dynamics models is the interface with the model's clients/users. The more complex a model is the more researched its interface must be. The interface must be clear, informative and revealing. For complex models, a selection must be done between what to show and what not to show. Also important is the order in which results are presented (what is emphasised is shown first) and the way they are presented (graphs, tables or both).

The results of this model are presented in three sets of both graphs and tables. The first set reports on profit and loss data. It includes three graphs and related tables: profit and loss, cost structure and composition of turnover. The second set reports on balance sheet data and includes four graphs: (stock of fertilizer bags, bag production and shipments, staff employed and bank balance) and two tables (fertilizer bags and cash position).

The third and last set is concerned with production data and includes three individual graphs and a set of four graphs: waste collection, raw waste and compost stock, other stocks (compost, dry compost, processed mix) and plant capacities.

4.7.1: Base Case Simulation

Except with small and simple models, it is usually not possible to predict the simulation outcome of a given mix of assumptions fed into a model. Simulation exercises are, therefore, trial and error processes which start from the analysis of a base case built upon a set of reasonable assumptions and progress through making reasonable and realistic modifications to these base assumptions. Fig. 27 shows the aggregated profit and loss components (turnover, costs and margin) resulting from the base case assumptions.

The results of the base case simulation show a loss. The plant's gross margin is negative all along the five-year period and, therefore, leads to plant closure. It is clear from the analysis in Fig 27, which shows the four components of total cost, and Fig 28, which shows the composition of the plant's turnover, that the problem does not originate from revenues but from costs. The cost for factory workers is too high. This is the result of their low productivity which requires the plant to maintain a large number of workers in the factory (Fig 31). The solution is either to increase workers' productivity or to reduce labour cost: Both options were simulated. You may have to look for better staff; if you can find, you may have to increase the price.

PROFIT AND LOSS: graph

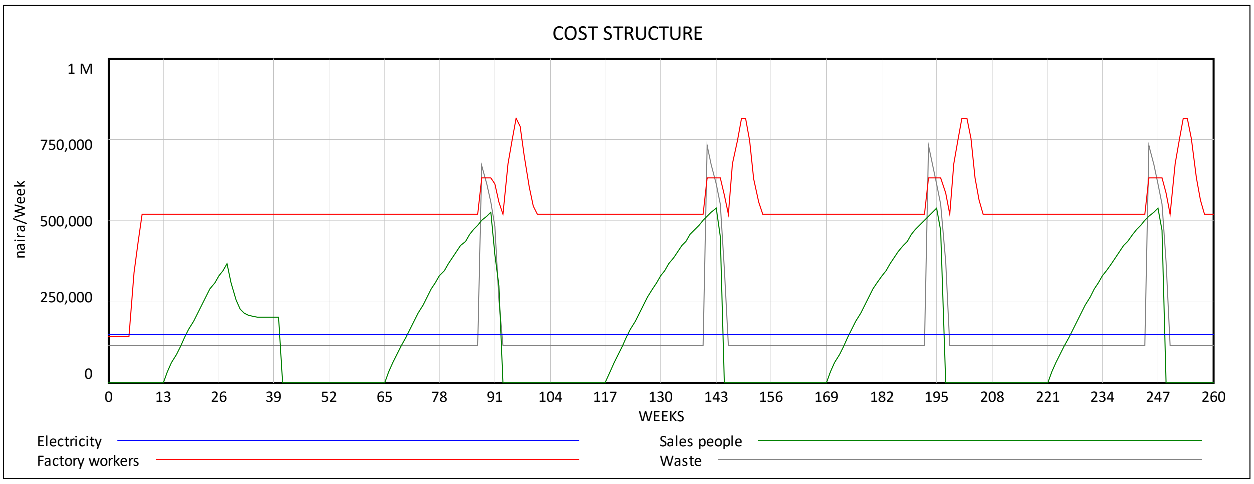
PROFIT AND LOSS: table

YEARLY GROSS PROFIT					
WEEK	52	104	156	208	260
TURNOVER	52.97 M	71.44 M	74.44 M	74.71 M	74.75 M
TOTAL COST	68.32 M	81.46 M	82.41 M	82.49 M	82.49 M
GROSS MARGIN	-15.36 M	-10.02 M	-7.965 M	-7.778 M	-7.742 M

Fig 26: Profit and loss; Base Simulation

Source: Simulation output, 2015

COST STRUCTURE: graph



COST STRUCTURE: table

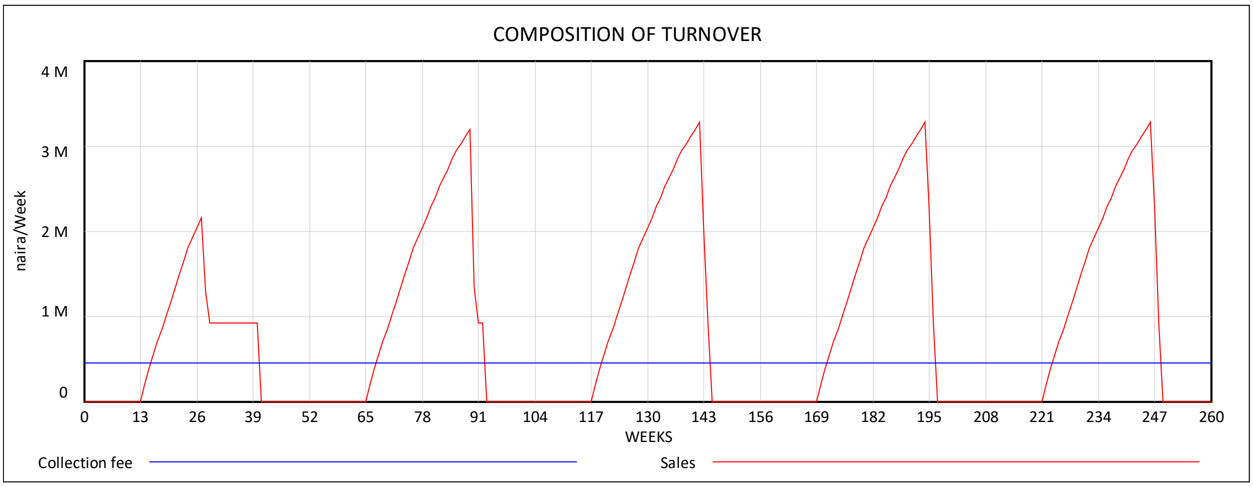
YEARLY COST STRUCTURE

WEEK	52	104	156	208	260
FACTORY WORKERS	24.49 M	28.72 M	28.87 M	28.89 M	28.89 M
SALES PEOPLE	5.737 M	8.403 M	8.700 M	8.719 M	8.719 M
ELECTRICITY	7.764 M	7.764 M	7.764 M	7.764 M	7.764 M
WASTE	5.85 M	7.861 M	8.203 M	8.225 M	8.225 M
TOTAL	43.84 M	52.75 M	53.54 M	53.60 M	53.60 M

Fig 27: Cost Structure; Base Simulation

Source: Simulation output, 2015

TURNOVER COMPOSITION: graph



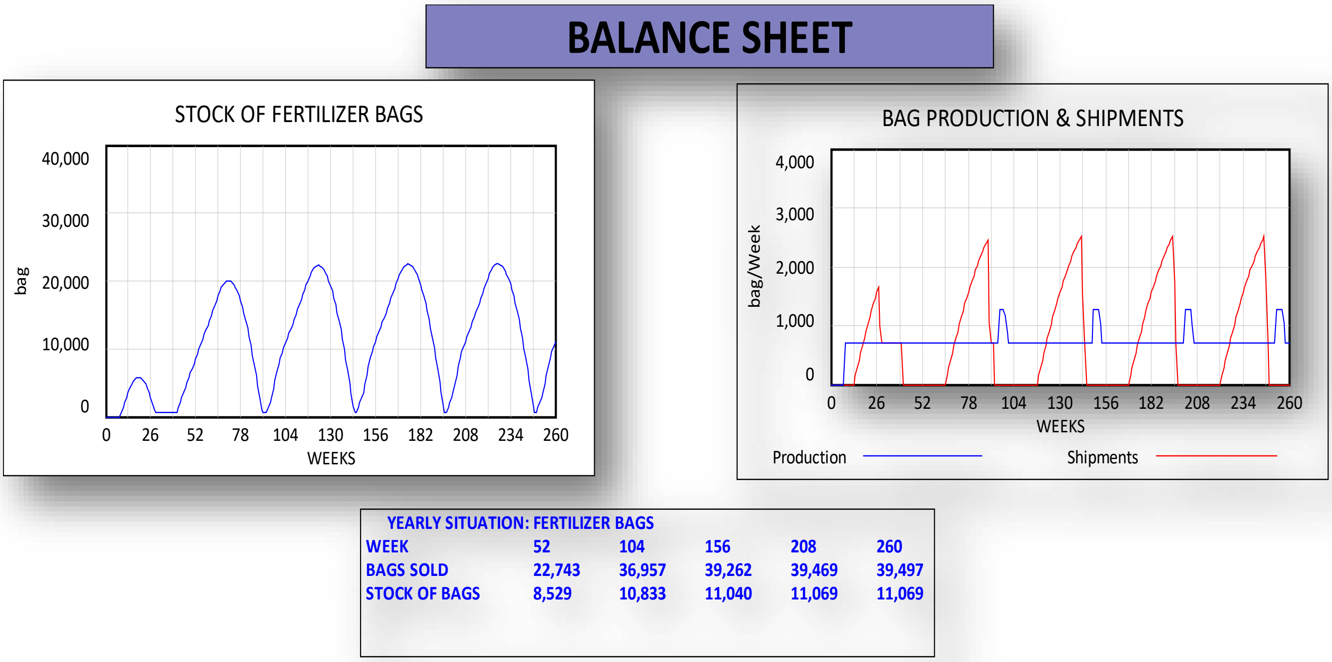
TURNOVER COMPOSITION:table

YEARLY TURNOVER COMPOSITION

WEEK	52	104	156	208	260
COLLECTION FEE	23.4 M	23.4 M	23.4 M	23.4 M	23.4 M
SALES	29.57 M	48.04 M	51.04 M	51.31 M	51.35 M
TOTAL	52.97 M	71.44 M	74.44 M	74.71 M	74.75 M

Fig 28: Turnover Composition; Base Simulation

Source: Simulation output, 2015



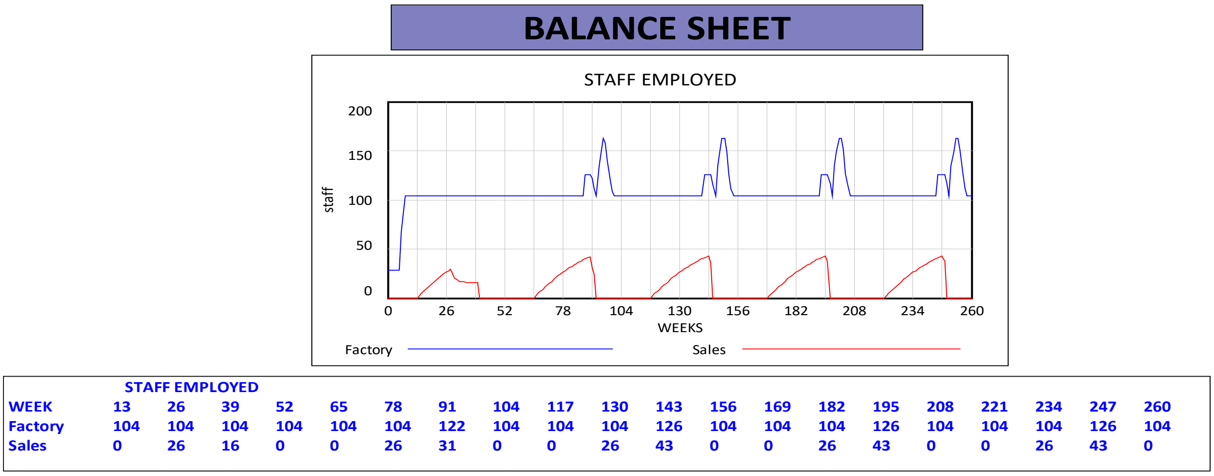
YEARLY SITUATION: FERTILIZER BAGS

WEEK	52	104	156	208	260
BAGS SOLD	22,743	36,957	39,262	39,469	39,497
STOCK OF BAGS	8,529	10,833	11,040	11,069	11,069

Fig 29: Stock of fertilizer bags, bag production and shipment; Base Simulation

Source: Simulation output, 2015

Fig 30 provides a detailed analysis of the production, sales and stock of fertilizer bags while Fig 33 details the production process from waste collection to the stock of processed mix. Fig 32 shows the impact on the plant’s bank balance of a persistently negative margin. Under the conditions set for the base simulation, the fertilizer plant cannot survive.

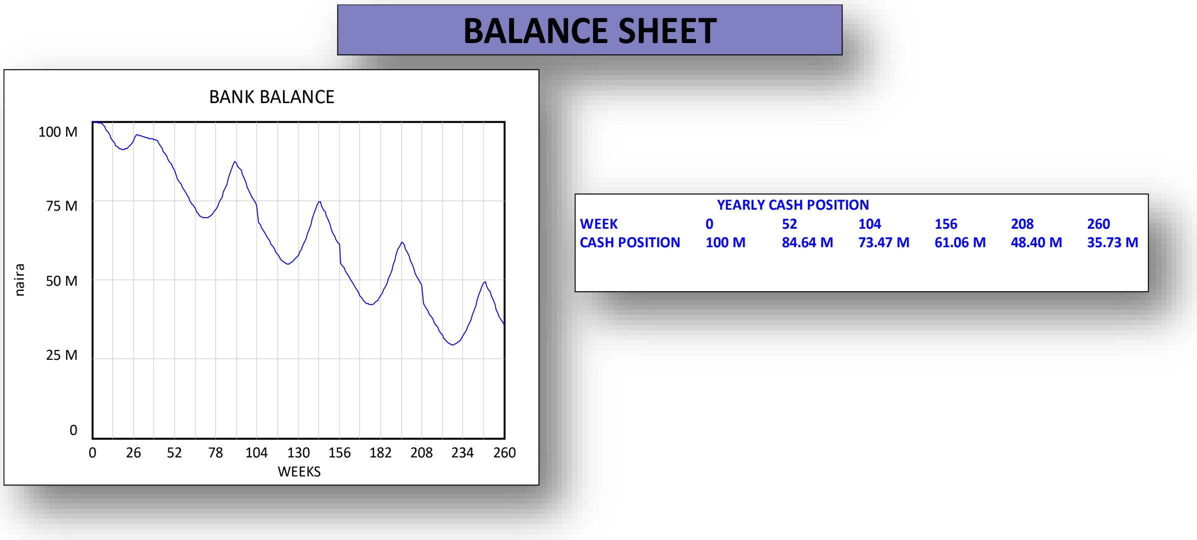


STAFF EMPLOYED

WEEK	13	26	39	52	65	78	91	104	117	130	143	156	169	182	195	208	221	234	247	260
Factory	104	104	104	104	104	104	122	104	104	104	126	104	104	104	126	104	104	104	126	104
Sales	0	26	16	0	0	26	31	0	0	26	43	0	0	26	43	0	0	26	43	0

