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DETERMINING THE DRIVERS AND DETERRENTS OF CLIMATE-SMART CROP ADOPTION: THE CASE OF CASSAVA IN MPUMALANGA PROVINCE, SOUTH AFRICA

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Abstract. Climate change and its perilous effect on the food security of Sub-Saharan African countries has resulted in a call for more investment in what has become known as climate-smart crops, such as cassava, which promote sustainable agricultural production. This study investigated the factors that could deter and drive the adoption of cassava among smallholder farmers in Mpumalanga Province in South Africa. Using data collected from a sample of 120 smallholder farmers, this study ran a binary regression model probing farmers' willingness to participate in the commercial production of cassava. The study's findings concur with past research and reiterate that farmers' knowledge of technical factors are key determinants of the growth in cassava production and commercialization. The study recommends that efforts be made to develop programs that empower farmers with production knowledge and skills to advance the development of the cassava industry. It contributes to literature by highlighting the role of cultural norms (unwritten rules in society) on crop commercialization and how, in this case, they could provide a unique opportunity that can be used to advance women's participation in agriculture.

Keywords: sustainable agriculture, climate change adaptation, culture and African agriculture, commercialization, agricultural extension, farmers' perceptions

INTRODUCTION

Globally, the agricultural sector is one of the industries that uses most of the water resources in a country. In South Africa, the sector utilizes more than 50% of the available water (Fanadzo et al., 2010). The sector occupies a central part of the country's economy where it is a critical producer of food and fiber, an employment and vocation creator, and a foreign currency earner. However, the high occurrences of droughts and changing rainfall patterns experienced in the country have shone a spotlight on the need to improve the use and management of water in this water-consuming industry (Chipfupa and Wale, 2018; Ngobeni and Nkosi, 2023). The situation is dire as South Africa is currently categorized as a water-stressed country and is forecast to experience physical water scarcity by the year 2025 with an annual freshwater availability of less than 1000 m^3 per capita (McNally et al., 2019). Such grave predictions have resulted in investigations into various ways of enabling more prudent ways of using the resource (Hlatshwayo et al., 2023). Various studies have investigated ways to develop and adopt water-saving infrastructure, irrigation systems, production technologies, farming practices, food systems, and crop varieties (Khantri-Chhetri et al., 2017; Manganyi et al., 2023).

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One such water-saving crop that has been promoted as having unexplored potential in addressing the forthcoming water insecurity is cassava (Abass et al., 2017). According to FAO (2018), there has been wide recognition of cassava as a choice crop in the context of climate change adaptation strategies, particularly in eastern and southern African countries that regularly endure sustained periods of drought. Cassava has been reported to have the smallest water footprint (21 m3/GJ) when compared to other staple crops (Wang et al., 2011). According to Olasanmi (2015) and Dankor et al. (2022), it has the ability to thrive in drought conditions and requires low input of agrochemicals. When compared with other staple crops (maize, wheat, rice, potatoes, and sweet potatoes), cassava has the highest yielding of carbohydrates per hectare (4.742 kg/carb). It is also the most adapted to all ecological zones and is better adapted to production in poor soils (Okudoh et al., 2014; Nassar and Ortiz, 2010). These facts make cassava a competitive alternative.

Despite its various valuable attributes, cassava production has not gained popularity in South Africa (Ngobeni and Nkosi, 2023). Limited quantities of cassava are grown by smallholder farmers as a secondary crop which is used to produce food, industrial starch, and/or animal feed (Ogola et al., 2013; Hlatshwayo et al., 2023). Much research in the Natural Sciences fields (i.e., breeding, agronomy, crop protection, and post-harvest studies) has been done on the technical reasons for the low adoption of cassava, and numerous solutions on how to ameliorate this state of affairs have been provided; however, research which investigates the social aspects remains outstanding (Mudombi, 2010; Amelework et al., 2021). This is a critical gap in research as social aspects such as age, experience, education, and gender have been reported to affect the adoption of climate-smart crops. Specifically, the influence of institutions on adoption has received limited attention. Mutyaba et al. (2016) investigated the influence of formal policy institutions but did not venture into probing the influence of society's informal institutions or societal norms on cassava production. Societal norms (i.e., non-written rules in society) which take up forms of societal perceptions, gender biases, and class norms have been highlighted in past studies as influencing the space and pattern of cassava adoption (Nweke et al., 2002; Masamha et al., 2018; Mobio et al., 2021; Dankor et al., 2022) and they could have a significant bearing on the crop's adoption. Hence, this study aims to investigate the influence of informal institutions and other socio-economics factors on farmers' willingness to participate in the commercial production of cassava in Mpumalanga province, South Africa. We hypothesize that these socio-economic factors will have a significant effect on farmers' willingness to participate in the commercial production of cassava.

