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SMALL-SCALE FARMERS' PARTICIPATION IN AGRO-PROCESSING ACTIVITIES AND EFFECTS ON HOUSEHOLD FOOD SECURITY IN GAUTENG PROVINCE, SOUTH AFRICA

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ABSTRACT

Agro-processing is widely regarded as a pathway to improve farmers' household food security through value addition, income diversification, and increased food preservation. The level of household food security remains low even after the government interventions in Gauteng Province. Small-scale farmers encounter several challenges, including poor infrastructure and limited access to markets and credit, which hamper their participation in agro-processing activities. This raises the question of whether agro-processing effectively contributes to household food security outcomes. Various studies have analysed agro-processing participation in Gauteng province; however, the effect of this participation on household food security remains inadequately quantified. Therefore, the current study analysed participation in agro-processing activities and evaluated its effect on household food security among small-scale farmers in Gauteng Province. The study was conducted in the three metropolitan municipalities and two district municipalities of Gauteng Province. An online survey was used to collect data from 115 farmers using a structured questionnaire. The participants were selected using simple random sampling. Using Stata/SE 15.0, binary logistic regression, Inverse Probability Weighted Regression Adjustment (IPWRA) and Propensity Score Matching (PSM) were employed to analyse the data. The results revealed that 31% of small-scale farmers participate in agro-processing activities, and about 36% of them are food secure. Logistic results revealed that education level, financial support, off-cropping season, and crop diversification enhanced farmers' participation in agro-processing activities, whereas extreme weather events, such as snow, adversely affected it. The PSM results showed that the effects of agro-processing on household food security are robust. Moreover, the IPWRA and logistic regression results showed that participation in agro-processing activities positively affected household food security. The study recommends continued financial support, investment in farmers' education and training, as well as climate-resilient infrastructure to improve farmers 'participation in agro-processing activities. Enhancing participation in agro-processing activities could thereby improve household income, purchasing power, and dietary intake, resulting in improved levels of food security, taking into account food availability, utilisation, and accessibility.

Key words: Agro-processing, Household food insecurity, Inverse probability weighted regression adjustment

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INTRODUCTION

Food insecurity has been a problem worldwide since most household's experience challenges in accessing nutritious, safe and affordable food. According to the publications by the State of Food Security and Nutrition worldwide in 2024, 29% of the worldwide population suffers from moderate to severe food insecurity, highlighting the lack of access to consistent, adequate food [1]. Statistics South Africa (StatsSA) reported that in 2023, roughly 20%, which is about 4 million households, faced moderate to severe food insecurity, while approximately 8%, which is roughly 1.5 million households, faced severe food insecurity in South Africa [2].

In South Africa, households continue to face food insecurity challenges, despite the country being food secure at the national level [3]. Even during harvest, households still experience food shortages. This indicates that food availability does not imply food and nutrition security. Food may be available but not accessible to households and may also lack the nutrients required for growth and development [3]. The FAO indicated that "food security exists when all people, at all times, have physical, social, and economic access to sufficient, safe, and nutritious food that meets the daily needs and preferences for an active and healthy life" [4]. The World Food Summit emphasised that food security can exist when four dimensions, namely, food availability, accessibility, utilisation, and stability of both availability and accessibility, are met [4]. The South African government has recognised agro-processing as a strategic tool, with a set of industries contributing to economic growth, job creation, and food security.

The agro-processing sector is classified as the second-largest manufacturing sector, after the automotive industry, in terms of gross value added (GVA) in South Africa. It produces about 18% of the manufacturing output per annum [5]. Agro-processing involves the change of agricultural products using techno-economic activities to expand their shelf lifespan [6]. It is characterised by the division of manufacturing sectors, including beverages, tobacco, food, textiles, and wood products. The activities involved in agro-processing include value chain actions that are economic, nutritional, and technological, through which raw primary agricultural products undergo processes to change their form. Small-scale farmers in Gauteng Province usually engage in low-cost value-addition activities that require simple technology and minimal capital investment. These usually incorporate secondary agro-processing (such as on-farm processing and value addition) activities such as sorting, cleaning, grinding, slicing, packaging, and labelling of agricultural products [7]. These operations are market-oriented, enabling small-scale farmers to increase the shelf life of their products, improve and diversify farm income, and reduce post-harvest product waste.

