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## SOCIO-ECONOMIC CHALLENGES AFFECTING SMALL- SCALE MACADAMIA NUTS PRODUCING FARMERS IN MPUMALANGA LOWVELD REGION, SOUTH AFRICA

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## ABSTRACT

The purpose of the study was to investigate socio-economic challenges affecting small-scale macadamia producing farmers in the Mpumalanga Lowveld. In South Africa, the macadamia industry has shown substantial growth, especially in the Limpopo, Mpumalanga and KwaZulu-Natal provinces, respectively. However, Mpumalanga is by far the leading province in macadamia nut production. Contrastingly, the growth of the industry has not translated into the accelerated entry and participation of small-scale farmers in the sector. To understand the socio-economic challenges faced by these producers, a survey study was conducted between September and November 2020 within the Bushbuckridge Local Municipality (BLM). A total of 26 farmers were purposively sampled, with the assistance of extension officers. Data was collected through structured questionnaires and analysed using descriptive statistics and crisp-set Qualitative Comparative Analysis (CsQCA). The study results showed that 76.9% of the respondents were males while only 23.1% were females. Half (50%) of the respondents were between the ages of 51-60. The study found equivalent levels of satisfaction and dissatisfaction with the macadamia nut crop amongst the respondents. The reasons for dissatisfaction cited were competition with other crops (100%), high cost of orchard establishment (92.3%), low profit margins (92.3%), lack of capital (69.2%) and lack of production knowledge (46.2%). The results also suggest that older farmers with access to markets, extension services, and SAMAC (South African Macadamia Growers' Association) awareness consistently report higher satisfaction, while farmers who lack SAMAC awareness, extension services, and market access consistently reported lower satisfaction. These findings demonstrate that access to irrigation, extension services, and engagement with institutional structures such as SAMAC were critical factors influencing farmer satisfaction. Dissatisfaction was also linked to limited access to inputs like fertilizers and pest control technologies, as well as exclusion from more profitable segments of the value chain. While some farmers reported satisfaction and intended to continue with macadamia production, others were discouraged by unmet expectations and poor returns. Notably, youth and women were underrepresented among producers, though this study does not conclusively determine the reasons for their limited participation. The findings suggest that improving access to support services and inputs, alongside inclusive policies tailored to local conditions, could enhance participation and sustainability among small-scale macadamia farmers.

**Key words:** Small-scale farmers, macadamia nuts, socio-economic challenges, agricultural development

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## INTRODUCTION

South Africa has emerged as a significant player in the global macadamia nut industry, ranking among the top producers alongside Australia, Kenya, and China [1]. Macadamia production makes an important contribution to rural employment and the country's agricultural GDP [2]. Traditionally, macadamia production has been dominated by commercial production, however, greater participation by smallholder and emerging farmers is being reported, particularly in the Mpumalanga Lowveld region [3]. This shift has been partially linked to land reform, diversification, and the perceived profitability of macadamia nuts [2]. Notably, smallholders have had to deal with unique socio-economic issues that have not received sufficient focus in academic or policy discourse.

Most macadamia nuts in South Africa are sold to processing firms or international markets, predominately in Asia, Europe, and the United States of America [3]. As previously noted, macadamia production is aligned to the international market to a large extent, and producers can earn price premiums for quality, nut-in-shell (NIS) grading, and consistency of delivery in volume [4]. In contrast, small-scale producers often rely on middlemen or informal traders and receive lower and more volatile prices [5]. Furthermore, the market price for macadamia nuts is often determined by different factors such as nut moisture content, shell integrity, oil composition, and prevailing international demand [3]. These disparities in value chain participation contribute to unequal returns and compound the structural disadvantages faced by emerging producers.

The subtropical nature of the Lowveld's climate is considered ideal for nurturing macadamias due to its mild winters and high summer rainfall. However, beyond climatic conditions, producing commercial macadamia nuts requires specific inputs and agronomic conditions. Young macadamia trees, especially in the first five to seven years before they mature, require additional moisture where there is prolonged dry weather, for growth and nut set [6]. This is especially necessary for the semi-arid part of the Lowveld region that may not have consistently higher rainfall. Yet, many smallholder farmers do not have access to reliable irrigation infrastructure, and this has led to production constraints, which further contribute to dissatisfaction and yield variability [7]. Moreover, macadamia trees are input-intensive, as they require regular fertilisation with nitrogen, potassium, and trace elements, including zinc and boron [8]. Macadamia nuts are also susceptible to several pests which cause productivity loss, including stink bugs, nut borers, and husk spot, which require chemical pest control [9]. Without adequate access to these necessary inputs, which is often due to high costs and poor institutional support, smallholder farmers struggle to maintain consistent yields and scale up their production.



These agronomic and structural barriers raise important questions about the sustainability and equity of smallholder participation in macadamia farming. The study reported in this paper seeks to examine the socio-economic conditions affecting small-scale macadamia nut producers in the Mpumalanga Lowveld. Particular attention is given to institutional support, access to production inputs, producer satisfaction, and the wider development implications. By doing so, this study contributes to an underexplored area of agricultural development and provides a basis for more inclusive and evidence-informed policy interventions.

## MATERIALS AND METHODS

### Description of the study site

The study site is in the South-eastern part of the Limpopo province and the North-eastern part of the Mpumalanga province with GPS co-ordinates denoted at 24.8398° S, 31.0464° E. The sampled respondents were spread across the region from Thulamahashe to Mkhuhlu. The annual average rainfall ranges from 560-640mm while the temperatures range from the minimum of 16°C to 32°C in summer months. The highest rainfalls are recorded in summer with insignificant rains falling during the winter period. It is characterized by warm winters and hot summers with low humidity. The site is endowed with conducive climatic conditions suitable to produce many tropical and subtropical crops as well as vegetables [7]. These growing conditions present near perfect conditions for macadamia nuts production.

