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TECHNOLOGICAL CAPABILITIES OF MAIZE FARMERS IN ADAMAWA AND TARABA STATE, NIGERIA

BY

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Abstract

The study examined technological capabilities of maize farmers in Adamawa and Taraba State. Specifically, the study examined technological capabilities of maize farmers, identified the sources of information among the farmers, determined constraints in acquiring technological capabilities of farmers, and identified strategies for improving technological capabilities of maize farmers in the study area. Multistage sampling procedure, purposive, simple random, and snowball sampling were used. Data were analysed using percentages, mean, standard deviation, and varimax rotated factor analysis. The result showed that majority (84.7%) of farmers had high investment capabilities in equipment. About 54.0% of farmers made minor changes in planting dates and 69.4% made major changes in the use of improved maize seed varieties. Also significant were linkages of extension agents with farmers ($\bar{x}$= 3.0) and farmers with other farmers is ($\bar{x}$ = 4.4). Sourcing of information on maize innovation across farmers showed that about 93.6% of maize farmers obtained information from fellow maize farmers. Types of linkages between farmers with extension agents (97.1%) were formal and farmers with other farmers (79.3%) as were informal. Results also depicts that linkage level between extension agents and farmers was strong ($\bar{x}$ = 3.2). Constraint to technological capabilities of farmers were poor funding to research, ($\bar{x}$ = 3.6), poor funding for teaching on maize innovation ($\bar{x}$ = 3.6), insufficient fund to procure equipment for maize production ($\bar{x}$ = 3.7). These factors were further named organizational/linkage, training/funding, knowledge, linkage, funding related among others. Strategies for improving technological capabilities for farmers were provision of favourable enabling environment by government to motivate youths to engage in maize production ($\bar{x}$ = 3.84). The study, therefore, recommended among others that there should be more synergy or collaboration among researchers, educators, extension agents, and farmers for efficient and effective enhancement of their technological capabilities in the maize innovation system in the study area.

Keywords: Technological, Capabilities, Maize, Farmers, Adamawa, Taraba.

1.1. INTRODUCTION

Technology has been the major driver of economic and social development globally, but most developing nations are yet to nurture the technical capabilities resident in them to develop and maintain technologies that it requires to make living conducive for their citizenry, one of reasons is lack of collaboration that should project them strategically as a technologically developed nation has not been given keen attention (Ogbaudu, 2016).

Technological capabilities are the information and skills - technical, managerial, and institutional - that allow productive enterprises and individuals to utilize equipment and technology efficiently (Obiora and Madukwe, 2012). Such capabilities are in the general sector and firm-specific, a form of institutional knowledge that consists of the combined skills accumulated by its members over time. The development of technological capabilities should not be thought of as the ability to undertake leading-edge innovation only, though innovative capabilities are an important element of technological capabilities.

Technological capabilities comprise a much broader range of effort that every enterprise must itself undertake to absorb and build upon the knowledge that has to be utilized in production. Technological capability is more, however than the simple sum of the education and training of actors. It includes the learning undergone by individuals in the course of working in the enterprise and who the firm combines and motivates individuals to function as an organization. To some extent, any enterprise that tries to use a new technology acquires some capabilities as an automatic result of the production process. Such passive learning goes some way to developing the necessary capabilities. Skills are easily learned on the job.

A benefit of learning on the job is that modification of products, processes and equipment creates new knowledge, often leading to further improvements. This process of "minor" innovation can accumulate over time to significant improvements in productivity. Every application of technology begins with an investment. Investment capabilities are the skills and information needed to identify feasible investment projects, locate and purchase suitable technologies, while production capabilities are the skills and knowledge needed for the operation of equipment and machines. Capabilities range from routine functions to intensive and innovative efforts to adapt and improve the technology (Biggs, Shah & Srivastava, 1995) cited in Augustyn (2019). Generating and applying new knowledge is important for all enterprises, including maize farming. This lack of innovation in maize farming has led to the search for new frameworks such as innovation systems.

Maize refers to as corn (*zea mays*) also called Indian corn is a cereal plant of the grass family (Poaceae) and it's an edible grain. The domesticated crop originated in the Americas as it is one of the most widely distributed of the world's food (Augustyn, 2019). In 2018, about 10.2 million tons of maize was produced from 4.8 million hectares, making Nigeria the highest producer in Africa Kamara, Kamai, Omoigui, Togola Ekeleme and Onyibe (2020), with Adamawa State as one of the leading States Odusanya (2018). But up to 12 tons per acre can be realized if there is more collaboration between actors in the innovation system (seed companies, research, education, and extension) (Udegbunam, 2019). The demand for maize is increasing at a faster rate daily (Sadiq, Yakasai, Ahmad, Lapkene & Abubakar, 2013).

According to the Food and Agriculture Organization (FAO) (2019b), about 4.7 million tons of maize were produced on average between 1990-2015. In Nigeria and the contribution of maize to total grain produced in Nigeria increased from 8.7% in 1980 to about 22% in 2003. About 56,139,729 hactares of Nigerian land were planted with maize which constitutes about 61% of total cultivable land in Nigeria. Nigeria produced 10.5million metric tons of maize in 2016/2017, 11,000MM tonnes in 2018 growing at an average annual rate of 6.72% and in 2019, maize production for Nigeria was 11,000 metric tonnes (FAO, 2017). Maize production of Nigeria increased from 1,310 metric tonnes in 1970 to 11,000 metric tonnes in 2019 growing at an average annual rate of 6.89% and 11,500 tonnes in 2020 (Knoema, 2019 & World data Atlas, 2019).