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In South Africa, agro-processing was emphasised in several documents, such as the NDP [8] and NGP [9], and by various government entities as a strategic tool towards industrialisation [10]. It was also identified by the President of South Africa in 2019 and the National Treasury as the potential strategy to revive the economy and transform low-skilled labour and small businesses [11, 12]. According to Woldemichael *et al.* [13], agro-processing has the potential to enhance food security and reduce poverty at the household level. Studies such as Khoza *et al.* [14] and Mthombeni *et al.* [15] further showed that agro-processing is widely regarded as a pathway to improve farmers' incomes, increase market participation, and promote household food availability. Newfarmer *et al.* [16] indicated that food security could be increased through reduced food spoilage and waste, as well as higher prices for agro-processed foods. This implies that the contribution of agro-processing to household food security is not only direct, through increased food availability and utilisation, but also indirect, through improved food accessibility.

The Tshwane Economic Development Agency (TEDA) [5] highlighted the need to expand agro-processing in South Africa and the City of Tshwane, as only 30% of output enters the agro-processing sector. Furthermore, it indicated the need for research and development in agro-processing by research institutes in Gauteng Province. In response to this, several studies were conducted to investigate the level of agro-processing participation by small-scale farmers in Gauteng Province. According to the Industrial Development Corporation (IDC) [17], agro-processing has been neglected as a powerful tool for transforming small-scale farmers into commercial producers, improving income distribution, and thereby enhancing food security. There are numerous barriers to entry in agro-processing faced by small-scale farmers in Gauteng and other provinces of South Africa. Inter alia, the barriers include poor and inadequate on- and off-farm infrastructure, the inability of farmers to comply with mandatory food manufacturing standards, insufficient financial support specific to agribusiness, and, most importantly, inadequate support in agro-processing research and development [18].

Different studies were conducted on agro-processing participation [7, 14, 19]. Moreover, the food security concept was quantified by numerous studies, including Simelane *et al.* [20] and Modibedi *et al.* [21], specifically in Gauteng Province. However, the level of households' food security and participation in agro-processing remains low. Khoza *et al.* [14] and Thindisa *et al.* [7] reported that less than 50% of small-scale farmers in Gauteng Province participate in agro-processing, while only 49% of households in the same province are food secure [20]. There is a shortage of literature investigating the influence of agro-processing activities on food security among small-scale farmers. Therefore, following the agro-processing participation and food security literature, this study intends to analyse participation in agro-

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processing activities and evaluate its effect on household food security among small-scale farmers in Gauteng Province.

MATERIALS AND METHODS

Study area

The study took place in Gauteng Province, as displayed in Figure 1. Gauteng Province is categorised into three metropolitan municipalities, namely, the City of Ekurhuleni, City of Johannesburg and City of Tshwane Metropolitan Municipalities and two district municipalities, namely, West Rand and Sedibeng. The study area will be in all metropolitan municipalities and districts.

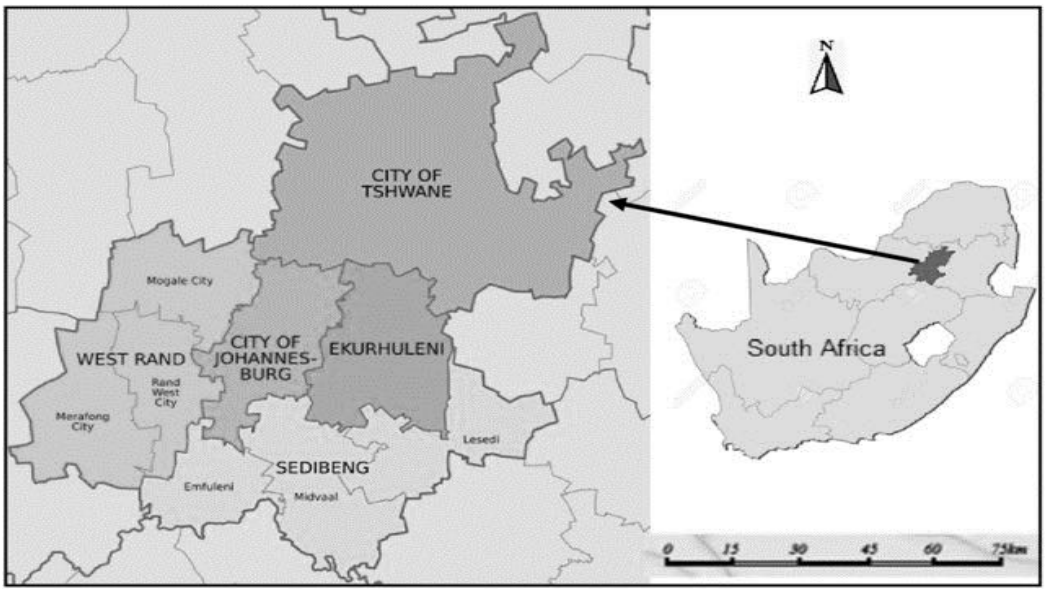

Figure 1: Map of Gauteng Province showing metropolitan municipalities and districts