This study is conducted at an opportune time in South Africa when the government is starting to look into ways of promoting the production and commercialization of cassava. The government's efforts aim to create much-needed economic stimulus in rural economies by filling the unsatisfied domestic industrial starch market, which offers competitive prices when compared to maize, potato, or wheat starch (Amelework et al., 2021). Manganyi et al. (2023) report that the state parastatal, the Agricultural Research Council initiated a process to coordinate the cassava research and development in South Africa in light of the growing importance of the crop. The study is also timely because, Tongaat Hulett Starch, PhilAfrica Foods, and Unilever are looking to improve their sourcing of starch and sorbitol on the African continent. Leveraging from cassava successes in the production of cassava-brewed beer SABMiller and Diageo are also looking to expand their geographic production (Amelework et al., 2022). Hence, this study feeds into these efforts to try and ensure that the socio-economic factors are not overlooked as possible areas that need to be given attention when developing programs that are geared toward increasing cassava adoption. A comprehensive assessment of the factors influencing cassava adoption among South African cassava farmers is critical for informed decision-making, policy formulation, targeted interventions, and the long-term growth of the cassava value chain (Tirra et al., 2019).

METHODS AND MATERIALS

Data for this study were collected in Mbombela municipality, the Mpumalanga province of South Africa. The municipality is located in the lowveld region of the Mpumalanga province which has a sub-tropical climate (average of 27°C (81°F) during hot months and 667 mm of rain per year) that is conducive for cassava production (Ogola et al., 2013). The limited lowveld region in Mpumalanga was suitable for this study because it is home to farmers who have had experience in the commercial production of cassava for the food and industrial starch

market (DAFF, 2010; Amelework et al., 2022). Mbombela municipality is located in the north-eastern part of the Mpumalanga province and is home to the provincial capital, Nelspruit (Mbombela). The Municipality covers an area of 5,394 km^2 and has a population of 44,082 people, made of both urban and rural settlements.

Data were collected using a survey that was administered during one-on-one interviews. The Krejcie and Morgan (1970) method for sample size determination was used to calculate the number of respondents that were suitable to provide a representative sample. Given the population of the Mbombela municipality, a sample of 116 smallholder farmers was determined. One hundred and forty-one responses were collected but after incomplete responses were dropped, the sample size was reduced to 120. Survey participants were identified using two sampling techniques which purposively selected rural wards in the first stage and randomly selected smallholder farmers in the second stage. Data collection was carried out with the aid of a questionnaire that was divided into three sections. The first section contained questions on respondents' demographic information, section two enquired about the information farmers have on cassava, and section three probed about the farmers'

Table 1. Variable descriptions and prior expectations

Variables	Type of variable	Description	Expected sign
Dependent variable			
Willingness to participate in commercial cassava production	Dummy	1 indicates a willingness to participate in commercial cassava production 0 indicates otherwise	
Explanatory variables			
Technical factors			
Farming experience	Continuous	Number of years farming	+/–
Knowledge about cassava	Dummy	1 indicates that respondent agrees they have knowledge about cassava production 0 indicates otherwise	+/–
Institutional factors			
Cassava production suitable for women	Dummy	1 indicates a willingness to participate in commercial cassava production 0 indicates otherwise	+/–
Cassava is farmed by poor people	Dummy	1 indicates that the respondent agrees that cassava is farmed by poor people 0 indicates otherwise	+/–
Cassava is eaten by poor people	Dummy	1 indicates that the respondent agrees that cassava is eaten by poor people 0 indicates otherwise	+/–
Association membership	Dummy	1 indicates the respondent belongs to a farmers' association 0 indicates otherwise	+/–
Other socio-economic factors			
Farm size	Continuous	Number of hectares used for farming by the respondent	+/–
Livestock ownership	Continuous	Number of livestock owned by the survey respondent	+/–
Land ownership	Dummy	1 indicates respondent owns the land used for farming 0 indicates otherwise	+/–
Gender	Dummy	1 indicates respondent is female 0 indicates otherwise	+/–
Age of respondent	Continuous	Number of years	+/–

production planning. Ethical clearance for the study was granted by the University of Mpumalanga's Faculty of Natural and Agricultural Science Ethical Committee.

