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A Business Case for Enhanced Investments in the Groundnut Value Chain in Tanzania

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Cover photo: The TARI-Naliendele breeder seed farm under irrigation.

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Abstract

Apart from providing food, agriculture contributes to economic growth and the livelihoods of people in both urban and rural areas through trade. This study analyzes the business case for groundnut farmers and off-takers in Tanzania and beyond to identify opportunities for enhancements along the commodity value chain. A systematic sampling was used to collect data from 300 groundnut farmers in 11 districts across seven agro-ecological zones through individual interviews. Of the farmers interviewed, 240 were from Tropical Legumes (TL) III project intervention districts and 60 were from non-intervention districts. Also, 123 off-takers were purposively selected from commercial areas. Secondary data was obtained from literature and the Tanzania Agricultural Research Institute at Naliendele. Descriptive statistics, probit regression model, cost-benefit analysis and economic efficiency model were used for data analysis. The empirical results showed that a total of 17 improved groundnut varieties have been released with their adoption rate among groundnut farmers being 35%. The adoption rate was found to be influenced by age and gender, farmer group membership, availability of improved seed and seed cost. Results further showed that only 25% of the groundnut produced annually is used for subsistence purposes while 75% is for commercial purpose. It was further revealed that a farmer is assured of gaining at least TZS 475,000/ha annually by way of groundnut farming. However, only 31% economic efficiency in grain production was noted among farmers, as this was influenced by their level of education, experience and group membership. Finally, it was observed that about 21 t of groundnut grain varieties similar to those available in Tanzania is imported from neighboring Malawi and Zambia.

Keywords: Groundnut commodity, adoption, improved varieties, stakeholders' platform, Tanzania, value chain

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Acronyms and abbreviations

ACB	African Centre for Biodiversity
AE	Allocative efficiencies
ASA	Agricultural Seed Agency
CBA	Cost-Benefit Analysis
DALGO	District Agricultural Local Government Offices
DASPA	Dodoma Agricultural Seed Production Association
DDA	Demand Driven Approach
DE	Data Envelopment
EAC	East African Community
EE	Economic efficiencies
FAO	Food and Agriculture Organization of the United Nations
FBOs	Faith-based Organizations
FGs	Farmer groups
HH	Household
ICRISAT	International Crops Research Institute for the Semi-Arid Tropics
ISTA	International Seed Testing Association
MHEG	Mbozi Highland Economic Group
MLE	Maximum Likelihood Estimates
NAES	National Agricultural Extension Services
NARI	National Agricultural Research Institute
NBC	National Biotic Committee
NBS	Tanzania National Bureau of Statistics
NGOs	Non-Governmental Organizations
NSC	National Seed Committee
NVRC	National Variety Release Committee
PVP	Plant Variety Protection
QDS	Quality Declared Seeds
REPOA	Research on Poverty Alleviation

SA	South Asia
SADC	Southern African Development Community
SSA	Sub-Saharan Africa
TARI	Tanzania Agricultural Research Institute
TASTA	Tanzania Seed Trade Association
TE	Technical efficiencies
TFDA	Tanzania Food and Drug Authority
TL	Tropical Legumes
TOSCI	Tanzania Official Seed Certification Institute
TR	Total revenue
TVC	Total variable cost
TZS	Tanzanian shillings
UPOV	International Union for the Protection of New Varieties
USAID	United States Agency for International Development

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EXECUTIVE SUMMARY

This business case for groundnut in Tanzania covering farmers and grain off-takers was aimed at identifying opportunities for enhancements along the commodity value chain. The study covered 11 districts in seven agro-ecological zones. It examined grain demand, crop production outlook, adoption of improved varieties, seed demand, seed policy and institutional linkages among stakeholders as well as the role of the private sector in enhancing seed production and delivery in the country. Through systematic sampling, 300 farmers were randomly selected, of which 240 farmers were from Tropical Legumes (TL) III project districts and 60 farmers were from non-intervention districts. A total of 123 off-takers were purposively selected from commercial areas.

Data analysis included descriptive information, computing the total value of variables like market demand for groundnut, grain demanded by zones, imports and exports. The adoption of improved varieties by the total sample was also computed.

The study found that in the year 2017, a total of 4,777,531 households out of 9,109,184 in the Tanzanian mainland were engaged in farming. Of the farming households 1,114,175 were also engaged in groundnut production. Men were found to dominate both production and off-taking of groundnuts. At the farm level, about 68.3% from intervention districts and 50.4% from non-intervention districts were men. In the case of off-takers, 81% were men. Also, about 100% of the farmers were able to access markets, although they had farm sizes of <2 ha.

Furthermore, while groundnut farmers were spread out all over the agricultural zones of the Tanzanian mainland, the major producing zones were Lake zone (29%), Western zone (26%), Southern Highlands (18%), Central zone (17%) and Southern zone (9%).

The study assessed the extent to which groundnut seed producers could increase their productivity and profitability if they efficiently adjust inputs. The result of input elasticities for land (0.412) and seed (0.563) were statistically significant ($p < 0.05$); the mean estimates were 56%, 66% and 38% for Technical efficiency (TE), Allocative efficiency (AE) and Economic efficiency (EE), respectively. Against grain, inputs elasticities for land (0.384) and seed (0.053) were statistically significant ($p < 0.01$ and $p < 0.05$), respectively. The grain producer's mean estimates were 54%, 52% and 31% for TE, AE and EE, respectively. In terms of grain vs. seed, the Cost-Benefit Analysis (CBA) showed that for grain, the lowest and highest gross incomes were 462,500 TZS/ha and 742,500 TZS/ha in Ushetu and Mbozi districts, respectively and for seed, the lowest gross income was 545,000 TZS/ha and the highest gross income was 1,337,000 TZS/ha.

Farmers produced groundnut grain mainly for commercial purpose (75%) and the rest (25%) for subsistence use. Most farmers had adopted over 15-year-old varieties due to their yield and maturity benefits, but these varieties were susceptible to abiotic and biotic stresses. The old varieties included Dodoma bold, Red mwitunde, Nyota, Johari, Sawia and Pendo. The study further revealed that the overall rate of adoption of improved varieties was 35%, with age, gender, membership in farmer organizations, availability of seed and seed cost influencing preferences and adoption. Recently improved varieties include Naliendele 2009, Mangaka 2009, Mnanje 2009, Nachigwea 2009, Masasi 2009, Narinut 2015, Kuchele 2015 and Nachi 2015 that are high yielding (1.0-2.0 t/ha) and rosette-tolerant confectionery type. The other improved varieties are Naliendele 2016, Tanzanut 2016 and Mtwaranut 2016.

The study revealed the following categories of seed producers: government research centers, private seed companies, farmer groups, individual seed entrepreneurs, farmer associations, religious organizations and Non-Governmental Organizations (NGOs). Total seed production has been increasing over the years and reached a maximum of 4,611.50 t in 2018. Mtwara was the leading

seed producing region (27%), followed by Geita (24%) and Tabora (23%). Singida and Mbeya regions were observed to have the least record of seed producers (2%).

The adopting farmers were highly motivated to use improved varieties that are high yielding (50%), drought tolerant (23%) and preferred by the market (16%). A majority (62.2%) of interviewed farmers replaced varieties only after seven years or more, and applied a seed rate of 17.5-37.5 kg/ha, which is less than the recommended 80 kg/ha for medium sized and 100 kg/ha for large sized varieties. The study further identified 15 organizations and their roles in the seed sector and explored the links between them. It also identified opportunities for private companies to invest in seed multiplication of improved varieties, labour-saving technologies and in setting up oil processing industries.

1. INTRODUCTION

1.1. Background

Groundnut or peanut (*Arachis hypogea* L.) is a domesticated pulse and leguminous oilseed rich in protein. It is related to the wild *Arachis* species indigenous to Brazil, Bolivia, Uruguay and northern Argentina (Purseglove 1968). There are three basic groundnut types: Virginia (the largest variety, used in the roasted snack industry), Runner (medium sized, common in confectionery and peanut butter) and Spanish/Valencia (small, high in oil content and also used in peanut candy, confectionery and as peanut butter). World trade in groundnut began with the industrial extraction of groundnut oil in Marseilles in mid-19th century (Purseglove 1968).

Groundnut kernels contain 40-50% fats, 20-50% protein and 10-20% carbohydrates (Sørensen et al. 2004). They are nutritional sources of vitamin E and minerals such as niacin, folacin, calcium, phosphorus, magnesium, zinc, iron, riboflavin, thiamine and potassium. Groundnut is useful in the treatment of haemophilia. It can cure stomatitis and prevent diarrhoea and is beneficial to pregnant women, nursing mothers and growing children (Akobundu 1998). The kernels can be eaten raw, roasted or boiled and the haulm is used as fodder for cattle (Pompeu 1980).

Groundnut is also used to produce industrial materials such as oilcake and fertilizer. Oil from the kernel is used as a cooking medium and other crop extracts are used as animal feed (Nigam and Lenné 1996). The crop's multiple uses make it an important food and cash crop for domestic consumption and export in many developing and developed countries. Globally, groundnut is grown in more than 100 countries situated in tropical, sub-tropical and warm temperate regions (Upadhyaya et al. 2012). China is the largest producer in the world, accounting for more than 40%, followed by India with a 15% share (FAOSTAT 2018). In Africa, Nigeria and Sudan are the leading producers that each contribute about 20% of the total production, followed by Tanzania and Chad (7% each) (FAOSTAT 2018). Yields of groundnut in Tanzania are reported to be very low, between 500 kg/ha and 1,000 kg/ha compared to between 1,500 kg/ha and 2,500 kg/ha reported in other parts of Africa. In 2018, mean groundnut yield (unshelled) was 984 kg/ha in Tanzania, compared to 2500 kg/ha reported in Algeria and 2400 kg/ha in Kenya (FAOSTAT 2018). Shinyanga, Tabora, Dodoma, Mbeya and Kigoma are the major groundnut producing regions in Tanzania (NBS 2017). Given its land fertility and adequate land for production, Tanzania has the potential to increase production. Nevertheless, the low adoption of seed technologies and poor coordination among value chain actors are hindrances (Daudi et al. 2018).

The most important biotic factors affecting groundnut production and productivity in the country are groundnut rosette disease (groundnut rosette assistor virus, groundnut rosette virus and a satellite RNA), rust (*Puccinia arachidic* Speg), early leaf spot (*Cercospora arachidicola* Hori), and late leaf spot (*Phaseoisariopsis personata* Berk. & Curtis) (Daudi et al. 2018). The use of improved groundnut cultivars and production technologies is essential to boost crop yields across the country. At the same time, an in-depth knowledge of farmers' preferences, production challenges and priorities are prerequisites to develop production technologies (Ramadhani et al. 2002). Groundnut production is also greatly challenged by weed infestation.

1.2. Challenges

Groundnut production in Tanzania has shown a progressive increase in terms of both yield and area from 2001 to 2015 (FAOSTAT 2018). While production increased from 206,800 t in 2001 to 1.83 million t in 2015, area grew from 247,300 ha in 2001 to 1.62 million ha in 2015. Despite this, productivity among Tanzanian farmers is low compared to that in Malawi and Nigeria that range from 1.5 t/ha to 2.5 t/ha (FAOSTAT 2015).

Efforts have been made to address challenges pertaining to improved varieties and seed systems to ensure that farmers' capacity to increase production and productivity is enhanced. TARI-Naliendele in collaboration with other groundnut stakeholders is working on developing improved groundnut varieties. Currently, more than 17 improved groundnut varieties and allied technologies have been developed. However, their very low adoption contributes to low productivity ranging from 0.5 t/ha to 1 t/ha (Daudi et al*.* 2018). Similarly, there is a poor market linkage between groundnut farmers, off-takers and other value chain actors which has caused an imperfect market (Mangasini et al. 2014).

Reliable investment information is needed by traders, processors, exporters and other stakeholders in the value chain to enable sound decisions. Such information will go a long way in attaining the Tanzanian Government's 2025 vision of transforming Tanzanians to at least middle-income earners.

This study sheds light on these critical issues in the groundnut value chain and commodity business development in Tanzania.

1.3. Objectives

The study's overall objective is to develop a business case for groundnut and identify opportunities for investments along the commodity value chain in Tanzania. Its five specific objectives are to:

- Analyze grain production and its main uses;
- Determine grain demand and the main off-takers;
- Explore improved groundnut varieties in Tanzania, their yield potential and adoption rate;
- Characterize groundnut seed producers in the country; and
- Assess the institutional linkages, policies and private sector roles to scale up groundnut seed.

2. LITERATURE REVIEW

2.1. Adoption of improved technologies

Technology adoption has been defined as a systematic application of newly introduced resources to solve problems through control over nature and human processes (Mustapha et al. 2012). The adoption of a technology is preceded by both information and an awareness period (Diamara and Skuras 2003). Individuals are regarded as adopters if they use at least one improved technology in one or more seasons (Ogunyemi and Ojo 2014). In the current study, improved technology refers to the improved groundnut varieties released by TARI-Naliendele in collaboration with ICRISAT and other development partners. These varieties include Natal common, Dodoma bold, Nyota 1983, Johari 1985, Sawia 1998, Pendo 1998, Mangaka 2009, Naliendele 2009, Mnanje 2009, Masasi 2009, Nachingwea 2009, Nachi 2015, Kuchele 2015, Narinut 2015, Mtwaranut 2016, Naliendele 2016 and Tanzanut 2016. Improved varieties are defined (Nkonya 2001) as those bred through formal plant breeding methods and which are highly resistant to both biotic and abiotic stresses that include drought, high rainfall, pests and diseases.

2.2. Seed technologies in Tanzania

In the early 2000s, groundnut production in Africa faced challenges of seed shortage, especially in small affordable packs, lack of modern machinery on small farms, informal farmer groups were the main seed dissemination channels and unreliable formal seed systems (Monyo and Varshney 2016; FAO 2018). To resolve these challenges, the Tropical Legumes (TL) projects were implemented from 2007 to 2019 to boost groundnut production through the release of improved varieties. The project activities were implemented in Burkina Faso, Ghana, Mali, Niger, Nigeria, Senegal, Ethiopia, Kenya, Malawi, Mozambique, Tanzania, Uganda and Zimbabwe in sub-Saharan Africa (SSA), and India and Bangladesh in South Asia (SA) (Monyo and Varshney 2016).

In Tanzania, groundnut researchers are striving to introduce superior options to a popular early-maturing groundnut variety called Pendo 1998, which is highly susceptible to rosette disease. Under the TL projects, efforts to develop and disseminate varieties that overcome the limitations of Pendo 1998 and other old varieties led to the release of three rosette-tolerant varieties with specific improved traits: Naliendele 2009 (ICGV-SM 99555) which is early maturing; Mangaka 2009 (ICGV-SM 99557) which has two-three kernels/pod and Masasi 2009 (ICGV-SM 01721) which is bold. In 2018, three more varieties were released by TARI: Narinut 2015 (ICGV-SM 01731), Kuchele 2015 (ICG 8326) and Nachi 2015 (ICGV-SM 90704) which are being used primarily for the confectionery market.

2.3. Seed systems in Sub-Saharan Africa

A seed system is an ensemble of the physical, organizational and institutional components that determine seed supply and use in quantitative and qualitative terms (Van Amstel 1996). An efficient seed system involves a complex combination of public sector support and private sector commercial activities. The public sector plays a bigger role in plant breeding and some aspects of regulations while the private sector contributes to seed multiplication, processing and distribution (Minot et al. 2007). However, seed systems can vary by type of farmer targeted (small or commercial), production system (self-pollinating, cross-pollinating or vegetatively propagated crops) and location (ACB 2015).

Generally, there are two distinctive and interacting seed delivery systems, namely formal and informal. However, Wekundah (2012) adds to this list the integrated seed supply system found in Africa. ACB (2015) presumes that seed systems in SSA are generally classified as being formal, semi-formal and informal, in line with ASARECA/KIT (2014) that reports the co-existence of formal, informal and semi-formal systems in Eastern and Central Africa. However, despite differences in these seed systems, the degree of integration between them in SSA is significant (Sperling et al. 2013).

2.4. Groundnut seed systems in Tanzania

The groundnut seed system in Tanzania can be categorized into the formal and informal. The formal system comprises variety development, seed production and seed multiplication by government institutions, processing and distribution. The government, through TOSCI, is in charge of seed inspection in the formal seed system. This system is still not fully developed to facilitate growth and partnership that would lead to a sustainable groundnut seed delivery system in Tanzania. It was strengthened by the TL project led by ICRISAT and facilitated by TARI-Naliendele.

Currently, basic seed is produced by Agricultural Seed Agency (ASA) and private seed companies, namely Temnar Company Limited in Masasi, ALSSEM Company Limited in Bahi and IFFA Seeds in Mbozi. ALSSEM Company Limited, Dodoma Agricultural Seed Production Association (DASPA) in Chamwino, LIMA Africa Company Limited in Tabora and Mbozi Highland Economic Group (MHEG) in Mbozi have ventured into certified seed production to feed the groundnut seed production systems and the entire groundnut value chain in Tanzania. Red and tan coloured groundnut varieties that are in high demand in the market have been prioritized for production based on agro-ecological zones. Across the country, other stakeholders (6 seed companies, 530 farmer research groups, 316 individual seed entrepreneurs and a few agro-dealers) are being mobilized to increase groundnut production.

Under the informal system, farmers select the healthiest grains after harvest and store them for the next season. This system supplies about 80% of the seed needs of smallholder farmers in most African countries, including Tanzania, proving to be the key seed source of their staple crops (Crissman et al. 1993; Louwaars and De Boef 2012; Wekundah 2012).

2.5. Empirical studies on farmer challenges

In a study on groundnut production constraints, farming systems and farmer-preferred traits in Tanzania (Daudi et al. 2018), 87.7% respondents reported diseases and 84.9% reported pests as constraints. Rust caused by *Puccinia arachidis* Speg. was the major cause of yield reduction reported by 30% of the respondents. Drought stress and the non-availability of seed were other important constraints reported by 83.9% and 76.1% of the respondents, respectively. The agronomic traits preferred by farmers were high yield (78.4%), disease resistance (71.2%), early maturity (66%), drought tolerance (63.0%) and pest resistance (63%). Medium to large grain size (reported by 62.6% of the respondents) and tan and red seed colour (59.2%) were the main farmer- and market-preferred traits. The study recommended addressing these constraints through varietal development programs.

In a study on socio-economic factors limiting smallholder groundnut production in Tabora region (Mangasini et al. 2014), it was found that time spent on farming, land size cultivated, the price of groundnut from the previous season, the cost of seed and the cost of pesticides significantly influenced groundnut production in the area. Data further indicated that groundnut contributes to 6% of total household income after tobacco (65%) and petty trading (11%). The study also revealed gender disparity in land ownership. Few women owned land despite being the major providers of labour. Based on the evidence, the study recommended that the government expand extension services to ensure that smallholder groundnut farmers have access to seed of high-yielding groundnut varieties, agrochemicals, improved farm inputs, storage and marketing facilities.

Bucheyeki et al*.* (2008) conducted an on-farm evaluation of promising groundnut varieties for adaptation and adoption in Tanzania. The study revealed that Pendo 1998 (1,444 kg/ha) and Johari 1985 (1,163 kg/ha) outyielded other varieties. Statistically, the sum of squares for genotypes and environments accounted for most of the variability in yield, contributing 38% and 33%, respectively. Mamboleo and Sawia 1998 varieties showed high genotype and environmental stability. Farmers and researchers ranked Pendo 1998 and Johari 1985 as the most preferred genotypes and the best varieties. In another study, Bucheyeki et al*.* (2008) identified drought and low-yielding varieties as the most serious problems in Tabora. The study also revealed that researchers' and farmers' variety selection criteria coincided. Based on the information generated by the study, Pendo 1998 and Johari 1985 were then recommended.

Ramadhani et al. (2002) noted low yields despite the importance of groundnut in Tanzania. For the past 15 years, groundnut production (unshelled) has experienced increase in both area and production, from 0.25 million ha and 0.21 million t in 2001 to 1.61 million ha and 1.81 million t in 2015, respectively. Both area and production exhibited fluctuations in 2016 (0.78 million ha and 0.55 million t), 2017 (1.54 million ha and 1.34 million t) and 2018 (0.96 million ha and 0.94 million t), respectively (FAOSTAT 2018).

2.6. Research gaps

Most studies have concentrated on researching agricultural technology, groundnut diseases, groundnut varieties, socio-economic factors hindering groundnut production and the crop's contribution to household income for poverty reduction. Scant attention has been paid to the groundnut value chain and investment opportunities in it. This study seeks to reduce this knowledge gap by examining the groundnut production value chain and investment opportunities.

3. METHODOLOGY

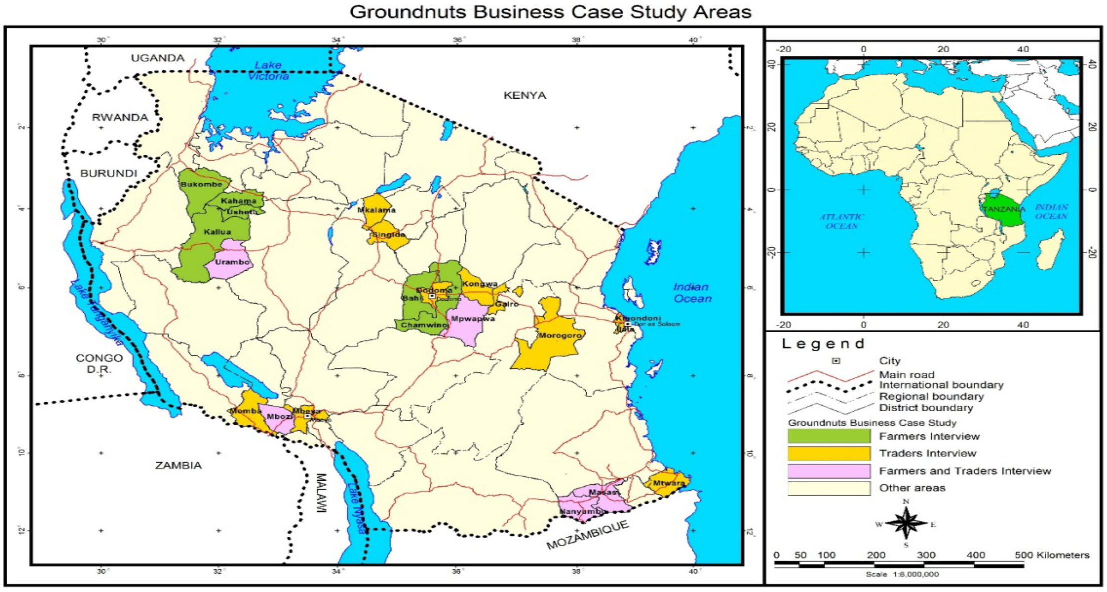
3.1. Study areas

3.1.1. Location, sampling procedures and data sources

The United Republic of Tanzania being one of six East African Community (EAC) member states, borders Kenya and Uganda to the north; Rwanda, Burundi and the Democratic Republic of Congo to the west; Zambia, Malawi and Mozambique to the south and the Indian Ocean to the east. The present study focused on mainland Tanzania which has seven agro-ecological zones: Lake, Northern, Eastern, Western, Southern, Southern Highlands and Central, where the majority of groundnut farmers in rural areas are concentrated.

The study districts covered select farmers and off-takers on the production and business sides, respectively (Figure 1). On the production side, 11 districts were covered, of which 9 came under TL III interventions and 2 didn't. Four districts were covered in the Central zone, 2 in the Western zone, 2 in the Southern zone, 2 in the Lake zone and 1 district in the Southern Highlands zone. The study employed a systematic sampling procedure to select 300 farmers, of which 60 were non-intervention respondents and 240 from the TL III intervention districts (Table 1).

