Research Article

Pig farming profitability and constraints in smallholder households in Rwanda: a case study of Musanze district.

Gaspard Ntabakirabose[1], Félicien Ndaruhutse[2], Jean Pierre Mpatswenumugabo[3] and Marie Jose Dusengimana[4]

[1]*Department of Research, Forest Protection Programme, Rwanda Forestry Authority, MoE, Huye, Kigali-Rwanda.*
[2] *Department of Impact Product and Brand, One Acre Fund, Kigali-Rwanda*
[3]*College of Agriculture, Animal Sciences and Veterinary Medicine, University of Rwanda, Kigali-Rwanda.*
[4]*Department of Biology, Ministry of Education, Kigali-Rwanda*
Corresponding author e-mail: gmutago@gmail.com

ABSTRACT

The increasing human population risks food insecurity especially food of animal origin. Pig plays an important role in household income in all production. The main aim of this study was to analyze the pig farming profitability and constraints in smallholder households in Rwanda. A multistage sampling technique was employed for the success of the research. The study was carried out in five sectors of Musnze district. A purposive sampling technique was used to select Musanze district and five sectors. However, a random sampling method was used to have a sample size of 120 pig farmers' respondents. The cost and returns associated with pig farming production were carried out to determine the profitability of pig production while a stochastic frontier production function was used to determine factors influencing pig farming in small householders using STATA. The findings indicated that men are the majority of the respondents in pig farming production in the study area. The findings of the regression analysis indicated that five factors namely education level, market availability, off-farm generation, feed availability, and access to veterinary services were positive, and statistically significant at $P \leq 0.01$ level of probability and influenced pig farming in the study area. The findings also indicated that the Total Revenue (TR), Total Cost (TC), Gross Margin (GM), and Net Farm Income (NFI) were statistically significant at ($p < 0.01$). The research findings indicated that pig farming is a profitable business in the study area. The result of regression analysis also indicated that the three factors namely income generation, employment opportunities, and new job creation had positive and statistically significant impacts on pig farming in the study area at $P \leq 0.01$ level of probability. The findings of this study revealed that the most common constraints for pig farming in smallholder households were the high cost of feeds, inadequate initial capital, feeds sacristy and quality, lack of conservation facilities, pests, and diseases outbreaks, high cost of piglets, lack of farming information, and poor housing. Despite the constraints indicated by different respondents in the study area. Pig farming is an economically profitable business in the study area and it is capable of creating new jobs, enhancing employment opportunities, generating income, and clearly improving the standard livelihood of farmers. Based on the findings of the study, it has been recommended to promote interventions that can help provide initial start-up capital for farmers or marketing groups to help kick-start their farming operations; and to train and equip pig farmers and veterinaries in new technologies and innovations. Promote the analysis of profitability, opportunities, and constraints along the pig value chain as well as to support and improve the underlying business progress or stunting well as to make a good decision.

Keywords: Pig Farming, Profitability, Smallholder, Households.

INTRODUCTION

Population growth, urbanization, income growth, and changes in the diets of people are predicted to fuel massive demand for food of animal origin (FAO, 2006; Thorton, 2010). The increasing human population risks food insecurity especially food of animal origin if viable methods of producing it are not exploited. The livestock sub-sector of the agricultural sector is vital to the national economy since it is the main supplier of essential animal protein. The importance of the livestock sub-sector is in line with the recommendation of the FAO (2003) that on an average basis, a man's daily protein intake should be between 65-72 grams and 53% (about 35 grams) of this should be animal-based. The livestock sector contributes 40% of the global

agricultural output, employs about 1.3 billion people globally, and directly supports the livelihoods of over 600 million poor smallholder farmers in the developing world (FAO, 2011; Thorton *et al.,* 2006*)*. Pig production is widely scattered across the world. Asia is the largest producer of pork in the world accounting for 56% of the global pork production, surpassing Europe (25%) and North America (17%). China alone accounts for 48% of the total world pork production (FAOSTAT, 2011). One of the major advantages of pigs is the ability to convert different kinds of feed including kitchen waste to meat (Rahman *et al.*, 2009). Considering general feed conversion, pig is by far the most efficient among farm animals in the conversion of feed energy to body energy. The high rate of productivity is another major advantage of pigs, ranging from 9.3 to 9.96, live piglets per sow. CTA (1995), and Okoli (2006).

It has been estimated that there will be an increase of up to 155% in annual pork consumption from 2000 to 2030 in Sub-Sahara Africa and an even higher increase of 167% in annual pork consumption globally in countries deemed to be of low income (FAO 2011). Profitable pig production will however not be achieved unless the right products are produced in the right place at the right price. It is therefore important for the intending pig producer to understand the economic, physical, social, ethnic, and religious forces, that operate to determine the effective way of producing swine. All over the world, meat production remains overwhelmingly the main purpose of keeping pigs (FAO, 2018). The pork can be utilized by the producer and his family or sold as a source of income. Processed meats such as bacon sausage are also being produced and are increasingly gaining recognition. By-products such as pigskin and bristle are used in the manufacturing of light leather and brushes especially in Asian countries (FAO, 2018). It is relatively easy to establish intensive pig production in developing countries if capital is available and adequate feed supplies are assured (Ogunniyi and Omoteso, 2011). Pigs provide a ready and regular source of cash to meet rural families' needs, such as paying school fees, health expenses, and farm inputs, on a day-to-day basis. Pig manure is a valuable fertilizer and can be aerobically digested to produce cooking gas; it also stimulates the growth of microorganisms and plants for feeding freshwater fish and ducks (Okoli, 2006).

