Journal of Infrastructure, Policy and Development 2024, 8(12), 8192.
https://doi.org/10.24294/jipd.v8i12.8192

Article

Determinants of household participation in the cassava value-chain in South Africa

Moses Herbert Lubinga[1,2*], Bhekani Zondo[1], Bernard Manganyi[1], Thulani Ningi[1]

[1] Markets and Economic Research Centre, National Agricultural Marketing Council, Private Bag X935, Pretoria 0001, South Africa
[2] Department of Agricultural Economics, Extension and Rural Development, University of Pretoria, Pretoria, South Africa
*** Corresponding author:** Moses Herbert Lubinga, moseslubinga@yahoo.co.uk

CITATION

Lubinga MH, Zondo B, Manganyi B, Ningi T. (2024). Determinants of household participation in the cassava value-chain in South Africa. Journal of Infrastructure, Policy and Development. 8(12): 8192. https://doi.org/10.24294/jipd.v8i12.8192

ARTICLE INFO

Received: 25 July 2024
Accepted: 18 September 2024r
Available online: 6 November 2024

COPYRIGHT

Copyright © 2024 by author(s). *Journal of Infrastructure, Policy and Development* is published by EnPress Publisher, LLC. This work is licensed under the Creative Commons Attribution (CC BY) license. https://creativecommons.org/licenses/by/4.0/

Abstract: Cassava's adaptability to different agroecological conditions, high yield, as well as its ability to thrive under harsh climatic conditions, makes it an essential food security crop. In South Africa, the cassava value chain is currently uncoordinated and underdeveloped, with a couple of smallholder farmers growing the crop for household consumption and as a source of income. Other farmers regard it as a secondary crop and hardly any producers grow it for industrial purposes. Hence, this study sought to analyze the determinants of household participation in the cassava value chain in South Africa. The study employed the multivariate probit model to analyze the determinants of household participation in the cassava value chain in South Africa, using a primary dataset collected through a simple sample method from smallholder farmers in KwaZulu-Natal, Mpumalanga, and Limpopo provinces. Results show that livestock ownership has a positive and significant effect on the likelihood of farmers participating in the value chain by growing cassava for household food consumption. Also, findings reveal that hiring labour in cassava production and an increase in the yield during the previous season increases the probability of farmers' interest in selling cassava tubers along the value chain. Hence, the positive and statistically significant influence of hiring labour during cassava production in driving the farmers' interest in selling cassava tubers and cuttings implies that the development of the cassava value chain presents great opportunities for creating jobs (employment) in the country. Also, policy interventions that ensure land tenure security and empower farmers to increase their cassava yields are bound to encourage further participation in the value chain with an interest in selling fresh tubers, among other derived products to generate income. Lastly, programmes that empower and encourage youth participation in the cassava value chain can increase the number of farmers interested in selling cassava products.

Keywords: cassava; multivariate probit; smallholder farmers; cassava value-chain

1. Introduction

Cassava (*Manihot esculenta* Crantz) originated in the Latin America and largely grown by the indigeneous Indian population dating back over 4000 years (Howeler, 2006). Currently, cassava is the fourth most essential staple food crop, following rice, wheat, and maize, consumed by over a billion people globally (Adebayo, 2023). In addition, in Sub-Saharan Africa (SSA), the crop is regarded as the second most essential food staple, serving as a primary source of energy for a about 40% of the SSA population. In 2021, Nigeria was the leading cassava producer globally, accounting for about 63.03 million metric tons (MT), followed by the Democratic Republic of Congo (DRC) with 45.67 million MT, then Thailand (30.11 million MT), Ghana (22.68 million MT), Brazil (18.1 million MT), and Indonesia (17.75 million

MT), among others (Statista, 2023). Adebayo (2023) reckons that the SSA region currently accounts for the highest cassava consumption per capita of 800g per person a day. Despite Cassava's wide spread farming across the African continent, the crop is not well known and adopted in South Africa. According to the Agricultural Research Council (ARC, 2024), cassava is only produced on a few commercial farms covering less than 5000 hectares (ha) of land on relatively small. While cassava production is characterized by relatively low input farming systems and technology adoption, its farming is increasingly becoming popular due to the crop's versatility and the diverse use of cassava products.

Cassava is well documented to be a climate-smart crop (Amelework et al., 2021; Department of Science and Technology (DST), 2015; Lukhele et al., 2023; Chisenga et al., 2019; Mutyaba et al., 2016; Mudombi, 2010). Cassava's adaptability to different agroecological conditions, high yield, as well as its ability to thrive under harsh climatic conditions, makes it an essential food security crop. According to Adebayo (2023), although cassava is resilient to drought and depleted soils, it usually performs and grows well in rich sandy-clay soils. Moreover, the use of cassava for industrial purposes is equally well documented. For instance, in the food industry, Chisenga et al. (2019) posit that cassava-derived flours and starches are often blended with other starches to create edible films which can be used for packaging food products, providing a biodegradable and edible alternative to traditional packaging materials. Furthermore, the scholars note that cassava-derived flours and starches are key ingredients in soups and creams, bread making, and used in the making of bioethanol, among others uses. In the non-food industry, Otálora et al. (2024), Gunathilake and Somendrika (2024), Cedera and Vilpoux (2023) elaborate the various uses and innovative products derived from cassava.

In South Africa, whereas the Department of Science and Innovation (DSI) through the Bio-economy strategy emphasizes the use of multi-purpose, climate-smart crops (such as cassava) to intensify agricultural production given their potential to contribute towards multiple national priorities, the cassava value chain remains underdeveloped and poorly coordinated. The value chain is mainly driven by smallholder farmers who grow cassava for household consumption and occasionally sell the surplus to generate an income. Some farmers regard the crop to be secondary and are yet to commit to produce at commercial scale for industrial purposes. Moreover, there is limited knowledge on the factors influencing households' participation in the cassava value-chain in South Africa. The existing cassava-related literature focusing on South Africa's context does not provide a clear overview of the inherent factors since such literature is either anchored on a segment of the value chain (Manganyi et al., 2023) or does not take into consideration of all cassava producing provinces (Lukhele et al., 2023) or is limited to experimental analysis (Amelework et al., 2021, 2022, 2023; Modombi, 2010). It is thus against this background that there is the need to assess the determinants of household participation in the cassava value chain in South Africa. This study bridges the knowledge gap on determinants influencing households' participation in the cassava value chain by covering respondents from the three-cassava producing–Limpopo, Mpumalanga and KwaZulu Natal. These provinces were purposively chosen given that fact that cassava grows well in these frost-free areas and it is in these provinces where field experimental trials

were conducted by the Agricultural Research Council (ARC) (Amelework et al., 2022, 2023). To the best of our knowledge, this is the first socio-economics oriented study that endeavors to cover all the three cassava producing provinces.