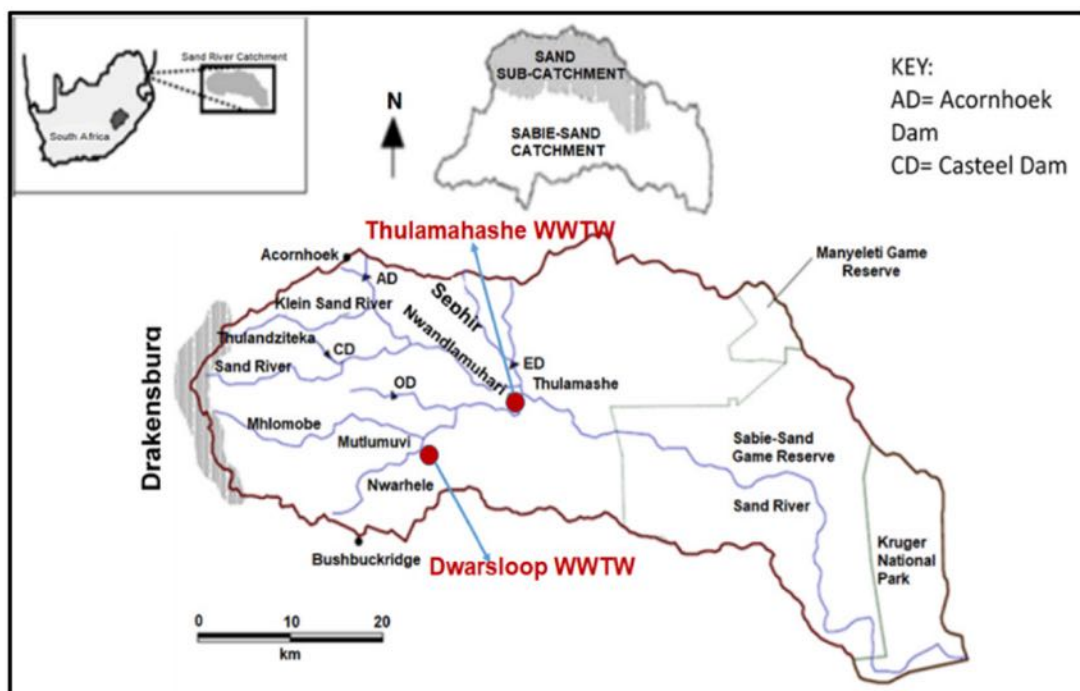


Figure 1: Map of Bushbuckridge Local Municipality within the Mpumalanga Lowveld

Source: World Atlas [10]

## Research design

The study followed the quantitative design, variables were measured with the resultant numeric data and was analysed using Statistical Package for Social Sciences (SPSS). This study followed a descriptive approach. The data are presented in the form of descriptive statistics. Face-to-face interviews were conducted in the study area. A questionnaires instrument was used to collect quantifiable data from the participants.

## Unit of analysis and sampling procedure

The survey study focused on the Bushbuckridge Local Municipality (BLM) geographically located within the Mpumalanga Lowveld. Smallholder farmers within the defined study area were purposively selected from the local Bushbuckridge Department of Agriculture database based on their suitability in relation to the study being conducted. Although the general definition of smallholder farmers varies in both global and local contexts, the study relied mainly on the farmer classifications of the Department of Agriculture. Therefore, for the purpose of this study, smallholder farmers were defined as those who produce for both household use and markets, subsequently earning ongoing revenue from their farm business. Furthermore, these are farmers operating with limited resources, relying predominantly on family labour and local markets, who also have the potential to expand to a commercial scale with adequate assistance.

These farmers were listed in the agricultural office database along with their type of farm enterprise, and many practised diversified farming with vegetables as the primary crop. However, the study focused only on farmers who were actively producing macadamia nuts at a small scale, regardless of whether they produce other crops or not. Through the assistance of local extension officers, 32 small-scale macadamia farmers were identified within the study area from the database. All the farmers were purposively selected as participants for the study. The main objective of the purposive sampling was to arrive at a sample that could sufficiently answer the research objectives. In addition, the purposive sampling was chosen due to the limited population set in the geographic area.

## Data collection techniques

Macadamia nut producing farmers are few in the area mainly because of the cost and labor demands, and because it requires about 12 months to reach full maturity. Initially, 32 farmers were identified and selected as participants. However, only 26 of the farmers were available and willing to participate in the study. Four (4) farmers could not be reached during the time of the survey, while the other 2 expressed disinterest to participate. Thus, the study surveyed a total of 26 farmers using a structured questionnaire instrument. The fieldwork and data collection for this study were conducted from September to November 2020. The researchers administered



the structured barcoded-assigned questionnaires with the assistance of trained enumerators and agricultural extension officers. Furthermore, given the geographical spread, efforts were made to ensure a diverse and representative sample as possible. Farmers were included if they were growing macadamia nuts on a small scale, regardless of whether macadamia nuts were the primary focus of their production or not. The questionnaire entailed a question and multiple responses from which to choose. The questionnaire was developed in English and translated orally into local languages (Xitsonga, Sepedi/Sepulana, isiZulu and siSwati) by the researcher and trained enumerators who are familiar with the area and language. Moreover, extension officers who were fluent in both English and the respondent's language assisted with the translation and explanation of technical and/or scientific terms. On the age and literacy levels of some of the farmers, an individual farmer's response was marked on the questionnaire by the researcher/enumerator. This was to ensure precise capturing of the responses. The resultant questionnaires with completed responses were used for further analysis and interpretation.

### **Data analysis and interpretation**

In this study, completed barcoded questionnaires were scanned and statistically analysed using the Statistical Package for the Social Sciences (SPSS) Version 29 in which descriptive statistics were created. Results were presented by means of figures and tables to determine interaction and relationships amongst variables.

To determine the combinations of socioeconomic factors which contribute to farmer satisfaction, Crisp set qualitative comparative analysis (CsQCA) was used. This method is based on the set theory and Boolean algebra and makes it possible to analyse complex causal links and many pathways to a result, especially in small-medium sample investigations [11]. Small-scale macadamia growers encounter a variety of socioeconomic challenges, and CsQCA offers a sophisticated understanding of how these factors combine to affect farmers. The outcome variable in this dataset, which includes 26 cases of small-scale macadamia growers, is measurement of farmer satisfaction (binary: 0 = not satisfied, 1 = satisfied). While satisfaction is inherently a continuum, the variable was coded as binary for the purpose of applying Crisp-set QCA, which requires binary outcomes. This operationalization aligns with existing QCA protocols for small-sample studies [11].