Fig 30: Staff Employed; Base Simulation

Source: Simulation output, 2015



YEARLY CASH POSITION

WEEK	0	52	104	156	208	260
CASH POSITION	100 M	84.64 M	73.47 M	61.06 M	48.40 M	35.73 M

Fig 31: Bank Balance; Base Simulation

Source: Simulation output, 2015

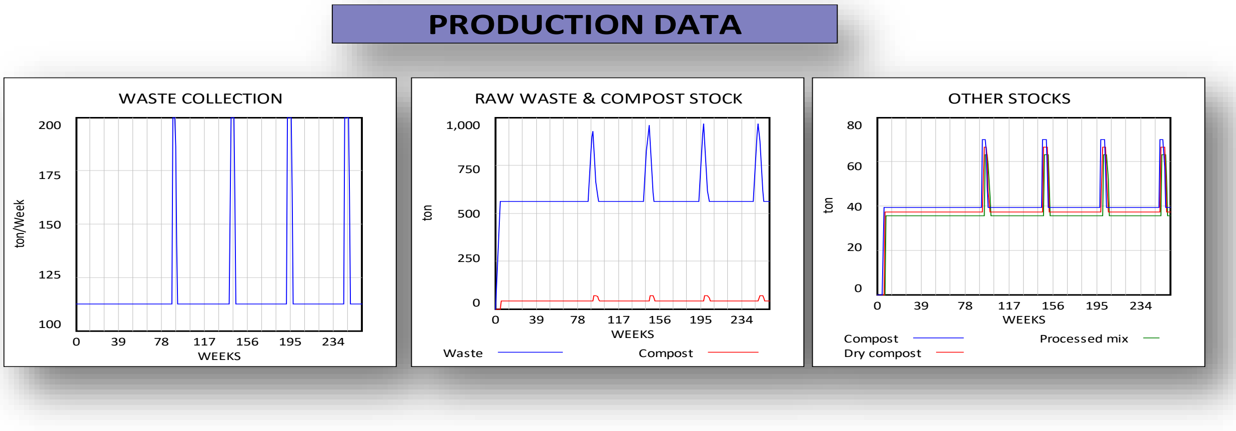


Fig 32: Production Data; Base Simulation

Source: Simulation output, 2015

Fig. 33 shows that the plant maintains a comfortable capacity margin, except for four brief periods of three weeks each (weeks 88-90, 141-143, 193-195 and 245-247) when, as a result of surges in sales, its collection capacity fells short of requirements.

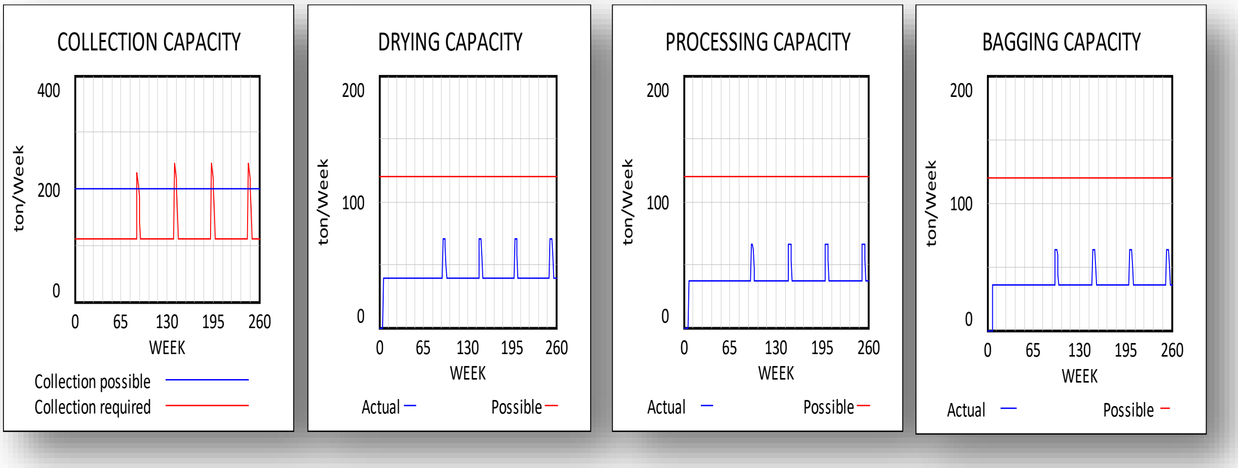


Fig 33: Fertilizer Plant Capacity; Base Simulation

Source: Simulation output, 2015

4.7.2. Justification for choice of simulations

1. The base simulation served as the basis or reference point for the remaining four. It is the starting point in the use of the system dynamics model. This simulation resulted in a loss because of high wages.

2. The second simulation, the first alternative simulation, is to see what happens with lower wages. Wages are cut by half and this results in the business now making money. With a much lower initial cash reserve of ₦5m.every year, the cash reserve keeps on increasing, unlike what happened with the base simulation.

3. In the 3rd selected scenario, the second alternative simulation, we want to know the robustness of cost changes. Waste collection cost is reduced from four thousand naira to three thousand naira while cost of purchasing is increased from four thousand to five thousand naira. The initial bank balance is now ₦10m. The result is that the gross margin is on the increase and the turnover stabilised throughout the period. The bank balance reduced sales, owing to the increase cost of fertilizer stock accumulated.

4. The fourth scenario, i.e the third alternative simulation, has to do with the impact of increased sales budget fraction. Any higher value of the same budget fraction will reduce profit. This resulted in the turnover coming down.

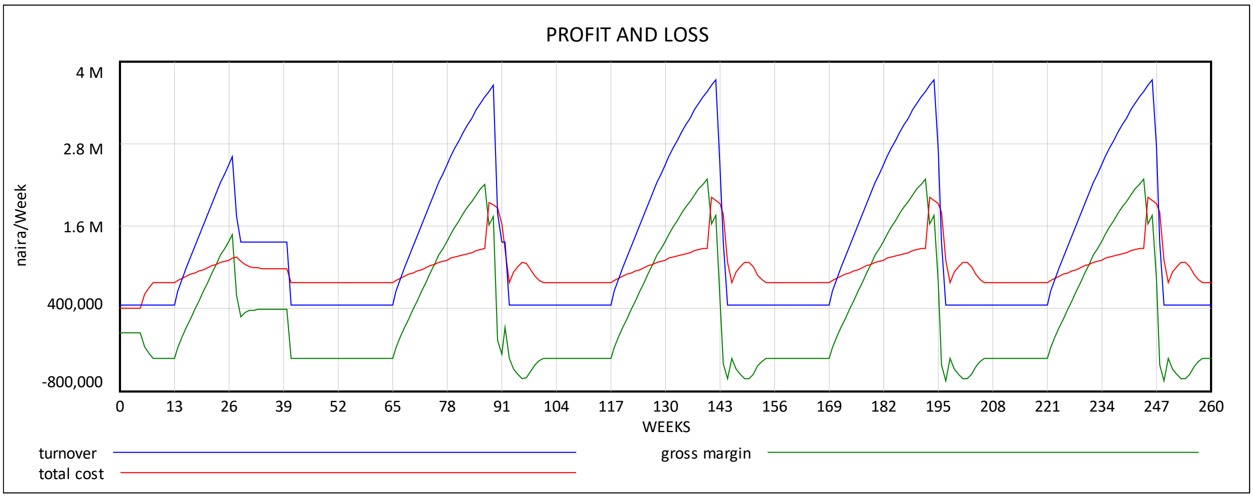
5. The fifth scenario, which is the fourth alternative simulation, has to do with the impact of reduced bag price from ₦1,300.00 to ₦1,100.00. Gross margin falls. Turnover also

falls while costs start increasing from the second year and continue that way. Gross margin increases marginally and remains constant throughout. More fertilizer bags were produced.

4.7.3 Reduction in Factory Staff Salary (by half) - First Scenario

The analysis of the base simulation of the fertilizer plant model suggests that the main obstacle to reaching profitability is likely to be the fact that factory labour costs are too high. There are two ways to correct this situation: either increase productivity or decrease costs. The easier option is to cut costs. This first alternative simulation, therefore, assumes that factory workers’ salaries are cut by half from ₦10,000 a week to ₦5,000. This is the only change in assumption from the base case, but it has a major impact: gross margin turns positive (Fig 34).

PROFIT AND LOSS: graph



PROFIT AND LOSS: table

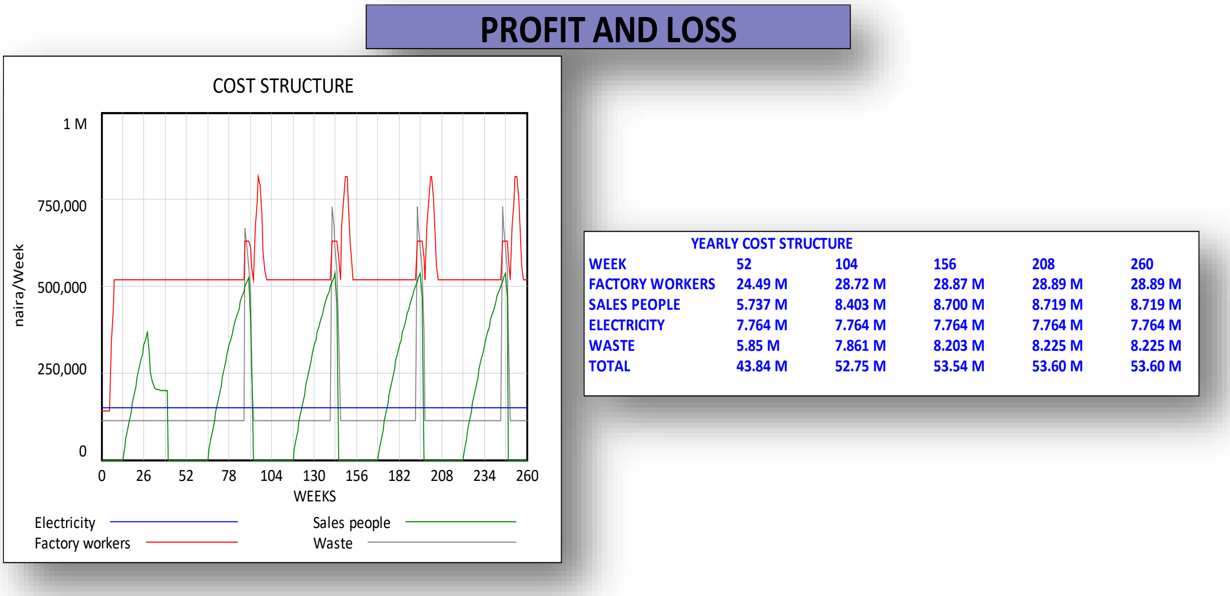
YEARLY GROSS PROFIT

WEEK	52	104	156	208	260
TURNOVER	52.97 M	71.44 M	74.44 M	74.71 M	74.75 M
TOTAL COST	43.84 M	52.75 M	53.54 M	53.60 M	53.60 M
GROSS MARGIN	9.129 M	18.70 M	20.90 M	21.11 M	21.15 M

Fig 34: Profit and loss; Reduction in factory staff salary

Source: Simulation output, 2015

Fig 34 and Table 24 compare yearly gross margin data of the base simulation to that of the present one. Fig. 35 shows the plant’s new cost structure. Table 36 compares factory workers’ cost data of the base simulation with that of the present one (All other costs are unchanged).



YEARLY COST STRUCTURE

WEEK	52	104	156	208	260
FACTORY WORKERS	24.49 M	28.72 M	28.87 M	28.89 M	28.89 M
SALES PEOPLE	5.737 M	8.403 M	8.700 M	8.719 M	8.719 M
ELECTRICITY	7.764 M	7.764 M	7.764 M	7.764 M	7.764 M
WASTE	5.85 M	7.861 M	8.203 M	8.225 M	8.225 M
TOTAL	43.84 M	52.75 M	53.54 M	53.60 M	53.60 M

Fig 35: Cost Structure; Reduction in factory staff salary

Source: Simulation output, 2015

Table 35: Yearly Gross Margin of the Base Simulation :First scenario

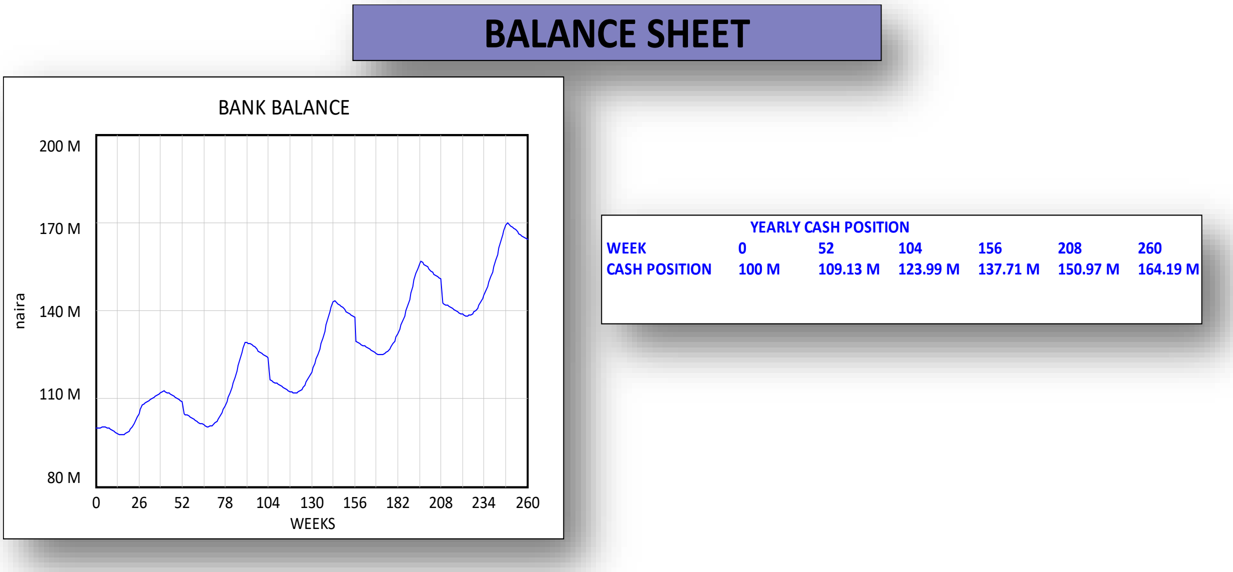
YEAR	1	2	3	4	5
BASE	₦15.4M	₦ 10.0M	₦8.0M	₦7.8M	₦7.7M
1st Scenario	₦9.1M	₦18.7M	₦20.9M	₦21.1M	₦21.1M

Table 36: Business Cost Structure with Factory Workers Salaries Cut By Half

YEAR	1	2	3	4	5
BASE	₦49.0M	₦57.4M	₦57.7M	₦57.8M	₦57.8M
PRESENT	₦24.5M	₦28.7M	₦28.9M	₦28.9M	₦28.9M

The only other variable which changes from the base case simulation is the plant's bank balance situation. Fig 36 and Table 37 illustrate the substantial long-term financial improvement which results from the reduction in factory workers' cost. Moreover, an analysis of weekly data (Table 38) indicates that the plant only experienced cash flow problems for 14 weeks (from week 8 to week 21) when cash reserves fell below ₦100 million and only to the extent of a maximum of ₦2.3 million.