It has been observed by Olaniya (2015) that maize consumption is widespread across the country and among households. According to the Mundi index, maize consumption in Nigeria in 2017 stood at 10.9 million metrics tons. Users of maize alone or in combination with other food materials as staple food or snacks in Nigeria are not limited to kunu, akamu, ogi (in hot and cold forms) tuwo, donkunnu, masa, couscous, akple, groate, hakai, egbabari, dakowa, ajepasi, aadun, kokoro, elekute, kafa. Zea mays have high germ content. At the national level, hybrid and ordinary maize are used largely for animal feed and commercial starch production for industrial uses. (World data Atlas, 2019; Ranum, Péna-Rosas & Garcia-Casal, 2014). Improved agricultural technologies are known to enhance and improve agricultural production among farmers in a nation. Maize production in Nigeria and particularly in Adamawa State has not been sufficient enough to meet the needs of people and livestock feeds (Zalkuwi, Ibrahim & Kwakanapwa, 2014). Many maize technologies have been developed in national research stations but most of them are yet to be adopted by farmers (Oginiyi & Olagunju, 2015). The key aspects contributing to low maize productivity in the study area include weak institutional structures, often with little or no contact between actors. The idea of linear transfer of technology has to give way to a dynamic understanding of the maize innovation system in which new ideas and practices are again experimented on and adopted by farmers, researchers (private and public) extensionists, and other actors in the system. Poor technological capability remains one of the major constraints to African's effort to achieve sustainable development (African Development Bank Group, 2014) and Adamawa State in the Northeast zone of Nigeria is not an exception.

Some commonly practiced maize technology in Adamawa State include; conservation agriculture, such as minimum or zero tillage, maintenance of soil cover through cropping or mulching and crop rotation, intercropping/crop diversification, integrated soil fertility management (FAO, 2020). Thus, the adoption of improved agricultural technologies is essential to the attainment of Sustainable Development Goals (SDGs) one and two of ending poverty and hunger (Theophilus, Robert & Paul, 2019).

North-east Nigeria particularly Adamawa and Taraba States being among the highest producers of maize in the country have the potential of producing enough maize to meet the country's need and even be exported as a cash crop. The crop has the potential of contributing immensely to the nation's gross domestic product (GDP). This can only be realised if the technological capabilities of actors in the maize innovation system in enhance, developed, and improved continually. The potential inherent in the region should be harnessed for higher incomes and ultimately better livelihood for the farmers who are the users of innovation.

1.2. Statement of the Problem

Nigeria is the largest maize producer in Africa, with South Africa holding the second place. It genetic plasticity has made it the most widely cultivated crop in the country from wet evergreen climate of the forest zone to the dry ecology of the Sudan Savanna. Being photoperiod insensitive, it can be grown any time of the year, given great flexibility to fitting into different cropping patterns (Kamara *et al*., 2020). Annually, Nigeria produces about 8 million tons of this food crop with the largest volumes produced in the Northern region. However, the leaders in the crop production are Niger, Taraba, Kaduna, Adamawa, and Plateau States (Odusanya, 2018). Nevertheless, lack of technological capability among maize farmers has been instrumental in low out in maize production in Nigeria.

Poor technological capability remains one of the major constraints to African's effort to achieve sustainable development (African Development Bank Group, 2014). The pace of skills and technological development and innovation has been slow in Africa mainly because of the absence of a critical mass of university-educated manpower skilled in hand on technology (Hambissa, 2014). Low-income countries often lack the resources and capacities to fully develop their innovation system. The capacity gap is particularly large in the tropical regions where poverty is pervasive (Aerni *et al*., 2016). Farmers also lack agricultural information and this factor promotes ignorance of modern farm technologies (Mgbenka and Mbah, 2016). This scenario is not different from the present situation in the North-eastern States of Adamawa and Taraba.

There are few studies addressing the technological capabilities of maize farmers in Adamawa and Taraba State. Prominent among the studies conducted are that of Chidike and Udeanya (2019) conducted on technological capabilities of mill operators in palm oil procession enterprise; Modirwa and Oladele (2017) who studied linkage activities among researchers, extension agents, farmers, input dealers, and marketers towards agricultural innovation system. More so Obiora (2014) surveyed on the constraints to the development of technological capabilities of climate change actors in agricultural innovation system; promotion of agricultural the innovation system approach and study by Wambura *et al* (2016) who assessed policy implications for maize extension and advisory services. Disappointedly none of these researches focused on the technological capabilities of maize farmers in Adamawa and Taraba State. These thus necessitated this study as it seeks to fill this gap by assessing the technological capabilities of Maize farmers in Adamawa and Taraba State, Nigeria.

1.3. Objectives of the Study

The main objective of the study was to examine the technological capability of maize farmers in Adamawa and Taraba states. The study was specifically designed to:

i. examine the technological capabilities of maize farmers in Adamawa and Taraba State,
ii. identify the sources of information among maize farmers in the study area,
iii. determine constraints in acquiring technological capabilities among maize farmers,
iv. identify strategies for improving technological capabilities among maize farmers in the study area.

2.0. METHODOLOGY

2.1. Study Area

The study was carried out in Adamawa and Taraba States. Adamawa is a State in North-eastern Nigeria occupies about 36,917 square kilometres. It is bordered by the states of Borno to the North West, Gombe to the west, and Taraba to the Southwest. Its eastern border forms the national eastern border with Cameroon. It is a mountainous land crossed by the large river valleys-Benue, Gongola, and Yedsarem. The valleys of mount Cameroon, Mandara Mountains, and Adamawa plateau form part of the landscape (Adamawa State, 2020). Adamawa State lies between the coordinates latitude 11º 17′ 31 ″E to 13º 48′ 42 ″E and longitude 7º 19′ 45 ″N to 10º 56′ 5 ″N (Adamawa State, 2021).

The Adamawa State Agricultural Development Programme (AADP) was established to raise productivity, income, and standard of living of rural farmers in Adamawa State. It consists of four agricultural zones namely zone I (Mubi zone), zone II (Gombi zone), zone III (Mayo Belwa zone), and zone IV (Guyuk zone). The ADP consist of fourty (40) blocks and 287 cells evenly distributed in the block areas. Each cell consists of at least 1000 farm families. The number of extension agents as at 2021 stood at one hundred and two (102) and Fadama III has twenty-two (22) extension staff across the twenty-one (21) local governments. The numbers of maize farmers in the State as recorded by ADP in 2020 was 88,289, (Adamawa Agricultural Development Programme [AADP], 2021).