2. Literature review

Given that agricultural output in the Sub-Saharan region has been trailing behind population growth, there is an increasing emphasis on improving the production of crops that can thrive under challenging conditions (Enete, 2005). However, the participation of households in the cassava value chain in Sub-Saharan Africa is influenced by a range of factors. Enete (2009) conducted a study on cassava market participation decisions among producing households in Africa, which underscores this point. The study highlights the crucial role of efficient cassava marketing for both consumer living costs and producer income. However, the effectiveness of using food price policies to stimulate short-run marketed surplus has been questioned, leading to considerations of non-price strategic variables that may motivate farm households to participate in commodity markets (Enete, 2009).

Furthermore, Onya (2016) conducted a similar study on market participation and the value chain of cassava farmers in Abia State, Nigeria. The results from the study highlighted that a significant percentage of cassava farmers added value to their produce by processing, while a majority sold unprocessed produce at local markets. The study further highlighted that factors like the level of education, marital status, distance to the market, farm size and transaction costs influence market participation in the cassava market (Onya, 2016). Both Onya (2016) and Enete (2009) emphasise the importance of market access, market information, and the use of strategic variables such as granule production in Sub-Saharan Africa. Onya (2016) further highlighted the following limiting factors in participating in cassava value chains: high cost of processing cassava, high transaction costs, poor coordination among actors in the value chain, lack of storage facilities, poor road network, price fluctuation, high cost of cassava tubers, and poor access to market information. However, the study could not fully capture the complexities and challenges faced by cassava farmers in the value chain, potentially limiting the generalisation of the results. Also, the study failed to capture significant barriers to market participation and value chain development.

A similar study by Murathi (2018) used the Heckman two-stage model on smallholder farmers in general to assess determinants of commercialization and employed. Identified factors positively influencing commercialization include, the household head's years of schooling, asset ownership, gender of the decision maker in the household, non-farm income, access to agricultural extension services, crop yield and the quantity sold, among others. Whereas the study acknowledges that it does not take into consideration of the farmers' entrepreneurial mindset, which is bound to affect the interpretation of the results, it is commended that there is a need to increase access to extension services, agricultural credit and insurance for the smallholder farmers. To determine the factors influencing participation in cassava production and marketing among smallholder cassava farmers in the Case of Dak Lak Province of Vietnam, Ao et al. (2019) used a two-stage Heckman model, with probit and ordinary least squares estimators. It was found that the level of education,

experience in producing cassava, access to credit as well as land area exerted a significant effect on the participation of women in the producing and marketing of cassava. To foster gender equality, the study recommends customized policies in favor of women to increase their access to agricultural resources, for instance agricultural credit. Hegana and Teshome (2022) also assessed smallholder farmers' market participation determinants employing the Heckman two-stage econometric model in Ethiopia. The scholars found that the larger the family, the more likely it was for a household to partake in market participation, coupled with access to credit, access to extension services and availability of irrigation services. More interestingly, smallholder farmers were more willing to participate in the marketing of vegetable if the market price in the previous season was higher.

Other similar studies in SSA include Tirra (2019) who emphasized the role of household characteristics, including level of education, age of the household head, and farm size, as well as the influence of factors such as access to extension services, the price and quantity of cassava products. For instance, Onya (2016) found that marital status positively influenced household participation in the cassava value chain. This implies that households headed by married people are more likely to participate in the cassava value chain than households for the unmarried. Emerole et al. (2014) suggest that activities involved in cassava production on one side require support of household labour and on the other side, the enterprise generates attractive returns which are enough to help households cushion the effect of food and financial insecurity associated with married life.

On the other hand, Nwachukwu (2020) found that age negatively influences household participation in the cassava value chain. This suggests that as households age, their participation in the cassava value chain diminishes. Enete (2005) stresses that labour is a major influencing factor in household participation in the cassava value chain. The use of hired labour is crucial for cassava production growth since cassava root yield responds positively to the application of hired labour (Enete, 2005). Both Tirra (2019) and Onya (2016) attest that labour plays a huge role throughout the value chain of cassava. Olaoma and Molnar (2022) suggests that households with high household sizes are more likely to participate in the cassava value chain than households with low household sizes. This is motivated by the fact that households with many people residing in one household have available labour to participate in the cassava value chain. Olaoma and Molnar (2022) found that the level of education for the household head positively influences households to participate in the cassava value chain. Households with high education have the ability to process information, allowing farmers to have better access to understanding and interpreting information. Randela et al. (2008) attest that being educated comes in handy for cassava producers as it reduces search, screening, and information costs. However, Tirra (2019) found contradicting results that the level of education of the household head negatively affects participation in the cassava value chain. Contradicts exist in literature in relation to the factors influencing household participation in cassava value chain. Oyoke et al. (2010) stress that educated household heads are more likely to be self-sufficient, hence the likelihood of not participating in the cassava value chain.

On the other hand, distance to the market is another important factor influencing participation in the cassava value chain. Onya (2016) found that the distance to the

market place negatively influences participation in the cassava value chain since close proximity to the market will offer more opportunities to actively participate in the market without having to incur additional costs like transportation. Furthermore, the gendered nature of the cassava value chain is also a significant factor, with Masamha (2018) noting the dominance of men in high-value nodes such as marketing. Weak linkages within the cassava value chain, highly gendered with women dominating production and processing nodes but being less integrated into high-value nodes such as marketing and transportation to lucrative markets (Masamba, 2018). Cassava processing is mainly conducted by women at the household level and within small-scale cooperatives. While men play a prominent role in the control of resources, marketing, and income (Masamba, 2018). The potential for cassava commercialization in South eastern Africa is explored by Haggblade (2012), who identifies the need for strategic investment in public goods. On the other hand, Anaglo (2011) underscores the importance of livelihood features, such as access to credit and transport facilities, in influencing the adoption of new technologies in the cassava value chain. Literature on cassava participation in Sub-Saharan Africa argues that most studies are conducted in specific counties, which may limit the generalizability of the findings to other regions, thus requiring similar studies to be undertaken in similar regions.