The initial value of ₦100 million assumed for level BANK BALANCE is therefore much too high as an initial cash reserve of ₦5 million is more than enough to cover initial cash needs provided, as the model assumes, that there is no delay in payments. This is another significant financial improvement on the base case scenario.



YEARLY CASH POSITION

WEEK	0	52	104	156	208	260
CASH POSITION	100 M	109.13 M	123.99 M	137.71 M	150.97 M	164.19 M

Fig 36: Cost Structure; Reduction in factory staff salary

Source: Simulation output, 2015

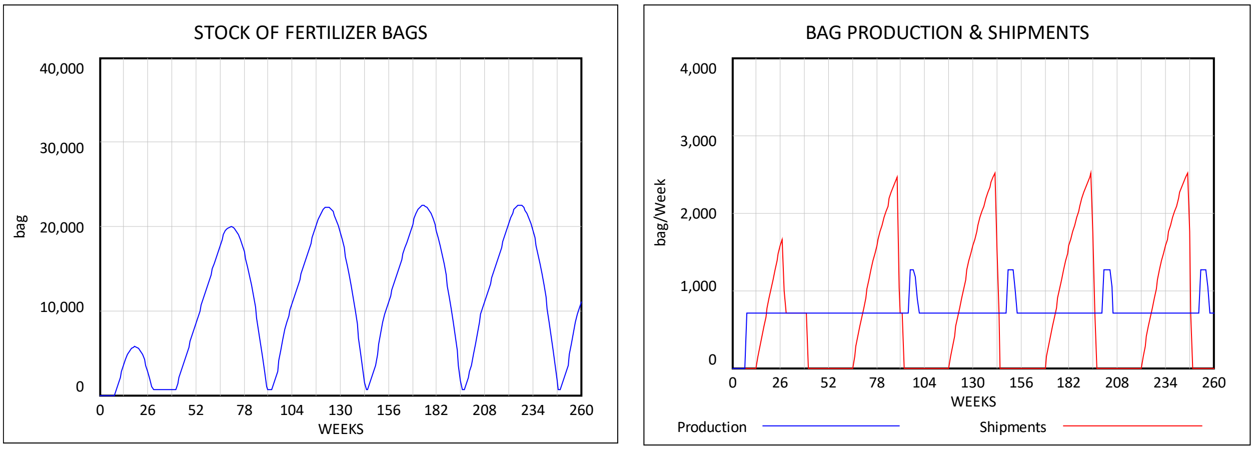
Table 37: Plant Bank Balance with Factory Workers Salaries Cut By Half

YEAR	1	2	3	4	5
BASE	49.0M	57.4M	57.7M	57.8M	57.8M
PRESENT	109.1M	124.0M	137.7M	151.0M	164.2M

Table 38: Comparison of Bank Balances

WEEK	BANK BALANCE
8	99.9
9	99.6
10	99.2
11	98.9
12	98.6
13	98.2
14	97.9
15	97.7
16	97.7
17	97.8
18	98.1
19	98.5
20	99.0
21	99.6

PRODUCTION, SHIPMENTS & STOCK OF FERTILIZER BAGS: graph



PLANT CAPACITIES

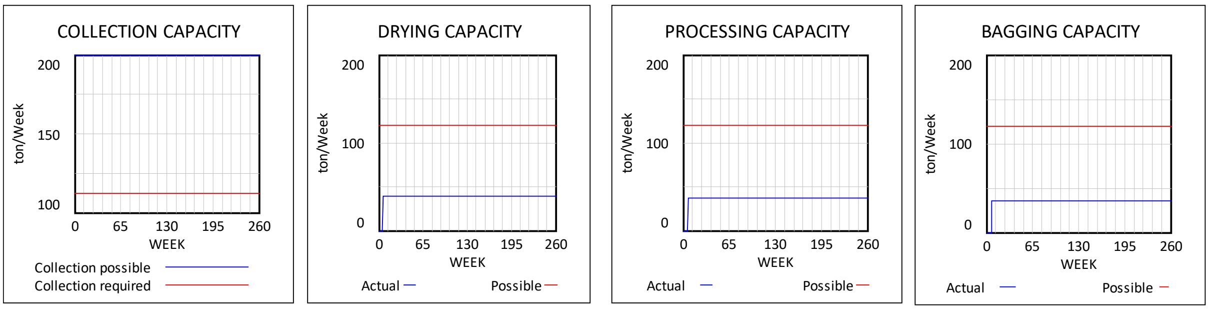


Fig 37: Plant Capacities; Reduction in factory staff salary

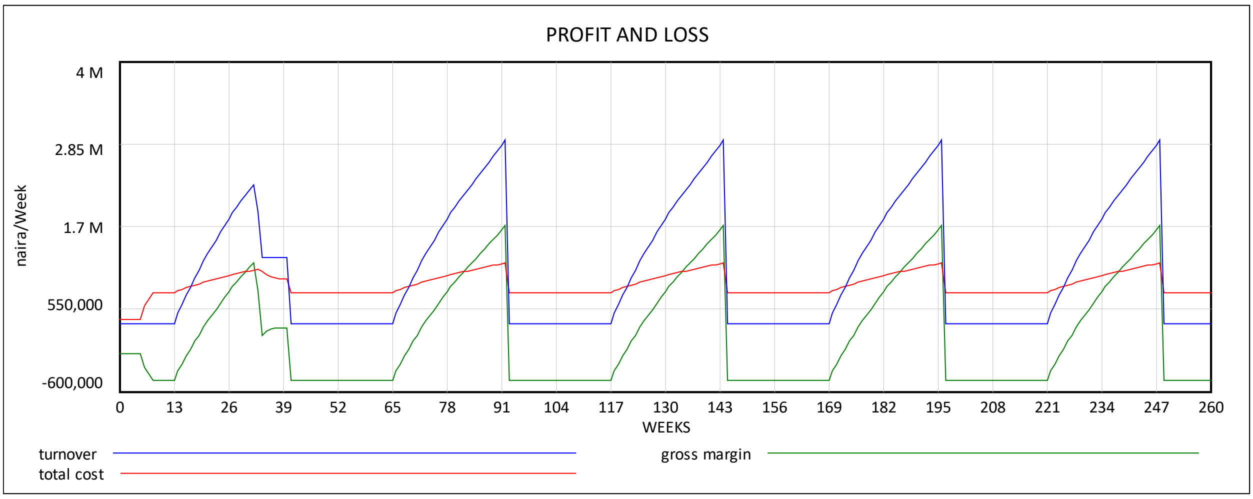
Source: Simulation output, 2015

4.7.4 Robustness in cost increase (Collection fees reduced by ₦1,000, waste cost increased by ₦1,000, initial bank balance at ₦10 million)

The first alternative simulation of the fertilizer plant model has demonstrated that good profitability can be attained (gross margin turns positive) if factory workers' salaries are cut by half from ₦10,000 a week to ₦5,000. It has also established that the initial value of ₦100 million arbitrarily assumed for level BANK BALANCE is much too high. An initial bank balance of ₦5 million is more than enough to cover cash requirements provided there are no delayed payments.

The second alternative simulation of the fertilizer plant model is aimed at testing the project's robustness in respect of costs. To that effect, it is assumed that the unit collection fee paid to the plant per ton of chicken excreta collected is reduced from ₦4,000 to ₦3,000 while the unit collection cost incurred by the plant to buy a ton of chicken excreta is increased from ₦4,000 to ₦5,000. In addition, the changes in assumption in the first alternative simulation (lower factory worker salaries and initial cash reserve) are conserved. Profit and loss data are shown in Fig 39.

PROFIT AND LOSS: graph



PROFIT AND LOSS: table

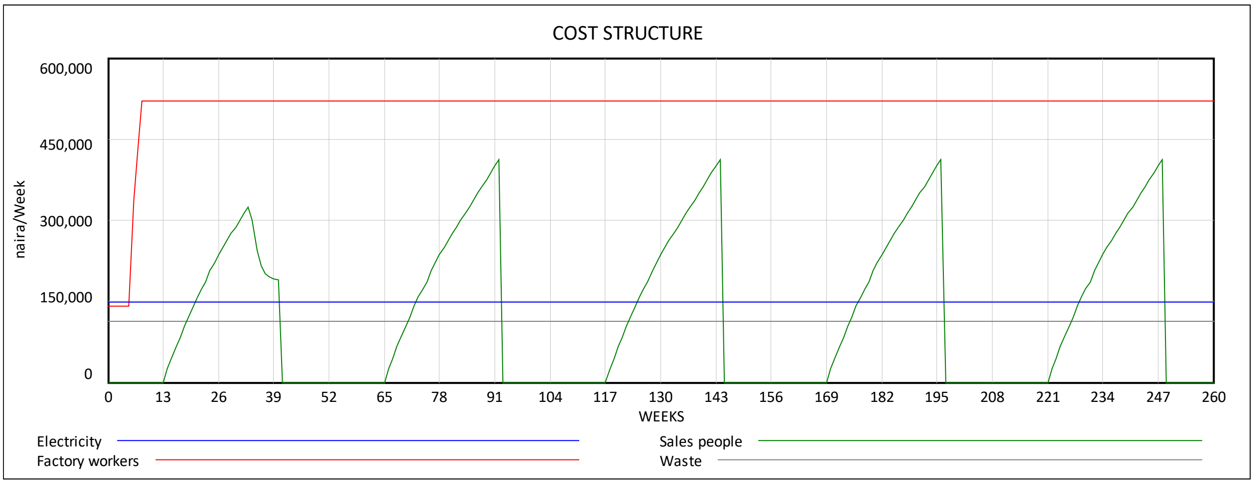
YEARLY GROSS PROFIT

WEEK	52	104	156	208	260
TURNOVER	47.12 M	57.49 M	57.49 M	57.49 M	57.49 M
TOTAL COST	43.41 M	47.05 M	47.05 M	47.05 M	47.05 M
GROSS MARGIN	3.706 M	10.44 M	10.44 M	10.44 M	10.44 M

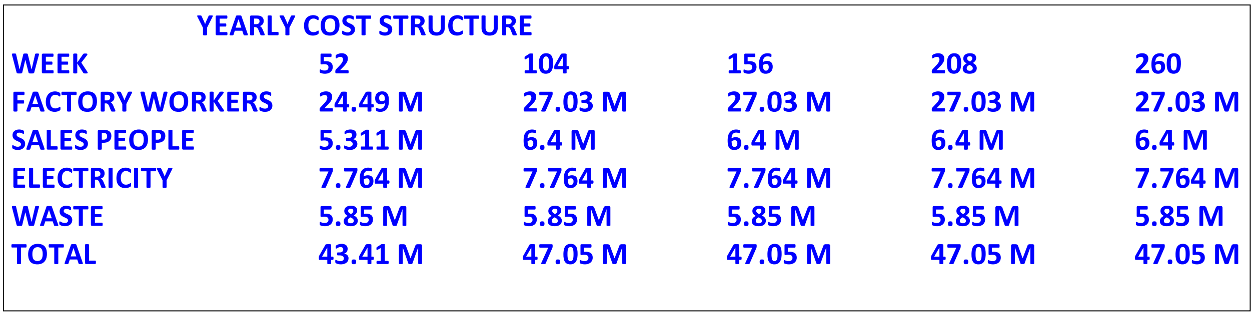
Fig 38: Profit and loss; Robustness to cost increase

Source: Simulation output, 2015

COST STRUCTURE: graph



COST STRUCTURE: table



YEARLY COST STRUCTURE

WEEK	52	104	156	208	260
FACTORY WORKERS	24.49 M	27.03 M	27.03 M	27.03 M	27.03 M
SALES PEOPLE	5.311 M	6.4 M	6.4 M	6.4 M	6.4 M
ELECTRICITY	7.764 M	7.764 M	7.764 M	7.764 M	7.764 M
WASTE	5.85 M	5.85 M	5.85 M	5.85 M	5.85 M
TOTAL	43.41 M	47.05 M	47.05 M	47.05 M	47.05 M

Fig 39: Cost structure; Robustness to cost increase

Source: Simulation output, 2015

Table 39 compares yearly gross margins in the first and second alternative simulations. The plant can cope with significant cost increases and gross margin continues to be positive. As would be expected, however, profit falls: it is reduced by about half.

Fig 39 shows the plant's modified cost structure. All costs, except electricity costs, change as higher unit cost and lower unit fee reduce activity. Tables 40 to 43 compare individual cost data in the first and second alternative simulations. The most striking difference between both simulations is the absence of peaks of activity and of extra waste purchases (and, therefore, processing) in the second simulation.

Table 39: Yearly Gross Margins in the First and Second Alternative Simulations.

YEAR	1	2	3	4	5
PREVIOUS	9.1M	18.7M	20.9M	21.1M	21.1M
PRESENT	3.7M	10.4M	10.4M	10.4M	10.4M

Table 40: Cost Structure with Reduced Collection Fee and Increased Collection Cost

YEAR	1	2	3	4	5
PREVIOUS	24.5M	28.7M	28.9M	28.9M	28.9M
PRESENT	24.5M	27M	27M	27M	27M

Table 41: Comparison of Factory Workers Cost

YEAR	1	2	3	4	5
PREVIOUS	5.7M	8.4M	8.7M	8.7M	8.7M
PRESENT	5.3M	6.4M	6.4M	6.4M	6.4M

Table 42: Comparison of Sales People's Cost

YEAR	1	2	3	4	5
PREVIOUS	5.8M	7.9M	8.2M	8.2M	8.2M
PRESENT	5.8M	5.8M	5.8M	5.8M	5.8M

Table 43: Comparison of Waste Cost

YEAR	1	2	3	4	5
PREVIOUS	43.8M	52.7M	53.5M	53.6M	53.6M
PRESENT	43.4M	47.1M	47.1M	47.1M	47.1M

Table 44: Comparison of Total Plant Cost

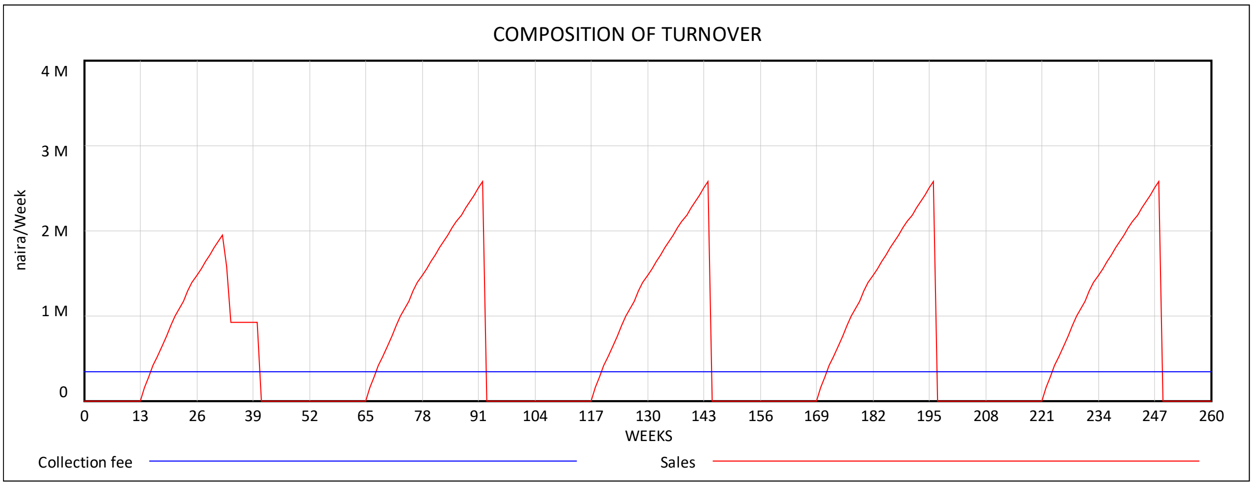
YEAR	1	2	3	4	5
BASE	29.6M	48M	51M	51M	51M
PRESENT	29.6M	39.9M	39.9M	39.9M	39.9M

Table 45: Comparison of Sales Revenue

YEAR	1	2	3	4	5
BASE	53M	71.4M	74.4M	74.7M	74.7M
PRESENT	47.1M	57.5M	57.5M	57.5M	57.5M

The decrease in collection fee from ₦23.4 million to ₦17.6 million has both a direct negative impact on turnover and an indirect one through the reduction in sales budget and, therefore, in sales (Fig. 41). Tables 44 and 45 respectively show the reduction in sales and total turnover from the base case simulation.

