8-2021

Financial Feasibility and Factors that lead to Profitability for Small-Scale Farmers in Rwanda.

Saheed Adeniyi Orimadegun
sorimade@vols.utk.edu

To the Graduate Council:

I am submitting herewith a thesis written by Saheed Adeniyi Orimadegun entitled "Financial Feasibility and Factors that lead to Profitability for Small-Scale Farmers in Rwanda.." I have examined the final electronic copy of this thesis for form and content and recommend that it be accepted in partial fulfillment of the requirements for the degree of Master of Science, with a major in Agricultural and Resource Economics.

Carlos Omar Trejo-Pech, Major Professor

We have read this thesis and recommend its acceptance:

Jada Thomson, Tom Gill, Margarita Velandia

Accepted for the Council:
Dixie L. Thompson

Vice Provost and Dean of the Graduate School

(Original signatures are on file with official student records.)

Financial Feasibility and Factors that lead to Profitability of Small-Scale Farms in Rwanda

A Thesis Presented for the

Master of Science

Degree

The University of Tennessee, Knoxville

Saheed A. Orimadegun

August 2021

Acknowledgements

The author thanks major professor, Dr. Carlos Trejo-Pech, whose patience and expertise made the execution of the analysis in this research work possible. Additionally, the committee members: Dr. Jada Thompson, Dr. Tom Gill, and Dr. Margarita Velandia were invaluable team members providing support and expert knowledge in shaping and formulating ideas all through the research process. The researcher thanks his entire family and especially Fasilat, Maryam, Aliyah, and Amidat, Orimadegun for their patience and constant encouragement which has remained undeterred by excessive time zones and distance.

This research was made possible with funding from the United States Agency for International Development. Without the help and cooperation of the Feed the Future, Tworore Inkoko, Twunguke poultry project, the availability and collection of the data integral to this research would not have been available half a world away. I am grateful for all the inputs, the author of all the documents I consulted and the many people that influenced my interest in this discipline.

Abstract

This study will analyze small-scale poultry farming in the Musanze district of Rwanda. Poultry farming offers a source of protein and economic subsistence for households in this region. Previous studies suggest that the small-scale farmers in this region need training for the effective production of broilers. To this end, the Feed the Future Tworore Inkoko, Twunguke (TI) program, funded by the United States Agency for International Development (USAID) and the African Sustainable Agriculture Project (ASAP) Foundation, and led by the University of Tennessee Institute of Agriculture (UTIA) and Zamura Feeds Ltd., was initiated to help small-scale broiler farmers be technically and economically efficient. In this study, the progress made by farmers from the inception of the program in 2017 to its end in 2020 is evaluated using capital budgeting analysis and scenario analysis methods.

This study will analyze data obtained from the 2020 Rwanda Broiler Production database from the TI program. This data source contains about 2260 flock/farmer observations collected from more than511 farmers from different areas of the Musanze district in Rwanda over three years and eight months (January 2017 – September 2020). Production costs, revenue, investment cost, and other demographic and production parameters were collected by technicians who provide extension support to the small-scale broiler TI farmers. Scenario analyses of capital budgeting valuation are performed to evaluate the profitability and the risk implications of these small-scale broiler farmers. This study is a continuation of previous studies but with updated data. The findings of this analysis suggest that at a break-even price of RwF 1,361.2, the project's net present value equals zero, implying that the project generates an annual rate of return of 14%. The project's net present value is most sensitive to parameters such as WACC, inflation, mortality rate, cost of feed, and unit cost of DOCs.

Table of Contents

List of Tables

List of Figure(s)

List of Abbreviations

AEPA – Agricultural Extension Planning Areas

ANR –Annual Net Returns

ASAP – Africa Sustainable Agricultural Project

BCR – Benefit Cost Ratio

CBA – Cost Benefit Analysis

DCF – Discounted Cash Flow Method

DOC – Day Old Chicks

EBA – Enterprise Budget Analysis

FAFS – Framework for African Food Security

FAO – Food and Agricultural Organization

FCR – Feed Conversion Ratio

FOS – Federal Office of Statistics

GDA – Global Development Alliance

HIV – Human Immunodeficiency Virus

ILRI – International Livestock Research Institute

INFL – Inflation

IRR – Internal Rate of Returns

Kg – Kilogram

MINAGRI – Ministry of Agriculture and Animal Resources

MIRR – Modified Internal Rate of Returns

NISR – National Institute of Statistics of Rwanda

NPV – Net Present Value

PV – Present Value

R-LMP – Rwanda Livestock Master Plan

RORI – Rate of Return on Investment

RwF – Rwandan Francs

TI – Feed the Future, Twororo Inkoko

TR – Total Revenue

TVC – Total Variable Cost

USAID – United States Agency for International Development

USD – United States Dollar

WACC – Weighted Average Cost of Capital

WFP – World Food Program

Chapter I

1.0 Introduction

1.1 Background

The Rwanda National Institute of Statistics estimates that 40% of Rwandans live in poverty. Most of these people are in rural areas and suffer from malnutrition (NISR, 2015). This is one of the reasons why the vision 2020 of the Rwandan Government is to transform the country's economy into a middle economy by the year 2030 (USAID, 2018). One of the causes of malnutrition is households' limited access to protein from meat sources. Rural Rwandans seldom eat meat and when they do, it is usually beef; few families have access to poultry meat due to its high price (USAID, 2018). Chicken is identified as a good source of meat-based protein for Rwandans mostly because it contains the nine essential amino acids required for a complete human diet. The GDP of Rwanda is agriculturally-based. Supporting broiler production can ameliorate the dual problem of income and nutrient (protein) supply.

Rwanda's Ministry of Agriculture and Animal Resources suggests that small-scale broiler farming for semi-commercial purposes is the ideal production system for mitigating the problem of income and nutrient supply (MINAGRI, 2012). Thus, there is an increasing demand for animal protein that are relevant for the diet of humans relative to plant protein demand (Gill et al. 2020). It is still a problem that the right nutrients for the human diet are not readily available, leading to food insecurity in over 60% of households in Rwanda (World Food Programme, 2015). This food insecurity must incorporate discourse on markets and nutrition, supply, and dietary diversification according to a Comprehensive Africa Agriculture Development Programme (CAADP) Framework for African Food Security (FAFS) (Gill et al. 2020).

However, many issues militate the proliferation of broiler farming and the continuous supply of the needed nutrients. Using information from MINAGRI (2012), Gill et al. (2020) list some of these issues, including: limited supply of day-old chicks, quality and price of feed, limited access to credit and grants, poor condition of the already established poultry farms, and very few options to market chicken products. In order to tackle some of these problems, the TI program was initiated by the USAID in collaboration with UTIA, ASAP and Zamura Feeds Ltd. in the Musanze district of Rwanda to help small-scale farmers to be more productive and to have access to chicken meat. The small-scale broiler farmers in this study are farmers rearing 100 birds per cycle (5 cycles per year) under the TI program.

The small-scale broiler farmers in the TI program are technically trained in poultry production when they are accepted to be part of the program. Farmers in Rwanda who are producing poultry meat for the purpose of providing meat-based protein for private and commercial use in most cases do not have sufficient knowledge of modern farming techniques, farm record keeping and profit analysis to make their farming ventures economically and financially viable.

As meat-based protein contains significant amounts of the nine essential amino acids that meet human dietary requirements, broilers' production for meat supply has the potential to meet the needs of protein-deficient diets. The TI program was initiated to help small-scale broiler farmers in Musanze district, Rwanda, to increase their farms’ profitability and increase the supply of protein-based food in the region, thus alleviating poverty and nutrition deficiencies. The mission of the TI program is to increase the availability of protein from animal sources and help households to earn more from their poultry business by increasing the capacity of small-scale farmers to produce chicken meat (USAID, 2018). This increase in yield and capacity will keep happening due to the impact of this program on the knowledge of proper farm management accounting, knowledge of factors that lead to profitability and the advancement of knowledge and experience in modern poultry farming. The knowledge of the factors mentioned above has the potential to increase yield and financial output. A recent study by Abolink et al. (2018) of small-scale farmers in a comparable sub-Saharan African setting in Zambia suggests that farmers are not trained to perform financial analysis for their farms to know their farm's financial situation; hence do not know when they are making profits or incurring a loss. The purpose of this thesis is to evaluate the impact of the TI program on the productivity and profitability of the small-scale broiler operations that participated in this program.

1.2 The Feed the Future Tworore Inkoko, Twunguke Program

The TI program, a Global Development Alliance (GDA) is a public-private partnership funded by the United States Agency for International Development (USAID) and the African Sustainable Agriculture Project (ASAP) Foundation. This grant program, led by the UTIA and Zamura Feeds Ltd., was initiated to help the small-scale broiler farmers in Musanze district, Rwanda, to be technically and economically efficient. The TI program uses a private extension model to train poultry farmers, supply them quality inputs, provide micro-loans for initial investment and recurring expenses, provide technical support and marketing support services, and a guaranteed buy-back option after each production cycle has been completed. The TI program intends to increase earnings of subsistence small-scale farmers and improve protein-based nutrition.

The farmers enrolled in the TI program receive two types of funding: one to establish the broiler facility and one to run the broiler operation. They receive funding (zero interest loan) to cover the start-up expenses from coop construction, buying of drinkers, feeders, and clay pots. All of these expenses represent approximately $558 per farmer. After establishing the facility, the farmers receive a loan with an interest rate of 14% yearly that covers the procurement of day-old chicks, feed, vaccine, disinfectant, charcoal, litters, and light/energy for one production cycle. The day-old chicks (DOC) are purchased from the best hatcheries approved by the TI program to improve livability rates and maximum feed conversion ratio (FCR); usually, Ross 308 DOCs are used since this is the best genetic breed available in Rwanda (Gill et al. 2020). Some farmers prefer the Cobb-500 breed because of its growth performance potential (Mbuza et al. 2016; Kenner et al. 2019).The coops are standardized and built by a local contractor for all the farmers enrolled in the TI program (Gill et al. 2020). After each cycle of production, TI employees help the farmers to sell their birds, and each is paid based on revenue from the sales after the line of credit has been deducted. The farmers in the TI program receive regular technical visits and instructions from the TI employees who are trained specifically for such purpose.[1]

The TI program's official funding from USAID was from the period of January 2017 to September 2020, although the program has continued as a private business with the name Zamura Foods. A total of 487 farmers are still in the program under Zamura Foods and are being provided with microfinance loans from Goshen Finance (Gill, 2021).[2] Production halted between April and October 2020 due to the Covid-19 lockdown but started again in January 2021. There is a production plan of 5,000 birds per week; that is, 50 farmers producing 100 birds per week in a 10-week rotational format (Gill, 2021).

1.3 Research Problem

Previous research has analyzed data from the TI program (Kenner et al. 2019; Gill et al. 2020). Using capital budgeting and simulation methods, Kenner et al. (2019) analyzed

[1]This part of this thesis is a summary of Gill et al., (2020) who is the principal investigator of the TI program processes and funding.
[2] Dr. Gill of the UTIA was the principal investigator of this grant and provided most of the information surrounding the processes and funding of the TI program.

profitability and risk of small-scale farmers in this program, finding that in the long-term the program is likely to generate a negative net present value, meaning that its economic sustainability might be at risk (i.e., the present value of expected cash flows is lower than the present value of the investment). More specifically, Kenner et al.'s stochastic analysis showed that in about 50% of the simulations, the project would destroy economic value (e.g., negative NPV) and in 50% of cases, economic value would be generated. Kenner et al.'s analysis, however, was performed at the start of the TI program, and included a relatively small dataset of 125 observations. These observations were extrapolated over a twenty-year horizon, given the production efficiency of the first TI farmers. Besides a potential bias of results given the small sample even despite applying a bootstrapping methodology, it is possible that at the start of the program –data collected from September 2017 to April 2018– farmers lacked the production expertise that they might have gained overtime in the project and/or that the TI technical services and program education also improved over time. Production experience gained by farmers in the two years participating in the program may increase the economic potential of the program and/or reduce its risk. Thus, there is a need to revisit and re-evaluate the long-term profitability and risk of the TI program using data across a longer program period (2017-2020) to better understand the financial value of experience and learning over the course of the program and provide updated long-term financial projections.

Gill et al. (2020) analyzed the first 18 months (September 15, 2017 to March 31, 2019) of the TI program finding that average livability was 89%, a relatively high rate due to the emphasis placed on bio-security in the TI program; and the average profitability per flock ranged between $18 to $89. The first 18 months witnessed an increase in farms' profitability for the farms in the TI program and an increase in nutrient supply for the farmers participating in this program. The study analyzed five cycles per year with an average time for maturity or production cycle between 48 to 80 days, depending on the FCR of the birds. However, the study showed that the livability, weight, and time of maturity were greatly influenced when the feed was changed from mash feed to pelletized feed.

This study will explore the same research problem as in Kenner et al. (2019); that is, to analyze profitability and risk of small-scale farmers, but with an extended dataset of 2200 flock observations. This study will adopt a long-term investment horizon hence the need for capital budgeting analysis, which is potentially useful for stakeholders of the TI program.

1.4 Significance of the Research

The problem identified, which calls for the evaluation of the long-term profitability and risk of Rwanda small-scale poultry farmers under the TI program, with updated farmers' production expertise and yields, prices and costs, is expected to provide different results than those reported by Kenner et al. (2019). Conditions might have changed for the small-scale farmers in the TI program from April 2018 (when Kenner et al.'s study was conducted) to May 2020 (when the USAID grant ended), which justifies additional analysis with an updated dataset. This is necessary to measure the impacts of the TI program on farmers during the entire grant performance period. The updated dataset contains around 2260 flock records versus the 125 flock records analyzed by Kenner et al., and 739 records analyzed by Gill et al. (2020). There may be a significant effect on the generation of economic value owing to the additional learning and experience over time and the increase in the number of data records. The results from this study will enable proper long term capital budgeting/financial projections for investors and government agencies.