In the South African context, literature on the factors affecting household participation in the cassava value chain has been largely missing. This is despite scholars such as Masamba et al. (2018) and Tirra (2019) emphasizing the importance of determining the factors driving cassava market participation in different regions and countries in Sub-Saharan Africa, considering different geographical dynamics across Sub-Saharan Africa. Recently, Manganyi et al. (2024) argued that cassava production and its marketing in South Africa are by far much lower than the other traditional starch crops such as maize, potatoes, and wheat. The current low level of cassava production in South Africa and the fragmented marketing mechanisms are attributed to several factors, such as market access constraints and an undeveloped value chain in general (Amelework et al., 2021). Scholars argue that higher cassava productivity can increase the quantity available for sale, thereby leading to higher sales by volume and potentially a higher accrued income to farmers (Adejuwon and Agundiminegha, 2019; Otim et al., 2021). Therefore, there is a need to assess the determinants of household participation in the cassava value chain in South Africa.

3. Research methodology

3.1. Study area and data collection

This study was conducted across multiple districts in three provinces in South Africa, namely KwaZulu-Natal, Limpopo, and Mpumalanga. A multi-stage sampling approach was used to select the respondents for the study. Firstly, the provinces were purposively selected due to their significance in cassava production and their distinct geographical, climatic, and socio-economic characteristics (Manganyi et al., 2023). Moreover, it is in these provinces where cassava experimental trials were conducted by the ARC (Amelework et al., 2022, 2023). Then, the study purposively selected farmers randomly based on their involvement in cassava cultivation and representation from various districts within the three provinces. In KwaZulu-Natal province, data

were collected from the uMkhanyakude and King Cetshwayo district municipalities, while in Limpopo province, data was collected from the Mopani district in the local municipalities of Giyani, Tzaneen, Greater Letaba, and Ba-Phalaborwa. On the other hand, in Mpumalanga province, data was collected from farmers in Bushbuckridge local municipality in the Ehlanzeni district. The above-mentioned district municipalities are the major cassava producing areas within the respective province. In total, 240 cassava farmers were selected for the study using a purposive sampling technique.

A semi-structured questionnaire was developed to gather both qualitative and quantitative data from cassava farmers. The questionnaire comprised open-ended and closed-ended questions to allow for in-depth responses while ensuring standardized data collection. The questionnaire was designed to capture the socio-economic factors and demographics of farmers as well as several aspects and levels of participation in the cassava value chain, such as cultivation practices, marketing, processing and income generation. Local enumerators were trained on the questionnaire and interview techniques. Ethical considerations and informed consent procedures were emphasized. Enumerators visited selected districts and interviewed cassava farmers. Face-to-face interviews allowed for clarification of responses and building rapport. Regular check-ins and meetings were held to ensure data quality and consistency. Field supervisors provided oversight to address any issues encountered during data collection. Collected data was cross-validated through spot-checks and re-interviews in some cases.

3.2. Analytical framework and empirical estimation

Farmers are regarded as utility maximizers, hence, the decision for farmers participation in the value chain is made when the perceived utility or net benefit of participating in the value chain is significantly greater than that of not participating. Although the utility is not directly observed, the actions of farmers or households are often observed through the choices they make.

If U_i and U_j are assumed to represent farmers perceived utility for two choices i and j, respectively. Also, assume that X_i and X_j represents vectors of exogeneous variables that influence the perceived desirability of participating in the value chain for interest i and j. Following from previous research (Greene, 2003; Yirga et al., 2015), the linear random utility function can be specified as the following Equation (1) below:

$$U_i = \beta_i X_i + \varepsilon_i \text{ and } U_j = \beta_j X_j + \varepsilon_j \tag{1}$$

where β_i and β_j are coefficients to be estimated and ε_i and ε_j are the error terms. The error terms are both assumed to be distributed independently and identically.

$$U_{ij}\left(\beta_j X_i + \varepsilon_j\right) > U_{ik}(\beta_k X_i + \varepsilon_k), k \neq j \tag{2}$$

$$\begin{aligned} P(Y = 1 \mid X) = P\left(U_{ij} > U_{ik}\right) &= P(\beta_i X_i + \varepsilon_i - \beta_k X_i + \varepsilon_i > 0 \mid X) \\ &= P\left(\beta_j X_i - \beta_k X_i + \varepsilon_j - \varepsilon_k > 0 \mid X\right) \\ &= P\left(\beta^* X_i + \varepsilon^* > 0 \mid X = F(\beta^* X_i)\right) \end{aligned} \tag{3}$$

where P is a probability function, while U_{ij}, U_{ik}, and X_{ij} are as defined above. On the other hand, $\varepsilon^* = \varepsilon_j - \varepsilon_k$ is the random error term, $\beta^* = \beta_j - \beta_k$ is a vector of unknown coefficients which can be interpreted as the net influence of the vector of exogeneous variables influencing farmers interest in participating in the cassava value chain, and $F(\beta^* X_i)$ is the cummulative distribution function of ε^* evaluated at $\beta^* X_i$. The exact distribution of F depends on the distribution of the random error term ε^*.

The analysis of a household's decision to participate in the cassava value chain requires the use of a multivariate (instead of a univariate) modeling framework to account for the multiple choices of participation in the value chain, and the possibility of simultaneity of the decision-making process. Hence, this study employed the multivariate probit (MVP) model to assess farmers decision to participate in the cassava value chain. The MVP model is a statistical model used when you have multiple binary outcomes that are correlated. The model is an extension of the probit model, allowing for the joint estimation of multiple equations (Greene, 2003; Yirga et al., 2015).

This MVP model allows for the correlation between the binary outcomes, providing a more realistic representation of the underlying relationships in the data. Thus, in the MVP estimated in this study, the farmers choice of participating in particular level in the cassava value chain to a binary choice (yes/no) equation and the choices are modeled jointly while accounting for the correlation among disturbances. Yirga et al. (2015) argues that model estimates from the multivariate specification are superior than those from univariate specifications when the error correlations are significantly different from zero, or else the two model specifications would yield similar results.