On the business side, grain off-takers were selected from main markets and town business centers in the districts of Bahi, Dodoma, Mpwapwa, Kongwa and Singida (Central zone); Kinondoni, Ilala, Morogoro and Gairo (Eastern zone); Urambo (Western zone) and Kahama (Lake zone), Momba, Mbeya and Mbozi (Southern Highlands zone) and Nanyumbu and Masasi (Southern zone) (Table 2). About 123 grain off-takers were purposively selected for the interviews, of which 104 were large traders transacting at least 50 t/year and 19 were small traders transacting less than 50 t/year (Table 2).



Source: Variety business case survey, 2019.

Figure 1. The study districts in Tanzania.

Table 1. Distribution, economic activities and status of intervention and non-intervention farmers interviewed.

District	Region	Population	Number of farmers	Major economic activities	TL III project intervention
Chamwino	Dodoma	366,801	26	Crops and livestock	Yes
Bahi	Dodoma	245,958	23	Crops and livestock	Yes
Ushetu	Shinyanga	302,683	30	Crops, livestock and mining	Yes
Bukombe	Geita	256,054	27	Crops, livestock and mining	Yes
Vwawa	Songwe	274,189	28	Crops and livestock	Yes
Kaliua	Tabora	455,305	32	Crops and livestock	Yes
Urambo	Tabora	225,141	27	Crops and livestock	Yes
Nanyumbu	Mtwara	160,375	30	Crops	Yes
Masasi	Mtwara	277,312	17	Crops	Yes
Mpwapwa	Dodoma	338,518	30	Crops and livestock	No
Mkalama	Singida	221,955	30	Crops and livestock	No

Source: Population and crop census of 2012, 2016/2017 (URT 2013; NBS 2017).

Table 2. Distribution of off-takers interviewed in the target locations.

Market /town	District	Region	Number of off-takers	Type of off-takers	Agro-ecological zone
Kariakoo	Ilala	Dar-es-salaam	4	Traders	Eastern
Tandale	Kinondoni	Dar-es-salaam	7	Traders	Eastern
Mawenzi	Morogoro	Morogoro	6	Traders	Eastern
Manzese	Morogoro	Morogoro	4	Traders	Eastern
Gairo town	Gairo	Morogoro	2	Traders	Eastern
Bahi town	Bahi	Dodoma	7	Traders and processors	Central
Kibaigwa	Kongwa	Dodoma	24	Traders	Central
Mpwapwa	Mpwapwa	Dodoma	4	Traders	Central
Dodoma	Dodoma	Dodoma	11	Traders and processors	Central
Singida	Singida	Singida	7	Traders	Central
Kahama	Kahama	Shinyanga	6	Traders and processors	Lake
Urambo	Urambo	Tabora	5	Traders	Western
Uyole	Mbeya	Mbeya	2	Traders	Southern Highlands
Mlowo	Mbozi	Songwe	13	Traders	Southern Highlands
Tunduma	Momba	Songwe	2	Traders	Southern Highlands
Likokona	Nanyumbu	Mtwara	6	Traders	Southern

Market /town	District	Region	Number of off-takers	Type of off-takers	Agro-ecological zone
Manganga	Nanyumbu	Mtwara	6	Traders	Southern
Masasi	Masasi	Mtwara	3	Traders	Southern
Mtwara	Mtwara (municipal)	Mtwara	4	Traders	Southern
Total			123		

Source: Variety business case survey, 2019.

3.1.2. Economic activities

Farmers in the surveyed areas were mainly engaged in growing crops, keeping livestock and running small businesses (Table 1). In districts involved in crop production and livestock keeping, the main crops grown were sugarcane, paddy, maize, cassava and banana. Other crops grown included beans, millet, cowpea, potato, groundnut, citrus fruits, mango, jackfruit, coconut, tomato and eggplant.

3.1.3. Population

The distribution of population in the surveyed districts (Table 1) shows that Nanyumbu in Mtwara region has the lowest population (160,375) while Kaliua in Tabora region has the highest population of 455,305 (URT 2013).

3.2. Data analysis

Data was organized and processed objective-wise and analyzed using Microsoft Excel and Stata software version 11 (Table 3). Data analysis included reviewing descriptive information, obtaining or developing a total value of variables like market demand for groundnut, grain demanded by zones, imports and exports. Ratios were computed to determine the number of adopters of improved varieties. Gross income and production costs (land, seed, fertilizer, weeding, ridging, herbicides, insecticides and pesticides, harvesting labour, transportation, security, threshing, winnowing, shelling, grading and packaging) were computed. The total production cost for each farmer was computed to get the average production cost for each variety/ha in all the districts surveyed. Total revenue was obtained by multiplying the yield by its average price (in TZS) for each farmer. Finally, the gross margin was computed by subtracting the total variable cost (TVC) from the total revenue.

To identify the determinants of adoption of improved groundnut seed, adopters and non-adopters were classified. The probit model was used to analyze factors affecting adoption of improved varieties because of the normality distribution of data, whereby every farmer who used seed of improved varieties was considered an adopter. The model was used to identify farmer's adoption decisions based on gender, age, education, group membership, production purpose, farm size, seed price, grain market accessibility and seed accessibility.

Dependent variables of the model were 0, 1 (dummy variables), which were indicated as 1 if a groundnut farmer adopted an improved variety, and 0 if a farmer did not adopt an improved variety.

Table 3. Tools used for data analysis by objective and description.

Objective	Software used	Description
Production and main uses	Microsoft Excel	Ratios and ranking of grain use
Market demand and main grain off-takers	Microsoft Excel	Sum of grain demanded by zone, import and export
Improved varieties, yield potential Efficiencies	Microsoft Excel Frontier 4.1	Percentage of a variety of adopters/total interviewed Iterative optimization procedures and simultaneous estimation of coefficients
Adoption rate Seed demand analysis	Microsoft Excel Microsoft Excel	Percentage of adopters of a variety/total interviewed
Gross income analysis Determinants of adoption	Microsoft Excel Stata	Total Revenue (TR) - Total Variable Cost (TVC) for the respective farmer Analyzing socio-economic factors
Institutional linkage and private sector's role		Information on different institutions and key informant interviews

Source: Variety business case survey, 2019.

3.3. Theoretical framework

3.3.1. Theories of adoption decisions

The study used the static probit regression model to isolate factors that affect farmers' decision to adopt improved varieties of groundnut in Tanzania. It did not involve the element of time that may influence a farmer's decision to adopt an improved technology (Ghadim and Pannell 1999). In adoption studies, researchers either apply the binary econometric probit or logit models that enable the analysis of a farmer's adoption of new technologies (Musimu 2018). Together, these models can provide more detailed information on the behaviour or characteristics of a farmer who adopts an improved technology (Feder et al. 1985). However, the probit model is favoured over other static models due to its assumption of normal distribution (Wooldridge 2010).

Equation 1 delineates the probit model:

Y_i=F (X_i β) + ε_i…………………………………………………………………………… (Eq. 1)

Where, Y_i = 1 if adopted, 0 otherwise; Ɛ~N (0, 1) β = maximum likelihood, i = cumulative distribution functions of standard normal distribution, ε = error term, Y_i = dependent variable (i.e., the use or not of improved groundnut varieties) and X = set of independent variables (Table 4).

Then the marginal effect is

$\frac{\partial E(\frac{y}{x})}{\partial x}$…………………………………………………………………………………………(Eq. 2)

3.3.2. Theories of production and profit maximization

The study was guided by production and profit maximization theories in which farmers make a decision on the choice of production inputs that maximize profit, subject to resource constraints. The production theory explains the relationship between inputs and outputs, which is the transformation of factor inputs into outputs (Thomas and Maurice 2008). Productivity can be briefly defined as production (output) divided by input (Rasmussen 2012). It is the ratio of farm outputs to the values of inputs used in farm production (Farrell 1957). Profit maximization can be defined as the difference between the revenue a firm receives and the costs that it incurs (Varian et al. 2004). According to Derbetin (2012), the farmer's profit is equal to total revenue (TR)–total cost (TC).

Gross income analysis is among the tools to determine profitability. It involves determining all variable costs and revenue associated with an enterprise. The difference between revenue and total variable costs is the gross income of the enterprise (Leslie 2013). It is a simple method to compare the performance of enterprises that have similar input requirements of capital and labour (Heaslip et al. 2013).

Gross income (GI) = TRi–TVCi………………………………………………………..… (Eq. 3)

Where, GI = gross income of a farmer *i* /kg/year, TR_i = total revenue of a farmer *i*/kg/year and TVCi = total variable cost of a farmer *i*/kg/year

Likewise, Cost-Benefit Analysis (CBA) examines enterprises in isolation from other enterprises and ignores the fixed costs of the farm; hence there is no measure of the profit of a particular enterprise (Leslie 2013). However, it provides a useful tool in terms of farm budgeting and estimating the likely returns or losses of a particular factor of production.

3.3.3. Allocative Efficiency (AE), Technical Efficiency (AE) and Economic Efficiency (EE)

The efficiency of agricultural productivity can be estimated by non-parametric and parametric methods (Simar and Wilson 2015). The most commonly used non-parametric approach is Data Envelopment (DE) analysis, which adopts linear programming and the most profitable firm in the sample to develop production frontiers, assuming all deviations have resulted in inefficiency (Charnes et al. 1978). The flexible parametric approach uses the Stochastic Frontier Analysis (SFA) technique. The error term in the stochastic approach is split to cover factors that are out of the farmer's control and the technical inefficiency of farmers (Meeusen and Van den Broeck 1977). It is hard to accept that inconsistency in production is solely associated with inefficiency, as presumed in the non-parametric model (Bauman et al. 2016). Hence this study used the SFA approach, as used by Dlamini et al. (2010); Gedara et al. (2012) and Xu et al. (2015).

The theoretical framework was developed based on a theory of the firm and a theory of efficiency of resource use in agricultural production. The theory of the firm has three fundamental concepts: maximization, equilibrium and efficiency (Kaine 2011). The maximization concept regards firms as rational entities, in that they allocate their resources in a way that maximizes their profits. The production efficiency is based on the production frontiers, defined as the lowest production inputs needed for the firm to operate at the maximum (Chukwuji et al. 2007). Farrel (1957) illustrated efficiency measures with the example of firms that use two inputs, x1 and x2, to yield a particular product y. Suppose the production function is given as y=f (x1,x2), assuming that increase in inputs will have the same effect on the rate of output increases, it can be written as 1=f (x1,x2), where 1 is a unit isoquant, i.e., the technological frontier can be represented by a unit isoquant UU' as presented in Figure 2 (adapted from Førsund et al. 1980).

By assuming that increases in inputs will have the same effect on the rate of output increases, Farrell (1957) observed that input per unit of output values (input-output ratios) for firms would be above the so-called unit isoquant. This is represented by the space around point A in Figure 2. Thus, the OB/OA ratio, i.e., the ratio of inputs needed to produce observed output measures technical efficiency. Similar to the deviations from UU' were the estimation of the technical inefficiency of firms. Other types of efficiencies (allocative and economic) can also be illustrated by introducing the isocost line PP' (representing relative input prices). Then allocative inefficiency can be estimated by the OD/OB ratio. Furthermore, there are similarities in terms of point D (cost) and point C (allocative efficient). According to Førsund et al. (1980), then the sum of efficiency is given as the ratio of OD and OA. Economic efficiency is achieved when a firm produces output at the lowest costs for a given technology (Kopp and Diewert 1982). At a point in the production process that attains both TE and AE, the consequence will be EE. Thus, AE=EE/TE.

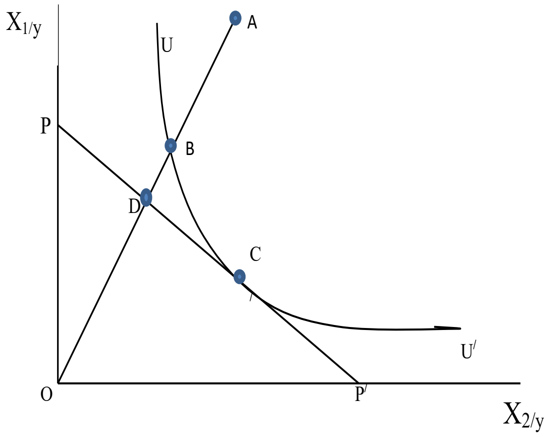


Figure 2. Allocative Efficiency, Technical Efficiency and Economic Efficiency.

Source: Førsund et al. (1980).

3.4. Empirical models

3.4.1. Probit model

$P_i\ (0, 1) = B_0 + B_1X_1 + B_2X_2 \ldots\ldots + B_nX_n + e \ldots\ldots$ (Eq. 4)

$P_i\ (0,1) = B_0 + B_1X_{Age} + B_2X_{sex} + B_{3}X_{Land\ ownership} + B_4X_{Farmsize} + B_5X_{Group\ membership} + B_6X_{education} + {} + B_8X_{Grain\ price} + B_9X_{seed\ availability} + ei \ldots\ldots$ (Eq. 5)

Table 4. Expected signs for variables in the probit empirical model.

Explanatory variable	Unit	Type and expected sign	Description
Age of the farmer	Years	Continuous (+/-)	Farmers who are old tend to be more traditional than young farmers in terms of using improved technologies. Conversely, lack of experience may deter young farmers from using new technologies.
Gender of the farmer	1=Male 0=Otherwise	Dummy (+)	Male farmers are expected to adopt improved varieties compared to female farmers because they are the decision makers in male-headed households.
Land ownership	1=Settler 0=Otherwise	Dummy (-)	Settlers are expected to adopt more improved technologies compared to landlords because they aim to make a good profit on investment.
Group membership	1=Member 0=Otherwise	Dummy (+)	A farmer in a group is expected to adopt improved technologies due to easy access to information and knowledge shared by group members than a farmer operating individually.

Explanatory variable	Unit	Type and expected sign	Description
Farm size	Acres	Continuous (+)	Farmers with large farms are more likely to adopt improved technologies.
Education	Years spent in school	Discrete (+)	The greater the farmer's education, greater is the likelihood of adopting new and improved technologies due to increased awareness.
Experience	Years	Continuous (+)	The more experienced farmers are, greater is the likelihood of their adopting improved varieties.
Grain price	Tanzanian Shillings	Continuous (+)	As the price of grain increases, the adoption of improved varieties is expected to increase as well because farmers will opt for the variety that pays more.
Seed availability	1=Available 0=Otherwise	Dummy (+)	When improved varieties are readily available to farmers, adoption is expected to increase compared to when they are not easily available.

3.4.2. Gross income

$$GIi = \sum_{n=1}^{n} TR_i - \sum_{n=1}^{n} TV_i \ldots\ldots\ldots (Eq.6)$$

$$GIi = \sum_{n=1}^{n} P_{yj} . Y_i - \sum_{i=1}^{n} P_{xij} . X \ldots\ldots\ldots (Eq. 7)$$

Where, GI = gross income, n = farmer interviewed, Y=output, Py=price of output, j=jth district, X = input, Pxij =price incurred by farmer i in purchasing the ith input in jth district and P_{yj}=price of the output in jth district.

3.4.3. Specification of the frontier production and cost functions

The empirical specification is based on the model proposed by Battese and Coelli (1995), where inefficiency effects are incorporated in the stochastic log-log production frontier. This approach enables the researcher to estimate the determinants and the distribution of the farmer's efficiencies. This approach involves retrogressing against factors of production as well as socio-economic variables that determine inefficiency levels in seed production. The implicit Cobb-Douglas functional form is specified as:

$$\ln(Y_i) = \beta_0 + \sum_{a=1}^{4} \beta_a \ln(X_{ai}) + V_i - U_i;$$

i = 1, 2, 3, …, n observations ……………………………………………………………… (Eq. 8)

Where, β_0, $\beta_{a,\ a = 1,2,3,4}$ are parameters to be estimated. Explicitly, the model to be estimated is developed as follows:

$$ln(Y_i) = \beta_0 + \beta_1 lnLand_i + \beta_2 lnLab_i + \beta_3 lnSeed_i + \beta_4 lnFer_i + V_i - U_i \ ;$$

i = 1, 2, 3, …, n observations ……………………………………………………………… (Eq. 9)

Where, Y_i = total amount of seed produced by the i^{th} farmer in kg, $\beta_{a,\, a = 0,1,2,3,4}$ are parameters to be estimated, $Land_i$ = total area planted by i^{th} farmer in hectares, Lab_i = total amount of labour utilized by the i^{th} farmer in human days, $Seed_i$ = total quantity of seed utilized by the i^{th} farmer in kg, Fer_i = total quantity of fertilizer utilized by the i^{th} farmer in kg, V_i = random variable for the i^{th} farmer associated with disturbances in the production process and U_i = farm socio-economic characteristics related to the production inefficiency.

According to the specification by Battese and Coelli (1995), the implicit Cobb-Douglas cost function of stochastic frontier is given by:

$$\ln(C_i) = \alpha_0 + \alpha_y \ln(Y_i) + \sum_{a=1}^{4} \alpha_a \ln(p_{ai}) + V_i + U_i;$$

i = 1, 2, 3, … n observations …………………………………………………………. (Eq. 10)

Where, C_i = total cost for farm i^{th}, α_y and $\alpha_{a,\, a = 0,\, 1,2,3,4}$ are parameters to be estimated, p_i = input price for the i^{th} farmer and Y_i, V_i, and U_i are as defined previously. Explicitly, the model to be estimated for our study is as follows:

$$ln(C_i) = \alpha_0 + \alpha_1 lnY_i + \alpha_2 lnLandCost_i + \alpha_3 lnLabCost_i + \alpha_4 lnSeedCost_i + \alpha_5 lnFerCost_i + v_i + u_i$$

; i = 1, 2, 3, …, n observations ……………………………………. (Eq. 11)

Where, C_i = total cost of producing seed for the i^{th} farmer in TZS, $\alpha_{c,\, c = 0,1,2,\ldots 4}$ are parameters to be estimated, Y_i = total amount of seed produced by the i^{th} farmer in kg, $LandCost_i$ = the land lending price for the i^{th} farmer in TZS/ha, $LabCost_i$ = the price of labour utilized for the i^{th} farmer in TZS/human-day, $SeedCost_i$ = the price of seed for the i^{th} farmer in TZS/kg and $FerCost_i$ = the price of fertilizer for the i^{th} farmer in TZS/kg.

3.4.4. Estimation of elasticities

Considering equation 8, elasticities of mean output with regard to the used inputs can be estimated as follows:

$$\varepsilon_a = \frac{\partial \ln E(Y_i)}{\partial \ln X_a} = \beta_a$$ ………………………………………………………………… (Eq. 12)

Where, a=1, 2, 3, 4 are the four inputs used.

3.4.5. Estimation of AE, TE and EE

As proposed by Meeusen and Van den Broeck (1977) and Aigner et al. (1977), the error term ε_i of the stochastic production function is split into two independent components: $\varepsilon_i = V_i - U_i$, where V_i is independently and identically distributed normally with mean zero and variance σ_v^2, while U_i is the independently distributed random variable with variance σ_u^2. As per Aigner et al. (1977), parameters for log-likelihood function are given as:

$$lnL(Y \backslash \beta, \sigma, \gamma) = -\frac{n}{2} ln\left(\frac{\pi\sigma^2}{2}\right) + \sum_{i=1}^{n} ln\Phi\left(-\frac{\varepsilon_i \gamma}{\sigma}\right) - \frac{1}{2\sigma^2}\sum_{i=1}^{n} \varepsilon_i^2$$ ……………. (Eq.13)

Where, Y is a vector of log-outputs (seed produced) and $\Phi(x)$ is a function cumulative of random normal variable evaluated at x.

$\sigma^2 = \sigma_v^2 + \sigma_u^2$ ………………………… ……………………………………. (Eq. 14)

and $\gamma = \frac{\sigma_u^2}{\sigma^2}$ …………………………………………………………………….... (Eq. 15)

where, σ^2 = the sum variation in the amount of seed produced (kg) which is a combination of technical inefficiency effect (U_i) and random error (V_i) and γ = the impact of inefficiency on the output.

The MLE of equations 9 and 11 with FRONTIER 4.1 software provides consistent estimations of β, σ and γ. The parameter γ must lie between 0 and 1. When the estimate of γ lies nearer to 0, it signifies the difference in the observed output from the frontier as a result of unexpected events. Similarly, if the estimated γ is nearer to 1, it signifies that most of the difference in output is a result of technical inefficiency effects.

The maximizing equation (12) involves taking the first derivatives to each unknown parameter and setting them to zero. However, first-order conditions are highly nonlinear and cannot be solved analytically for β, σ and γ (Coelli et al. 2005). The solution lies in using iterative optimization procedures (Judge et al. 1985) with FRONTIER 4.1 software program, considering that specification of equations (8) and (10) as the production function used is Cobb-Douglass and given the number of estimated parameters is known. Then the estimated TE for farm i^{th} can be indicated as follows:

$$\widehat{TE} = E\{\exp(-u_i)\} = 2\Phi(-\sigma_u)exp\left\{\frac{\sigma_u{}^2}{2}\right\}$$ ………………………………………….. (Eq. 16)

3.4.6. Determining socio-economic factors affecting efficiency levels

Inefficiency model specification can be derived by regressing the inefficiency component (U_i) to the farm socio-economic characteristics, as follows:

$U_i = \delta_0 + \delta_1 Land_i + \delta_2 Exp_i + \delta_3 Gr_i + \delta_4 Edu_i + \delta_5 Sex_i + \delta_6 Age_i$; i = 1, 2, 3, …, n observations ……………………………………………………………………….....(Eq. 17)

Where, U_i = farm socio-economic characteristics related to the production inefficiency; $\delta_{b,\ b = 0,1,2,\ldots6}$ are parameters to be estimated, $Land_i$ = land tenure (1 = own, 0 = rented), Exp_i = experience of i^{th} farmer in years, Gr_i = part of farming group by the i^{th} farmer (1 = if farmer is a member of a farming group, 0 = if farmer is not a member of a farming group), Edu_i = number of years i^{th} farmer attended schooling, Sex_i = gender of the i^{th} farmer (1 = male, 0 = female) and Age_i = age of the i^{th} farmer in years.

4. RESULTS

4.1. Socio-economic profile of respondents

4.1.1. Profile of groundnut farmers

The study revealed that there are more male farmers (68.3% and 50.04%) than female farmers (49.6% and 31.7%) in groundnut production in the intervention and non-intervention districts, respectively (Table 5). Most of the farmers interviewed were between the ages of 35 and 50 years in both categories. The average number of years of formal education was 7.2 in intervention and 7.1 in non-intervention districts. The majority of farmers, 84.2% in intervention districts and 91.7% in non-intervention districts, had 1-7 years of formal education. About 5% of the farmers in intervention districts and 1.6% in non-intervention districts had no formal education. The maximum number of years of schooling was 16 years in intervention districts and 12 years in non-intervention districts.

Also, about 37.9% of the farmers in intervention districts and none in non-intervention districts were organized into groups. About 44.6% and 35% of the interviewed farmers were landlords from intervention and non-intervention districts, respectively. About 95.4% in intervention districts and 90% in non-intervention districts had a farm size of less than 2 ha. Regarding technology use, only 33% of the interviewed farmers used seeds of improved variety. The findings indicate that neither fertilizers nor pesticides were used by farmers in groundnut production in both categories of interventions. Only 5.3% of the farmers in the intervention districts had access to organizations producing improved seeds, while it was none in non-intervention districts. Lastly, about 62% of the farmers interviewed in the intervention districts recycled grain as seed and 100% in the non-intervention districts.

Table 5. Socio-economic profile of 300 interviewed groundnut farmers.

