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# Competitive Analyses of the Pig Industry in Swaziland

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**Abstract:** Over recent decades, Swaziland's pork industry has been stagnant, failing to meet the domestic demand for pork. It is only in recent years that the number of pig farmers has increased rapidly, with smallholder farmers taking the lead. However, while higher demand for pork could lead to opportunities for growth, with uncertain future markets, increased pig production capacity could subject farmers to extreme market competition and failure to sell their produce. This study used a survey and SWOT analysis to assess the current pig production and market performance of smallholder farms in Swaziland. To quantify SWOT factors, the Analytical Hierarchy Process (AHP) was used to derive priorities for subsequent formulation of potential pig production strategies that are resilient both to market and climate changes. Strategy formulation was based on Porter's cost leadership strategy. The findings revealed that, currently, the pig industry is attractive, and that the present is probably the best time for smallholder farmers to maximize their profits. Unfortunately, the industry was found to be threatened by the expected increase in production capacity, future market competition, and the socio-environmental challenges associated with expansion. Despite this, the findings suggest that smallholder farmers can survive future market challenges by strategically using agro-industrial by-products as alternative feed ingredients to reduce production cost. The formation of farmers' associations could benefit smallholder farmers through economies of scale, processing and product value addition, and increased access to markets, and unity could strengthen their position in the market when bargaining for better prices.

**Keywords:** Analytic Hierarchy Process (AHP); market competition; pig industry; Porter's cost leadership strategy; smallholder farmers; SWOT analysis

## 1. Introduction

Global demand for food is projected to increase by 59% to 98% by 2050 [1]. However, climate change continues to threaten agricultural sustainability [2], particularly, the erratic rainfall and fluctuating temperatures that compromise agricultural food production systems [3,4]. The severity of climate change is more pronounced in developing countries like Swaziland, as mitigation and adaptation strategies are not fully implemented, or probably, they are not yet in place. Over the past three decades, Swaziland has consistently failed to produce enough food to meet its domestic requirements, producing only 20% of the total domestic consumption [5]. Consequently, the country has been condemned to poverty and food insecurity issues, with 45% of the population living on less than 1 US$ per day [6].

To address future food challenges associated with global climate change, Swaziland recently selected the pig as the animal of choice for quick turnaround results. Pigs are fast-growing species with

efficient feed conversion ratios [7], after poultry and dairy. This was in response to the suggestions in previous studies of [2,8,9], stating that adoption of climate-resilient agriculture was paramount to adequately feeding the growing population. Pigs are favoured for their prolificacy and relatively high rate of returns, and their meat is the most consumed globally; thus, they contribute to both food and financial security of households [7,10,11]. In light of limited feed resources due to persistent droughts, because pigs have flexible feeding habits, they are ideal animals to solve food insecurity issues. Pigs can literally eat anything from agricultural by-products to industrial waste, converting inedible feeds into valuable products such as meat for proteins, fats, vitamins, and minerals [10,12].

In spite of the fact that the pig industry was commercialized as early as 1990 [13], it has remained in its infancy, failing to meet the domestic demand for pork over the years. It is only in recent years that pig production has intensified. In an endeavor to promote swine production, the government of Swaziland launched the "Pig Industry Enhancement Project" in 2016, with technical and financial support from Taiwan International Cooperation and Development Fund (Taiwan ICDF). The goal was to produce high-quality breeding stock for smallholder farmers to scale up their production capacity.

While the growing demand for pork and the government support structure facilitates opportunities for growth and expansion to smallholder farmers, when viewed from a broader perspective with all stakeholders considered, it also poses challenges on the economic stability of smallholder farmers, the environment, and the social well-being of the society. Within the economic context of smallholder farmers, it could subject farmers to extreme market competition and ultimate failure to sell their pigs when domestic production is at its peak. It is apparent that increased supply will alter the market environment. An increase in supply of a commodity is associated with volatile market conditions [14]. Along with uncertain future markets, the proposed expansion in the swine industry could be too risky for smallholder farmers, who often lack sufficient resources to increase their production capacity to actively compete in formal markets [15,16]. In most developing countries, the plight of smallholder farmers has been the lack of resilience to market fluctuations due to limited access to new technology, and the lack of developed markets and insurance cover [4,17].

Within the environmental context, increased pig numbers are associated with potential challenges of manure handling and disposal. Improper manure handling and disposal could result in an increased risk of land, water, and air pollution [18–21]. Recent literature highlights the need of ensuring sustainable consumption and production patterns. It is therefore very important to understand that, normally, whilst in pursuit of increasing global food supply through intensified production systems, unfortunately, the overall sustainability of the environment that produces the food is threatened.

With regard to social well-being, the anticipated increase in pig production promises to benefit the society in terms of food and nutrition security, increased job opportunities, and as an additional income-generating project. However, this could be outweighed by the increased risk to human health. [18,21] reported increased human respiratory health problems in regions with densely-concentrated pig producing farms.

Thus, it seems increasingly important that, as much as smallholder farmers need to scale up their production capacity to address food and nutrition security issues, there is an urgent need to develop new farming strategies that are tailored to take market fluctuations into account. Such strategies should be intertwined with the environment and human health. It is within this context that we explore, in this study, potential strategies that would enable farmers to respond quickly to market changes, foster resilience, and be innovative enough to consider the environment and health issues of society. More specifically, we seek to know how smallholder farmers are responding to changes in production capacity and market environment. How can they align themselves to remain competitive while not compromising the social well-being of society and the environment in which they are?

To the author's knowledge, although numerous SWOT studies conducted on the swine industry were mainly intended to help understand the business environment for strategic planning purposes [22–25], no other study has examined the economic sustainability of the pig industry, along with the consequences of pig production on the socio-environment following the recent government

support initiative. Because of the failure of the SWOT analysis to prioritize the SWOT factors [22], the present study aims to fill that gap by further integrating the Analytic Hierarchy Process (AHP) to give weightings according to the significant importance of SWOT factors. As suggested by [22], the AHP improved the quantitative information from SWOT analysis with its eigenvalue calculation framework.

In the present study, we intend to foster shared values for all stakeholders by extending our focus beyond profit maximization while ensuring sustainable agricultural production. Our strategy is based on Porter's cost leadership strategy [26,27], which is rooted in innovativeness and creativity, to reduce production costs in order to survive market competition [28]. Recently, scholars have been increasingly calling for a win-win idea, in terms of improving profits without compromising the socio-environment [29]. Our response to these calls is to maintain the economic stability of smallholder farmers through the strategic use of locally-available resources, along with innovative waste management practices within the swine industry.