The critical question in this survey enquired about farmers' willingness to participate in commercial cassava production. The responses to this question were recorded using a binary variable, where 1 was assigned to a farmer who was willing to participate in the commercial production of cassava markets and 0 to a farmer not willing to participate. In line with the form of this independent variable, the binary logic regression was used to determine which socioeconomic factors had the most significant influence on the farmers' willingness to expand cassava production. This model is represented mathematically in Equation 1 below. Where Y is the dependent variable, α is a constant, X_{in} = are independent variables, u_i is the error term, and β_0 are parameters estimated in the regression model,

$$Y_i = \alpha\_ + \beta x\_ \Sigma X_{in} + u_{i\_} \quad (1)$$

RESULTS

Descriptive statistics

Table 2 provides a summary of the socio-economic characteristics of the survey respondents. As shown, the majority of respondents (57.50%) were female, while 42.50% were male. Sixty percent of the farmers were under the age of 51, and the majority of the respondents (30.83%) were between the age of 31 and 40. The majority of the survey respondents (58.34%) had received a secondary school education or better. Only thirty percent of the farmers were married while the remainder of the sample were either never married, divorced, widowed, or separated. Less than half of the farmers (42.50%) reported that they were involved in commercial agriculture and 84.17% of the farmers mentioned that they had not received any extension services in the past 12 months. On average, each farmer farmed a 4.19-hectare piece of land and had about 15 years of experience. The majority of the farmers used their own

Table 2. Demographic characteristics of the sample

Characteristic	Sample (N = 120)	Percentage (%)
1	2	3
Gender	Female – 51 Male – 69	Female – 42.50 Male – 57.50
Age	31–40 – 37 41–50 – 23 51–60 – 27 61–70 – 25 71–80 – 7 81–90 – 1	31–40 –30.83 40–51 – 19.17 51–62 – 22.50 63–73 – 20.83 74–84 – 5.83 84–95 – 0.83
High level of educational attainment	None –12 Primary school – 38 Secondary school – 62 Tertiary school – 8	None – 10% Primary school – 31.67 Secondary school – 51.67 Tertiary school – 6.67
Marital status	Married – 36 Single – 27 Divorced – 17 Widowed – 26 Separated – 14	Married – 30.00 Single – 22.50 Divorced – 14.16 Widowed – 21.67 Separated – 11.67
Reason for farming	Subsistence – 69 Subsistence and commercial – 51	Subsistence – 57.50 Subsistence and commercial – 42.50
Extension services received in the last 12 months	None – 101 Once – 11 Twice – 8	None – 84.17 Once – 9.17 Twice – 6.67

Table 2 – cont.

1	2	3
Land ownership	Yes – 105 No – 15	Yes – 87.50 No – 12.50
Crop selection	Perennial = 12 Annual = 75 Both = 26 None = 7	Perennial – 10 Annual – 62.50 Both – 21.67 None – 5.83
Financiers of farming activities	Government = 12 Formal private organisation = 3 Non-governmental organisation = 2 Remittances and own capital = 70 Informal private loan = 51	Government – 10 Formal private organisation – 2.50 Non-governmental organisation – 1.67 Remittances and own capital – 58.33 Informal private loan – 42.50
Knowledge of cassava production	Yes = 106 No = 14	Yes – 88.33 No – 11.67
Cassava production is more suited for women	Yes – 97 No – 23	Yes – 106 No – 14
Cassava consumption and consumption is for the poor	Yes – 56 No – 64	Yes – 46.67 No – 53.33
Willingness to participate in the commercial production of cassava	Yes – 63 No – 57	Yes – 52.50 No – 47.50
Farm size	Average – 4.19 hectares	
Farming experience	Average – 14.93 years	
Revenue for commercial farmers	Average – R3 241.57 per farmer	

capital or remittance to finance their agricultural activities. The majority of the respondents (87.50%) owned the land they farmed, 88.33% of the farmers had knowledge of cassava production, and 80.83% had knowledge of cassava processing.