Consequently, if a farmer has M choices of level of participating in the value chain, M equations each describing a latent endogenous variable that corresponds to the observed binary outcome for each choice would be needed to be estimated simultaneously. Following Cappellari and Jenkins (2003) as cited by Yirga et al. (2015), a system of simultaneous probit equations to be constructed for level of participation in the cassava value chain for food consumption, selling cassava tubers, and selling cassava cuttings will be classified as follows:

$$Y^*_{(im)_i} = B_m X_{im} + \varepsilon_{im} \tag{4}$$

$$Y_{im} = 1 \text{ if } Y^*_{im} > 0 \text{ and 0 otherwise}$$

ε_{im}, m = 1, …, M are error terms distributed as multivariate normal, each with a mean of zero, and variance–covariance matrix V, where V has values of 1 on the leading diagonal and correlations $\rho_{jk} = \rho_{kj}$ as off-diagonal elements. If ε_{im} is assumed to be idenpendently and identically distributed with a univariate normal distribution, then Equation (4) defines M univariate probit models. This assumption of the independent distribution of error terms means that the information of farmers choice of the level of participation in the cassava value chain does not affect the prediction of the same farmers' probability of choosing another level of participation in cassava value chain. Therefore, if the unobserved correlations among outcomes are ignored, the whole set of

M equations in (4) could be estimated separately as univariate probit models. However, if the correlations are ignored, then the estimates become biased and inefficient.

Hence, the most important hypothesis to tested was to determine if all the M cross-equations simultaneously equate to zero. According to Hausman (1978), the most popular diagnostic test for the null hypothesis of zero correlation across equations is the Wald test. Therefore, if there is no substantial evidence to reject the null hypothesis, the conclusion is that the choices are independent. This implies that the M independent univariate probit models could be fitted independently of each level of participation in the cassava value chain. Conversely, if the null hypothesis is rejected, then the estimation of the M independent univariate probit equations for each level of participation in the value chain would result to inefficient estimates and thus, there will be a need for the simultaneous estimation of all M equations as shown in (4).

3.3. Definition of variables

Table 1. Definition of variables used in the regression.

Variable	Description	Values
Dependent variables		
Food Consumption	Interested in participating in the cassava value chain for consumption	1 = Yes; 0 = No
Selling Cassava Tubers	Interested in participating in the cassava value chain for selling cassava tubers	1 = Yes; 0 = No
Selling Cassava Cuttings	Interested in participating in the cassava value chain for selling cassava cuttings	1 = Yes; 0 = No
Independent variables		
Agricultural Land Size	Land under agricultural production in hectares (ha)	
Farming Experience	Farming experience in years	Number of years
Livestock Ownership	Farmers livestock ownership status	1 = Yes; 0 = No
Household Size	Number of people living within the farming household	Number
Marital Status	Marital status of the household head	1 = Yes; 0 = Otherwise
Gender	Household head gender	1 = Male; 0 = No
Age	Household head age	Number of years
Membership to FBO	Membership to farmer-based organization	1 = Yes; 0 = No
Access to Extension Services	Farmers access extension services support	1 = Yes; 0 = No
Land Size Under Cassava in 2021/22	Land under cassava production in the 2021/22 season (ha)	Ha
Hired Labour	Hired labour for cassava production	1 = Yes; 0 = No
Yield	Kilograms per hectare (Kg/ha)	

The endogenous variables considered in the MVP model include three dummy variables relating to farmers' interest to participate in the cassava value chain for food consumption, selling cassava tubers, and selling cassava cuttings, as depicted in **Table 1.** Data were also gathered on several exogenous variables on socio economic factors (i.e., age, gender, education, household size, etc.), farm characteristics (e.g., farm size,

farming experience, etc.), as well as social factors (such as memberships to farmer-based organizations (FBO).

3.4. Ethics statement

This study did not require ethical clearance, especially since right from its inception, representatives of the targeted respondents were fully involved in all project activities and provided input into the questionnaire. Essentially, stakeholders' desire to gain a comprehensive grasp of the dynamics involved along the cassava value chain served as a major driving force behind the study. Moreover, due to the COVID-19 pandemic restrictions, the research team foresaw delays that could have negatively impacted the data collection process. Prior to administering the questionnaire, written informed consent (as provided for on the questionnaire) was sought from each respondent. Furthermore, each respondent was assured that the collected information would only be used for the purpose of the study, and enumerators clarified that participation in this study was voluntary. Based on Afrocentric principles, the data collection process was participatory and facilitated respondents' active participation, which improved their sense of empowerment. To ensure the privacy and confidentiality of respondents' information, as well as to comply with the Protection of Personal Information (POPI) Act, the collected data was anonymized with unique numbers generated using MS Excel.

4. Results and discussion

4.1. Descriptive statistics

A descriptive summary presented in **Table 2** reveals that the average land size devoted for agricultural production is approximately 2.08 hectares (ha), suggesting that these farmers practice smallholder farming. This description aligns with the basic definition of a smallholder farmer by the Food and Agriculture Organization of the United Nations (FAO), which states that smallholders manage or cultivate land ranging from less than a hectare to approximately 10 hectares (FAO, 2013). Regarding farming experience, the majority of sampled farmers were experienced with the average farming experience estimated at about 20.55 years. On average, approximately 64% of sampled farmers own livestock, thereby suggesting that majority of respondents practice mixed farming which contributes to households' resilience against agriculture-related shocks and sustainability in food supply. Moreover, the average household size was estimated at about seven people at a given point in time.

Household size ranged from a minimum of one to 17 people. In terms of marital status and gender distribution, the data shows that only 36% of the respondents were married, and approximately 32% were male. The majority of sampled respondents being female indicates the significant role women play in the cassava value chain and agricultural production at large. This shows the need and importance of gender-sensitive interventions in agricultural development to address the unique challenges faced by female farmers. Empowering women in agriculture can lead to improved productivity and livelihoods, benefiting both women and their communities. The

average age of the respondents was estimated at about 57.8 years. This demographic trend may have implications for succession planning and the future of farming in the cassava producing communities. Additionally, it highlights the need for targeted support and training programs to engage younger farmers and ensure the continuity of agricultural activities.

Membership to a Farmer-Based Organizations (FBOs) was approximately 62%, suggesting a strong sense of collaboration among respondents across cassava producing communities. FBOs play a crucial role in facilitating access to markets, resources, and knowledge sharing, thereby enhancing the overall resilience of farming communities against shocks. Despite the benefits of membership to a FBO, access to extension services remains limited, with only about 11% of respondents having access. Extension services are essential for disseminating agricultural best practices, technological innovations, and market information. The low access rate to extension services suggests the need for improved extension service delivery to support farmers in enhancing their productivity and livelihoods.

Table 2. Descriptive statistics.