Additionally, the results from the analyses will be used to determine the factors that lead to the profitability of these small-scale farmers. The factors to be evaluated include the type of feed used and the feed conversion ratio of the DOCs, among others. The results from the analyses might help policymakers and agencies to make decisions on the sort of feed and DOCs to prescribe to the farmers that will give the most favorable result. Basically, these policymakers are: 1) the government, 2) private investors, and 3) development partners (ILRI, 2017). These decisions might include recommendations such as what sort of coop to build or when is the best time to harvest. For example, Gill et al. (2020) revealed that some farmers who switched from bran feed to pelletized feed gained more livability than others. The results might help policymakers to make better decisions.

1.5 Objectives of the Research

The objectives of this research, which will be consistent with, but not dependent on Kenner et al. (2019), are the following:

(1) To evaluate expected long-term profitability of small-scale broiler farmers in Rwanda by extrapolating historical production and financial values from the TI program between 2017 and 2020.

(2) To evaluate risk of expected long-term profitability of small-scale broiler farmers in Rwanda by performing scenario and sensitivity analyses to results from (1) above.

(3) To compare the financial performance of the program at three different points in time viz one year after the start of the program (with 510 observations), two years after the start of the program (with 1770 observations) and the end of the program (with 2260 observations) to enable the TI program organizers to monitor the progress made by the farmers.

(4) To provide recommendations to policymakers, funding agencies, government agencies, and in general to stakeholders, on these type of funded programs (e.g., how to

engage small-scale broiler farmers, how and when to provide funding, households to target, etc.).

The research is expected to analyze expected value and variance of returns (cost of production, market prices, and production uncertainty) that are associated with production strategies to enable long term financial projections. To achieve objective (1), financial outputs such as the Net Present Value (NPV) and project's modified internal rate of return will be evaluated. For objective (2), sensitivity and scenario analyses will help detect key inputs affecting profitability level and variability. For objective three (3), mortality rates, the profit margins, and the shortcomings of the program will be used for the evaluation of future proposals. For objective four (4), general progress made and results from the concluded TI program will inform policymakers on the best decisions and actions to take at every point in time.

Chapter II

2.0 Literature Review

Previous studies related to the topic of this thesis are reviewed in this section. The studies are grouped according to the specific information they convey and the financial analysis performed. These articles were systematically chosen following the criteria indicated below.

1. The research work must be published in English.

2. The article should reflect a geographic spread of the African continent to be able to have a view of different practices across African countries.

3. The research must be empirical, a product of field research.

4. The research must make use of known research and analysis tools that are well accepted worldwide.

5. The research must address issues related to small-scale farmers.

6. The research is preferred if it relates to the analytical tools (e.g., capital budgeting, financial analysis, and scenario analysis) that will be used in this study.

To identity the studies discussed in this section, we searched library catalogs of Scopus and Web of Science accessed through the University of Tennessee's library subscription. The keywords initially used for the search were: broiler production in Africa, poultry farming in Africa, financial analysis, feasibility study, uncertainty analysis, and profitability analysis. As expected, there were hundreds of journal articles relating to these topics. The search grid was lowered to financial analysis of broiler farming in Africa and the Middle East and we obtained 33related articles fulfilling the criteria listed above. We further discretionarily selected some articles based on the geographical spread of Africa (e.g., North Africa, West Africa, South Africa, and East Africa) to provide a geographically diversified selection of articles discussed.

2.1 Production and Break-Even Analysis

Poultry farmers in Zambia suffer, on average, economic losses, according to Abolink et al. (2018). There is evidence that farmers in Zambia ignore when they are making profits or incurring losses because they lack the knowledge and ability to conduct basic financial analysis. The authors report that 70% of Zambians in the sample of this study, who are mostly women and orphans due to the high prevalence of HIV in the area, practice rural poultry. Rural poultry was defined as a practice of keeping birds on a small scale for domestic consumption or as a practice where birds are produced for marketing purposes and are reared with minimal resources (Abolink et al. 2018). This type of poultry rearing is popular because it does not require huge capital for startup and because of the resistance of the birds to some diseases (Copland and Alders 2009). On the downside, consistent with Mtileni et al. (2012) and Roberts (2018), Abolink et al. (2018) also identify some of the disadvantages of this type of poultry farming, such as: (1) low feed conversion ratio and (2) low egg production yield which inversely affects the profitability of this venture. This is against the seeming buoyant nature of commercial poultry containing broilers and hybrid chicks.

In addition, the major challenges of indigenous poultry in Zambia include, but are not limited to, low productivity and high mortality rates (Abolink et al. 2018). These researchers used financial and production data obtained from Eastern Zambia to conduct financial analysis that compared the sales performance of indigenous poultry production relative to that of broiler and layer production. Data on rural poultry production, including the cumulative cost of production and marketing and the rate of poultry viability, were obtained by surveying 459 farmers in approximately 200 villages and 40 different veterinary camps from the area of study. The researchers used statistical and spatial analyses to examine quantitative and qualitative data and to calculate the percentage of income poultry farming contributes to households per district in the area of study.

Researchers applied an Annual Enterprise Output model to ascertain the total value of poultry products sold and the value of poultry products consumed by the household. Then they applied a break-even analysis by comparing those income values to variable costs (e.g., set up cost and farm gate costs) (Malcolm et al. 2005; Cafferky 2010). Results show that mortality rates for native chickens, hybrid broilers and layers are 45%, 15% and 5%, respectively, for every year (Abolink et al. 2018). It was also found that the majority of poultry farmers who filled the questionnaires ignored the cost of production of their poultry enterprises; hence they did not know the income or loss they realized from the sales of their poultry products.

Abolink et al. (2018) acknowledge that the accuracy of data provided by experts regarding the percentage of poultry products consumed by the farmer's household, and labor, marketing and investment costs are likely to affect the accuracy of the financial analysis. Despite these potential measurement problems, this research reveals to a large extent the gap small-scale farmers in Zambia need to fulfill and what efforts the government or other institutions need to work with in funding poultry farming. This research also highlights the need to establish enough disease awareness to reduce mortality rates. The research also reveals how important poultry farming is to the average Zambian farmer (African farmers by extension), hence the need to employ more means of financial analysis to guide profitability measurement and assessment and adequate accounting and bookkeeping practices. Financial analysis based on basic gross margin analysis and break-even estimation has been brought to the fore as an efficient and effective way of analyzing cost implications and making ultimate decisions relating to profitability and proper accounting in the farm, according to Abolink et al. (2018).An example of basic gross margin analysis is sale revenues minus cost of goods sold, all divided by sale revenues, while an example of break-even estimation is a given production or sales level required for sales revenues to equal cost of sales plus other operating expenses.

2.2 Comparative Study of Poverty in Poultry Farmers and Non-Poultry Farmers

Maganga (2012) examined the gap in poverty levels between poultry and non-poultry farmers and determined the impact of poultry farming on the level of poverty of rural dwellers in Malawi. The data analyzed by Maganga (2012) was collected from the Mzimba district of Northern Malawi among Agricultural Extension Planning Areas (EPAs). The author used headcount, poverty gap measures and poverty indices to conduct a poverty analysis of the selected samples. Headcount measure estimates the absolute number of poor individuals in the sample, poverty gap measures the rate of poverty based on the income between two variables (poultry farmers and non-poultry farmers), while poverty incidences estimate the percentage of poor people in the sample. The study established a poverty parameter. The researcher further used the stochastic dominance algorithm to compare the level of poverty among poultry and non-poultry farmers.

The study finds that there is a gap between the effects of poverty on poultry farmers (30%) and its effect on non-poultry farmers and that the poverty is lower for poultry farmers when measured by headcount index than those who are not non-poultry farmers. Maganga (2012) concludes that poultry farming helps in poverty reduction and should be adopted in improving the lives of rural dwellers. The author also argues that there is enough evidence in the sample analyzed to suggest that poultry farming can help people overcome poverty and increase their well being, especially in rural settlements, if the right policies and investments are put in place.

2.3 Profitability and Efficiency Analysis

Oluwatayo et al. (2016) studied profitability and efficiency of small-scale broiler farmers in South Africa. The specific goals of the study were: (1) to estimate the profitability of small-scale broiler production, (2) to determine factors influencing productivity, and (3) to identify the constraints facing small-scale broiler production. To achieve these goals, the researchers measured profitability in terms of gross margin and net profit. Small-scale farmers in this context cultivate crops on small scale and raise livestock for consumption and subsistence purposes. Broiler farming for these small-scale farmers in South Africa mostly relies exclusively on family labor. These small-scale farmers face financial constraints such as taxes, high interest rate on loans, lack of technical know-how and trainings on the acceptable standards required in the market for livestock production, poor infrastructure–lack of good roads, steady electricity, water, adequate production and effective processing facilities and market constraints (Oluwatayo et al. 2016).

Oluwatayo et al. (2016) adopted a random sampling technique to analyze data obtained from the farmers. The analysis of productivity was implemented with the stochastic frontier production technique. Gross margin analysis was also implemented for the analysis. The high cost of feed and increasing prices of their products, leading to low sales and consequently low income, are the major reasons why farming in the area is not highly profitable. One of the challenges of the small-scale broiler farmers is the relatively high cost of procuring feed for the birds. Financing is also relevant. Some small-scale farmers who are able to obtain loans for the business have an advantage over others that do not receive a loan. In cases where farmers are able to negotiate for better prices with suppliers and buy higher volumes of inputs to make provision for years without shortages, small scale farmers would increase their profit margin and increase productivity. The authors note that inefficiency in broiler production is reduced by increased years of farming experience. They also find that private farms are less economically efficient due to lack of funds and loans from government agencies.

Oluwatayo et al. (2016) advised that training programs on technical and marketing efficiency should be made available. This would help in reducing production costs and increase savings that are a necessity to cover for contingencies. The researchers also recommended that for there to be competition, the degree of labor use should be reduced while also making inputs available for the small-scale poultry producers at competitive prices. They also recommended that training for farmers with little experience will enhance their potential to profit from their enterprises. The study revealed that there are constraints for the small-scale broiler farmers such as being exposed to theft, inadequate water, lack of training, poor infrastructure, non availability of collateral to acquire credits, high prices of resources, among others. Furthermore, the research revealed that other factors that affect the productivity of the broiler producers include feed, stock size, and vaccines. The study also revealed that small-scale broiler farmers in the Mopani District could save up to 23.4% in production costs. This is due to the farmers' level of education, which has influenced their technical efficiency. Overall, the study concluded that the farmers make profits in their broiler production.

2.4 Comparative Profitability Analysis

Away from broiler and livestock production, a profitability analysis on Shea butter was conducted by Deng et al. (2017). This study is important to this research because it uses benefit/cost ratio (BCR) and regression analysis to determine the profitability of individual respondents as will be done in the present research; it also evaluates how improvement in technology can affect yield and outputs. Furthermore, the research examined farmers' profitability using regression and investment analyses. According to researchers, the choice of Ghana to conduct this study was made because of the comparative advantage of Ghana over other West African countries in the production of Shea Butter. According to Deng et al. (2017), the research is geared at revealing the extent to which the net revenue from shea butter processing can be increased when certain advanced technologies are adopted, and the efficiency of the farmers is increased.

Regression analysis was used to establish the relationship between socio-economic variables and the net revenue of shea butter in the area of study. Also, enterprise budgetary analysis was used to estimate the cost and return in shea butter processing and marketing. BCR as a tool of financial analysis was adopted to examine the business profitability. The importance of BCR was highlighted by Issahaku et al. (2011), who believe that a business is termed a profitable venture when the BCR is greater than one as required by the investment criteria. In addition, the Rate of Return on Investment (RORI) was calculated to evaluate profitability.

In order to maximize profitability, the producers might reduce the cost of production by reducing transport, raw materials, and storage costs. Results indicated that the increase in the units of production, experience of workers in the establishment and their years of education affected the profit of the enterprise positively.

2.5 Profitability Analysis and Feasibility Analysis

Hamra (2010) examined an about-to-be set-up broiler farm in South Lebanon to determine the potential profitability of such venture (i.e., this is a feasibility analysis). The importance of this study to this research lies in the clear way it presented the effect of DOC purchase timing on yield and overall profitability of a poultry farm. Depending on the farm's size, the budget included projected income, fixed and variable costs, investment amounts, profits, and other variables. Rhodes et al. (2008) state that determining these values by adopting an enterprise budgeting analysis will enable the broiler farmer to assess the feasibility of the venture.

Comparatively, the major data collection method for this study is the historical data collection method and the other is the forecasting of changes related to the establishment of the poultry. The researcher states that the historical data model presents a separate forecast of isolated trends, cyclical and seasonal components (Hamra 2010). Data of previous years; times when poultry feed is more costly or cheaper, when raw materials for building of farms are cheaper or more expensive or when poultry diseases are predominant makes up the historical data. These historical data are projected to forecast for the coming year, the year of establishment of the poultry. Regression analysis was implemented to show a linear trend to the data provided by the historical model. A sensitivity analysis was also conducted to determine profitability when market prices are at their peak and to forecast likely future movements in costs and revenues.

Hamra (2010) forecast the price of day-old chicks, finding that prices are very high in March and April, then drop in May and increase again in October. These trends seem to be linear both for feed cost and cost of day-old chicks. This study concludes that farmers can time better the establishment of farms using the forecast and historical data models. Specifically, farmers can take into consideration the fact that non stable prices usually compensate for each other resulting in a positive net profit (Hamra 2010).

2.6 Allocative Efficiency

Discussing the factors surrounding the production, marketing, and accounting costs of broiler in Africa without reviewing literature from Nigeria will not give a clear picture of the whole issue because Nigeria is the most populous black nation, most populous in Africa and the biggest economy in this continent. It alludes that animal protein is in short supply in Nigeria owing to the massive population explosion in the rural area, which constitutes over 70% of the population and represents 85% of the people in extreme poverty in Nigeria (FOS, 1995; Chukwuji et al. 2002). Taking these factors into consideration, Chukwuji et al. (2006) conducted research on broiler farming in one state of South-West Nigeria to evaluate the quantitative determination of allocative efficiency in broiler production. The data for this study was collected over 14 months among 96 farmers from sample areas of the South-Western state.