Source: Nhamo *et al.* [22]

Gauteng Province serves as an economic engine of South Africa. It contributes about 34.8% of South Africa's gross domestic product (GDP). The province is home to many commercial and industrial businesses. Among others, agro-processing is one of the many businesses contributing to GDP in Gauteng province [23]. The study was conducted in this province because it is regarded as the centre of agro-processing in South Africa, since it is close to the large markets and neighborhood exports market [5].

Sampling and data collection

The population of the study was unknown, and therefore, the sample size was calculated using the following formula [24].

$n = z^2(p)(1-p)/ c^2$

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Where:

z = standard normal deviation set at 95% confidence level.
p = percentage picking a choice or response is 50% = 0.5.
c = confidence interval is 0.05 = ±5.
Therefore, $n = (1.96)^2(0.5)\ (1-0.5) / (0.05)^2$
= 384.16 (therefore 384 was the estimated sample size).

The initial estimated sample size was 384. However, the small-scale farmers did not participate as expected due to non-response and unavailability; hence, the sample was reduced to 115. Even though the final sample size was smaller than the initial sample size proposed by Cochran, which limits statistical power and broad representativeness, the small sample remains adequate for the inferential and exploratory goals of the study. It produces reliable, significant findings, particularly when examining populations that are difficult to reach or those with limited resources. Different studies argue that rigorous adherence to traditional sample size thresholds might not always be required; strong evidence can still be obtained through careful interpretation, confidence intervals, and effect estimates [25, 26]. The permission to interview the farmers was granted by the Gauteng Department of Agriculture and Rural Development (GDARD). Data were collected through an online survey using a structured questionnaire from March to April 2025. The personal information, such as surnames, names, ID numbers, and contact details of the participants, was not collected in the questionnaire to comply with the Protection of Personal Information Act (POPIA). The participants' answers were anonymous and confidential.

Conceptual framework

This study is grounded in two theories, namely the sustainable livelihood framework and the agricultural value chain theory, to examine the relationship between agro-processing activities and household food security. According to sustainable livelihood theory, households can combine their available assets and livelihood methods to attain the desired welfare outcomes [27]. The notion of agricultural value chain theory emphasises that market integration and value addition enhance agricultural output and profit [28]. In this context, agro-processing is viewed as an important livelihood strategy that improves household food security through interconnected pathways. Farmers engaged in agro-processing can add value to their primary agricultural products, thereby improving their farm income and access to profitable markets. Greater market access minimises price volatility and stabilises food availability. Improved income will increase household purchasing power [29]. Additionally, agro-processing supports livelihood diversification by fostering the growth of non-farm businesses, thereby increasing resilience to climate and economic disruptions [30].

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However, the effectiveness of participation in agro-processing activities in enhancing household food security depends on socio-economic factors, asset possessions, and external factors. Farm-related variables, such as the number of employees, land underutilisation, farming experience, transport availability, livestock ownership, and the quantity of products harvested, facilitate agro-processing ventures and enhance household food security [7, 14, 31]. Demographic factors, including age, education level, source of income and household size of the farmer, as well as the institutional factors like government financial support and extension services, affect participation in agro-processing and the capacity of the households to convert economic benefits into improved food security outcomes [14, 19]. Therefore, in this study, participation in agro-processing activities is hypothesised to affect household food security through two pathways: direct and indirect. The direct relationship stems from household consumption of value-added agricultural products, thereby improving household dietary intake. An indirect relationship involves improving household food security by increasing income, enhancing market access, and diversifying livelihoods. Figure 2 presents a conceptual framework that illustrates the direct and indirect relationships between agro-processing activities and household food security.