Taraba State is located in the North Eastern part on Nigeria. Taraba State is bounded in the west by NassarawaandBenue States, bounded to the northwest by Plateau State, to the north by Bauchi and Gombe States, and to the northeast by Adamawa State. Taraba State has an international border with the Republic of Cameroon at the east and south. **Taraba State has** an estimated land area of about 54,428 sq. km, lies between coordinates latitude 9º 3′ 32 ″E to 11º 55′ 3 ″E and longitude 6º 24′ 30 ″N to 9º 41′ 32 ″N Taraba State is in the Northeast geopolitical zone of Nigeria and lies largely within the tropical zone with a vegetation of low forest in the southern part and grassland in the northern part. Population of Taraba State as of 2006 was 2,294,800 and population projection as of 2018 was 3,342,762 (National Population Commission [NPC], 2018).

Taraba Agricultural Development Programme has four agricultural zones namely zone I (Zing zone), zone II (Wukari zone), zone III (Takum zone), and zone IV (Gembu zone). The number of extension agents as at 2021 in the ADP stands at 17 and Fadama II project has 16 extension agents (Taraba State Agricultural Development Programme, [TADP], 2021). The number of registered maize farmers across all 16 local governments is 3,807 (Maize Farmers Association of Nigeria [MAAN], 2021).

2.2. Sample and Sampling Technique

Farmers were randomly selected from the two zones of each State using their sample frames. Zone II & III of Adamawa had thirty-six thousand eight hundred and twenty-six (36,826) maize farmers. Registered maize farmers from zone I & II of Taraba had two thousand three hundred and sixty-two (2,362) maize farmers bringing the total of maize farmers from the four zones that were considered for the study to thirty-nine thousand, one hundred and eighty-eight (39,188), using Krejcie and Morgan (1970) table at 5% for determining sample size for a known population. A sample size of two hundred and eighteen (218) cells and four hundred and thirty-six (436) was used for farmers in both the States, thereafter, simple random sampling was used to select two farmers from each cells.

2.3. Method of Data Collection

Structured questionnaires were used for data collection. Information were solicited from the maize farmers.

Section A: sought information on technological capabilities of maize farmers in Adamawa and Taraba State. Section B sought information on the sources of information among maize farmers in the study area. Also, Section C sought information on the constraints encountered by the maize farmers in acquiring technological capabilities among maize farmers and Section D sought to identify the strategies for improving technological capabilities among maize farmers in the study area.

2.4. Analytical Techniques

Frequency, mean score, and percentages were used to analyse the technological capabilities of maize farmers. Sources and constraints to technological capabilities of maize farmers was analysed using mean score and varimax rotated factor analysis. Only variables with loadings of 0.4 and above (10% overlapping variances) will be used in naming the factors while variables that loaded high in more than one factor was discarded (Comrey, 1962) while mean, standard deviation, ranking, and factor analysis were used to determine strategies for the acquisition of technological capabilities of among maize farmers.

3.0 RESULTS AND DISCUSSION

3.1 Investment capabilities of farmers

3.1.1 Investment in equipment

Table 3.1.1 shows the distribution of respondents' investment in equipment. The result shows that 84.7% of farmers invested in equipment with regard to maize innovation in the last three years. The majority (78.0%) of the farmers made an investment in agro-chemicals, 76.1% in the purchase of improved maize varieties, 68.4% on fertilizer application, 64.2% in weeding/weed control, 57.0% in pre-planting and 55.6% invested in new maize varieties training, 55.6% invested on acquisition of more farm area/land. This implies higher investment on agro-chemicals, fertilizer application, weeding/weed control equipment, purchase of improved maize seed varieties, the introduction of improved maize seed, training on improved maize variety, and acquisition of more farmland. Thus, there has been a substantial investment in equipment with regards to maize innovation probably because of the profit derived from the crop. This result is in contrast with the findings of Chidike and Udanya (2019) that investment both in terms of equipment and human resources is low among mill operators in palm oil processing enterprise in Anambra State, Nigeria. Investment in equipment is one important factor that will help in building and enhancing the technological capabilities of actors in the maize innovation system. Investment in form of procured suitable equipment and technologies will improve actor capabilities for efficiency and wealth creation in the maize innovation system. Access to and availability of improved maize seed is very important in maize productivity. The provision of training on improved seeds and distribution by government and non-governmental organizations (NGOs) will to a great extend help in the improvement of maize farmers' investment capabilities, hence maize productivity. This result agrees with the findings of Sime and Aune (2019) that an increase in household skills, experience, and knowledge of the use of improved seeds improved farm income and food security in the central rift valley of Ethiopia.

Table 3.1.1: Farmers investment in equipment

Investment Capabilities	**%* (n = 405)**
Any investment in equipment, input, skill acquisition, and information on maize innovation	84.7
Pre-planting	57.0
Planting	32.6
Weeding/Weed control	64.2
Improvement of soil fertility	60.0
Fertilizer application	68.4
Pest control	43.0
Harvesting	27.9
Processing	24.7
Storage	38.0
Irrigation	20.0
Tractor equipment	22.0
Purchase of improved maize variety	76.1
Acquisition of additional farmland	55.6
Agrochemicals	78.0
Training on new maize technology	57.0
Conference on maize production	18.8

Source: Field Survey, 2021
(*Multiple responses*)

3.1.2. Farmers' investment in human resources

Table 3.1.2 shows farmers' investment in human resources. 45.0% of the famers' invested in human resources, 34.8% in pre-planting and improvement of soil fertility, 37.8% in planning, 42.0 in fertilizer application, while 39.5% in weeding, 37.0% in pest control, 35.8% in harvesting and 28.4% in processing. Others are 37.1% on storage operations and 28.1% in marketing. This implies that farmers have low human resource investment capabilities which could be because the farmers are smallholder farmers and cannot engage in large-scale maize production, hence their inability to invest in human resources by training and retraining their workforce. Low human investment capabilities of the farmers will impede their technological capabilities, hence, low productivity. This result agrees with the findings of Chidike and Udeanya (2019) that mill operators had little investment in terms of both equipment and human resources in farm oil processing enterprises in Anambra State, Nigeria. Similarly, it collaborates the findings of Wei *et al.* (2021) that human capital is not optimized by farmers in Northwest China.