Allocative efficiency resonates with the efficient method of producing a product with the least amount of resources to obtain a given amount. This happens when technically inefficient methods are eliminated in order to choose between technically efficient alternatives (Chukwuji et al. 2006). Oh and Kim (1980) and Chukwuji et al. (2006) refer to allocative efficiency as the ratio of total cost of producing one unit of an output, using actual factor proportion in a technically efficient manner, to total cost of producing the same unit of output, using optimal factor proportions in a technically efficient manner.

The data collected for this research included the number of broilers raised, quantity of feed used in the production process, cost of medications, marketing costs, inputs of labor, capital inputs, socio-economic characteristics of respondents, and other variables. Using regression analysis, the marginal revenue, marginal physical products, marginal value products, and marginal factor cost were determined by the researchers to evaluate the allocative efficiency, which is the ratio of marginal value product and marginal factor cost. The results show that (1) the Nigerian farmers in the sample are inefficient in allocating their resources, and (2) farmers appear to be underutilizing their resources because their scale of production system is small. The authors recommended that these inefficiencies can be mitigated by making production credits available to farmers at affordable prices.

2.7 The TI Program Small-scale Broiler Farmers

Gill et al. (2020) evaluate the progress of a pilot project called *Tworore Inkoko, Twunguke* (TI), a program designated to train and support small-scale farmers in Rwanda through intense and controlled broiler production. The program aimed to train farmers to raise 100 birds per cycle in six cycles in a uniform coop constructed in100 square meters. Gill et al. (2020) studied data from the first 18 months of farmer production of broilers on the TI program. The research objectives were (1) to confirm if Rwandan small-scales achieve livability as other standard large scale broiler farmers around the world; (2) to confirm if small-scale broiler farmers generate enough income from broiler sales; and (3) to confirm if the broiler farmers reserve broilers for their family consumption.

Gill et al. (2020) reported that 386 farmers, 176 males and 210 females, had enrolled in the TI program and finished producing at least one flock as of March 31st 2019. Small-scale farmers enrolled in the program were trained, provided a loan to start up their broiler farm and purchase DOC, feed, litter, disinfectants, and were guaranteed buy back of broilers at harvest time. The farmers were further advised to keep some broilers for consumption by their household. The TI program further helped deliver inputs to the farmers to ensure quality and uniformity of production inputs. The data for the study was obtained from the TI records between the beginning of the program and March 31st, 2019.

The study finds that DOC achieved 89% livability, compared with the 90% livability achieved by large scale models of broiler farming. The Ross 308 breed also had a good FCR as it took them 48 days to reach market weight. In addition, it was reported an increase in the profitability of the farmers due to an increase in experience with broiler production, which usually leads to a reduction in the cost of production and consequently leads to an increase in the revenue.

Since the goal of the program was not just to obtain profits but also to supply meat-based protein, it was expected farmers to keep some broilers for consumption. It was found that within the first 18 months of the TI program, there was a significant trend pointing to the increase of the farmers' income and balancing of diet for the farmers' households. The research suggested scaling up the TI program to other areas of Rwanda, considering the reliable supply of quality DOC to the farmers and giving control of the poultry value chain to the farmers.

2.8 Comparing Broiler Farmers in the TI Program and Random Broiler Farmers

Earlier in 2016, Mbuza et al. (2016) conducted a similar study to Gill et al.'s (2020), with a smaller sample of small-scale farmers (total 37 farmers) from different areas in Rwanda, especially from Kigali. Most of the farmers (62%) were male, bought imported DOC, and the majority (68%) produced less than 500 birds per cycle. The mortality rate was higher than what was observed by Gill et al. (2020) and the average time for keeping the broiler until sale was 60 days compared to 48 days in Gill et al. (2020). The aim of Mbuza et al. (2016) was to evaluate the broiler system in Rwanda and determine the management status-quo, marketing, and production practices, to identify the difficulties faced by the farmers and to involve stakeholders for the purpose of interventions and consolidation of better practices.

Mbuza et al. (2016) interviewed 37 farmers from the Eastern, Western, Northern and Southern parts of Rwanda between 2014 and 2015. The respondents were drawn from urban (37.8%), peri-urban (48.6%) and rural (13.5%) areas. Respondents had minimal level of education and used their family members for labor in the poultry farms. DOCs used by these farmers were mostly imported (94.6%) from neighboring countries like Uganda, with acceptable feed conversion ratios and livability rates. The price of DOCs was higher in this study compared to Gill et al.'s because most were imported; farmers also source them by themselves, unlike farmers under the TI program who get supplies of DOC from the local hatcheries.

Most of the farmers in the Mbuza et al.'s (2016) study had permanent poultry houses and kept farm records, especially feed usage. The study reported that only 35% of the farmers in this sample had former training in poultry farming; some of the farmers did not know about required ventilation levels for broilers, and some were under-stocking chickens, which is not economically efficient for the farmers. As a matter of fact, the feed used by the farmers consisted of maize bran (97.0%), rice bran (33.29%) and wheat bran (17.65%), farmers rarely bought premixed commercial feed as the TI program farmers studied by Gill et al. (2020) did. Mbuza et al. (2016) reported that some of the raw materials for the feed are imported, and this has led to an increase in the price of feed in the Rwandan market. Farmers were advised to use locally made feed from cottonseed and tree forage. Most importantly, it was suggested to improve health and safety practices in order to reduce the high mortality rate of 14% reported by Mbuza et al. (2020). All the below standard practices affect the broilers yield with special mention of high age at slaughter, which is inefficient because it results in excess expenses on feeding the birds and managing the poultry and delays distorting the production cycle. The same marketing modes of direct sale, contract sale, and farm gate sale as that of the TI program farmers were adopted, the difference being that there was not a buy-out contract like the one offered by Zamura Feed in the TI program.

Some of the problems addressed by the TI program are the problems these farmers, randomly included in the sample by Mbuza et al. (2016), faced. These problems included lack of quality feed, prevalence of poultry disease leading to low livability, poor access to the broiler market, lack of control on standard poultry farming practices, and inadequate financing and access to credit. The study recommended improvement in production and marketing organization in the poultry value chain. The researchers also suggested farmers' training in management and production, identifying and commercializing alternative sources of poultry feed; paying attention to research and development, indigenizing technology and global standard practices and having more access to credit are needed.

2.9 The Rwanda Livestock Master Plan

Consequent to the need for improvement in the supply of meat-based protein and the need to increase profitability of farmers in the poultry sector, the Rwanda Livestock Master Plan (R-LMP) was developed by the International Livestock Research Institute (ILRI) in 2017 in collaboration with the Ministry of Agriculture and Animal Resources (MINAGRI) and the Rwanda Agriculture Board. The R-LMP was funded by the United Nations Food and Agriculture Organization (FAO) (ILRI, 2017). The R-LMP working plan is to introduce food and health services, provide better information to agencies, and investment interventions, which alongside complementary policy support will help to meet the national development plan of Rwanda to improve productivity of cow dairy, red meat, poultry, and pork (ILRI, 2017). In addition, the ILRI (2017) study discusses efforts at reducing poverty, contributing to economic growth and foreign exchange earnings, achieving food and nutritional security, and contributing to industrialization and employment. This comes after a study reported that

40% of Rwandans lived in poverty, in rural areas, and suffered from malnutrition (NISR, 2015). The R-LMP is not only critical for rural dwellers but also to position the livestock sector to affect the feeding habit of urban consumers through the provision of the required animal protein, and invariably rendering animal products affordable (IRLI, 2017).

The researchers in the R-LMP projected that interest and investment in poultry have the capacity to produce and supply enough meat for the protein needs in Rwanda and this would enable them to export red meat and pork while settling for chicken meat due to its health benefits (IRLI, 2017). In the chicken value chain development roadmap (2017/2018 – 2021/2022), the vision is to transform the poultry industry into a sector that is market and profit oriented to be able to add value to poultry products (IRLI, 2017). This will be done by improving the traditional value chain of chicken from traditional family chicken to improved family chicken through a tripartite mode of (a) improving productivity and marketing; (b) improving the commercial chicken subsystem, and (c) integrating the chicken subsystem with the upper-end value chain (IRLI, 2017). Going from traditional family chicken to improved family chicken could be achieved by getting the best breeds, healthy feed, and management interventions. This will necessitate a 77% increase from chicken meat production of 5100 tonnes in 2016/2017 to 9000 tonnes in 2021/2022 and a 72% increase in GDP contribution from RwF 20,317 million in 2016/2017 to RwF 37,128 million in 2021/2022 (IRLI, 2017).

These projections inform the massive investment and interest in poultry farming in Rwanda since broiler is produced exclusively for meat. The interest in broiler farming has been supported in the Musanze district of Rwanda by the TI program funded by the USAID, led and monitored by the UTIA and executed by Zamura Feeds Inc. The data and progress from this TI program have been very beneficial to researchers and the farmers themselves. Data from the TI program, covering the complete grant's performance period of three years, will be analyzed in this thesis.

Partial data from the TI program (e.g., covering only a portion of the grant's performance period) was analyzed by Kenner et al. (2019), who evaluated stochastic net present value (NPV) of small-scale poultry farmers. Kenner et al. (2019) used capital budgeting techniques and simulation methods to analyze profitability and risk of the first cohorts of small-scale farmers enrolled in the TI program (with a total of 125 observations). The study reported that in the long-term this program is likely to generate a negative net present value (NPV). The implication of this is that the economic sustainability of the TI program might be at risk. More specifically, Kenner et al.'s stochastic analysis showed that in about 50% of the simulations, the project would destroy economic value (e.g., negative NPV) and in 50% of cases, economic value would be generated. Table 1 provides a brief summary of the studies discussed in this section.

Chapter III

3.0 Economic Framework and Methods

3.1 Economic Framework

3.1.1 Discounted cash flow

Discounted cash flow (DCF) methods will be used because the time value of money needs to be considered when valuing multi-period projects. That is, the farmer in the TI program enters poultry production by acquiring a coop and complementary equipment with the expectation of using those assets for more than one year. Thus, to financially evaluate the project from the perspective of an average TI farmer, it is important to forecast the cash outflows and inflows in the project over the number of years the project is expected to be operating.

Forecasting and then discounting yearly free cash flow is the proper way of measuring profitability in a newly established poultry farm. The Net Present Value and the Internal Rate of Return are financial metrics used to evaluate livestock projects, as a newly established poultry farm in the TI program (Meek et al. 1999; Shulz et al. 2016 and Bruhin 2019). DCF method as a technique of capital budgeting will give proper consideration to the time value of money, unlike other capital budgeting techniques such as the pay-back period and the average accounting rate of return methods.

The DCF method will be the primary framework of analysis because it will be used to analyze the profitability, risk, and break-even prices of the broiler farms expected to last during multiple periods (i.e., 15 years of investment expected useful life).

3.1.2 Net Present Value (NPV) and Modified Internal Rate of Return (MIRR)

To forecast free cash flow (FCF), the expected capital investment and the cost of production for a given year are subtracted from revenues (Yeboah et al. 2013). Revenue per flock, then extended on a yearly basis, for the broiler farm can be calculated using production parameters such as percentage of livability, the number of days the broiler takes until achieving market size, the weight of the broiler, and expected market prices. Cost of production includes all the operational expenses in items such as feed cost, charcoal expenses, litter, DOC, disinfectants, and others.

The NPV and MIRR will be evaluated after the values used for the financial analysis have been forecasted. The NPV will show the total amount below or above the investor's expectation, which is the total amount of gain or loss of what the investor is expecting after the expected value has been determined considering the FCFs and the opportunity cost of the capital (Trejo-Pech et al. 2019).

The annual FCF is calculated as follows,

$$FCF = NOPAT + DEP - CAPEX \tag{1}$$

where $NOPAT$is net operating profit after taxes with depreciation expenses already subtracted,$DEP$is depreciation expenses of coop and equipment, and $CAPEX$is the value of capital expenditures (coops and equipment) in the given period (Brigham et al. 2013; Bruhim 2019).FCFs are estimated for 15 years, 5 cycles per year (further elaborated in the next chapter).The equipment depreciates over 5 years, meaning that after year 5 we anticipate and forecast a re-investment in equipment, and again after year 10. In contrast, the coop is assumed to last the complete 15-year period of analysis. For all expenses, investment, and revenues, we consider a projected inflation rate of5% (Rwanda Bureau of Statistics, 2018).

There is a need to estimate the present value of the projected FCFs (15 years) of this project by using a discount rate to make future values equivalent to present values. The weighted average cost of capital (WACC) is used as the discount when calculating the NPV of the project. The WACC is the weighted average of the annual cost of debt and cost of equity estimated or assumed over the useful life of the project. Bruner et al. (1998) state that the use of WACC is the most standard way of expressing the cost of capital of a company. The WACC is estimated as follows:

$$\text{WACC} = \frac{Debt}{Assets} \times d \times (1 - tx) + \left(1 - \frac{Debt}{Assets}\right) \times e \qquad (2)$$

where *d* is the loan rate, debt is the value of all loans, assets is the book value of assets, *tx* is the farmer's income tax rate, and *e* is the expected opportunity cost of equity (Bruhin et al. 2021). Estimating a cost of equity is difficult even for publicly traded firms that have stock prices, from which the cost of equity could be estimated. For a farmer, or in general, for entities not trading in stock exchanges, a technical estimation is not possible. In this study, it is assumed that the cost of equity is the same as the loan rate.