Empirical results

Table 1 below shows the results of the binary logic model used to analyze the factors that influence farmers' willingness to participate in the commercial production of cassava. The results from the regression model show that the willingness to venture into commercial cassava production was not only influenced by technical factors such as the knowledge and experience of the crop's production but was also influenced by informal institutional norms (gender and class norms) and various socio-economic variables (land ownership, farm size, and livestock ownership).

As shown, having knowledge about cassava production and experience in producing cassava had a positive influence on the farmers' willingness to engage in the commercial production of cassava. These two variables were statistically significant at the 1% level. This indicates that there was a very strong causal relationship between the technical issues around the farming of the crop and willingness to participate in the commercial production of cassava. This is an expected result, and it could be because the crop is different from the common crops promoted in the country; hence, an intricate knowledge of the crop's production practices would be key for success in this enterprise when a farmer ventures into it. These findings point out farmer education as a critical requirement for expanding cassava adoption and commercialisation. The importance of technical knowledge in cassava production has been highlighted in findings provided by Raufu et al. (2018) and Sewando et al. (2011) which indicated that production issues had a very strong influence on the level commercialisation of cassava in Nigeria and Tanzania.

The results show that institutional factors also influenced farmers' willingness to produce cassava on

Table 3. Results of the binary logic model

Variables	Coefficients	SE	Wald	P-value	*Exp*(*B*)
Technical factors					
Farming experience	2.650	0.294	5.033	0.002***	.972
Knowledge about cassava	2.542	0.796	10.373	0.001***	.815
Institutional factors					
Cassava production suitable for women	.385	.420	.838	.0360**	.681
Cassava is farmed by poor people	1.553	.795	1.309	.001***	1.841
Cassava is eaten by poor people	.318	.585	.295	.587	1.375
Association membership	1.162	.784	.974	.956	.678
Other socio-economic factors					
Farm size	.072	.042	2.919	.088*	1.075
Livestock ownership	–.348	.210	2.731	.098*	.706
Land ownership	.988	0.554	1.599	.077*	1.010
Gender	–.503	0.414	1.479	.224	1.069
Age of respondent	.007	0.014	0.219	.639	1.023
Number of observations = 120 Log likelihood = −140.970 Cox & Snell R^2 = 0.189 Nagelkerke R^2 = 0.252					

a commercial scale. The belief that cassava production was suitable for women and the belief that cassava production was for poor people positively influenced the dependent variable, and these variables were statistically significant at the 5% and 1% level, respectively. The belief that cassava is for poor people could be because most profitable agribusiness enterprises such as citrus and sugarcane production in the surrounding area were done by relatively wealthier farmers, while cassava production was done by relatively poorer farmers. The belief that cassava production was suitable for women was suitable for female farmers was promoted by evidence that showed that most female farmers produced cassava to ensure food security in their rural households. Interestingly, these farmer perceptions encouraged the willingness to participate in commercial cassava production. Previous research (Ogunniyi, 2011; Isitor et al., 2017; Mobio et al., 2021; Opondo and Owuor, 2018) from other countries indicated that these perceptions formed hinderances to the industry's growth. Studies by Sewando et al. (2011), Raufu et al., (2018), and Opondo and Owuor (2018) reported that societal norms determined the pattern of cassava adoption and commercialisation in African countries.

The results from control variables (farm size, livestock ownership, and land ownership) were in line with prior expectations as they have a statistically significant influence on farmers' willingness to participate in the commercial production of cassava. These were statistically significant at the 10% level. The size of the farmland has had a mixed effect on farmers' willingness to cassava commercialisation in past studies. While some studies (Isitor et al., 2017; Manganyi et al., 2023) reported a positive correlation between the two variables, others (Egbetokun and Omonona, 2012; Tirra et al., 2019) reported that some farmers felt that large tracks of land were better suited for more remunerative crops than cassava. Hence, a negative relationship between the two variables was reported in some cases. These results on the effect of land ownership and enterprise diversification into livestock farming were in line with prior expectations. The positive relationship between

animal husbandry and cassava production could indicate that the farmers' decisions were influenced by the understanding that they can take advantage of the multipurpose use of cassava for livestock feed production (Abass et al., 2013). This finding concurs with Manganyi et al. (2023), who found that cassava production was associated with livestock farming in three different regions in South Africa due to the crop's dual purpose in rural households. Sewando et al. (2011) findings concurred with the current study as these showed that farm size and landholding had an influence on a farmer's decision in favour of cassava production.