Variable	Category	Percentage of respondents in intervention districts (n=240)	Percentage of respondents in non-intervention districts (n=60)
Age	< 20	0.4	0
	20 -35	24.2	20.0
	35 – 50	50.4	48.3
	50 – 65	17.9	30.0
	>65	7.1	1.7
Gender	Male	50.4	68.3
	Female	49.6	31.7
Years of formal education	No formal education	5.0	1.6
	1-7	84.2	91.7
	8-11	8.3	6.7
	12 and above	2.5	0
Land ownership	Settlers	37.9	56.7
	Landlord	44.6	35.0
	Both	11.7	0
	Others	5.8	8.3
Group membership	Yes	37.9	0
	No	62.1	100

Variable	Category	Percentage of respondents in intervention districts (n=240)	Percentage of respondents in non-intervention districts (n=60)
Farm size (ha)	<2	95.4	90.0
	>2	4.6	10.0
Market accessibility	Yes	100	100
	No	0	0
Seed use	Yes	33	0
	No	67	100
Fertilizer use	Yes	0	0
	No	100	100
Pesticide use	Yes	0	0
	No	100	100
Seed accessibility	Yes	5.3	0
	No	94.7	100
Recycle grain as seed	Yes	62	100
	No	38	0

Source: Variety business case survey, 2019.

4.1.2. Profile of off-takers

The findings showed that 19% of grain off-takers interviewed were women and 81% men (Table 6). Also, 88% of the off-takers were traders. Traders facilitated business along the value chain by taking grain from the farm gate to other market destinations (rural, urban and export). Only 8% of grain off-takers were processors and the remaining 4% were middlemen. About 76% of them had 1 to 7 years of formal education, 5% had 8 to 11 years, 16% had 12 and more years and only 3% had no formal education. Also, 82% of the traders were transacting 50 t of grain and more, who under this study were regarded as large grain off-takers; and 18% were transacting less than 50 t of grain and regarded as small traders. The traders interviewed were from six agro-ecological zones: Central (42%), Eastern (19%), Southern (15%), Southern Highlands (14%), Lake (5%) and Western (5%).

Table 6. Socio-economic profile of 123 grain off-takers.

Variable	Category	Percentage
Gender	Female	19
	Male	81
Off-taker category	Middlemen	4
	Processors	8
	Traders	88
Years of formal education	1-7	76
	8-11	5
	12 and above	16
	No formal education	3
Group membership	Yes	5
	No	95

Variable	Category	Percentage
Capacity (t)	<50	18
	> = 50	82
Business zone	Southern	15
	Eastern	19
	Central	42
	Western	5
	Southern Highlands	14
	Lake	5

Source: Variety business case survey, 2019.

4. 2. Grain production and its main uses

4.2.1. Population and proportion of farmers

The population of mainland Tanzania was estimated to be 50 million in 2017. Of these, about 4,777,531 people in 9,109,184 households were involved in groundnut farming. Farming households varied in number across agro-ecological zones: 1,072,040 in Lake zone, 958,276 in Western zone, 663,143 in Eastern zone, 645,382 in Southern Highlands zone and 554,405 in Southern zone. Central zone (409,264) and Northern zone (475,021) had the least number of farming households (Table 7). Lake zone had the highest percentage of farming households (22%), followed by Western zone (20%). Region-wise, Kigoma had the highest share of farming households (about 13%), followed by Morogoro (9%), Tabora (7%), Mwanza (7%) and Manyara (7%) (Table 7).

Table 7. Population and number of farming households by agro-ecological zone.

Zone	Region	Population	Household/zone	Farm households	Household (%)
Southern	Mtwara	1,351,038	344,834	307,326	6.43
	Lindi	905,947	225,972	247,079	5.17
	Total	2,256,985	570,806	554,405	11.60
Southern Highlands	Mbeya	1,929,359	635,047	107,643	2.25
	Iringa	996,105	223,028	77,453	1.62
	Njombe	730,555	170,160	154,523	3.23
	Rukwa	1,179,149	199,766	67,941	1.42
	Ruvuma	1,530,955	303,071	114,850	2.40
	Songwe	1,173,667	-	61,000	1.28
	Katavi	663,685	101,224	61,972	1.30
	Total	8,203,475	1,632,296	645,382	13.51
Central	Dodoma	2,312,141	453,844	286,123	5.99
	Singida	1,539,286	258,280	123,141	2.58
	Total	3,851,427	712,124	409,264	8.57
Eastern	Dar es Salaam	5,781,557	1,095,095	28,400	0.59
	Morogoro	2,495,462	506,289	435,917	9.12

Zone	Region	Population	Household/zone	Farm households	Household (%)
	Coast	1,224,120	257,511	198,824	4.16
	Total	9,501,139	1,858,895	663,143	13.87
Northern	Arusha	1,943,196	378,825	49,602	1.04
	Kilimanjaro	1,790,113	384,867	68,110	1.43
	Manyara	1,670,191	273,284	327,831	6.86
	Tanga	2,286,528	438,277	29,478	0.62
	Total	7,690,028	1,475,253	475,021	9.95
Lake	Mwanza	3,217,328	486,184	338,109	7.08
	Kagera	2,879,231	524,793	176,909	3.77
	Geita	1,983,653	286,757	189,896	3.97
	Shinyanga	1,701,220	261,766	163,524	3.42
	Simiyu	1,736,839	229,946	90,151	1.89
	Mara	1,972,173	312,444	113,451	2.37
	Total	13,490,444	2,101,890	1,072,040	22.50
Western	Kigoma	2,399,121	374,488	617,520	12.93
	Tabora	2,652,514	383,432	340,756	7.13
	Total	5,051,635	757,920	958,276	20.06
	Grand total	50,045,133	9,109,184	4,777,531	

Source: NBS (2017); URT (2013).

4.2.2. Groundnut production

Groundnut productivity, area and production in Tanzania were computed, disaggregated by agro-ecological zone. Findings showed that Western zone used more land but had less productivity (485.14 kg/ha) compared to Lake zone (598.3 kg/ha) which had less land but more yield. Productivity was highest (771 kg/ha) in Southern zone. Lake zone contributed about 29% of the total production, followed by Western zone with 26%, Southern Highlands zone with 18%, Central zone with about 17% and Southern zone about 9%. Tabora region was found to allocate 30% of the area to groundnut production. Dodoma, Geita and Shinyanga regions allocated 11% of the area. However, the four regions that allocated the least area were Njombe (0.36%), Iringa (0.24%), Dar es Salaam (0.03%) and Tanga (0.05%) (Table 8).

Table 8. Area, production and yield of groundnut by region and zone.

Zone	Region	Area (ha)	Production (t)	Yield (t/ha)	Area (%)	Production (%)
Southern	Mtwara	24,626	14,717	0.6	5.04	6.21
	Lindi	2,616	5,624	2.15	0.54	2.37
	Total	27,242	20,341	0.75	5.58	8.58
Southern Highlands	Mbeya	29,887	16,136	0.54	6.12	6.81
	Iringa	1,175	1,895	1.61	0.24	0.80
	Njombe	1,766	1,034	0.59	0.36	0.44

Zone	Region	Area (ha)	Production (t)	Yield (t/ha)	Area (%)	Production (%)
	Rukwa	6,118	4,549	0.74	1.25	1.92
	Ruvuma	5,079	4,053	0.8	1.04	1.71
	Katavi	12,851	15,544	1.21	2.63	6.56
	Total	56,876	43,211	0.76	11.64	18.23
al	Dodoma	53,824	30,052	0.56	11.02	12.68
	Singida	21,261	9,422	0.44	4.35	3.97
	Total	75,085	39,474	0.53	15.37	16.65
Eastern	Dar es Salaam	137	39	0.28	0.03	0.02
	Morogoro	3,913	1,101	0.28	0.80	0.46
	Total	4,050	1,140	0.28	0.83	0.48
Northern	Kilimanjaro	5,050	1,506	0.3	1.03	0.64
	Tanga	256	253	0.99	0.05	0.11
	Total	5,306	1,759	0.33	1.09	0.74
Lake	Mwanza	13,151	1,568	0.12	2.69	0.66
	Kagera	4,274	2,186	0.51	0.87	0.92
	Geita	52,655	15,728	0.3	10.78	6.64
	Shinyanga	51,474	12,834	0.25	10.54	5.41
	Simiyu	17,691	34,207	1.93	3.62	14.43
	Mara	4,950	1,802	0.36	1.01	0.76
	Total	144,195	68,325	0.47	29.51	28.82
Western	Kigoma	28,213	17,975	0.64	5.77	7.58
	Tabora	147,618	44,811	0.3	30.21	18.90
	Total	175,831	62,786	0.36	35.99	26.49
				0.43		
	Grand total	488,585	237,036			

Source: NBS (2017).

4.2.3. Groundnut farming households (HHs) and farm size

About 1,114,175 households in the country are engaged in groundnut production (Table 9), which is 23% of the total farming HHs in mainland Tanzania. The national average farm size per farming household is 1.11 ha. Dodoma region had the highest farm size of about 2.6 ha/farming HH, followed by Tabora (2.03 ha/farming HH). Njombe, Dar es Salaam and Kagera had the lowest farm sizes/farming HHs of 0.75 ha, 0.75 ha and 0.71 ha, respectively. Moreover, groundnut farm size by region indicates that most of the farmers have small farm sizes, an average of 0.44 ha. Lindi region had the largest average farm size allocated to groundnut (0.92 ha), followed by Iringa (0.82 ha), Shinyanga (0.69 ha) and Dodoma (0.64 ha). Regions like Rukwa, Dar es Salaam and Arusha had the smallest average groundnut farm sizes of around 0.1 ha.

Table 9. Groundnut farming households and farm size.

Zone		Region	Households	Average farm size (ha)	Average groundnut farm size (ha)
Southern		Mtwara	74,049	1.55	0.6
		Lindi	2,897	1.24	0.92
Southern Highlands		Mbeya	30,385	1.14	0.49
		Iringa	1,429	1.12	0.82
		Njombe	4,724	0.75	0.37
		Rukwa	17,700	1.38	0.01
		Ruvuma	14,961	0.83	0.34
		Songwe	30,000	1.001	0.51
		Katavi	23,319	1.08	0.62
Central		Dodoma	83,434	2.6	0.64
		Singida	34,776	1.83	0.61
Coastal		Dar es Saalam	1,646	0.75	0.11
		Coast	4,414	1.63	0.54
Northern		Arusha	8,767	1.1	0.15
Lake		Mwanza	41,753	0.87	0.31
		Kagera	65,948	0.71	0.2
		Geita	114,293	1.48	0.46
		Shinyanga	71,053	2	0.69
		Simiyu	55,035	1.57	0.32
		Mara	17,555	1.07	0.28
Western		Kigoma	295,551	1.01	0.23
		Tabora	120,486	2.03	0.5
		Grand total	1,114,175	1.11	0.44

Source: NBS (2017).

4.2.4. Major crops produced by respondents

4.2.4.1. Crops preferred and their share of area

Findings showed that in 10 districts where farmers were interviewed, crops with the highest share of area were groundnut followed by maize. Farmers from Mpwapwa (56%), Urambo (52%) and Chamwino (52%) allocated the most land to groundnut. Mbozi district allocated about 71% of land to maize and 20% to groundnut. Both crops were grown in all 11 districts; sunflower was grown in 7 districts (Urambo, Mkalama, Mpwapwa, Chamwino, Masasi, Urambo and Bahi). The rest of the crops varied in availability in each district; for example, only Kaliua district had farmers growing tobacco (Table 10).

Table 10. Crops preferred by interviewed farmers and their share of area by district.

District	Crop	Share of area (%)	District	Crop	Share of area (%)
Bahi	Groundnut	40	Bukombe	Groundnut	30
	Maize	25		Maize	28
	Sorghum	10		Cotton	19
	Sunflower	18		Rice	11
	Cassava	7		Beans	12
Chamwino	Groundnut	52	Masasi	Groundnut	51
	Maize	17		Maize	45
	Sunflower	24		Sunflower	2
	Millet	4		Bambaranut	2
Kaliua	Groundnut	43	Mpwapwa	Groundnut	56
	Maize	33		Sorghum	26
	Cotton	1		Millet	6
	Tobacco	15		Sunflower	8
	Rice	8		Maize	4
Mbozi	Groundnut	20	Urambo	Groundnut	52
	Maize	71		Maize	46
	Sorghum	7		Sunflower	2
	Beans	2			
Nanyumbu	Groundnut	44	Mkalama	Groundnut	39
	Maize	27		Sunflower	41
	Millet	11		Sorghum	7
	Sunflower	10		Maize	10
	Sorghum	8		Rice	3
Kahama	Sorghum	3			
	Groundnut	36			
	Maize	25			
	Cotton	17			
	Rice	12			
	Millet	10			

Source: Variety business case survey, 2019.

4.2.4.2. Major crops grown by zone

Maize is grown throughout the country (Appendix 1). Southern Highlands and Lake zone dominated both cultivated area and production. Southern Highlands had higher productivity (1.6 t/ha) than Lake zone (1.2 t/ha). Groundnut appears among the top five crops grown in three zones: Western (196,565 ha and 132,735 t, equivalent to 0.76 t/ha; Southern (140,613 ha and 96,839 t, equivalent to 0.75 t/ha) and Central (62,301 ha and 29,456 t, equivalent to 0.53 t/ha).

4.2.5. Farmers' motivation to produce groundnut

The estimated amount of groundnut commercialized was 68,279 t, accounting for about 75% of the total groundnut produced, whereas 22,706 t was the estimated quantity used for subsistence, equivalent to 25% of the total grain produced by farmers. In Chamwino district, the grain used for subsistence purposes was 1,851 t (58%) of the total produced, which was higher than the quantity used for commercial purposes (1,361 t) (Table 11).

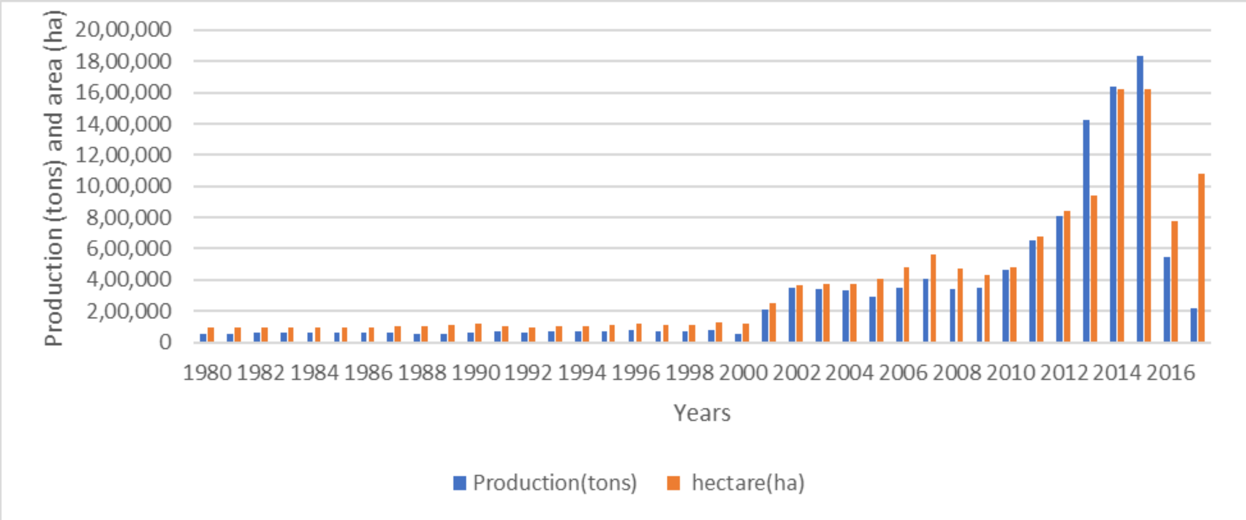
Table 11. Subsistence vs. commercial use of groundnut by 300 farmers.

Zone	District	Grain used for subsistence (t)	Farmer (%)	Grain for commercial use (t)	Farmer (%)
Southern	Masasi	935	17	4,428	83
	Nanyumbu	1,620	11	12,630	89
	Overall	2,555	13	17,058	87
Western	Kaliua	3,366	25	9,924	75
	Urambo	1,441	28	3,651	72
	Overall	4,807	26	13,575	74
Southern Highlands	Mbozi	1,441	17	7,017	83
	Overall	1,441	17	7,017	83
Central	Bahi	649	27	1,973	73
	Chamwino	1,851	58	1,361	42
	Mpwapwa	3,556	26	10,220	74
	Mkalama	4,804	29	11,596	71
	Overall	10,860	30	25,150	70
Lake	Bukombe	1,245	39	1,925	61
	Ushetu	1,798	34	3,554	66
	Overall	3,043	36	5,479	64
	Grand total	22,706	25	68,279	75

Source: Variety business case survey, 2019.

4.2.6. Groundnut production trends in Tanzania, 1980 – 2018

The study found a progressive increase in both area under production and total production between 1980–2018. However, the increase was limited and not very visible. Increase in area approximately doubled between 2001 and 2016. As shown in Figure 3, the highest gain in production was reached in 2015; area and total production were 1.6 million ha and 1.8 million t, respectively. This boost in groundnut production can be attributed to the Tropical Legumes project interventions that encouraged farmers to use seed technologies and adopt good agronomic practices (Figure 3 and Appendix 2).



Source: FAOSTAT (2018).

Figure 3. Grain production trend in Tanzania from 1980 to 2018.

4.2.7. Production challenges and mitigation strategies adopted by farmers

Despite the increase in grain production over time, our study showed that the interviewed farmers faced several challenges. Among the major production challenges faced were drought (25%), diseases and insect pests (22.10%), limited seeds (15.80%) and poor farming implements (13.70%). It was found that 8.50% of the farmers complained of limited markets and market information, 3.80% of limited knowledge on agronomic practices and 1.8% of high operational costs. About 1.2% experienced land conflicts with pastoralists, whereas 0.70% experienced high cost of improved varieties (Table 12). To cope with these challenges, farmers opted to use recycled seed, modify time of planting and harvest and use local farming implements.

Table 12. Challenges faced and mitigation strategies adopted by 300 farmers.

Challenges	Farmers (%)	Mitigation strategies adopted
High cost of seeds	0.70	Recycle seed
Land conflict with pastoralists	1.20	Use small area
High operational cost	1.80	Mixed cropping and cultivating small area
Limited knowledge of agronomic practices	3.80	Use local farming practices
Limited capital	7.40	Manageable credit
Limited markets and market information	8.50	Sell at low price and use middleman
Poor farming implements	13.70	Use local farming implements
Limited seeds	15.80	Recycle seed
Diseases and insect pests	22.10	Modify planting and harvesting time
Drought	25.00	Modify planting time

Source: Variety business case survey, 2019.

4.2.8. Main uses of groundnut

Groundnut produced by farmers was used in different ways in the country. It was sold as grain by 42%, sold as seed during planting by 29%, consumed by 26.4%, used to extract oil by 2% and bartered for other food crops like rice by 1%. (Table 13).

Table 13. Frequency of grain use (%) by interviewed farmers.

Type of use	Absolute frequency	Relative frequency (%)
Barter	1	1
Consumption	31	26
Extracted oil	4	2
Sale as grain	52	42
Sale as seed	35	29

Source: Variety business case survey, 2019.

The findings further showed that the sale of groundnut as seed was high in Mkalama district by 43.3% (non-intervention area), followed by Mbozi and Kahama rural districts (36.7%). Urambo district had the highest proportion of interviewed farmers (14.2%) involved in groundnut oil extraction. Kaliua and Urambo districts used groundnut for both sale (83%) and consumption (82.2%) (Table 14).

Table 14. Groundnut use by interviewed farmers.

District	Sold seed as grain (%)	Oil processing (%)	Sale and consumption of grain (%)	Bartered (%)
Urambo	3.6	14.2	82.2	0.0
Nanyumbu	33.3	0.0	66.7	0.0
Mbozi	36.7	3.3	60.0	0.0
Masasi Town	22.0	0.0	78.0	0.0
Kaliua	17.0	0.0	83.0	0.0
Kahama rural	36.7	3.3	60.0	0.0
Chamwino	30.0	0.0	70.0	0.0
Bukombe	13.3	0.0	86.7	0.0
Bahi	33.3	0.0	66.7	0.0
Mpwapwa	20.0	0.0	80.0	0.0
Mkalama	43.3	0.0	54.0	2.7

Source: Variety business case survey, 2019.

4.2.9. Per capita consumption by zone

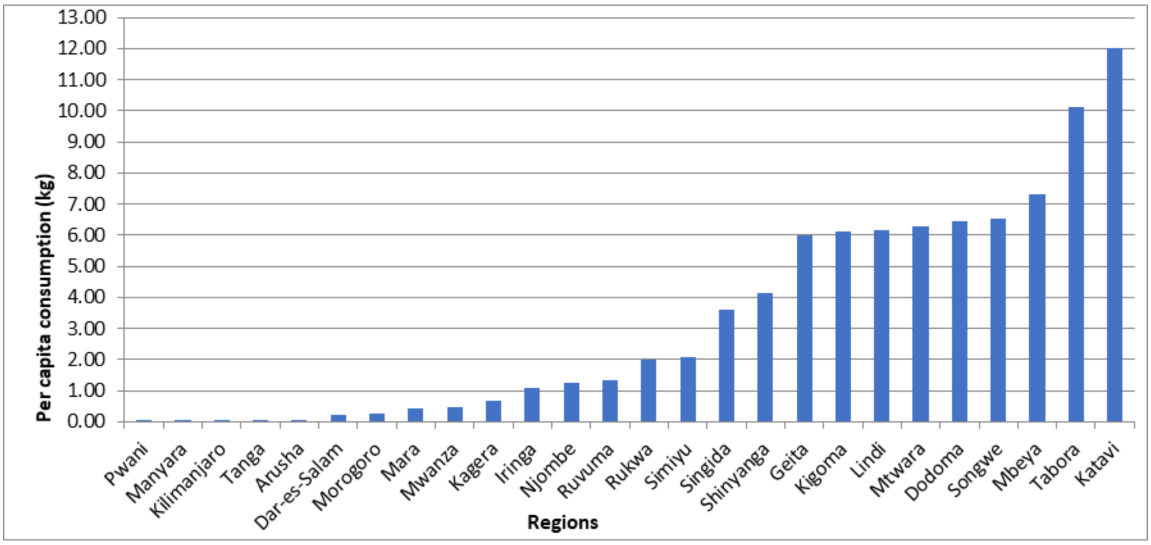
The findings showed that national per capita consumption of groundnut was 3.26 kg/year, but varied across zones and regions. The study indicated that zones with high groundnut production recorded high per capita consumption compared to zones with low production. For example, Western zone had the highest per capita consumption of 8.12 kg/year, while Northern zone had the lowest per capita consumption of 0.05 kg/year (Table 15). Northern, Eastern and Lake zones had per capita consumption of less than 2.5 kg/year while Southern Highlands, Central, Southern and Western zones had per capita consumption ranging between 4.5 kg/year and 8 kg/year (Table 15).

Table 15. Per capita annual consumption of groundnut by study zone.

	Northern zone	Eastern zone	Lake zone	Southern Highlands zone	Central zone	Sout-hern zone	Western zone	National
Per capita consumption (kg)	0.05	0.17	2.29	4.52	5.02	6.21	8.12	3.26

Source: NBS (2016/2017).

The results further showed that of the 26 regions in mainland Tanzania (Figure 4), 10 regions (38%) had a per capita consumption of less than 1 kg/year, 7 regions (19%) had a per capita consumption of less than 5 kg/year and 9 regions (34%) had a per capita consumption ranging from 5–12 kg/year.



Source: NBS (2017).

Figure 4. Per capita consumption of groundnut in 26 regions of Tanzania.