The NPV will be estimated by the present discounted value of benefit minus present discounted values of expenditures, in other words, by discounting FCFs (Guttinger 1982).The NPV is calculated over a fifteen-year planning horizon as follows:

$$NPV = \sum_{t=0}^{k} \frac{\text{FCFt}}{(1+\text{WACC})\text{t}} + \text{T(k)} \qquad (3)$$

where WACC is the discount rate, t is the production period or the particular year, starting from the moment of investment (t=0) to the end of the project (t=k = 15 years), k is the number of years of forecasted operation, and T(k) is the terminal value, the recovery value of equipment and building, if any, at the end of the forecasted period.

The NPV of a project is the deviation between the present value of cash inflows of an investment and the cash outflows. The discount rate in NPV is very critical to the projects it evaluates, it is the profitability benchmark to compare performance, and this is mostly determined by using the opportunity cost of the investment capital. The initial cash flow of this project came in the form of a loan and paying back the loan requires management and monitoring of cash flow through the years of the useful life of the project.

Most decision makers and investors use the NPV and/or the Modified Internal Rate of Return (MIRR) since they are very comparable, with the former providing a monetary value and the latter providing an annual rate of return. MIRR is preferred to the traditional IRR for the purpose of this thesis due to its high accuracy and because it avoids the potential of multiple and misleading IRRs. The MIRR is the discount rate at which the NPV equals zero. The MIRR, therefore, indicates how high the cost of capital could be without generating a negative NPV (Asqutth and Bethel 1995). To calculate the MIRR, the future value of cash inflows (FV using the reinvestment rate, WACC) and the present value of cash outflow (PV using financing rate, WACC assumed as well) are first estimated. As shown by Trejo Pech et al. (2021), MIRR is estimated as:

$$MIRR = \left(\frac{FV_T^+}{PV_0^-}\right)^{\frac{1}{T}} - 1 \qquad (4)$$

where FV_T^+ is the future value at time $T{=}15$ – the end of the forecasted period – of all positive FCFs composed at the opportunity cost of capital, and PV_0^- is the absolute value of the present value at time zero of all negative FCF discounted at the opportunity cost of capital.

The MIRR will sum the discounted negative cash flows to the beginning of the first period, and will sum the positive cash flows to the end of the last period adjusting for the reinvestment rate.

3.2 Methods

3.2.1 Spreadsheet Model

The Excel® spreadsheet model developed for the analysis was formulated and fed with data obtained from the field by the TI program team, as explained in the data section. Excel® is flexible for complex analyses when the spreadsheet is properly formulated, since the software has add-in tools such as What If Analysis, used in this thesis for scenario analysis. The model was developed to perform the DCF evaluation in a way that all the parameters of production, expenditures, and inputs were fully represented and tabulated according to the farm's field outcome. FCF, NPV, and MIRR were all calculated and the results along with scenarios presented and discussed.

3.2.2 Break-even Analysis

Break-even analysis will help to establish the relationship between fixed costs, variables costs, profits, and sales revenue. In accounting, there is a need to establish a point-price (price for a given quantity) or quantity produced for a given price–where the total revenue (TR) equals the total cost of production (TC) (Mahama et al. 2013).

Unlike accounting break-even, in a DCF model, which considers multi-period and hence varying revenues, costs, and a discount rate, the break-even point is the price for a given quantity or quantity given a price at which NPV equals zero (Trejo-Pech et al. 2019). At break-even, both debt holders (for instance, loan providers in the TI program) and equity holders (TI farmers) would obtain a given annual rate of return, which is the estimated or assumed discount rate.

3.2.3 Scenario Analysis

Scenario analysis will be conducted to compare various scenarios to get the most desired result. These scenarios involve different outputs generated from different uncertain inputs. Different scenarios include farmers enrolled in the (1) first year of the TI program, (2) first two years of the TI program, and (3) complete three years TI program. A deterministic scenario analysis will be performed because there are more than one specific scenario of different outcomes involved (Yoe 2019). In scenarios (1) and (2), flock observations will be limited to their corresponding period (and changing the input variables using the mean values during the period analyzed) and NPV and MIRR outputs will be compared with the baseline scenario (3). The value of the WACC will be determined from the excel spreadsheet which will in turn be used to determine if the NPV is negative, neutral or positive. A baseline scenario, which has been established as number (3) above, containing information from the complete TI program period, will be established where other scenarios can be compared against it.

Further, a sensitivity (what if) analysis will be performed with the excel file by using parameters such as WACC, mortality rate, inflation, cost of feed, and cost of DOC as provided in the database. Sensitivity analysis will be used to assess risks qualitatively and quantitatively. The rate of sensitivity to risk of each variable will be evaluated to determine how influential each variable is (Clemen and Reilly 2013; Yoe 2019).

The sensitivity analysis will be used to examine the effect of selected variables on the NPV and rate of profitability and evaluate the impact of relevant variables. Forecasting future movements of cost and revenue is also necessary. Due to inflation over the years of the project, any increase in the price of DOCs or price of feed will affect the net income whether other costs remain constant or not, there will still be effect on the profitability. As assumed in the data, the selling price will increase as inflation rises.

Chapter IV

4.0 Data

4.1 Area of Study

The TI program, evaluated in this study, was implemented in the Musanze District of Rwanda. The Musanze district is located in the Northern province of Rwanda, bordering Uganda and the Democratic Republic of Congo, with an estimated population of 368,000 according to the 2012 census and a population density of 694 per kilometer (USAID, 2018). The central area of Rwanda, where the capital of the country is located, has the highest number of broiler farms among the five districts of Rwanda (Leding et al. 2013). The Eastern province has the second highest concentration of broiler farms followed by the West and South. The Northern district of Rwanda, where Musanze belongs, is dominated by layers production, unlike the other districts that majorly deal with broiler production (Leding et al. 2013).

Musanze houses in its capital city Ruhengeri the first Rwandan commercial feed mill, Zamura Feeds LTD which is one of the partners of the TI project alongside USAID and UTIA. Further, Musanze is a typical Rwandan rural area both in poverty rate and malnourishment rate (NISR, 2015), standing as a good location to evaluate whether poultry farming contributes to the supply of protein for nourishment and for increased income to fight poverty. Other sectors within Musanze are Muhoza, Gataraga, Kinigi, Kimonyi and Cyuve. These sectors are further divided into villages and into cells. Due to the proximity of the feed mill, Musanze presented itself as the ideal location for the study.

4.2 Data

4.2.1 Database

The data for this study were collected from all small-scale broiler farmers participating in the TI program. The TI farmers had the goal to produce100 chicks per flock between 2017 to 2020. Researchers and/or team members of the TI program collected data pertaining production costs (e.g., feed, vaccines, light, etc.), selling prices, and production parameters, among other data. In particular, the database for this study was built and curated by Dr. Carlos Trejo-Pech by combining several reports (e.g., USAID reporting, flock performance report, and farmers export report, among others) available in the Rwanda Flock App, which has access restricted to TI researchers and stakeholders. The combination of several reports was necessary to have a database with the variables needed for a capital budgeting analysis.

4.2.2 Broiler Production

4.2.2.1. Broiler production in Rwanda

Broiler production investment starts with the construction of coops, which have to be approved by planning authorities considering environmental factors such as minimizing odor, noise and refuse disposal. These coops are constructed so that they do not constitute environmental or health hazard and also in such a way that the safety of the birds is not threatened (Wood et al. 1998). For commercial broiler farming in Rwanda, the coops are usually open sided, with five to ten chickens per square meter (Cocchini and terSteeg2019). Most of the farmers rear the broiler from day old stage until two weeks and are transferred to another chicken house until they are ready to be sold either as live chicken or slaughtered chicken; this is usually when the birds have matured to a certain extent (Cocchini and terSteeg 2019). However, there is no documented evidence of this practice as part of broiler farming in the TI program, maybe due to the fact that there is only one coop involved in the broiler production in farms under the TI program.

The broiler farmers prefer to use genetically modified breeds of DOCs while stocking their farms due to their comparative advantage in FCR, livability rate, resistance to diseases and because in most cases, the price also determines the breed farmers prefer. In Rwanda, farmers generally use Ross 308 breed sourced locally from private hatcheries, while some farmers prefer imported breed from countries such as South Africa, Uganda, Belgium and the Netherlands (Kenner et al. 2019). The most popular of the imported breeds are the Cobb-500 and Young Stock imported from neighboring Uganda due to its growth potential (Mbuza et al. 2016). However, local hatcheries are springing up in Rwanda, with companies like EasyHatch limited, Rwanda chick limited and Uzima chicken having a combined supply capacity of 8 to10 million DOCs yearly (Cocchini and terSteeg 2019).

The DOCs stage (from the hatchery to two weeks old) of broiler farming is usually the most sensitive stage in the management of a poultry farm due to the fragile nature of the birds and their susceptibility to disease. A good disease prevention program is necessary for the birds at this stage because diseases can be transmitted through humans, pests, and contaminated equipment (Mobley et al. 2007). Some large-scale poultry farms are equipped with facilities like feed mills, hatcheries, cold rooms for storage and slaughter house (Cocchini and terSteeg 2019), while small scale poultry farms like those analyzed in this study have basic equipment like feeders, drinkers, litter and charcoal pots.

The broilers are fed with either pelletized feed or mash feed (Gill et al. 2020). Mbuza et al. (2016) report that maize bran makes up 97% of the main feed of the broilers. In some places, supplements are added to the feed to increase the weight gain of the broilers and potentially increase profitability. Most big farms produce their feed by themselves to save cost since feed is the single highest expenditure for a poultry farm (Jenkins et al. 2016; Kenner 2018). Most modern commercial farms use semi-automatic or automatic feeding systems with basic bio-security measures (Cocchini and terSteeg 2019). The birds are given proper vaccinations periodically and medications until they reach the desired weight and are ready for sale or slaughter.

The maturity age of the broiler varies; depending on factors like the breed type, FCR, farm practices and farmers' decisions based on market demand. On average, the maturity age is between 48 days and 80 days depending on the growth rate of the broiler (Gill et al. 2020). There have also been reports of 45 days or less with an average weight of 2.4-2.5kg per bird (Cocchini and terSteeg 2019). Most commercial farmers produce 4 or 5 cycles or flocks in a year with particular observance of spacing between restocking and selling in order to clean the coops and give time before restocking.

In general, small scale farmers sell their birds as live chicken in the market while the big commercial poultries with facilities such as cold room slaughter their birds and store in cold rooms where they are sold from. A standard slaughter facility can process up to 400 birds per hour and they are stored in freezers between zero to five Celsius degrees.

4.2.2.2. Broiler production parameters in the TI program

In this study, production parameters for the capital budgeting model are determined according to data in the TI farmers/flocks database. Table 2 provides key production parameters.

Capacity utilization of the broiler operation is the maximum number of birds that the operation can handle in a production cycle of 52 days on average (Table 2). Production capacity was defined by the TI program research team and funders as constant across TI farmers. The small-scale farms in Musanze are equipped with a coop and equipment sufficient to produce 100 birds per cycle. Capacity utilization in this context is an essential decision variable that the producer can control as one of the production strategies (Ragsdale, 2004). In this study, capacity utilization is assumed to be 100% for all but the investment period (t=0) of the fifteen-year horizon (t=0 through t=15) due to the expectation that the producer wants to maximize profit, and assuming their marginal profit is positive for each bird produced.

The production cycle is the number of days required to grow a flock of chicks to maturity, sell the flock, and allow a cleanout period before starting another flock (Table 2). The production cycle ends when the farmer clears the coop to bring in new chicks, which it is fourteen days (Gill et al. 2020) and begins when the farmers bring in new birds. This study has identified that the period for the birds to attain an average market size of 3.04kg by an FCR of 2.34 is 52 days.

Assuming 365 days per year, and dividing 365 by 52, and rounding the results down, we assume 5 cycles per year for the capital budgeting evaluation in this study (Table 2). The five cycles per year assumption are consistent with prior studies (Kenner et al. 2019; Gill et al.2020).The annual broiler capacity, the number of birds capable of being produced by the operation in a year, is 500 (e.g., 5 cycles times 100 birds per cycle).

4.2.3 Investments Cost

Investment cost, measured in RwF and converted into USD for illustration purposes, is the amount spent on equipment. For the Musanze TI program operation, this cost was the same for each small-scale and paid by Zamura Feeds as an investment loan (Table 3). Investment costs in the financial model include the costs of equipment, buildings, land, and utility installation necessary for the household to begin growing broilers.

$$C_{Inv} = Eqp + Bld + Lnd + Utl \quad (5)$$

Here, C_{Inv} is investment cost, and *Eqp,* the cost of equipment, is the sum of tube feeders cost (RwF21,600; $22.22), chick feeders cost (RwF10,000; $10.29), drinker cost (RwF7,600; $7.82), and clay pots cost (RwF3,400; $3.50). The variable *Bld* is building cost, or the cost to construct the coop (RwF500, 000; $514). According to Kenner (2018), the variable *Lnd* is the cost of land used for the operation, calculated as:

$$Lnd = Area_{Lnd} \cdot P_{Lnd} \cdot (1 + C_{Over}), \quad (6)$$

where $Area_{Lnd}$ is the area of land purchased for the operation, P_{Lnd} is the price of land purchased, and C_{Over} is the cost overrun factor. C_{Over} is a percentage of the overall cost expected to occur on a project, such as building a coop which is provided as a loan from the TI program. Area, price, and cost overrun are assumed to be zero because the coops are built on the small-scale's existing property and are only 100 square meters, so no additional land needs to be purchased from the capital expenditures loan. The variable *Utl* in equation 6 is the cost of installing utilities, such as electricity and water, which is already considered in the total value of the construction of the coop and handled by the same contractors of the TI program.