## 2. Background of Pig Production in Swaziland

### *2.1. The Dynamics of the Pig Industry in Swaziland*

Since the inception of the swine industry back in 1990, pork production has remained relatively low in Swaziland, failing to meet the domestic demand over these years [13]. To explain how the industry has remained in a state of infancy, we can reflect to domestic production capacity for pork over the past five years. Figure 1 shows stagnant growth: 900.09, 856.85, 724.68, 785.07, and 916.10 tonnes between the years 2012, 2013, 2014, 2015, and 2016. The low domestic production capacity implies that, currently, there is high demand for pork, meaning that the industry is highly profitable and attractive to farmers. Perhaps, the low supply of pork can be explained by the fact that the industry is mainly dominated by smallholder farmers, who have limited access to resources and technology that could enable them to scale up their production capacity [30].

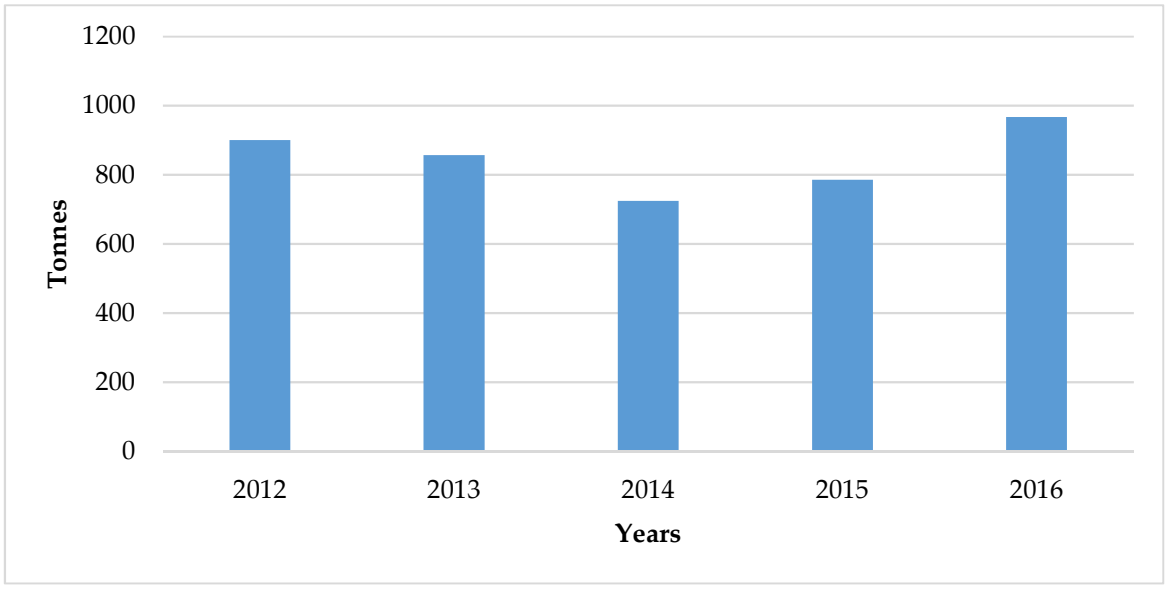


**Figure 1.** Domestic pork production for the years 2012–2016.

However, in spite of the low domestic supply, pork has remained the most accepted meat among all meat products in Swaziland [31]. In order to meet domestic market demand for pork, the country heavily relies on imports [13,31]. Over the years, the amount of pork imported into the country has been increasing steadily (Figure 2). The significant increase was from 422.2 to 591.21 and to 635.95 tonnes in the years 2014, 2015, and 2016 [31]. Accordingly, the amount of exported pork dropped significantly as well, from 74.81 tonnes in 2015 to 37.10 tonnes in 2016 [31].

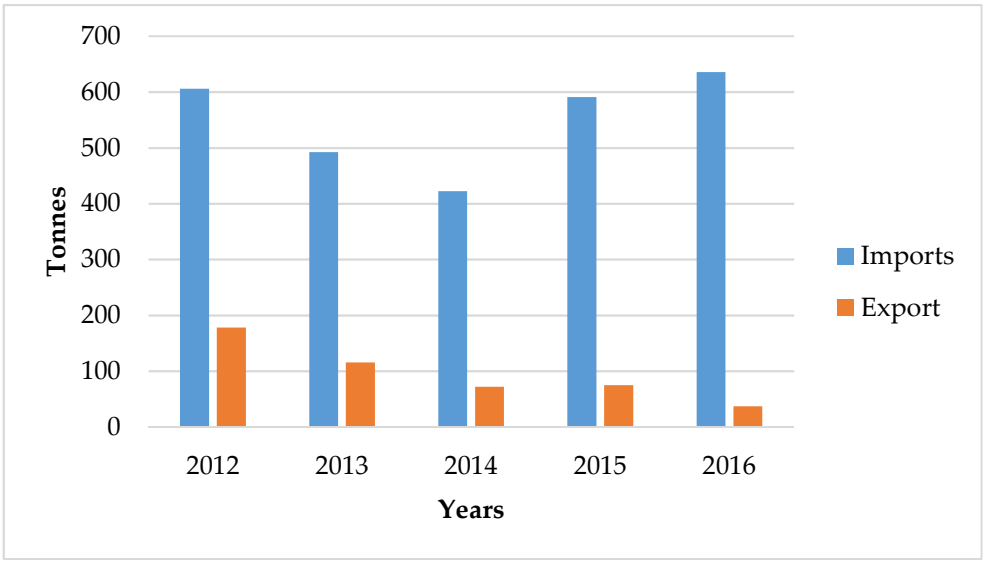


**Figure 2.** Quantities of pork imports and exports for the years 2012–2016.

However, Swaziland's relience on importation to meet food needs has been met with different acceptance levels, and seems to be too risky, as sustainabily was not gauranteed, and was further accused of dwarfing or suppressing growth of the local industry. This was in accordance with the literature, as several studies reported that relience on imports for food security was too risky, and full of insecurities and uncertanities nowadays due to climate change [32–34]. In response, the government of Swaziland has since launched the "Pig Industry Enhancement Project" in 2016, to underline the importance of, and the country's commitment to, improving food and nutrition security through sustainable agriculture [34]. This initiative promises to stimulate and sustain economic development that reduces poverty by creating employment opportunities and fosters good quality life within the society.