Using thresholds based on theoretical and empirical knowledge, the following conditions were also binary coded into Crisp sets: gender (0= female, 1= male), education level (0= grade R to matric, 1= tertiary), age (0= 40 years or younger, 1= older than 40), awareness of SAMAC (South African Macadamia Growers' Association) (0= no, 1= yes), access to markets (0= no, 1= yes), access to extension services (0= no, 1= yes), access to irrigation facilities (0= no, 1= yes), and participation in information sessions (0= no, 1= yes). To examine the combinations



of these conditions and their consistency with the outcome, a truth table was created using CsQCA software [12]. Consistency thresholds were set at 0.8 to ensure more accurate results.

### **Ethical considerations**

Ethical clearance for the study was granted by the University of Free State research ethics committee (UFS-HSD2020/0885/0807). Permission to conduct this study was sought and granted by the District Department of Agriculture in the Bohlabela District within its area of jurisdiction. An Extension Officer was assigned to assist in the identification of the farmers and collection of the data. Informed consent was sought and granted by the farmers prior to the administration of the questionnaire through consent forms. They were duly informed about the nature of this study and what it intends to achieve. They were guaranteed anonymity and that their personal information will not be shared. Participation in the study was on a free will basis and no participants were forced to be part of the study. Participants in the study were made aware that they have the freedom to withdraw from the study at any time without any negative consequences.

## **RESULTS AND DISCUSSION**

### **Socio-demographic characteristics of small-scale macadamia farmers in the study area**

A summary of the socio-demographic characteristics of the study participants is shown in Table 1. As shown in the table, males accounted for 76.9% of the 26 small-scale farmers interviewed for macadamia nut production, while females accounted for 23.1%. The results are consistent with a study which discovered that males are more involved in macadamia production [13]. Similarly, a comprehensive study on smallholder macadamia producers in Malawi found that males constitute the majority of macadamia farmers among surveyed cooperative members, with further quantitative analysis confirming that being male significantly increased the likelihood of growing macadamia [6]. According to the data in Table 1, 3.8 % of the 26 small-scale farmers who participated in the study were between the ages of 36-40. Furthermore, 23.1 % of the respondents were between the ages of 41-50, while 50.0 % of the respondents were between the ages of 51-60. Lastly, 23.1% of the respondents were 61 years or older. The results of the study agree with results obtained from previous studies, which found that older people are the ones who are more involved in agricultural production [14].

Table 1 further indicates the number of years the farmers have been in the macadamia nuts production. Of the twenty-six (26) small-scale farmers who participated in the survey research, 3.8% had less than 5 years of farming experience, while 7.7% had more than 5 years, but less than 10 years of farming



experience. Furthermore, 38.5% of the respondents had more than 10 years but less than 20 years of farming experience, while 50.0% of the respondents had more than 20 years of farming experience. This significant level of experience observed in most of the respondents highlights the farmers' accumulated expertise in crop management and serves as a foundation for decision making. This finding aligns with previous research, which emphasized that farming experience plays a critical role in improving farmers' decision-making [15].

The number of dependents of the small-scale farmers who participated in the study was also investigated. Of the twenty-six (26) participants, 3.8% indicated that they had two or less dependents, while 15.4% indicated that they had three dependents. Furthermore, 38.5% of the farmers who participated indicated that they had four dependents, while 15.4% and 3.8% had five and six dependents respectively. Moreover, 15.4% of the respondents indicated that they had seven dependents, and 7.7% indicated they had eight or more dependents. Previous studies have indicated that the number of dependents significantly influences labor availability and farm productivity [16]. The presence of dependents for most respondents highlights the potential labor allocation and enhanced productivity.

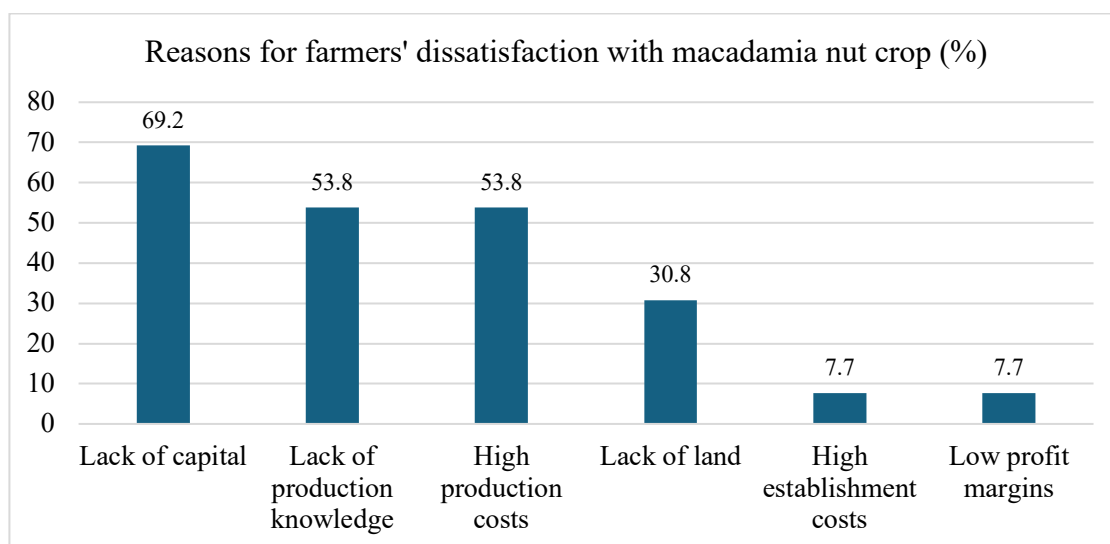
Table 1 also highlights the farmers' years of farming with macadamia nuts. Of the twenty-six respondents, 3.8% said they had 1-3 years, while another 3.8% said they had 4-6 years. Furthermore, 23.1% of the respondents said they had years between 7 and 9, while 69.2% of the participants said they had 10 years or more farming with macadamia nuts. Macadamia farming experience is a key factor influencing market participation and marketing channel selection among small-scale farmers [17]. The accumulated experience helps farmers to better navigate challenges related to quality standards, market access, and marketing decision-making. As shown in Table 1, the results also indicate that, out of the 26 participants in the study, 50% indicated that they were satisfied with the macadamia crop, whereas the other half indicated that they were dissatisfied. According to Zuza *et al.* [6], farmers who face challenges related to pests and diseases, limited market access, and inadequate agricultural advisory services are likely to express dissatisfaction as these challenges affect productivity and profitability. Conversely, farmers who have effective mitigation strategies against these challenges are likely to express higher satisfaction levels. The results show that 34.6% of the respondents indicated that they have land ownership, while 65.4% have no ownership. Research shows farmers' insecurity over their property rights usually results in inefficient use of agricultural land [18]. Thus, the low level of land ownership amongst the respondents may be a discouraging factor for the farmers, especially in their efforts to achieve large-scale production. Although the questionnaire did not explicitly ask about motivations, informal discussions revealed that some farmers adopted macadamia



farming based on perceived profitability and recommendations from extension officers. Others cited the crop's long-term returns and growing export demand as motivating factors. However, a mismatch between initial expectations and actual profitability contributed to dissatisfaction among some farmers.