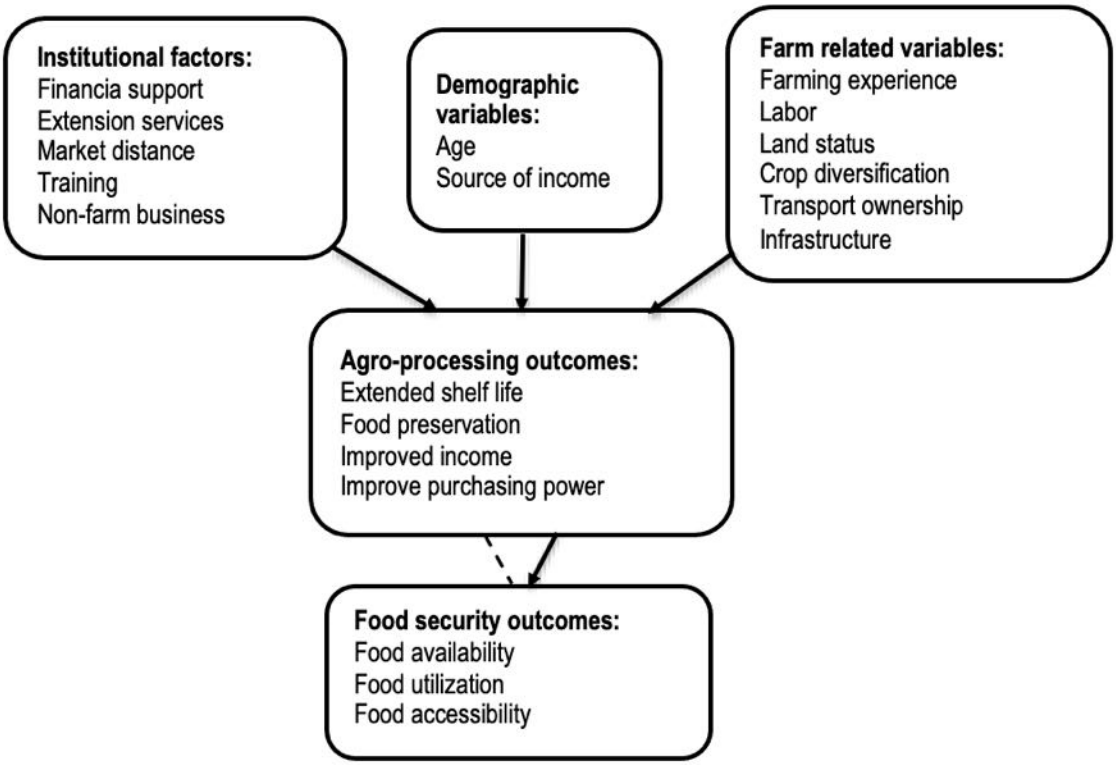

Figure 2: Agro-processing and food security conceptual framework

NB. The bold line represents the direct effect, and the dotted line represents the indirect effect

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Analytical framework

Household Food Insecurity Access Scale

The study used the Household Food Insecurity Access Scale (HFIAS) following the existing literature, Stats SA [2] and Kasongo [32] to measure household food security among small-scale farmers in Gauteng Province. Based on the HFIAS, household food security was assessed using eight standardised questions developed by the Food and Nutrition Technical Assistance Project [33]. The questions were eight (Table 1) and focused on eight items influenced by resource constraints. Farmers were asked to answer the questions based on 12 months recall. Every question answered by Yes was coded 1, and No was coded 0. The codes were added to calculate the HFIAS score. A score less than two is regarded as food secure, a score between two and five is regarded as food insecure, and a score between six and eight is regarded as severely food insecure [2]. To generate the binary dependent variable for this study, a score less than two is food secure, while scores between two and five, as well as scores between six and eight, are regarded as food insecure. Therefore, food security was measured as a binary variable, 1 if the farmer is food secure and 0 if the farmer is food insecure.

Binary logistic regression

The study used binary logistic regression, Inverse Probability Weighted Regression Adjustment (IPWRA) and Propensity Score Matching (PSM) models to achieve the study objective. Binary logistic regression was used to identify factors affecting farmers' participation in agro-processing activities and to evaluate the effect of participation on household food security. The farmers were asked whether they participated in agro-processing activities. The question was then followed by the products they process. These involved participation in on-farm processing and value addition of some products. In contrast to multivariate probit regression, which is appropriate for simultaneously modelling numerous dependent variables, binary logistic regression was chosen because each outcome variable was regressed individually and quantified as a binary variable. Moreover, the logistic model does not necessitate the assumptions of homoscedasticity and normality linked to the Ordinary Least Squares model, which makes it suitable for cross-sectional data [34]. Participation in agro-processing activities was coded as 1 if the farmer participated, 0 if they did not, while household food security was coded as 1 if food secure, 0 if food insecure. The binary logistic model is mathematically expressed as [35].

$$\text{Logit}(\beta) = \alpha + \delta_1 ¥_1 + \delta_2 ¥_2 + \delta_3 ¥_3 + \delta_4 ¥_4 \ldots\ldots\ldots\ldots \delta_k ¥_k + \mu_i \quad \text{Equation (1)}$$

α is the term of interception
δ is the coefficient of regression
¥ is the different independent variables used in the model
μ_i is the error term.