4.2.10. Challenges faced by groundnut off-takers

Results in Table 16 show the challenges faced by groundnut off-takers in the study area. The major challenges reported were multiple fees and taxes (23.60%), lack of storage places (16.30%), price fluctuations (11.40%), poor infrastructure (3.2%), limited grain (2.30%), lack of reserved areas for industrialization (3.9%), poor market linkages (0.8%), poor seeds (1.60%) and limited knowledge of actors and other users (0.8%).

Table 16. Challenges faced by 123 grain off-takers.

Challenge	Off-takers (%)
Price fluctuation	11.40
Poor quality grain	8.90
Multiple fees and tax	23.60

Challenge	Off-takers (%)
Poor infrastructure	3.20
Limited grain	2.30
Limited market	4.10
Lack of storage	16.30
Import of grain	3.30
Poor grading	0.80
Limited promotion	3.30
Lack of market linkage	0.80
Limited information	0.80
Poor seeds	1.60
Some grain traits missing	4.10
Lack of reserved area for industrialization	3.90
Limited big traders	0.80
Poor knowledge of groundnut	0.80
Others (low turnover, low hydroelectric power)	4.90
Tariffs, lack of uniform weights and balance	5.10

Source: Variety business case survey, 2019.

4.3. Grain market demand and main groundnut off-takers

4.3.1. Share of groundnut in off-takers' business

The share of groundnut in an off-takers business varied from trader to trader. The present study regarded every off-taker for whom groundnut represents 50% or more of the grain business as a committed off-taker and those for whom groundnut represents <50 of the total business as not committed. The study found that 100 off-takers (82%) were committed while 19% were not. It was estimated that about 85,759 t were transacted by committed off-takers and 714 t by non-committed off-takers (Table 17).

Furthermore, it was estimated that at least 41,316 t were transacted in Dodoma and 32,106 t in Songwe regions, suggesting their large market share in the grain business compared to other regions.

Although women were few among off-takers, they showed high ability in the grain business, with 90% of groundnut traded in Shinyanga region transacted by them. About 26% of women in Songwe region contributed about 23% of the total groundnut transacted in the region (Table 17).

Table 17. Share of groundnut in the business of off-takers.

Region	Gender (M/F)	Number of off-takers	Total transactions (t)	≥50% share of business	≥50% of business (t)	<50% share of business	<50% of business (t)
Mtwara	M	18	2,030	13	1,915	3	115
	F	1	50	3	50	-	
Mbeya	M	2	2,331	1	2,156	1	175
	F	0	-	0	-	-	-
Songwe	M	10	26,090	12	32,106	-	
	F	5	6,110	-	-	3	94
Singida	M	6	165	3	135	3	50
	F	1	150	1	150	-	
Dodoma	M	42	41,296	39	41,246	3	50
	F	3	20	3	-	-	
Morogoro	M	7	255	3	250	4	5
	F	5	605	3	590	2	15
Dar es Salaam	M	11	1,327	7	1,117	4	210
	F	0	-	-	-	-	
Tabora	M	3	250	3	250	-	
	F	3	270	3	270	-	
Shinyanga	M	5	524	6	5,524	-	
	F	1	5,000	-	-	-	
Total		123	86,473	100	85,759	23	714

Source: Variety business case survey, 2019.

4.3.2. Traits preferred by off-takers

Traders are not the final users of groundnut. They are involved in buying and selling with the aim of maximizing profit. Therefore, traders/off-takers get involved in the exchange of varieties with qualities/traits demanded by the final users. The present study found that off-takers in Western zone and Lake zone shared similar groundnut trait preferences because of their similar markets for groundnut. Table 18 shows the pattern of groundnut traits preferred by zone and region. Off-takers were observed to be interested in buying improved varieties around all the regions. The preference for improved varieties opens a market for seed business and signals higher productivity among farmers.

Table 18. Groundnut trait preferences of off-takers by region and variety.

Zone	Off-takers	Region	Trait preference by variety
Southern	Trader	Mtwara	Medium size, tan colour (Pendo 1998 and Johari)
		Lindi	Medium size, tan colour (Pendo1998 and Johari)
Southern Highlands	Trader	Mbeya	Large size, white colour (Nachi 2015); large size, red colour (Mnanje 2009)
		Iringa	Large size, white colour (Nachi 2015); large size, red colour (Mnanje 2009)

		Njombe	Large size, white colour (Nachi 2015); large size, red colour (Mnanje 2009)
		Rukwa	Large size, white colour (Nachi 2015); large size, red colour (Mnanje 2009)
		Ruvuma	Large size, white colour (Nachi 2015); large size, red colour (Mnanje 2009)
		Songwe	Large size, white colour (Nachi 2015); large size, red colour (Mnanje 2009)
		Katavi	Large size, white colour (Nachi 2015); large size, red colour (Mnanje 2009)
Central	Trader	Dodoma	Medium size, tan colour (Pendo 1998); medium size, red colour (Dodoma bold)
		Singida	Large size, red colour (Mnanje 2009); large size, white colour (Nachi 2015)
Coastal	Trader	Dar es Salaam	Medium size, tan colour (Pendo 1998, Johari); large size, red colour (Mnanje 2009); medium size, red colour (Dodoma bold); large, white colour (Nachi 2015)
		Morogoro	Medium size, tan colour (Pendo1998, Johari); large size, red colour (Mnanje 2009); medium size, red
Northern	Trader	Arusha	Large size, red colour (Mnanje 2009); medium size, red colour (Dodoma bold)
		Kilimanjaro	Large size, red colour (Mnanje 2009); medium size, red colour (Dodoma bold)
		Manyara	Large size, red colour (Mnanje 2009); medium size, red colour (Dodoma bold)
Lake	Trader	Kagera	Medium size, tan colour (Pendo 1998, Johari); large size, red colour (Mnanje 2009)
	Trader and processor	Geita	Medium size, tan colour (Pendo 1998, Johari); large size, tan colour (Nachi 2009)
Western	Trader	Kigoma	Medium size, tan colour (Pendo 1998, Johari); large size, tan colour with high oil content
		Tabora	Medium size, tan colour (Pendo1998, Johari); large size, tan colour with high oil content

Source: Variety business case survey, 2019.

4.3.3. Price variation along the value chain

Despite there being similar varieties in different regions, grain prices offered by off-takers varied through different seasons in a year within a zone (harvesting, post-harvest, and planting) and also varied by zone. Grain price tends to decrease when there is a surplus, while during post-harvest and planting periods, it tends to increase compared to the harvesting period. According to the interviewed grain off-takers from all the agro-ecological zones, months with low and high purchasing prices ranged from March to July and August to January, respectively (Table 19). The months with low selling prices were March to June and with the high selling prices August to January each year (Table 19).

Table 19. Months during which groundnut was bought and sold at low and high prices in a year in the study zones.

Buying periods				
Low price			**High price**	
Zone	**months**	**Reasons for low price**	**months**	**Reasons for high price**
Eastern	Apr, May, Jun	High supply, low grain demand and low consumption	Sep, Oct, Nov	Low supply due to off season and high grain demand
Central	Mar, Apr, May	High supply, low grain demand and low consumption	Aug, Sep, Oct	Low supply due to off season and high grain demand
Lake	Mar, Apr, May	High supply, low grain demand and low consumption	Nov, Dec, Jan	Low supply due to off season and high grain demand
Western	Mar, Apr, May	High supply, low grain demand and low consumption	Nov, Dec, Jan	Low supply due to off season and high grain demand
Southern Highlands	May, Jun, Jul	High supply, low grain demand and low consumption	Oct, Nov, Dec	Low supply due to off season and high grain demand
Southern	Apr, Jun, Jul	High supply, low grain demand and low consumption	Oct, Nov, Dec	Low supply due to off season and high grain demand
Selling periods				
Low price			High price	
	months	Reasons for low price	months	Reasons for high price
Eastern	Apr, May, Jun	High supply, low grain demand and low consumption	Aug, Sep, Oct, Nov	Low supply due to off season and high grain demand
Central	Apr, May, Jun	High supply, low grain demand and low consumption	Oct, Nov, Dec	Low supply due to off season and high grain demand
Lake	Mar, Apr, May	High supply, low grain demand and low consumption	Oct, Nov, Dec	Low supply due to off season and high grain demand
Western	Mar, Apr, May	High supply, low grain demand and low consumption	Sep, Oct	Low supply due to off season and high grain demand
Southern Highlands	Apr, May, Jun	High supply, low grain demand and low consumption	Nov, Dec	Low supply due to off season and high grain demand.
Southern	Mar, Apr, May, Jun	High supply, low grain demand and low consumption	Nov, Dec, Jan	Low supply due to off season and high grain demand

Source: Variety business case survey, 2019.

Also, the findings showed that Southern zone had the highest prices along the commodity value chain, whereas the Central zone had the lowest prices (Table 20).

Table 20. Price variation (in TZS) in groundnut by zone and markets along the value chain.

Price variation	Central	Lake	Western	S. Highlands	Southern
Lowest buying price at farm gate	650	900	800	850	1,300
Highest buying price at farm gate	1,550	1,400	1,600	1,650	2,500
Average buying price at farm gate	1,100	1,150	1,200	1,200	1,900
Global average buying price at farm gate	1,100	1,150	1,200	1,233	1,900
Lowest buying price at a rural market	700	950	900	950	1,400
Highest buying price at rural market	1,600	1,450	1,700	1,750	2,600
Average buying price at rural market	1,150	1,200	1,300	1,300	2,000
Global average buying price at farm gate	1150	1,200	1,300	1,333	2,000
Lowest grain buying price at urban market	850	1,000	1,000	1,050	1,500
Highest grain buying price at urban market	1,750	1,500	1,800	1,850	2,700
Average grain buying price at urban market	1,250	1,250	1,400	1,400	2,100
Global average grain buying price at farm gate	1,283	1,250	1,400	1,433	2,100
Lowest selling price at rural market	750	1,000	900	950	1,400
Highest selling price at rural market	1,600	1,450	1,700	1,750	2,600
Average selling price at rural market	1,150	1,250	1,250	1,300	2,000
Global average selling price at rural market	1,167	1,233	1,283	1,333	2,000
Lowest selling price at urban market	950	1,200	1,100	1,050	1,500
Highest selling price at urban market	1,850	1,650	1,900	1,850	2,700
Average selling price at urban market	1,350	1,450	1,450	1,400	2,100
Global average selling price at urban market	1,383	1,433	1,483	1,433	2,100

Source: Variety business case survey, 2019.

4.3.4. Groundnut traded within the country and imported

The study found that about 18,297 t (21%) of groundnut was imported from neighbouring countries by the interviewed grain off-takers, whereas 68,286 t (79%) were purchased from within the country. The varieties imported were similar to those present in the country (Table 21). Songwe region imported the most, i.e., 16,216 t (89%). These results show that there is market competition for grain producers in Tanzania.

Table 21. Groundnut traded by variety across different regions within the country and imported.

Region	Traded in Tanzania (t)	Variety	Imported (t)	Variety	Total (t)	Variety
Mtwara	1,930	Pendo 1998, Johari, Nachi 2015	150	Nachi 2015	2,080	Pendo 1998, Johari, Nachi 2015
Songwe	18,315	Mnanje 2009	16,216	Mnanje 2009	34,531	Mnanje 2009
Singida	165	Mnanje 2009	150	Mnanje 2009	315	Mnanje 2009

Region	Traded in Tanzania (t)	Variety	Imported (t)	Variety	Total (t)	Variety
Dodoma	41,260	Dodoma bold, Pendo 1998	-	-	41,260	Dodoma bold, Pendo 1998
Morogoro	300	Mnanje 2009	726	Mnanje 2009	1,026	Mnanje 2009
Dar es Salaam	272	Pendo 1998, Johari, Nachi 2015	1,055	Mnanje 2009	1,327	Pendo 1998, Johari, Nachi 2015, Mnanje 2009
Tabora	520	Mnanje 2009, Mamboleo	-	-	520	Mnanje 2009, Mamboleo
Shinyanga	5,524	Pendo 1998, Mnanje 2009, Naliendele 2009	-	-	5,524	Pendo 1998, Mnanje 2009, Naliendele 2009
Total	68,286		18,297		86,583	

Source: Variety business case survey, 2019.

4.3.5. Existing corridors of groundnut trade and traits preferred for export

Exports were observed to influence production and trade in Lake and Western zones. Grain traits preferred in these zones were medium size and tan coloured (Pendo 1998), large size and tan (Local variety) and large size and red (Mnanje 2009) (Table 22). These traits were in demand in Kenya, Uganda, Rwanda and Burundi (Table 22). In the Southern Highlands, most of the groundnut was exported to Angola, DRC and South Sudan, where the most preferred traits were large size and tan (Nachi 2015) and large size and red (Mnanje 2009). Central and Southern zones had similar preferences which were medium size and tan (Pendo 1998 and Johari 1985). It was reported that groundnut of the same varieties had minor differences in colour and sheen across the zones. For example, groundnut from the Southern zone had a greater sheen than that from the Central zone, probably due to soil differences. Groundnut from these zones were exported to India, Malaysia, Comoros and Japan (Table 22).

Table 22. Groundnut traits preferred in the export market.

Zone	Region	Producing districts	Domestic consumers	Export countries	Traits preferred
Southern	Mtwara	Masasi, Tunduru and Nanyumbu	Mtwara, Lindi, Dar es Salaam and Morogoro	India, Malaysia and Comoros	Medium size, tan colour (Pendo 1998 and Johari 1985)
	Lindi	Liwale and Nachingwea	Mtwara, Lindi, Dar es Salaam and Morogoro	India, Malaysia and Comoros	Medium size, tan colour (Pendo 1998 and Johari 1985)
Southern Highlands	Mbeya	Tukuyu, Kyela and Mbarali	Mbeya, Dar es Salaam, Songwe and Morogoro	Angola, DRC and South Sudan	Large size, tan colour (Nachi 2015); large size, red colour (Mnanje 2009)
	Ruvuma	Namtumbo	Songwe, Mbeya, Mtwara and Dar es Salaam	Angola, DRC and South Sudan	Large size, tan colour (Nachi 2015); large size, red colour (Mnanje 2009)
	Songwe	Mbozi and	Vwawa, Mbeya,	Angola, DRC and	Large size, tan colour

		Momba	Tunduma and Dar es Salaam	Iraq	(Nachi 2015); large size, red colour (Mnanje 2009)
	Katavi	Mpanda	Mbeya, Dar es Salaam, Songwe and Morogoro	DRC, Southern Sudan and Iraq	Large size, tan colour (Nachi 2015); large size, red colour (Mnanje 2009)
Central	Dodoma	Chamwino, Bahi, Mpwapwa and Kongwa	Dodoma, Dar es Salaam and Arusha	India, Malaysia, Comoros and Japan	Medium size, tan colour (Pendo 1998); medium size, red colour (Dodoma bold 1960)
	Singida	Mkalama	Kahama, Singida and Mwanza	Rwanda, Burundi, Kenya and Uganda	Large size, red colour (Mnanje 2009); large size, tan colour (Nachi 2015)
	Morogoro	Gairo	Morogoro, Dodoma and Dar es Salaam	India, Malaysia and Comoros	Medium size, tan colour (Pendo 1998, Johari); large size, red colour (Mnanje 2009); medium size, red colour
Lake	Geita	Bukombe	Kahama and Mwanza	Rwanda, Burundi, Kenya and Uganda	Medium size, tan colour (Pendo 1998, Johari); large size, red colour (Mnanje 2009)
Western	Kigoma	Kibondo and Kasulu	Kahama and Mwanza	Rwanda, Burundi, Kenya and Uganda	Medium size, tan colour (Pendo 1998 and Johari); large size, tan colour with high oil content
	Tabora	Kaliua and Urambo	Kahama, Tabora and Mwanza	Rwanda, Burundi, Kenya and Uganda	Medium size, tan colour (Pendo 1998, Johari); large size, tan colour with high oil content

Source: Variety business case survey, 2019.

4.3.6. Stock carryover and market gaps

The study found no annual stock carryover in any region under the study. However, there were market gaps in terms of the quantity required and quality. Market gaps were more evident in the Southern Highlands than in other zones. Farmers who produced groundnut for sale did not grade them; they mixed grain of different sizes making them less marketable. Traders, especially Raphael Group Ltd in Southern Highlands, demanded red, large groundnuts which they had been importing from Malawi for several years. Red groundnut is available in limited quantities in Sumbawanga and Mpanda districts. The company claimed to have the ability to purchase groundnut for the whole country if the quality standards were met.

4.3.7. Practices limiting marketing

The study showed that there were various challenges faced by groundnut actors, such as taxation, poor communication linkages and issues related to research and development which were beyond their control. Farmers and traders facing these challenges had coping mechanisms and possible interventions (Table 23).

Table 23. Practices limiting marketing of groundnut, coping strategies and possible interventions.

Zone	Challenges	Coping strategies	Possible interventions
Southern	Aflatoxin	Timely harvesting	Enhance post-harvest education to farmers
	Poor grading by farmers	Sale at a low price	Educate farmers on the importance of sorting and grain grading
	No market linkage between farmers and final users	Storage or sale at a low price	Enhance market linkage along the groundnut value chain
Southern Highlands	No market linkage between farmers, traders and final users	Sale to middlemen and other small traders at a low price	Enhance market linkage (between farmers, and traders to the final users)
	Use of non-standardized measuring vessels	Use of local non-standardized measuring vessels like tins, gallons	Enforce the use of standard measuring equipment
	Grain competition, e.g., local vs imported	Low price of locally produced grain	Improve the quality of local produce and restrict imports
	Poor quality grain	Sale at a lower cost	Educate farmers on the importance of good post-harvest management
	Prices information asymmetry	Make use of available price information to enhance business	Make market information available to producers and off-takers
	Poor quality grain	Sale at a lower cost	Educate farmers on the importance of good post-harvest practices
	Growing cost of grading grain by traders	Grain sorting and grading after buying from farmers	Educate farmers on the importance of good post-harvest practices
Eastern	Poor grain grading	Sale at a lower cost	Educate farmers on the importance of good post-harvest practices
	Poor market information	Making use of available price information to enhance business	Make market information available along the value chain
	Use of non-uniform weighting balance	Use of local non-standardized measuring vessels	Enforce the use of standard measuring equipment
Lake	Varied middlemen prices	Sale to middlemen at low prices	Make market information available to producers and off-takers
	Limited price information	Making use of available price information to enhance business	Make market information available to all stakeholders
	Double fees charged by local government authorities	Paying overcharged taxes and fees	Report to the respective local governments
	Poor transport outlets to the villages	Sale to middlemen at a low price	Improve road transport facilities to production areas
Western	Non-standardized weighing vessels	Use of local non-standardized weighing vessels	Enforce the use of standard measuring equipment
	Price information asymmetry	Use of available price information to enhance business	Make market information available along the value chain
	Limited market linkage	Sale to middlemen and other traders at a low price	Make market information available to producers and off-takers

Source: Variety business case survey, 2019.

4.4. Available improved varieties, yield potential, nutrient content and adoption rate

4.4.1. Improved varieties and yield potential

A total of 17 improved varieties have been released (Table 24). Their yield potential on-station ranged between 1100 kg/ha and 2000 kg/ ha. The minimum on station yield ranged between 1,050 kg/ha and 1,500 kg/ha. Among all varieties, Nachi 2015 had the highest yield potential ranging from 1,500 kg/ha to 2,000 kg/ha. The yield of these varieties under farmer management was relatively low compared to that on station, where maximum yield ranged between 900 kg/ha and 1,300 kg/ha.

Table 24. Improved groundnut varieties released, their attributes and yield potential.

Variety	Year of release	Top 3-5 agronomic, genetic, market attributes	Expected yield (kg/ha)		
			Max. on station	Min. on station	Under farmer management
Mtwaranut 2016	2018	Medium maturing, resistant to rosette disease, tan colour, large size, drought tolerant	1300	1100	1040
Tanzanut 2016	2018	Medium maturing, resistant to rosette disease, large size, tan colour, drought tolerant	1500	1200	1095
Naliendele 2016	2018	Medium maturing, tolerant to diseases and drought, bold size, red colour, high oil content	1500	1200	1050
Narinut 2015	2015	Medium maturing, large size, brown colour, resistant to rosette disease, best for confectionary market	2000	1300	1000
Kuchele 2015	2015	Large size, brown colour, resistant to rosette disease, best for confectionary market	2000	1200	1000
Nachi 2015	2015	Medium maturing, resistant to rosette disease, bold size, tan colour	2000	1500	1300
Mangaka 2009	2009	Early maturing, tan colour, tolerant to diseases and drought	1500	1000	1000
Naliendele 2009	2009	Early maturing, tan colour, tolerant to diseases and drought	1100	1000	900
Mnanje 2009	2009	Medium maturity, tolerant to diseases and drought, bold size, red colour, high oil content	1500	1300	1100
Nachingwea 2009	2009	Medium maturing, resistant to rosette disease, bold size, tan colour	1250	1050	950
Masasi 2009	2009	Medium maturing, resistant to rosette disease, bold size, red colour	1600	1100	1000
Pendo 1998	1998	Short duration, tolerant to disease and drought, bold size, tan colour, good shelling percentage, medium kernel size, soft pod	1500	1400	1100
Sawia 1998	1998	Light pink and small kernels, light green plant, early maturing with 58% oil content, sprouting at maturity if harvesting is	1500	1200	950

Variety	Year of release	Top 3-5 agronomic, genetic, market attributes	Expected yield (kg/ha)		
			Max. on station	Min. on station	Under farmer management
		delayed, tolerant to early leaf and late leaf spots, rosette and leaf rust			
Johari 1985	1985	Virginia bunch type, medium-sized tan kernels, dark green plant, medium maturing, semi-spreading	1200	1000	850
Nyota 1983	1983	Light pink and small kernels, light green plant, early maturing with 58% oil content, sprouting at maturity if harvesting is delayed, tolerant to early leaf and late leaf spots, rosette and leaf rust	1500	1000	800
Red mwitunde 1976	1976	Virginia bunch type, small size, red colour, two to three kernels, medium maturing	1000	800	600
Dodoma bold 1960	1960	Spanish bunch type, tan colour, small size, two to three kernels, early maturing	1000	800	600

Source: URT (2007, 2016, 2018).

4.4.2. Nutrient content of some improved groundnut varieties

According to the analysis done by Tanzania Food and Drug Authority (TFDA), improved groundnut varieties contained a satisfactory amount of fats, protein, minerals and carbohydrates. The specific amount of each nutrient varied with variety. For example, Mnanje 2009 had the highest oil (51.50% w/w) and iron (65.40 mg/kg) content. Naliendele 2009 had the highest protein (34.50% w/w) and Mangaka 2009 the highest zinc (94.50 mg/kg) content (Table 25).

Table 25. Nutrient profile of improved groundnut varieties.

Varieties	Oils (%) (w/w)	Protein (%) (w/w)	Iron (Mg/Kg)	Zinc (Mg/Kg)
Pendo 1998	44.50	32.30	41.10	82.00
Mnanje 2009	51.50	29.50	65.40	35.30
Naliendele 2009	40.10	34.50	50.70	84.10
Mangaka 2009	41.10	32.90	47.80	94.50
Masasi 2009	46.70	25.40	20.60	23.10
Nachigwea 2009	44.50	31.30	23.40	77.50
Nachi 2015	43.70	32.40	33.90	66.00
Narinut 2015	46.20	24.20	20.50	25.20

w/w = Weight by weight; Mg = Milligram.

Source: Akpo et al. (2021).

4.4.3. Rate of adoption of improved varieties

The findings indicated that the adoption rate of improved varieties coincided with the time of release. This means that varieties which had been released earlier had high adoption rates than the ones released recently. This was the case with Pendo with 17.08% adoption, released in 1998; Mnanje with 5.42% adoption, released in 2009 and Mangaka with 5.42% adoption, released in 2009. Only Naliendele released in 2009 and Nachi released in 2015 had the lowest adoption rates of less than 1% (Table 26), and overall adoption rate was 35%.