Livestock production constitutes a critical and basic part of the agricultural economy of Rwanda, a contribution that goes beyond direct food production and incorporates the generation of employment, source of income to farmers, development of a country's economy, source of vocation to farmers, and other multipurpose uses (FAO,2012; MINAGRI, 2019). The sub-sector of animal husbandry contributed to about 8.8% of the Gross Domestic Product (MINECOFIN, 2007) and the main species raised in Rwanda are cattle (991,697 heads), goats (1,270,973heads), sheep (371,766heads), pigs (211,918heads), poultry (2,482,124heads) and rabbits (489,401heads). Livestock production does not satisfy the feeding requirements of the country in terms of animal production (MINAGRI, 2008).

Today, animal husbandry faces many constraints especially related to the nutritional quality of feedstuffs particularly forages, which become the main factor that limits animal productivity. The animal will not highlight their genetic potential or stay in good health if the feeding is not good (MINAGRI, 2008). Pig farming is a noteworthy sub-sector in the livestock industry. However, pig alone constitutes as much as 21% of all meats produced and consumed currently in Rwanda. Pig production is unique in that it offers the highest turnover rate and the quickest returns to investment outlay in livestock enterprises (FAO, 2011).

Rwanda is currently recording unprecedented increased growth in livestock production. Livestock production is climbing and is expected to keep the momentum in the future. This is particularly due to various policy interventions contributing to food security. Cattle contributed significantly to meat production with 46% of the share while Pigs' contribution is at 21% (MINAGRI, 2019). The production of animal products has been increasing over the years. This is attributed to different programs supporting the development of the livestock sector, mainly the livestock intensification program, and small stock development, among others (MINAGRI, 2019).

Through these programs implemented by MINAGRI, Districts, and other stakeholders, priority is given to genetic improvement, animal health, animal feeding, and livestock infrastructure development. The government initiated some project in the framework of improving diet. Animal protein is an essential component of a human diet, especially for children. Small livestock are the most efficient way to produce protein on little land, which is a scarce commodity in Rwanda (MINAGRI, 2019). The Government supports increased pig production and consumption through subsidies to alleviate poverty in poor households and control food security in vulnerable families, investments, and favorable policies for medium to large-scale industrial operations (MINAGRI, 2019).

In terms of livestock, 68% of all households in Rwanda own some type of livestock. A slight decrease in Musanze District where 69% of all households own some type of livestock. This showed that Musanze District is above the national average in terms of households raising livestock. The number of households raising livestock, especially pigs was 91,000 in this district. However, the number of population raising livestock in Musanze is still low with a ratio of about 3% for the whole country. This means that Musanze still depends on agricultural production due to insufficient livestock and its market development (EICV 3, NISR, 2011).

Pig production in Rwanda is relatively well-developed (FAO, 2012) and has grown steadily in the last ten years despite some obstacles in the sector. These include the high cost of feeds, limited access to credit, inadequate

genetically high-quality breeding boars, diseases, poor marketing opportunities, lack of basic knowledge on pig management practices, poor extension services, and lack of skilled veterinarians on pig diseases and preventive health (FAO 2011; MINAGRI, 2019).

Pig plays an important role in household income in all production. Pig farmers generate income from the sale of piglets and sale of live adult pigs. Pigs are also a source of wealth; manure; waste disposal; nutrition and food security. Due to the pig's short breeding cycle, many farmers take the view that pig keeping is the livestock equivalent to cash crops and has the potential to improve rural livelihoods. The sale of pigs provides money needed to pay school fees, and hospital bills, buy clothes, food and build better house systems (FAO, 2012; Dietze, 2011).

Many pig farmers in developing countries/ Tropics allow pigs to forage on pasture and supplement with available farm waste (Rangoma, 2013). In the study area, most households have some kind of kitchen waste, which can be exploited by a pig; however, this is not enough and has good quality for the partial feeding of three mature pigs per household whereas in advanced systems pigs are totally confined and provided a balanced diet. To provide a balanced diet the nutritional requirements of the different classes of pigs must be known and met. It is therefore prudent for pig farmers to purchase already prepared rations from reliable commercial sources (Rangoma, 2013).

Smallholder pig farmers face significant challenges that hinder them from benefiting from the rising demand for pork through better marketing opportunities. These challenges include limited access to inputs, extension service, agricultural insurance, credit, and other financial services; poor husbandry and farm management practices; poor quality feeds and pig nutrition practices; lack of genetic and breeding strategies; poor slaughter technologies and limited value addition; low production and productivity levels; low farm-gate prices and distress selling of pigs; lack of organized producer groups and organizational strategies to achieve economies of scale; low bargaining power; and lack of fair and efficient market linkages of smallholder farmers (Tatwangire, 2013).

Feed cost is the most important variable in pig production. Feed costs take 75-80% of the total cost of rearing pigs (Smith, 2006; FAO, 2012). Grains make up between 55-70% of pig rations (Smith, 2006). However, in many developing countries, there is not enough grain to feed both humans and livestock hence a major limitation (Petrus *et al.,* 2011). Small-scale pig farmers in developing countries face problems of high feed costs and shortages as well (Peters, 2004). The amount of feed and the number of times fed is vague in most studies. The amount of feed depends mainly on age, the physiological state of pigs (Hossain *et al.,* 2011), and the availability of feed (Kagira, 2010).

Proper housing, availability, accessibility, and affordability of pig feed are some of the common challenges pig producers are facing in Rwanda. For farmers to improve the pigs' productivity, and weight, and make reasonable profits, they must feed the pigs on balanced commercial or homemade feeds. This is hardly so as most pig producers use agricultural wastes and other feedstuffs of low nutritional value to feed their pigs. Most mortality of pigs occurs during the early life of the piglets (FAO, 2012).