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When using binary logistic regression, the dependent variable is coded as 1 and 0. It is assumed that these set variables predict that the probability is X = 1.

The formula for X = 1 was derived from the regression equation.

$P(X=1) = \frac{1}{1} + \exp [- \alpha(\alpha + \delta_1¥_1 + \delta_2¥_2 + \delta_3¥_3 + \delta_4¥_4)]$ Equation (2)

The function above is known as the logistic distribution function, and it can be estimated by the maximum likelihood method. This function ensures that the probability ranges between 0 and 1. Logistic estimates produce positive and negative infinite values called log odds [35]. Log odds are expressed as below. Table 1 outlines the dependent and independent variables used in the study.

$Logit\ [P(X=1)] = \alpha + \delta_1¥_1 + \delta_2¥_2 + \delta_3¥_3 + \delta_4¥_4$ Equation (3)

$Logit\ [P(X=1)]\ loge\ [\frac{P(X=1)}{1} - P(X=1)]$

Therefore

$\ln [\frac{p}{1-p}] = \alpha + \sum diyi$

The final version of the model will be expressed as

$\ln [\frac{p}{1-p}] = \alpha + \delta_1x_1 + \delta_2x_2 + \delta_3x_3 + \delta_4x_4 \ldots\ldots\ldots\ldots \delta_kx_k + \mu_i$ Equation (4)

In addition, the study employed PSM and IPWRA to mitigate endogeneity and self-selection bias in agro-processing participation. Thus, PSM was used to create a counterfactual cohort of non-participating farmers with similar observable traits, thereby mitigating selection bias [36]. Since PSM depends exclusively on observable variables, IPWRA was also used to obtain double-robust estimates [37] and to assess the actual effect of agro-processing on household food security. According to Rubin [38], and Rosenbaum and Rubin [36], PSM and IPWRA are mathematically expressed as follows:

PSM is expressed as $Y\ (V_i = 1|X_i) = \text{logistic}\ (X_i\beta)$ Equation (5)

V_i equals 1 if the farmers participate in agro-processing and 0 if they do not, and X_i are the covariates of the independent variables.

Impact estimation is expressed as:

$ATT = U\ [X\ (1) – X(0)\ |\ B=1]$

$ATT = U\ [X_i|B_i = 1, p(Y_i) - U[X_j|B_j = 0, p(Y_j)]$ Equation (6)

Where Xi signifies household food security outcomes.
IPWRA is mathematically expressed as below.

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The treatment model is like PSM. Whereas the outcome model is expressed as:
For participants U $[X_i|B_i = 1, Y_i] = Y_i \beta_1$
For non-participants U $[X_i|B_i = 0, Y_i] = Y_i\beta_0$

Therefore, the treatment effect is expressed as

$$ATE/ATT = U [X_i(1) – X_i (0)] \quad \text{Equation (7)}$$

Equation seven represents the average effect of agro-processing on household food security among small-scale farmers. $X_i(1)$ signifies food security outcomes if farmers participate in agro-processing, and Xi (0) signifies food security outcomes if farmers do not participate in the agro-processing. Table two presents the description and summary statistics of the variables used in the current study.

RESULTS AND DISCUSSION

Participation in agro-processing activities and food security status among small-scale farmers in Gauteng

Table three presents the status of participation in agro-processing activities and food security among the small-scale farmers in Gauteng Province. The results revealed that only 31% of small-scale farmers in Gauteng are involved in processing primary agricultural products, whereas the majority (69%) are not. Similarly, Khoza *et al.* [14] reported that only 19% of farmers in Gauteng participate in agro-processing. The results further showed that approximately 36% of participants and 41% of non-participants were food-secure, while around 64% of participants and 59% of non-participants were food-insecure. Corresponding findings were reported by Modibedi *et al.* [21] reported that the majority of small-scale farmers in Gauteng Province are mildly food insecure.