Table 26. Varieties adopted in intervention and non-intervention districts.

Variety	Year of release	Adoption (%) in intervention districts (n=240)	Adoption (%) in non-intervention districts (n=60)
Nachi 2015	2015	0.42	-
Naliendele 2009	2009	0.83	-
Mnanje 2009	2009	5.42	-
Mangaka 2009	2009	5.42	-
Pendo 1998	1998	17.08	-
Johari 1985	1985	5.82	-
Total		35	-

Source: Variety business case survey, 2019.

4.4.4. Adoption by gender and across ages

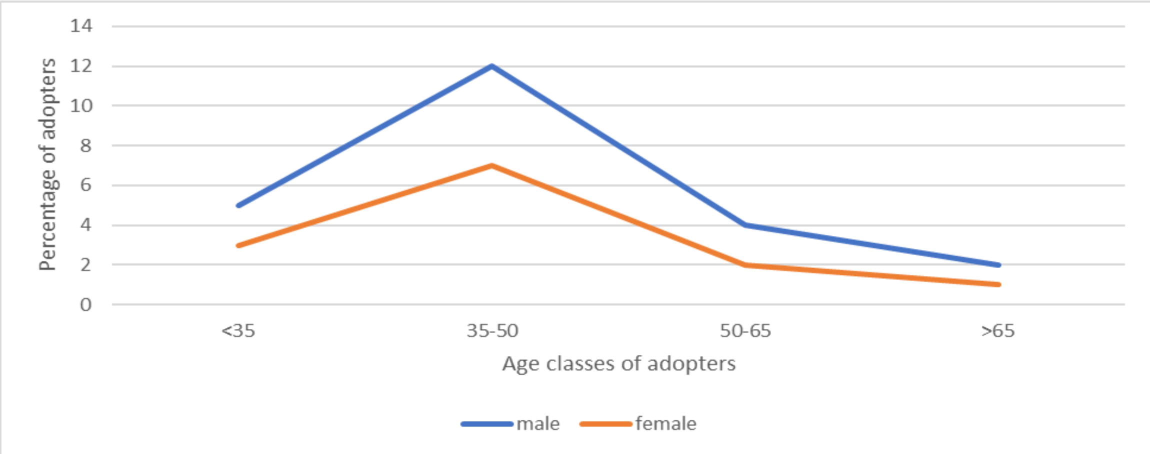
The adopters' gender was found to be dependent on age with the $\chi^2 = 12.05$ being significant ($p<0.001$). Findings indicated that among the 35% adopters of improved groundnut varieties, 22% were male and 13% were female. Further, it was observed that farmers with an active economy and age class between 35 and 50 years had the highest adoption rate of 12% and 7% among both men and women, respectively. However, among youth, male adopters outweighed female adopters by 13% (Table 27).

Table 27. Farmer adoption of improved groundnut varieties by gender and age.

Age	Male adopters (%)	Female adopters (%)
<35	5	3
35-50	12	7
50-65	4	2
>65	2	1
Total	22	13

Source: Variety business case survey, 2019.

Further, the distribution of adoption is skewed to the right (Figure 50), where the curves are steeper on the right side than on the left side, indicating that adoption of improved groundnut varieties increased with age. The adoption ability of farmers regardless of their gender increased among youth and the active economic age group between 35 and 50 years, and started to decrease beyond the age of 50 years and above, other factors being constant.



Source: Variety business case survey, 2019.

Figure 5. Adoption of groundnut varieties by gender and age.

4.4.5. Factors influencing farmer adoption of improved varieties

The estimated outputs through the probit model are presented in Table 28. The estimate of the empirical results was conducted by the maximum likelihood method with a model being significant ($p<0.1$). Also, χ^2 (Prob < 0.000) showed that the likelihood ratio statistic was significant, which implies that the explanatory power of the model was strong. Therefore, from the probit regression model, gender, group membership, availability of seed and seed cost variables were found to be positive and significant in influencing farmer decision to adopt improved groundnut varieties.

Table 28. Probit regression result of determinants of adoption of improved varieties.

Variable	Coefficient	Std. Err	Z	p>|z|
Age	0.0162	0.0069	1.54	0.023**
Gender	0.6268	0.1944	3.22	0.001***
Land ownership	-0.075	0.1826	-0.14	0.681
Group membership	0.4114	0.2132	1.93	0.054**
Farmer acreage	-0.0003	0.0031	-0.11	0.323
Education level	0.0035	0.0036	0.99	0.913
Experience	0.0447	0.0346	1.29	0.197
Grain price	0.00002	0.0003	0.75	0.452
Availability of seed	1.2258	0.2654	4.62	0.002***
Seed cost	-0.0002	0.0007	2.75	0.006***
Constant	-1.93	0.3897	-4.95	0

n = 300, LH χ^2 (10) = 72.54, Prob <0.000, Pseudo R^2 = 0.2127.

*** Significant at 1%, **Significant at 5%. Source: Variety business case, 2019.

A post-estimation of the probit equation's results was done and marginal effects were obtained, as shown in Table 29.

Table 29. Marginal effects on determinants of adoption of improved groundnut varieties.

Variable	Marginal effect	Std. Err	Z	P>|Z|
Age	0.2011	0.0601	3.24	0.067
Gender	0.1703	0.0509	3.35	0.001
Group membership	0.1117	0.0572	1.95	0.015
Availability of seed	0.333	0.0643	5.18	0.001
Seed cost	-0.0029	0.0019	1.55	0.12

Source: Variety business case survey, 2019.

The coefficient for age was 0.2011, implying that an increase in the age of the farmer by one year increases farmers' adoption of improved groundnut varieties by 20%. The coefficient for gender was 0.1703, implying that being male increases farmers' adoption by 17%. Also, the estimated marginal effect for group membership was 0.1117, implying that being in a group increases the chance of adoption by 11%. The estimated marginal effect of availability of seed was 0.333, implying that a 1% increase in seed availability among groundnut farmers will lead to an increase in adoption by 33%. The estimated coefficient for seed cost was 0.029, implying that a unit increase in seed cost would decrease adoption of improved groundnut variety by 2.9%.

4.4.6. Farmer-preferred traits in improved varieties

The study showed that 35% of the interviewed farmers used recently released improved varieties in the 2017/2018 production season. The highly preferred traits were high yield (50%), drought tolerance (23%) and market preferences (16%) (Table 30).

Table 30. Farmer-preferred traits in improved varieties.

Traits	Relative frequency (%)
Diseases resistant	2
Easy to harvest	3
High oil content	3
Early maturity	4
Market preferences	16
Drought tolerance	23
High yield	50
Total	100

Source: Variety business case survey, 2019.

4.4.7. Replacing seed with improved varieties

Farmers were observed to exercise two modes of replacing seed: by replacing them with those of the same variety and replacing seed only when there is a new variety (Table 31). About 70.20% of groundnut farmers replaced seed only when a new variety was introduced. Meanwhile, around 29.80% of improved variety adopters replaced seed with that of the same variety. About 44% of farmers were replacing seed after six years when there was a new variety, whereas around 18% replaced them with seeds of the same variety.

Table 31. Farmers' tendency to replace seed with improved varieties.

Tendency to replace seed varieties	Relative frequency (%)	Years to replacement	Relative frequency (%)
Replacement of seed only with a new variety	70.2	<4	7.2
		4 to 6	11.7
		>6	44.1
Usually replace seed of the same variety	29.8	<4	7.2
		4 to 6	11.7
		>6	18.1

Source: Variety business case survey, 2019.

4.4.8. Adoption of agronomic practices

Table 32 shows that the average seed rate of adopters in the study area was 62.5 kg/ha, which is 17.5 kg/ha less than the recommended 80 kg/ha for medium seeds like Pendo 1998 and Johari 1998. The seed rate reported by adopters was less than the recommended 100 kg/ha for varieties of large size like Nachi 2015 and Mnanje 2009. It was reported that farmers in the study area did not apply insecticides, fertilizers and pesticides (Table 32).

Table 32. Adoption of recommended agronomic practices by farmers.

Recommended practices	Quantity used (kg/ha)
Average seed rate	62.5
Insecticides, fertilizers and pesticides	0.0

Source: Variety business case survey, 2019.

4.4.9. Challenges faced by adopters of improved varieties

Adopters of improved varieties reported the following challenges: pests and diseases (33%), high cost of seeds (24%), susceptibility to prolonged drought (19%) and lack of desirable market traits (12%). Other challenges reported were limited knowledge of agronomic practices (6%) and non-availability of seeds (6%) (Table 33).

Table 33. Challenges reported by farmers who planted improved varieties.

Challenges	Relative frequency (%)
Non-availability of seed	6
Limited knowledge of agronomic practices	6
Lack of desirable market traits	12
Susceptible to drought	19
Expensive	24
Pests and diseases	33
Total	100

Source: Variety business case survey, 2019.

4.4.10. Packaging and marketing of groundnut seeds

Results in the study area showed that 55% of the interviewed farmers preferred groundnut seeds packed in 1 kg bags, 24% preferred them in 3-5 kg bags and 0.3% preferred them in 50 kg bags. Moreover, 54% of the farmers interviewed preferred to purchase unshelled seeds and 46% of them purchased shelled seeds (Table 34). The findings showed that groundnut farmers were willing to pay TZS 1500 – 2000/kg for shelled groundnuts.

Table 34. Seed packaging and groundnut form preferred by groundnut farmers.

Variable	Category	Relative frequency
Packaging	1 kg	55
	2 kg	18
	3-5 kg	24
	8-10 kg	2.7
	50 kg	0.3
Shelling	Unshelled	54
	Shelled	46

Source: Variety business case survey, 2019.

4.4.11. Seed supply to groundnut farmers

About 82% of the interviewed farmers did not purchase seeds in the production season of 2017/2018 and 18% of them did. About 0.6% of them purchased it from the local market, whereas 1% purchased it from neighbours (Table 35).

Table 35. Markets where farmers purchased seed.

Market	Buyers (%)
Farmer groups	16
Local market	0.6
Neighbours	1

Source: Variety business case survey, 2019.

4.5. Seed production

4.5.1. Seed production by region

In the 2018 production season, a total of 4,611.5 t of seed (all seed classes) was produced (Table 36). The findings showed that Mtwara led in seed production (27%) by producers, followed by Geita (24%), Tabora (23%) and Singida and Mbeya (2%). Mtwara region led in both seed production and seed producers, while Geita had a large proportion of seed producers but a low amount of seed produced than Tabora.

Table 36. Seed production by region in 2018.

Region	Production (t)	Production (%)
Dodoma	374.5	7
Geita	631.5	24
Lindi	275.8	6
Mbeya	266.3	2
Mtwara	1,508.2	27
Ruvuma	304.5	6
Shinyanga	171.6	3
Singida	41.0	2
Tabora	1,038.0	23
Total	4,611.50	100

Source: Variety business case survey, 2019.

4.5.2. Seed producer categories

Groundnut seed production in Tanzania involves various categories of seed producers ranging from government research centers, private seed companies, farmer groups, private individuals, farmer associations, religious organizations and NGOs (Table 37). TARI-Naliendele is the national center mandated for groundnut breeding in Tanzania, and is the sole producer of pre-basic seeds. Farmer research groups, individual seed entrepreneurs, faith-based organizations and farmer associations and primary and secondary schools produce QDS.

Total seed production has been increasing over the years and reached a maximum of 4611.5 t in 2018. Around 79.7% of the total seed produced in 2018 (78% QDS and 1.7% basic seed) was produced by farmer research groups, who produce basic seeds under a contract with TARI-Naliendele. Public and private seed companies have also started engaging in seed production and marketing. However, the amount produced by these actors remains low.

Table 37. Seed production by producer category, 2015-2018.

Category	Seed class	2015 (t)	2016 (t)	2017 (t)	2018 (t)	Producers (2018) (%)
Farmer research groups	QDS	205.0	2,533.0	3,643.0	3,724.5	78
Private seed companies	Certified	-	-	1.8	2.5	1
Public seed companies (ASA)	Basic	-	4.0	0.5	1.4	0.002
Farmer research groups	Basic	43.6	325.0	412.6	532.3	1.7
Non-Governmental Organization (NGOs)	QDS	34.8	292.0	8.4	36.8	1
Research institutions	Breeder	23.0	21.2	40.1	30.0	0.002
Individual seed entrepreneurs	QDS	62.4	212.0	171.4	192.0	17
Faith-based organizations and farmer associations	QDS	29.7	89.7	23.0	44.4	1

Category	Seed class	2015 (t)	2016 (t)	2017 (t)	2018 (t)	Producers (2018) (%)
Primary and secondary schools	QDS	13.9	43.3	51.9	47.6	1
Total		412.4	3,520.2	4,352.7	4,611.5	100

Source: Variety business case survey, 2019.

4.5.3. Seed price variation

Mtwara region had the highest seed price ranging between from TZS 2,500/kg and TZS 3,500/kg. Dodoma region was observed to have the lowest seed price of TZS 800/kg. Generally, the lowest and highest seed prices fluctuated between TZS 800/kg and TZS 2,000/kg and TZS 1,500/kg and TZS 3,500/kg, respectively, depending on the season and agro-ecological zone. The months with the highest seed prices were January, September, October, November and December, and those with the lowest prices were February, March, April, May, June and July (Table 38).

Table 38. Seasonal variation in seed prices.

		Highest price (TZS)				Month of highest price	Lowest price (TZS)				Month of lowest price
District	Region	Min	Av. min	Max	Av. max		Min	Av. min	Max	Av. max	
Urambo	Tabora	1,600	1,700	2,000	1,900	Sept, Oct, Nov, Dec	900	950	1,500	1,550	Feb, Mar, Apr
Nanyumbu	Mtwara	2,500	2,700	3,500	3,000	Sep, Oct, Nov	1,200	1,300	2,000	1,900	Apr, May, Jun, Jul
Mbozi	Songwe	1,800	1,850	2,500	2,000	Nov, Dec, Jan	850	870	1,200	1,000	Jun, Jul, Aug
Masasi	Mtwara	2,500	2,800	3,500	3,000	Oct, Nov, Dec	1,000	1,300	2,000	1,800	Apr, May, Jun
Kaliua	Tabora	1,800	1,900	2,200	2,000	Sept, Oct, Nov, Dec	1,000	1,100	1,500	1,400	Mar, Apr, May
Kahama	Shinyanga	2,000	2,000	2,500	2,200	Oct, Nov, Dec, Jan	1,200	1,150	1,500	1,350	May, Jun, Jul
Chamwino	Dodoma	1,500	1,550	2,000	1,950	Nov, Dec, Jan	800	850	1,500	1,400	Mar, Apr, May
Bukombe	Geita	2,000	2,150	2,500	2,300	Sept, Oct, Nov	1,200	1,300	17,00	1,500	May, Jun, Jul
Bahi	Dodoma	2,000	2,050	2,500	2,300	Sept, Oct, Nov, Dec, Jan	800	1,000	1,500	1,300	May, Jun
Mpwapwa	Dodoma	1,600	1,650	2,200	2,000	Nov, Dec, Jan	800	900	1000	950	Mar, Apr, May
Mkalama	Singida	2,000	2,100	2,500	2,200	Sept, Oct, Nov, Dec, Jan	1,000	1020	1100	1050	Mar, Apr

Source: Variety business case survey, 2019.

4.6. Gross Margin (GM) analysis

4.6.1. Groundnut production

Since the main aim of groundnut farmers is to commercialize their produce, the average gross margin was computed. Grain producers were found not to be using fertilizer, thereby reducing production cost. Also, the variation in total cost was explained by differences in land preparation, weeding and harvesting costs per district. The highest gross incomes were recorded from Mbozi (TZS 742,500/ha), Bukombe (TZS 735,000/ha) and Ushetu (TZS 732,500/ha) districts (Table 39).

Table 39. Gross margin analysis of groundnut production.

Region	District	Total cost (TZS/ha)	Average variable cost (TZS/kg)	Output (kg)	Total revenue (TZS/ha)		Gross income (TZS/ha)	Average gross income (TZS/kg)
Shinyanga	Ushetu	712,500	814	875	1,445,000		732,500	837
Geita	Bukombe	720,000	818	880	1,455,000		735,000	835
Tabora	Kaliua	725,000	840	863	1,425,000		700,000	811
Tabora	Urambo	725,000	848	855	1,412,500		687,500	804
Dodoma	Bahi	762,500	1,141	668	1,237,500		475,000	711
Dodoma	Chamwino	762,500	1,150	663	1,225,000		462,500	698
Songwe	Mbozi	745,000	876	850	1,487,500		742,500	874
Mtwara	Nanyumbu	1,062,500	1,340	793	1,662,500		600,000	757
Mtwara	Masasi	1,075,000	1,344	800	1,675,000		600,000	750
Dodoma	Mpwapwa	750,000	1,037	723	1,337,500		587,500	813
Singida	Mkalama	750,000	1,034	725	1,225,000		475,000	655
Overall averages		800,000	1,022	790	1,417,000		618,000	782

Source: Variety business case survey, 2019.

4.6.2. Seed production

4.6.2.1. Quality Declared Seed (QDS)

Total Variable Cost (TVC) for NGOs who ventured into QDS farming varied with varieties cultivated. It was TZS 1,297,918/ha, TZS 1,285,835/ha and TZS 1,337,500/ha for Mnanje 2009, Mangaka 2009 and Naliendele 2009, respectively. Both Naliendele 2009 and Mangaka 2009 varieties had the same average productivity of 753 kg/ha. The production cost of Naliendele 2009 (TZS 1,337,500/ha) was relatively high compared to that of Mangaka 2009 (TZS 1,285,835/ha). Mnanje 2009 was the best in Dodoma due to its productivity of 775 kg/ha and gross income of TZS 1,027,083/ha, keeping the price at TZS 3,000/kg (Table 40).

Production costs, productivity and gross incomes of QDS farming varied by agro-ecological zone. QDS farmers from Masasi district (Southern zone) incurred relatively higher production costs compared to those from Ushetu district (Lake zone), which ranged from TZS 1,032,500/ha to TZS 1,095,955/ha and TZS 577,500/ha to TZS 775,955/ha, respectively. In terms of gross income and productivity, Pendo 1998 recorded the highest yield (820 kg/ha) with a total gross margin of TZS 1,275,000/ha, while Nachingwea 2009 recorded the highest gross income of TZS 1,338,750/ha with a yield of 765 kg/ha. Both varieties were from QDS farmers in Ushetu district. The variety with the lowest yield was Mnanje 2009 (507.5 kg/ha) in Ushetu district. Mangaka 2009, Mnanje 2009 and Nachingwea 2009 recorded good yields of 662.5 kg/ha, 632.5 kg/ha and 650 kg/ha, respectively in Masasi district (Southern zone). Moreover, Table 40 shows the total average cost of about TZS 7,022,500/ha incurred in producing breeder seeds. These seeds were produced through the projects' fund and thereafter distributed to stakeholders who later paid in kind. Further, in the production of breeder seed, shelling activities had the highest cost of TZS 1,000,000 while transportation cost of TZS 20,000/t was the least cost incurred (Appendix 3).

Table 40. Gross margin analysis of seed.

District	Category	Seed class	Variety	TVC (TZS/ha)	AVC (TZS/kg)	Yield (kg/ha)		Average price (TZS/kg)	Gross income (TZS/ha)	Average gross income (TZS/kg)
Masasi	Groups	QDS	Mangaka 2009	1,095,955	1,654	663		2,500	1,656,250	846
Chamwino	NGOs	QDS	Mangaka 2009	1,285,835	1,709	753		3,000	2,257,500	1,291
Masasi	Groups	QDS	Mnanje 2009	1,032,500	1,632	633		2,500	1,581,250	868
Ushetu	Groups	QDS	Mnanje 2009	577,500	1,138	508		2,500	1,270,500	1,362
Chamwino	NGOs	QDS	Mnanje 2009	1,297,918	1,675	775		3,000	2,325,000	1,325
Masasi	Groups	QDS	Nachingwea 2009	1,079,168	1,660	650		2,500	1,625,000	840
Ushetu	Groups	QDS	Nachingwea 2009	577,500	755	765		2,500	1,916,250	1,745
Chamwino	NGOs	QDS	Naliendele 2009	1,337,500	1,777	753		3,000	2,257,500	1,223
Bahi	Groups	QDS	Pendo 1989	863,000	1,190	725		2,000	1,450,000	810
Ushetu	Groups	QDS	Pendo 1989	775,000	945	820		2,500	2,050,000	1,555
Overall average				992,188	1,414	705		2,600	1,838,925	1,187
Masasi	Private	Certified	Naliendele 2009	1,518,750	2,450	620		4,000	2,437,500	1,450
Masasi	Private	Certified	Nachi 2015	1,518,750	2,921	520		3,750	1,950,000	829
Overall average				2,278,125	2,686	880		3,875	3,412,500	1,865
Mtwara	Govt	Breeder	Mangaka 2009	6,962,500	5,548	1,255		0	0	0
Mtwara	Govt	Breeder	Naliendele 2009	6,962,500	6,189	1,125		0	0	0
Mtwara	Govt	Breeder	Masasi 2009	7,062,500	6,811	1,037		0	0	0
Mtwara	Govt	Breeder	Nachi 2015	7,062,500	6,924	1,020		0	0	0
Mtwara	Govt	Breeder	Mnanje 2009	7,062,500	6,011	1,175		0	0	0
Overall average				7,022,500	6,297	1,122		0	_	_

0 = Do not sell. Source: Variety business case survey, 2019.

4.6.2.2. Certified seed

The average variable cost and average gross revenue from certified seed produced in 2017/18 were computed. Naliendele 2009 and Nachi 2015 had an average gross revenue of TZS 2,450/kg and TZS 1,450/kg, respectively. Cost-benefit ratios were 1.60 for Naliendele 2009 and 1.28 for Nachi 2015. The CBR value was positive and above 1, indicating that groundnut seed production is a profitable enterprise. The findings showed that the total variable cost of producing certified seed was TZS 2,278,125/ha. The average cost of producing 1 kg of certified seed was TZS 6,297/ha, with an average output of 1,122 kg/ha.

4.6.2.3. Pre-basic (breeder) seed

The study shows that all varieties generated negative gross income (Table 40). To increase seed access, adoption and attract the private sector, seeds produced were distributed to farmer groups and private seed producer companies. Production costs for Mnanje 2009, Masasi 2009 and Nachi 2015 were TZS 7,062,500/ha, relatively higher compared to those for Mangaka 2009 and Naliendele 2009 (TZS 6,962,500/ha). The difference in production costs is due to variations in seed rate. The recommended seed rate/ha for large seeds such as those of Mangaka 2009, Naliendele 2009, Mnanje 2009, Masasi 2009 and Nachi 2015 is 100 kg/ha while that for medium- sized seed of Pendo 1998 is 80 kg/ha.

4.7. TE, AE and EE of seed and grain

4.7.1. Post-estimation test for models' fitness

Before making an inference from these results, post-estimation tests were done for the fitness of models, the existence of inefficiency effects in variation in both seed and grain produced and total cost of production for both production and cost frontiers, as proposed by Battese and Coelli (1995). From the seed farmer models, the Likelihood Ratio (LR) test statistic for production function (14.919) and cost frontier (1.657) were significant ($p < 0.01$ and $p < 0.1$, respectively) (Table 41). Likewise, from the grain farmer models, the LR test statistic for production function (16.634) and cost frontier (10.062) were both significant ($p < 0.01$) (Table 42). The variance parameters for the seed and grain production functions were 0.885 and 1.256, respectively. Both values were statistically significant ($p < 0.05$). Coefficient of variance parameters for cost function were 62.158 for seed and 1.754 for grain and were significant at $p < 0.01$ and $p < 0.05$, respectively. These results indicate a good fit and precision to the distributional form assumed for the composite error term, and indicate that the sampled farmers have the likelihood of being true representatives of the targeted population (Nyamweru 2018; Bakari, 2018). The estimated values of gamma for the production and cost functions for seed were 0.904 and 0.683, respectively both values were statistically significant at $p < 0.01$ and $p < 0.05$, respectively (Table 41). Meanwhile, the estimated values of gamma for the production and cost functions for grain were 0.807 and 0.777, respectively and were statistically significance at $p < 0.01$ (Table 42).