DISCUSSION

This study sought to determine the factors that could affect the adoption of cassava as a commercial enterprise in South Africa. Technical factors, i.e., knowledge of how to produce cassava, emerged as one of the most important factors that could aid in the successful commercialization of the crop. This result points to the need for government intervention in the provision of farmer training, production information, and field demonstrations. Previous studies show that the cassava industry is one sector that has required much government intervention to thrive. According to Haggblade et al. (2012) and Nweke et al. (2002), this is because the colonial era was characterized by strong messages of discouraging the cultivation of cassava. Hence, the adoption of cassava requires a significant amount of government incentives (Dankor et al., 2022). Governments have also gone as far as intervening the creating a sustainable market for cassava through policy instruments. In the main, the crop's proliferation across the world has been aided through statutory instruments which have seen its mandatory use in the production of key products such as bread (for example in Nigeria and Brazil) and biofuel (Ghana and Thailand) (Kemausuor et al., 2015; OECD/FAO, 2020). Such government efforts have seen cassava become the second most important food staple in terms of calories consumed per capita in Africa (OECD/FAO, 2020). It is a major source of calories for roughly two out of every five Africans (Ogunyinka and Oguntuase, 2020).

Due to its low production levels, statutory policies have not been implemented in South Africa. In South Africa's case, market incentives are present in the agro-processing market. South Africa meets only 33% of its demand for cassava starch and industrial cassava is more remunerative than corn starch (Amelework et al., 2021). This presents an opportunity for import substitution and the promotion of sustainable livelihoods that have been fully explored. Steps to encourage the crop's production have already started as it was recently classified as an industrial crop. This means that it is now possible for the government to support prospective business opportunities or proposals through funding instruments in the Technical Innovation Agency and the Department of Trade and Industry (DAFF, 2010). Manganyi et al., 2023 report that the state parastatal, the Agricultural Research Council, has initiated a process to coordinate cassava research and development in South Africa in light of the growing importance of the crop. These are very important steps as previous successes in commercialising cassava in the study area and surrounding communities were short-lived due to various challenges in the value chain (Amelework et al., 2021). Additional research will be required to determine other bottlenecks in the cassava value beyond the farm gate.

INSTITUTIONAL FACTORS

This study took a special interest in the institutional factors that could affect cassava adoption and commercialization. The results showed that most of the interviewed farmers in Mbombela municipality shared the same societal norms as those reported in other parts of Africa. However, their beliefs about how groups of people interact with cassava did not serve as a deterrent to the willingness to commercialize cassava. This was different to findings reported by Ngenoh et al. (2020), who found that farmers in West Africa had a culture where cassava was a food security crop and grown only by women for the household. Hence, the lack of masculinity associated with the crop prevented male farmers, who were more commercially inclined in their farming enterprises, limited its widespread commercialization. The current study's finding is important as it presents cassava as an option that could be suitable to introduce women to agriculture. However, further research is required to determine how the perception changes when the different commercialization markets are presented for consideration. Some studies (Tirra et al., 2019; Sewando et al., 2011) have indicated that female participation has promoted participation in the less lucrative food-processing industry for making baking

goods while being suppressed in more rewarding activities such as supplying to the starch and flour factories (Ngenoh et al., 2020).