Housing is very important because pre-weaning mortality in piglets is common due to piglets being exposed to bad weather conditions such as cold, rain, and predators. The mortality of young pigs can be avoided by providing adequate and secure housing (Madzimure *et al.,* 2013). Good housing makes management easier and helps the farmer to successfully rear 85% of all the live-born piglets to market weight in the shortest possible time (Gikonyo, 2010). The lack of meat inspectors and poor husbandry practices in rural areas make worm infestation a serious public health problem (Veary and Monato, 2008). Major pig diseases include; African Swine Fever (ASF), Porcine Cysticercosis, mange, pediculosis, worms, ticks and jigger infestations (FAO, 2012). Other studies show that diseases and pests are a major constraint in pig production (Muhanguzi *et al.,* 2012).

Another challenge to improved pig production in developing countries including Rwanda and others is the lack of organized breeding programs to facilitate genetic improvement (Kahi *et al.,* 2008). The limitation of genetic improvement programs has been the lack of sufficient reliable records and good pedigree structure. Most pigs in the country are highly inbred and there is an urgent need to address this challenge (Kahi *et al.,* 2008). Agriculture extension is a powerful tool with a rich potential to empower and support rural livelihoods (Rola *et al.,* 2002) but it has been observed that the current system in Rwanda is ineffective and not able to meet the needs of the local farmer (FAO, 2012).

The establishment of a reliable market is a very important aspect of any production system more so in pig production (Michael Levy, 2014).

Pig production in the rural areas is poorly developed and does not meet community needs, which include food and nutritional security and improved incomes. These are due to some constraints like lack of initial capital for investment, the smallness of land reserved for livestock keeping, lack of information, and the Muslim faithful and their religion prohibits the rearing of pigs, and consumption (FAO, 2018). Despite the challenges listed above, currently, there is an increasing number of people who have an interest in consuming pork. The price of other meats is rising compared to pork and an increase in the number of outlets such as local butcheries, and small-scale processors, means that farmers have a wider choice of markets for their products (FAO, 2018).

In this area, there are the majority of customers who demand a high quantity of pig meat. Despite the significance of the pig industry through the contribution of pig production, the nutritive value of pig meat, and the

series of agricultural activities. There was no study conducted to assess the profitability and constraints of pig farming in the study area. However, this study aimed to analyse the pig farming profitability and constraints in smallholder households in Rwanda—a case study of Musanze district. The specific objectives are to identify the factors influencing pig farming in smallholder households in the study area, to analyze the profitability of pig farming in smallholder households in the study area, to determine the contribution of pig farming to smallholder households in the study area, a and to find out the constraints of pig farming in smallholder households in the study area.

MATERIALS AND METHODS
Description of Study Area
The study was conducted in Musanze district of the five composed northern province of Rwanda. Musanze district is located at 1.50 latitude and 29.63 longitude and it is situated at elevation 1849 meters above sea level. It is Rwanda's most mountainous district, containing the largest part of the Volcanoes National Park. It is also in this district that most of Rwanda's mountain gorillas are found, making it the most popular tourist destination in the country. The district has two distinct zones and consequently related types of soils; one being a volcanic area with moderate slopes and volcanic ash soils with lava-predominant stones, the average altitude is 1860 m (www.musanze.gov.rw.).

The other part comprises steep hills where erosion is active. Musanze District has a tropical climate of high altitude with an average temperature of 20ºC and rain that varies between 1400 mm and 1800 mm. Agriculture is the lifeblood of the District. At least 91% of the population is engaged in agriculture. Musanze is considered a country granary. The total area of the district is 530, 4 km². Musanze is divided into 15 sectors 68 cells and 432 villages. In 2012, the total population was 368,563, and a gross density of 695 inhabitants per km². It has an average annual growth rate of 1.8% where Males stand at 174,760 and Females at 193,803 (NISR, 2012).

Sampling Technique and Sample Size
The population of interest for this research study was the pig farmers in Musanze district. The study adopted a cross-section research design to identify and analyse social economic factors influencing pig farming in smallholder households, profitability, and social economic impact on smallholder households as well as the constraints in the study area. A multistage sampling technique was employed for the success of the research. The first stage involved a purposive sampling of the Musanze district and five sectors (Rwaza, Nkotsi, Muko, Kimonyi, and Remera). The second stage involved the random selection of twenty-four (24) pig farmers from each of the chosen sectors making 120 pig farmers using the list of pig farmers available in the district agriculture office provided by District Veterinary Officer. These sectors have been chosen due to the high number of pig

farmers found there compared to the other ten sectors found in Musanze. Primary data were collected through structured questionnaires from the selected pig farmers. The data obtained from those farmers were analysed using descriptive statistics, cost benefit analysis, and stochastic frontier production function.

Data analysis techniques
This study used descriptive statistics such as frequencies, and percentages to describe the socio-economic characteristics of the pig farmers such as gender, age, educational level, farming experience, occupation, marital status and family size. This was analysed using Statistical Package for social science (SPSS) version 20. However, the stochastic frontier production function was used to determine factors influencing pigs farming in small householders using STATA and finally, Cost-benefit analysis was used to estimate profitability of pig farming through farm net revenue for pig production. Pig production is profitable if its BCR ≥ 1. The higher the BCR, the more profitable the pig production business is.

Model Specification
The cost and returns associated with pigs farming production was carried out to determine the profitability of pig production. Net farm income and gross margin were used to determine the cost and returns of pig production in the study area using budgetary techniques. The farm budgetary analysis helps to determine the total cost and total revenue that accrued to the enterprise within a specific production period.