Table 41. Estimation of the stochastic production and cost frontiers of seed production.

Frontier production function				Frontier cost function			
Variable	**Parameter**	**Coefficient**	**t-ratio**	**Variable**	**Parameter**	**Coefficient**	**t-ratio**
Intercept	β_0	5.755***	14.381	Intercept	α_0	-74.035	0.841
Land	β_1	0.412**	2.917	Land	α_2	- 0.074	0.383
Labour	β_2	-0.401	1.409	Labour	α_3	0.245**	2.576
Seed	β_3	0.563**	4.128	Seed	α_4	0.107	0.997
Fertilizer	β_4	--0.122**	4.071	Fertilizer	α_5	0.962***	2.566
Log-likelihood		-42.566		Log-likelihood		366.046	
Likelihood ratio test statistic	LR	14.919***		Likelihood ratio test statistic	LR	1.657*	
Sigma-squared	$= \sigma_v^2 + \sigma_u^2$	0.885**	3.934	Sigma-squared	$\sigma^2 = \sigma_v^2 + \sigma_u^2$	62.158***	57.101
Gamma	$\gamma = \frac{\sigma_u^2}{\sigma^2}$	0.904***	26.583	Gamma	$\gamma = \frac{\sigma_u^2}{\sigma^2}$	0.683**	5.581
Technical inefficiency				Cost inefficiency			
Intercept	δ_0	0.937***	20.161	Intercept	δ_0	0.992***	13.081
Land tenure	δ_1	0.034	0.605	Land tenure	δ_1	0.043	1.022
Experience	δ_2	- 0.002*	1.804	Experience	δ_2	0.019	1.257
Group member	δ_3	- 0.043*	1.611	Group member	δ_3	0.020	4.207
Education	δ_4	-0.057	0.812	Education	δ_4	- 0.010	1.565
Gender	δ_5	-0.198**	3.353	Gender	δ_5	0.283***	30.016
Age	δ_6	0.002	0.175	Age	δ_6	- 0.126*	1.655
Log-likelihood		23.901		Log-likelihood		-22.942	
Likelihood ratio test statistic		18.565***		Likelihood ratio test Statistic		21.080***	
Sigma-squared	$= \sigma_v^2 + \sigma_u^2$	0.837***	46.683	Sigma-squared	$= \sigma_v^2 + \sigma_u^2$	0.531***	6.475
Gamma	$\gamma = \frac{\sigma_u^2}{\sigma^2}$	0.89***	11.608	Gamma	$\gamma = \frac{\sigma_u^2}{\sigma^2}$	0.822***	7.64

*, ** and *** indicate significance at $p < 0.1$, $p < 0.05$ and $p < 0.01$, respectively.

Source: Variety business case survey, 2019.

4.7.2. Maximum Likelihood Estimates (MLE)

Estimates of factors of production for seed production showed that the coefficients of land (0.412) and quantity of seed (0.563) had positive values and both were statistically significant ($p < 0.05$) (Table 42). Similarly, both coefficients of the amount of fertilizer (-0.122) used in production and labour in human days (-0.401) had negative values. The coefficient of the amount of fertilizer was statistically significant at $p < 0.05$. The estimate of factors of production for grain showed that the coefficients of land (0.384) and quantity of seed (0.053) had positive values and both were statistically significant at $p < 0.05$ (Table 42). Labour used in the production process in human days had a negative value (-0.399) and was statistically insignificant (Table 42).

Table 42. Estimation of the stochastic production and cost frontiers of grain production.

Frontier Production Function				Frontier Cost Function			
Variable	**Parameter**	**Coefficient**	**t-ratio**	**Variable**	**Parameter**	**Coefficient**	**t-ratio**
Intercept	β_0	5.356***	41.621	Intercept	α_0	4.586**	8.164
Land	β_1	0.384**	7.766	Land	α_2	- 0.067	0.023
Labour	β_2	-0.399	0.809	Labour	α_3	0.007	0.165
Seed	β_3	0.053**	1.753	Seed	α_4	0.021***	6.409
Log-likelihood		-35.178		Log-likelihood		343.472	
Likelihood ratio test statistic	LR	16.634***		Likelihood ratio test statistic	LR	10.062***	
Sigma-squared	$= \sigma_v^2 + \sigma_u^2$	1.256**	7.315	Sigma-squared	$\sigma^2 = \sigma_v^2 + \sigma_u^2$	1.754**	7.201
Gamma	$\gamma = \frac{\sigma_u^2}{\sigma^2}$	0.807***	12.894	Gamma	$\gamma = \frac{\sigma_u^2}{\sigma^2}$	0.777***	10.973
Technical inefficiency				Cost inefficiency			
Intercept	δ_0	0.775***	18.335	Intercept	δ_0	0.673**	5.536
Land tenure	δ_1	-0.057**	3.119	Land tenure	δ_1	0.145	1.022
Experience	δ_2	- 0.036**	8.204	Experience	δ_2	-0.154*	1.763
Group member	δ_3	- 0.135	0.623	Group member	δ_3	-0.013	0.216
Education	δ_4	-0.362***	8.137	Education	δ_4	-0.012**	2.515
Gender	δ_5	-0.026**	2.853	Gender	δ_5	0.011	1.050
Age	δ_6	0.008	0.131	Age	δ_6	-0.122*	1.654
Log-		113.793		Log-		-43.335	

Frontier Production Function				Frontier Cost Function			
Variable	**Parameter**	**Coefficient**	**t-ratio**	**Variable**	**Parameter**	**Coefficient**	**t-ratio**
likelihood				likelihood			
Likelihood ratio test statistic		14.533***		Likelihood ratio test statistic		20.769***	
Sigma-squared	$= \sigma_v^2 + \sigma_u^2$	0.773***	7.939	Sigma-squared	$= \sigma_v^2 + \sigma_u^2$	4.072***	11.644
Gamma	$\gamma = \frac{\sigma_u^2}{\sigma^2}$	0.94***	3.811	Gamma	$\gamma = \frac{\sigma_u^2}{\sigma^2}$	0.898***	8.878

*, ** and *** indicate significance at $p < 0.1$, $p < 0.05$ and $p < 0.01$, respectively.

Source: Variety business case survey, 2019.

Regarding the estimates of the cost function in seed production, both coefficients of fertilizer in TZS/kg (0.962) and labour in TZS/ human days (0.245) were positive and statistically significant at $p < 0.01$ and $p < 0.05$, respectively. However, both coefficients of cost of land in TZS/ha (-0.074) and the cost of seeds in TZS/kg (0.107) were statistically insignificant. Again, the estimates of the cost function in grain production showed that coefficients of seed in TZS/kg (0.021) and labour in TZS/human days (0.007) had a positive value. The coefficient value of seed was statistically significant at $p < 0.01$. However, the coefficient of land was negative (-0.067) and statistically insignificant (Table 42).

4.7.3. Comparison of efficiency and inefficiency estimates of seed vs. grain production

The mean TE, AE and EE of seed production in the study area were 56%, 66% and 38%, and of grain production 54%, 52% and 31%, respectively (Table 43). Socio-economic variables were employed to assess both technical and cost inefficiencies in seed and grain production. The variables used were land tenure, experience, group member, education, gender and age. The results of seed production inefficiency function, coefficients of land tenure (0.034) and age (0.002) had positive values but were not statistically significant. Variables that had negative coefficient values were experience (-0.002), group membership (-0.043), education (-0.057) and gender (-0.198). Variables for experience and group membership were statistically significant ($p < 0.1$), while that for gender was statistically significant ($p < 0.05$). The results of grain production inefficiency function showed that coefficients of land tenure (-0.057) and gender (-0.026) had negative values and were statistically significant ($p < 0.05$). Coefficients of experience (-0.036), group membership (-0.135) and education (-0.362) were negative and statistically insignificant. Age had a positive value (0.008) and was statistically insignificant.

Coming to cost inefficiency function for seed production, variables that had positive values included land tenure (0.043), experience (0.019), group member (0.020) and gender (0.283). Education and age scored negative values of -0.010 and -0.126, respectively. Among all socio-economic variables used to access cost inefficiency, only gender and age were statistically significant at $p < 0.01$ and $p < 0.1$, respectively (Table 43). Similarly, for grain cost inefficiency function, coefficient for experience was -0.154 and significant at 10%. The coefficients for education and age were -0.012 and -0.122 and statistically significant at $p < 0.01$ and $p < 0.1$, respectively. Coefficient for group membership was -0.013 and statistically insignificant. Coefficients for land tenure (0.145) and gender (0.011) were positive and statistically insignificant (Table 43).

Table 43. Comparison of efficiency estimates of seed vs. grain production.

Statistics	Seed (n=55)			Grain (n=300)		
	TE	AE	EE	TE	AE	EE
Mean	56	66	38	54	52	31
Standard dev.	23	30	4	19	17	9
Minimum	5	17	20	12	11	6
Maximum	93	98	89	86	92	79
Efficiency ranges						
Below 25	6	-	24	23	34	164
25-49	21	10	25	101	102	133
50-79	15	37	6	163	154	3
Above 80	13	8	-	13	10	-

Source: Variety business case survey, 2019.

4.8. Seed requirement analysis

Findings show that the amount of groundnut bought by off-takers differed by variety. To meet the estimated minimum amount of market demand (80,744 t), an estimated 6,701 t of seed was required. Based on sowing practice, this would mean 100 kg/ha of large-sized seeds of Mnanje 2009 and Nachi 2015. Also, Mangaka 2009 and Naliendele 2009 which replace a medium-size Pendo 1998 and Johari 1998 require 100 kg/ha of seed.

Table 44. Seed demand to meet the minimum market demand surveyed (n =123).

Variety	Minimum seed needed (t)	Minimum farm size (ha)	Minimum market demand (t)
Mangaka 2009, Naliendele 2009	198	1,980	2,080
Nachi 2015, Mnanje 2009	2,300	23,000	34,531
Mangaka 2009, Naliendele 2009	3,930	39,295	41,260
Mangaka 2009, Naliendele 2009	224	2,240	2,353
Mangaka 2009, Naliendele 2009	50	495	520
Total	6,701	67,010	80,744

Source: Variety business case survey, 2019.

These seed estimates do not limit the number of seeds that can be produced in a zone; they merely highlight the minimum demand by the 123 grain off-takers surveyed.

4.9. Institutional linkages, policies and private sector roles

4.9.1. Organizations and their roles

About 15 organizations were identified as being part of the groundnut seed business. These organizations have roles which influence the productivity and marketability of groundnut seeds (Table 45). About 47% of the organizations were public, namely: TOSCI with a total of 5 offices; ASA with 3 groundnut farms; TARI with 1 research center at Naliendele; District Agricultural Offices with 94% of the total districts in Tanzania; the National Variety Release Committee; Ministry of Agriculture, the National Agricultural Extension service and Tanganyika Farmers Association. About 53% of the organizations were private organizations.

The findings showed that the public organizations were involved in primary activities of seed variety development, maintenance and production, whereas the private organizations were involved in producing and marketing seeds to farmers (Table 45).

Agro-dealers, banks, Tanganyika Farmers Association and Tanzania Seed Trade Association (TASTA) were under-represented in groundnut seed production and marketing.

Table 45. Organizations involved in the groundnut seed business and their major roles.

Organizations	Main role
TOSCI	Monitor, inspect and supervise the seed industry
ASA	Produce, process and market both basic and certified seeds
TARI-Naliendele	Seed development, production, maintenance and marketing
NGOs	Capacity building and promoting the use of improved variety
Individual enterprises/seed companies	Produce, promote and markets seeds
District agricultural offices	Provide extension services to farmers
Farmers and farmer associations	Seed production and marketing
National Variety Release Committee	Review data and results of a proposed new variety, recommend entering into list or not
National agricultural extension service	Boost agricultural productivity
Tanzania Seed Trade Association	Industrial promotion, technical support and market information
Tanganyika farmers association	Input supply
Ministry of Agriculture	Food security, quick economic recovery through the implementation of Demand Driven Approach (DDA)
Banks	Provide financial services to the general public and businesses
Agro-dealers	Retailing of certified seeds from seed companies
National Seed Committee	Formulate the National Seed Policy and coordination of the seed industry

Source: Seed Acts of 2003 and 2007.

4.9.2. Institutional linkages

Figure 6 shows the institutions that work to ensure quality seed of groundnut is produced and well marketed in a legally recognized chain. The National Seed Committee (NSC) supervises and monitors formal seed and advises the Ministry of Agriculture, Ministry of Finance and the Ministry of Agriculture and Food Security. It is also responsible for formulating the National Seed Policy and coordination of the seed industry. The Ministry of Agriculture through TARI develops seed varieties to be examined by the National Variety Release Committee (NVRC) and the National Biotic Committee (NBC). Upon approval, seed companies produce and market groundnut seeds. These private companies produce and market certified and some basic seeds. Likewise, agro-dealers are involved in the retail of certified seed from various seed companies.

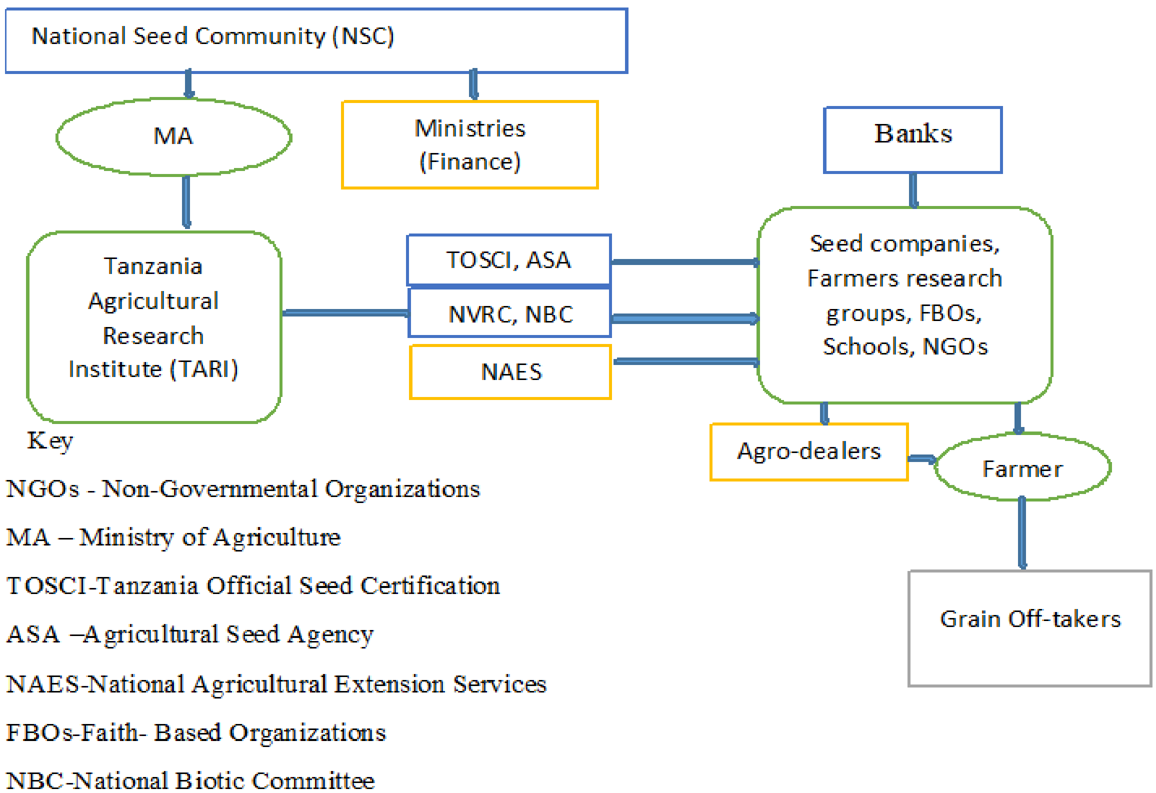


Figure 6. Organizations, roles and linkages in the seed sector.

4.9.3. Expected vs. actual roles of organizations

Every main actor in the groundnut seed system has a role to play as per the Seed Act No 29, 1973 and Seed Act No 18, 2003 (Table 46). Findings show that TARI-Naliendele, individual enterprises, district agricultural extension agents and TOSCI performed all the functions. However, challenges associated with the limited number of TOSCI centres (5 countrywide) hinder easy access to services by seed sector stakeholders. NGOs and farmer organizations are partially involved in seed extension often as part of projects, but largely in a facilitation role for QDS production. ASA has been experiencing an improvement in seed production and marketing over the years. As a public agency, it takes the lead in ensuring that enough basic seeds are produced and disseminated to other private seed companies.

Table 46. Seed sector actors' expected and actual roles in the groundnut seed system.

Actor	Expected role	Actual role
TOSCI	Conducting seed inspections	Conducts seed inspections
	Conducting sampling and testing	Conducts sampling and testing
	Authorizing seed sampling and seed testing laboratories	Authorizes seed sampling and seed testing laboratories
	Training seed producers, seed inspectors and seed analysts	Trains seed producers, seed inspectors and seed analysts
	Liaising with international organizations and International Seed Testing Association (ISTA)	Liaises with international organizations and ISTA
	Carrying out variety performance tests	Carries out a variety performance tests
	Carrying out pre- and post-control tests	Carries out pre- and post-control tests
ASA	Producing, processing and marketing basic and certified seeds	Produces and markets groundnut basic and certified seeds, which are Mangaka 2009 and Mnanje 2009.
	Promoting private sector participation in seed production	Promotes private sector participation in seed production
	Promoting the use of improved varieties	Promotes the use of improved groundnut seeds
	Collaborating with research institutes on matters related to the availability of new varieties	Collaborates with research institutes on matters related to the availability of new varieties
TARI-Naliendele	Seed variety development and maintenance	Develops and maintains seed varieties
	Producing and marketing basic and certified seeds	Produces and markets basic seeds
	Promoting private sector participation in seed production	Promotes companies for seed production
	Promoting the use of improved varieties	Promotes the use of improved varieties
NGOs	Promoting the use of improved varieties	Promotes improved varieties
	Producing and marketing Quality Declared Seeds	Produces and markets Quality Declared Seeds
Individual enterprises	Producing and marketing basic and certified seeds	Produces and markets basic and certified seeds
District agricultural officers	Conducting seed inspections on behalf of TOSCI	Conducts seed inspections on behalf of TOSCI
	Provide extension services to seed producers and farmers	Provides extension services to seed producers and farmers
Farmers	Buying either QDS or certified seeds to produce grain	Purchases QDS and certified seeds to produce grain

Source: Variety business case survey, 2019

4.9.4. Relationship between organizations in the seed sector

The findings showed four levels of relationship between organizations in the groundnut seed sector: no relationship, small, medium and strong (Table 47). TARI had a strong relationship with organizations like TOSCI and ASA and at the same time no relationship with other institutions like banks. TARI-Naliendele has a strong relationship with the following: TOSCI which controls TARI's pre-basic seeds, basic and certified seeds; four NGOs to whom it provides certified seeds for the production of QDS; two seed companies producing seed and five other newly recruited seed companies who are producing certified seeds for the first time; and more than 10 district agricultural local government offices in Tanzania. ASA has strong relations with TARI and TOSCI. TARI sells pre-basic seeds to ASA, whereas TOSCI controls seed quality. It also has a strong relationship with district agricultural local government offices who have provided three groundnut seed farms in Mbozi, Dabaga and Msimba. NGOs have been observed to have a strong relationship with farmer groups which produce QDS, while district agriculture officers monitor QDS production on behalf of TOSCI. Banks and TASTA were under-represented in the study and had no relationship with organizations in the seed sector.

Table 47. The levels of relationship between organizations in the groundnut seed sector.

Organization	TOSCI	ASA	TARI	NGOs	SC	DALGO	Bank	Agro-dealers	TASTA	Farmer groups
TOSCI										
ASA										
TARI										
NGOs										
SC										
DALGO										
Bank										
Agro-dealers										
TASTA										
Farmer groups										

Source: Variety business case survey, 2019.

= Strong relationship; = Medium relationship and = Weak relationship.

4.9.5. Seed policies

The government of the United Republic of Tanzania has policies and a regulatory framework that stem from the Seeds Act No 29 of 1973 and Seeds Act No 18 of 2003 to guide the seed industry and ensure the steady flow of quality seeds to farmers. The country has a strong legal regime that regulates seed variety release, seed certification and quarantine and phytosanitary measures, such as the Seeds Act of 2003, read together with the Seed Regulations of 2007, the Plant Protection Act of 1997, read together with the Plant Protection Regulations of 1998 and the Plant Breeders Right No 222, 2002.

Prior to 1989, the public sector was involved in all steps of the seed chain, from plant genetic resource management to seed production and marketing. Since then, private seed companies have been allowed by law to be involved in the production and marketing of certified seed and some basic seed. That means the Tanzanian policy and legal framework allows the existence of public and private bodies as intermediaries to produce and distribute QDS in the local district. In particular, the policy supports local and international bodies to participate in breeding and seed production and the private sector is involved in the multiplication of pre-basic and basic seed and promoting the production of certified seed and QDS by local seed businesses. These are opportunities that groundnut seed stakeholders can explore to enable groundnut farmers to access quality seeds.

Accessibility to and adoption of seed of new varieties also hinge on the regional policy and framework. Tanzania has been a member of EAC since 2000 and SADC since 1992, which have both made efforts to harmonize seed sector policies and frameworks among member states to ensure a good supply and demand of seeds, and thereby an increase in productivity. EAC has managed to harmonize seed policies and regulations among member states in the key areas of variety evaluation and registration, seed certification, seed phytosanitary regulations, plant variety protection, seed import and export documentation and procedures. However, it has been reported that despite member states adopting the policies successfully, there has been no impact (EAC, 2019). SADC too has made reasonable efforts in this direction. At an agricultural meeting on seed sector held on 7-8 December 2005 in Maputo, Mozambique, member states proposed the harmonization of policies in SADC variety testing, registration and release; seed certification and quality assurance; and quarantine and phytosanitary measures. In February 2010, a Memorandum of Understanding (MoU) for the implementation of the 'SADC Harmonized Seed Regulatory System' was signed by every member state, and came into effect in 2013, wherein every member had to adopt and adhere to all the regulations agreed to. Domestication became a precondition for SADC's harmonized regulation to come into effect (USAID 2016). However, these efforts were hampered (i) by the failure of member states such as Malawi to synchronize national legislation to those in SADC; (ii) a constitutional crisis hindering the operationalization of the legislation in SADC, as in Zambia; and (iii) economic, political, social reforms of SADC legislation raising concerns about threats to national priorities, loss of sovereignty, changes in institutional responsibilities and the need for additional resources (USAID 2016).

There were also challenges at the regional level that led to slow access to and adoption of improved varieties among community members, such as high transaction costs for big traders, especially for import and exports; the limited quality and quantity of seeds among member states and the use of recycled grain as seed.

Tanzania created the Plant Variety Protection (PVP) in 2002 to comply with the World Trade Organization's Trade-Related Intellectual Property Rights (TRIPS) of 1994 for plant breeders. Despite this, there has been a lower number of applications than expected from private breeders, both local and international. In 2015, Tanzania became a member state of the Union for the Protection of New Varieties (UPOV) which makes PBR more effective. It also attracts more international and local plant breeders, which will increase the availability of quality seeds in the country.