### Reasons farmers are dissatisfied with the macadamia nut crop

Figure 2 depicts various factors responsible for farmers' dissatisfaction with macadamia crop. The lack of capital was ranked the most important factor driving dissatisfaction amongst farmers and accounting for 69.2%. This was followed by high production costs (53.8%). Lack of land (30.8%), and production knowledge (53.8%) also proved to be the challenging factors fuelling the dissatisfaction. High establishment costs and low profit margins were both ranked the least important factors, both constituting only 7.7%, respectively. Generally, lack of capital coupled with high production costs collectively contributed significantly to the farmers' dissatisfaction with the macadamia crop. This is in line with previous studies, which indicate that farmers who face challenges of inadequate resources and insufficient institutional support are likely to express dissatisfaction [6].

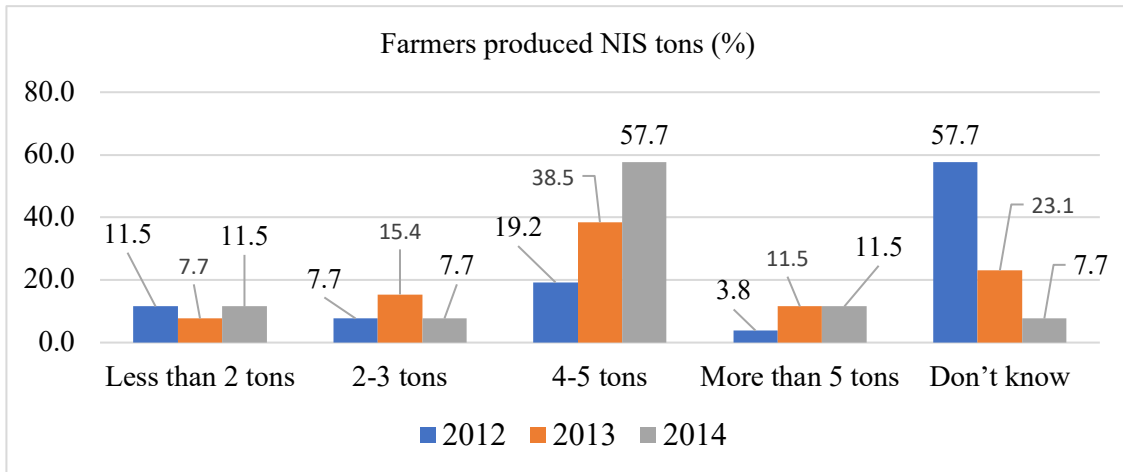


**Figure 2: Reasons for farmers' dissatisfaction with macadamia nut crop**

### Tons produced by farmers – Nut-In-Shell (NIS)

Farmers' production tons are represented in Figure 3. Only 11.5% achieved less than 2 tons of NIS in both 2012 and 2014, respectively. While only 7.7% achieved less than 2 tons in 2013. The highest yields achieved was 4-5 tons in 2013 and 2014 and achieved by 38.5% and 57.7% of the farmers, respectively. In 2013 and 2014 only 11.5% of the farmers achieved more than 5 tons. This is an excellent production in line with the industry standard of an economical and viable yield of 3-4 tons/ha NIS [19]. However, in 2012 about 57.7% of the farmers did not know the exact tonnage achieved. This translates to lack of proper record, which is necessary to

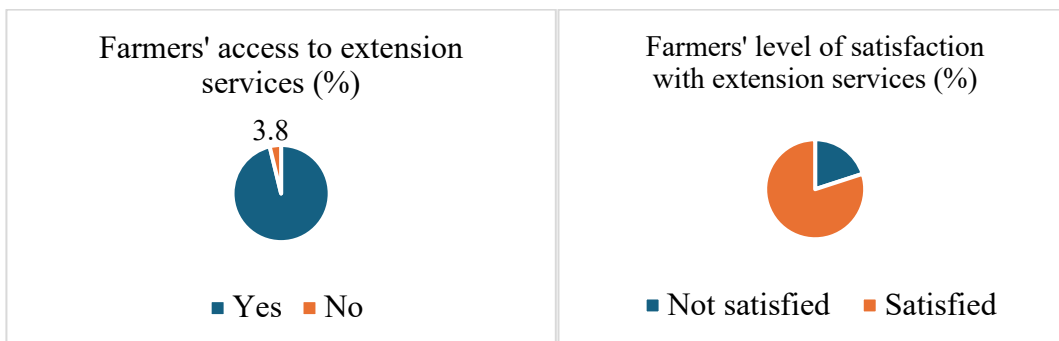
enhance forward planning and management. Although fieldwork for the study was conducted in 2020, farmers reported yield data from 2012-2014 due to lack of more recent records. The reported figures were recorded when agricultural extension services increased support for smallholder macadamia farmers in the area. These figures helped assess production volumes and trends, but since then, consistent record keeping has been lacking. Thus, these self-reported figures were used cautiously to indicate historical trends rather than current productivity.