Variable	Observations*	Mean	Standard Deviation	Min	Max
Agricultural Land Size	237	2.08	4.08	0	42
Farming Experience	237	20.55	14.37	0	61
Livestock Ownership	237	0.64	0.48	0	1
Household Size	237	7	4	1	27
Marital Status	237	0.36	0.48	0	1
Gender	237	0.32	0.47	0	1
Age	237	57.57	12.69	24	96
Membership to FBO	237	0.62	0.49	0	1
Access to Extension Services	237	0.11	0.32	0	1
Land Size Under Cassava in 2021/22	237	0.66	1.40	0	17
Hired Labour	237	0.34	0.48	0	1
Yield	237	369.05	664.41	0	5000
Farmers consuming cassava	237	0.92	0.27	0	1
Farmers selling cassava tubers	237	0.52	0.50	0	1
Farmers selling cassava cuttings	237	0.03	0.18	0	1

* Whereas 240 respondents were interviewed from KwaZulu-Natal, Limpopo, and Mpumalanga Provinces, South Africa, three questionnaires were incomplete. Thus, data from the 237 full questionnaires was used in the analysis.

The average land size devoted to cassava production was estimated at about 0.66 hectares, with a maximum of 17 hectares, indicating the significant role of cassava cultivation among respondents. However, the majority of respondents grow cassava primarily for household food consumption, accounting for about 92% of the respondents. In contrast, approximately 53% of respondents cultivate cassava with the intention of selling fresh cassava tubers. Furthermore, only a small percentage of farmers participate in the cassava value chain for selling cassava cuttings or planting material, with about 3% engaging in such activities. Approximately 34% of respondents were hiring labour for cassava production. Cassava production entails

various activities such as land preparation, planting, weeding, and harvesting. These activities are laborious, especially for larger farms or when farmers have limited family labour to work on the farm. Hiring labour allows farmers to manage these tasks more efficiently, ensuring timely cultivation and harvesting of the crop.

Additionally, hiring labour may also be necessary to meet increased production demand or to address labour shortages during peak farming seasons. The average yield of fresh cassava tubers was estimated at about 369.05 kg/ha, with considerable variability ranging from 0 kg/ha to about 5000 kg/ha. This variability in yield may be influenced by factors such as farming practices, using recycled propagation materials, limited access to inputs, and environmental conditions. The results show that the majority of respondents grew cassava for household food consumption, accounting for about 92% of the sampled farmers. Very few respondents (3%) participate in the cassava value chain with the interest of selling cassava cuttings or planting material.

4.2. Empirical results and discussion

This study used multivariate probit (MVP) analysis to investigate the determinants of household participation in the cassava value chain in South Africa. Prior to the empirical analysis of the determinants, the possibility of multicollinearity amongst the exogenous variables was tested using the Variance Inflation Factor (VIF). **Table 3** shows the VIF test results for multicollinearity among the explanatory variables. The mean VIF of 1.28 is less than 10, indicating that variables used in the specified model are not affected by multicollinearity.

Table 3. VIF test results for multicollinearity.

Variable	VIF	1/VIF
Agricultural Land Size	1.45	0.6919
Age	1.49	0.6695
Farming Experience	1.54	0.6504
Livestock Ownership	1.16	0.8651
Household Size	1.19	0.8401
Marital Status	1.25	0.8016
Gender	1.25	0.8020
Membership to FBO	1.26	0.7938
Access to Extension Services	1.16	0.8645
Land Size Under Cassava in 2021/22	1.29	0.7776
Hired Labour	1.27	0.7901
Yield	1.13	0.8834
Mean VIF	1.28	

According to the results of the Wald test presented in **Table 4**, the null hypothesis that all coefficients in each of the equations of the dependent variables are jointly equal to zero was rejected. The test statistic for the Wald test for the overall significance of the model was found to be significant at 1% level (p-value = 0.0002). This means that variations in the exogenous variables included in the model explain significant portions of the variations in the dependent variables. Moreover, the likelihood ratio

test statistic was statistically significant at 5% level of significance, further indicating that univariate models were inappropriate and the multivariate probit specification was the best fit for the data.

The analysis focused on three dependent variables: (i) household participation in selling cassava tubers; (ii) household participation in selling cassava cuttings; and (iii) household consumption of cassava. These variables were chosen to capture different aspects of household engagement in the cassava value chain, including commercial activities (selling tubers and cuttings) and subsistence consumption (household consumption) unlike work by Manganyi et al. (2023). Whereas the study examined how various factors influence households' decisions to participate in these aspects of the cassava value chain, the discussion of results draws much focus on significant results.

Table 4. Multivariate probit estimates and marginal effects for the determinants of farmers participation in the cassava value chain in South Africa.

	Food Consumption			**Selling Cassava Tubers**			**Selling Cassava Cuttings**		
	Coefficient	**Standard Error**	**Marginal Effect**	**Coefficient**	**Standard Error**	**Marginal Effect**	**Coefficient**	**Standard Error**	**Marginal Effect**
Agricultural Land Size	–0.0283	0.0301	–0.0035	–0.0412	0.0255	–0.0162	–0.0100	0.0677	–0.0003
Farming Experience	0.0004	0.0119	0.0002	–0.0027	0.0077	–0.0011	–0.0275*	0.0159	–0.0009
Livestock Ownership	0.6732**	0.2868	0.0757	–0.0218	0.2019	–0.0062	–0.4202	0.4179	–0.0116
Household Size	0.0287	0.0450	0.0029	0.0042	0.0271	0.0025	–0.0319	0.0691	–0.0011
Marital Status	–0.1649	0.2947	–0.0154	–0.3456*	0.2057	–0.1447	–0.1142	0.4676	–0.0040
Gender	0.1055	0.3140	0.0137	–0.1095	0.2157	–0.0461	0.2434	0.4944	0.0086
Age	0.0118	0.0127	0.0012	–0.0279***	0.0090	–0.0113	0.0219	0.0161	0.0007
Membership to FBO	–0.5288	0.3266	–0.0608	0.2188	0.2079	0.0910	–0.1803	0.4628	–0.0091
Access to Extension Services	–0.0684	0.3928	–0.0101	0.2549	0.3302	0.1169	0.3705	0.6191	0.0102
Land Size Under Cassava in 2021/22	–0.0001	0.0946	–0.0006	0.0206	0.0787	0.0075	–0.1650	0.3480	–0.0047
Hired Labour	–0.2997	0.2868	–0.0303	0.6156***	0.2184	0.2543	0.8544*	0.4388	0.0226
Yield	–0,0001	0.0001	–0.0000	0,0007***	0.0002	0.0003	–0.0013	0.0011	–0.0000
Constant	0.8078	0.6898		1.3605	0.5112		–2.1385	0.9866	
Observations	237								
Wald Test (36)	73.12***								
Likelihood Ratio Test	7.75**								
Mean VIF	1.28								

NB: Statistical significance: * at 10%; ** at 5%; *** at 1%. FBO stands for Farmer Based Organization.