Where:
GM = Gross Margin
TR = Total Revenue
TVC = Total Variable Cost
TFC = Total Fixed Cost
NR= Net Returns
TC= Total Cost
NFI= Net Farm Income
ROI= Returns On Investment
GR=Gross Ratio
OER=Operating Expense Ratio
DER=Depreciation Expense Ratio
NFIR=Net Farm Income Ratio
BCR=Benefit Cost Ratio

RESULTS AND DISCUSSION
Socioeconomic Characteristics of Surveyed Pig Farmers
The findings in Table (1) indicated that men are the majority of the respondents (59.2%) in pig farming production, while the females (41.8%) of the pig farmers in the study area. This indicates that men were more involved in pig production than females. The study was supported by Umeh *et al.,* (2015) in his study indicated that men are mostly involved in pig production and also suggested that sex may increase technical efficiency as male producers who often are the head of the family, are energetic to procure and administer production inputs are the majority of pig farmers in the study area. However, the study of Osondu *et al.,* (2014) showed that the male

is more involved in pig production, females also contributed to labor on light farm operations such as serving of feed and water, and cleaning of the piggery as corroborated.

The findings in Table (1) showed that majority of the pig farmers' age are between 36-45 years with 37.5% followed by the respondents who are in range of 18-35 constitutes (34.2%) of the pig farmers in the study area, and the age of above 45 years constitute 25.8% of the pig farmers. The lowest class was of the respondents who are below 18 years represented by (2.5%). This shows that young people are less involved in pig farming. This should be due to the problem of lack of initial capital for investment in the pig business. However, the adults are more engaged in pig farming production in the study area due to the possession of initial capital.

The findings in Table 1 also showed that the majority of pig farmers in the study area are those who have a primary education level (46.7%) followed by those with a secondary level (24.2%). The tertiary education level and non-formal education have (18.3%) and (10.8%) respectively. This implies that pig farmers have an education level, which highly facilitates the adoption of new technologies and innovation for both the quality and quantity of pigs' products.

The findings in Table (1) discovered that the Majority (69.1%) of the pig farmers in the study area are married followed by single with (19.2%). While widows constitute (9.2%) of the pig farmers in the study area. In this research study, the findings showed that divorced people engaged in pig farming constitute (2.5%) of all the respondents surveyed. The low involvement of widows and divorced people could be due to the lack of capacity to afford a pig or piglet to start this business because they always have different tasks to solve themselves rather than those families have both husband and wife to help each other as said that two hands are better than one.

The results in Table 2 also indicate that the majority of pig farmers are (1-5) with (43.3%) followed by those of 6-10 with (37.5%). The family size is greater than 11 members (19.2%) and the last class with low percentage in the study area for pig farming production. This is due to the labour force provided by family members. This means that, the higher the number of family members, the higher the labour force engaged in different activities required by pig farming production.

The farming experience of the pig farmers indicated that those having 2-6 years of farming experience have the highest population (51.7%) in pig farming in the study area followed by those of 7-11 with (28.3%). Those with 12-16 years of farming experience are represented by (6.7%) of the population of the study area. However, the last category of greater than 17 years represent (3.3%). This is because pigs farming was shown by respondents to be the new business in study area about compared to other livestock farming especially cattle, goat, and sheep which are considered as traditional activity.

Table 1. Socioeconomic Characteristics of Surveyed Pig Farmers

Socioeconomic Characteristics	Frequency	Percentage (%)
Gender		
Male	71	59.2
Female	49	40.8
Total	120	100
Age		
<18	3	2.5
18-35	41	34.2
36-45	45	37.5
>45	31	25.8
Total	120	100
Education level		
Primary	56	46.7
Secondary	29	24.2
Tertiary	22	18.3
Non formal education	13	10.8
Total	120	100
Marital status		
Married	83	69.1
Single	23	19.2
Divorce	3	2.5
Widow	11	9.2
Total	120	100
Family Size		
1-5	52	43.3
6-10	45	37.5
>11	23	19.2
Total	120	100
Farming Experience		
2-6	62	51.7
7-11	34	28.3
12-16	20	16.7
>17	4	3.3
Total	120	100

The Factors Influencing Pig Farming Production in Smallholder Households

In order to determine the factors influencing pig farming production in smallholder households, a multiple regression analysis was used. The socioeconomic factors were age, gender, education level, land size for pig farming, farming experience, market availability,

income generation, feed availability, cost of feed, access to credit facilities, access to veterinary services, and access to information. The findings of the regression analysis in (Table) indicated that eight out of the twelve variables were positive and significant where among them five namely education level, market availability, off-farm generation, feeds availability, and access to veterinary services were statistically significant at P ≤ 0.01 level of probability. The findings also showed that an R-squared of 0.76 implies that 76% of independent variables explain the influence of these variables on pig farming production in the study area.

Table 2. The Factors Influencing Pig Farming Production in Smallholder Households

Variables	Coefficient	Standard Errors	P-value
Age	-0.807	0.525	1.651
Gender	0.291	0.739	0.045
Education level	0.617	0.038	0.000
Land size to pig farming	1.047	0.692	0.860
Farming experience	0.452	2.416	0.069
Market availability	0.911	0.630	0.004
Off-farm generation	1.123	0.743	0.009
Feed availability	0.318	0.014	0.000
Cost of feed	-0.876	3.087	0.000
Access to credit facilities	-0.405	2.914	0.043
Access to veterinary services	0.072	0.059	0.000
Access to information	0.811	0.536	0.075
Constant	-4.552	3.011	0.000

Number of obs = 120 R^2 = 0.76011
F(12, 107) = 64.22   Adj R-squared = 0.7395

The level of education level, market availability, income generation, feed availability, and access to veterinary services had a positive coefficient. This for instance implies that a 1-year increase in the level of education of the respondent will lead to increased pig farming production by 0.6%. It also implies that a unit increase in feed availability, and market availability will lead to increased pig farming production by 0.3 and 0.9% respectively. This could be because education helps the farmers to understand better the innovation introduced to them as regard pig farming production and help them to make sound and useful economic and managerial decisions. The level of education should also determine the quality of skills of farmers, their allocative abilities, and how well-informed they are about the innovations and technologies around them. This is because people with higher educational level attainment are usually faster adopters of innovation in different domains.