**Figure 3: Farmers' produced tons (NIS) over the 3-year period**

#### Farmers' access to extension services

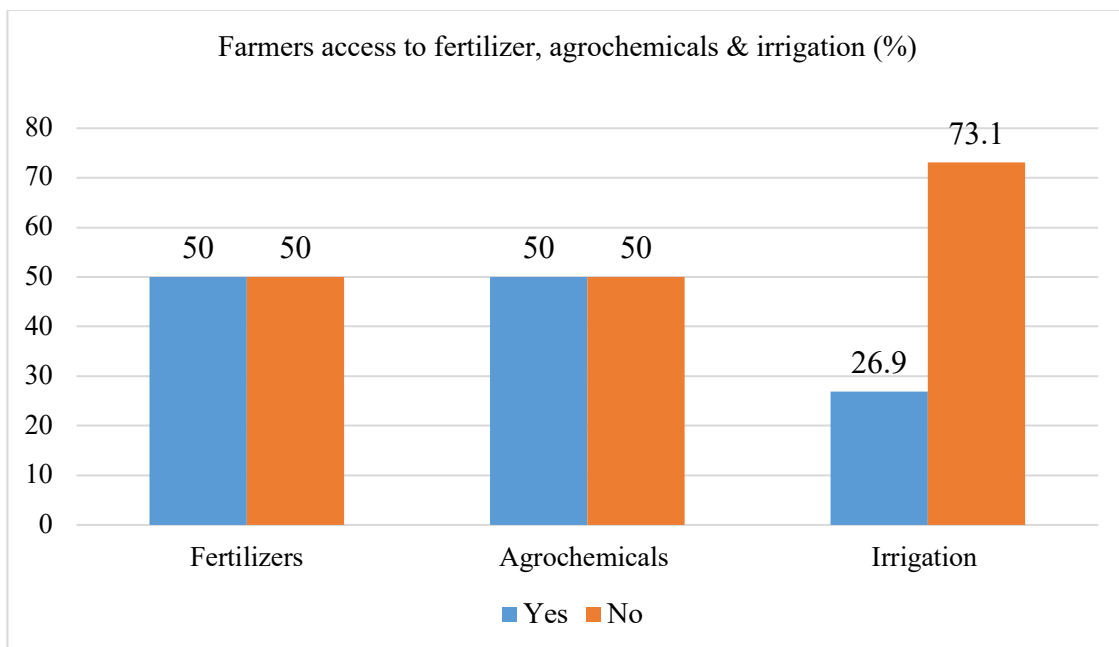
The farmers' access and satisfaction about extension services listed in Figure 4. Most of the farmers (96.2%) indicated that they have adequate access to extension services provided by government extension practitioners. In addition, 80% of the farmers were satisfied with the nature and extent of extension services provided. The farmer's access to extension services is key in ensuring dissemination of information and guidance aimed at developing the farmers [20]. Again, the level of satisfaction builds working trust between the farmers and the extension agents and ultimately ensures the betterment of the smallholder farmers production systems.



**Figure 4: Farmers' access and level of satisfaction with extension services**

### Farmers' access to fertilizer, agrochemicals and irrigation

Figure 5 shows the extent to which farmers have access to fertilizers, agrochemicals, and irrigation. Half (50%) of the sampled farmers indicated that they have access to both fertilizers and agrochemicals respectively, whereas 73.1% of the farmers had access to irrigation. Access to important production inputs such as fertilizers, agrochemicals and irrigation is key in ensuring successful macadamia nut production. Recent studies indicate that optimized fertilization improves both the productivity and nut quality of macadamia trees [8], which are important for smallholder farmers who would like to commercialize their production. Integrated pest management, which includes careful use of agrochemicals, also helps minimize yield losses due to pests and diseases [9]. Furthermore, effective irrigation scheduling is crucial for maintaining high yields and kernel quality, particularly in the face of changing climate conditions [6]. Thus, the results suggest that further interventions are needed to improve the farmers' access to fertilisers and agrochemicals.

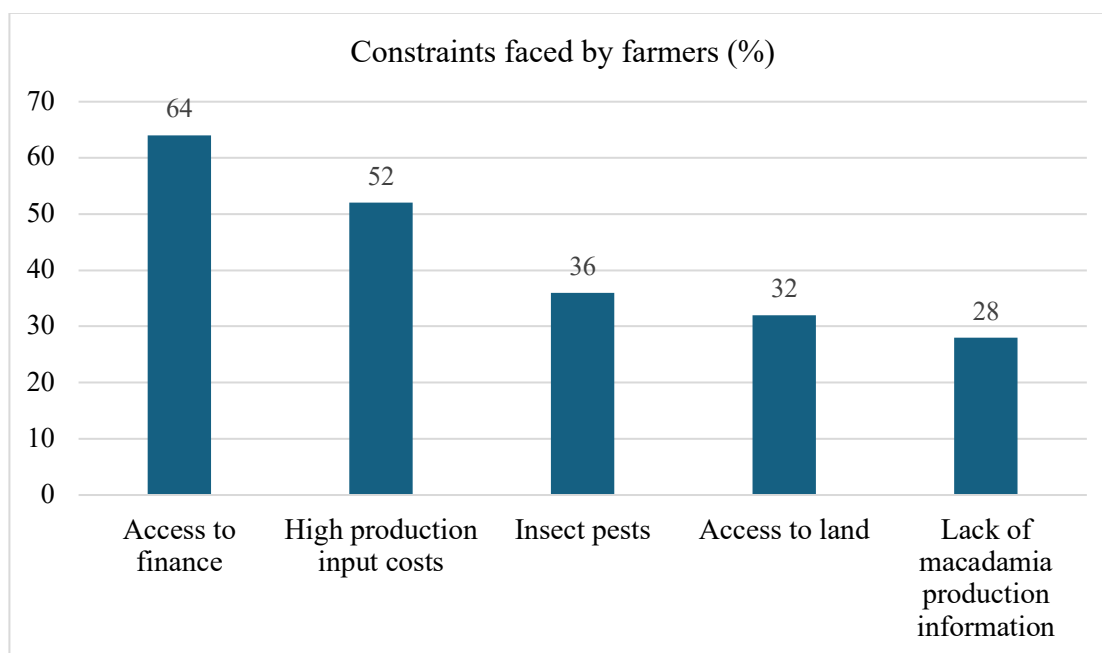


**Figure 5: Farmers access to fertilizer, agrochemicals and irrigation**

### Constraints faced by small-scale macadamia nut farmers

The cited production constraints experienced by the farmers are listed in Figure 6. The results show that farmers are faced with a variety of challenges, but noteworthy, access to finance (64%) and high production input costs (52%) proved to be the most cited challenges, largely constraining most of the sampled farmers. These observations are consistent with previous studies [21-24], which found that most small-scale farmers struggle with financial constraints. This indicates that access to finance is critically important for the small-scale farmers. Moreover, insect pests

(36%), access to land (32%), and lack of macadamia production information (28%) were also listed as occurring challenges.