It is becoming increasingly obvious that the swine industry is yet to expand, following the much celebrated investment by the government which provides farmers with high-quality breeding herds at highly subsidized prices. While the potential for growth is enticing to smallholder farmers, increased pig numbers might pose significant challenges to smallholder farmers. Improved production capacity is expected to change the forces of supply and demand for pork, thereby intensifying market competion, which will result in low market prices and reduced profit margins. Intensified market competition results in significantly reduced profit margins [28,35]. It is worth noting that the expected expansion may not affect the farmers, but might have implications on the environment and the well-being of the society.

### *2.2. Intensified Pig Production Systems, Food Security, the Environment, and Climate Change*

Over recent decades, increasing demand for food due to population expansion and climate change has fueled rapid transitions in consumption patterns, towards the adoption of livestock-based diets [36–38]. Among livestock products, meat has been by far the most preferred, with 63% growth in consumption rates over the last 40 years [38,39]. The much heralded "meat revolution" has been spearheaded by the swine industry, and pork is currently the most consumed meat world-wide [19,21,36,40], with a projected of 40% further increase by 2050 [41].

There is no doubt that expansion of the swine industry will contribute massively towards addressing food security issues. However, pig intensification is linked with manure accumulation, which in turn exerts pressure on the environment and human health when not well managed [21,40,42]. Many pig farms have been criticized for water, soil, and air pollution [21,43–47]. Globally, pork accounts for 9% of greenhouse gases (GHG) mainly from feed production and manure [48–50].

Recently, several scholars have reported a growing public concern regarding intensification of livestock production system, particularly pigs. Intensified production systems continue to face acceptability problems because they strain the environment in terms of water, land, and energy resources, while their emissions cause pollution, affect human health, and further contribute to global climate change [21,40,42,51–53]. The idea of fostering a win-win situation is not only limited to agriculture; the industrial sector too has been calling for the development of eco-strategies that could have positive impacts on the environment, on firms, and on society [29,54–56].

From where we stand, it seems impossible for smallholder pig farmers to maintain their economic sustainability. Such is confirmed by [52,57], as they both reported that increasing global food supply by intensifying production systems seems to be at crossroads with agricultural operations that preserve humanity and the environment. We intend to build on Porter's hypothesis framework (HP), hoping that considering the socio-economic impacts, while maximizing production, will trigger creativity in the formulation of innovative adapting strategies fueled by resilience to both the market and climate change [54,58,59].

## 3. Materials and Methods

The study was descriptive, employing both qualitative and quantitative procedures.

### *3.1. Data Collection*

Several data collection procedures including surveys, SWOT analyses, and the Analytical Hierarchy Process (AHP) were used to assess and describe the pig industry and the environment on which it is operating. Triangulation was performed to confirm and improve the accuracy of the results, since the process favored quantitative procedures [60].

#### 3.1.1. Survey and Instrumentation

A survey was conducted to provide an overall analysis of the pig industry in Swaziland as shown in Table 1. Supplementing the qualitative-based SWOT analysis with a survey was mainly for quantification purposes [61]. To outline present and future market conditions, smallholder pig farmers were identified as principal stakeholders responsible for the realization of improved market participation. Purposive sampling procedures were followed in the present study, as the researchers selected only active pig producers with a substantial number of pigs to ensure that relevant, in-depth information was obtained. A sample $n$ = 80 smallholder pig farmers were selected from the target population ($N$ = 488) to provide their insights on pig marketing in Swaziland. Prior to data collection, respondents were requested to participate in the study, and were further assured that their responses were going to be treated with the utmost confidentiality. Consequently, consent forms were signed by the respondents.

The survey instrument was developed following a desk review of government reports and journal articles on issues regarding [60] the production of pork. The questionnaires utilized semi-structured questions to assess perceptions of smallholder farmers inform of beliefs, opinions, and observations regarding pig production, changes in production patterns, and marketing in Swaziland. It was structured in six parts: the background and demographic information of the respondents; observed production patterns; perceived strengths (S); weakness (W); opportunities (O); and threats (T) to actively participate to pig production and marketing. The criteria used to assess farmers' perceptions were by means of a 6 point Likert scale, with end-points 1: "Strongly disagree" to 6: "Strongly agree". Face and content validity of the instrument was established by a panel of four swine specialists, and results from pre-testing confirmed that the instrument was reliable (Cronbach's alpha 0.89).

**Table 1.** Demographic characteristics of surveyed pig farmers ($n$ = 80).

| Characteristics | | Frequency | Percentage (%) |
|---|---|---|---|
| Gender | Female | 51 | 63.75 |
| | Male | 29 | 36.25 |
| Age | From 18–30 years | 9 | 11.25 |
| | From 31–40 years | 32 | 40 |
| | From 41–60 years | 18 | 22.50 |
| | Above 61 years | 21 | 26.25 |
| Marital status | Single | 15 | 18.75 |
| | Married | 53 | 66.25 |
| | Divorced | 7 | 8.75 |
| | Widowed | 5 | 6.25 |
| Highest level of education | Tertiary education | 17 | 21.25 |
| | High school education | 31 | 38.75 |
| | Secondary school education | 19 | 23.75 |
| | Primary school education | 6 | 7.5 |
| | No formal education | 7 | 8.75 |
| Farm location | Rural | 49 | 61.25 |
| | Urban | 31 | 38.75 |
| Trained in pig production and marketing | Yes | 71 | 88.75 |
| | No | 9 | 11.25 |

#### 3.1.2. SWOT Analysis

The SWOT analysis is considered an ideal qualitative tool that has the potential to simultaneously analyze the interactions of internal and the external environment of an enterprise [22,62]. It has been extensively used to foresee future market conditions, probably because of their simplicity and track records [63,64]. Recently, the SWOT analysis has been applied with success in issues relating to production and the environment [65–68]. In the present study, findings from SWOT analysis help to provide a clear understanding of the current state of the pig industry in Swaziland, what has been achieved based on the industry's strengths, and where are we failing, in terms of the weaknesses. And finally, what are the challenges and threats? And do we have opportunities that can be exploited to develop a strategy that would result in a good fit between the internal and external environment. Unfortunately, the SWOT analysis lacks the ability to numerically evaluate the effects of the potential strategies [22]; hence, the Analytical Hierarchy Process (AHP) as the final analysis of the present study was chosen.