Farming experience also showed a positive coefficient with pig farming production. This indicates that 1-year increase in pig farming experience of the respondents in the study area will result in high pig farming production by 0.4%. This should be because, with more experience, the farmers are likely to manage the farm better and make decisions that are more informed. The findings were supported by the study of (Oluwatayo *IB et al.,* 2008) indicated that that farmers with more experience would be more efficient, have better knowledge of climatic conditions and market situation, and are thus, expected to run a more efficient and profitable enterprise. It also supports the findings of (Onyebinama UA,2004), that previous experience in farm business management enables farmers to set realistic time and cost targets, allocate, combine, and utilize resources efficiently, and identify production risks.

The findings induced that off-farm income was positive and significantly influenced pig farming production at P ≤ 0.01 level of probability which suggested that the increased off-farm income from other domains influenced pigs farming production in the study area. This implies that 1% increase in off-farm income for the respondents, the pig farming production should be increased by 1.1%.

The findings revealed that gender was positive and significant influenced pig farming production at P ≤ 0.05 level of probability, which suggested that the increased gender balance in pig farming influenced pig farming production in the study area. This implies that a unit increase in number of women in pig farming will help to increase pig farming production by 0.3%. The study was supported by the study of Osondu *et al.,* (2014) showed that male is more involved in pig production, and females also contributed to labor on light farm operations such as serving feed and water and cleaning the piggery as corroborated. Umea *et al.,* (2015) also indicated that men are mostly involved in pig production and suggested that sex may increase technical efficiency as male producers who often are the head of the family, and are energetic in procuring and administering production inputs are the majority of pig farmers in the study area. The study results indicated that the cost of feed and access to credit facilities had negative coefficients and influenced pig farming production in the study area. This for example implies that a unit increase in the cost of feed of pig will decrease the number of farmers and directly pig farming production by 0.8%. This is because the greater the increase in cost or price of feed, the higher the number of farmers left the domain due to unfordable prices and the low quantity of pig production in the area.

Profitability of Pigs Farming in Smallholder Households

The economic returns associated with pig farming in smallholder households were analyzed and compared using the cost–benefit method. The measures of pig farmers' economic conditions encompass the cost and

profitability. The findings also indicated that the farm revenue, total cost, gross margin, and net farm income were statically significant at (p < 0.01).

Table 3. Profitability (Cost-Benefit) Analysis of one Female Pig Production per Year

Cost/Returns	Average Amount (RWF)	Total Amount (RWF)	F-Test (Sig)
Total Revenue (TR)	55000	1100000	0.000
Variable Cost			
Cost of stocking	3000	36000	0.008
Feeds	275	576262.5	0.003
Water	1	6570	0.000
Drugs and vaccines	3750	45000	0.000
Total Variable Cost		663832.5	0.011
Fixed Cost			
Housing Cost	7000	84000	0.045
Feeders	15000	180000	0.010
Total Fixed Cost (TFC)		264000	0.002
TC= TFC+TVC		927832.5	0.000
GM= TR-TVC		436167.5	0.000
NFI/NR= GM-TFC/ TR-TC		172167.5	0.009
ROI= NR/TC		0.2	
BCR= TR/TC		1.2	
GR= TC/TR		0.8	
OER=TVC/TR*100		60.3	
DER=FC/TR*100		24	
NFIR=NFI/TR*100		15.7	

The findings in table 3 by comparison indicated the investment costs and economic returns per one female pig in a smallholder household unit area. By calculation, the Net farm income per female pig was (172167.5Rwf) while the gross margin was (436167.5). This indicates that the greatest pig farming production occurred by under-educated and experienced farmers than the new comes in the domain. This should be due to some different skills and knowledge from schools and experience and training provided by veterinary and technicians visiting the existing farmers in the study area. In addition, the low economic return in the study area should largely be attributable to the high cost of feeds caused by COVID-19 and the closure of boards between countries, particularly Rwanda and Uganda boards. The findings also revealed that the total farm revenue, total cost, gross margin, and net farm income were statistically significant at (p < 0.01).

The research findings indicated that the operating expense ratio which is a measure of what percentage of farm revenue is allocated to the variable operating expenditures was (60.3%). However, the t net farm income ratio was (15.7%). Similarly, the benefit-cost ratio (BCR) was (1.2), suggesting that one franc of investment in the study area generates 1.2 francs of revenue. The benefit-cost ratio (BCR) of 1.20, shows that pig farming is a profitable business in the study area because the ratio is greater than one. Generally, the high economic return associated with pig farming production could be attributed to regular proper feeding, and vaccination, which help maximize the weight and health of pigs. Proper feeding especially rich in different nutrients also promotes the fully and well-developed pig and subsequently results in higher production or number of piglets per mature female pig in the study area.

In addition, the depreciation expense ratio was (24%) while the returns on the investment were 0.2%. Further, the economic investigation and analysis revealed that despite some negative effects like the high depreciation cost, the problem of high cost of feeds in pig farming production as business was common in the study area due to the problems caused by the Covid-19 pandemic disease the world and lack of international trade between countries. However, in order to improve and increase efficiency in terms of technique and pig farming production, farmers should be encouraged to breed the modern pigs and sell the piglet for around seven months as well as to maximize net farm income rather than sell piglets of two moths as indicated by farmers in the study area.