This study has also provided insights into class norms that could affect cassava production. The presence of findings of a statistically significant influence of societal norms on the willingness to participate in the commercial production of cassava serves as a warning regarding the education that has to be taken when marketing cassava in the South African market. Although these did not have negative effect in this study, these may have negative effects in other parts of the country. Additional research would be required to ascertain this. Nevertheless, precolonial misbeliefs may seep into the market and render the crop unattractive and drive the profitability of the cassava enterprises down. According to Ogunniyi (2011), Isitor et al. (2017), Mobio et al. (2021) and Opondo and Owuor (2018), cassava is believed to be suitable for consumption by the poor only because it has a low food value. It is also believed to have a bad omen from which consumers distance themselves from. Due to the cyanide content in cassava, it can be lethal when roots are mishandled, leading to avoidance of the crop by potential consumers (Ngenoh et al., 2020). Numerous studies have been conducted to bunk various myths (Nweke et al., 2002; Cock, 1985). However, studies continue to show that the sluggish adoption behaviour of smallholder farmers to the crop is linked to a lack of knowledge of cassava (Raufu et al., 2018; Adeyonu and Aniegboka, 2017), lack of access to information (Osikabor et al., 2011), and a myriad of other socio-economic factors. In some countries like Nigeria, cassava production has since been repositioned to be an attractive crop because there is a general acceptance of cassava and its products across all classes (Isitor et al., 2017; Adeyonu and Aniegboka, 2017; Raufu et al., 2018). FAO (2018) reported rising demand for the staple and enhancing food security and the rural economy high on the sub-Saharan Africa region's agenda. Positive perceptions and producers' acceptance continue to be critical to the industry's growth.

CONCLUSION

The study set out to determine the factors that could drive or hinder the production of cassava in Mbombela municipality in Mpumalanga province, South Africa. This investigation was motivated by the need to introduce more climate-smart sources of carbohydrates in South Africa as it is a water-scarce country. The study found that farmers' willingness to participate in the commercial production of cassava was influenced by their knowledge of cassava production, societal norms, and other socio-economic factors. The study's findings provide information that highlights the technical and cultural matters that can be used to encourage the adoption of cassava. It also provides information on the areas higher up in the value chain, where these two factors may require further research. The information provided is important for designing developmental programs that seek to increase cassava production and commercialization.

Given the key influence of technical factors highlighted in the findings, this study recommends that government interventions be developed to increase farmer education on how to successfully farm cassava. These interventions could be in the form of training programs, distribution of pamphlets, podcasts or other audio tools, and farmer field schools. As this study did not differentiate the different types of information that are demanded by farmers, further research could examine the differences in need for the information sets. The study also recommends further research on societal norms around cassava production as this study focused on the effect on primary production. Additional research is required to determine if these norms will affect farmers in different regions (Limpopo, KwaZulu Natal and Eastern Cape province) where cassava is produced. Further research should be done on the effect of societal norms on market access and market participation.

REFERENCES

Abass, A., Amaza, P., Bachwenkizi, B., Alenkhe, B., Mukuka, I., Cromme, N. (2017). Adding value through the mechanization of post-harvest cassava processing, and its impact on household poverty in north-eastern Zambia. Appl. Econ. Lett., 24(9), 579–583, 10.1080/13504851.2016.1213356

Abass, A., Mlingi, N., Ranaivoson, R., Zulu, M., Mukuka, I., Abele, S., Bachwenkizi, B., Cromme, N. (2013). Potential for commercial production and marketing of cassava: experiences from the small-scale cassava processing project in East and Southern Africa. Retrieved Jun 12th 2023 from: https://biblio1.iita.org/bitstream/handle/20.500.12478/1789/U13BkAbassPotentialothomDev.pdf?sequence=1

Akinola, R., Pereira, L.M., Mabhaudhi, T., de Bruin, F., Rusch, L. (2020). A review of indigenous food crops in Africa and the implications for more sustainable and healthy food systems. Sustainability, 12 (3493). 10.3390/su12083493

Amelework, A.B., Bairu, M.W., Maema, O., Venter, S.L., Laing, M. (2021). Adoption and promotion of resilient crops for climate risk mitigation and import substitution: A case analysis of cassava for South African agriculture. Front. Sustain. Food Syst., 5(617783). 10.3389/fsufs.2021.617783

Amelework, A.B., Bairu, M.W., Marx, R., Owoeye, L., Laing, M., Venter, S.L. (2022). On-farm multi-environment evaluation of selected cassava (Manihot esculenta Crantz) cultivars in South Africa. Plants, 11, 3339. doi.org/10.3390/plants11233339

Chipfupa, U., Wale, E. (2018). Farmer typology formulation accounting for psychological capital: implications for on-farm entrepreneurial development. Dev Pract., 28(5), 600–614. https://doi.org/10.1080/09614524.2018.1467377

Cock, J.H. (1985). Cassava. New potential for a neglected crop. London: International Agricultural Development Service and Centro de Internacional Agricultura Tropical.