### *3.2. Data Analysis*

For data analysis, the analytical hierarchy process of [69] was employed.

#### Analytical Hierarchy Process (AHP)

SWOT analysis has been criticized for its failure to numerically evaluate or rank factors according to their significant importance [22,63,70]. Therefore, since the qualitative SWOT factors cannot be measurable, the role of the Analytical Hierarchy Process was to derive priority scales of the SWOT factors. This technique enabled evaluation of SWOT factors according their weighting (ranking) to establish the order of priorities in the formulation of potential market and climate resilient strategies.

Several studies have used this mathematical method to analyze data with both qualitative and quantitative attributes [71,72]. In the present study, the swine specialist who also served as the technical consultant of the "Pig Industry Enhancement Project" launched in Swaziland made judgements using pairwise comparisons to derive priorities for alternative strategies. The choice of the expert was based of his knowledge and vast experience in project planning, implementation, and evaluation. The expert

has successfully set up numerous livestock-based projects all over the world, having served as a technical expert for Taiwan International Cooperation and Development Fund (Taiwan ICDF) for more than 10 years. Moreover, following intensive field visits, inspections, and evaluation of the on-going "Pig Industry Enhancement Project" over the past two years, we felt that the swine expert was best positioned to give the most accurate judgements.

Priorities were derived by means of an eigenvalue technique which provided the decision maker with new quantitative information, ensuring that the intangibles could be measured. Readers that are interested in more in-depth information about the AHP are referred to [69]. However, for the purposes of the present study, we will only explain the basic concepts of the Analytic Hierarchy Process adopted from [73] and modified as follows:

Findings from the SWOT analysis provided a pool of factors from four fields (strengths, weaknesses, opportunities, and threats), which served as a cornerstone upon which future mitigation strategies can be mapped for sustained pork production. At this step, SWOT groups together with the SWOT factors still lack weighting. The defined goal of this study consisted of determining the most sustainable pork production strategies under challenging environments due to climate change and expensive feed ingredients. The AHP was performed with the sole objective of developing weightings (ranking) of SWOT groups and SWOT factors to facilitate weighing possible options in the strategy formulation. The criteria followed in the present study were that SWOT groups were classified as Strengths, Weaknesses, Opportunities, and Threats. Within each SWOT group were the identified SWOT factors that could either enhance or improve production and market performance (strengths and opportunities) or negatively affect the swine industry (weakness and threats). As suggested by [69], factors should not exceed 10, as the number increases rapidly after pairwise comparisons.

SWOT factors (strength, weaknesses, opportunities and threats) were compared against each other to determine their relevant importance or ranking. The same principle is applied with the identified SWOT factors. The degree of importance of the identified factors was based on a matrix comparison. Pairwise comparison between factors were made based on the judge's perceived relative importance of the compared factors. Since the identified SWOT were qualitative, the evaluating swine specialist used a pre-calculated scale ranging from 9 to 1/9 to make pairwise comparisons to establish priority ranking. The swine specialist "judge" used the Eigenvalue technique to give judgements on how much he perceived one of the compared factors as being more important than the other, thereby giving the SWOT factors a quantitative aspect, and thus allowing them to be ranked according to their importance. Basically, the established priorities reflected how the judges perceived the relative importance of the compared factors.

The pairwise comparisons are shown in a matrix (Equation (1)), where factor aij = 1/aij and thus, when i = j, aij = 1. The value of $w$i may vary from 1 to 9. Where 1/1 indicates equal importance, 9/1 indicates extreme importance, 7 indicates very strong, 5 indicates strong, 3 indicates moderately strong, 1 indicates equal importance, 1/3 indicates moderate strong, 5 indicates strong, 1/7 indicates very strong, and 1/9 indicates extreme importance.

$$\mathbf{A} = (a_{ij}) = \begin{bmatrix} 1 & \frac{w_1}{w_2} & \cdot & \cdot & \cdot & \frac{w_1}{w_n} \\ \frac{w_1}{w_2} & 1 & \cdot & \cdot & \cdot & \frac{w_2}{w_n} \\ \cdot & \cdot & \cdot & \cdot & \cdot & \cdot \\ \cdot & \cdot & \cdot & \cdot & \cdot & \cdot \\ \frac{w_n}{w_1} & \frac{w_n}{w_1} & \cdot & \cdot & \cdot & 1 \end{bmatrix} \quad (1)$$

In some instances, priorities can be established by a group of experts, and in that case, **A** may contain some inconsistencies. Therefore, in the comparisons, some inconsistences can be expected and accepted [73]. The estimated priorities can still be obtained by using the matrix [Equation (1)] as an input using the Eigenvalue technique [Equation (2)].

$$(\mathbf{A} - \Lambda max\ \mathbf{I})\mathbf{q} = 0 \quad (2)$$

where $\Lambda_{max}$ is the largest Eigen factor of matrix **A**; **q** is its correct Eigen factor; and **I** is the identity matrix. The correct Eigen factor, **q**, constitutes the estimation of relative priorities. Thus, a consistency index can be constructed based on [74], who demonstrated that $\Lambda_{max}$ of a reciprocal matrix **A** is always greater or equal to $n$ (=number of rows = number of columns). However, if the pairwise comparisons do not include any inconsistencies, $\Lambda_{max} = n$. The more consistent the comparisons, the closer of the computed $\Lambda_{max}$ is to $n$. Consequently, the consistency index (CI) can be constructed using Equation (3).

$$\mathrm{CI} = (\Lambda max - n)/(n - 1) \tag{3}$$

While CI estimates the level of consistency with respect to a comparison matrix, and because CI is dependent on $n$, a consistency CR ratio which is also dependent on $n$ is calculated using Equation (4). CR can be estimated by calculating the average consistency index (ACI), which varies functionally according to the size of the matrix [69].

$$\mathrm{CR} = 100(\mathrm{CI}/\mathrm{ACI}) \tag{4}$$

CR measures the coherence of the pairwise comparisons; a CR of 10% or less is considered to be acceptable [73]. Note: In the present study, pairwise comparisons were performed by only one expert, the project consultant; therefore, the consistency index (CI) and consistency ratio (CR) were not calculated. However, they are discussed at length for the benefit of the reader.