Likewise, the government should set durable measures aimed at facilitating farmers to get access to agricultural credit in order to maximize profit. It should also be better to increase the extension and veterinary services as well as to minimize pig and piglet mortality through better provision of knowledge and skills pertaining to the factors of pig farming production, especially the proper feeding, vaccination, and housing that in return increase income from pig farming.

Table 4. The Average Quantity of Proper Feeds for a Female Pig at Gestation Period

Female weight(kg)	A mixture of feeds per day according to piglets gestated(kg)		
	8 piglets	10 piglets	12 piglets
150	4.5	5.3	6
200	5	5.8	6.5
250	5.5	6.2	7
300	6	6.7	7.5

Despite the high costs of feeds involved, pig farming is a profitable business in the study area, as indicated by the profitability ratio technique employed in the analysis. As a pig, farming is a very attractive and profitable business. To farm pigs successfully farmer needs training and learn more things about farming. This is because to farm pigs effectively farmers should make perfect shelter for pigs. They should give proper food and proper medical protection. Without rearing pigs properly, it is not possible to earn a large number of money.

Contribution of Pig Farming on Smallholder Households in Study Area

The result of Tobit regression analysis in Table4 indicates that seven factors such as (income generation, animal manure, employment opportunities, protein supply, access to agricultural credit, access to information, and infrastructures) out of ten have been positively impacted by pig farming on smallholder households in Burera and Musanze districts. The findings in Table 4 showed that the three factors namely income generation, employment opportunities, and new job creation had positive and statistically significant impacts on pig farming in the study area at P ≤ 0.01 level of probability. The four factors such as animal manure, Nutrition supply, access to agricultural credit, and access to information had a positive and significant impact on pig farming in the study area at P ≤ 0.05 level of probability. Therefore, one factor namely infrastructure has a positive coefficient but is not significant with pig farming in the study area. In contrast, two variables (poverty reduction, and food security control) had a negative influence on pig farming in the study area. Many respondents in the study area indicated that pig farming positively affected their livelihoods. They said that with pig production particularly meat and oil, they created new jobs, especially restaurants. They said that they preferred restaurants over other activities because the number and quantity of demand increase day per day especially in towns where the number of visitors/guests and tourists is at a high level compared to the rural areas. This for example means that 1% increase in pig farming should increase the income generation in the study area by 0.5%. This is because the higher the demand for pig production (meat), the higher the supply at a good price encouraging pig farming in the study area. Increase in pig production also private investors and the government to build new infrastructures like modern slaughterhouses, electricity, markets, and feeder roads.

By the construction of these new infrastructures, there was a huge provision of new jobs to different levels of people in rural communities both educated and non-educated, especially Labor Day and workforce. This also implies that a 1% increase in pig farming should affect human livelihood by enhancing employment opportunities by 0.8%. This is because once the number of customers demanding meat increases there is a need for graduate veterinarians to follow day-to-day the standards of produced meat which is a source of employment opportunities. Communities indicated that, in the past period, local people were not interested in pig farming and consumption especially females largely due to the incompatibility with the culture of the predominantly low level of education and lack of self-confidence.

Nowadays, despite the growing interest of men, rural Rwandans particularly those located near Musanze town are happy about the job opportunities in pig farming and serving in restaurants of pig meat. Some respondents especially young women from different regions of the country said that they are often very proud of terms salary they get. Generally, this shows that pig farming

is a profitable business in the study area as indicated by the results of regression analysis. Normally, the high economic return associated with pig farming production could be attributed to the regular proper feeding enhanced by good and high production of different crops produced in the area that support feeds from the market.

Table 5. Contribution of Pig Farming on Smallholder Households in Study Area

Variable	Coefficient	Standard Error	p-value
Income generation	0.491	0.070	0.009
Poverty reduction	-0.059	0.361	0.001
Animal manure	0.172	0.307	0.030
Employment opportunities	0.857	0.098	0.000
Food security control	-0.177	0.523	0.072
Nutrition Supply	0.046	0.604	0.040
Access to agricultural credit	0.054	0.511	0.057
Access to information	0.143	0.328	0.055
Infrastructures	0.2854	0.052	0.892
New jobs creation	0.745	0.298	0.000
Constant	1.491	0.545	0.000

Number of observations = 120
Prob > F = 0.0000
Log likelihood = -59.644
Pseudo R^2 = 0.7188

Constraints of Pig Farming in Smallholder Households

Pig farming is one of the most profitable businesses all over the world for various reasons, especially income generation. In Rwanda, mainly both smallholders and large farmers do not yet keep pigs as a business. Many important factors should be addressed to ensure that you have a healthy flock of pig/piglets where two are mostly considered management and environment. When pigs are healthy, they eat less food, break for a longer time, and produce a desirable quantity of meat both in quality and quantity. They are less trouble to look after and less money is spent on medical costs when they have proper housing and good feeder for feeding and follow other needs. Moreover, (Tatwangire, 2013) indicated that smallholder pig farmers face significant challenges that hinder them from benefiting from the rising demand for pork through better marketing opportunities. These challenges include limited access to inputs, extension services, agricultural insurance, credit, and other financial services, poor quality feeds and pig nutrition practices; lack of genetic and breeding strategies; poor slaughter technologies and limited value addition. However, the findings of this study revealed that the most common constraints for pig farming in smallholder households were the high cost of feeds, inadequate initial capital (100%), feeds sacristy and quality (9.5%), lack of conservations facilities (89.9%), pests and diseases

109

outbreak (75.6%), high cost of piglets (70.1%), lack of farming information (65.7%), and poor housing with (50.4%).