TURNOVER COMPOSITION: graph



TURNOVER COMPOSITION:table

YEARLY TURNOVER COMPOSITION

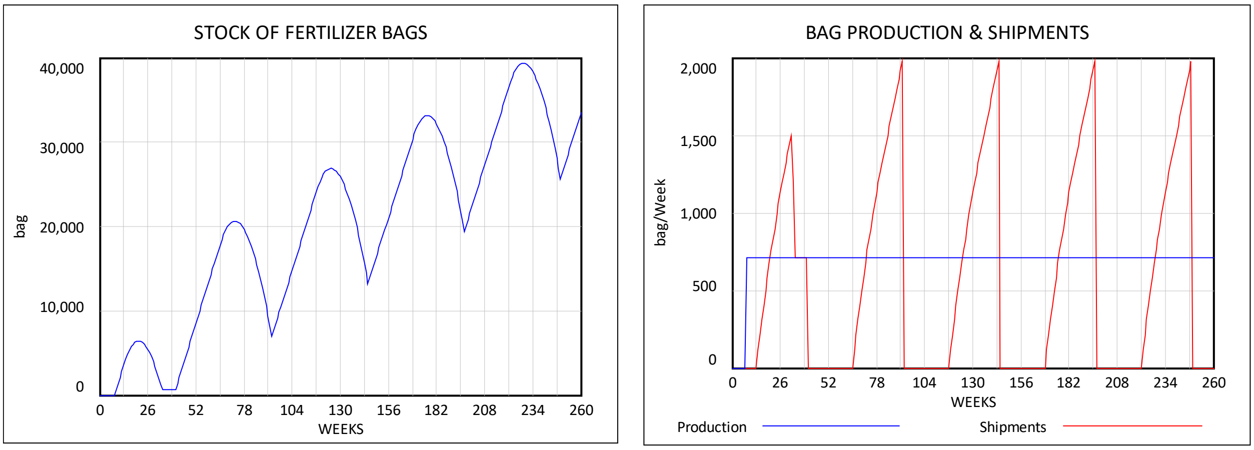
WEEK	52	104	156	208	260
COLLECTION FEE	17.55 M	17.55 M	17.55 M	17.55 M	17.55 M
SALES	29.57 M	39.94 M	39.94 M	39.94 M	39.94 M
TOTAL	47.12 M	57.49 M	57.49 M	57.49 M	57.49 M

Fig 40: Turnover composition; Robustness to cost increase

Source: Simulation output, 2015

As a result of the combined impact of lower sales and an unchanged waste collection system, the gap between production and shipments grows and fertilizer bags accumulate in the plant (Fig. 41). At the end of the 5 year period, the plant has 33,500 bags in stock as opposed to 11,100 in the base simulation. The reduction in activity is also reflected on employment (Fig. 42).

PRODUCTION, SHIPMENTS & STOCK OF FERTILIZER BAGS: graph



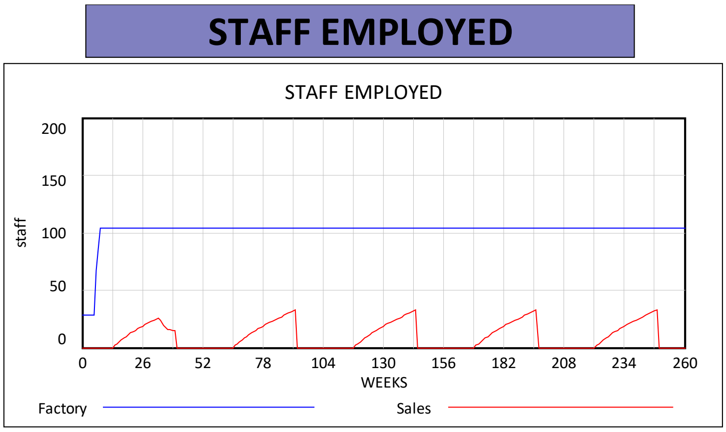
PRODUCTION, SHIPMENTS & STOCK OF FERTILIZER BAGS: table

YEARLY SITUATION: FERTILIZER BAGS

WEEK	52	104	156	208	260
BAGS SOLD	22,743	30,720	30,720	30,720	30,720
STOCK OF BAGS	8,529	14,766	21,003	27,241	33,478

Fig 41: Production, Shipments and Stock of Fertilizer Bags; Robustness to cost increase

Source: Simulation output, 2015



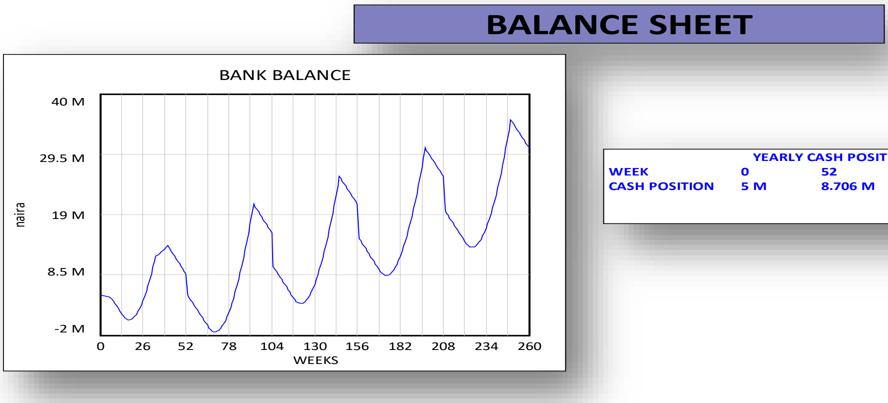
STAFF EMPLOYED

WEEK	13	26	39	52	65	78	91	104	117	130	143	156	169	182	195	208	221	234	247	260
Factory	104	104	104	104	104	104	104	104	104	104	104	104	104	104	104	104	104	104	104	104
Sales	0	19	15	0	0	19	32	0	0	19	32	0	0	19	32	0	0	19	32	0

Fig 42: Staff Employed; Robustness to cost increase

Source: Simulation output, 2015

The major difference between the present simulation and the base case is that the number of factory workers employed is constant throughout the period (no peak hiring) while peak hiring of sales personnel reduces. As a result of persistently positive yearly profits, the plant's bank balance grows but the overall increase is about halved (Fig 44). With an initial cash reserve of ₦5 million, however, the plant experiences wide cash fluctuations and cash flow problems as a result of reduced activity (Fig 45).



YEARLY CASH POSITION

WEEK	0	52	104	156	208	260
CASH POSITION	5 M	8.706 M	15.92 M	20.81 M	25.71 M	30.60 M

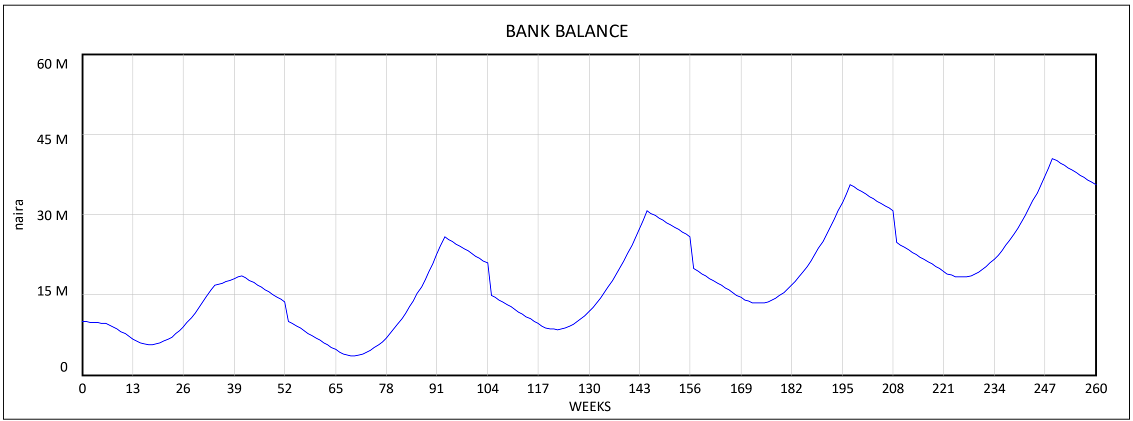
Fig 43: Bank Balance; Robustness to cost increase

Source: Simulation output, 2015

Table 46: Plant Bank Balance with Reduced Collection Fee, Increased Collection Cost and Initial Cash Reserve of ₦5 Million

WEEK	BANK BALANCE
0	5
18	.69
28	5.7
41	13.6
70	-1.37
82	5.5
93	20.8
122	3.5
146	25.2
174	8.4
197	30.6
226	13.3
249	35.5
260	30.6

BANK BALANCE:graph



BANK BALANCE:table

	YEARLY CASH POSITION					
WEEK	**0**	**52**	**104**	**156**	**208**	**260**
CASH POSITION	**10 M**	**13.71 M**	**20.92 M**	**25.81 M**	**30.71 M**	**35.60 M**

Fig 44: Bank Balance; Robustness to cost increase

Source: Simulation output, 2015

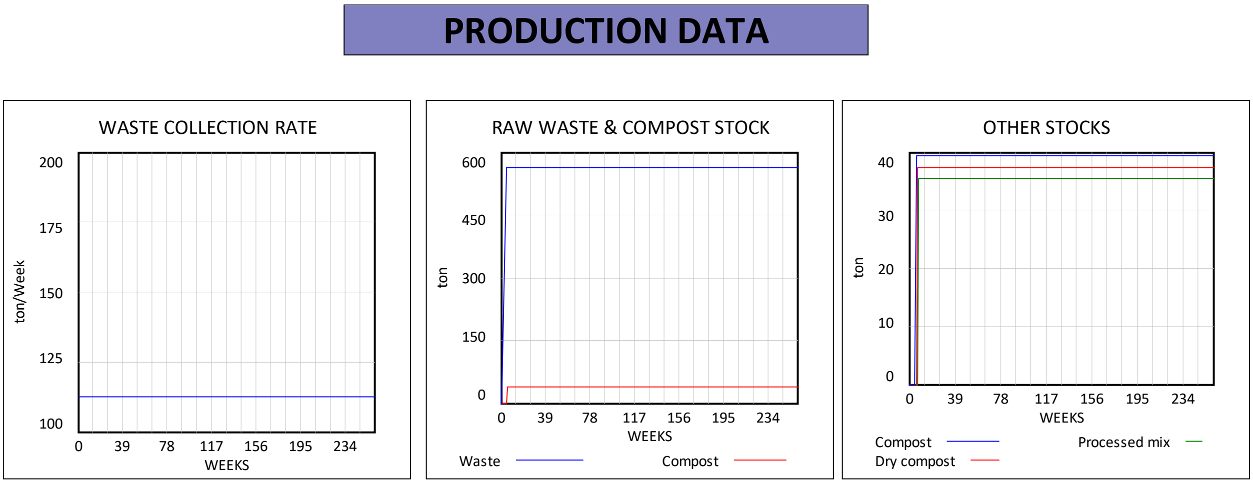


Fig 45: Production Data; Robustness to cost increase

Source: Simulation output, 2015

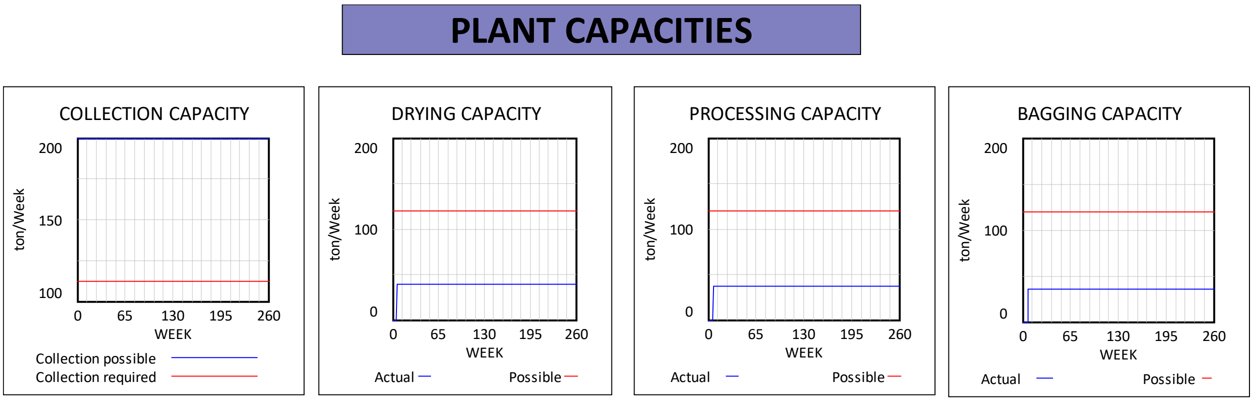


Fig 46: Plant capacities; Robustness to cost increase

Source: Simulation output, 2015

The plant can cope with significant cost increases, and gross margin continues to be positive. As would be expected, however, profit falls: it is reduced by about half. Fig. 15 shows the plant’s modified cost structure. All costs, except electricity cost, change as higher unit cost and lower unit fee reduce activity.

Tables 30 to 33 compare individual cost data in the first and second alternative simulations. The most striking difference between both simulations is the absence of peaks of activity and of extra chicken excreta purchases (and, therefore, processing) in the second simulation. The decrease in collection fee from ₦23.4 million to ₦17.6 million has both a direct negative impact on turnover and an indirect one through the reduction in sales budget and, therefore, in sales (Fig 16).

As a result of the combined impact of lower sales and an unchanged waste collection programme, the gap between production and shipments grows and fertilizer bags accumulate in the plant (Fig 17). At the end of the 5 year period, the plant has 33,500 bags in stock as opposed to 11,100 in the base simulation.

The reduction in activity also reflects on employment (Fig 18). The major difference between the present simulation and the base case is that the number of factory workers employed is constant throughout the period (no peak hiring) while peak hiring of sales personnel reduces.

As a result of persistently positive yearly profits, the plant's bank balance grows but the overall increase is about halved (Fig 19). With an initial cash reserve of ₦5 million, however, the plant experiences wide cash fluctuations and cash flow problems as a result of reduced activity (Fig 20). The problem is resolved by increasing the plant's initial bank balance to ₦10 million (Fig 21). (Table 11: plant bank balance with reduced collection fee, increased collection cost and initial cash reserve of ₦10 million) The last impact of a reduced activity level is to free capacities. In contrast with the base simulation, the second alternative simulation does not show any sign of capacity constraint in any of the plant's segments.