Categories of agro-processing activities performed by small-scale farmers in Gauteng

Table four presents the categories of agro-processing activities performed by the small-scale farmers in Gauteng Province. The results showed that the majority of farmers (28%) were engaged in the processing of spices and condiments. The processed products included chillies, chilli sauces, salt, and herbal spices. This category is followed by beverage processing operated by 22% farmers. The examples of the products processed included beetroot and carrot juice, moringa juice and potato coffee. The results further showed that 11% of farmers practised apiculture and produced processed honey. About 14% of farmers were engaged in vegetable and animal by-product processing, including atchar, vegetable packaging, and packaging and branding of eggs, meat, and milk. Lastly, less than 10% of farmers were involved in fruit and grain processing.

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Participation in agro-processing activities and household food security among small-scale farmers in Gauteng: Binary Logistic regression results

Table 5 presents the results of a binary logistic regression on the determinants of participation in agro-processing activities and household food security. Before estimating the determinants of participation in agro-processing activities, multicollinearity and goodness-of-fit tests were conducted because they are relevant in cross-sectional studies. Variance inflation factor results for multicollinearity indicated a mean VIF of 1.45, suggesting no multicollinearity among the independent variables [39]. Similarly, the Hosmer-Lemeshow test yielded a p-value of 0.779, indicating that the model fit the data well. Additionally, Prob > chi^2 results were significant at the 5% level, indicating the strongest relationship between participation in agro-processing activities, household food security and the independent variables.

The determinants of participation in agro-processing activities among the small-scale farmers

The results showed that education level (EDUCLEV) increased the probability of participating in agro-processing activities by 33%, indicating that farmers with tertiary education are more likely to participate. This might be attributed to the idea that educated farmers have the necessary agricultural knowledge and skills, understand market demands well, and have accumulated the resources for agro-processing activities. Over time, farmers learn to avoid post-harvest losses through value addition activities. This result is in line with the findings by Thindisa *et al.* [7], who indicated that human capital, such as education, positively influenced agro-processing participation. The small-scale farmers who received financial support from the government (FINSUPPT) had an 70% higher probability of participating in agro-processing activities. The results are grounded on the assumption that public support promotes value-added activities. Government support serves as a stimulus to agro-processing expansion, enabling small-scale farmers to transition from primary agriculture to value-added ventures. This will enhance food security, job creation, and farmers' competitiveness in South Africa. In line with the findings, the South African government supported agro-processing through the Agro-Processing Support Scheme (APSS) to increase participation by small-scale farmers [40].

The results showed that extreme weather events, such as SNOW, decreased the likelihood of participating in agro-processing activities by 31%. The results imply that small-scale farmers who experienced snow during the previous production period were less likely to participate. The findings suggest that the lack of participation may be due to this weather event destroying production, thereby decreasing the quantity and quality of agricultural output. Consequently, farmers have nothing to process or add value to. The latter contradicts Christian et al. [31] findings, which indicated that

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an increased quantity of produce harvested positively correlates with participation in processing.

Climate adaptation strategies, such as off-cropping (OFFCROPI) seasons and crop diversification (CROPDIVI), were statistically associated with participation in agro-processing activities among small-scale farmers. Small-scale farmers who adopted off-cropping had a 56% chance of participating in agro-processing activities. The assumption, based on the finding, is that during the off-season, the supply of some agricultural products is limited, thereby increasing farm prices for the available products. Farmers are often assumed to take advantage of these supply shortages and price increases by participating in agro-processing activities. The study by Cedrez et al. [41] corroborated the idea that prices slightly increase during the off-season, thereby encouraging farmers to participate in agro-processing activities. Moreover, small-scale farmers who produced different types of crops had a 33% higher chance of participating in agro-processing activities. The finding is grounded in the idea that crop diversification increases the number of raw products to be processed, eliminates production risks and uncertainty, and creates multiple income sources. Therefore, farmers who diversify their crops are assumed to participate in agro-processing activities.

The effects of participation in agro-processing activities on household food security based on binary logistic, PSM and IPWRA results

Logistic results in Table 5 showed that participation in agro-processing activities (AGROPROC) positively influenced household food security at the 5% statistical significance level. The farmers who participated in agro-processing activities had 52% higher chances of being food secure. Additionally, Table 6 presents the treatment effects of participation in agro-processing activities on household food security among small-scale farmers using PSM and IPWRA. The PSM was used to address selection bias, while IPWRA was used to assess the actual effect of participation in agro-processing activities on household food security. These models were used by several studies to diminish selection bias and attain robust fundamental estimates [42, 43]. The consistency of the findings from both models confirms the reliability of the estimated effect of agro-processing on household food security.