To establish priorities in the present study, the swine specialist (Pig Industry Enhancement Project consultant) used the above matrix (Equation (1)) as the input, using the Eigenvalue technique. Normalized principal Eigen vectors obtained from pairwise comparisons from the matrix were further computed in a Microsoft excel calculation. An excel template sheet was obtained online from [69]. From each group, the factor with the highest priority was chosen to represent the group. This was performed to determine the overall priority for the subsequent ranking of internal and external environmental factors. When scaled up, the Eigen factors must sum up to 1 to obtain the priorities. Since judgements were made by only one decision maker (project consultant) in this study, there was no problem of inconsistencies.

While the inputs in this study were the identified SWOT factors which were qualitative, the AHP output comes in numerical values. Presenting the AHP results in quantitative values enables decision makers to evaluate alternative strategies based to their weighting (priority). This provided a platform where new goals may be set, with clearly defined strategies on how such goals can be achieved. Understanding the quantitative information about the environment gave leverage to harness the most important opportunities and strengths in the strategy formulation, while most critical threats were revealed and cushioned. Determination of the priority enabled our judge to rank alternative strategies with regard to cost and benefit analysis, keeping in mind the social and environmental issues.

## 4. Results and Discussion

### *4.1. The SWOT Analysis of Current Pig Production and Marketing in Swaziland*

In this work, we intend to develop resilient pig production strategies to be adopted by smallholder farmers to survive market shocks and other production challenges related to climate change. In order to retain a competitive edge within the industry, [75–77] suggested that the analysis of current and future market competition is crucial for a predetermined response. References [77] further suggested that the response should be guided by the following questions: what is driving the competition currently and in the future? Who are current and future competitors? What are they likely to do in order to survive competition? And how can the industry respond in order to achieve and sustain a competitive advantage? In an attempt to address these concerns, Figure 3 shows the identified SWOT factors.


**Figure 3.** SWOT analysis of pig production and marketing in Swaziland.

#### 4.1.1. Strengths

The survey revealed that the majority of smallholder farmers were relatively young, 31–40 years (40%), and possessed the required basic educational background—tertiary, 21.25%; high school, 38.25%; and secondary education, 23.75%—to effectively compete in the swine production industry. This demographic profile promises a smooth adoption of technology and recently-identified innovative production and marketing strategies to remain competitive within the industry. With regard to the current generation, they are more likely to own smartphones, which could be an added advantage for information sharing and dissemination. Farmers could create applications, where they share information through their circles on pork marketing and sales, production, management, breeding, and pest and disease control.

Similar findings were reported by [7,14], as they highlighted that basic education was a requirement for the adoption of smart farming. Perhaps these findings suggest that famers have the capacity to grow, adapt, and evolve within the swine industry, accumulating the necessary experience to adjust to the changing dynamics of the industry and future challenges. More importantly, whilst swine rearing is viewed as a labour-intensive and time-consuming agricultural enterprise [78], having

the most active and hard working age range (31–40 years) contributes positively to the future of the pig industry [7,14].

Another identified strength relates to good government support structures. Smallholder pig farmers have benefited from the "Pig Industry Enhancement Project" launched by the government of Swaziland, as they sourced high-quality breeding herds at highly-subsidized prices. This government support initiative demonstrates the positive impact of donor-funded projects together with good strategic planning by the government in prioritizing national agendas by addressing food security issues through increased agricultural production. Recently, growth in agriculture and food production systems, along with declining poverty, has been reported in Africa, thanks to international organizations and donor agencies [79,80]. Probably this follows huge investments on international research programs that have focused on climate change, agriculture, and food security programs initiated to solve food security issues for the developing world [40,52].

The low domestic supply of pork ensures a readily-available market, and is thus a positive attribute in swine industry. Shortfalls in food supply have been associated with major increase in food prices, providing an opportunity for profit maximization [79]. The findings of the study are in agreement with findings from several studies who reported that the ability to sell and market your produce ensures profitability and potential for growth in the industry [25,80].

The availability of labour has often been reported as a major limiting factor on pork meat industries [79,80]. However, in Swaziland, labour is currently available and is cheap due to high unemployment rates since the global financial crisis of 2007/2008 [81]. Similar trends have been reported in Africa, where 2.11% growth (2003–2008), and 1.73% growth (2008–2015) labour productivity was reported [82]. In contrast to the findings of the present study, [83] reported consistently falling Japanese agricultural production due labour shortages and significant migration of rural agriculture to off-farm income in urban areas.

#### 4.1.2. Weaknesses

Attributes found to be working against the production performance of pig farmers were found to be high feed costs, land tenure system, lack of collaboration, and the remote location of pig farms. Profitability in swine production is mostly influenced by the cost of feed, as it represents between 60 and 70% of total production costs [84,85]; therefore, manifestation of this weakness is paramount. Compounding the situation further is the fact that, currently, smallholder farmers in Swaziland operate in isolation. This negatively affects their performance as they are deprived numerous benefits of association, including benefits from economies of scale, sourcing external funding, and access and control of market prices. Similar findings were reported by several other studies which highlighted how working in isolation reduced smallholder farmers to price takers, as their bargaining power for better prices is stripped by their low production scale [86,87]. Reference [88] further reported that in developing countries, small-scale pig producers, who often lack resources, technology, and knowledge to produce more efficiently, have very limited opportunities to sell their produce in an efficient and profitable manner.

The land tenure system in Swaziland has been found to be working against the expansion of the swine industry. The dual land tenure system means that farmers do not have full ownership of the land; thus, smallholder farmers are denied the opportunity to use it as a collateral when sourcing external funding [30,89]. This means limited prospects of expansion within the swine industry. Previous studies linked full land ownership with improved agricultural activity and efficiency [90], encouraged long-term farm investments, and the adoption of new technology [91,92] when used as a collateral [93].

In an attempt to ease the environmental pressure associated with pig production, smallholder farmers (61.25%) have positioned their farms away from the city center to secluded and remote areas with lower population density. Remote locations were chosen to avoid the effects of emissions from manure such as dust and bad odour, which can be a public nuisance, and have the potential to cause respiratory infections among people living in close proximity to the farm, as well as to further avoid

water pollution from manure through run-off and leaching, and the accumulation of heavy metals such as zinc (Zn) and copper (Cu) [21,40,42,94,95]. Unfortunately, remote locations result in limited access to feed resources, abattoirs, proper storages facilities, and distribution of produce to markets. Reference [96] reported long distances to markets and poor road infrastructure as significant barriers to market participation. Farmers working in remote locations were found to have low profit margins, as they have to bear the extra cost of transporting their produce to markets [97–100].