Table 3.1.2: Farmers investment in human resources

Investment Capabilities	%* (n = 405)
Any investment in human resources	45.0
Pre-planting	34.8
Planting	37.8
Improvement of soil fertility	34.8
Fertilizer application	42.0
weeding/Weed control	39.5
Pest control	37.0
Harvesting	35.8
Processing	28.4
Storage	37.1
Marketing	28.1

Source: Field Survey, 2021
(*Multiple responses*)

3.1.3 Input, skill, and information required by farmers to enhance technological capabilities b

Table 3.1.3 shows that 84.7% of the respondents reveal that investment should be made in new the maize technologies training to enhance their technological capabilities in maize innovation system, 74.5% indicated that investment should be made in harvesting, 73.8% on the introduction of new improved seeds, 71.6% on storage, 70.3% on pest control and soil fertility management to enhance their capability in the maize innovation system. Furthermore, 66.2% on land preparation, 65.7% on panting, 69.6% on weeding, 45.5% on fertilizer application, 40.2% on irrigation, 37.8% on tractor, 33.1% on acquisition of more farmland, 63.7% on agrochemical and 84.7% on training on new maize technologies. Maize is an important staple food crop cultivated in Nigeria and particularly in the North Eastern States of Adamawa and Taraba. The crop has relatively high requirement for fertilizer input, therefore, inadequate nutrient input continues to expose the region's maize-growing fields to a high degree of nutrient depletion. Investment in soil fertility management technology among maize farmers in the study area will go a long way to enhance their technological capabilities in the maize innovation system. Also, the need for accessibility to new improved seed varieties is important for the improvement of the farms' technological capabilities leading to higher maize yield and income. This agrees with the findings of Lawal (2021) that many farmers had awareness on the use of inorganic fertilizer but lack adequate training on composting, combined use of organic and inorganic fertilizer and farmers largely relied on seeds from the previous harvest and those procured from the market or local input dealers but had no or little access to improved seeds. This implies that even though reasonable investments have been made by farmers on equipment and the purchase of suitable technologies, they need to invest more in new maize technologies that will enable them to produce more and have high yielding with minimal resources and maize harvesting technologies that will make harvesting process less cumbersome and less wasteful.

Table 3.1.3 Input, skill, and information required by farmers to enhance their technological capabilities

Equipment	%* (n = 405)
Land preparation	66.2
Planting	65.7
Weeding/Weed control	69.6
Fertilizer application	45.4
Pest control	70.3
Harvesting	74.5
Storage	71.6
Irrigation	40.2
Tractor	37.8
Acquisition of additional farm land	33.1
Soil fertility and maintenance	70.3
Agrochemicals	63.7
Training on new maize technology	84.7
Introduction of new improve maize seed	73.8

Source: Field Survey, 2021
(*Multiples responses*)

3.2.1 Learning capabilities of farmers

Table 3.2.1 shows that 79.5% of the farmers did not provide any form of learning for their workforce probably because most of the farmers cultivate maize in smallholdings and so they do not have the financial capacity to provide any form of learning for their workforce. Also, 70.6% of the farmers have built-in mechanisms for acquiring information from other actors like extension agents and researchers. About 73% have built-in mechanisms for learning through feedback. This implies that in their interaction with extension agents, there is provision for learning through feedback, this will ensure the flow of information to and from researchers and that means the smooth transfer of technology to them. This information and skills acquired may play a very important role in their adoption of these new technologies, hence improvement in their technological capabilities and increased productivity. The majority of farmers (76.6%) learned about fertilizer application probably because fertilizer is an important requirement for maximum yield in maize production, 74.3% learned about weeding operations, 72.1% about planting operations, and 67.9% about storage, 66.4% about harvesting. About 62% learn about pest control, 52.0% about the importance of soil fertility, and 47.6% about processing. This implies that farmers had high learning capabilities in fertilizer application, weeding, planting, storage, harvesting, pest control, and soil fertility operations and had low learning capabilities in processing. The acquisition of knowledge and skills in maize husbandry practices may help the farmers to adopt new technologies and result in higher maize output and better livelihood. This corroborates with a study by Mishra *et al.* (2018) who reported that a lack of adequate knowledge about sustainability and unfamiliarity with technology significantly and negatively related to less adoption of sustainable agricultural practices among farmers in Kentucky, USA.

Table 3.2.1: Learning capabilities of farmers

Learning Capabilities	**%* (n = 405)**
Learning provision for workforce	20.5
Built-in-mechanism for acquiring new information from other actors	70.6
Built-in-mechanism for learning through feedback	73.8
Improved maize seed varieties	69.1
Pre-planting operation	63.3
Planting operation	72.1
Weeding operation	74.3
Fertilizer application	76.6
Soil fertility	52.0
Pest control	62.7
Improvement of soil fertility	51.9
Harvesting	66.4
Processing	47.6
Storage	67.9
Marketing	23.5

Sources: Field Survey, 2021
(*Multiple responses*)

3.3.1 Farmers need to enhancement of capabilities

Table 3.3.1 shows that 82.5% of the respondents want to be trained on the improvement of soil fertility, 75.1% need to be introduced to new maize seed varieties, 55.6% on planting operations, 74.1% need to be trained on processing, 71.1% need to be trained on pest control, 68.8% on storage, 58.8% on harvesting and planting operations while 55.6% on pre-planting operations and 25.2% on marketing strategies respectively. Others are other forms of fertilizing maize. This implies that farmers' needs for enhancement of capabilities are training on improvement of soil fertility and use of improve maize seed variety, planting operation, processing, pest control, storage, harvesting, planting, and pre-planting operations. If farmers are trained from time to time on maize technologies it will enhance the adoption of maize these technologies, hence, improve maize production. Training organized by extension agents and agricultural institutes is important for enhanced maize productivity. Training can be in form of workshops, agricultural shows, and field days. This will improve farmers' knowledge and skills in maize innovation, therefore, enhancing their technological capabilities. This corroborates Shasani and Ray (2018) whose finding shows two training institutes namely Krishi Vigyan Kendra (KVK) and Regional Institute of training on extension (RITE) which mainly deals with imparting training to the rural farming communities in Dhenkanal district of Odisha, India.