The PSM results showed that participation in agro-processing activities has a robust effect on household food security, underscoring the significant role of agro-processing in this regard. In particular, the results showed that participation in agro-processing activities was positive and statistically significant at 1% level for all farmers, agro-processing participants, and their counterfactuals. Based on the IPWRA model, the ATE and ATT results indicated that participation in agro-processing activities increases the likelihood of being food-secure by 89.6% among

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all small-scale farmers in the study and by 92.1% among agro-processing participants. Additionally, if non-participants decide to participate, agro-processing activities would increase food security by 10%.

These results suggest that participation in agro-processing activities, both directly and indirectly, contributes to household food security. The results are supported by sustainable livelihood and agricultural value chain theories, which hold that agro-processing is not only a value-adding activity but also a vital livelihood diversification strategy that enhances household food security and improves market participation. By participating in agro-processing activities, small-scale farmers can extend the shelf life of primary agricultural products, preserve food, and reduce post-harvest waste by changing the products' form. This will directly contribute to households' food utilisation and availability, as well as to improved dietary intake. Additionally, farmers could have better access to the market, experience higher prices from the processed food, and more jobs could be generated from agro-processing activities in the community. Consequently, this will indirectly contribute to household food security through improved household income and purchasing power, which is the food accessibility or affordability pillar.

The current findings are in line with those of FAO [44], which indicated that agro-processing plays a vital role in improving households' livelihoods and food security by linking small-scale farmers to markets and reducing post-harvest losses. Rutta [45] indicated that to ensure food security among farmers, an increase in crop productivity should be aligned with efforts to prevent post-harvest food losses, which can be achieved through agro-processing. Lastly, the study by Wang *et al.* [46] found that participation by small-scale farmers in value-addition activities reduces poverty at the household level.

The results further showed that household food security is positively influenced by socio-economic factors, such as farmer association membership and land status, as well as by climate change adaptation strategies, namely off-cropping season and crop diversification. On the contrary, socio-economic variables, including education level and extreme weather events (for example, snow and floods), negatively influenced household food security among the small-scale farmers in the study.

CONCLUSION AND RECOMMENDATIONS FOR DEVELOPMENT

The study analysed participation in agro-processing activities and evaluated its effect on household food security among small-scale farmers in Gauteng Province. The results revealed that only 31% of small-scale farmers participate in agro-processing activities, and about 36% of them are food secure. Binary logistic results showed that socio-economic variables, such as education level, and institutional factors, such as government financial support, as well as climate change adaptation

strategies related variables, such as off-cropping and crop diversification, enhanced participation in agro-processing activities among small-scale farmers. Whereas extreme weather event-related variables, such as snow, negatively affected farmers' participation in agro-processing activities. Logistic and IPWRA results showed that agro-processing activities strongly and positively affected household food security. The participation contributed to households' food availability, food utilisation, and food accessibility.

Based on the findings, this study recommends that the government and agricultural-related institutions invest in farmers' education and training in agro-processing technologies, value addition, and food preservation. These parties could also promote on-farm processing and value addition among farmers involved in off-season cropping and diversification by providing processing machines and equipment, technical expertise to operate and handle them, and market linkages. Due to the adverse effects of snow on participation in agro-processing activities, the study recommends investing in climate-resilient infrastructure to mitigate weather interruptions. Enhancing participation in agro-processing activities could thereby improve household income, purchasing power, and dietary intake, resulting in improved levels of food security, taking into account food availability, utilisation, and accessibility.

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Table 1: household food insecurity access scale statement

Category	Statement
Worried	If households were worried that they would run out of food.
Heathy	If households were unable to consume healthy food.
Few food	A case where households ate little food.
Skipped	If households skipped a meal.
Ate less	A case where households ate less food.
Run out	If households ran out of food.
Hungry	A case where households were hungry with no food to eat.
Whole day	A case where households spent the whole day without eating.

Source: Stats SA, 2022

Table 2: Variable descriptions

Variables codes	Variables descriptions	Participants	Non-participants	All farmers
		Mean (Std err)	**Mean (Std err)**	**Mean (Std err)**
EDUCLEV	1 if the farmer has a tertiary qualification, 0 otherwise	0.666 (0.114)	0.552 (0.081)	0.538 (0.069)
FRMASSOC	1 if the farmer is a member of the farmer association, 0 otherwise	0.388 (0.118)	0.315 (0.076)	0.250 (0.060)
LIVESTOC	Livestock in numbers	2.055 (0.055)	2.052 (0.036)	2.038 (0.026)
LANDST	1 if the farmer owned the land, 0 otherwise	0.228 (0.072)	0.392 (0.055)	0.342 (0.044)