In 2018, the Tanzanian seed sector's ability to trade seeds abroad received a major boost with the accreditation of TOSCI's National Laboratory by ISTA. The accreditation will enhance the availability of quality seed in Tanzania and increase the seed sector's confidence in TOSCI's seed certification, boosting Tanzania's seed trade with EAC countries and beyond.

5. DISCUSSION

5.1. Socio-economic profile of farmers

Production in both intervention and non-intervention districts were dominated by male farmers, probably because groundnut is turning from a staple to a commercial crop. The finding is contrary to those of Joseph and Mwakimata (2017), who found that female farmers dominated groundnut production in Tanzania. Our finding signals a positive direction in groundnut prosperity since men are the major decision makers in the family (Doss and Morris 2000). However, the inclusion of women is vital in groundnut production since it does not require high capital and involves less energy compared to other income-generating crops like rice and tobacco (NARI 2010; Ndabila and Mlay 2018).

Production in both intervention and non-intervention districts is dominated by farmers aged 35-50 years who tend to be more conservative in adopting new technologies (Kansiime et al. 2014). Conversely, Mignouna et al. (2011) found that older farmers can take risks due to their long years of experience. Findings show that the unemployment rate among youth in Tanzania and other developing countries remains bleak; for instance, more than 3.65% of youth in Tanzania are unemployed due to either limited white collared jobs or the lack of capital for self-employment (Haji 2015). Hence, encouraging youth in groundnut production is important as the crop has high demand but doesn't require high capital investment. Moreover, production in the intervention districts is dominated by farmers who are settlers while those in the non-intervention districts are farmers who are landlords. The dominance of settlers may imply that the interventions have drawn the attention of farmers investing in groundnuts. However, for those who are hiring land, it means an increase in the cost of production. Also, farm management in terms of soil fertility is presumed to be poor when it is controlled by settlers compared to when it is managed by landlords (Debertin 2012).

Majority of farmers in the intervention districts did not belong to groups or associations and had gone through primary education, while there were none in the non-intervention districts. Limited or lack of association membership implies negligible synergies and collective action in the purchase of inputs and in obtaining market information, while low education implies the farmer's limited ability to understand crop information and rigidity in accepting changes (Chechen et al*.* 2019). Also, the small farm sizes in both intervention and non-intervention districts imply that most farmers are less wealthy and taking fewer risks. Oladeji et al. (2015) observe that most farmers with large farm sizes may be wealthier, risk takers and experiment with new technologies. Farmers with larger farm sizes may strictly follow recommended practices like optimum seed rate to avoid losses, probably because they also produce for commercial purpose.

5.2. Land availability and production workforce

There was almost a balance of older and younger farmers. While older farmers bring to the table their experience and managerial skills to enhance agricultural productivity, young farmers are likely to be efficient in tasks such as weeding, harvesting, drying and packaging. This is supported by Adebayo and Onu (1999) who confirm that age is one of the socio-economic features that affect productivity. Male-headed households are common in African traditions where most societies are patrilineal and men control most of the household resources (Duze and Mohamed 2006). Studies have shown that both men and women are equally efficient as farm managers. However, women are often claimed to have less access to resources compared to men (Quisumbing 1995). Land ownership refers to the arrangements or rights under which the owner holds or uses the land (NBS 2017).

5.3. Inputs productivity

Land and seed were inputs significantly affecting seed and grain production. An increase in the use of these inputs would lead to a significant increase in output and technical efficiency. This finding is in line with those of Andrew and Phillip (2015). Levels of utilization of these inputs were far below optimal levels; hence an increase in their use is required as recommended by Nyamweru (2018).

The expansion of land for farming is not a problem in Tanzania since the country has 44,000,000 ha of arable land (Mosha et al. 2018). Of this, about 17,120,571 ha is under farming; 16,977,740 ha (92.2%) in the mainland and 142,831ha (0.8%) in the islands of Zanzibar and Pemba (NBS 2017). Studies show that all land resources globally will be lost within one century, and the reserve of highly productive land will be gone in 25 years (Buringh 1985). So the use of best agronomic practices is recommended under such a scenario.

The estimated coefficients of production with respect to seed input for seed and grain production were positive and statistically significant ($p < 0.05$), implying that at 1% significance level, a 1% increase in seed used will lead to an average increase of 0.56% and 0.05% in the production of seed and grain, respectively, other inputs being constant.

The findings show that there is room to improve seed and grain production using higher quantity of seed during planting. Seed is currently underused by farmers as the study shows; on an average a farmer plants 55 kg of seed/ha, which is very low compared to the recommended 80-100 kg/ha, presuming that training in agronomic practices, sound sowing methods and the use of 80-100 kg/ha of seed according to NARI (2010) would help farmers. While 100 kg of seed should be used for large varieties like Mnanje 2009 in the Southern Highlands zone, 80 kg of seed should be used for small and medium seeded varieties like Nachi 2009 and Naliendele 2009. Data showed that a farmer harvests an average of 750 kg/ha of groundnut, which is low compared to 1000 kg/ha (Daudi et al. 2018). Land and fertilizer inputs showed higher responses to seed farming than grain farming.

5.4. Cost function estimates

Fertilizer and labour had a positive and statistically significant effect on total seed production cost. For instance, the coefficient of labour cost (0.245) could be interpreted as when labour costs increased by 100%, holding all other input prices constant, total production cost could go up by about 24.50%. It is clear that groundnut is a labour-intensive crop, especially in operations like sowing, weeding, harvesting and drying. However, the non-availability of labour at the right time has hampered timely operations resulting in low yield realization (Govindaraj and Mishra 2011). The practice of using inorganic boosters and fertilizers in crop production in the country is below the minimum recommended rate of 50 kg/ha set by the Abuja Declaration (Nyuma 2016). In Tanzania, crop research does not specify fertilizer recommendation for oilcrops, including groundnut (Kamhabwa 2014). Like most crops grown by smallholder farmers, groundnut production is characterized by fluctuating yields as cultivation is not usually done in irrigated land and is characterized by erratic rainfall and low application of fertilizers due to high prices (Kamhabwa 2014).

For example in seed production, the coefficient of fertilizer cost of 0.962 could be interpreted as when fertilizer cost increases by 100%, holding all other inputs prices constant, total production cost rises by about 96%. This indicates the huge potential of narrowing yield gaps through fertilizer application.

On the grain production side, the coefficient of seed input (0.021) was statistically positive, influencing production of the crop in the study areas, meaning that when seed cost increases by 100%, keeping other factors of production prices constant, total production cost rises by about 2.1%. These findings are consistent with results from various studies (Bakari 2018; Nyamweru 2018; Ahmed and Melesse 2018; Govindaraj and Mishra 2011; Msuya and Ashimogo 2005). The groundnut seed system in Tanzania is still not very advanced; the result is seasonal variations in seed price throughout the year.

5.5. Implications of AE, TE and EE on production

The average TE values of about 56% and 54% for seed and grain, respectively meant that seed and grain farmers only attained an output equal to 56% and 54%, respectively of potential output, and they could get an additional output of 44% for seed and 46% for grain, without additional resources, through proper and more efficient use of existing inputs and technology (Shanmugam and Venkataramani 2006).

The TE range showed that the producer who had achieved an average TE needed to reach the highest TE, and could save 37% on inputs for seed producers and 32% for grain producers. Also, the most technically inefficient farmer of seed and grain could achieve a saving of 88% and 74%, respectively.

The mean AE was 66% for seed and 55% for grain production, meaning farmers were efficient in input use relative to input prices by 66% and 55% for seed and grain production, respectively. Economic efficiency values were 38% for seed production and 31% for grain production, a product of AE and TE.

Economic efficiency shows how producers effectively make correct input use choices and reach a point where the marginal value of the products (MVP) equals their marginal factors. Farmers could adjust the input combinations to the levels that achieve minimum cost while producing the maximum output possible.

These results validate previous studies where growers could not reach full efficiency. For instance, Msuya and Ashimogo (2005) show that the average TE for sugarcane farming in Morogoro Tanzania was 76%. Nyamweru (2018) reported that the mean EE of rice farmers in Rwanda was 58%, while Andrew and Phillip (2015) indicate that the mean AE for rainfed rice production in Taraba state was 69%. Related findings have been reported by Bifarin et al. (2010); Haile (2015); Ahmed and Melesse (2018) and Karimov (2014).

5.6. Factors affecting TE

The estimated coefficients in the inefficiency models for seed and grain production were of particular interest to this study and are depicted in Tables 41 and 42. A wide range of TEs among the seed and grain producers justifies the need to analyze their causes. As supported by the values of gamma for seed (0.904) and grain production (0.807) functions which were statistically significant ($p < 0.01$), technical inefficiency had a significant effect on both outputs (Wadud and White 2000; Sharma et al. 1997; Hjalmarsson et al. 1996).

The results revealed that farmers who had been growing seed for many years were more technically efficient than their peers. This is supported by Okike et al. (2004) who showed that experience is an important component that enhances TE. Also, the coefficient of education showed negative values for grain farmers, suggesting that farmers with a higher level of education have an added advantage compared to less educated ones. This concurs with Dey et al. (2000) who found that education enhances knowledge, facilitated by the long term practice of agricultural activities and higher production efficiencies.

The coefficient of group membership for farmers showed a negative sign and was statistically significant in the seed production inefficiency model. The importance of membership in farmer organizations was reported by Tchale (2009), wherein maize farmers in groups in Malawi had the advantage of shared information on production and availability and access to input markets, enhancing their TE. Sanyang (2014) and Wakili and Isa (2015) reported a similar relationship between TE and group membership, with the former demonstrating that farmers in groups generally enjoy easy support that comes from value chain stakeholders.

The gender of the seed farmers had a negative value and was statistically significant ($p < 0.05$). Male groundnut producers were more technically efficient than their female counterparts. Therefore, gender plays a significant role in influencing TE of groundnut seed production in Tanzania. Donkoh et al. (2013) in a study in Ghana found that male farmers were harvesting more from inputs than female farmers. Female farmers are generally less educationally qualified than their male subordinates, resulting in lower adoption of various agriculture practices and technologies (Ragasa 2012).

The land ownership status of seed and grain farmers had a significant positive impact on TE in production. Those who owned land were more efficient than those who did not. This is consistent with Krishna et al. (2016) who found that land ownership plays a significant role in determining the effect of land resources and tenure systems on the productivity and effectiveness of paddy producers in the Philippines. Also, Mohamed et al. (2002) demonstrate that hired land is less technically efficient than own land due to restrictions imposed by owners on the former. The domination of people who hire land implies increasing costs of production for the farmer and poor farm management (in terms of soil fertility) when it is controlled by settlers compared to landlords (Debertin 2012).

5.7. Factors influencing the adoption of improved groundnut varieties

The use of improved high-yielding varieties is an important avenue for increasing food productivity. Low adoption of improved groundnut varieties is among the main causes of low farm productivity and the high incidence of poverty and food insecurity. Farmers produce an average of 745 kg/ha of groundnut, which is way below 1000 kg/ha, the average productivity range of improved varieties (Mwalongo et al. 2020). The use of obsolete varieties by farmers has also been reported as one of the major causes (Daudi et al. 2018).

The analysis revealed that age, gender, group membership, seed cost and seed access play significant roles in adoption decisions.

Farmers aged between 35 and 50 years were the highest adopters of the improved varieties. These results are contrary to expectations since older farmers are known to be more conservative in adopting new technology. Our results are similar to those of Kansiime et al. (2014) who noted that older farmers easily adopt improved varieties based on their vast experience of various stresses affecting groundnut production. As farmers in Tanzania have experienced increasing drought (Feder 1985), it may have given older and experienced farmers the opportunity to compare the changes and adopt improved varieties more readily than those in other age groups.

The study also found that group membership was positive and significant for the adoption of improved varieties, implying that as farmers join professional farming groups, their ability to adopt improved groundnut varieties increases. Group membership ensures cohesiveness, good mandate, resource availability, integrity, access to relevant information and greater managerial capacity of members (Mwaura 2014). Tchale (2009) reports similar findings in Malawi, where smallholder farmers in groups benefited from shared knowledge on modern farming methods among peers and from economies of scale while accessing input markets as a group. Hence, such farmers become good adopters of improved varieties. Farmers who belong to an organized group were usually found to have opportunities to access quick support from the government, NGOs, donors and other stakeholders (Doss and Morris 2000). In Tanzania, Kansiime et al. (2014) report on farmer groups being supported with seeds from research and development organizations.

Finally, seed availability and price were found to significantly influence the adoption of improved groundnut varieties, implying that the availability of low-cost improved groundnut seeds among farmers in Tanzania considerably increases their ability to adopt improved groundnut varieties. These findings are similar to those of Mwangi et al. (2021).

5.8. Existing opportunities in the groundnut value chain

The following key business opportunities were identified in the existing groundnut value chain:

- There is wide scope to expand groundnut production. According to NBS (2017), 27 million ha are suitable for farming but unutilized. Also, Gross Margin Analysis of grain production shows positive net income.
- The current population of 57 million is expected to increase to 72.7 million by 2025, an extra 15.7 million who will need to be food secure.
- There is scope to stimulate groundnut consumption in big cities in the Coast and North zone, such as in Dar es Salaam (5,781,557 million) and Arusha (1,943,196 million), where consumption is relatively low (0.17 kg/year and 0.05 kg/year, respectively).
- Private companies can invest in seed multiplication of improved varieties to cover at least 6,701 t.
- Groundnut requires bulk seeds/ha. Private companies can invest in labour-saving technology to help farmers use more seeds and hence create a large market for them.
- Oil processing industries can be set up in high producing regions like Tabora, Simiyu and Dodoma.
- There are opportunities to export within the EAC and out of East Africa since 85% of the approved export is among the member states.

6. CONCLUSIONS AND RECOMMENDATIONS

The study found that 55% of the respondents were male, 67% were using old varieties of seed, 96% were literate and 69% belonged to farmer groups. Crop production was the main activity of about 95% of the respondents. In semi-arid regions, 50% of the interviewed farmers ranked groundnut as their first crop of choice which earns them income and food. It is important to note that Tanzania has about 27 million ha of idle and fertile land.

The interviewed farmers used groundnut in five ways: for consumption (26%), in oil processing (2%), to sell as grain (42%), as traded goods (1%) and as grain sold as seed (35%). Groundnut farmers face challenges such as lack of seeds, low market prices, diseases and drought. On the other hand, off-takers were interested in buying improved varieties rather than old ones; hence they import grain (more than 21 t) from neighbouring countries, mostly Malawi and Zambia. Off-takers are mostly challenged by poor quality grain from farmers, grain shortage and multiple fees the local government imposes on the grain they buy. The main imported varieties are Mnanje 2009 and Nachi 2015 which are available in Tanzania as well, specifically in Mbozi and Mpanda.

Coming to production efficiencies, the study estimated the extent to which farmers in Tanzania can increase their productivity and profitability if they efficiently adjust the use of inputs (land and seed). Farm size and seed were statistically significant and had a positive effect on groundnut seed and grain production. This means that levels of utilization of these inputs were below optimal levels; increasing their use would lead to an increase in seed production. The Government, through the Ministry of Agriculture and other stakeholders, can make a huge impact by strengthening the agricultural extension system to provide advisory services on good agronomic practices to farmers that would enable an improvement in their technical efficiency.

The mean seed and grain estimates were 56%, 66% and 38% and 54%, 52% and 31% for TE, AE and EE, respectively. This implies that seed producers were more likely to be allocatively efficient than they are technically or economically. Meanwhile, grain producers were more likely to be technically efficient than they are allocatively or economically. The determinants of technical inefficiency for seed producers were gender, experience and group membership, while for grain producers they were land tenure, education, gender and experience. Farmers with many years of experience and those in groups were more technically efficient than less experienced and individual farmers. Therefore, nucleus farms and farmer field schools that allow less experienced farmers to tap accumulated knowledge would improve groundnut seed and grain production. Farmers should be encouraged to organize themselves into professional groups to benefit from shared knowledge on modern farming practices and economies of scale in accessing input markets.

Although the cost-benefit analysis ratios indicate that both seed and grain farming are good businesses to invest in, there is room to improve farmers' yields. For example, the average yields of QDS, certified and breeder seed producers were 705 kg/ha, 880 kg/ha and 1,122 kg/ha, respectively. Improving farm management by adhering to recommended agronomic practices could enhance optimum yields.

For the country to exploit the potential of groundnut in local and world markets, quality seeds, knowledgeable farmers, well-informed off-takers and favourable laws are key. Therefore, there is a strong need for a strategy to improve the performance of stakeholders in the groundnut grain value chain.

The study recommends that both NGOs and government organizations invest in raising farmer awareness of the benefits of using improved groundnut varieties compared to old ones. Mass media could be used to accelerate the spillover of improved variety of seeds from intervention areas to non-interventions ones.

The Government needs to collaborate with gender and youth-based organizations in enabling women and youth to use improved groundnut varieties for their economic well-being, given that it only requires a small capital investment.

In addition, a national policy is required to encourage groundnut farmers to use improved groundnut seeds to reduce the impact of abiotic and biotic stresses as well as benefit from their high economic value. Equally important is the need to encourage private businessmen and women to invest in seed production in the regions, districts, divisions and villages across the country, depending on farmer demand from the regions.

To ensure sufficient supply of seeds to farmers, ascertaining national seed demand is paramount, as is encouraging private investors to invest in various zones, regions and districts to exploit the available seed market. Engaging private companies that can maintain seed quality, compete in international trade and strongly promote QDS are solutions.

Also, the government should introduce and implement seed subsidization policies to reduce seed costs to both seed producers and farmers. Setting up more farmer groups can increase the rate of adoption of improved varieties while reducing the high cost an individual farmer bears in accessing new information. Group membership can aid the sharing of information on markets and inputs and skills related to the challenges they face. Lastly, establishing a clear link to the business value chain is a prerequisite.

REFERENCES

ACB (African Centre for Biodiversity). (2015). The expansion of commercial seed sector in Sub-Saharan Africa: Major players, key issues and trends. Johannesburg: African Centre for Biodiversity. 49 pp.

Adebayo EF and Onu JI. (1999). Economic of rice production in Yola North and South local government area. Nigerian Journal of Tropical Agriculture 1:15–20 African Institute of Cooperate Citizenship (AICC). Malawi Groundnut Outlook. 2016. Available online at www.aiccafrica.org (accessed on 27 February 2020).

Ahmed M and Melesse K. (2018). Impact of off-farm activities on technical efficiency: evidence from maize producers of eastern Ethiopia. Agricultural and Food Economics 6(3): 1–15.

Aigner D, Lovell C and Schmidt P. (1977). Formulation and estimation of stochastic frontier production function models. Journal of Econometrics 6(1):21–37.

Akobundu O. (1998). Basic elements for improved weed management in the developing world. Pages 93–101 *in* Report of the Expert Consultation on Weed Ecology and Management. Rome, Italy: FAO.

Akpo E, Bakari H, Alex G, Daudi H, Muricho G, Minja A, Nzunda J, Ojiewo C and Varshney R. (2021). Comparative advantage of newly-released varieties of groundnut in Tanzania. Policy Brief 36. Available on line at http://oar.icrisat.org (accessed on 25.11.2021).

Andrew R and Philip D. (2015). Determinants of technical efficiency among smallholder coffee farmers in Kigoma Region, Tanzania. Journal of Continuing Education and Extension (JCEE) 6 (2):932–951.

ASARECA/KIT. (2014). Tanzania seed sector assessment: A participatory national seed sector assessment for the development of an Integrated Seed Sector Development (ISSD) programme in Tanzania. April 2014, Entebbe, Uganda. 169 pp.

Bakari H. (2018). Challenges facing sugar cane supply to Mtibwa factory: Empirical evidence from Mtibwa sugarcane outgrowers scheme morogoro, Tanzania. MSc Thesis. Sokoine University of Agriculture. Morogoro, Tanzania. 73 pp.

Battese G and Coelli T. (1995). A model for technical inefficiency effects in a stochastic frontier production function for panel. Empirical Economics 20: 325–332.

Bauman A, Jablonski B and Thilmany D. (2016). Evaluating scale and technical efficiency among farms and ranches with a local market orientation. 2016 Annual Meeting, 31 July – 2 August 2016, Boston, Massachusetts (No. 236057). Agricultural and Applied Economics Association. 28 pp. *Available online at* https://ideas.repec.org/p/ags/aaea16/242364.html (accessed on 30 August 2021).

Bifarin J, Alimi T, Baruwa O and Ajewole O. (2010) Determinant of technical, allocative and economic efficiencies in the plantain (*Musa* spp.) production industry, Ondo state, Nigeria. Acta Hort 879:199–210.

Bucheyeki T, Shenkalwa M, Mapunda T and Matata W. (2008). On-farm evaluation of promising groundnut varieties for adaptation and adoption in Tanzania. African Journal of Agricultural Research 3(8): 531–536.

Buringh P. (1985). Land resources agriculture. Journal of Biological sciences 310 (1144):151–159.

Charnes A, Cooper WW and Rhodes E. (1978). Measuring the efficiency of decision making units. European Journal of Operational Research 2(6): 429–444.

Chenchen R, Hans V, Stefan R, Shuqin J, Hongbin L and Baojing G. (2019). The impact of farm size on agricultural sustainability. Journal of Cleaner Production 10:1–44.

Chukwuji C, Inoni O and Ike P. (2007). Determinants of technical efficiency of garri processing in Delta state, Nigeria. Journal of Central European Agriculture 8(3): 327–336.

Coelli T, Rao P, O'Donnel C and Battese G. (2005). An introduction to efficiency and productivity analysis. Second Edition. Springer, New York. 341 pp.

Crissman C, Crissman L and Carli C. (1993). Seed potato systems in Africa: A case *study. Lima, International Potato Center. Available online at* http://pdf.usaid.gov/pdf_docs/PNABS629.pdf (accessed on 20 May 2019).

Daudi H, Hussein S, Okori and Mark D. (2018). Groundnut production constraints, farming systems, and farmer-preferred traits in Tanzania. Journal of Crop Improvement 32 (6): 812–828.

Derbetin L. (2012). Agricultural production economics. Macmillan Publishing Company, a division Macmillan Inc, Upper Saddle River, NJ, USA. 427 pp.

Dey MM, Paraguas FJ, Bimbao GB and Regaspi PB. (2000). Technical efficiency of tilapia growout pond operations in the Philippines. Aquaculture Economics & Management *4*(1-2): 33-47.

Diamara E and Skuras D. (2003) Adoption of agricultural innovations as a two-stage partial observability process. Agricultural Economics 28(3): 187–196.

Dlamini S, Rugambisa J, Masuku M and Belete A. (2010). Technical efficiency of small scale sugarcane farmers in Swaziland: A case study of Vuvulane and Big bend farmers. African Journal of Agricultural Research 9: 935–940.

Donkoh S, Ayambila S and Abdulai S. (2013). Technical efficiency of rice production at the Tono Irrigation Scheme in Northern Ghana. American Journal of Experimental Agriculture 3(1): 25–42.

Doss C and Morris M. (2000). How does gender affect the adoption of agricultural innovations? The case of improved maize technology in Ghana. Agric. Econ. 25: 27–39. [CrossRef]

Duze M and Mohamed ZI. (2006). Male knowledge, attitudes and family planning practices in Northern Nigeria. African Journal of Reproductive Health 10(3): 53–65.

East African Community. (2019). Enhancing Trade Intergration in the East African Community: Available online at https://www.eac.int/tradeconference (accessed on 19 July 2019).

FAO (2018).Statistical Data on Crops, Groundnut, Area, Production Quantity of Tanzania, Africa and the World. Available online at http://Faostat.fao.org (accessed on 17 January 2019).

FAOSTAT (2015). Statistical data on crops, groundnuts, area, production quantity of Tanzania, Africa and the world. Available online at http://Faostat.fao.org (accessed on 17 June 2019).