Table 3.3.1: Farmers needs for enhancement of capabilities

Qualification, Skills, and Equipment	**%* (n = 405)**
New maize seed variety	75.1
Pre-planting operation	55.6
Planting operations	58.8
Improvement of soil fertility	82.5
Fertilizer application	59.3
Weed/Weed control	63.7
Pest control	71.1
Harvesting	58.8
Processing	74.1
Storage	68.8
Marketing	25.2
Others	0.2

Source: Field Survey, 2021
(*Multiple responses*)

3.3.2 Farmers' Minor Change Capabilities

Table 3.3.2 shows farmers' minor change capabilities. The result shows that 54.1% of the farmers' made minor changes in planting dates, 68.4% made minor changes in planting operation, 70.1% made minor changes in weed control, 66.9% made minor changes in harvesting, fertilizer application (77.6%), post-harvest (57.3%) and pre-planting operation (62.2%). This implies that the farmers acquired high minor changes in planting dates, harvesting, and fertilizer application, post-harvest, and pre-planting operation. It is pertinent for actors in the maize innovation system to keep up with advances and changes in science and technology so that they can reap the benefit that accrues to it. Minor changes in planting date could be due to variation in the onset of rain due to climate change. Therefore, adjustment of the planting date will be necessary to maintain high productivity because maize crop is very sensitive to the slightest disturbance during cultivation. This corroborates the findings of Semi and Aune (2019) that farmer's adjusted plating time and selected adapting crops varieties to balance the effect of rainfall variability in the central rift valley of Ethiopia. The minor changes in harvesting could be the harvesting either earlier or later than the normal time due to rainfall variability. Minor changes in fertilizer application could be a decrease in quantity to reduce its burning effects on crops and germinating seeds or an increase in the rate of fertilizer application to improve crop yield. Farmers in the central Rift Valley of Ethiopia made minor changes by reducing fertilizer rate to reduce its burning effects on germinating seeds to promote seed germination, and establishment and to reduce risks of the investment in fertilizers following crop failure or yield reduction. Minor changes in post-harvest operation could be in the use of Pardue improved crop storage (PICS) bags storage instead of the usual storage bags.

Table 3.3.2: Farmers minor change capabilities

Minor Change	%* (n = 405)
Planting date	54.1
Modification of implement	32.8
Pre-planting operations	62.2
Planting operation	68.4
Weeding/Weed control	70.1
Fertilizer application	76.6
Harvesting	66.9
Post-harvest operation	57.3
Short training for workforce	11.1

Source: Field Survey, 2021
(*Multiple responses*)

4.3.3 Farmers' Major Change Capabilities

The farmers' major changes could include the adoption and use of technologies that have not been in use as the use of animal manure or compost crop residue. Table 3.3.3 shows farmers' major change capabilities. The result shows that 69.4% of the farmers have made major changes in the use of improved maize seeds, 64.4% in mixed cropping, 62.2% in seed dressing, 61.9% in the use of agrochemicals, 61.7% in crop rotation, 60.5% in the use of animal manure, 57.5% in minimum tillage, and 56.0%, in the use of compost crop residue. This finding implies that farmers acquired major change capabilities in the use of improved maize seeds, mixed cropping, storage practices, seed dressing, use of agrochemicals, crop rotation, use of animal manure, adaptation to existing technologies, minimum tillage and use of compost crop residues. This implies that the farmers have high major change capabilities in the use of improved maize seeds, mixed cropping storage practices, seed dressing, agrochemical, crop rotation, animal manure, minimum tillage, and compost crop residues. According to Semi and Aune (2019) farmers in the central rift valley, Ethiopia adopted new cropping approaches such as diversification which increase the spread of risk. Such practices among others minimized crop losses and improved the income of the farmers. Farmers' have made major changes in the use of improved maize seeds. This could be because the local seeds that have been used by farmers are not giving them maximum yield. This is in contrast with Riungu *et al.* (2021) whose finding shows low adoption of new introduced improved seed among maize and bean producers in Eastern and Midwestern Uganda. Mix cropping increases water use efficiency, decreases nitrogen leaching, increases biodiversity, and is economically viable, therefore the practice of mix cropping will enhance maize productivity, higher income, and better livelihood for farmers. Seed dressing or treatment will reduce losses and increased yield, therefore increasing productivity. High major change capabilities of farmers may improve maize production.

Table 3.3.3: Farmers major change capabilities

Major Change	%* (n = 405)
Increase in planting frequency	23.2
Minimum tillage	57.5
Zero tillage	24.2
Mulching	19.0
Crop rotation	61.7
Mixed cropping	64.4
Improved seed	69.4
Seed dressing	62.2
Use of animal manure	60.5
Use of compost crop residue	56.0
Use of agrochemicals	61.9
Mechanized farming	44.4
Processing practices	47.2
Micro-inventions	18.0
Purchase of equipment	32.9
Marketing (Use of off takers)	21.5

Source: Field Survey, 2021.
(*Multiple responses*)

3.3.4 Farmers' linkage capabilities

The result in Table 3.3.4 shows the linkage between farmers and research institutes is $\bar{x}$ = 0.9, with other farmers ($\bar{x}$ = 4.4), with farmers group ($\bar{x}$ = 3.5), with educators ($\bar{x}$ = 0.8), with extension agents/agencies ($\bar{x}$ = 4.0), with financial institutions ($\bar{x}$ = 1.5), with NAFDAC ($\bar{x}$ = 1.0), with cooperative societies ($\bar{x}$ = 2.5), processors association ($\bar{x}$ = 2.4), marketers association ($\bar{x}$ = 1.3), input provider association ($\bar{x}$ = 2.1), with consumers association ($\bar{x}$ = 2.0) and Non-governmental organizations ($\bar{x}$ = 2.3). This implies that there is a high linkage between farmers and other farmers, farmers groups, and extension agents/agents and a low linkage between farmers and the other actors, institutions, and associations. Close collaboration between farmers and extension agents will enhance the technology dissemination and adoption process which will enhance the technological capabilities of actors. Low linkages between researchers/research institutes and farmers could be research institutes do not directly have access to contact the farmers, consequently, the adoption rate will be impeded, hence, low capability. This agrees with the findings of Yeboah *et al*. (2019) that there is an interaction between extension services and farmers in Ghana. Similarly, the findings of Modirwa and Oladele (2017) showed a close relationship between farmers and extension agents in Northwest province, South Africa. Also, Mengal *et al.* (2017) showed that linkages between researchers and farmers were inadequate. Researchers neither had active linkage with the farmers that absorbed it product nor have an active linkage with extension agents in Baluchistan.