4.2.4 Operation Cost

The operational expenses values are the amount spent on feed (kg), charcoal (45 Kg per bag), litter (sack), vaccines (bottle), birds (100 each), water and energy, and disinfectants, as shown in Table 4. Total operational cost (Op_{Costs}) per flock is calculated as,

$$\text{OpCost} = Feed + Charcoal + Litter + Vaccines + Birds + disinfectants + WaterandEnergy + Labour \quad (7)$$

The first line in Table 4, Birds, is the cost of birds (DOCs) purchased for the farm (average = 582, median = 572, standard deviation = 54, min = 478, max = 1,862, count = 2,189). The birds purchased for the TI program are usually the Ross-308 breed and 100 birds for each cycle based on the specification of the coops. The DOC per flock is the number of birds planned to be used (B_p) times the price of DOCs (P_{Doc}). All other variables in table 4 are calculated similarly.

Feeding the birds consumes the highest percentage of the operational expenses, equivalent to 58.4% in the TI program (Table 4). The feed is either mash feed or pelletized feed, depending on which gives the best FCR. The feed is measured in kg. (average = 352, median = 349, standard deviation = 45, min = 211, max = 686, count = 2189).

The vaccine, measured in bottles, is the required vaccines for the treatment of the birds. Only one bottle is used throughout the production cycle (cost of vaccines statistics: average = 607.5, median = 576.2, standard deviation = 58.7, min= 551.5, max = 833.0, count = 2,164.0). The cost of vaccines (0.2%) represents the lowest portion of the total cost of operation.

The cost of water and energy is assumed to be RwF150 per day and a total of RwF 7,761 since it is not measured in the TI database (USAID, 2018). Litter bought/measured in sacks (2.6; average 3 sacks) including the transportation cost as part of the variables (average = 1,205, median = 1,139, standard deviation = 195, min = 915, max = 2,363, count = 2,179). Disinfectant cost was assumed to use one bottle bought at the same time is used for the whole production cycle (average = 1,249, median = 1,384, standard deviation = 503, min = 0, max = 7.057, count = 2,140).

Charcoal sold in sack and measured in RwF as a variable was calculated for 3 sacks including the cost of transportation (average = 10,664, median =10,439, standard deviation = 1,956, min =964, max = 23,863, count = 2,195).

A 2011 World Bank report states that Rwanda suffered from 36% underemployment, with the average worker being employed less than 26 hours every week (World Bank, 2015). Generally, farm labor is characterized into skilled and unskilled labor. In a small-scale broiler farm, almost all the necessary labor is sourced from the household of the farmer. There is no provision for skilled labor since the farmer and his household provide the expertise and their wages are in the form of the profits from the venture (Kenner 2018). The small-scale farmers in the TI program receive adequate training in broiler farming to manage the small-scale broiler farms (USAID, 2018).

The TI program provides a technician, skilled labor, who advises the farmer on feed dosage and the approximate maturity of the broilers and how to deliver birds to that markets (Kenner 2018). The farmers are paid RwF 52,000 on average per cycle; this money is for the maintenance of the household as opportunity cost for the indirect employment on the farm (USAID, 2018). However, the farmers in the TI program are not actually paid by the grant.

4.2.5. Financing

The farms under the TI program are fully funded by USAID. Farmers who successfully enroll in the TI program are granted a loan for both the capital expenditures and operating cost of the farm.

4.2.5.1 Loan for Capital Expenditures

An interest free loan of approximately RwF 542,600 to cover the cost of building the coop, buying of drinkers, feeders and clay pot are granted to TI farmers (Gill et al. 2020). This one-time loan is given equally to the farmers since the estimated cost of starting the new poultry farm is the same for all the farmers for a given flock. The collateral for the loan is the coop and coop equipment purchased with the coop package. The TI program coordinator reserves the right to deconstruct the coop and reuse it for placement in the location of another enrollee if a farmer defaults in the loan repayment or drops out of the program (USAID, 2018). The coop is built by technicians provided by the TI program to have the same dimension and be made of the same material. This capital expenditure loan was expected to be paid back in three years, but some farmers defaulted and some are still paying back the loan because payments also depended upon farmers' profits (Gill, 2021). The loans are paid back based on a percentage of profit calculated by the TI team after each cycle of production. Table 5 shows the percentage of loan to be paid according to profit tiers (Gill, 2021). Table 5 shows that the higher the profit, the higher the percentage of loan farmers repay.

4.5.2.2 Loan for Recurring Expenditures.

After establishing the poultry farm, the farmers in the TI program are granted a second loan that covers the expenses for the procurement of farm inputs –DOC, feed, vaccine, etc. (Gill et al. 2020). This loan is not constant across farmers like the loan for capital expenditures, with amounts varying between RwF 250,000 to RwF 400,000 depending on the prices of farm inputs at every point in time (Gill, 2021). This loan charges an interest rate of 14% yearly and is paid back by the farmer after the sale of birds at the end of each cycle of production (Gill et al. 2020; Gill 2021). USAID (2019) reports that this line of credit is optional as farmers who have enough cash can use their money to purchase and fund the operational expenses at the start of the cycle.

The profit to be made by the farmer is determined and paid after the recurrent line of credit is deducted from the revenue generated from birds' sales (Gill et al. 2020). The farmers do not have control over how their birds are sold or the price of the birds because some are sold as live while others are sold as dressed. However, standard rates are put in place to reflect fair payments based on the farmer's efficiency (USAID, 2018).

Table 6 concentrates into one table the different parameters discussed above, along with some descriptive statistics including average, standard deviation, minimum and maximum.

Chapter V

5.0 Result and Discussions

5.1 NPV and MIRR Break-Even Analysis

The break-even price of chicken when NPV = 0 is RwF 1,361.2per kilogram. This is a point where the long-term total discounted cash flows equals the total costs, including expected opportunity cost (i.e., both the equity holders and debt holders will obtain a particular annual rate of return, which is 14% per year). The break-even price of broilers after each cycle of production, when the NPV = 0, is close but a little higher than the actual average price of chicken, at RwF1,314.3, that TI farmers received during the three years period. However, notice that according to the assumptions of this model, the price of live chicken will increase as the inflation rate increases due to an increase in the cost of production and inputs (Table 7.1 – 7.3). It is expected to increase from RwF 1,361.2 to RwF 2,707 within the 15 years life of the project with a forecasted inflation rate of5%. The calculated break-even price is expressed in 2020 values.

The forecasted price that yielded NPV = 0 is equivalent to MIRR equal to14%, which is the expected opportunity cost or interest rate in Rwanda. In other words, a farmer selling at break-even price will obtain an annual rate of return of 14% after paying the financing costs. If the farmer sells chicken at a price below the break-even price, he/she will still make a profit, but the rate of return will be lower than 14% after paying the cost of financing. The NPV was calculated using the assumed WACC, which in turn assumes that the farmers in the TI project repay the loan they were given at 14% per year. The discount factor kept decreasing from 0.877 to 0.140 (Table 8.1 - 8.3) within the useful life of the project. This discount factor is important to keep track of the return of the capital expenditure on a yearly basis and to keep comparing this with the initial investment. This is done by using the discount factor to bring the future expected cash flow back to the present value (Yoe 2019). If debt holders and equity holders require 14% WACC, the NPV will be equal to 0 (positive) if they can sell the first year at the calculated break-even price.

The DCF that yielded NPV =0, where WACC equaled MIRR at 14% has the FCF increasing from year one to year 15. The DCF has a slight reduction at year 6 and year 11 due to the cost of replacing the equipment (to be replaced every 5 years due to anticipated obsolescence).

5.2 Scenario Analysis

Scenario analysis was implemented to compare the performance of farmers enrolled in the first year of the program only, first two years of the program, and the complete farmers in the three years program (all farmers in the TI database or baseline, as discussed in the previous section). While implementing the scenario analysis, it is observed that there are a total of 174 farmers and 510 flock observations in the first year (2017 – 2018), 429 farmers and 1770 flock observations in the first two years (2017 – 2019), and 511 farmers remaining at the end of the program with 2260 observations (2017 –2020) (Table 9). These data subsets were obtained from the Excel spreadsheet created using field data from the TI program. Output variables used for the comparison are NPV at 14% WACC and MIRR at 14% and these were performed in the Excel spreadsheet. The average price of live chicken was RwF 1,314.3 in the third scenario, RwF 1,282 in the second scenario, and RwF 1,260 in the first scenario (Table 11).

For the first scenario, when the WACC is at 14%, the NPV is negative –RwF-215,878 ($-221.9), while the second scenario's NPV is positive at RwF 314,318 ($323.0). The third scenario, which is the baseline scenario, is where the NPV equals 0; this is neutral because it has the capacity to generate positive or negative NPV in the future. The MIRR at 14%

WACC in the first scenario is 10.2%, lower than the second scenario with the highest MIRR at 17.5%, while the third scenario has a lower MIRR than the second scenario and a higher MIRR than the first scenario at 14.0%.

From the analysis, the complete collection of farmers in the TI program from 2017 – 2020 generated an NPV=0 when WACC is 14%. The first year of the program generated a negative NPV with 14% WACC pointing to the fact that the program in its first year is worth less than what had been invested. From the scenario analysis, it seems production expertise which grew over the years from 2018 to 2020, contributed to making the NPV positive as against the negative NPV generated in the first year of the program. As indicated in Table 11 below, production parameters such as FCR and weight of live chicken improved in the second and third year while unit cost of feed dropped in the second year. The price of live chicken also improved in the second and third year; these factors were responsible of changing the NPV, which is negative in the first year to positive in the second year. With the increasing trend from negative to positive and higher positive numbers, the program might keep generating positive NPV in subsequent years if the program continues operating and production parameters further improve. There was an increasing trend both in the number of farmers for the three scenarios, increasing number of flock observations, and increasing NPV. The MIRR did not follow this trend as the second scenario has higher MIRR of 17.5% more than the third scenario at 14.0% and the third more than the first scenario at 10.2%.

5.3 What if Analysis

A sensitivity analysis was also conducted where different potential changes in cost variables and/or production parameters were assumed to occur individually rather than simultaneously, to examine the change of output; that is how the change of variables' levels affects the NPV and MIRR values. The variables changed for the sensitivity analysis are the

WACC, mortality rate, expected inflation, cost of chicks, and the cost of feed. The WACC is the discount rate for the free cash flows and it is the primary measure of risk and value creation. It is important to know how the assumed discounting rate affects the NPV or value of the project. It is also very important to know how the projected inflation and mortality rates affect the NPV and MIRR since the two have a direct bearing on the production cost and revenue from the farm for each production cycle. The cost of feed and cost of DOC are some of the most important factors to be considered by every farmer as any slight change in price greatly affects the output and NPV of a poultry venture. Table 4 (in chapter 4) shows that cost of DOCs accounts for 16.4% of the total cost of production while feed cost accounts for 58.4% of the total cost of production per cycle. They both account for 74.8% of the total cost of production per cycle. Thus, performing sensitivity analysis on these variables is relevant.

The simulated NPV and MIRR values showed significant sensitivity to the changes in the WACC. When the WACC is lower than the baseline, at 12.5%, the NPV is positive at RwF 48,660.72 and consistently, MIRR is greater than the WACC. When the WACC is higher than 14%, the NPV is negative and there is a significant increase in the MIRR. At 17% and 25% WACC, the NPV generated is RwF -80,231.18 and RwF – 219,265.46 respectively.

The mortality rate was also used against the NPV and MIRR, and the NPV was positive at RwF 866,438.139, RwF 345,260.17, and RwF 149,818.43 when the mortality rate is assumed to be5%, 8.20%, and 9.40% respectively. The mortality of 10% generated an NPV equal to 0 with a corresponding MIRR of 14% that equals the WACC. The NPV became negative at RwF -322,499.10 as the mortality rate surpassed the baseline of 10% and increased to12.30%. The MIRR at this instance decreased to 7.52%, far below the baseline of 14%. As the mortality rate decreases, the NPV and the MIRR increases, and vice versa.

The third parameter used in the sensitivity analysis is the projected inflation rate. As the inflation percentage increases, the NPV increases. At 5% percentage inflation which is the baseline, the NPV = 0 and the MIRR equals the WACC at 14%. As the inflation depreciates below 5%, negative NPV is generated. A 2% inflation resulted in an RwF -75,029.37 NPV and MIRR of 12.87%. A 2.4% inflation resulted in an RwF -65,943.57 and MIRR increased to 13.02%.At 4.25% inflation, RwF -20,322.97 is generated and a higher MIRR of 13.71%.When the inflation is above 5%, a positive NPV is generated and a MIRR higher than the 14% baseline. As shown in Table 10, 10% inflation generates RwF 168,714 NPV and the highest MIRR of 16.08%. Increases in the inflation rate result to increases in the NPV and the MIRR, and vice versa.

Price changes of DOCs have a significant effect on the NPV. With the price of DOCs assumed to vary one standard deviation from the baseline (+54), at Rwf 636.5, the NPV generated is negative at RwF -213,434 and a decreased MIRR of 10.26%. In contrast, the NPV increased to RwF211,815.49 and increased more to RwF410,659.10 with MIRR of 16.53% and 18.36% with a value of RwF 528.5 (standard deviation -54) and 478 (minimum unit cost of DOCs). The maximum price of DOCs at RwF 1,862 generated the lowest NPV at RwF – 2,285,447.15 and a percentage of MIRR lower than 0.

Similarly to price changes of DOCs, the cost of feed has the greatest impact on the NPV. Any slight increase in the price of feed affects the NPV, and the same applies to a decrease in the price of feed, as shown in Table 10.As an example, an increase in the price of feed at RwF 397 (st. dev. +45 from the baseline price), generates a negative NPV of RwF -1,048,226 with MIRR below 0%.

The scenario analysis shows how sensitive NPV is to changes in input values. While farmers in the TI program do not have control over some inputs, they can improve production parameters such as mortality rates and FCR, which would improve revenues and reduce costs respectively, hence improve NPV and MIRR values.