FAOSTAT (2018). Statistical data on crops, groundnuts, area, production quantity of Tanzania, Africa and the world. Available online at http://Faostat.fao.org (accessed on 5 March 2019).

Farrell M. (1957). Measurement of productive efficiency. Journal of the Royal Statistical Society 120 (3): 253–290.

Feder G, Just R and Zilberman D. (1985). Adoption of agricultural innovations in Ethiopia. Journal of Agricultural Economics 4 (1): 27–43.

Førsund F, Lovell A and Schmidt P. (1980). A survey of frontier production functions and their relationship to efficiency measurement. Journal of Econometrics 13: 5–26.

Gedara K, Wilson C, Pascoe S and Robinson T. (2012) Factors affecting technical efficiency of rice farmers in village reservoir irrigation systems of Sri Lanka. Journal of Agricultural Economics 63(3):627–638.

Ghadim A and Pannell D. (1999). A conceptual framework of the adoption of an agricultural innovation. Journal of Agricultural Economics 21:145–154.

Govindaraj G and Mishra A. (2011). Labour demand and labour-saving options: A case of groundnut crop in India. Agricultural Economics Research Review 24(1): 423–428.

Haile B. (2015). Determinants of technical, allocative and economic efficiencies among onion producing farmers in irrigated agriculture: empirical evidence from kobo district, Amhara region, Ethiopia. African Journal Agricultural Research 10(20): 2180–2189.

Haji M. (2015). Report on youth employment in Tanzania: Taking stock of the evidence and knowledge gaps. International Development Research Centre. Available online at https://www.idrc.ca/sites (accessed on 11 February 2020).

Heaslip J, Shannon D and Casement D. (2013). Farm gross margin and enterprise planning guide 2012: A gross margin template for crop and livestock enterprises. Rural Solutions SA, South Australia. 80 pp.

Hjalmarsson L, Kumbhakar S and Hesmati A. (1996). DEA, DFA and SFA: A comparison. Journal of Productivity Analysis 7:303–327.

Joseph H and Mwakimata R. (2017). Analysis of gender yield gape among groundnut farmers in Tanzania. MSc Thesis. Sokoine University of Agriculture. 88 pp.

Judge G, Griffiths W, Hill R, Lutkepohl H and Lee T. (1985). The theory and practice and econometrics, New York, John Wiley. 1019 pp.

Kaine A. (2011). Investigation of factors affecting technical infancy of Akpu Processing in Delta State, Nigeria. Journal of human ecology 33(2):133–137.

Kamhabwa F. (2014). Consumption of fertilizers and fertilizer use by crop in Tanzania. International Fertilizer Development Center, Muscle Shoals, USA. 23 pp.

Kansiime MK, Wambugu SK and Shisanya CA. (2014). Determinants of farmers' decisions to adopt adaptation technologies in Eastern Uganda. Journal of Economics and Sustainable Development 5(3): 189–199.

Karimov A. (2014). Factors affecting the efficiency of cotton producers in rural Khorezm, Uzbekistan: Re-examining the role of knowledge indicators in technical efficiency improvement. Karimov Agricultural and Food Economics 2(7): 1–16.

Kopp R and Diewert W. (1982). The decomposition of frontier cost function deviations into measures of technical and allocative efficiency. Journal of Econometrics vol. 19:213, 319–331.

Krishna HK, Mishra A and Mohanty S. (2016). Impact of land ownership on productivity and efficiency of rice farmers: the case of the Philippines. Land Policy use 50: 371–378.

Leslie DM. (2013). Gross margins for selected fruit, vegetable and root crops for the sugar cane belt in Fiji. Secretariat of the Pacific Community, Suva, Fiji. 68 pp.

Louwaars N and De Boef W. (2012). Integrated seed sector development in Africa: A conceptual framework for creating coherence between practices, programs, and policies. J. Crop Imp. 26: 39–59.

Mangasini A, Mwanahawa M, Arbogast M and Neema K. (2014). Socio-economic factors limiting smallholder groundnut production in Tabora Region. Research report 14/1. Available online at https://www.repoa.or.tz/wp-content/uploads/2 (accessed on 27 July 2020).

Meeusen W and Van den Broeck J. (1977). Efficiency estimation from Cobb-Douglas production functions with composed error. International Economic Review 18: 435–444. Available online at http://www.jstor.org/stable/2525757 (accessed on 17 January 2020).

Mignouna B, Manyong M, Rusike J, Mutabazi S and Senkondo M. (2011). Determinants of adopting Imazapyr-resistant maize technology and its impact on household income in Western Kenya: Ag. Bio forum 14(3): 158–163.

Minot N, Smale M, Eicher C, Jayne T, Kling J, Horna J and Myers R. (2007). Seed development programs in Sub-Saharan Africa: A review of experiences. Prepared for the Rockefeller Foundation. Washington, D.C.: International Food Policy Research Institute.

Mohamed M, Berhanu G, Samwel B and Simioni E. (2002). Measurement and sources of technical efficiency of land tenure contract in Ethiopia. Environmental and development economics 7: 507–527.

Monyo E and Varshney R. (2016). *Seven seasons of learning and engaging smallholder farmers in the drought-prone areas of sub-Saharan Africa and South Asia through Tropical Legumes, 2007–2014.* ICRISAT, Patancheru. ISBN 978-92-9066-568-7.

Mosha D, Vedeld P, Katani J, Kajembe G and Tarimo A. (2018). Contribution of paddy production to household income in farmer managed irrigation scheme communities in Iringa Rural and Kilombero districts, Tanzania. Journal of Agriculture studies 69(2): 100–122.

Msuya E and Ashimogo G. (2005). Estimation of technical efficiency in Tanzanian production in Tanzania. A case study of Mtibwa Sugar Estate Outgrowers Scheme. Munich Personal RePEc Archive Paper No. 3747.

Musimu J. (2018). Economics of smallholder common beans production in Mbeya, Tanzania Dissertation for Award of MSc Degree in Sokoine University of Agriculture. 32 pp.

Mustapha S, Makinta A, Zongoma B and Iwan A. (2012). Socio-economic factors affecting adoption of soya bean production technologies in Takum Local Government Area of Taraba State, Nigeria. Asian Journal of Agriculture and Rural Development 2(2): 271–276.

Mwalongo S, Akpo E, Lukurugu G A, Muricho G, Vernooy R, Minja A, Ojiewo C, Njuguna E, Otieno G and Varshney R. (2020). Factors influencing preferences and adoption of improved groundnut varieties among farmers in Tanzania. Agronomy 10(9): 1271.

Mwangi B, Macharia I and Bett E. (2021). A multi-dimensional adoption approach for improved sorghum varieties in eastern Kenya: a climate change adaptation perspective. Climate and Development 13(4):283– 292.

Mwaura F. (2014). Effects of membership of group farming cooperatives on farmers food production and poverty status in Nigeria. African Crop Science Journal 22(4):917–927.

NARI (2010). Annual Report. 2009. Naliendele Agricultural Research Institute: Mtwara.11 pp. (Google Scholar)

NBS (National Bureau of Statistics). (2017). Annual agriculture sample survey crop and livestock report.

Ndabila A and Mlay G. (2018). Adoption of system of rice intensification and effect on yield in Mbarali district Mbeya, Tanzania. Dissertation for Award of MSc Degree in Sokoine University of Agriculture. 88 pp.

Nigam SN and Lenne JM. (1996). *Groundnut in ICRISAT programs.* Grain Legumes (14): 25–27.

Nkonya E. (2001). Cross-pollinated crop variety adoption studies and seed recycling: The case of maize in Tanzania: Astern Africa Journal of Rural Development 17: 25–34.

Nyamweru J. (2018). Economic efficiency of smallholder rice producers in Maramvya irrigated scheme, Burundi. A dissertation submitted in partial fulfilment of the requirements for the degree of Master of Science in agricultural and applied economics of Sokoine University of agriculture. Morogoro, Tanzania.

Nyuma H. (2016). Response of three groundnut (*Arachis Hypogaea* L.) genotypes to calcium and phosphatic fertilizers. MSc Thesis. Sokoine University of Agriculture. Morogoro, Tanzania. 74 pp.

Ogunyemi A and Ojo S. (2014). Analysis of factors influencing the adoption of improved cassava production technology in Ekiti State, Nigeria. International Journal of Agricultural Sciences and Natural Resources Natural Resources 1(3): 40–44.

Okike I, Jabbor M, Manyong V, Smith J, Akinwumi J and Ehui S. (2004). Agricultural intensification and efficiency in the West African Savannahs: Evidence from Northern Nigeria. Socioeconomics and Policy Research Working Paper 33, ILRI (International Livestock Research Institute), Nairobi, Kenya. 54 pp.

Oladeji B, Kola K, Abiona T, Montgomery A, Araya R and Gureje O. (2015). A pilot randomized controlled trial of a stepped care intervention package for depression in primary care in Nigeria. Journal of BMC Psychiatry 10(15):1–11.

Pompeu AS. (1980). Groundnut production, utilization, research problems and further research needs in Brazil. Pages 244–246 in Proceedings of the International Workshop on Groundnut, 13-17 October 1980, ICRISAT Center, Patancheru, India. Patancheru, AP, India: ICRISAT.

Purseglove J. (1968) Tropical crops: Dicotyledons. Essex, UK: Longman. 224–236 pp.

Quisumbing AR. (1995). Gender differences in agricultural productivity: A survey of empirical evidence. Food Consumption and Nutrition Division. International Food Policy Research Institute. 72 pp.

Ragasa C. (2012). Gender and institutional dimensions of agricultural technology adoption: A review of literature and synthesis of 35 case studies. Research paper prepared for presentation at the International Association of Agricultural Economists Triennial Conference, 18-24 August 2012, Foz do Iguaçu, Brazil. 57 pp.

Ramadhani T, Otsyina R and Franzel S. (2002). Improving household income and reducing deforestation using rotational woodlots in Tabora District, Tanzania. Agriculture Ecosystem and Environment 89 (3): 229–239.

Rasmussen S. (2012). Production economics: The basic theory of production optimisation. Springer Science and Business Media, Copenhagen. 287 pp.

Sanyang B. (2014). Evaluation of technical, allocative and economic efficiency of rice producers: A case study in Central River Region North & South of Gambia. MPhil. Unpublished Thesis, Department of Agricultural Economics, Agribusiness and Extension, Kwame Nkrumah University of Science and Technology. 144 pp.

Shanmugam E and Venkataramani K. (2006). Technical efficiency in agricultural production and its determinants: An exploratory study at the district level K.R. Ind. Jn. of Agri. Econ. 61(2):170–184.

Sharma K, Leung P and Zalenski H. (1997). Productive efficiency of the swine industry in Hawaii: Stochastic Frontier vs. Data Envelopment Analysis. Journal of Productivity Analysis 8: 447–459.

Simar L and Wilson P. (2015). Statistical approaches for non-parametric frontier models: a guided tour. Int Stat Rev 83(1):77–110

Sørensen B, Jørgensen E, Debel C, Jensen F, Jensen H, Jacobsen T and Halling K. (2004). Improved design of large wind turbine blade of fibre composites based on studies of scale effects. Risø National Laboratory. Roskilde. Denmark. 36 pp.

Sperling C, Jones K and Mathews K. (2013). Derived demand for cattle feeding inputs. Journal of Agribusiness 26(1): 41–60.

Tchale H. (2009). The efficiency of smallholder agriculture in Malawi. World Bank, Lilongwe, Malawi. AFJARE 3 (2): 101–121.

Thomas CR and Maurice SC. (2008). Managerial Economics (9^{th} ed). McGraw-Hill/Irwin. 746 pp.

Upadhyaya H, Mukri G, Nadaf H and Singh S. (2012). Variability and stability analysis for nutritional traits in the mini core collection of peanut. Journal of Crop Science 52: 168– 78.

URT (2007). Annual report, ministry of agriculture, food security and cooperative on improved agricultural research technologies recommended in Tanzania. (Accessed on 11 August 2019.)

URT (2013). 2012 Population and housing census, population distribution by administrative area. Available online at http://www.tzdpg.or.tz/fileadmin/documents/dpg_internal/dpg_working_groups_clusters/cluster_2/water/WSDP/Background_information/2012_Census_General_Report.pdf (accessed on 17 October 2019).

URT (2016). Press release report, ministry of agriculture and fisheries on improved seeds released in Tanzania. (Accessed on 20 November 2019.)

URT (2018). Press release report, ministry of agriculture and fisheries on improved released seed varieties in Tanzania. (Accessed on 1 December 2019.)

USAID (2016). A report on Feed the Future enabling environment for food security: Southern Africa Regional Seed Sector (SARSS) assessment. Available online at https://www.agrilinks.org (accessed on 25 February 2020).

Van Amstel. H. (1996). Farm system and household economy as frameworks for prioritizing and appraising technical research: A critical appraisal of current approaches. *In* D. H. M. Haswell (Ed.), Rural households in emerging societies: Technology and change in Sub- Saharan Africa. Oxford: Berg.

Varian HR, Farrell J and Shapiro C. (2004). The economics of information technology: An introduction. Cambridge University Press. 102 pp.

Wadud A and White B. (2000). Farm household efficiency in Bangladesh: A Comparison of Stochastic Frontier and DEA methods. Applied Economics 1665-1673.

Wakili A and Isa A. (2015). Technical efficiency of small scale rice production in Adamawa State, Nigeria. Pages 20–25 *in* International Conference on Chemical, Food and Environment Engineering (ICCFEE ’15), 11-12 January 2015 Dubai, UAE.

Wekundah J. (2012). Why the informal seed sector is important in food security: Africa Technology policy studies network, Biotechnology Trust Africa. Special series paper No. 43. 18 pp.

Wooldridge JM. (2010). Econometric analysis of cross-section data and panel data. USA: MIT Press. 735 pp.

Xu TIAN, Sun FF and Zhou YH. (2015). Technical efficiency and its determinants in China's hog production. Journal of Integrative Agriculture 14(6): 1057–1068.

APPENDICES

Appendix 1. Area (ha) and production (t) of five major crops by region and zone.

Zone	Region	Maize (ha)	Maize (t)	Sorghum (ha)	Sorghum (ha)	Simsim (ha)	Simsim (t)	Cashew (ha)	Cashew (t)	Cassava (ha)	Cassava (t)
Southern	Mtwara	143,566	95,519	11,309	2,749	21,301	2,709	220,883	133,489	75,250	228,431
	Lindi	199,483	92,243	54,769	36,035	267,532	77,489	157,707	41,220	19,875	19,044
	Total	343,049	187,762	66,078	38,784	288,833	80,198	378,590	174,709	95,125	247,475
Southern Highlands		**Maize (ha)**	**Maize (t)**	**Paddy (ha)**	**Paddy (t)**	**Irish potato (ha)**	**Irish potato (t)**	**Simsim (ha)**	**Simsim (t)**	**Groundnut (ha)**	**Groundnut (t)**
	Mbeya	356,563	539,726	124,734	132,540	25,362	88,341	34,072	31,445	97,242	45,393
	Iringa	237,770	442,584	820	4,014	2,601	9,857	3,059	118	7,943	4,220
	Njombe	128,192	204,367	50	8	19,465	35,226	0	0	1,419	1,093
	Rukwa	248,595	465,138	37,230	35,468	0	0	13,437	4,472	9,204	10,997
	Ruvuma	173,822	172,480	25,408	21,748	0	0	0	0	0	0
	Songwe	0	0	0	0	0	0	0	0	0	0
	Katavi	150,420	187,762	39,504	77,318	0	0	34,017	6,076	24,805	35,136
	Total	1,295,362	2,012,057	227,746	271,096	47,428	133,424	84,585	42,111	140,613	96,839
Central		**Maize (ha)**	**Maize (t)**	**Sorghum (ha)**	**Sorghum (t)**	**Sunflower (ha)**	**Sunflower (t)**	**Groundnut (ha)**	**Groundnut(t)**	**Simsim (ha)**	**Simsim (t)**
	Dodoma	438,149	164,803	176,346	81,854	185,906	62,487	41,040	20,034	134,832	21,746
	Singida	367,072	197,324	112,963	48,688	139,662	67,682	21,261	9,422	3,684	664
	Total	805,221	362,127	289,309	130,542	325,568	130,169	62,301	29,456	138,516	22,410
Eastern		**Maize (ha)**	**Maize (t)**	**Sweet potato (ha)**	**Sweet potato (t)**	**Paddy (ha)**	**Paddy (t)**	**Sugarcane (ha)**	**Sugarcane (t)**	**Simsim (ha)**	**Simsim (t)**
	Dar es Salaam	143	673	4,598	12,001	3,623	3,834	0	0	0	0
	Morogoro	193,561	204,059	542,207	325	158,296	197,931	390,421	37,187	13,591	8,116
	Coast	147,190	95,885	3,615	3,137	90,481	79,561	0	0	14,267	2,575
	Total	340,894	300,617	550,420	15,463	252,400	281,326	390,421	37,187	27,858	10,691

		Maize (ha)	Maize (t)	Wheat (ha)	Wheat (t)	Sorghum (ha)	Sorghum (t)	Beans (ha)	Beans (t)		
Northern	Arusha	221,935	131,585	14,687	15,886	10,066	9,846	76,019	25,956		
	Kilimanjaro	149,983	194,855	20,642	15,692	457	650	59,595	44,674		
	Manyara	391,826	308,688	11,082	9,752	15,486	5,359	2,850	6,031		
	Tanga	547,082	587,042	146	0	1,422	420	76,019	47,229		
	Total	1,310,826	1,222,170	46,557	41,330	27,431	16,275	2144,83	123,890		
Lake		**Cotton (ha)**	**Cotton (t)**	**Maize (ha)**	**Maize (t)**	**Paddy (ha)**	**Paddy (t)**	**Sunflower (ha)**	**Sunflower (t)**	**Sorghum (ha)**	**Sorghum (t)**
	Mwanza	32,735	24,285	378,894	260,451	155,785	1968,25	0	0	24,770	13,385
	Kagera	0	0	178,744	190,867	20,996	36,915	3,580	4,424	9,264	5,801
	Geita	40,974	72,613	399,948	546,836	174,201	726,490	4,958	3,109	5,893	3,099
	Shinyanga	82,932	194,194	409,518	362,882	284,522	392,549	6,082	7,034	41,819	17,986
	Simiyu	214,003	112,396	448,251	274,610	45,355	30,609	17,559	8,798	58,399	34,214
	Mara	21,843	48,457	304,927	351,302	6,681	6,626	0	0	92,928	107,463
	Total	392,487	451,945	2,120,282	1,986,948	687,540	1,390,014	32,179	23,365	233,073	181,948
Western		**Maize (ha)**	**Maize (t)**	**Beans (ha)**	**Beans (t)**	**Bulrush (ha)**	**Bulrush (t)**	**Tobacco (ha)**	**Tobacco (t)**	**Groundnut (ha)**	**Groundnut (t)**
	Kigoma	814,104	703,769	3,563	627	34,139	14,283	72,402	98,608	108,826	94,623
	Tabora	359,464	423,823	110,897	92,527	4,038	4,648	4,698	12,607	8,7739	3,8112
	Total	1,173,568	1,127,592	114,460	93,154	38,177	18,931	77,100	111,215	196,565	132,735

Source: NBS (2017).

Appendix 2. Production, area and export of groundnut in Tanzania (1980-2017).

Year	Production (t)	Area (ha)	Export (t)
1980	54,000	92,000	0
1981	56,000	94,000	0
1982	58,000	96,000	0
1983	58,000	96,000	0
1984	59,000	98,000	0
1985	59,000	98,000.	0
1986	58,701	98,000	0
1987	60,000	100,000	0
1988	53,900	100,000	0
1989	55,000	110,000	0
1990	60,000	115,465	0
1991	70,000	99,866	15,000
1992	65,000	91,972	6,000
1993	70,000	101,591	0
1994	70,836	104,405	0
1995	72,000	113,000	170
1996	74,000	116,000	510
1997	72,000	109,866	695
1998	73,000	113,010	231
1999	74,000	127,671	848
2000	52,000	117,000	367
2001	206,800	247,300	973
2002	346,790	366,940	3,626
2003	339,225	370,745	13,151
2004	331,660	374,550	3,975
2005	293,870	409,320	3,776
2006	350,000	480,000	481
2007	408,058	560,000	11,310
2008	340,770	470,670	14,817
2009	347,970	428,550	5,886
2010	465,290	482,310	3,899
2011	651,397	675,226.	2,006
2012	810,000	839,631	17,209
2013	1,425,000	943,676	4,081
2014	1,635,335	1,619,500	844
2015	1,835,933	1,624,683	117
2016	550,000	780,000	95
2017	216,433	1,076,656	1,471

Source: NBS (2016/2019) Crop Census Survey.

Appendix 3. Gross cost analysis of producing five seed varieties sourced from NARS on own land of 1 ha through rainfed and irrigation modes.

	Mangaka 2009	Naliendele 2009	Mnanje 2009	Masasi 2009	Nach 2015
Land cost (TZS)	100,000	100,000	100,000	100,000	100,000
Land preparation cost (TZS)	500,000	500,000	500,000	500,000	500,000
Quantity of seed (kg)	80	80	100	100	100
Total quantity (kg) and cost (TZS) of seed	80 kg, 1,200,000	80 kg, 1,200,000	100 kg, 1,300,000	100 kg, 1,300,000	100 kg, 1,300,000
Seed planting labour cost (TZS)	250,000	250,000	250,000	250,000	250,000
Fertilizer applied, quantity and dosage	DAP, 50 kg, 40 kg/ha	DAP, 50 kg, 40 kg/ha	DAP, 50 kg, 40 kg/ha	DAP, 50 kg, 40 kg/ha	DAP, 50 kg, 40 kg/ha
Total cost of fertilizer used (TZS)	250,000	250,000	250,000	250,000	250,000
Cost of fertilizer application (TZS)	110,000	110,000	110,000	110,000	110,000
Cost of weeding (TZS)	500,000	500,000	500,000	500,000	500,000
Amount harvested (kg)	1,255	1,125	1,175	1,038	1,038
Harvesting cost – labour (TZS)	750,000	750,000	750,000	750,000	750,000
Transportation cost (TZS)	20,000	20,000	20,000	20,000	20,000
Security/guard cost (TZS)	120,000	120,000	120,000	120,000	120,000
Threshing/shelling cost – labour (TZS)	1,000,000	1,000,000	1,000,000	1,000,000	1,000,000
Grading cost – labour (TZS)	375,000	375,000	375,000	375,000	375,000
Total packaging/bagging cost labour	112,500	112,500	112,500	112,500	112,500
Sub-total (TZS)	**5,287,500**	**5,287,500**	**5,387,500**	**5,387,500**	**5,387,500**
Total cost of seed dressing chemicals (LC) (TZS)	175,000	175,000	175,000	175,000	175,000
Total seed certification costs (LC) (TZS)	1,250,000	1,250,000	1,250,000	1,250,000	1,250,000
Other cost (storage) (TZS)	250,000	250,000	250,000	250,000	250,000
Sub-total (TZS)	**1,675,000**	**1,675,000**	**1,675,000**	**1,675,000**	**1,675,000**
Total cost (TZS)	**6,962,500**	**6,962,500**	**7,062,500**	**7,062,500**	**7,062,500**
Seed selling price	-	-	-	-	-

Source: NBS (2017).

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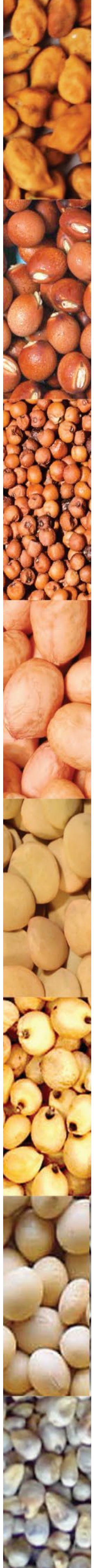

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