4.7.5 Impact of increased sales budget fraction (same assumptions as 3 with sales budget fraction at 15.5%. Any higher value reduces profit)

PROFIT AND LOSS: graph

PROFIT AND LOSS: table

YEARLY GROSS PROFIT

WEEK	52	104	156	208	260
TURNOVER	47.12 M	65.59 M	68.98 M	68.47 M	69.15 M
TOTAL COST	43.67 M	53.54 M	53.80 M	54.31 M	53.80 M
GROSS MARGIN	3.441 M	12.05 M	15.18 M	14.16 M	15.35 M

Fig 47: Profit and loss; Impact of increased sales budget fraction

Source: Simulation output, 2015

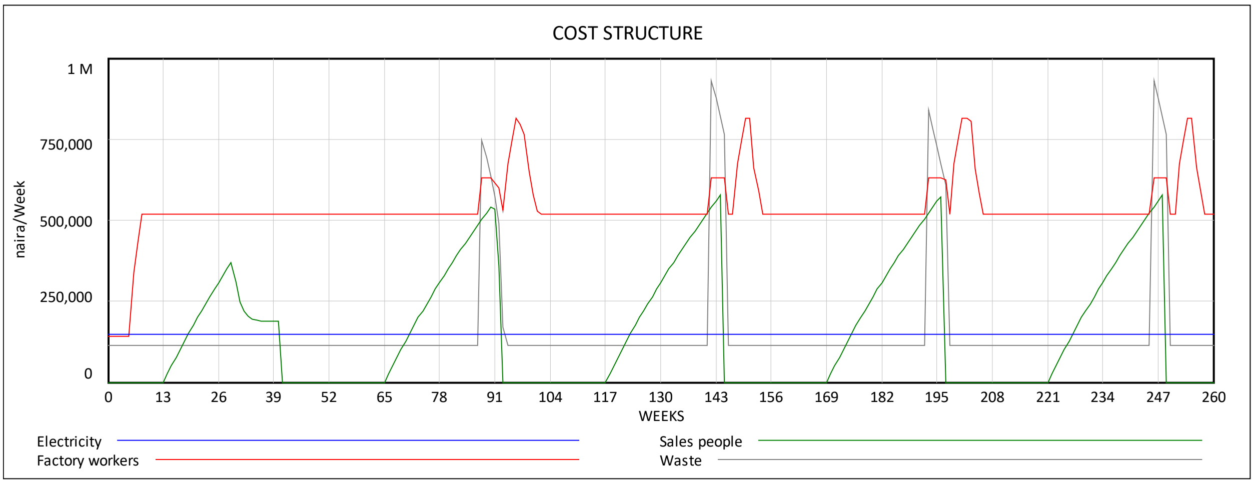
The fourth scenario, i.e the third alternative simulation, has to do with the impact of increased sales budget fraction. Any higher value of the same budget fraction will reduce profit. This resulted in the turnover coming down.

Table 47: Comparison of Gross Margin

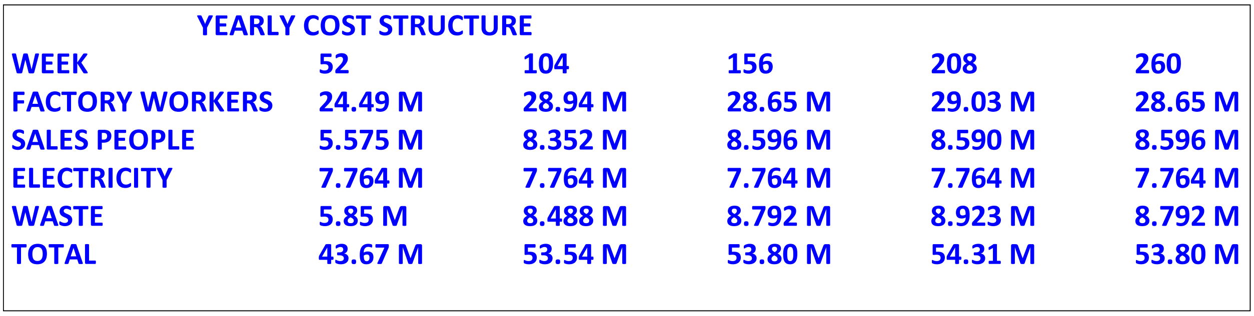
YEAR	1	2	3	4	5
PREVIOUS	3.706.M	10.44M	10.44M	10.44M	10.44M
PRESENT	3.44M	12.1M	15.18M	14.16M	15.35M

Yearly gross margin in the third alternative simulation with the fourth alternative simulation. The plant can cope with marginal increases in budget fraction from scenario 3 and 4 (15% to15.50%). Gross margin continues to be positive even despite the increased in budget faction as compared to the third scenario; the turnover continued to be positive.

COST STRUCTURE: graph



COST STRUCTURE: table



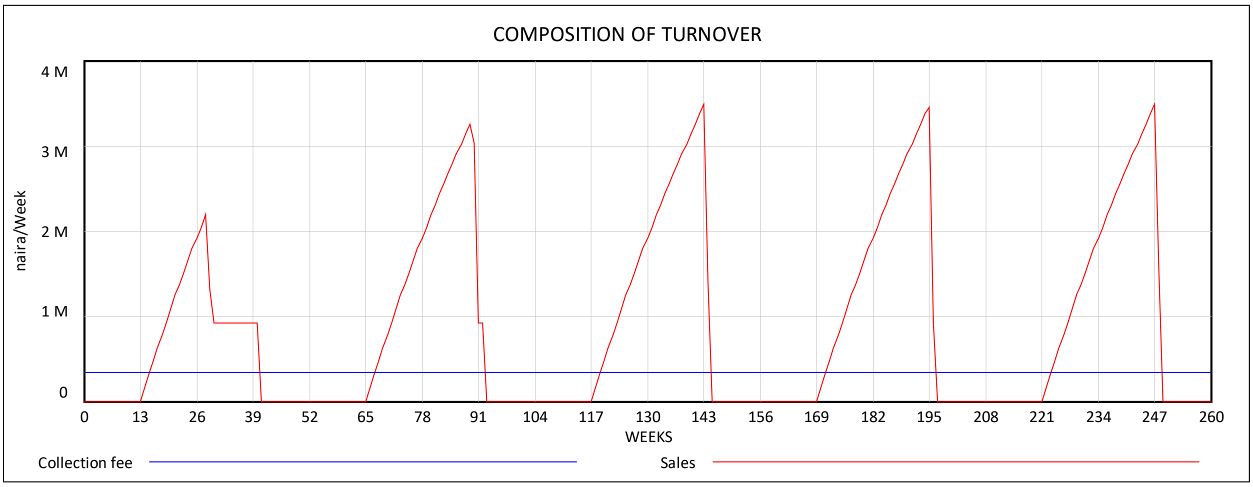
YEARLY COST STRUCTURE

WEEK	52	104	156	208	260
FACTORY WORKERS	24.49 M	28.94 M	28.65 M	29.03 M	28.65 M
SALES PEOPLE	5.575 M	8.352 M	8.596 M	8.590 M	8.596 M
ELECTRICITY	7.764 M	7.764 M	7.764 M	7.764 M	7.764 M
WASTE	5.85 M	8.488 M	8.792 M	8.923 M	8.792 M
TOTAL	43.67 M	53.54 M	53.80 M	54.31 M	53.80 M

Fig 48: Cost structure; Impact of increased sales budget fraction

Source: Simulation output, 2015

TURNOVER COMPOSITION: graph



TURNOVER COMPOSITION:table

YEARLY TURNOVER COMPOSITION

WEEK	**52**	**104**	**156**	**208**	**260**
COLLECTION FEE	**17.55 M**	**17.55 M**	**17.55 M**	**17.55 M**	**17.55 M**
SALES	**29.57 M**	**48.04 M**	**51.43 M**	**50.92 M**	**51.60 M**
TOTAL	**47.12 M**	**65.59 M**	**68.98 M**	**68.47 M**	**69.15 M**

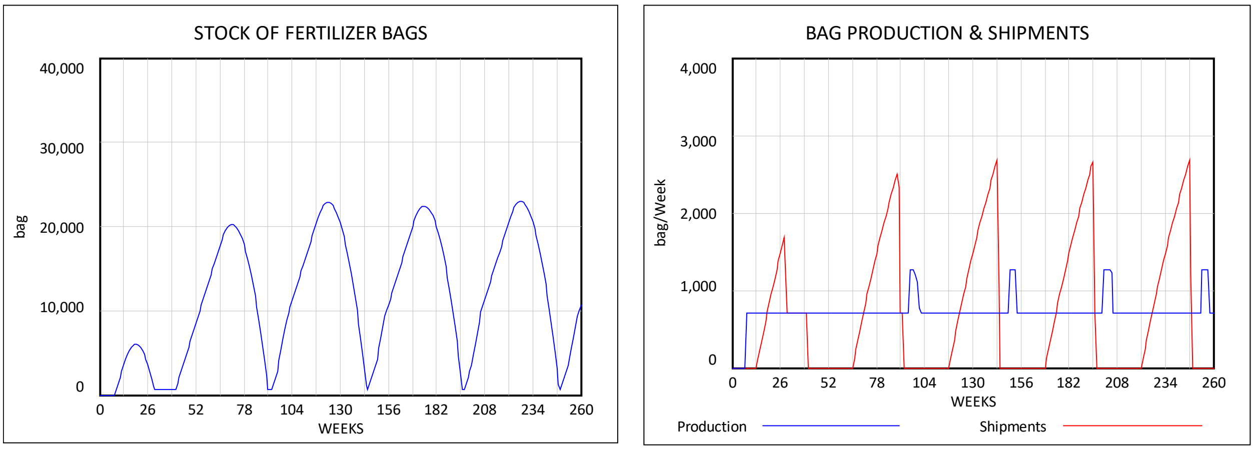
Fig 49: Turnover composition; Impact of increased sales budget fraction

Source: Simulation output, 2015

Table 48: Comparison of Turnover

YEAR	1	2	3	4	5
PREVIOUS	₦47.12M	₦57.49M	₦57.49M	₦57.49M	₦57.49M
PRESENT	₦47.12M	₦65.59M	₦68.98M	₦68.47M	₦69.15M

PRODUCTION, SHIPMENTS & STOCK OF FERTILIZER BAGS: graph



PRODUCTION, SHIPMENTS & STOCK OF FERTILIZER BAGS: table

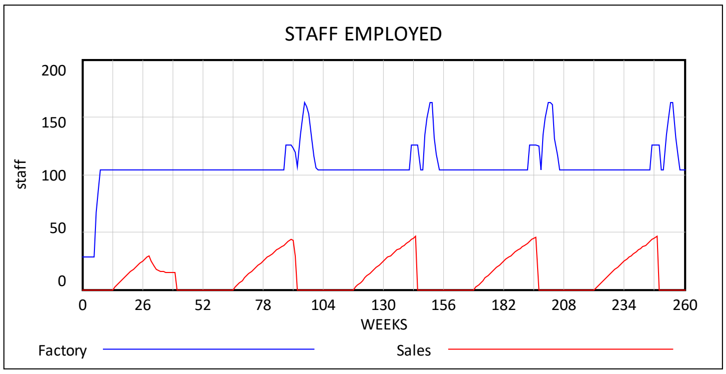
YEARLY SITUATION: FERTILIZER BAGS

WEEK	52	104	156	208	260
BAGS SOLD	22,743	36,957	39,561	39,168	39,690
STOCK OF BAGS	8,529	11,132	10,740	11,261	10,740

Fig 50: Production, shipments and stock of fertilizers bags; Impact of increased sales budget fraction

Source: Simulation output, 2015.

STAFF EMPLOYED



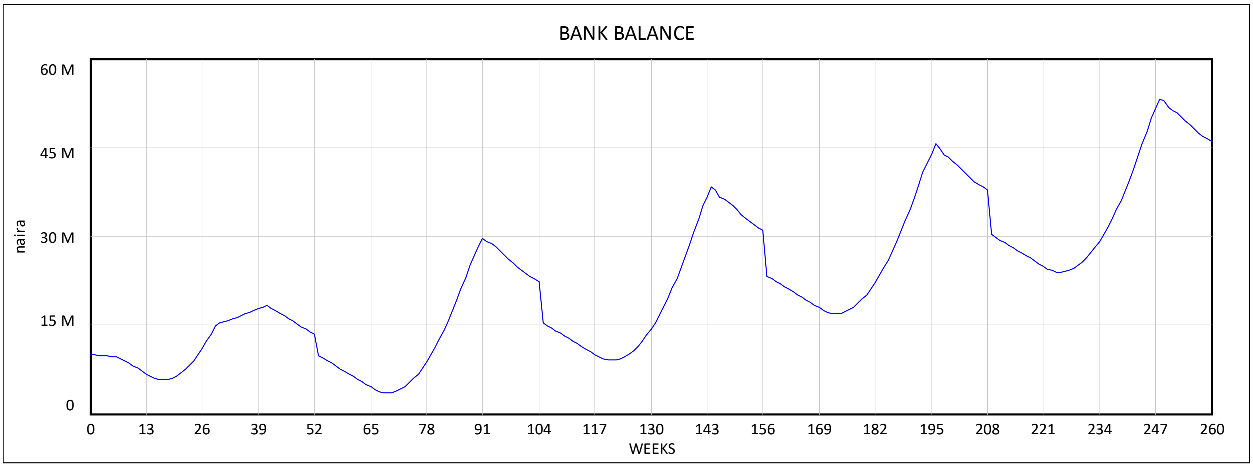
STAFF EMPLOYED

WEEK	13	26	39	52	65	78	91	104	117	130	143	156	169	182	195	208	221	234	247	260
Factory	104	104	104	104	104	104	123	104	104	104	126	104	104	104	126	104	104	104	126	104
Sales	0	25	15	0	0	25	43	0	0	25	45	0	0	25	45	0	0	25	45	0

Fig 51: Staff employed; Impact of increased sales budget fraction

Source: Simulation output, 2015

BANK BALANCE: graph



BANK BALANCE: table

YEARLY CASH POSITION

WEEK	**0**	**52**	**104**	**156**	**208**	**260**
CASH POSITION	**10 M**	**13.44 M**	**22.36 M**	**31.01 M**	**37.87 M**	**46.06 M**