#### 4.1.3. Opportunities

It is anticipated that increased pig production in Swaziland could result in improved food and nutrition security. Indeed, the government of Swaziland together with its development agencies have played an important role in setting up small livestock projects aimed at reducing poverty, creating employment, and improving nutrition [34]. Findings form the survey revealed that smallholder farmers were women (63.75%), mostly married (66.25%) and probably charged with the responsibility of feeding their families. In African communities, women are traditionally unemployed; yet, they have the added responsibility of feeding their families [101]; therefore, their engagement in the industry would greatly improve the collective well-being of society [102,103].

The flexible feeding habits of pigs offers an opportunity to feed them alternative feed ingredients in order to reduce the cost of feed. Pigs can eat absolutely anything, ranging from chicken waste to agro-industrial by-products, converting them to valuable food products [10,12]. While farmers' associations are not common in Swaziland, smallholder farmers could exploit that opportunity to improve their production efficiency and capacity [13]. Consequently, this could facilitate product value addition, future expansion, and improved production capacity, as well as access to regional and international markets. Several studies have indicated that the formation of farmers' associations has enabled smallholder farmers to expand their scale of operations, and has further enhanced their market share [86–88,98,104].

#### 4.1.4. Threats

To meet the food demands of the population growing at 2.5% in Swaziland [89], there is an urgent need for smallholder farmers to intensify their production systems. However, it seems that food supply systems are intertwined with socio-environmental impacts. In the present study, the swine industry was found to be threatened by emissions from pig manure, which create pressure on the environment, putting human health at risk. Improper manure handling and disposal from pig farms results in water, air, and soil pollution [21,40]. Furthermore, emissions in the form of dusts, nitrous gases, and bad odour from the pig farms have been held responsible for increased incidences of human respiratory problems to those living nearby [21,40,105].

In expanding pig production, we foresee an increased threat of climate change and global warming. This is because pigs are the second contributor to greenhouse gas emissions in the livestock sector [48], and emissions are mainly from feed and housing systems [40,48–50]. It is an unhidden truth that increased pig numbers will hasten the accumulation of greenhouse gases, thus threatening the sustainability of food production systems. Therefore, efforts should be made to preserve the quality of the environment and the promote the sustainable use of resources.

Furthermore, the expected increase in the supply of pork emanating from increased production capacity could alter the competitive climate. This implies a decrease in demand for pork, low market prices, and hence, diminished profitability of the industry. In Vietnam, smallholder farmers' market participation was reported to be low due to failure to compete with giant foreign investors [88]. The findings further revealed that changes in consumer preferences will continue to threaten the swine industry, as nowadays people are more concerned about their health, opting for meat with low fat content [106–110].

Finally, the emerging Muslim religion threatens the swine industry. Swaziland is known as a Christian country, and the consumption of pork has never been regarded as a taboo. However, since

the endorsement of the new bill that allowed freedom of every religion [111], the number of Muslims has grown. The bulging Muslim demographic is a threat to the swine industry, as consumption of pork is condemned in their religion.

For this study, understanding how the internal processes (strengths and weakness) interact with each other, and their subsequent influence on swine production, has provided us with much needed information to formulate possible responses towards the changing market environment. For sustained swine production performance, it is very important that we strike a good balance in terms of integrating opportunities that are associated with technology and creativity, while responding to threats. Therefore, the following section presents and discusses results from the AHP analysis.

### *4.2. The Analytical Hierarchy Process of the SWOT Factors*

The previous section provided us with a pool of SWOT factors that could be used to formulate our action plans; unfortunately, they are qualitative, and they lack the quantitative aspect (magnitude) upon which we can base or justify our choices. Consequently, SWOT factors in Figure 3 were chosen in the analytical hierarchy process (AHP) to establish priorities according their significant importance (weighting). The AHP output enables each of the SWOT factors to be prioritized according to the magnitude it carries. Factors that carry more weight are more important in maintaining or improving pig production performance than the lower ones [22,63,69,73]. In our context, factors with higher weightings means they offer more economically stable courses of action in our strategy formulation; thus, they should be given priority over the lower ranking factors.

Table 2 shows calculations from the AHP model, demonstrating strengths of SWOT groups and their factors. The analysis revealed that, currently, the pig industry is safe and is serving as an enabling environment. This is explained by the fact that the positive internal factors (strengths, 0.279) out-weigh the external negative ones (weaknesses, 0.104). The findings imply that as things stand, the market environment is not yet competitive, but is attractive and profitable to smallholder farmers. The overall weighting of positive internal factors further explains the current state of the swine industry. The currently-available market (0.124) and high market demand suggest that farmers are still selling their produce in a profitable manner. It is also worth mentioning that farmers background profiles have a positive impact their production performance; they are young and promises to grow, accumulating the much-needed experience to adapt to future challenges within the industry (0.086). However, if farmers need to remain competitive in the industry, there is an urgent need to work on their feeds and feeding, as their profit margins seem to be threatened by the high costs of feed (0.052).

Insecurity about the future prospects of the swine industry may cause hesitation among farmers, and this will, in turn, affect their production performance. Farmers might be troubled by unanswered questions about the sustainability and profitability of the industry, future production capacity, along with available opportunities and threats. When projecting the future of the swine industry, the study analyzed the external environment; the major finding was that positive factors (opportunities 0.567) were found to outweigh the negative ones (threats 0.050). These findings suggest a potential for growth; hence farmers should be motivated to remain within the swine industry.

Because pigs can literally eat anything, it means that there is an opportunity to reduce the cost of feed by using alternative feed resources (0.197). Interestingly, this opportunity promises to provide the much-needed counter response to the most threatening weakness (high costs of feed, 0.05). The potential use of locally-available feed resources, ranging from kitchen waste, agro-industrial waste, and agricultural by-products, offers a cheap and sustainable pig production strategy, thereby increasing the profit margin.

Another opportunity that could be exploited is the available pig manure. The strategic use of manure (0.147) offers both economic and environmental stability. However, even though the analysis revealed some socio-environmental related threats, their magnitude was low, and it seems that they can be easily taken care of during strategy formulation. Finally, it is worth noting that increasing competition and diminishing profitability (0.019) was the factor that was deemed to be the most

threatening to farmers' profit margins in the swine industry. The following section (future outlook) discusses how the AHP output was used to formulate market and environmentally resilient strategies to be adopted by smallholder pig farmers faced with climate change.