Table 4 illustrates the estimated coefficients of the MVP regression model for the determinants of farmers participation in the cassava value chain as well as the corresponding marginal effects. In accordance with a priori expectations, farmers' livestock ownership status had a statistically significant positive influence on the farmers interest in participating in the cassava value chain for household food consumption. The likelihood of a farmer growing cassava for food consumption would increase by 7.5% if the farmer owns livestock. Among the wide variety of cassava uses, the crop is also widely used for feeding livestock, hence the observed positive relationship between growing cassava for food consumption and owning livestock. If

the household consumes fresh cassava tubers, cassava leaves can be fed to livestock or vice versa. However, the variable was found to be negative and insignificant for farmers who sell tubers and cuttings. This suggests that farmers prioritize using cassava for feeding livestock and household consumption over selling it commercially. Our findings resonate with the study conducted in Ghana, where it was revealed that 65% of farmers participated in at least two cassava value-addition practices, primarily to enhance the marketability of their produce (Bosompem et al., 2024). The main value addition that farmers engaged in were strategic sale of tubers to processors, retailers, or consumers; storage of tubers; and collective transportation of cassava products.

In terms of farmers' participation in the cassava value chain with an interest of selling cassava tubers, having hired labour for production purposes, as well as cassava yield realized in the previous season exhibited statistically significant positive influences on the farmers interest in selling cassava tubers. The results shows that a unit increase in cassava yield as well as hiring labour for cassava production increases the likehood of growing cassava for selling tubers by 0.03% and 25.4%, respectively. This is because cassava production is labour intensive (Masamha et al., 2018). Findings imply that the use of hired labour significantly increases the likelihood of participating in these commercial aspects of the value chain. Yield exhibited a statistically significant positive effect at 1% level among respondents who sell cassava tubers, but results were not significant for respondents who produce cassava for food consumption and for the selling cuttings. This suggests that it is possible that farmers prioritize using higher yields for sale rather than for household consumption or processing into cuttings, which may require different qualities or varieties of cassava. Additionally, the insignificant findings for respondents who sell cassava cuttings might be interpreted in such a way that the market for cassava cuttings is less responsive to variations in yield compared to the market for cassava tubers.

Age was found to be negative and significant at the 1% level among respondents who sell cassava tubers but insignificant among those who produce cassava for either food consumption or to sell cassava cuttings. This suggest that older farmers are less likely to participate in the commercial sale of cassava tubers by 1.13% as for each year they become older. This aligns with the broader context of smallholder farming, where access to mechanization is limited, and manual labor plays a crucial role in agricultural activities. Older farmers may face challenges in meeting the labor demands of cassava production, which might explain the observed negative and significant effect of age on the likelihood of respondents who sell cassava tubers. Comparing selling cassava activities to the commercialization dependent variable used by Otekunrin et al. (2022), they find that commercialization of cassava farming is driven by factors such as the age of farmers, farm size, distance to markets, marketing experience, and access to healthcare. Younger farmers with larger farms, more years of marketing experience, and better access to healthcare are more likely to achieve higher levels of commercialization, while older farmers and those with smaller farms tend to commercialize less. Additionally, longer distances to markets are surprisingly linked to higher commercialization levels, highlighting the complexity of market dynamics in cassava farming.

In contrast, farmers' marital status was found to be negative and statistically significant in influencing farmers' interest in selling cassava tubers. If a farmer was

married, the likelihood of participating in the cassava value chain with keen interest to sell tubers decreased by 14.5%. Marital status was significant at the 10% level for respondents who produce with the aim of selling the tubers. This finding suggests that being married reduces the likelihood of respondents engaging in the commercial sale of cassava tubers. The finding also implies that married respondents may prioritize other aspects of their livelihoods or have different risk preferences compared to their unmarried counterparts, leading to a lower propensity to sell cassava tubers. Married farmers may be more inclined to focus on meeting household needs or may have other sources of income, hence reducing their reliance on income generated from the selling of cassava tubers. Additionally, married respondents may have more responsibilities and commitments, such as caring for family members, which could limit their time and resources available for engaging in commercial activities like selling cassava tubers. Marital status can also be explained in the aspect of gender. Masamha et al. (2019) shows that one major factor regarding gender is the discrepancy in the high proportion of single female household heads, mainly through divorce or from being widowed. Although women tended to have smaller numbers of dependents, single parents are likely to have many additional responsibilities that would affect the time available for cassava production and marketing.

In terms of farmers interested in selling cassava cuttings, farming experience and hiring labour had statistically significant influence but with different effects. The results show that an increase in farmers' farming experience had a statistically significant negative influence on the probability of a farmer being interested in selling cassava cuttings at the 10% level. A unit increase in farming experiences reduces the probability of selling cassava tubers by 0.09%. The significant result suggests that more experienced farmers are less likely to engage in selling cassava cuttings unlike less experienced farmers. On the other hand, hiring labour for cassava production had a positive and statistically significant influence on farmers interest in selling cassava tubers. This finding aligns with the study by Mugonola et al. (2017), which shows that marketing experience, education level, and land allocated to cassava production and group marketing significantly increase the sales revenues of processed cassava products. Employing hired labour on farm increases the probability of a farmer's interest in selling cassava tubers by 2.3%. Findings imply that the use of hired labour significantly increases the likelihood of participating in commercial aspects of the cassava value chain.

Membership to a Farmer Based Organization (FBO) was not statistically significant across all the different categories of respondents, i.e. those who produce cassava for either food consumption or selling cassava tubers or selling cassava cuttings. Our findings are in contrast with Otekunrin et al. (2022) who note that being a member of an association positively influences cassava commercialization. For now, FBOs may not provide significant market access or marketing support specifically for cassava products, especially that the cassava value chain is still at its infancy level of development and uncoordinated. Respondents expressed that to gain access to markets, they rely more on personal networks or other channels to sell their produce. Also, access to extension services was not statistically significant for any of the dependent variables, thereby suggesting that at the current level of development of the value chain, extension services do not significantly influence farmers' decisions to

participate in the value chain. This suggests that the quality and relevance of the information provided by extension services do not meet the specific needs or challenges faced by cassava farmers.