**Figure 6: Farmers Access to finance, access to land, insect pests, lack of macadamia production**

### The empirical findings of the study

To determine the combinations of socio-demographic factors which contribute to farmer satisfaction, the study utilized Crisp set qualitative comparative analysis (CsQCA) as outlined in the data analysis and interpretation section.

A comprehensive summary of the different socioeconomic factors and how they relate to farmer satisfaction is shown in the truth table (Table 2). Each row presents a distinct set of conditions, and the consistency score shows how strongly these combinations result in the desired outcome (satisfaction = 1). With a consistency score of 1, cases 18 and 16 are particularly noteworthy. Older farmers (age = 1) with access to markets, extension services, and SAMAC awareness are involved in these cases. The presence of these resources consistently leads to satisfaction, suggesting that institutional support and access to markets are critical for improving farmers' well-being. This is consistent with research that emphasizes how extension services and cooperatives can improve agricultural resilience and productivity [25-26]. The consistency score for Case 9, which includes a farmer with irrigation access and SAMAC awareness, is also 1. This emphasizes how crucial irrigation infrastructure is to tackling water scarcity, which is a significant problem for small-scale farmers [27]. Low consistency scores (0 and 0.5, respectively) are found in cases 21 and 14, and 25, which lack SAMAC awareness, extension services, and

market access. These cases demonstrate the challenges experienced by farmers who are excluded from institutional support networks. Regardless of other factors, farmers are less likely to be satisfied if they do not have access to these resources.

The sufficient conditions for farmer satisfaction, each with a consistency score of 1, are shown in Table 3. These conditions reflect socioeconomic factor combinations that reliably result in satisfaction. In cases 18 and 16, the combination "gender-AGE-SAMAC" is sufficient for satisfaction, as the table illustrates. It involves elderly male farmers who are aware of SAMAC (gender = 1, age = 1). The presence of SAMAC awareness implies that institutional support is essential for achieving farmer satisfaction, especially for older farmers who may possess greater social capital and experience. The findings also demonstrate that in cases 22 and 10, higher levels of education (education = 1) are sufficient for satisfaction. Given that educated farmers are more likely to embrace new technology and techniques, this finding emphasizes the value of education in enhancing farmer productivity [28]. In cases 9 and 24, respectively, the combinations "IRRIGATION-SAMAC" and "IRRIGATION-information session" are also sufficient for satisfaction. To address water constraints, which is a significant challenge for small-scale macadamia farmers, these findings emphasize the significance of irrigation access. Access to irrigation greatly increases satisfaction when paired with institutional support (SAMAC awareness or information sessions attendance). The sufficient conditions identified in Table 3 suggest that multiple pathways lead to farmer satisfaction. For example, older farmers with SAMAC awareness (cases 18 and 16) achieve satisfaction through institutional support, while educated farmers (cases 22 and 10) benefit from their ability to adopt innovative practices. These findings align with the concept of equifinality in QCA, which refers to the concept that different combinations of conditions can lead to the same outcome [29]. In this case, different combinations of farmer characteristics lead to farmer satisfaction, highlighting that multiple supportive pathways exist.

Table 4 presents the top solutions for farmer satisfaction, combining multiple sufficient conditions. Both solutions have a consistency of 1 and explain 46.2% of the outcome cases. "gender-AGE-SAMAC, EDUCATION, IRRIGATION-SAMAC, and IRRIGATION-information session" are all combined in the first solution. This solution emphasizes how institutional factors like SAMAC awareness and information session attendance interact with individual characteristics like age and gender. This solution, for instance, covers cases 9 (irrigation + SAMAC) and 24 (irrigation + information session), highlighting the significance of institutional support and resource access in attaining satisfaction. The second solution preserves the same consistency and coverage by substituting "SAMAC-information session" for "IRRIGATION-information session". This solution highlights how information sessions, especially when paired with SAMAC awareness, can improve farmer



satisfaction. This is demonstrated in case 18 (SAMAC + information session), emphasizing the value of farmers working together and exchanging knowledge. The top solutions suggest that integrated interventions are needed to address the multifaceted challenges faced by small-scale farmers. For example, combining irrigation access with institutional support such as SAMAC awareness or information sessions can significantly enhance satisfaction. This finding is consistent with studies that emphasize the importance of holistic approaches to agricultural development [30].

Different socioeconomic factors, including market access, extension services, irrigation infrastructure, and institutional support, all influence farmer satisfaction, according to the CsQCA analysis. These results are in line with the broader literature on agricultural development, which highlights the importance of institutional support, education, and resource access in improving farmer livelihoods [31-32]. Thus, addressing these challenges through targeted policies and interventions can improve the livelihoods of small-scale macadamia farmers.

## CONCLUSION AND RECOMMENDATIONS FOR DEVELOPMENT

This study explored the different socio-economic challenges facing smallholder macadamia nut producers in the Mpumalanga Lowveld region in South Africa, using a survey methodology alongside crisp-set Qualitative Comparative Analysis (CsQCA). The results showed that there was a strong link between satisfaction of the farmer with the macadamia nut and structural factors, as compared to demographic characteristics. Limited access to key inputs such as irrigation, fertilizers, fungicides and insecticides as well as underutilization of support offered by organizations like SAMAC and government extension services had the greatest effect on farmers' level of dissatisfaction. Some farmers expressed optimism about the long-term potential for the crop, while others expressed frustration about low returns, variability of yields, and a lack of attention from the sector. The study also found that most respondents were older males, although this demographic pattern alone does not sufficiently explain the challenges experienced or the potential for youth and women participation.

These findings suggest that improving the performance and satisfaction of smallholder macadamia producers requires a combination of structural and institutional reforms. There is a need for more inclusive and responsive support from both public institutions and non-governmental industry structures. Governmental departments and organizations such as SAMAC should expand localized training and extension outreach tailored to the needs of smallholders, particularly in relation to input use, pest management, and market access. In addition, enhancing access to irrigation, whether through community-managed irrigation schemes or subsidized



technology, could encourage farmers and help increase their productivity, especially in areas facing water scarcity. Additionally, the relative absence of youth from the sector suggests some structural limitations such as long gestation periods and capital intensity. To overcome these limitations, there is a need for comprehensive and systemic interventions, including funding mechanisms, entrepreneurship training, and targeted mentorship, which can make the sector more attractive to younger entrants.