Fig 52: Bank balance; Impact of increased sales budget fraction

Source: Simulation output, 2015

PRODUCTION DATA

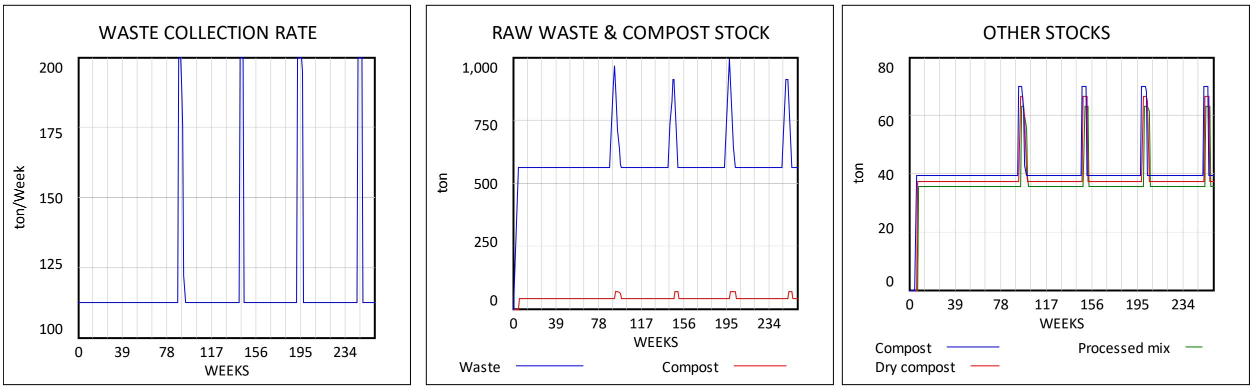


Fig 53: Production data; Impact of increased sales budget fraction

Source: Simulation output, 2015

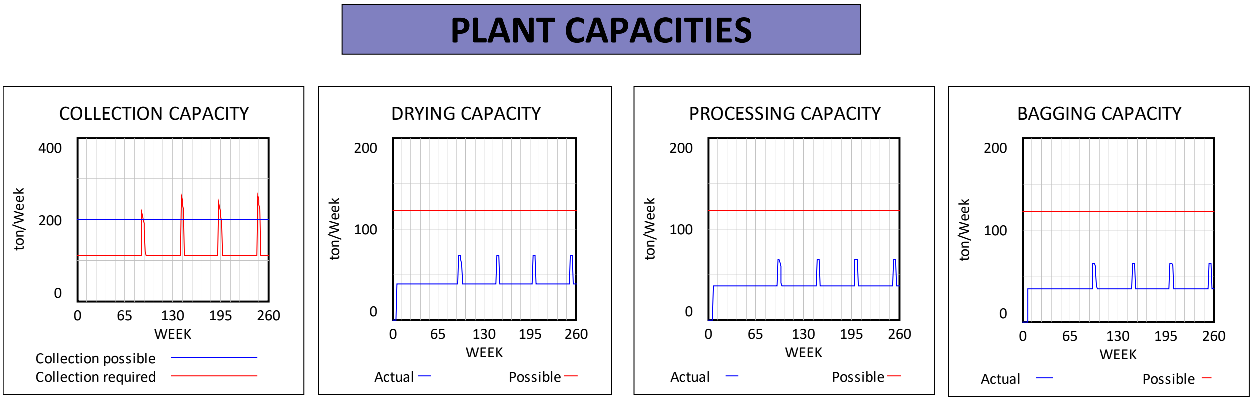


Fig 54: Plant capacities; Impact of increased sales budget fraction

Source: Simulation output, 2015

After the first year in the previous scenario, the turnover is the same throughout while the present turnover continues to increase.

With the increase in budget fraction, there is a steady increase in the cost of acquiring chicken excreta. If this continues, it will decrease or erode the profit margin accruing to the organic fertilizer plant.

4.7.6 Impact of reduced bag price (from ₦1,300 to ₦1,100 with data from simulation 2)

PROFIT AND LOSS: graph

PROFIT AND LOSS: table

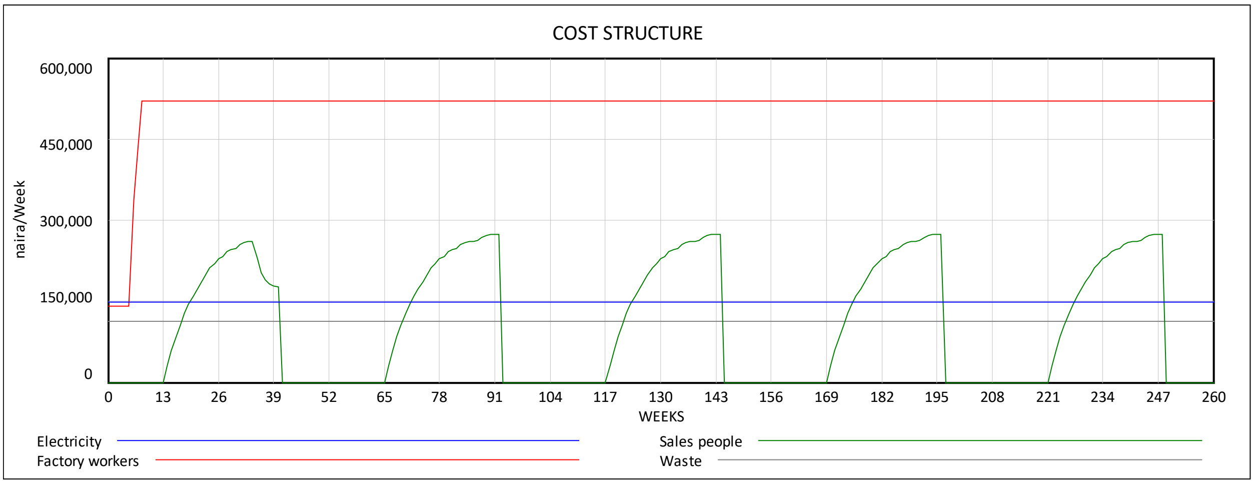
YEARLY GROSS PROFIT

WEEK	52	104	156	208	260
TURNOVER	48.42 M	52.77 M	52.77 M	52.77 M	52.77 M
TOTAL COST	43.20 M	46.21 M	46.21 M	46.21 M	46.21 M
GROSS MARGIN	5.220 M	6.563 M	6.563 M	6.563 M	6.563 M

Fig 55: Profit and loss; Impact of reduced bag price

Source: Simulation output, 2015

COST STRUCTURE: graph



COST STRUCTURE: table

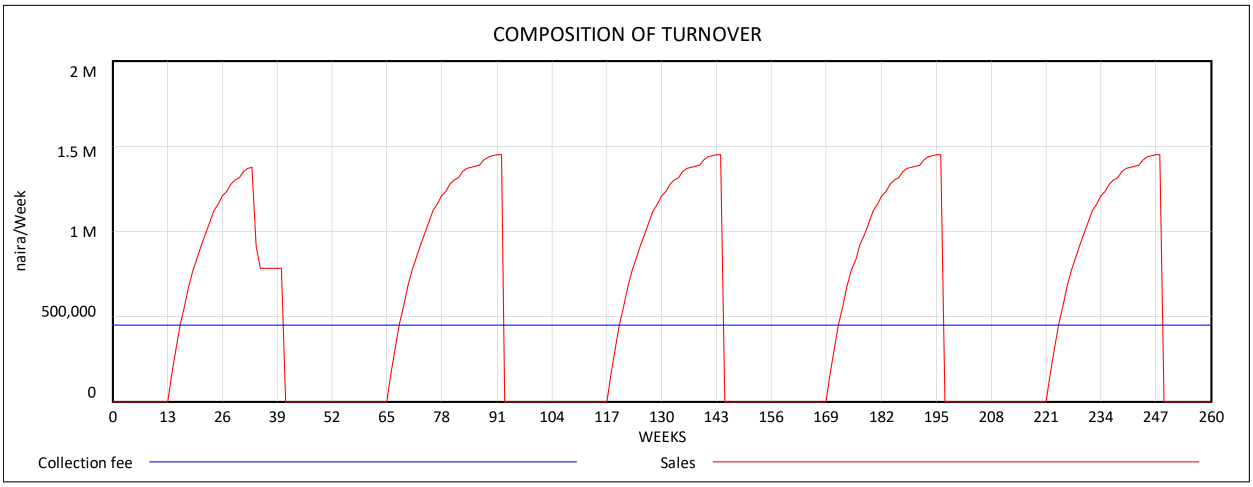
YEARLY COST STRUCTURE

WEEK	52	104	156	208	260
FACTORY WORKERS	24.49 M	27.03 M	27.03 M	27.03 M	27.03 M
SALES PEOPLE	5.098 M	5.563 M	5.563 M	5.563 M	5.563 M
ELECTRICITY	7.764 M	7.764 M	7.764 M	7.764 M	7.764 M
WASTE	5.85 M	5.85 M	5.85 M	5.85 M	5.85 M
TOTAL	43.20 M	46.21 M	46.21 M	46.21 M	46.21 M

Fig 56: Cost Structure; Impact of reduced bag price

Source: Simulation output, 2015

TURNOVER COMPOSITION: graph



TURNOVER COMPOSITION:table

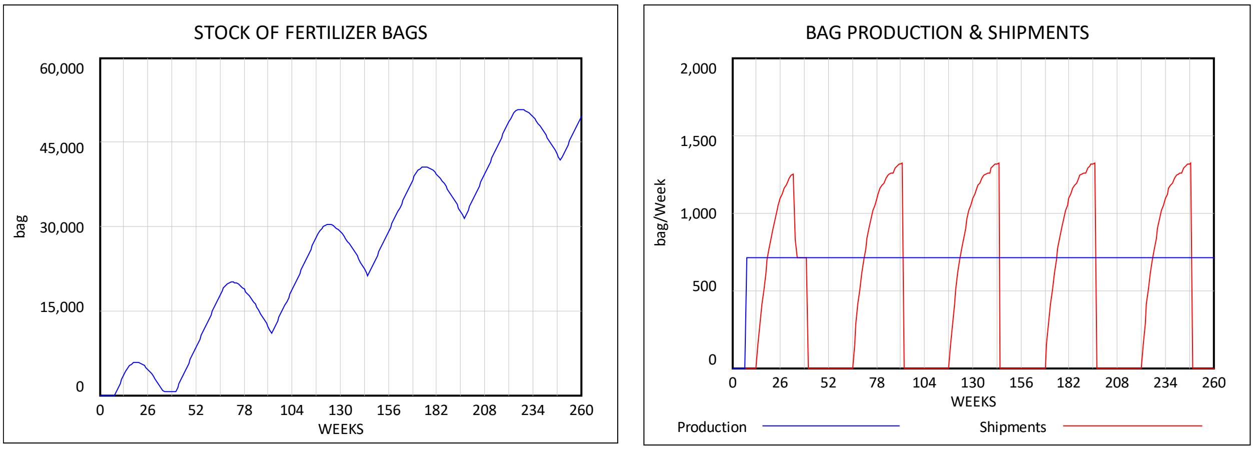
YEARLY TURNOVER COMPOSITION

WEEK	**52**	**104**	**156**	**208**	**260**
COLLECTION FEE	**23.4 M**	**23.4 M**	**23.4 M**	**23.4 M**	**23.4 M**
SALES	**25.02 M**	**29.37 M**	**29.37 M**	**29.37 M**	**29.37 M**
TOTAL	**48.42 M**	**52.77 M**	**52.77 M**	**52.77 M**	**52.77 M**

Fig 57: Turnover Composition; Impact of reduced bag price

Source: Simulation output, 2015

PRODUCTION, SHIPMENTS & STOCK OF FERTILIZER BAGS: graph



PRODUCTION, SHIPMENTS & STOCK OF FERTILIZER BAGS: table

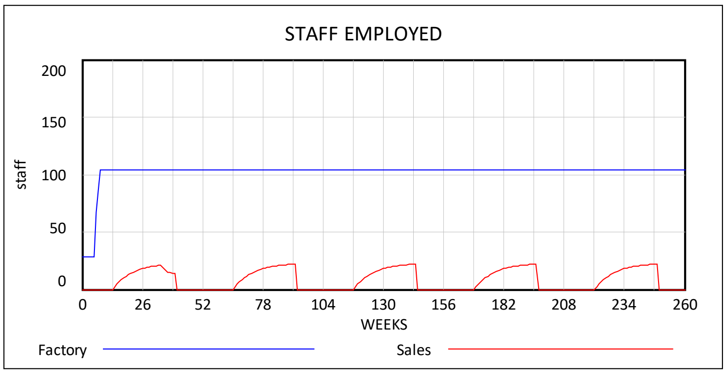
YEARLY SITUATION: FERTILIZER BAGS

WEEK	**52**	**104**	**156**	**208**	**260**
BAGS SOLD	**22,743**	**26,702**	**26,702**	**26,702**	**26,702**
STOCK OF BAGS	**8,529**	**18,784**	**29,039**	**39,295**	**49,550**

Fig 58: Production, Shipment and Stock of Fertilizer Bags; Impact of reduced bag price

Source: Simulation output, 2015

STAFF EMPLOYED



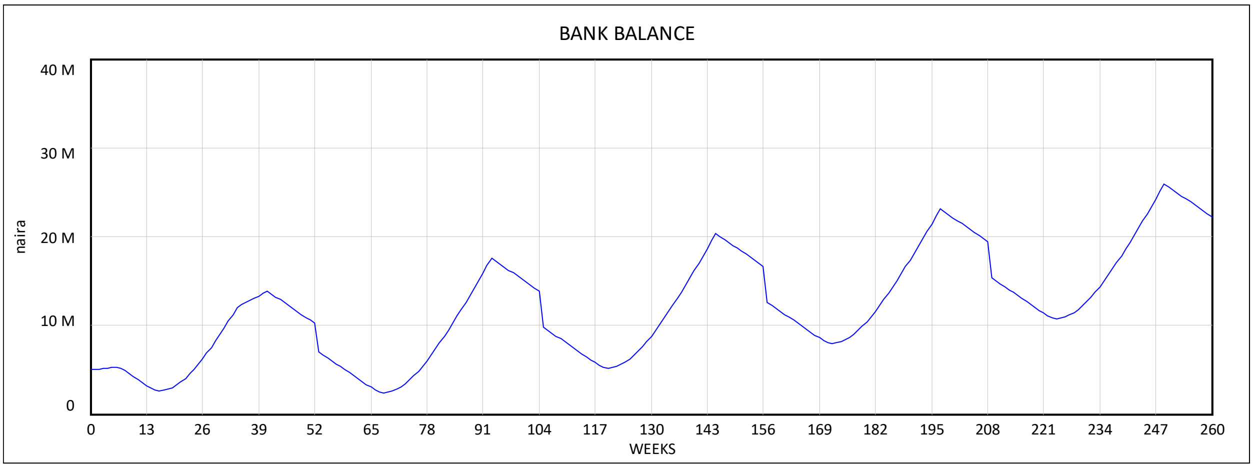
STAFF EMPLOYED

WEEK	**13**	**26**	**39**	**52**	**65**	**78**	**91**	**104**	**117**	**130**	**143**	**156**	**169**	**182**	**195**	**208**	**221**	**234**	**247**	**260**
Factory	**104**	**104**	**104**	**104**	**104**	**104**	**104**	**104**	**104**	**104**	**104**	**104**	**104**	**104**	**104**	**104**	**104**	**104**	**104**	**104**
Sales	**0**	**18**	**14**	**0**	**0**	**18**	**22**	**0**	**0**	**18**	**22**	**0**	**0**	**18**	**22**	**0**	**0**	**18**	**22**	**0**

Fig 59: Staff Employed; Impact of reduced bag price

Source: Simulation output, 2015

BANK BALANCE: graph



BANK BALANCE: table

YEARLY CASH POSITION

WEEK	**0**	**52**	**104**	**156**	**208**	**260**
CASH POSITION	**5 M**	**10.22 M**	**13.90 M**	**16.68 M**	**19.46 M**	**22.24 M**