Table 3.3.4: Farmers' linkage capabilities

Actors	Mean ($\bar{x}$)
Other farmers	4.2*
Farmers group	3.3*
Tertiary institutions	1.3
Extension agents	3.8*
Researchers/Research institutes	1.6
NGOs	1.9
Financial institutions	1.4
NAFDAC	1.0
Cooperative societies	2.6
Processors association	2.6
Input providers association	2.1
Consumers association	1.9
Marketers association	1.3

Source: Field Survey, 2021 * = Significant at 3.0
(*Multiple responses*)

3.4 Sources of information

3.4.1 Farmers' sources of information on maize innovation

The result shows that 93.6% of farmers obtained information from fellow maize farmers, 84.9% from extension agents, 82.5% from friends, and 62.0% from input suppliers while 55.1% from Television, 49.1% from maize producers' association, 47.2% and 43.7% obtain information from Non-Governmental Organizations (NGOs) and consumers association. This implies that farmers obtain technical information on maize from fellow farmers, extension agents, friends, and input suppliers. Farmers communicate with one another and participate in almost the same cropping system; this will promote social learning where farmers learn from each other with the sense of being part of a group. They also obtain technical information from extension agents. This means that they have contact with extension agents. Information is key to any innovative process because for adoption to take place, awareness of new technologies in particular its potential benefits is an important condition and this can only take place through a source. Sources of information will determine the authenticity of the information received, if the knowledge and information received are from reliable sources like extension agents, it will facilitate adoption. Therefore, government, extension outfits, and NGOs need to ensure that agricultural information should be made available to research scientists, educators, extension workers, and farmers at the right time so that they can all perform their roles effectively and efficiently in the maize innovation system. This agrees with the findings of Adebayo *et al.* (2018) that the majority of maize farmers were reached with adequate information by extension agents. Access to information on techniques of production like the use of a tractor for land clearing, ploughing, rigging, harrowing, fertilizer application, control of pest and diseases and the use of improving maize seed varieties, and use of chemical application for weed control, treated maize seeds through face to face contact. The result also corroborates the study of Awolabi *et al.* (2018) which reported that respondents' major sources of information were friends and relatives among others. A similar study carried out by Mbanda-Obura *et al.* (2017) and Anaglo *et al.* (2020) showed that farmers' most preferred sources of information were fellow farmers and extension agents in Ndiwa, Sub-County, Western Kenya, and Eastern Region of Ghana respectively.

Table 3.4.1: Farmers sources of information on maize innovation

Institution/Organizations	%* (n = 405)
Researchers/Research institutes	25.2
Educators	10.0
Newspapers	19.5
Television	55.1
Extension agents/Agencies	84.9
Internet	37.3
Fellow maize farmers	93.6
Friends	82.5
Maize producers association	49.1
Input suppliers	62.0
Non-governmental organizations (NGOs)	47.2
Journals, annual reports and research bulletins/publications	24.2
Professional meetings	17.3
Processors association	18.3
Marketers association	39.8
Consumers association	43.7

Source: Field Survey, 2021
Multiple Responses

3.5. Constraints to technological capabilities of farmers

Table 3.5shows factors constraining technological capabilities as perceived by farmers in the study area. Based on variable loading, three factors were identified and named. Factor one was name organizational/information-related factor. Factors loading high under it were unavailability of equipment for farmers to upgrade knowledge on maize innovation (0.63), lack of feedback from researchers to farmers (0.64), poor access to information and communication technology (0.78), unavailability of information and communication technology (0.54), poor collaboration between farmers and researchers (0.69), lack of access to bulletins, annual reports, and magazines (0.85), poor support of donor agencies to farmers in maize innovation (0.84) and insecurity in terms of the inability of farmers to carry out maize production (0.56).

Knowledge flow facilitates learning, technology transfer, and adoption. The unavailability of equipment for farmers to upgrade knowledge on maize innovation may impede their technological capabilities. This could be a result of inadequate funds to acquire such equipment. This corroborates the findings of Chidike and Udeanya (2019) that inadequate funding could not allow actors to invest in business expansion, training and development, or state-of-the-art technology acquisition for mill operators in palm oil processing enterprise in Anambra State, Nigeria.

Poor collaboration between farmers and research may be a result of inadequate feedback between them. Networking and collaboration capabilities are crucial to the flow of information and knowledge between actors. The flow of information, not just one-way but both ways will enable adequate sharing of information in a way that will benefit the farmers. Therefore, putting a procedure in place or channel by extension agencies, government, and development partners, that will enable actors to interact will enhance their capabilities. The role of information and communication technology (ICT) in maize innovation system cannot be overemphasis. Therefore, the availability and accessibility of ICT is important in enhancing the efficiency and effectiveness of farmers in the maize productivity. This will enhance the adoption of new maize technologies and their technological capabilities.

Factor two was name manpower/linkage related. Factors loading high under it were lack of manpower for the training of workforce (-0.50), lack of training opportunities for farmers on maize innovation (0.60), inadequate attention of extension agents to the needs of farmers (0.69), poor collaboration between farmers and extension agents (0.71) and poor extension visit to farmers (0.74). Lack of manpower for the training of workforce may probably be because most of the maize farmers are smallholder farmers. They do not cultivate maize in commercial quantity, so they do not have a permanent workforce that may warrant manpower for the training of their workforce. However, the findings of Chidike and Udeanya (2019) show that lack of skilled manpower has been identified as an important factor for the low level of technological capabilities of mill operators in palm oil processing enterprise in Anambra State, Nigeria.