Additionally, the outreach of extension services may be limited, leading to a low level of engagement with farmers. Moreover, farmers may have access to alternative sources of information, such as peers, agro-dealers, or online resources, which could diminish the relative importance of extension services. Furthermore, resource constraints within extension services, such as limited staffing or funding, also limit their effectiveness in reaching and supporting cassava farmers, since cassava is not among prioritized crop enterprises at provincial departments of agriculture. Notably, the coefficients for agricultural land size and the size of land under cassava cultivation were found to be statistically insignificant for food consumption, selling cassava tubers, or selling cassava cuttings. Therefore, implying that these factors may not necessarily influence respondents' participation in the cassava value chain. Similarly, Otekunrin et al. (2022) did not find any significant relationship between access to extension services and commercialization of cassava.

5. Limitations of the study and areas for further research

The study is cognizant of the following limitations. First, the study was based on cross-sectional data, which limits the ability to track changes over time on how cassava producers have been participating in the value chain. Second, the analysis does not take into consideration of the entrepreneurial mindset of the respondents. This is fundamental since it might have a bearing on the interpretation of the results. Third, the study was limited to respondents in the major cassava farming communities in each of the three provinces, thus the results may not be generalized to the entire province(s). Moreover, other value chain role players like the traders who are predominantly found in cities and urban areas far away from the production communities were not included in the study. For instance, Gauteng province-based traders who import various cassava products from neighbouring countries (Lubinga et al., 2024) were not considered in this study.

For further research, there is a need to undertake a more in-depth study of the market chain of cassava to gain a better understanding of the link between the different value chain actors, including farmers, traders and consumers. Furthermore, the study might assist in identifying and prioritization of cassava products to be embarked on for processing into high value products, taking into consideration of the most vulnerable demographic groups like women and youth.

6. Conclusion

The aim of this study was to analyze the determinants of household participation in the cassava value chain in South Africa. The study employed the MVP model, using a primary dataset of 240 respondents collected through a multi-stage but simple purposive sampling method from smallholder farmers in KwaZulu-Natal, Mpumalanga, and Limpopo provinces. The results of the analysis provide valuable insights into the determinants of household participation in the cassava value chain in South Africa as well as insights into appropriate policy recommendations and

interventions required to further develop the cassava value chain in South Africa, while at the same time bolster smallholder farmers' level participation.

The study concludes that livestock ownership positively influences the likelihood of farmers participating in the cassava value chain by growing cassava for household food consumption. Additionally, hiring labour for cassava production and an increase in yield from the previous season boost the probability of farmers' interest in selling cassava tubers. Conversely, being married and older reduce the likelihood of farmers having an interest in selling cassava tubers. Furthermore, the study notes that hiring labour on the farm increases the likelihood of participating in the cassava value chain with a focus on selling fresh cassava tubers, while greater farming experience reduces the interest in selling cassava cuttings.

Based on the findings of the study, the following recommendations are proposed to enhance farmers' participation in the cassava value chain. First, it is essential to support farmers in accessing affordable hired labour through interventions that promote cooperative labour arrangements and provide training on effective labour management practices. Additionally, policy interventions that empower farmers to increase their cassava yields like increased land tenure security can encourage greater engagement in the cassava value chain, particularly with an interest in selling fresh tubers for income generation.

Furthermore, programs that empower and encourage youth participation in the cassava value chain are crucial, since they can significantly increase the number of farmers interested in selling fresh cassava tubers. Promoting integrated farming systems, where cassava is used as commercial livestock feed, can also offer multiple benefits and enhance overall agricultural productivity. Lastly, to support older farmers and ensure their continued engagement in the cassava value chain, it is important to provide access to labour-saving technologies, support for succession planning, and training on market opportunities to cater for the specific needs and limitations of older farmers. These interventions are expected to contribute to the sustainable development of the cassava value chain in South Africa.

Author contributions: Conceptualization, BZ and MHL; methodology, BZ; software, BZ; validation, MHL, BZ, TN and BM; formal analysis, BZ and MHL; investigation, MHL, BZ, TN and BM; resources, MHL; data curation, BZ and MHL; writing—original draft preparation, BZ; writing—review and editing, MHL, BZ, TN and BM; supervision, MHL; project administration, MHL; funding acquisition, MHL. All authors have read and agreed to the published version of the manuscript.

Conflicts of Interest: The authors declare no conflict of interest.

References

Adebayo, W. G. (2023). Cassava production in Africa: A panel analysis of the drivers and trends. Heliyon, 9(9).

Amelework A. B., Bairu M. W., Marx R., et al. (2023). Genotype × Environment Interaction and Stability Analysis of Selected Cassava Cultivars in South Africa. Plants, 12(13), 2490. https://doi.org/10.3390/plants12132490

Amelework A. B., Bairu M. W., Marx R., et al. (2022). On-Farm Multi-Environment Evaluation of Selected Cassava (Manihot esculenta Crantz) Cultivars in South Africa. Plants, 11(23), 3339. https://doi.org/10.3390/plants11233339

Amelework, A. B., Bairu, M. W., Maema, O., et al. (2021). Adoption and promotion of resilient crops for climate risk mitigation and import substitution: A case analysis of cassava for South African agriculture. Frontiers in Sustainable Food Systems, 5, 617783.

Anaglo, J. N. (2011). Understanding the influence of livelihood features on cassava value chains [PhD thesis]. University of Greenwich.

Ao, X. H., Vu, T. V., Le, K. D., et al. (2019). An analysis of the smallholder farmers' cassava (Manihot esculenta Crantz) value chain through a gender perspective: the case of Dak Lak province, Vietnam. Cogent Economics & Finance, 7(1). https://doi.org/10.1080/23322039.2019.1645632

Bosompem, M., Arhin, P., Nunoo, J., Amoah, K. K. (2024). Smallholder farmers' participation in Cassava value addition practices: What drivers matter in Ghana? Journal of Agriculture and Food Research, 16, 101120.

Cereda, M. P., Vilpoux, O. F. (2023). Starch Industries: Processes and Innovative Products in Food and Non-Food Uses. Elsevier.