**Table 2.** Priorities of comparisons of the SWOT groups and SWOT factors carried out by the project consultant (swine expert).

| Criteria (SWOT Group) | Priority of the Group | Sub-Criteria SWOT Factors | Priority of the Factor within the Group | Overall Priority of the Factor |
|---|---|---|---|---|
| Strengths | 0.279 | - Capacity to adapt and grow within the swine industry | 0.306 | 0.086 |
| | | - Good government support structure | 0.094 | 0.026 |
| | | - Availability of market | 0.446 * | 0.124 |
| | | - Availability of labour | 0.154 | 0.043 |
| Weaknesses | 0.104 | - High costs of feed | 0.499 * | 0.052 |
| | | - Lack of collaboration by smallholder farmers | 0.166 | 0.017 |
| | | - Land tenure system | 0.242 | 0.025 |
| | | - Remote location of pig farms | 0.093 | 0.010 |
| Opportunities | 0.567 | - Increased nutrition and food security | 0.044 | 0.025 |
| | | - Potential use of alternative feed resources | 0.348 * | 0.197 |
| | | - Employment opportunities | 0.077 | 0.044 |
| | | - Pork processing and value addition | 0.113 | 0.064 |
| | | - Formation of farmer's associations | 0.158 | 0.090 |
| | | - Strategic use of pig manure | 0.260 | 0.147 |
| Threats | 0.050 | - Environmental threat from improper manure handling and disposal | 0.09 | 0.005 |
| | | - Emissions threatens human health | 0.147 | 0.007 |
| | | - Greenhouse gas emissions contributes to global climate change | 0.179 | 0.009 |
| | | - Increasing competition and diminishing profitability | 0.380 * | 0.019 |
| | | - Changes in consumer preferences | 0.169 | 0.008 |
| | | - Emerging Muslim society | 0.036 | 0.002 |

Overall priority of the factor is computed by multiplying the priority of the factor within the group by the priority of the group; * Indicates the greatest weighing factor in each SWOT group.

### *4.3. Future Outlook*

Recent studies on food sustainability revealed that there is an urgent need for interdisciplinary research efforts in agriculture, life and environmental sciences, economics, and social and sustainability sciences, to improve our understanding of food security and climate change [52,112,113]. It is therefore on this basis that our study intertwined the business ideas of porter's framework [28] along with SWOT-AHP output to formulate market and climate change resilient strategies that can be implemented to ensure that smallholder farmers remain economically sustainable within the swine industry.

Recognizing that competitiveness and productivity are very important aspects of successful production, our study adopted Porter's approach [28]. That is, in order to survive a competitive environment such as that which exists in the swine industry, [28] suggested the adoption of a cost leadership strategy. The strategy focuses on increasing profit by reducing the operational costs and charging lower prices. To achieve this goal, [28] came up with three supporting strategies: innovation and the need to be creative, investing in new technology and having efficient logistics that enable

growth of the industry, and finally, beating completion on costs through alliance, whereby, the industry competes through formalized relationships with other businesses.

Our first task was to react with force to the major weakness. With high costs of feed (0.052) as our major weakness, our key resilience strategy is focused on reducing the costs of feed by exploiting the flexible feeding nature of the pig. Consequently, our strategy was to feed pigs cheap and locally-available alternative feed resources (0.197) instead of expensive, conventional feed. Keeping in mind that the basic concentrate feed for swine is grain based, either with soymeal or fish meal as major sources of protein, our strategy was to replace the most expensive energy and protein sources in the ration with cheap and locally-available feed resources. With grain as a major feed ingredient, feed prices will remain high, especially following the global price hike for grain due the combined competition for grain by humans, livestock, and recently for their use in biofuels [114,115]. Based on recent literature, the high prices for grain are not the only reason we should seek alternative energy sources; we must also consider the impact to the environment. Inventoried analyses revealed that grain production from cultivation, because of the use of agro-chemical processing and subsequent transportation, scales up greenhouse emissions, thereby contributing to global climate change [42].

Many studies have indicated that the strategic use of locally-available feed resources such as agro-industrial byproducts significantly reduces the amount of purchased feed, and has been found to be the most feasible profitable feeding solution for most farm animals [79,116–119]. Moreover, it comes with environmental benefits [120]. To reduce the cost of production, our strategy is to feed our pigs a diet of locally-available energy sources that have the potential to meet the required energy levels of the pigs without compromising their growth performance and meat quality. Interestingly, we have a plentiful supply of cheap, locally-available feed ingredients ranging from kitchen waste to agro-industrial by products. These include lard, tallow, bagasse, rice husks, wheat husks, silage, oil form various oil plant, distilled dried grain solubles (DDGSs), homing chops, bakery by-products, and vegetable by products [117,119].

Sorghum offers another appealing alternative energy resource that could be used as a basic feed ingredient instead of maize, as far as nutrition and sustainability are concerned. In light of erratic rainfall due to climate change, we can grow sorghum as a replacement for maize (corn), since sorghum is drought tolerant. This innovative idea blends very well with the recently-developed perennial sorghum germplasm [121]. This strategy is encouraging, as perennial sorghum offers several harvests per year without having to replant; therefore, it has the potential to prevent and reverse soil degradation [122].

In replacing expensive protein sources such as soymeal and fish meal, our strategy used agro-industrial by-products such as blood meal, meat meal, hoof meal, bone meal, and feather meal from poultry and beef processing [15,116,117,119]. In an environmental context, it is interesting to note that the proposed alternative feed ingredients seem to be environmentally friendly, as we use organic protein sources; thus supplies of N compounds in the diet are in low concentrations. It is worth mentioning that there have been ongoing calls to decrease the protein content in swine diets by optimizing essential amino acids to reduce the amount of N compounds released into the atmosphere [123]. Other proposed alternative feed ingredients in our strategy included salts, bone and hoof meal, phosphate & calcite rocks, and ash from burning wood as potential sources of vitamins and minerals. Citrus peels, citrus pulp, and silage can also be fed to pigs as sources of organic acids to improve gastric health, since antibiotics prove to be too costly for smallholder farmers.