DAFF (Department of Agriculture Forestry and Fisheries) (2010). Cassava production guideline. The Directorate of Plant Production. retrieved Oct 2022 from: https://www.nda.agric.za/docs/Brochures/ProdGuideCassava.pdf

Dankor, E., Onakuse, S., Bogue, J. (2022). Income inequality and distribution patterns in the cassava value chain in Oyo State, Nigeria, a gender perspective. Brit. Food J., 124(13), 254–273. 10.1108/BFJ-06-2021-0663

Egbetokun, O.A., Omonona, B.T. (2012). Determinants of farmers' participation in food market in Ogun State. Glob. J. Sci. Front. Res. Agric. Vet. Sci. (12), 9.

Fanadzo, M., Chiduza, C., Mnkeni, P. (2010). Overview of smallholder irrigation schemes in South Africa: Relationship between farmer crop management practices and performance. Afr. J. Agric. Res., 5(25), 3514–3523.

FAO (Food and Agricultural Organisation) (2018). Food Outlook, Biannual report on global food markets. Rome: FAO Publishing. Retrieved from: https://www.globalagriculture.org/fileadmin/files/weltagrarbericht/Weltagrarbericht/02Hunger/2018FAOOutlookNov.pdf

Haggblade, S., Djurfeldt, A.A., Nyirenda, D.B., Lodin, J.B., Brimer, L., Chiona, M., Chiwona-Karltun, L. (2012). Cassava commercialization in South-eastern Africa. J. Agribus. Dev. Emerg. Econ., 2(1), 4–40. 10.1108/20440831211219219

Hlatshwayo, S.I., Ngidi, M.S.C., Ojo, T.O., Modi, A.T., Mabhaudhi, T., Slotow, R. (2023). The determinants of crop productivity and its effect on food and nutrition security in rural communities of South Africa. Front. Sustain. Food Syst., 7:1091333. 10.3389/fsufs.2023.1091333

Isitor, S.U., Adeyonu, A.G., Aniegboka, U.N. (2017). An analysis of technical efficiency of smallholder cassava farmers in Anambra State, Nigeria. Appl. Trop. Agric., 22(2), 10–15.

Kemausuor, F., Addo, A., Darkwah, L. (2015). Technical and socioeconomic potential of biogas from cassava waste in Ghana. Biotechnol. Res. Int., 828576. http://dx.doi.org/10.1155/2015/828576

Khatri-Chhetri, A., Aggarwal, P.K., Joshi, P.K., Vyas, S. (2017). Farmers' prioritization of climate-smart agriculture (CSA) technologies. Agric. Syst., 151, 184–191. https://doi.org/10.1016/j.agsy.2016.10.005

Krejcie, R.V., Morgan, D.W. (1970). Determining sample size for research activities. Educ. Psychol. Meas, 30(3), 607–610.

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, 14366. https://doi.org/10.3390/su151914366

Masamha, B., Thebe, V., Uzokwe, V.N.E. (2018). Mapping cassava food value chains in Tanzania's smallholder farming sector: The implications of intra-household gender dynamics. J. Rural Stud., 58, 82–92. https://doi.org/10.1016/j.jrurstud.2017.12.011

McNally, A., Verdin, K., Harrison, L., Getirana, A., Jacob, J., Shukla, S., Arsenault, K., Peters-Lidard, C., Verdin, J.P. (2019). Acute water-scarcity monitoring for Africa. Water., 11(1968). http://dx.doi:10.3390/w11101968

Mobio, A.J., Fokou, G., Aka, S., Kouassi, K.B., Kreppel, K.S., Kouakou, K.P., Amanzou, N.A.A., Dao, D., Bonfoh, B. (2021). Exploring beyond the conjunctural rhetoric: sociocultural drivers for the "cassava crisis" in Côte d'Ivoire. Agric. Food Econ., 9(2). https://doi.org/10.1186/s40100-020-00174-0

Mudombi, C.R. (2010). An ex-ante economic evaluation of genetically modified cassava in South Africa. [Dissertation]. Pretoria: The University of Pretoria.

Mutyaba, C., Lubinga, M.H., Ogwal, R.O., Tumwesigye, S. (2016). The role of institutions as actors influencing Uganda's cassava sector. J. Agric. Rural Dev. Trop. Subtrop., 1(117), 113–123.