Linkages between farmers and extension agents are crucial and will enhance the dissemination and adoption of new technologies by farmers. Poor collaboration between farmers and extension agents and poor extension visits to farmers will result in weak linkages. More so, weak linkages will impede farmers' technological capabilities and can limit their effectiveness in maize productivity. However, it has been established by Rimawi *et al.* (2013) that weak linkages will result in a systemic bottleneck in the agriculture innovation system and can limit actors' effectiveness in contributing to development. Similarly, the findings of Modirwa and Oladele (2017) that a lack of strong linkage disrupts technology flow and low adoption rates among actors in North West Province, South Africa.

Factor three was named funding/climate-related factors. Factors loading high under it were lack of funds to acquire equipment for maize innovation (0.64), the effect of climate change on maize innovation activities (0.45), and poor access to new maize technology for farmers (0.53). Poor access to new maize technologies to farmers could be due to the high cost of these new technologies. However, according to Modirwa and Oladele (2017), it may be because of the time lag between development and adoption of new technologies due to weak linkages which reduced efficiency in the use of resources among actors in North West Province, South Africa. Lack of funds to acquire equipment for maize innovation activities and poor access to maize technologies may impede the technological capabilities of farmers. This corroborates the findings of Obiora (2013) that unavailability of technology and equipment are among other factors constraining the technological capabilities of climate change actors in the agricultural innovation system in Southeast Nigeria.

The effect of climate change may necessitate the incorporation of some new maize husbandry practices that will help the farmers to over the effect of climate change. These practices may not be affordable for the farmers and this will impede their technological capabilities. Therefore, extension agents should ensure that maize production practices that are aimed toward overcoming the challenges of climate change should be affordable to the farmers so that it will enhance its adoption for increased maize productivity.

Table 3.5:Constraint to technological capabilities of farmers

Constraints	Factor 1	Factor 2	Factor 3
Lack of fund to acquire equipment for maize innovation	-.092	.024	.644*
Effect of climate change on maize innovation activities	.075	.312	.452*
Lack of manpower for training of workforce	.326	-.506*	.300
poor access to new maize technologies to farmers	.117	.301	.527*
Unavailability of equipment for farmers to upgrade knowledge on maize innovation	.637*	-.224	.355
Lack of training opportunity for farmers on maize innovation	.221	.606*	.137
Inadequate attention of extension agents to the needs of farmers	.026	.698*	-.042
Lack of feedback from researchers to farmers	.643*	-.337	-.144
Poor access to information and communication technology	.782*	-.123	.250
Unavailability of information and	.549*	-.024	.265

communication technology			
Poor farmers access to knowledge and information on new maize technologies	.536*	.563*	.116
Poor collaboration between farmers and researchers	.698*	-.389	-.223
Poor collaboration between farmers and extension agents	.390	.713*	-.167
Poor extension visit to farmers	.392	.747*	-.240
Lack of access to bulletins, annual reports, and magazines	.857*	-.132	-.099
Poor support of donor agencies to farmers in maize innovation	.845*	-.208	-.217
Insecurity in terms of inability of farmers to carryout maize production	.561*	.362	-.314

Extraction Method: Principal Component Analysis.
a. 3 components extracted.
Note: **Factor 1** = Organizational/information related, **Factor 2** = Manpower/Linkage related,
Factor 3 = Funding/climate-related
Rotated Method: Varimax with Kaiser Normalization (Loading at .4 above)

3.6 Strategies for improving technological capabilities

3.6.1 Strategies for improving the technological capabilities of farmers

Table 3.6.1 shows strategies for improving the technological capabilities of farmers. The most prominent response as ranked by the farmers was the provision of a favourable enabling environment by the government that will motivate the youths to engage in maize production activities ($\bar{x}$= 3.84), improvement of security for farmers to carry out production activities ($\bar{x}$ = 3.74), ranked 2nd, increased farmers access to information on new maize technologies ($\bar{x}$= 3.63), ranked 3rd, more frequent agricultural shows to motivate farmers ($\bar{\bar{x}}$ = 3.6), ranked 4th, improvement of knowledge, skills, and creativity for farmers ($\bar{x}$= 3.59), ranked 5th. The Table also shows regular training for farmers and their workforce ($\bar{x}$ = 3.57) ranked 6th, improvement of the feedback mechanism between farmers and extension agents ($\bar{x}$ = 3.53) ranked 7th, provision/improvement of communication technology to enhance farmers improved performances in maize production technologies ($\bar{\bar{x}}$ = 3.49), ranked 8th, access to facilities for communication of technical information ($\bar{x}$= 3.42), ranked 9th, encouragement of maize-related activities through assistance by government, donor agencies, and NGOs and improvement of learning opportunities for farmers ($\bar{\bar{x}}$ = 3.40) ranked 10th as strategies for improving the technological capabilities of farmers. The Table further indicates that strategies for improving the technological capabilities of farmers are improvement of the feedback mechanism between farmers and researchers ($\bar{\bar{x}}$ = 3.38), ranked 12th, a regular joint workshop between farmers and other actors and effective and efficient media for dissemination of information on maize innovation to farmers ($\bar{\bar{x}}$ = 3.40) ranked 13th, collaboration between farmers and private organizations like donor agencies and NGOs to enable free flow of information ($\bar{\bar{x}}$ = 3.34) ranked 15th. Joint supervision of project between farmers and other actors, ($\bar{\bar{x}}$ = 3.33) ranked 16th, strong linkage between farmers and other actors in the maize innovation system, improvement of the feedback mechanism between farmers and educators, and joint diagnosis of problems associated with maize innovation between farmers and other actors ranked 17th. Other are: the availability of technical information to farmers through bulletins, annual reports, handbooks, and magazines ($\bar{x}$ = 3.18), ranked 20th, and personal letters between farmers and other actors in the maize innovation system ($\bar{x}$ = 2.90) ranked 21st.