Table 11 presents a summary of the parameters in each scenario that affected the results we have in the analysis in section 5.2. The feed conversion ratio varied in the three different scenarios that were presented with its highest value in the second scenario. The weight of live chicken peaked in the second scenario due to the high FCR of the second scenario, while the unit cost of DOCs dropped to the lowest in the second scenario. The unit cost of feed, price of live chicken and total operational kept a steady increase from scenario one to scenario three.

Chapter VI

6.0 Conclusion and Recommendations

6.1 Conclusion

The aim of this research is to analyze data from the small-scale farmers enrolled in the TI program sponsored by USAID and facilitated by UTAI and Zamura Feeds to provide information that will enable the TI farmers to be more efficient and productive; while also providing necessary information to policymakers on the way forward in terms of broiler farming in Musanze district of Rwanda. This evaluation was done by implementing a capital budgeting analysis and a financial risk analysis that estimated NPV, MIRR, break-even and scenario analyses for the small-scale broiler farmers. Expected cash flow were forecasted while accounting for the variations arising from production uncertainty, price of adult chicken, cost of production, and depreciation of equipment over a period of 15 years. The scale for this production is 100 birds per cycle and 5 cycles per year, totaling 500 birds at the maximum per year. Each production cycle lasts for 52 days plus additional 14 days in between cycles for cleaning and disinfecting of the coops. The mortality rate is assumed at 10%, while the inflation rate is 5%. Other production parameters and cost variables for the baseline scenario were discussed in chapter 4.

Previous financial analyses with more limited datasets were published by Kenner et al. (2019) and Gill et al. (2020) analyzing farmers in the TI program. These previous studies are used throughout this document as references for comparison. This study found that the baseline scenario, which includes all farmers during the three-year program (with 2260 flock observations), yields NPV=0 at 14% WACC, when the estimated break-even price is RwF 1,361.2 per kilogram. When only farmers enrolled in the first year are analyzed keeping the same WACC and break-even price from the baseline, the project yielded a negative NPV of

RwF-215,478 and an MIRR of 10.2%. Further, when we analyze farmers enrolled during the first two years keeping the same WACC and break-even price used in the baseline, the project yields a positive NPV of RwF 313,318 and a MIRR of 17.5%..

From the analysis, the break-even price in the baseline scenario at which NPV = 0 is RwF 1,361.2 per kg while the actual average price of matured chicken with FCR of 2.34 weighing 3.04kg at selling time is RwF 1,314.3 during the complete three years of the program. Prices, weights, and FCRs varied over time, at RwF 1,260, 2.31 FCR, and 2.70kg per chicken during the first year; and RwF 1,281.9, 2.40 FCR and 3.07 kg for those in the first two years of the program. One can deduce that as the farmers gained experience, they performed better, with higher FCR, heavier weight, and higher prices, all this yielding higher NPV and MIRR. Farmers have no control over prices of chicken at all since chickens are sold under different schemes (e.g. live chicken or slaughter and through different market channels) by administrators of the TI program. Thus, while this is a limitation of the analyses, prices provide a reference for context. Kenner (2018) specified farm-gate prices of chicken at minimum price of RwF 1,152, median price at RwF 1,347 and maximum price at RwF 2,219, while contract sales at minimum price = RwF 1,323, median price = RwF 1,360 and maximum price = RwF 1,432. Other documented selling prices of live broiler in Rwanda are RwF 1300 (Cocchini and terSteeg 2019), RwF 1,200 in December 2018, and RwF 1,718 in August 2018 (Gill et al. 2020).

The sensitivity analysis shows that the project's NPV is most sensitive to the unit cost of feed (RwF/kg) and unit cost of DOCs (RwF), followed by the WACC, inflation and mortality rate. This is consistent with the fact that the cost of feeding and cost of DOCs contributes to 74.8% percent of the total cost of production.

Summarily, at the end of the program after a period of three years, the analysis showed that the venture is highly likely to be profitable in the long-term since the estimated break-even price is close the actual average price.

6.2 Recommendations

This study recommends that farmers should go for DOCs that have low mortality rate and high FCR so as to grow into a reasonable size for maximum profitability. This study found out that cost of feed and cost of DOCs are one of the most important factors affecting profitability, policymakers should help farmers to get access to cheaper feed by giving feed subsidy when necessary and helping farmers get the best breed of DOCs. Gill et al. (2020) found that pelletized feed helped the birds achieve more livability and weight, thereby increasing the market value of the birds. This has been confirmed by this study as it found out that FCR and weight of live birds increased after the first year of the program hence one of the reasons why the first year of the program generated negative NPV and the subsequent years have positive and zero NPV respectively. Policymakers should encourage farmers to use more pelletized feed than mash feed, as it has been proven by Gill et al. (2020) to improve speedy weight due to proximity of the feed supply.

In addition, farmers in the TI program are recommended to contact the TI technicians regularly and follow their recommendations on how to reduce mortality rates and improve feed conversion ratios. The TI program policy makers might promote, through the TI program technicians, the implementation of best production sharing practices among farmers in the program.

Finally, non-interest loan given to the farmers at the start of the program contributed to farmers' profitability. More funding agencies are needed to support Goshen finance and Zamura Foods to make more funding available to farmers in other parts of Rwanda to enable indigent farmers to make a living and have access to more meat-based protein for balanced nutrition.

Bibliography

Abolink, C., Dautu, B., Gummow, B., Mubamba, C., and Ramsay, G. 2018. "Analysing Production and Financial Data from Farmers can serve as a Tool for Identifying Opportunities for Enhancing Extension Delivery among the Rural Poultry Sub-sector in Zambia". *Preventive Veterinary Medicine* 158: 152 – 159. https://doi.org/10.1016/j.prevetmed.2018.08.005

Adegeye, A. J. & Dittoh, J. S. 1985. *Essential of Agricultural Economics*. Nigeria: Impact Publishers.

Anderson, E. 1993. *Value in Ethics and Economics*. Harvard University Press.

Andrew, A. & Jun, L. 2004. "How to Discount Cash Flows with Time Varying Expected Returns." *Journal of Finance,* LIX (6)

Asquth, D. & Bethel, J. 1995. "Using Heuristics to Evaluate Projects: The Case of Ranking Projects by IRR." *The Engineering Economist*, 40:287 – 294.

Aven, T. 2018. "An Emerging New Risk Analysis Science: Foundations and Implications" *Risk Analysis*, 38(5):876-888

Boardman, A.E., Greenberg, D. H., Vining, A. R., and Weimer, D. L. 2014. *Cost-Benefit Analysis Concepts and Practice.*4nd ed. Upper Saddle River, NJ 07458: Prentice Hall.

Brealey, R., Steward M., & Franklin A. 2011. *Principles of Corporate Finance*. New York: McGraw-Hill/Irwin.

Brigham, E. & Houston, J. 2017. *Fundamentals of Financial Management* (Ninth edition). Boston: Cengage Learning.

Brigham, F. & Houston, J. 2013. *Fundamentals of Financial Management; Concise Third Edition.* USA: Harcourt College Publishers.

Bruhin, J. M. 2019. "Determining the Optimal Start-up Strategy for a Cow-Calf Producer to Maximize Long-Term Profitability and Minimize Risk." Master's Thesis, University of Tennessee. Https://trace.tennessee.edu/utk_gradthes/5477

Bruhin, J., Trejo-Pech, C., Boyer, C., Smith, A. 2021. "Profitability, Risk and Cash Flow Deficit for Beginning Cow-Calf Producers." *Agricultural Finance Review,* Emerald Publishing Limited

Bruner, R., Eades, K., Harris, R., Higgins, R. 1998. "Best Practices in Estimating the Cost of Capital: Survey and Synthesis." *Financial Practice and Education*.

Cafferky, M. 2010. *Breakeven Analysis: The Definitive Guide to Cost-volume-profit Analysis*. Business Expert Press.

Chukwuji C. O., Inoni O. E., Osuagwu C. N. 2012. "Family Size, Purchasing Power and Strategies for Increasing Rural Household Protein Intake in Delta State, Nigeria." In: Aletor V. A. and Onibi G. E. (eds) *Proceedings of the 10th Annual Conference of the Nigerian Society of Animal Production*. Akure, Nigeria, pp380 -382

Chukwuji, O; Odjuvwuederhie, E; O'raye, D; Oyaide, W. 2006. "A Quantitative Determination of Allocative Efficiency in Broiler Production in Delta State, Nigeria." *Agriculture Conspectus Scientificus*, 71 (1): 21-26.

Clemen, R. & Reilly, T. 2014. *Making Hard Decisions with Decision Tools (3rd Edition).* Ohio: Cengage Learning.

Cocchini, S. &terSteeg, E. 2019. *Poultry Sector Analysis Rwanda*. Netherlands: Triade

Copland, J.W. & Alders, R.G. 2009. The Comparative Advantages of Village or Small-scale Poultry in Rural Development, In: Alders, R.G., Spradbrow, P.B., Young, M.P. (Eds.), *Village Chickens, Poverty Alleviation and the Sustainable Control of Newcastle Disease.* Proceedings of an International Conference Held in Dar Es Salaam Tanzania, pp. 235 5–7 October 2005. ACIAR Proceedings No. 131.

Deng, M., Dossou, N. and Tanko, M. 2017. "Profitability Analysis of Shea Butter in Northern Region of Ghana." Singaraj, A., (ed), *International Journal of Research and Development*, 2 (3): 23 -26. SJIF Impact Factor: 4.144 ISSN: 2455-7838(Online)

Farayola, O., Okpodu, V. & Oni, O. O. 2012. "Economic Analysis of Locust Beans Processing and Marketing In Ilorin, Kwara State, Nigeria." *International Journal of Agricultural Research Innovation & Technology,* 2 (2): 36-43.

Federal Office of Statistics (FOS). 1995. *Poverty Alleviation in Nigeria*. Federal Office of Statistics, Lagos, Nigeria.

Friedman, M. 1953. "The Methodology of Positive Economics." *In Essays in Positive Economics.* Chicago: University of Chicago Press.

Gill, T. 2021. *Personal Communication,* February 24 and March 15. Tennessee.

Gill, T., Urban, E. Ader, D. Nisengwe, R and Garner, E. 2020. "Piloting a Commercial Broiler Production Model for Smallholders in Rwanda." *African Journal of Food, Agriculture, Nutrition and Development* 20(2): 15660 – 15676. https://doi.org/10:18697/ajfand.90.18925

Guttinger, J. 1982. Economic Analysis of Agricultural Projects (Second Edition)

Hamra, C., F. 2010. “An Assessment of the Potential Profitability of Poultry Farms: A Broiler Farm Feasibility Case Study” Masters’ Thesis, University of Tennessee at Martin.

International Livestock Research Institute (ILRI). 2017. *Rwanda Livestock Master Plan (R-LMP)*. International Livestock Research Institute (ILRI): LMP Team Leaders: Shapiro, B., Gebru, G., Desta, S., Nigussie, K.

Issahaku, H., Ramatu, A. & Sarpong, D. B. 2011. “An Analysis of Allocative Efficiency of Shea Butter Processing Methods in the Northern Region of Ghana,” *Journal of Development and Agricultural Economics*, 3(4), 165-173.

Jenkins, G.P., Miklyaev, M., Ujeneza, N., Afra, S., Nduguste F., Hashemi, M., Bitter, M., and Nzomoi, J. 2016. *Rwanda Private Sector Driven Agricultural Growth Project* (PSDAG). Rep. AID-696-C-14-00002.

Kenner, B., D. Lambert, C. Trejo-Pech, J. Thompson, and T. Gill. 2019. “Financial Risks in Rwandan Smallholder Broiler Production.” *Journal of Agribusiness in Developing and Emerging Economies*, 9 (5): 569–83. https://doi.org/10.1108/JADEE-11-2018-0163.

Kenner, B., W. 2018. "Uncertainty in the Production Decisions of Smallholder Broiler Producers in Musanze, Rwanda" Master's Thesis, University of Tennessee, Knoxville.

Kornhauser, L. 2000. “On Justifying Cost Benefit Analysis” *The Journal of Legal Studies*, 29 (S2): 1037-1057.

Lawrence, A. & B. Pasternack. (2002) *Applied Management Science, Modeling, Spreadsheet Analysis and Communication for Decision Making*, 2nd ed. John Wiley & Sons.

Leding, M. & Miller, J. 2013. "Characteristics of the Rwandan Poultry Industry." *African Sustainable Agriculture Project Foundation.*

Maganga, A. 2012. “Poultry Production and Rural Poverty among Small-Scale Farmers in Mzimba District of Malawi” Munich Personal RePEc Archive https://mpra.ub.uni-muenchen.de/43964/ MPRA Paper No. 43964, posted 24 Jan 2013 15:32 UTC

Malama, E., Andah, E., Amegashie, D, Mensah-Bonsu, A. (2013) “Break Even Analysis of Broiler Production in the Accra-Tema and Kumasi Areas” 1st Annual International Interdisciplinary Conference, AIIC 2013, 24-26 April, Azores, Portugal.

Malcolm, B., Makeham, J., Wright, V. 2005. *The Farming Game: Agricultural Management and Marketing*. Cambridge University Press.

Management Science." in *Spreadsheet Modeling and Decision Analysis*. Mason, Ohio: Thomson/South-Western.

Markowitz, H. 1952. "Portfolio Selection." *Journal of Finance, 7*:77-91.

Mbuza, F., Manishiwe, R., Mahoro, J., Simbankabo, T., Nishimwe, K. 2016. "Characterization of Broiler Poultry Production System in Rwanda." *Tropical Animal Health Production*, 1 (49): 71–77. https://doi.org/10.1007/s11250-016-1160-0

Meek, M.S., Whittier, J.C., Dalsted, N.L., Thrift, F.A., Stanton, T.L. 1999. "Estimation of Net Present Value of Beef Females of Various Ages and the Economic Sensitivity of Net Present Value to Changes in Production." *The Professional Animal Scientist,* 15(1):46-52

MINAGRI. 2012. *Strategic Investment Plan to Strengthen the Poultry Industry in Rwanda.*Kigali, Rwanda.