Chisenga, S. M., Workneh, T. S., Bultosa, G. et al. (2019). Progress in research and applications of cassava flour and starch: A review. Journal of Food Science and Technology, 56, 2799–2813. https://doi.org/10.1007/s13197-019-03814-6

Department of Science and Technology (DST) (2015). The Bio-economy: Agricultural sector implementation plan (Draft as at April 2015). Department of Science and Technology (DST).

Emerole, C. O., Nwachukwu, A. N., Anyiro, C. O., et al. (2014). Cassava entrepreneurship and gender participation in Udi local government area of Enugu State, Nigeria. Scientific Papers Series Management, Economic Engineering in Agriculture and Rural Development, 14(1), 127–137.

Enete, A. A., Igbokwe, E. M. (2009). Cassava market participation decisions of producing households in Africa. Tropicultura, 27, 129–136.

Enete, A. A., Nweke, F. I., Tollens, E. (2005). Hired labour use decisions in cassava-producing households of sub-Saharan Africa. Agricultural economics, 33(3), 269–275.

FAO. (2013). Family Farming Knowledge Platform: Smallholders and Family Farmers. Available online: https://www.fao.org/docrep/018/ar588e/ar588e.pdf (accessed on 30 August 2024).

Greene, W. H. (2003). Econometric analysis fifth edition. Prentice Hall.

Gunathilake, I. A. D. S. R., Somendrika, M. A. D. (2024). Development of a biodegradable packaging with antimicrobial properties from cassava starch by incorporating Ocimum tenuiflorum extract. Food Chemistry Advances, 4, 100658.

Haggblade, S., Andersson Djurfeldt, A., Banda Nyirenda, D., et al. (2012). Cassava commercialization in Southeastern Africa. Journal of Agribusiness in Developing and Emerging Economies, 2(1), 4–40.

Hausman, J. A. (1978). Specification tests in econometrics. Econometrica: Journal of the econometric society, 46(6), 1251–1271.

Hegena, B., Teshome, A. (2022). Vegetable market supply by small holder farmers in Ethiopia. Cogent Social Sciences, 8(1), 2057058.

Howeler, R. (2006). Cassava in Asia: Trends in cassava production, processing and marketing. World, 203(18475), 11–02.

Lubinga, M. H., Rambau, M. D., Shiba, W. (2024). Cassava database version 1. Funded through the Agricultural Bio-Economy Innovation Partnership Programme (ABIPP)–Grant No. 2021/FUN116/AA. Available online: https://www.namc.co.za/about-cassava-project/statistics/trade-data/ (accessed on 30 August 2024).

Lukhele, J. C., Tsvakirai, C. Z., Tshehla, M. (2023). Determining the drivers and deterrents of climate-smart crop adoption: The case of cassava in Mpumalanga Province, South Africa. Journal of Agribusiness and Rural Development, 4(70), 391–400.

Manganyi, B., Lubinga, M. H., Zondo, B., Tempia, N. (2023). Factors Influencing Cassava Sales and Income Generation among Cassava Producers in South Africa. Sustainability, 15(19), 14366.

Masamha, B., Thebe, V., Uzokwe, V. N. (2018). Mapping cassava food value chains in Tanzania's smallholder farming sector: The implications of intra-household gender dynamics. Journal of Rural Studies, 58, 82–92.

Masamha, B., Uzokwe, V. N, Ntagwabira, F. E., et al. (2019). Gender influence on participation in cassava value chains in smallholder farming sectors: evidence from Kigoma region, Tanzania. Experimental Agriculture, 55(1), 57–72.

Mudombi, C. R. (2010). An Ex-Ante Economic Evaluation of Genetically Modified Cassava in South Africa (Order No. 30716225). Available online: https://www.proquest.com/dissertations-theses/ex-ante-economic-evaluation-genetically-modified/docview/2901811920/se-2 (accessed on 30 August 2024).

Mugonola, B., Ajok, W., Ongeng, D. (2017). Determinants of market participation for smallholder cassava processors in north and north-eastern Uganda. African Journal of Rural Development, 2(4).

Murathi, K. N. (2018). Determinants and welfare effect of smallholder farmers' commercialization in Kenya. Kenya Institute for Public Policy Research and Analysis.

Nwachukwu, C. N. (2020). Determinants of market participation among small holder cassava processors in Ikwuano local government area of Abia State, Nigeria. Nigeria Agricultural Journal, 51(1), 5–9.

Okoye, B. C., Onyenweaku, C. E., Ukoha, O. O. (2010). An Ordered Probit Model Analysis of Transaction Costs and Market Participation by Small-Holder Cassava Farmers in South-Eastern Nigeria. Nigerian Agricultural Journal, 41(2).

Olaomo, O. K., Molnar, J. J. (2022). Building an Inclusive Value Chain: Gender Participation in Cassava Marketing and Processing in Nigeria. Environmental Sciences and Ecology: Current Research, 3(8), 1078.

Onya, S., Oriala, S., Ejiba, I., Okoronkwo, F. (2016). Market Participation and Value Chain of Cassava Farmers in Abia State. Journal of Scientific Research and Reports, 12(1), 1–11.

Otálora González, C. M., Felix, M., Bengoechea, C., et al. (2024). Development and Characterization of Edible Films Based on Cassava Starch Modified by Corona Treatment. Foods, 13(3), 468.

Otekunrin, O. A., Ayinde, I. A., Sanusi, R. A., Otekunrin, O. A. (2022). Assessing the determinants of agricultural commercialization and challenges confronting cassava farmers in Oyo State, Nigeria. Journal of Socioeconomics and Development, 5(1), 76–87.

Randela, R., Alemu, Z. G., Groenewald, J. A. (2008). Factors enhancing market participation by small-scale cotton farmers. Agrekon, 47(4), 451–469.

Statista. (2023). Leading cassava producing countries worldwide in 2021(in million metric tons). Available online: https://www.statista.com/statistics/1391572/global-leading-cassava-producing-countries (accessed on 30 August 2024).

Tirra, A. N., Oluoch-Kosura, W., Nyanganga, H., Mwang'ombe, A. W. (2019). Determinants of Participation Decision in Cassava Marketing by Smallholder Farmers in Taita-Taveta and Kilifi Counties, Kenya. Journal of Agricultural Science, 11(17), 98.

Yirga, C., Atnafe, Y., Aw-Hassan, A. (2015). A multivariate analysis of factors affecting adoption of improved varieties of multiple crops: A case study from Ethiopian highlands. Ethiopian Journal of Agricultural Sciences, 25(2), 29–45.