Furthermore, there is a need to ground recommendations for gender equity in contextual realities. While most producers in this study were male, this finding does not automatically suggest that a gendered approach to intervention is merited. It is essential to explore whether barriers to participation, such as labor constraints, land access, or time burdens exist for women, or whether women are choosing not to participate based on rational opportunity-cost assessments. Any future gender-sensitive policy or program must be based on evidence rather than assumptions. Hence, future studies could explore the gender dynamics in smallholder macadamia farming to unpack the varying motivations for women's participation or lack thereof. Moreover, the study acknowledges that since 2020, shifts in rainfall patterns, market access, and macadamia prices may have further affected production. Thus, this study serves as a background and contributes towards the discourse to understand these evolving dynamics.

Lastly, the study findings suggest the need to explore production models or alternatives that reduce reliance on external inputs, as Materechera and Scholes highlighted [33]. These may include intercropping macadamia with leguminous cover crops that will enhance soil fertility or utilizing organic pest control measures where possible. Such innovations could offer more sustainable and cost-effective pathways for smallholder producers, especially those with limited resources [34]. Although macadamia farming provides important opportunities for livelihoods and nutrition in the Mpumalanga Lowveld, unlocking its full potential for smallholder development will depend on addressing the structural inequalities that shape input access, market integration, and institutional support [35]. Tailored, evidence-based interventions can play a critical role in building a more inclusive and resilient macadamia sector.

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## Conflict of interest

The authors declare no conflict of interest.



**Table 1: Distribution of farmers' socio-demographic characteristics**

Socio-demographic traits	Variables	N=26	Percentage (%)
Gender	Male	20	76.9
	Female	6	23.1
Age	31-40 years	1	3.8
	41-50 years	6	23.1
	51-60 years	13	50.0
	≥ 61 years	6	23.1
General farming experience	Less than 5 years	1	3.8
	5-10 years	2	7.7
	11-20 years	10	38.5
	More than 20 years	13	50
Number of dependants	2 or less dependants	1	3.8
	3 dependants	4	15.4
	4 dependants	10	38.5
	5 dependants	4	15.4
	6 dependants	1	3.8
	7 dependants	4	15.4
	8 or more dependants	2	7.7
Macadamia farming experience	1-3 years	1	3.8
	4-6 years	1	3.8
	7-9 years	6	23.1
	10 years or more	18	69.2
Satisfaction with macadamia nut crop	Yes	13	50.0
	No	13	50.0
Land ownership	Yes	9	34.6
	No	17	65.4

**Table 2: Truth table showing combinations of socioeconomic conditions and their consistency with farmer satisfaction**

Case ID	GE	LOE	AGE	ATM	ATES	ATII	AOSMAC	ISA	SAT	Consistency
21	0	0	0	1	1	0	1	1	0	0
14, 25	0	0	1	1	1	0	0	1	0	0,5
18	0	0	1	1	1	0	1	0	1	1
16	0	0	1	1	1	0	1	1	1	1
23	1	0	1	0	0	0	0	0	0	0
2, 20	1	0	1	1	1	0	0	0	0	0
1, 4, 5	1	0	1	1	1	0	0	1	0	0
6, 8, 12, 15, 17, 19, 26	1	0	1	1	1	0	1	1	0	0,57
9	1	0	1	1	1	1	0	1	1	1
24	1	0	1	1	1	1	1	0	1	1
3, 7, 11, 13	1	0	1	1	1	1	1	1	0	0,5
22	1	1	1	1	1	0	1	1	1	1
10	1	1	1	1	1	1	1	1	1	1

Note: GE= Gender (0= female, 1=male), LOE= Level of education (0= grade R to matric, 1=tertiary), AGE= Age (0= 40 years or younger, 1= older than 40), ATM= Access to Markets (0= no, 1= yes), ATES= Access to Extension Services (0= no, 1= yes), ATII= Access to Irrigation Infrastructure (0= no, 1= yes), AOSMAC= Awareness of SAMAC (0= no, 1= yes), ISA= Information Session Attendance (0= no, 1= yes), SAT= Satisfaction (0= not satisfied, 1= satisfied)

**Table 3: Sufficient conditions for farmer satisfaction**

Sufficient Condition	Cases	Consistency	Coverage
Gender-AGE-SAMAC	18, 16	1	0.154
EDUCATION	22, 10	1	0.154
IRRIGATION-samac	9	1	0.077
IRRIGATION-information session	24	1	0.077
SAMAC-information session	18, 24	1	0.154

**Table 4: Top solutions for farmer satisfaction, combining multiple sufficient conditions**

Solution	Consistency	Coverage
Gender-AGE-SAMAC + EDUCATION + IRRIGATION-samac + IRRIGATION-information session	1	0.462
Gender-AGE-SAMAC + EDUCATION + IRRIGATION-samac + SAMAC-information session	1	0.462



## REFERENCES

1. **Australian Macadamia Society.** Roundtable recap: Global macadamia production updates shared at 2024 INC Congress. 2024. Available at <https://australianmacadamias.org/industry/news/roundtable-recap-global-macadamia-production-updates-shared-at-2024-inc-congress> Accessed January 2025.
2. **Genis A** Subtropical fruit production by small-scale farmers in South Africa and employment-intensive land reform. GTAC/CBPEP/EU project on employment-intensive rural land reform in South Africa: policies, programmes and capacities. 2020; **40**. <http://hdl.handle.net/10566/5213> Accessed January 2025.
3. **Macadamias South Africa (SAMAC).** Information hub- South African Production. 2025. <https://samac.org.za/information-hub/> Accessed January 2025.
4. **Sibulali A** Market Intelligence Report: Macadamia Nuts. Macro & Resource Economics, Western Cape Department of Agriculture. 2021. <https://www.elsenburg.com/wp-content/uploads/2022/03/2021-Macadamias-MIR.pdf>) Accessed January 2025.
5. **Parshotam A** Cultivating smallholder inclusion in Southern Africa's macadamia nut value chains. *South African Institute of International Affairs: Pretoria, South Africa*. 2018. <https://www.jstor.org/stable/resrep28391> Accessed January 2025.
6. **Zuza EJ, Araya YN, Maseyk K, Bhagwat S, Brandenburg RL, Emmott A, Rawes W, Phiri P, Mkengala K and E Kenamu** Farmer preference for macadamia varieties and constraints to production in Malawi. *Plos one*. 2024; **19(2)**. p.e0293488.
7. **Van der Merwe JP, Wang T, Clarke C and SD Mansfield** Predicting temperature and rainfall for plantation forestry in Mpumalanga, South Africa, using locally developed climate models. *Agric. For. Meteorol.* 2023; **329**: 109275.
8. **Smith TE** Review of macadamia orchard nutrition. 2017. Project Report. *Horticulture Innovation Australia*.