In the study area, all respondents (100%) reported that the high cost of feeds, and inadequate initial capital (100%) were the first constraints of pig farming production in the study area. This is because the high cost of feeds reduces the number of farmers in the domain as well as the reduction of quantity and quality for pig farmers. The pests and disease outbreaks (75.6%) were also found to be one of the factors hindering pig farming production in the study area. This is because the disease can spread rapidly among pigs/piglets when they are usually kept together in improper pig houses. They also share the same food and water bowls, which can spread disease and infections from sick to healthy chickens. The main diseases said by respondents in the study area are (ascaris, salmonellosis, pest porcine, and colibacillosis).

The farmers indicated that disease has many consequences for their livelihoods at both the community and individual household levels. They said that within households, priority requirements change, as the piglets that would have been used to feed visitors/relatives or sold for survival are no longer available. The capital available to farmers is therefore reduced, especially when are not producing and dying. Therefore, all listed constraints particularly disease bring poverty to the household in rural areas.

In the constraints, inadequate feeds for pig was also shown in the major challenges. It sometimes comes when food for humans is scarce. At this time, pigs have less access to food, and production directly is reduced. In general, the high cost of adequate feeds and medicines for pig farmers, is the issue reducing the profitability of pig farming, especially as there is no sufficient also extension and veterinary services.
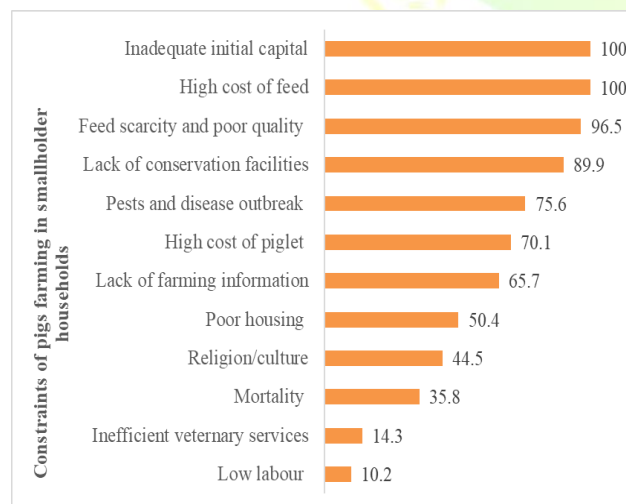
Figure 1. Constraints of pig farming in smallholder households in the study area

CONCLUSION

The main aim of this study was to analyse the pig farming profitability and constraints in smallholder households in Rwanda. A case study of Musanze district. The findings indicated that men are the majority of the respondents in pig farming production in the study area. The findings of the regression analysis indicated that five factors namely education level, market availability, off-farm generation, feed availability, and access to veterinary services were statistically significant at $P \leq 0.01$ level of probability and influenced pig farming in the study area. The findings also indicated that the farm revenue, total cost, gross margin, and net farm income were statically significant at ($p < 0.01$). The research findings indicated that the benefit-cost ratio (BCR) was (1.2) greater than a unit, suggesting that one franc of investment in the study area generates 1.2 francs of revenue showing that pig farming is a profitable business in the study area.

Without rearing pigs properly, it is not possible to earn much money. To farm pigs successfully farmer needs training and learn more things about farming. This is because to farm pigs effectively farmers should make perfect shelter for pigs. They should give proper food and proper medical protection. The result of Tobit regression analysis showed that seven factors out of ten have been positively impacted by pig farming on smallholder households in the study area. However, the three factors namely income generation, employment opportunities, and new job creation had positive and statistically significant impact with pigs farming in study area at $P \leq 0.01$ level of probability.

The findings of this study revealed that the even if there are many constraints in pig farming but the most common constraints for pig farming in smallholder households were the high cost of feeds, inadequate initial capital, feed sacristy and quality, lack of conservation facilities, pests and diseases outbreak, high cost of piglets, lack of farming information, and poor housing. Despite the constraints indicated by different respondents in the study area. Pig farming is an economically profitable business as indicated by different analysis methods. It broadly speaking helps create new jobs, enhances employment opportunities, generates income, and clearly improves the standard livelihood of farmers in the study area. Based on the findings of the study, the following recommendations have been made:

Mobilise and sensitize farmers' groups especially females on key principles of participatory group governance through fair elections and giving accountability in the long term. This should help lead to the establishment of strong farmers' organizations and the union of pig producers and marketing groups in the country. The union of pig producers and marketing groups helps to coordinate, promote, and regulate the development of the pig industry.

Promote interventions that can help provide initial start-up capital for farmers or marketing groups to help kick-

start their farming operations. Furthermore, savings groups can be created to help generate money for use through borrowing during periods of stress and peak markets.

Promote pig value chains that are sustainable by attracting more direct participation from the private sector and other appropriate boundary partners that have a comparative advantage in the development of smallholder households pig value chain operations in Rwanda especially in the study area. This may require the need to redefine objectives and find new ways to expand farmers' access to credit services, funding, training opportunities, and market for the pig products, particularly meat and pig dung.

As seen, pig farming production in the study area was profitable, but an increase in the scarcity of feeds and the high cost of feeds were found to be the biggest constraints in this business. However, government agencies/RAB should emphasize how to stabilize the price of feeds to smallholder households. In terms of minimizing cost feeds, the pig farmers in the study area should efficiently and economically learn how to formulate and increase their feeds by use of local crop feedstuffs as this area is the granary of the country, especially for potatoes.

CONFLICT OF INTEREST

The author here declares that there is no conflict of interest in the publication of this article.

REFERENCES

Alex Tatwangire. 2013. Successes and failures of institutional innovations to improve access to services, input and output markets for smallholder pig production systems and value chains in Uganda.

C.T.A. 1995. Agricultural Extension in Africa, Technical Centre for Agriculture and Rural Cooperation. Yaunde Cameron.