Mtileni, J., Muchadeyi, C., Maiwashe, A., Chimonyo, M., Mapiye, C., Dzama, K. 2012. "Influence of Socioeconomic Factors on Production Constraints Faced by Indigenous Chicken Producers in South Africa." *Tropical Animal Health Production,* 45: 67–74.

National Institute of Statistics of Rwanda (NISR). 2015. *District Profile: Musanze.* National Institute of Statistics of Rwanda, Kigali.

National Research Council. 2009. Committee on Improving Risk Analysis Approaches Used by the U.S. EPA. *Advancing Risk Assessment 2009*. Washington, DC: National Academies Press.

Oh, H. S. & Kim, J. B. 1980. "A Partial Analysis of Technical Efficiency and Returns to Scale in Korean Rice Production." *Journal of Rural Development,* 3 (4):1-10

Olubanjo, O. O. 1998. **"**Profile of the Poor and Poverty Alleviation in the Countryside: The Case of Four Spatial Settlements in Ogun State, Nigeria" *The Nigerian Rural Sociologist,* 2(1): 31-40.

Oluwatayo, I. B., Machethe, T. A., Senyolo, M. P. 2016. "Profitability and Efficiency Analysis of Smallholder Broiler Production in Mopani District of Limpopo Province, South Africa." *Journal of Agribusiness and Rural Development.*, 1(39): 145–154.

Ragsdale, C. 2004. "Spreadsheet Modeling & Decision Analysis: A Practical Introduction to

Regmi A. (ed). 2001. *Structure of Global Food Consumption and Trade* [Online]. Washington DC [USA]. Economic Research Service/USDA. Pp 103-107. http://www.ers.usda.gov/publications/wrs011/

Rhodes J.L., J Timmons, J.R. Nottingham, and W. Musser. 2008. *Broiler Production Management for Potential and Existing Growers, University of Maryland Cooperative Extension Poultry*, from: http://www.mdchick.umd.edu

Roberts, J.A. 2018. *Utilisation of Poultry Feed Resources by Smallholders in the Villages of Developing Countries*. FAO Document Repository (available online) http://www.fao.org/docrep/004/AC154E/AC154E12.html.

Samuelson, P. A. & Nordhaus, W. 1992. *Economics*, 14th ed.. Boston, MA: McGraw-Hill.

Satyasai, K.J.S. 2009 "Application of Modified Internal Rate of Return Method for Watershed Evaluation." *Agricultural Economics Research Review*, 22.

Schultze, C. & Mackie, C. (eds). 2002. A*t What Price? Conceptualizing and Measuring Cost-of-Living and Price Indexes*. Washington, DC: National Academy Press.

Schulz, L., Artz, G. and Gunn, P. (2016), "Succession Planning and Perceived Obstacles and Attractions for Future Generations Entering Beef Cattle Production." *Journal of Applied Farm Economics*, Vol. 1, pp. 1-17.

Schulz, L.L., Artz, G.M. and Gunn, P.J. 2017. "Succession Planning and Perceived Obstacles and Attractions for Future Generations Entering Beef Cattle Production." *Journal of Applied Farm Economics* 1(1): 18.

Sosthenes, M. 2013. "Comparative Investment Analysis for Small Scale Broiler and Layer Enterprises in Zambia" Master's Thesis, Kansas State University.

Trejo-Pech, C. & White, S. "Egg Production: Conventional or Cage Free?" *Case Journal* (Manuscript)

Trejo-Pech, C., Larson, J., English, B., Yu, E. 2019. "Cost and Profitability Analysis of a Prospective Pennycress to Sustainable Aviation Fuel Supply Chain in Southern USA." *Energies*, 12 (3055) doi:10.3390/en12163055

USAID. 2016. *Feed the Future Indicator Handbook: Definition Sheets.* Washington D.C.: Feed the Future.

USAID. 2019. "Feed the Future Tworore Inkoko, Twunguke: Annual Work Plan, Oct. 1, 2018 – Dec. 31, 2019". Tom Gill (University of Tennessee Institute of Agriculture)

World Food Programme. 2015. *Rwanda 2015: Comprehensive Food Security and Vulnerability.* World Food Programme, Rome.

Yeboah, A., Naanwaab, C., Yeboah, O., Owens, J. and Bynum, J. 2013. "Economic Feasibility of Sustainable High Oilseed-Based Biofuel Production: The Case for Biodiesel in North Carolina." *International Food and Agribusiness Management Review* 16(1):26.

Yoe, C. 2019. *Principles of Risk Analysis: Decision Making Under Uncertainty (2nd Edition).* NW: Taylor and Francis Group.

Appendix

Tables

Table 1: Summary of Literature review

Authors	Country of Study	Goal of the Study	Main Findings
Abolink et al. (2018)	Zambia	To compare the financial performance of indigenous chicken production to broiler and layer production.	Indigenous number of chicken required more number of products to be sold to make gain compared to broiler and layers. The study further showed that poultry farming ranked first in terms of popularity compared to other animals kept by the farmers.
Maganga (2012)	Malawi	To examine poverty levels between poultry farmers and non-poultry farmers.	Poultry farming helps in poverty reduction and should be encouraged.
Oluwatayo et al. (2016)	South Africa	To estimate the profitability of small-scale broiler farmers and to determine factors influencing productivity.	The poultry farming is profitable due to reduction in production cost. The farmers are productive due to increased years of farming experience and trainings.
Deng et al. (2017)	Ghana	To conduct profitability analysis using cost benefit ratio and regression analysis.	The producers have to reduce cost of production to be profitable.

Table 1 continued

Authors	Country of Study	Goal of the Study	Main Findings
Hamra (2010)	South Lebanon	To conduct a feasibility analysis of potential profitability of a broiler farm.	Using historical data, the farmers can time properly on when to purchase farm inputs to maximize profitability.
Chukwuji et al. (2016)	Nigeria	To evaluate the most efficient methods of producing broilers with the least resources while achieving desirable results.	Nigerian farmers in the sample are inefficient in allocating their resources. The farmers are underutilizing their resources because their scale of production is small.
Gill et al. (2020)	Rwanda	To evaluate the performance of hybrid broiler breeds in the TI program, to check their profitability and the rate of household consumption of broilers	There is steady increase in profitability as farmers gain more experience. Farmers’ households consume an average of 0.31chickens per flock in December, 2017, it increased to 1.5 – 2.0 in April 2018 and peaked to 4.0 in August, 2018 The hybrid broiler breeds achieved more livability than the regular one.

Table 1 continued

Authors	Country of Study	Goal of the Study	Main Findings
Mbuza et al. (2017)	Rwanda	To evaluate the broiler system in Rwanda and determine the management status-quo, marketing and production practices.	High mortality rate due to lack of adequate health and safety measures. They farmers are inefficient due to lack of training.
International Livestock Research Institute (2017)	Rwanda	To transform the chicken sector into a sector that is market and profit oriented.	Projected increase in chicken meat production.

Table 2: Production parameters of farmers under the TI program

Production Parameter	Units	Parameter
Harvest time	Days	52 (plus 14 days between cycles for cleaning of coops)
Cycles per year	Cycles	5
Capacity utilization	# of birds	100
Annual production capacity	# of birds	500
Mortality rate	%	10
Feed consumption rate	ratio	2.34
Average weight of adult chicken	Kg/bird	3.04

Notes:

1. Source: TI database as defined in the database section.

2. Harvest time is 52 days plus the extra 14 days in between production cycles for cleaning and disinfecting of the coop.

3. There are a total of 5 cycles per year. That is, 52 days for production and 14 days for cleaning = 66 days; 66 days times 5 cycles = approximately 330 days per year.

4. The coops are built in such a way that they can contain 100 birds per cycle of production and all farmers try to maximize productivity and profitability by stocking a maximum of 100 birds; there is no room for over stocking (USAID, 2018). Thus, the maximum annual production capacity of each farm is 500 birds.

5. The mortality rate is the mean value calculated using the actual rate of livability reported in the TI database.

6. The average feed conversion ratio is 2.34 per bird. This is calculated as $\frac{Total\ feed\ consumed\ (kg)}{Total\ weight\ at\ seling\ time\ (kg)}$ (8)

8. The average weight of matured chicken at 52 days is 3.04kg, the simple average calculated in the TI database.

Table 3: Investment costs per farmer

Capital Expenditures	Cost (RwF)	Annual Depreciation (RwF)	Cost (USD)	Annual Depreciation (USD)
Building (coop)	500,000	33,333	514.00	25.72
Equipment				
Drinkers (4)	7,600	1,520	7.82	1.56
Chick Feeders (2)	10,000	2,000	10.29	2.06
Tube Feeders (2)	21,600	4,320	22.22	4.44
Clay Pots	3,400	680	3.50	0.70
Total	42,600	8,520	43.83	8.77
Grand Total	**542,600**	**41,853**	**558.23**	**34.49**

Notes:

1. Source: As defined in the TI program database.
2. The cost of the coop and equipment were determined from the USAID projection of the price of construction of a standard coop and the prices of the equipment for 2019 and 2020 adjusted by inflation rates (USAID, 2018).
3. The land used for the coop is that of the farmer. Hence no price is assumed to it since it was not purchased with either of the loans given to the farm.
4. The annual depreciation rate of the equipment is calculated by dividing the value of the equipment by the useful life of the equipment which is 5 years (the equipment is assumed to be replaced every five years). The annual depreciation rate of the coop is calculated by dividing the actual worth of the coop by 15 years which is the expected useful life of the coop; the coop is not replaced every five (5) years like the equipment. The depreciation is constant until the end of the life period of the project.
5. The exchange rate used in this thesis is RwF 973 =1USD which is the average exchange rate during the period of this writing (https://www.bnr.rw/currency/exchange-rate accessed on 04/06/2021)

Table 4: Operating cost per production cycle or flock

Items	Units Required	Unit	Unit Cost (RwF)	Unit Cost (USD)	Total Cost Per Cycle in RwF	Total Cost in USD	Percentage of total cost
Birds	100	#	583.2	0.59	59,229.4	60.87	16.4%
Feeding	591.1	Kg	352.0	0.36	208,084.7	213.86	58.4%
Vaccines	1	Bottle	607.5	0.62	607.5	0.62	0.2%
Water and energy	51.7	Day	150	0.15	7,761.3	7.98	2.2%
Litter	2.6	Sack	1,204.8	1.24	3,123.1	3.21	0.9%
Disinfectants	1	Pack	1,249.4	1.28	1,249.4	1.28	0.4%
Charcoal	2.4	Sack	10,664	10.96	25, 323.6	26.01	7.1%
Labor	52	Day	1000	1.03	51,741.7	53.18	14.5%
Total					**357,121**	**367.01**	**100%**

Notes:

1. The prices used here are average prices of the corresponding variables in the TI database.
2. The unit requirements are averages of actual consumption.
3. The exchange rate is RwF973 per USD as used in Table 3 above.
4. To obtain the monthly fraction of the pay, the equating goes thus provided $UnSal_{Monthly}$ = monthly salary for unskilled worker in RwF

$UnSal_{Cycle}$= cycle salary for unskilled worker in RwF

Cyc_{Days} = length of cycle in days

30 = constant for number of days in a month (Kenner 2018)

$$UnSalMonthly = \text{UnSalaryCycle} * \frac{30}{CycDays} \quad (9)$$

Table 5: Schedule for loan repayments

Min profit level	Max profit level	Coop payment: % profit	RWF paid on coop (using Min profit level)
0	29,999	0%	0
30,000	49,999	10%	3,000
50,000	69,999	20%	10,000
70,000	89,999	30%	21,000
90,000	109,000	40%	36,340
110,000	Upwards	Reducing as profit increases	44,000

Table 6: Summary of parameters

Category	Variable	Units	Average	Min.	Max	St. Dev
Scale	Capacity of the farm	birds	100			
	Capacity utilization	%	100			
	Number of cycles	cycles	5			
	Annual broiler production capacity	birds	100			
Investment	Initial investment cost	RwF	542,600			
	Land requirement	Ha	0			
	Price of land	RwF	0			
	Buildings (coop)	RwF	500,00			
	Equipment	RwF	42,600			
	Tube feeders	RwF	21,600			
	Chick feeders	RwF	10,000			
	Drinkers	RwF	7,600			
	Clay Pots	RwF	3,400			
Operating	Vaccines	RwF/bottles	607.5	551.5		58.7
	Charcoal	RwF/sacks	10,664	964		1,956
	Feed	RwF/kg	352	211	686	45
	Litter	RwF/sacks	1,205	915	2,363	195
	Disinfectant	RwF	1,249	0	7,057	503
	Water/energy	RwF	150			
	Chick	RwF/chick	582	478	1,862	54
	Labor	RwF/day	1000			
Production	Inflation	%	5			
	Weight of adult chicken	Kg	3.0	0.0	4.6	0.5
	Feed conversion ratio	%	2.3	0.3	202.9	4.2
	Mortality rate	%	0.10			

Table 6 continued

Category	Variable	Units	Average	Min.	Max	St. Dev
	Price of mature chicken	RwF	1,314.6	195.6	2,255.6	145.5
	Days to harvest	Days	51.7	31.0	95.0	9.0
	Quantity of birds sold	Birds	87.1	46.00	99.00	7.7
	Farmer's revenue per cycle	RwF	349,463	49,078	755,309	82,057
	Farmer's profit per cycle	RwF	52,158	-280,660	449,211	56,587

Notes:

1. Average, Min., Max. and Standard deviation are calculated from observed field data of the TI program from 2017 - 2020.
2. The number of cycles used are calculated based on recent literature in the TI with the same data; Gill et al. (2020). The price of land is presumed to be 0 since it belongs to the farmer.
3. The coops are constructed uniformly with the same dimension by the TI program workers without the input of the farmer or his family (Gill et al. 2020; USAID, 2018). Also the useful life of the coop is 15 years.
4. The equipment are changed every five years.
5. The operating cost units were assumed from the TI program price projection (USAID, 2018).
6. The labor cost is calculated as opportunity cost for the labor supplied by the family members of the farmer at 1000RwF per day through the days till harvest period (Kenner 2008).
7. Inflation is assumed at 5% (Rwanda Bureau of Statistics, 2017)
8. The price of matured bird is subject to increase with the inflation rate.
9. This number of days to harvest is calculated without adding the extra 14 days (Gill et al. 2020) needed to clean the coops before restocking.