Nassar, N., Ortiz, R. (2010). Breeding cassava to feed the poor. Food Sci., 302, 78–84. https://doi.org/10.1038/scientificamerican0510-78

Ngenoh, G.C., Kariuki, I.M., Gathungu, E.W., Kiprop, S.K. (2020). Factors influencing the choice of marketing strategies among cassava microenterprises in Kenya. Afr. Crop Sci. J., 28(1), 117–129. doi.org/10.4314/acsj.v28i1.9S

Ngobeni, L., Nkosi, Z. (2023). Cassava: an untapped resource in South Africa. Retrieved Oct 2nd 2023 from: https://www.farmersweekly.co.za/crops/field-crops/cassava-an-untapped-resource-in-south-africa/

Nweke, F.I., Spencer, D.S.C., Lynam, J.K. (2002). The cassava transformation: Africa's best-kept secret. East Lansing Michigan: Michigan State University (p. 273–274).

OECD/FAO. OECD-FAO Agricultural Outlook 2020-2029. Rome/Paris: FAO/OECD Publishing; 2020. http://doi.org/10.1787/1112c23b-en

Ogola, J.B.O., Mathews, C., Magongwa, S.M. (2013). The productivity of cassava-legume intercropping system in a dry environment in Nelspruit, South Africa. Afr. Crop Sci. Conf. Proc., 11, 61–65.

Ogunniyi, L.T. (2011). Household consumption of cassava products in Oyo State. Glob. J. Sci. Front. Res., 11(6), 39–43.

Ogunyinka, O., Oguntuase, A. (2020). Analysis of cassava production and processing by various groups in support of cassava value chain in southwest of Nigeria. J. Sci. Food Agric., 9(1), 11–19. 10.5897/ISABB-JFAS2020.0113

Okudoh, V.I., Workneh, C.T., Schmidt, S. (2014). The potential of cassava biomass and applicable technologies for sustainable biogas production in South Africa: A review. Renew., 39, 1035–1052. http://dx.doi.org/10.1016/j.rser.2014.07.142

Olasanmi, B. (2015). High-resolution linkage map and chromosome-scale genome assembly for cassava (Manihot esculenta Crantz.) from 10 populations. G3: Genes Genom. Genet., 5, 133–144.

Opondo, F., Owuor, G. (2018). The effect of cassava commercialization on household income of smallholder farmers in arid and semi-arid land (Asal). A case of Kilifi County, Kenya. The 30th International Conference of Agricultural Economists; July 28 – August 2 2018; Vancouver, Canada.

Osikabor, B., Oladele, I.O., Ogunlade, A.I. (2011). Worth assessment of information and their access points by small sale cassava farmers in Nigeria. S. Afr. J. Agric. Ext., 39(2), 69–78.

Owusu, V., Owusu-Sekyere, E., Donkor, E. (2017). Consumer perceptions and willingness to pay for cassava-wheat composite bread in Ghana: A hedonic pricing approach. J. Agribus. Dev. Emerg. Econ., (7)2, 115–134. Retrieved from: https://www.emerald.com/insight/content/doi/10.1108/JADEE-11-2014-0044/full/html

Raufu, M.O., Adesina, B.A., Abdulazeez, A.A., Marizu, J.T. (2018). Cassava production and options of sales outlets in Oyo State. Int. J. Res. Stud., 5(4), 175–181.

Sewando, P.T., Mdoe, N.Y.S., Mutabazi, K.D.S. (2011). Farmers' preferential choice decisions to alternative cassava value chain strands in Morogoro Rural District, Tanzania. Agric. J., 6(6). http://dx.doi.org/10.3923/aj.2011.313.321

Tadesse, A., Gutema, T. (2021). Evaluation and popularization of processing, post-harvest handling and utilization of cassava food products in South Omo Zone. Int. J. Epidemiol. Publ. Health Res., 1(1). http://doi.org/03.2021/1.1007

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. J. Agric. Sci., 11(17), 98–109. https://doi.org/10.5539/jas.v11n17p98

Wang, W., Xie, L., Chen, J., Luo, G., Zhou, Q. (2011). Biohydrogen and methane production by co-digestion of cassava stillage and excess sludge under thermophilic conditions. Bioresour. Technol., 102, 3833–3839.