Dietze, K. 2011. Pigs for Prosperity. FAO Diversification booklet.

FAO 2012. Pig Sector Kenya, FAO Animal Production and Health Livestock Country Reviews, No. 3. Rome, FAO. http://www.fao.org/docrep/015/i2566e/i2566e00.pdf.

FAO. 2003. Agriculture in Nigeria. F.A.O of United Nations, Rome.

FAO. 2006. State of Food Insecurity in the World. Available at https://www.slideshare.net/KCNF/the state of-food-insecurity-the-world, accessed on 2nd May 2015.

FAO. 2011. World Livestock 2011, Livestock in food security. Food and Agriculture Organization, Rome, Italy.

FAO. 2011. Livestock and food supply. [Online] Available at: <http://www.fao.org/docrep/014/i237e/i237e.p dfaccessed on 2nd May 2015.

FAO. 2012. Livestock Country Reviews (3) Pig sector in Kenya. FAO animal production and health. Food and Agriculture Organization, Rome Italy.

FAO. 2018. Environmental performance of pig supply chains. Guidelines for assessment (Vision 1). Livestock environmental assessment and performance partnership. Rome, FAO.

Gikonyo, S. 2010. Pig Production Manual for the Department of Livestock Production, Ministry of Livestock, Kenya.

Hossain, M.E., Chakma, S., Khatun, M.M., Hasanuzzaman, M., Miah, M.Y. and Biswas, M.A.A. 2011. Production systems of swine in the rural areas of Rangamati and Khagrachari districts of Bangladesh. *Bangladesh Journal of Animal Science.*

Kagira, J.M., Maingi, N., Kanyari P.W.N., Githigia, S.M., Ng'ang'a J.C, Gachohi, J.M., 2010. Characteristics of pig trade in low-income settings in Busia District, Kenya, *Tanzania Veterinary Journal.*

Kahi A.K., Illatsia E.D., Githinji, M.G, Muasya, T. K. and Okeno. 2008. Genetic parameter estimates for growth traits of Large White Pigs in Kenya. *South African Journal of Animal Science.*

Madzimure, J., Chimonyo, M., Zander, K.K. and Dzama, K. 2013. Potential for indigenous pigs in subsistence-oriented and market-oriented small-scale farming systems of Southern Africa.*Tropical Animal Health Production*.

Michael Anthony Levy. 2014. Challenges and Opportunities of Smallholder Pig Production and Marketing in Western Kenya.

MINAGRI. 2008. Annual report, Kigali, Rwanda.

MINAGRI. 2019. Annual Report 2019-2020

MINECOFIN. 2007. Indicateur du développement, Kigali, Rwanda.

Muhanguzi D, Lutwama V, Mwiine FN 2012. Factors that influence pig production in Central Uganda-case study of Nangabo Sub-County, Wakiso district.

NISR 2012. Rwanda National Institute of Statistic, Statistical yearbook. Kigali, Rwanda. http://statistics.gov.rw/publications/statistical-yearbook-2012

NISR 2018. Agricultural Household Survey 2017 report

Ogunniyi L. T. and Omoteso O. A. 2011. Economic Analysis of Swine Production in Nigeria: A Case Study of Ibadan Zone of Oyo State.

Okoli, C.I. 2006. Topical Tips On Intensive Pig Production; Animal Management and Health Issues. Technical Notes. Tapas Institute of Scientific Research and Development.

Oluwatayo IB, Sekumade AB, Adesoji SA. 2008. Resource use efficiency of maize farmers in

Rural Nigeria, Evidence from Ekiti State. World Journal of Agricultural Science.

Onyebinama UA. 2004. Farm business management for smallholder farm firms in Nigeria. Owerri Alphabet Nigeria Publishers, Nigeria.

Osondu C. K., Ijioma, J.C., Anyiro, C. O., Obike K. 2014. Economic analysis of pig production in Abia State, Nigeria. International Journal of Applied Research and Technology.

Peters. D. 2004. Use of Sweet Potato in Pig Production in Asia: Agricultural & Socio-Economic Aspects, animalscience.com Review No.4, Pig News & Information **25**(1), 25N-34N CABI Publishing.

Petrus NP, Schneider MB, Nepembe M 2011. The constraints and potentials of pig production among communal farmers in Etayi Constituency of Namibia. Livestock Research for Rural Development. http://www.lrrd.cipav.org.co/lrrd23/7/petr23159.htm

Poulton C, Kydd J, Dorward A 2006. Overcoming Market Constraints on Pro-Poor Agricultural Growth in Sub-Saharan Africa. Development Policy Review.

Rahman. 2009. Reducing food insecurity in developing countries through meat production: the potential of the Guinea pig (Cavia porcellus).

Rangoma, M. 2013. Some credit facilities available to livestock farmers in Kenya. Available at *http://livestock Kenya.com/index.php/blog general.*Accessed on 14 April 2015.

Republic of Rwanda 2012. EICV3 District Profile Musanze, National Institute of Statistics of Rwanda, Kigali.

Smith, B. 2006. The Farming Handbook. Pietermaritzburg: CTA and University of Kwa Zulu- Natal Press.

Thorton, P.K. 2010. Livestock production; recent trends, future prospects. Philosophical transactions of the Royal Society B.

Umeh J. C., Ogbanje C., Adejo M. A. 2015. Technical efficiency analysis of pig production: A sustainable animal protein augmentation for Nigerians. Journal of Advanced Agricultural Technologies.

Veary, C.M. and Manoto, S.N. 2008. Neurocysticercosis: a possible cause of epileptiform seizures in people residing in villages served by the Bethanie clinic in the North West Province of South Africa. *Journal of the South African Veterinary Association.* www.musanze.gov.rw