9. **Alosa NA** Farmer Management Practices of Stink Bug (*Bathycycoelia Distincta*) and Its Occurrence in Selected Macadamia Growing Areas in Kenya. 2023 (Doctoral dissertation, University of Nairobi).
10. **WorldAtlas**. Map of Bushbuckridge. Available at <http://www.maphill.com/search/bushbuckridge/road-map/> Accessed January 2025.
11. **Ragin CC** Redesigning social inquiry: Fuzzy sets and beyond. University of Chicago Press. 2009.
12. **Cronqvist L** Tosmana [Version 1.61]. University of Trier. 2019. Available at: <https://www.tosmana.net> Accessed January 2025.
13. **Mwendwa FN, Muiruri P and S Mbuthia** Socio-Economic and Technological Factors Affecting Macadamia Farming Among Small-Scale Farmers in Meru County, Kenya. *East Afr. J. Agric. Biotechnol.* 2024; **7(1)**: 345-360.
14. **Shelembe N, Hlatshwayo SI, Modi A, Mabhaudhi T and MSC Ndgidi** Indigenous Crop on the Food Security Status of Farming Households in KwaZulu-Natal Province. *Agric.* 2024; **14(3)**: 415.
15. **Sapbamrer R and A Thammachai** Systematic review of factors influencing farmers' adoption of organic farming. *Sustainability.* 2021; **13(7)**: 3842.
16. **Atube F, Malinga GM, Nyeko M, Okello DM, Alarakol SP and I Okello-Uma** Determinants of smallholder farmers' adaptation strategies to the effects of climate change: Evidence from northern Uganda. *Agric. Food Secur.* 2021; **10(1)**: 1-14.
17. **Nthiga KM, Ndirangu SN and IH Nyarindo** Exploring Factors Influencing Market Engagement and Marketing Channel Selection among Smallholder Macadamia Farmers in Embu West Sub County, Kenya. *J. Glob. Innov. Agric. Sci.* 2024; **12(2)**: 333-339.
18. **Kombe M, Siamabele B, Kalumbi MM and M Kaliba** Traditional Land Ownership and Agricultural Productivity Among Small-Scale Farmers: A Case of Mutaba Agricultural Camp, Masaiti District. *Digit. J. Sci.* 2024; **1(1)**: 104.
19. **Nortje GP** Macadamia fertilization. Fertasa Soil Fertility and Plant Nutrition Symposium. 2017.



20. **Kassem HS, Alotaibi BA, Muddassir M and A Herab** Factors influencing farmers' satisfaction with the quality of agricultural extension services. *Eval. Program Plan.* 2021; **85**: 101912.
21. **Barbier EB, López RE and JP Hochard** Debt, Poverty and Resource Management in a Rural Smallholder Economy. *Environ. Resour. Econ.* 2016; **63**: 411-427. <https://doi.org/10.1007/s10640-015-9890-4>
22. **Gyorvary S and V Lamb** From sapphires to cassava: the politics of debt in northwestern Cambodia, ACME. *Int. J. Crit. Geogr.* 2021; **20**: 431-449.
23. **Natarajan N and K Brickell** Credit, land and survival work in rural Cambodia: rethinking rural autonomy through a feminist lens. *J. Agrar. Change.* 2022; **22(3)**: 473-488.
24. **Touch V, Cross R, Grünbühel C, Van Ogtrop F, Ampt P, Yorn T, Martin RJ, Cook BR and DKY Tan** Adaptation constraints and prospects for future research priorities in lowland rice-based farming systems: learning experiences from Northwest Cambodia. *Environ. Dev. Sustain.* 2023; **26**: 22555-22586.
25. **Khan N, Ray RL, Kassem HS, Ihtisham M, Siddiqui BN and S Zhang** Can cooperative supports and adoption of improved technologies help increase agricultural income? Evidence from a recent study. *Land.* 2022; **11(3)**: 361.
26. **Akinola A, Kehinde A, Tijani A, Ayanwale A, Adesiyun O, Tanimonure V, Ogunleye A and T Ojo** Impact of membership in agricultural cooperatives on yield of smallholder tomato farmers in Nigeria. *Environ. Sustain. Indic.* 2023; **20**: 100313.
27. **Morepje MT, Agholor IA, Sithole MZ, Mgwenya LI, Msweli NS and VN Thabane** An Analysis of the Acceptance of Water Management Systems among Smallholder Farmers in Numbi, Mpumalanga Province, South Africa. *Sustainability.* 2024; **16(5)**: 1952.
28. **Paltasingh KR and P Goyari** Impact of farmer education on farm productivity under varying technologies: case of paddy growers in India. *Agric. Food Econ.* 2018; **6(1)**: 1-19.
29. **Smela M** The qualitative comparative analysis: An overview of a causal complexity approach. In *SHS Web of Conferences.* 2021; **92**: 08020. EDP Sciences.



30. **Alongi M and M Anese** Re-thinking functional food development through a holistic approach. *J. Funct. Foods*.2021; **81**: 104466.
31. **Kephe PN, Petja BM and KK Ayisi** Examining the role of institutional support in enhancing smallholder oilseed producers' adaptability to climate change in Limpopo Province, South Africa. *OCL*. 2021; **28**: 14.
32. **Othman MS, Oughton E and G Garrod** Significance of farming groups for resource access and livelihood improvement of rural smallholder women farmers. *Dev. Pract.* 2020; **30(5)**: 586-598.
33. **Materechera F and M Scholes** Scenarios for Sustainable Farming Systems for Macadamia Nuts and Mangos Using a Systems Dynamics Lens in the Vhembe District, Limpopo South Africa. *Agric.* 2022; **12**: 1724.
34. **Wood L** Worldwide Macadamia Market (2020 to 2025)- Growth Trends and Forecasts. Dublin: Business Wire. 2020.
35. **Nisa FU and T Batool** The Nutritional and Therapeutic Aspects of Australian Macadamia Nuts. In *Ethnobotanical Insights into Medicinal Plants*. 2024; pp. 279-307. IGI Global.