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TRANSAVA	1 if the farmer has transport, 0 otherwise	0.542 (0.085)	0.379 (0.054)	0.429 (0.046)
NFAMBIZ	1 if the farmer owned a non-farm business, 0 otherwise	0.111 (0.076)	0.291 (0.051)	0.271 (0.041)
FLOODS	1 if the farmers experienced floods, 0 otherwise	(0.500) (0.121)	0.605 (0.080)	0.673 (0.065)
SNOW	1 if the farmer experienced snow, 0 otherwise	0.277 (0.108)	0.263 (0.072)	0.288 (0.063)
FOG	1 if the farmer experienced fog, 0 otherwise	0.222 (0.100)	0.289 (0.074)	0.326 (0.065)
FINSUPPT	1 if the farmer received financial support, 0 otherwise	0.202 (0.045)	0.171 (0 .064)	0.192 (0.037)
INFRAST	1 if the farmer had processing infrastructure, 0 otherwise	0.485 (0.085)	0.594 (0 .055)	0.561 (0.046)
OFFCROPI	1 if the farmer adopted the off-cropping season, 0 otherwise	0.222 (0.100)	0.263 (0.072)	0.288 (0.063)
CROPDIVI	1 if the farmer produces more than one crop, 0 otherwise	0.714 (0.077)	0.632 (0.054)	0.657 (0.044)

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Table 3: Participation in agro-processing activities and food security status

	participation in agro-processing			
	Participants		Non-participant	
	Frequencies	Percentages	Frequencies	Percentages
Participation in agro-processing activities	36	31	79	69
Food secure	13	36.11	32	40.51
Food insecure	23	63.89	47	59.49

Table 4: Agro-processing activities performed by farmers

Agro-processing activities	Examples of processed products	Frequencies	Percentages
Spices and Condiments	Chillies, chilli sauce, salt and herbal spices	10	27.78
Beverage processing	Beetroot and carrot juice, moringa, potato and coffee	8	22.22
Vegetable processing	Atchar and vegetable packaging	5	13.89
Animal byproduct processing	Eggs, meat and milk packaging and branding	5	13.89
Apiculture	Honey	4	11.11
Fruit processing	Canned fruit and dried tomatoes	3	8.33
Grain processing	Millet and quinoa meal	1	2.78

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Table 5: Logistic results and marginal effects

	Agro-processing activities		Household food security	
Variables	**dy/dx**	**Std Err.**	**dy/dx**	**Std. Err.**
AGROPROC			0.523	0.254**
EDUCLEV	0.332	0.149**	-0.395	0.205**
FRMASSOC	0.270	0.249	0.282	0.142**
LIVESTOC	0.749	0.376	-0.388	0.464
LANDSTAT	-0.052	0.165	0.543	0.206***
TRANSAVA	-0.247	0.173	0.241	0.220
NFAMBIZ	-0.169	0.149	-0.324	0.136
FLOODS	0.136	0.161	-0.852	0.129***
SNOW	-0.309	0.125**	-0.726	0.191***
FOG	-0.066	0.177	-0.236	0.144
FINSUPPT	0.697	0.197***	-0.172	0.183
INFRASTR	-0.126	0.171	-0.134	0.171
OFFCROPI	0.560	0.229**	0.435	0.154***
CROPDIVI	0.329	0.192***	0.385	0.155**
	N = 115 LR chi^2(13) = 21.53 Prob > chi2 = 0.043 Log likelihood = -20.578 Pseudo R^2 = 0.3435 Hosmer-Lemeshow test = 0.779 Mean VIF = 1.45		N = 115 LR chi^2(14) = 26.51 Prob > chi^2 = 0.022 Log likelihood = -21.392 Pseudo R^2 = 0.382	

N.B * and ** means statistically significant at 1% and 5%

Table 6: Treatment effects using PSM and IPWRA

	All farmers		Participants		Non-participants	
	ATE		ATT		ATU	
	Coef.	**Std. Err.**	**Coef.**	**Std. Err.**	**Coef.**	**Std. Err.**
PSM	0.912	0.033***	0.972	0.039***	0.078	0.031***
IPWRA	0.896	0.031***	0.921	0.031***	0.103	0.031***

NB *** means statistically significant at 1%; ATT means Average Treatment Effects on participants; ATU means Average Treatment Effect on non-participants; and ATE mean Average Treatment Effect on all farmers

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