While a potential increase in pig numbers presents manure handling and disposal challenges, there seems to be growing concern about the increased risk of water, air, and soil pollution. Swine intensification has been criticized in several studies, mainly for the inappropriate handling and disposal of pig manure and its implications for the environment [21,40,42,95]. Consequently, the present study revealed mild concern about environmental pressure related to manure accumulation (0.005) and risks to human health (0.007). However, the most threatening factor was the fear that increased manure could hasten greenhouse gas emissions, thus worsening the situation of global climate change (0.009).

Manure has been reported to be the second greatest contributor to greenhouse gases, along with feed in the pig production industry [2,40].

However, in anticipation of that predicament, our strategy was to take advantage of an otherwise unfortunate situation by optimizing the use of manure to increase profits. The strategic application of manure to soil will ensure that major plant nutrients such as nitrogen and phosphorus are recycled for crop production. This benefits the farmer, as it reduces the cost of buying fertilizer. Pig manure contain more phosphorus, even though phosphorus is considered to be an element with limited global depositions [124]; therefore, its recycling ensures phosphorus sustainability. Empirical findings reported a high risk of (i) nitrogen pollution from manure in some parts of Europe and United States [21], and (ii) accumulation of heavy metals such as copper (Cu) and zinc (Zn) in some parts of China and southern part of Brazil [95]. However, this has not been reported in Swaziland, perhaps due to low production capacities.

Finally, to prepare smallholder farmers for the upcoming volatile market environment which is characterized by increasing competition and diminishing profitability, our strategy was to foster the formation of farmers' associations. We aimed to reduce costs through alliance, and our analysis pointed to the formation of farmers' associations. This strategy is based on obtaining huge discounts to reduce the costs of production, break financial barriers by securing loans for new technology and future expansion, gain the power required to control markets, and the ability to sell products at relatively low prices without being cash strained [13].

The findings are in agreement with the recommendations and suggestions made by a team of visiting swine experts from Taiwan who were evaluating the ongoing "Pig Industry Enhancement Project". They recommended that the government should encourage collaboration amongst smallholder farmers, as this could strengthen links between markets and smallholder farmers. They were cognizant of the fact that pig farms were located in remote areas, with poor infrastructural development in terms of roads, poor storage facilities, and non-functional abattoirs. These factors are obviously hindrances to the distribution of farm produce. Therefore, the formation of farmers' unions could provide a platform to remove these barriers to trade. It was found that mobile abattoirs could be very handy, as they could move from farm to farm. This could be a giant step toward regional trade, as it would strip off trade barriers, such as the absence of inspection, the presence of functional abattoirs, and distances to markets for regional and international trade. The formation of farmers' associations could further facilitate processing and product value addition. In Swaziland, pork processing and value addition is very limited; this is explained by the increasing importation of processed pork, which rose from 75.75 to 237.40 and 232.24 tonnes in 2014, 2015, and 2016 respectively [31]. This suggests that there is huge potential for farmers to increase their market share through pork processing and value addition, as suggested by [13].

Overall, the formulated market and climate resilient strategies were found to be more profit-based than considerate of the environmental issues. This is explained by the low course of action in dealing with social and environmental threats associated with the expansion of the pig industry. However, this could explain the fact that, currently, domestic production for pork is still low for farmers who may be considering investing. However, the response shown by farmers' regarding social and environmental investments is captured by previous empirical findings, where they cited the additional costs incurred on environmental activities as being draining the firm's profit, and further eroding the firm's competitive advantage [59,125,126]. It is interesting to recognize how strategy formulation has dealt with issues of high feed prices and manure. However, there seems to be some aspects that can be attributed to the environment and social well-being.

## 5. Conclusions

The purpose of this study was to explore potential strategies that could be adopted by smallholder farmers to foster resilience to both markets and climate change. This was done by assessing the impact

of the "Pig Industry Enhancement Project" on the socio-environment, and the economic stability of smallholder farmers, specifically in terms of profitability, productivity, and market participation.

With regard to the social well-being, our empirical findings revealed that pigs are important contributors for both food and financial security for the rural poor. Therefore, for sustainability, there is a need to conduct continuous assessment of the environment in which the swine industry is operating for immediate risk detection and rapid response formulation. While concerns have been raised about pig intensification and the socio-environment, based on the results of this study, one can consider that, currently, the swine industry in Swaziland is well placed regarding environmental and social issues considering the nation's relatively low production capacity, along with manure recycling.

By performing SWOT analyses, we assessed the current production and market environments, along with future scenarios linked to both to the projected increase in production capacity and intensified market conditions. It can be concluded that the swine industry is currently attractive and profitable due to low domestic production and growing demand. However, the market environment is still yet to be very competitive, and remains volatile due to the anticipated increase in the domestic supply for pork. The supply of pork will continue to increase, especially in an era of recurring droughts, where cattle farmers are shifting to pig production, and smallholder farmers are effecting significant expansions to their enterprises (benefiting from the governments support structure), while imports are surging. This will consequently increase competition and rivalry among farmers, making the pig industry less attractive and less profitable.

Given uncertainties in relation to future market conditions and increased production capacity, one important question is: how can smallholder farmers survive future market competition faced with global climate change? One obvious way is to reduce production costs, as suggested by Porter's cost leadership strategy [26–28]. This called for creativity and innovation in identifying and reacting to key weaknesses and threats, while maximizing strengths and opportunities.

We found that the measurable SWOT-AHP output enabled us to successfully develop potential production strategies that can be adopted by smallholder farmers to increase resilience to both market and climate change. The findings revealed that increasing competition, and high feed costs, manure handling and disposal challenges threaten the future of the swine industry in Swaziland. Accordingly, our mitigation strategy focused on increasing profit margins by reducing the cost of production and charging low prices for pork in order to survive market competition. We found that flexibility in the feeding nature of the pig enabled replacement of expensive concentrated feed with cheap, locally-available feed resources in the form of agro-industrial by-products.

Finally, the findings revealed that smallholder farmers could beat market competition through the establishment of formalized relationships with other business enterprises. Such innovative alliances encourage the formation of farmers' associations which foster close cooperation, collaboration, and trust between producers, financial institutions, and markets. This will to create a more stable environment within the swine industry, improving economic stability among farmers, productivity and efficiency, encouraging product value addition, access to market information, and establishing a stable supply chain with stable markets. Conclusively, in this study, we found that flexibility of the feeding nature of the pig has huge potential in terms of strategically developing feed management strategies that are resilient to climate change.

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