This implies the main strategies for improving technological capabilities as perceived by farmers were the provision of a favourable enabling environment by the government that will motivate the youths to engage in maize production activities, improvement of security for farmers to carry out production activities, and increased farmer's access to new maize technologies. The youth population of any country is its heartbeat. Any nation that does not value and invest in its youth population is heading toward chaos. Rural youth's engagement is central to agricultural transformation. Youth engagement in agriculture will generate millions of new jobs. While maize farming may seem unattractive to the youths, it is the responsibility of government and non-governmental organizations to provide enabling environments that will motivate the youths to engage in maize production activities. However, Etim *et al.* (2020) agree that there is a pressing need to engage the youths in ways that they can see a promising future in agriculture as well as influence them to build capacity and effective participation of youth in farming in Akwa-Ibom State, Nigeria.

Insecurity of lives and property of maize farmers has continued to pose a threat to farmers' capability in the maize innovation system. This has reduced maize productivity resulting in food insecurity due to the displacement of maize farmers from their ancestral homes and lands. Insecurity has according to FAO (2021) resulted to the influx of internally displaced persons in the Northeastern part of Nigeria. This has placed an additional burden on host communities who are already faced with limited access to land for cultivation. Likewise, the inaccessibility of farmers to maize technologies could be due to the high cost of these technologies. If farmers must use new maize technologies, the government, development partners, and all stakeholders must ensure its availability, accessibility, and affordability. This agrees with the findings of Poku *et al.* (2018) that access to improved seed varieties has remained a major constraint in many countries despite liberalization and other reformed efforts. Likewise, the inaccessibility of farmers to maize technologies could be due to the high cost of these technologies. The high cost of mechanization which would have substituted human labour, reduced drudgery, and increase yield may have eluded many farmers for lack of affordability. This corroborates the findings of Adu-Baffour *et al.* (2019) that farmers who access tractor services for land preparation can almost double their income by cultivating a much larger share of the land that they own. The finding also shows that increased income is used for children's education and for purchasing more food. This means increased yield for farmers, higher income, and better livelihood. It was suggested by Sennunga *et al.* (2020) that there is a need to increase farmers' capital and credit facilities and make funds accessible to farmers. Also, that the government should ensure that policies that support the adoption of improved agricultural technologies are put in place among smallholder farmers in Kaduna State. Another reason for the inaccessibility of farmers to maize technology could be the bureaucratic nature of government procedures which may result in the delay of new technologies reaching the farmers in good time considering that most of the farmers practice agriculture under rain-fed conditions.

Table 3.6.1: Strategies for improving the technological capabilities of farmers

Strategies	Mean score ($\bar{x}$)	SD	Rank
Provision of a favorable and enabling environment by government that will motivate the youths to engage in maize production activities	3.84	0.576	1st
Improvement of security for farmers to carry out production activities	3.73	0.600	2nd
Increased farmers access to information on new maize technologies	3.63	0.551	3rd
More frequent agricultural shows to motivate farmers	3.60	0.636	4th
Improvement of knowledge, skills, and creativity for farmers	3.59	0.714	5th
Regular training of farmers and their workforce	3.57	0.548	6th
Improvement of feedback mechanisms between farmers and extension agents	3.53	0.736	7th
Provision/improvement of communication technologies to enhance farmers improved performances in maize production	3.49	0.441	8th
Access to facilities for communication of technical information on maize innovation	3.42	0.564	9th
Improvement of learning opportunities for farmers	3.40	0.600	10th
Encouragement of maize-related activities through assistance by government, donor agencies, and NGOs	3.40	0.600	10th
Improvement of feedback mechanism between farmers and researchers	3.38	0.636	12th
Regular joint workshop/conferences between farmers and other actors	3.37	0.602	12th
Effective and efficient media for dissemination of information on maize innovation to farmers	3.37	0.573	14th
Collaboration between farmers with private organizations (donor agencies and NGOs) to enable free flow of information	3.34	0.610	15th
Joint supervision of projects between farmers and other actors	3.33	0.685	16th
Strong linkage between farmers and other actors in the maize innovation system	3.28	0.710	17th
Improvement of feedback mechanisms between farmers and educators	3.28	0.743	17th
Joint diagnosis of problems associated with maize innovation between farmers and other actors	3.28	0.0609	17th
Availability of technical information to farmers through bulletins, annual magazines	3.18	0.737	20th
Personnel letters between farmers and other actors in the maize innovation system	2.90	0.957	21th

Source: Field Survey, 2021
(*Multiple Responses*)

4.0 CONCLUSION AND RECOMMENDATIONS

Conclusively this paper attempted to investigate the technological capabilities of maize farmers in Adamawa and Taraba State. Findings revealed that farmers had high investment capabilities in equipment, low capabilities in human resource investment while farmers did not provide any form of learning for their workforce. Also, farmers had high linkage capabilities with other farmers, farmers groups, and extension agent/agencies and farmers' major source of information on maize were fellow maize farmers. Types of linkages frequently used farmers were non-formal and linkage level between farmers/farmers groups, and the linkage level between farmers and farmers/farmers groups, was strong. Factors constraining the technological capabilities of farmers were poor. Results also depicts that the factor analysis for constraints to technological capabilities of farmers were named organizational/linkage related, training/funding related, knowledge related, linkage related, funding related, organizational/information related, manpower/linkage related, and funding/climate related. The most prominent strategies for improving the technological capabilities of farmers were funding to research, regular training of educators by institutions, regular training on maize innovations, and provision of favourable enabling environment by the government that will motivate youths to engage in maize production activities. It is therefore recommended that:

i. There should be more synergy or collaboration among researchers, educators, extension agents, and farmers will interact for efficient and effective enhancement of their technological capabilities in the maize innovation system in the study area.

ii. Extension agencies and partners should strengthen research-farmer linkages at zonal blocks and cells levels.

iii. Increased funding by government, NGOs, and individuals to research in maize innovations; practical teaching on maize, and for farmers to procure equipment for maize production.

iv. Stakeholders, public and private sectors should ensure accessibility to new improved maize seed varieties and other maize technologies for improvement of farmers' technological capabilities.

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