Table 7. 1: FCF (year 1 to year 5)

	Year 1	Year 2	Year 3	Year 4	Year 5
Total Revenue	1,869,287	1,962,752	2,060,889	2,163,934	2,272,130
Operating costs:					
Chicks	292,147	305,705	320,990	337,039	353,891
Vaccines	3,083	3,189	3,349	3,516	3,692
Feed	1,040,423	1.092,445	1,147,067	1,204,420	1,264,641
Water and Energy	38,806	40,747	42,784	44,923	47,169
Litter	15,616	16,396	17,216	18,077	18981
Disinfectant	6,247	6,560	6,887	7,232	7,593
Charcoal	126,618	132,949	139,596	146,576	153,905
Labor	285,709	271,644	285,226	299,488	314,462
Depreciation	41,853	41,853	41,853	41,853	41,853
Total Operating Cost	**1,822,457**	**1,911,487**	**2,004,969**	**2,103,125**	**2,206,188**
EBIT or Operating Income	**46,830**	**51,264**	**55,920**	**60,809**	**65,942**
NOPAT	**46,830**	**51,264**	**55,920**	**60,809**	**65,942**
FCF	**88,684**	**93,118**	**97,774**	**102,662**	**107,795**

Table 7. 2: FCF (year 6 to year 10)

	Year 6	Year 7	Year 8	Year 9	Year 10
Total revenue	**2,385,737**	**2,505,024**	**2,630,275**	**2,761,789**	**2,899,878**
Operating costs:					
Chicks	371,586	390,165	409,673	430,157	451,665
Feed	1,327,873	1,394,267	1,463,980	1,537,179	1,614,038
Vaccines	3,877	4,071	4,274	4,488	4,712
Water & Energy	49,528	52,004	54,604	57,335	60,201
Litter	19,930	20,926	21,973	23,071	24,225
Disinfectant	7,973	20,926	21,973	9,230	9,691
Charcoal	161,600	8,372	8,790	187,072	196,426
Labor	330,185	169,680	178,164	382,231	401,342
Depreciation	41,853	41,853	41,853	41,853	41,853
Total operating costs	**2,314,405**	**2,428,033**	**2,547,342**	**2,672,616**	**2,804,154**
EBIT or Operating Income	**71,332**	**76,991**	**82,933**	**89,173**	**95,724**
NOPAT	**71,332**	**76,991**	**82,933**	**89,173**	**95,724**
FCF	**113,185**	**118,844**	**124,787**	**131,026**	**137,577**

Table 7. 3: FCF (year 11 to year 15)

	Year 11	Year 12	Year 13	Year 14	Year 15
Total revenue	**3,044,872**	**3,197,116**	**3,356,971**	**3,524,820**	**3,701,061**
Operating costs:					
Chicks	474,248	497,961	522,859	549,002	576,452
Feed	1,694,740	1,779,477	1,868,451	1,961,874	2,059,967
Vaccines	4,948	5,195	5,455	5,728	6,014
Water & Energy	63,211	66,372	69,691	73,175	76,834
Litter	25,436	26,708	28,043	29,445	30,918
Disinfectant	10,176	10,685	11,219	11,780	12,369
Charcoal	206,247	216,559	227,387	238,757	250,695
Labor	421,409	442,480	464,604	487,834	512,225
Depreciation	41,853	41,853	41,853	41,853	41,853
Total operating costs	**2,942,269**	**3,087,290**	**3,239,562**	**3,399,447**	**3,567,327**
EBIT or Operating Income	**102,603**	**109,826**	**117,410**	**125,373**	**133,734**
NOPAT	**102,603**	**109,826**	**117,410**	**125,373**	**133,734**
FCF	**144,456**	**151,679**	**159,263**	**167,226**	**175,587**

Notes:

1. All figures are expressed in Rwanda Francs.
2. NOPAT is net operating profits after taxes.
3. Operating cost is the total amount of money spent in running the farm on yearly basis.
4. FCF is free cash flow.
5. Depreciation is the rate at which equipment purchased at the beginning of the venture reduces in quality, assumed to be replaced every five years in year six and year 11.
6. Tax rate is assumed = 0.

Table 8. 1: DCF (year 1 to 5)

		Year 1	Year 2	Year 3	Year 4	Year 5
FCF- project	**(542,600)**	**82,040**	**86,142**	**90,449**	**94,971**	**99,720**
Discounting factor		0.877	0.769	0.675	0.592	0.519
Discounted cash flow	**(542,600)**	**71,965**	**66,283**	**61,050**	**56,231**	**51,791**
Net Present Value	0					
MIRR	14.0%					
Project cost of capital	14.0%					

Table 8. 2: DCF (year 6 to 10)

		Year 6	Year 7	Year 8	Year 9	Year 10
FCF- project	**(542,600)**	**50,336**	**109,941**	**115,438**	**121,210**	**127,271**
Discounting factor		0.456	0.400	0.351	0.308	0.270
Discounted cash flow	**(542,600)**	**22,933**	**43,937**	**40,468**	**37,273**	**34,330**
Net Present Value	0					
MIRR	14.0%					
Project cost of capital	14.0%					

Table 8. 3: DCF (year 11 to 15)

		Year 11	Year 12	Year 13	Year 14	Year 15
FCF- project	**(542,600)**	**64,243**	**140,316**	**147,332**	**154,698**	**162,433**
Discounting factor		0.237	0.208	0.182	0.160	0.140
Discounted cash flow	**(542,600)**	**15,201**	**29,124**	**26,825**	**24,707**	**22,756**
Net Present Value	0					
MIRR	14.0%					
Project cost of capital	14.0%					

Notes:

1. The FCF is the estimated free cash flow for the period of 15 years which is the life of the project.
2. MIRR is the modified internal rate of return explained in chapter 3 above.
3. The project cost of capital is the WACC which serves as the discount factor for the analysis.

Table 9: Summary of data of three scenarios analyzed

	2017 – 2018 (First year)	**2017 – 2019 (Second year)**	**2017 -2020 (complete program)**
Number of farmers	174	429	511
# observations (flocks)	510	1770	2260
NPV at 14% WACC	-215,478	314,318	0
MIRR at 14% WACC	10.2%	17.5%	14.0%

Notes

1. NPV at 14% WACC and MIRR at 14% WACC, which showed NPV at RwF 0 and MIRR at 14.0% are the baseline models used in the scenario analysis.

Table 10: Different parameters used in the sensitivity analysis for the TI program, including all farmers enrolled from 2017 to 2020

Variables	NPV (RwF)	MIRR
WACC		
12.5%	48,860.72	13.15%
14% (baseline)	0	14.0%
17%	-80,231.18	15.76%
25%	-219,265.46	20.76%
Mortality Rate		
5%	866,438.13	21.49%
8.20%	345,260.17	17.80%
9.40%	149,818.43	15.87%
10% (baseline)	0	14.00%
12.30%	-322,499.10	7.52%
Inflation		
2%	-75,029.37	12.87%
2.4%	-65,943.57	13.02%
4.25%	-20,322.97	13.71%
5% (baseline)	0	14.00%
10%	168,714.59	16.08%
Cost of chicks (RwF)		
582.5 (baseline)	0	14.00%
528.5	211,815.49	16.53%
636.5	-213,434	10.26%
478	410,659.10	18.36%
1,862	-2,285,447.15	-1.00%
Cost of feed (RwF/Kg)		
352 (baseline)	0	14.00%
307	1,048,226	22.48%
397	-1,046,429	-1.00%
211	3,282,526	29.85%
686	-7,772,600	-1.00%

Notes:

1. The baseline values (used for the analysis in section 5.1) are indicated and labeled as baseline.
2. All the NPV values are in RwF.
3. The WACC values 12.50% (Bruhin et al. 2021), 17% (Kenner 2018) and 25% (Mahama et al. 2013) were chosen because of those are assumptions made in previous studies.
4. The mortality values of 5% (Kenner et al. 2019), 8.20% (Kenner 2018), 9.40% (Mbuza et al. 2016), 12.30% (Mbuza et al. 2016) were selected for a similar reason as in note 3.
5. The inflation percentages of 2% (Bruhin 2019), 2.4% (Bruhin et al, 2021), 4.25% (Jenkins et al. 2016), 10% (Kenner 2018) were selected for the same reason in notes 4 and 5.
6. The values of the cost of DOCs are defined according to the St. dev. (54), the minimum and the maximum price per bird from the TI database.
7. The values of the cost of feed are from the st. dev. (45), the minimum and the maximum price per kg in RwF.

Table 11: Summary of selected parameters that change results

Parameters/Variables	2017 - 2018	2017 - 2019	2017 - 2020
Feed conversion ratio	2.31	2.40	2.34
Weight of average chicken (Kg)	2.70	3.07	3.04
Unit cost of DOCs (RwF)	578.0	573.1	583.3
Unit cost of feed (RwF/Kg)	308	336	352.0
Price of live chicken (RwF/Kg)	1,260	1.281.9	1,314.3
Total cost of operational expenses per cycle	321,080	352,725	356,121

Figures

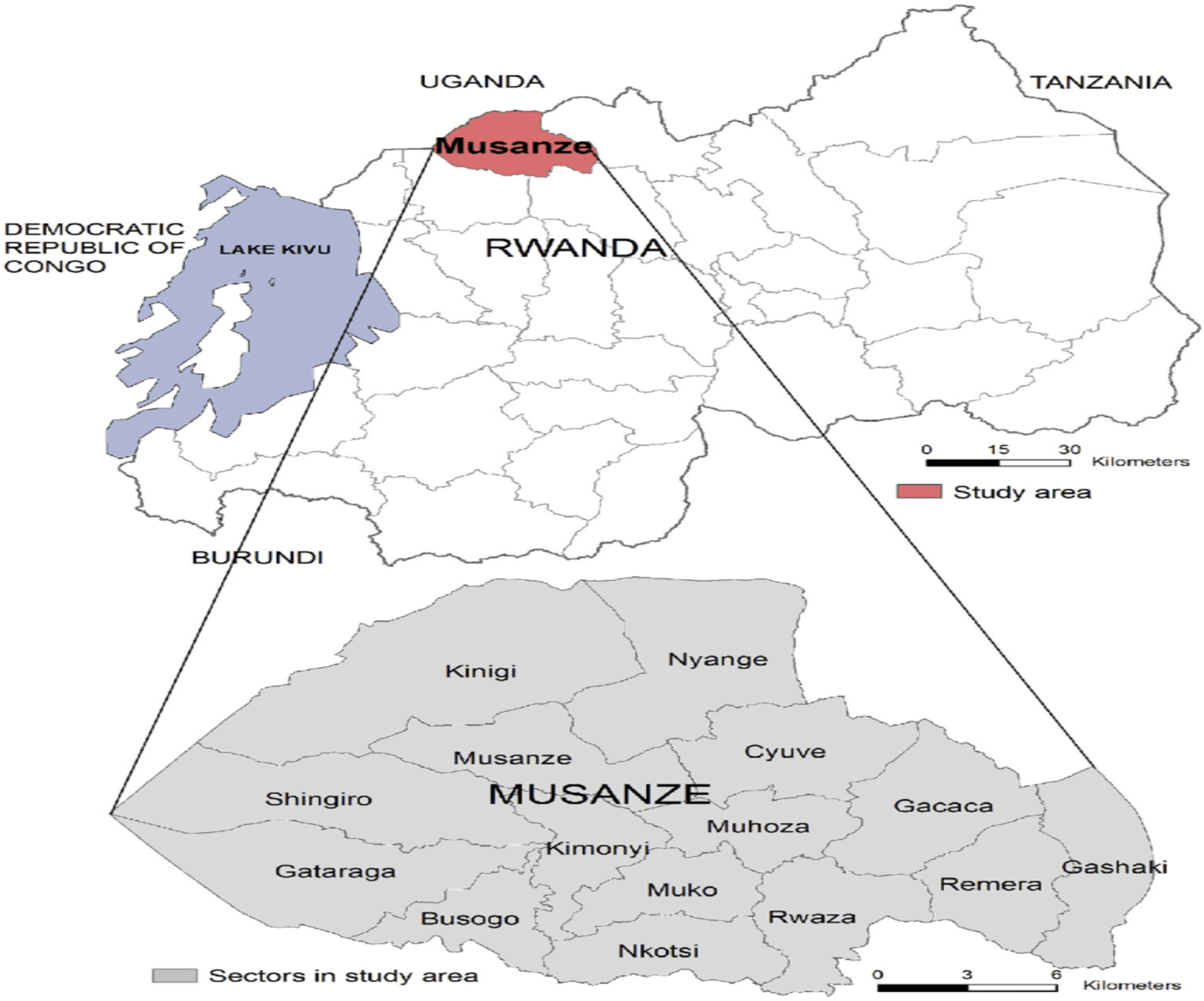

Figure 1: Map of Musanze, Rwanda (USAID, 2016)

Vita

Saheed, Adeniyi Orimadegun was born in Odeomu, Osun State, Nigeria on February 25, 1988. He attended elementary schools in Ayedaade Local Government Area and graduated from Osun State School of Science Ikirun in June, 2003. The following August, he gained admission into Ladoke Akintola University of Technology Ogbomoso, Nigeria and in December, 2010 received the Degree of Bachelor of Technology in Agricultural Economics and Extension. He entered University of Tennessee, Knoxville in August, 2019 and received a Master of Science degree in Agricultural and Resource Economics in August, 2021.