Fig 60: Bank Balance; Impact of reduced bag price

Source: Simulation output, 2015

PRODUCTION DATA

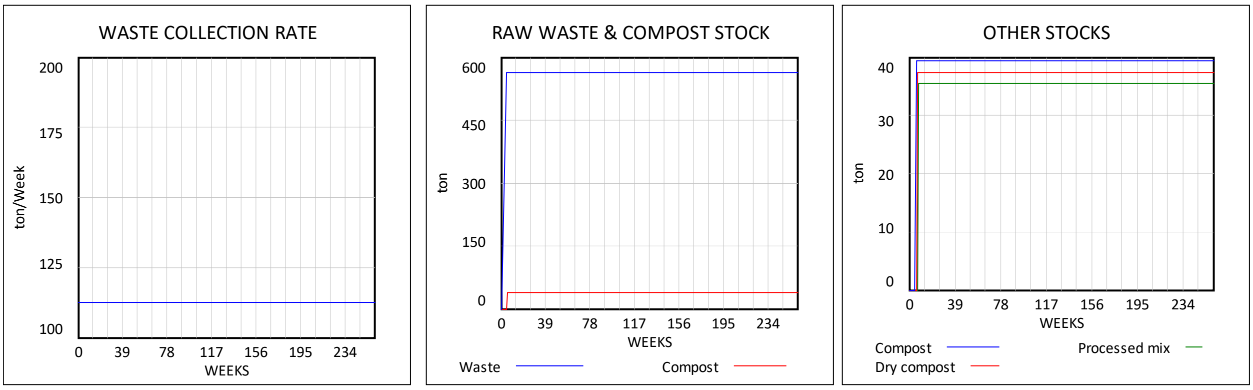


Fig 61: Production Data; Impact of reduced bag price

Source: Simulation output, 2015

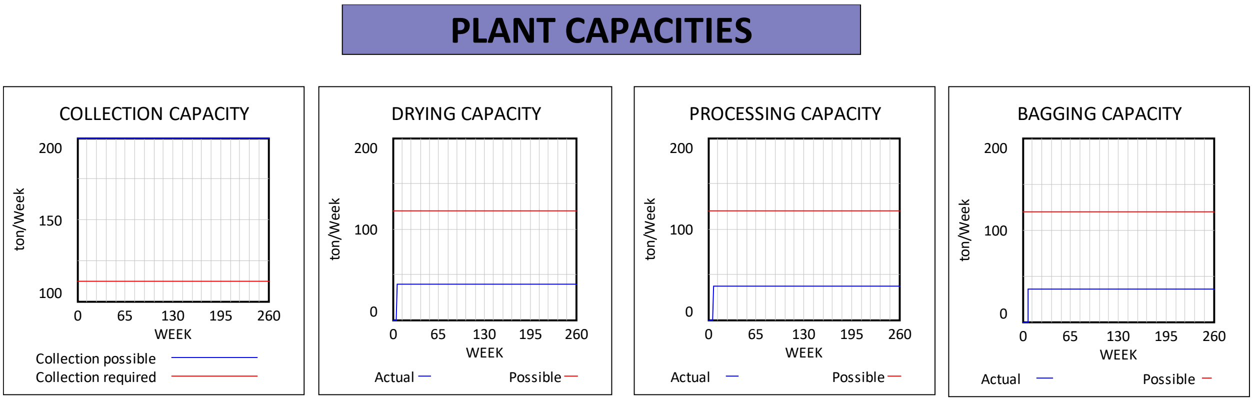


Fig 62: Plant Capacities; Impact of reduced bag price

Source: Simulation output, 2015

CHAPTER FIVE

5.0 SUMMARY, CONCLUSION AND RECOMMENDATIONS

5.1 Summary of major findings

This chapter presents the summary of the major findings from the study, conclusion, policy implications and recommendations aimed at improving chicken excreta management techniques in southwestern Nigeria.

Analysis of the socio-economic and demographic characteristics of chicken farmers in the study area shows that majority (85.07%) of the poultry farmers were male, married (86.43%), educated (81.0%), with a mean age of 41.01±.10.79 years and average household size of 5 members. On the average, 49.77% had between 5 to 10 years experience while only 5.43% had above 15 years' experience and above. Most (55.66%) of the chicken farmers practised the intensive form of poultry farming.

Majority (77.82%) generated chicken droppings while 56.11% generated poultry litter. The least generated forms of waste were offal and hatchery waste. Other forms of waste generated include feathers (19.91%) and condemned carcasses (33.77%). The findings reveal that most (51.67%) of the chicken farmers disposed their waste by converting them to manure while 50.67% disposed theirs on vacant lands. Most (52.5%) of the poultry farmers in both Oyo and Ogun States were moderately affected by environmental effects of chicken excreta. Residents around chicken farms were more affected (16.21) by the environmental effects of chicken excreta than chicken famers (14.82). They, therefore, had a more adverse perception of the environmental effects of poor chicken excreta disposal than the farmers. Farming experience, quantity of chicken excreta generated and income had a positive relationship with the perceived environmental effects of chicken excreta. Age, total income, total waste generated and education had a positive relationship with willingness to pay for poultry waste disposal in both states.

Poultry waste is not waste but a valuable input in agriculture and in organic fertilizer production. Most of the poultry farmers showed their willingness to pay for chicken excreta disposal. On the basis of the simulations involving the system dynamics model, the use of chicken excreta as the main ingredient in organic fertilizer production was projected to be feasible.

There is enough input for organic fertilizer plants to operate profitably, provided their cost structure is right. Plants without enough raw materials to meet demand could buy from farmers willing to sell. If the industrial activity of transforming poultry waste into organic fertilizer is implemented and sustained, the problem of environmental pollution caused by chicken excreta will be resolved.

Summary of Findings

Findings from the study show that most of the poultry farmers (77.82%) generated chicken excreta. Other forms of poultry waste generated were poultry litter, offal, hatchery waste, feathers and condemned carcasses. Common methods of chicken excreta disposal in the study area including using it as manure, dumping it on vacant lands, using it as fish feed, burying it, using it in compost making and selling it. These methods were not environment-friendly since they had adverse environmental effects.

Environmental effects of the common methods of chicken excreta disposal in the study area include odour, air pollution, water pollution, soil pollution and infectious diseases. The result of the study showed that the perception of the of the environmental effects of chicken excreta by poultry farmers and residents around these farms was not the same. Residents around the farms were more severely affected than the farmers. This is to be expected because those generating the waste will likely not appreciate its adverse environmental effect as much as those not directly involved.

Findings from the study also show that the willingness to pay (WTP) for chicken excreta disposal among poultry farmers depended on certain factors. Age, total income, level of education, and total chicken excreta generated positively influenced WTP. Most farmers (65%) were willing to pay for disposal of chicken excreta. Some of those not willing to pay were willing to sell their chicken excreta. These imply that most chicken farmers in the study area were aware of the inadequacies of their common methods of chicken excreta disposal, hence their willingness to pay for its disposal.

The result of the study also showed that chicken excreta was generated in sufficient quantities in the study area. This implies that a sustainable supply of chicken excreta as the main ingredient in organic fertilizer production in guaranteed. From simulation involving the system dynamics model, it was it was projected that the production of organic fertilizer using chicken excreta ins profitable and sustainable. Unlike the common methods of chicken excreta disposal in the study area, it is environmentally-friendly.

5.2 Conclusion

- On the basis of work done so far, it was found out that organic fertilizer production, using chicken excreta, is potentially profitable. The generation of enough poultry waste for optimum organic fertilizer production can be said to be guaranteed.
- Production of organic fertilizer is good business; people should be encouraged to go into it.
- The reduction or complete eradication of the adverse environmental effects of chicken excreta will be assured if it is adequately disposed of.
- It is important to be able to increase yields of organic crops. This can be done by increasing organic fertilizer usage especially in countries such as Nigeria where usage is low: 5-6kg/ha as opposed to 150-200 in Europe (World Bank 2012).
- Inorganic fertilizers have been shown to damage arable land with time. There is, therefore, a strong case for the promotion of the use of organic fertilizers, especially given the environmental benefits of recycling chicken excreta.
- This study fills the knowledge gap in the actual and potential use of chicken excreta for organic fertilizer production in Nigeria. Evidence from past studies in Nigeria suggests the need to assess the limitation and potential of organic fertilizer so as to confront the challenges of declining soil fertility and low productivity in Nigeria and meet the organic fertilizer needs for the emerging organic agriculture in Nigeria.

5.3 Recommendations

- Poultry Association of Nigeria (PAN) should make policies to ensure that chicken excreta farmers comply with environment-friendly chicken excreta disposal methods.

- Poultry farmers should be encouraged to be willing to pay for or be involved in recycling chicken excreta for organic fertilizer production.
- PAN should encourage individuals and organisations to go into the production of organic fertilizer. Apart from its environmental benefits, it also has financial and health benefits.

5.4 CONTRIBUTION TO KNOWLEDGE

The result of the study established the following:

1. The system dynamics model proved useful in ascertaining the viability and sustainability of a project.

. 2. Chicken farmers can utilize their chicken excreta to make economically viable by-products, while keeping the environment intact for future generations.

3 Chicken excreta should no longer be regarded as waste, since it can be recycled into very useful by products.

5.5 Suggestions for further studies

- The study can be replicated in other geo-political zones with an appreciable number of chicken farms.
- A study on the application of system dynamics in other agricultural practices can be conducted.

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APPENDIX 1

QUESTIONNAIRE ON

CHICKEN EXCRETA MANAGEMENT AND ITS PERCEIVED ENVIRONMENTAL EFFECTS IN SOUTHWESTERN NIGERIA

University of Ibadan, Ibadan.

Department of Agricultural Economics

Dear Sir/Madam,

Dear Respondent,

I am a doctoral student in the Department of Agricultural Economics, University of Ibadan and currently carrying out a study on chicken excreta management and its perceived environmental effects in southwestern Nigeria.

I hereby solicit your support by completing the questionnaire objectively. All responses will be treated with utmost confidentiality and used for research purposes only.

Adesope Adejare Ayinla

SECTION A. Socio economic characteristics of residents around the farm.

a) Personal characteristics

SECTION A

1. Age (yrs) ....
2. Sex : Male( ) Female ( )
3. Marital Status : Married ( ) Single ( )
4. Household size ( ) No of children ( ) No of male Adult ( ) No of Female Adult ( )
5. Highest educational level attained? Primary ( ) Secondary ( ) NCE ( ) OND ( ) HND ( ) B.Sc. ( ) M.Sc. ( ) Ph.D ( ) Others (specify) ( )
6. Years of schooling (years) ....
7. Household Size ( ) No of children ( ) N0 of male Adult ( ) N0 of Female Adult ( )
8. How long have you been leaving in your area?

9. What are the sources of water in your locality? Bore Hole ( ) Hand Dug Well ( )River/Stream ( )

10. Who owned the House you are leaving ? Rented ( ) personal House ( )

11. SECTION B. Environmental Effect

12. From the table below:

13. **ENVIRONMENTAL EFFECT**

14. From the table below, please score as appropriate from SA (5) to SD (1) on the effect of poultry waste disposal on the environment. SA - Strongly Agree; A- Agree; UD - Undecided; D - Disagree; SD - Strongly Disagree

	SA	A	UD	D	SD
1. Chicken excreta disposal results in an offensive odour around your house					
2. Poor chicken excreta disposal pollutes sources of water					
3. Infections or diseases are caused by poor disposal of chicken excreta					
4. Air is polluted as a result of improper waste disposal.					
5. Soil is polluted through poor poultry waste disposal					
6. Others (Specify)					

15. Which of these environmental effects of chicken excreta disposal is most prominent in your area? (you may tick more than 1) ....

Environmental effect	**Tick here**
1. Offensive odour around your house	
water pollution in and around your house	
3. Infections or diseases	
4. Air is pollution	
5. Soil pollution	

APPENDIX 2

The model's equations are listed below in alphabetical order. Parameters and initial values are in italics. Numerical data for parameters and initial values are supplied in the model simulation section.

(001) Bag production = Bagging * Kg per ton / Kg per bag Units: bag/Week

*(002) Bag sold per sales person = ... Units: bag/(Week*staff)*

(003) Bagging = MIN (capacity limit to bagging, Inventory limit to bagging) Units: ton/Week

(004) Bagging capacity = ... Units: ton

(005) Bagging shifts = ... Units: 1/Week

(006) Bags sold = Shipments Units: bag/Week

(007) BANK BALANCE= INTEG (Net cash in, Initial bank balance) Units: naira

(008) capacity limit to bagging = Bagging capacity * Bagging shifts Units: ton/Week

(009) Capacity limit to collection = Collecting capacity * Collecting shifts Units: ton/Week

010) Capacity limit to drying = Drying capacity * Drying shifts Units: ton/Week

(011) Capacity limit to processing = Processing capacity * Processing shifts
Units: ton/Week

(012) Clear bag = IF THEN ELSE ("Is end of year?" = 1, CUMULATIVE BAGS SOLD / Unit for time, 0) Units: bag/Week

(013) Clear electricity cost = IF THEN ELSE ("Is end of year?" = 1, ELECTRICITY COST CUMULATED / Unit for time, 0) Units: naira/Week

(014) Clear factory cost = IF THEN ELSE ("Is end of year?" = 1, WORKER COST CUMULATED / Unit for time, 0) Units: naira/Week

(015) Clear fee = IF THEN ELSE ("Is end of year?" = 1, CUMULATIVE FEE / Unit for time, 0) Units: naira/Week

(016) Clear other costs = IF THEN ELSE ("Is end of year?" = 1, OTHER COSTS CUMULATED / Unit for time, 0) Units: naira/Week

(017) Clear sales = IF THEN ELSE ("Is end of year?" = 1, CUMULATIVE SALES / Unit for time, 0) Units: naira/Week

(018) Clear sales cost = IF THEN ELSE ("Is end of year?" = 1, SALES COST CUMULATED / Unit for time, 0) Units: naira/Week

(019) Collecting capacity = ... Units: ton

(020) Collecting shifts = ... Units: 1/Week

(021) Collection fee = Waste sourced through willingness to pay * Unit collection fee Units: naira/Week

(022) COMPOST= INTEG (Wet compost production-Drying, Initial compost) Units: ton

(023) Composting = DELAY FIXED (Waste collection, Composting time, 0)Units: ton/Week

(024) Composting time = ... Units: Week

(025) Cost of electricity = Generator cost + Grid cost Units: naira/Week

(026) Cost of factory workers = Unit factory labour cost * Factory labour required Units: naira/Week

(027) Cost of sales person = SALES PERSON * Unit sales person cost Units: naira/Week

(028) Cost per kWh = ... Units: naira/kW/hour

(029) CUMULATIVE BAGS SOLD= INTEG (Bags sold - Clear bag, Initial cumulative bags sold) Units: bag

(030) CUMULATIVE FEE= INTEG (Collection fee - Clear fee, Initial fees cumulated) Units: naira

(031) Cumulative gross margin = Cumulative turnover - Total cumulated costs Units: naira

(032) CUMULATIVE SALES= INTEG (sales - Clear sales, Initial cumulative sales) Units: naira

(033) Cumulative turnover = CUMULATIVE SALES + CUMULATIVE FEE Units: naira

(034) Desired sales person = INTEGER (Sales budget / Unit sales person cost) Units: staff

(035) Desired stock of dry compost = IF THEN ELSE (Desired stock of fertilizer bags >FERTILIZER BAGS, Desired stock of fertilizer bags * Kg per bag / Kg per ton, 0) Units: ton

(036) Desired stock of fertilizer bags = INTEGER (SMOOTH (marketed sales, Smoothing factor) * Stock coverage fertilizer) Units: bag

(037) Desired stock of raw waste = (Desired stock of dry compost / (1 - Total weight loss)) * Stock coverage raw waste Units: ton

(038) Desired waste collection = raw waste stock gap / Time to adjust stock of waste Units: ton/Week

(039) DRY COMPOST= INTEG (Dry compost production-Processing, Initial dry compost)

Units: ton

(040) Dry compost production = Drying * (1 - Weight loss at drying) Units: ton/Week

(041) Drying = MIN (Capacity limit to drying, Inventory limit to drying) Units: ton/Week

(042) Drying capacity = ... Units: ton

(043) Drying shifts = ... Units: 1/Week

(044) ELECTRICITY COST CUMULATED = INTEG (Cost of electricity - Clear electricity cost, Initial electricity cost cumulated) Units: naira

(045) End week = IF THEN ELSE(Time / Week per year <= 1, last week in season, IF THEN ELSE (Time / Week per year <=2, last week in season + Week per year, IF THEN ELSE(Time / Week per year <= 3, last week in season + (Week per year * 2), IF THEN ELSE (Time / Week per year <=4, last week in season + (Week per year * 3), IF THEN ELSE (Time / Week per year<=5, last week in season + (Week per year * 4), 0))))) Units: Week

(046) Factory labour required = Labour collecting + Labour composting + Labour drying + Labour processing + Labour bagging Units: staff

(047) FERTILIZER BAGS= INTEG (Bag production - Shipments, Initial fertilizer bags)

Units: bag

(048) FINAL TIME = ... Units: Week (The final time for the simulation)

(049) Firing = SALES PERSON / Unit for time Units: staff/Week

(050) First week in season = ... Units: Week

(051) Generator cost = Total fuel cost + Maintenance cost + Repair and part cost

Units: naira/Week

(052) Generator operating hours = MAX (Operating hours - Hours of grid supply, 0)

Units: hour/Week

(053) Grid cost = Grid kWh consumption * Cost per kWh Units: naira/Week

(054) Grid kWh consumption = Installed grid capacity * Hours of grid supply

Units: kW*hour/Week

(055) Gross margin = Turnover - Total weekly costs Units: naira/Week

(056) Hourly fuel consumption = ... Units: litre/hour

(057) Hours of grid supply = ... Units: hour/Week

(058) Initial bank balance = ... Units: naira

(059) Initial compost = ... Units: ton

(060) Initial cumulative bags sold = ... Units: bag

(061) Initial cumulative sales = ... Units: naira

(062) Initial dry compost = ... Units: ton

(063) Initial electricity cost cumulated = ... Units: naira

(064) Initial fees cumulated = ... Units: naira

(065) Initial fertilizer bags = ... Units: bag

(066) Initial other costs cumulated = ... Units: naira

(067) Initial processed mix = ... Units: ton

(068) Initial raw waste = ... Units: ton

(069) Initial sales cost cumulated = ... Units: naira

(070) Initial sales person = ... Units: staff

(071) Initial tax payable = ... Units: naira

(072) INITIAL TIME = ... Units: Week (The initial time for the simulation)

(073) Initial worker cost cumulated = ... Units: naira

(074) Installed grid capacity = ... Units: kW

(075) Inventory limit to bagging = PROCESSED MIX / Unit for time Units: ton/Week

(076) Inventory limit to drying = COMPOST / Unit for time Units: ton/Week

(077) Inventory limit to processing = DRY COMPOST / Unit for time Units: ton/Week

(078) Inventory limit to shipments = FERTILIZER BAGS / Unit for time Units: bag/Week

(079) "Is end of year?" = IF THEN ELSE (Time = Week per year, 1, IF THEN ELSE (Time = 2 * Week per year, 1, IF THEN ELSE (Time = 3 * Week per year, 1, IF THEN ELSE (Time = 4 * Week per year, 1, IF THEN ELSE (Time = 5 * Week per year, 1, 0) Units: Dmnl

(080) Kg per bag = ... Units: kg/bag

(081) Kg per ton = ... Units: kg/ton

(082) Labour bagging = Bagging / Productivity bagging Units: staff

(083) Labour collecting = Waste collection / Productivity collecting Units: staff

(084) Labour composting = COMPOST / Productivity composting Units: staff

(085) Labour drying = Drying / Productivity drying Units: staff

(086) Labour processing = Processing / Productivity processing Units: staff

(087) last week in season = ... Units: Week

(088) Maintenance cost = (Generator operating hours / Time between maintenance) * Unit maintenance cost Units: naira/Week

(089) marketed sales = SALES PERSON * Bag sold per sales person Units: bag/Week

(090) Net cash in = Gross margin - tax paid Units: naira/Week

(091) Net hiring required = (Desired sales person - SALES PERSON) / Time to hire Units: staff/Week

(092) net recruit = IF THEN ELSE (Sales season = 1, Net hiring required, IF THEN ELSE (Season end = 1, -Firing, 0)) Units: staff/Week

(093) Operating hours = ... Units: hour/Week

(094) Other costs = ... Units: naira/Week

(095) OTHER COSTS CUMULATED = INTEG (Other costs - Clear other costs, Initial other costs cumulated) Units: naira

(096) PROCESSED MIX = INTEG (Processed mix production - Bagging, Initial processed mix) Units: ton

(097) Processed mix production = Processing * (1 - Weight loss at processing) Units: ton/Week

(098) Processing = MIN (Capacity limit to processing, Inventory limit to processing) Units: ton/Week

(099) Processing capacity = ... Units: ton

(100) Processing shifts = ... Units: 1/Week

*(101) Productivity bagging = ... Units: ton/(staff*Week)*

(102) Productivity collecting = ... Units: ton/staff/Week

(103) Productivity composting = ... Units: ton/staff

*(104) Productivity drying = ... Units: ton/(staff*Week)*

*(105) Productivity processing = ... Units: ton/(staff*Week)*

(106) Provision for tax = MAX (Gross margin * Tax rate, 0) Units: naira/Week

(107) RAW WASTE = INTEG (Waste collection - Composting, Initial raw waste) Units: ton

(108) raw waste stock gap = MAX (Desired stock of raw waste - RAW WASTE, 0)

Units: ton

(109) Repair and part cost = ... Units: naira/Week

(110) sales = Bags sold * Unit bag price Units: naira/Week

(111) Sales budget = MAX (Turnover * Sales budget fraction, 0) Units: naira/Week

(112) Sales budget fraction = ... Units: Dmnl

(113) SALES COST CUMULATED = INTEG (Cost of sales person - Clear sales cost, Initial sales cost cumulated) Units: naira

(114) SALES PERSON = INTEG (net recruit, Initial sales person) Units: staff

(115) Sales season = IF THEN ELSE (Time > Start week :AND: Time < End week, 1, 0)

Units: Dmnl

(116) SAVEPER = TIME STEP Units: Week (The frequency with which output is stored)

(117) Season end = IF THEN ELSE (Time = End week, 1, 0) Units: Dmnl

(118) Shipments = MIN (marketed sales, Inventory limit to shipments) Units: bag/Week

(119) Smoothing factor = ... Units: Week

(120) Start week = IF THEN ELSE (Time / Week per year <= 1, First week in season, IF THEN ELSE (Time / Week per year <= 2, First week in season + Week per year, IF THEN ELSE (Time / Week per year <= 3, First week in season + (Week per year * 2), IF THEN ELSE (Time / Week per year <= 4, First week in season + (Week per year * 3), IF THEN ELSE (Time / Week per year <= 5, First week in season + (Week per year * 4), 0))))) Units: Week

(121) Stock coverage fertilizer = ... Units: Week

(122) Stock coverage raw waste = ... Units: Dmnl

(123) tax paid = IF THEN ELSE ("Is end of year?" = 1, TAX PAYABLE / Unit for time, 0)

Units: naira/Week

(124) TAX PAYABLE = INTEG (Provision for tax - tax paid, Initial tax payable) Units: naira

(125) Tax rate = ... Units: Dmnl

(126) Time between maintenance = ... Units: hour

(127) TIME STEP = ... Units: Week (The time step for the simulation)

(128) Time to adjust stock of waste = ... Units: Week

(129) Time to hire = ... Units: Week

(130) Total cumulated costs = WORKER COST CUMULATED + SALES COST CUMULATED + ELECTRICITY COST CUMULATED + OTHER COSTS CUMULATED Units: naira

(131) Total fuel consumption = Generator operating hours * Hourly fuel consumption
Units: litre/Week

(132) Total fuel cost = Total fuel consumption * Unit fuel cost Units: naira/Week

(133) Total personnel employed = Factory labour required + SALES PERSON
Units: staff

(134) Total waste collection required = Waste sourced through willingness to pay + Waste purchased Units: ton/Week

(135) Total weekly costs = Cost of factory workers + Cost of sales person + Cost of electricity + Other costs Units: naira/Week

(136) Total weight loss = Weight loss at composting + Weight loss at drying + Weight loss at processing Units: Dmnl

(137) Turnover = sales + Collection fee Units: naira/Week

(138) Unit bag cost = ZIDZ (Total cumulated costs, CUMULATIVE BAGS SOLD)
Units: naira/bag

(139) Unit bag price = … Units: naira/bag

(140) Unit collection cost = … Units: naira/ton

(141) Unit collection fee = … Units: naira/ton

*(142) Unit factory labour cost = ... Units: naira/(Week*staff)*

(143) Unit for time = ... Units: Week

(144) Unit fuel cost = … Units: naira/litre

(145) Unit maintenance cost = … Units: naira

*(146) Unit sales person cost = … Units: naira/(Week*staff)*

(147) Unit waste cost = … Units: naira/ton

(148) Waste and other costs = (Waste purchased * Unit waste cost) + other costs
Units; naira/Week

(149) Waste collection = MIN (Total waste collection required, Waste collection possible)
Units: ton/Week

(150) Waste collection cost = Waste collection * Unit collection cost Units: naira/Week

(151) Waste purchase cost = Waste purchased * Unit waste cost Units: naira/Week

(152) Waste purchased = IF THEN ELSE (Desired waste collection >= Waste sourced through willingness to pay, Desired waste collection - Waste sourced through willingness to pay, 0) Units: ton/Week

(153) Waste sourced through willingness to pay = ... Units: ton/Week

(154) Week per year = ... Units: Week

(155) Weight loss at composting = ... Units: Dmnl

(156) Weight loss at drying = ... Units: Dmnl

(157) Weight loss at processing = ... Units: Dmnl

(158) Wet compost production = Composting * (1 - Weight loss at composting) Units: ton/Week

(159) WORKER COST CUMULATED = INTEG (Cost of factory workers - Clear factory cost, Initial worker cost cumulated) Units: naira

To facilitate the preparation of simulations, it is useful to organize assumptions in categories as is shown below:

Initial values of level:

Initial raw waste Units: ton

Initial compost Units: ton

Initial dry compost Units: ton

Initial processed mix Units: ton

Initial fertilizer bags Units: bag

Initial sales person Units: staff

Initial sales cost cumulated Units: naira

Initial worker cost cumulated Units: naira

Initial electricity cost cumulated Units: naira

Initial other costs cumulated Units: naira

Initial tax payable Units: naira

Initial bank balance Units: naira

Initial fees cumulated Units: naira

Initial cumulative sales Units: naira

Initial cumulative bags sold Units: bag

Time parameters:

INITIAL TIME = 0 Units: Week (The initial time for the simulation)

FINAL TIME = 260 Units: Week (The final time for the simulation)

TIME STEP = 1   Units: Week (The time step for the simulation)

Unit for time = 1   Units: Week

Week per year = 52   Units: Week

First week in season   Units: Week

last week in season   Units: Week

Policy parameters:

Operating hours   Units: hour/Week

Sales budget fraction   Units: Dmnl

Stock coverage fertilizer   Units: Week

Stock coverage raw waste   Units: Dmnl

Unit bag price   Units: naira/bag

Waste sourced through willingness to pay   Units: ton/Week

Technical coefficients:

Composting time   Units: Week

Kg per bag   Units: kg/bag

Kg per ton = 1,000   Units: kg/ton

Weight loss at composting   Units: Dmnl

Weight loss at drying   Units: Dmnl

Weight loss at processing   Units: Dmnl

Cost parameters:

Cost per kWh   Units: naira/kW/hour

Other costs   Units: naira/Week

Repair and part cost   Units: naira/Week

Unit collection cost   Units: naira/ton

Unit collection fee   Units: naira/ton

*Unit factory labour cost   Units: naira/(Week*staff)*

Unit fuel cost   Units: naira/litre

Unit maintenance cost   Units: naira

*Unit sales person cost   Units: naira/(Week*staff)*

Unit waste cost   Units: naira/ton

Productivity parameters:

*Bag sold per sales person   Units: bag/(Week*staff)*

Productivity collecting   Units: ton/staff/Week

Productivity composting   Units: ton/staff

Productivity drying   *Units: ton/(staff*Week)*

Productivity processing   *Units: ton/(staff*Week)*

Productivity bagging   *Units: ton/(staff*Week)*

Capacity parameters:

Collecting capacity   *Units: ton*

Collecting shifts   *Units: 1/Week*

Drying capacity   *Units: ton*

Drying shifts   *Units: 1/Week*

Processing capacity   *Units: ton*

Processing shifts   *Units: 1/Week*

Bagging capacity   *Units: ton*

Bagging shifts   *Units: 1/Week*

Time delays:

Smoothing factor   *Units: Week*

Time between maintenance   *Units: hour*

Time to adjust stock of waste   *Units: Week*

Time to hire   *Units: Week*

Unclassified parameters:

Hourly fuel consumption   *Units: litre/hour*

Hours of grid supply   *Units: hour/Week*

Installed grid capacity   *Units: kW*

Tax rate   *Units: Dmnl*

Table : Analysis of the objectives

S/N	OBJECTIVES	MEANING	DATA REQUIRED	SOURCE	METHOD OF DATA ANALYSIS
1	To examine the existing methods of poultry waste management in the study area.	To profile poultry waste generated by poultry farms	Information on the i. types of poultry waste generated by poultry farmers: e.g .manure, feathers, hatchery waste, condemned carcasses. ii. Methods/techniques of poultry waste disposal.	Primary	Descriptive statistics, (frequency table and percentages)
2	To evaluate the environmental effects of chicken excreta in the study area.	To assess the environmental effect of chicken excreta disposal methods and its side effects on the environment.	Information on environmental effect of chicken excreta such as odour, air and water pollution, and infections among others.	Primary	1. Descriptive statistics, (frequency table percentages) and the use of likert scale 2.Ordered Probit
3	To examine the determinants of willingness to pay for chicken excreta management in the study area. .	To determine the factors that influence willingness to pay (WPT) for chicken excreta management techniques	Information on willingness to pay for chicken excreta management techniques using contingent valuation method (CVM).	Primary	Probit
4	To predict the feasibility of using chicken excreta as a key ingredient in the production of fertilizers, using the system dynamics approach.	To determine the capacity to generate chicken excreta and whether the use of chicken excreta by organic fertilizers industries could be profitable	Information on quantity of poultry manure, litter, feather and intestines generated from poultry farms. Structural information about relevant industrial processes	Primary	System dynamics (simulation)