JETIR.ORG ISSN: 2349-5162 | ESTD Year : 2014 | Monthly Issue
JOURNAL OF EMERGING TECHNOLOGIES AND INNOVATIVE RESEARCH (JETIR)
An International Scholarly Open Access, Peer-reviewed, Refereed Journal

ANALYSIS OF FADAMA FARMING; PROSPECTS AND CHALLENGES OF FARMING LIVELIHOOD IN THE NORTH-WESTERN NIGERIA: JIGAWA STATE

[1]Musab Shuaibu, [2]Sani Saleh, [3]Shuaibu Garba, [4]Musa Saleh, [5]Ibrahim Shuaibu
[1]Department Of Curriculum Studies
[2]Department Of Physics
[3]Department Of Early Child-Care Education
[4]Department Of Social Studies
[5]Department Of History
Jigawa State College Of Education, Gumel, Nigeria

Abstract: In this research on analysis of fadama farming; prospects and challenges of farming livelihood in the North-Western Nigeria: Jigawa State axis, descriptive statistics indicate a mean annual income of ₦400,000 with a standard deviation of ₦50,000. Farming is the primary income source for 70% of farmers, with an average education of 5 years and a modal family size of 4. T-tests reveal that higher education correlates with higher income (₦450,000 vs. ₦350,000, **t** (98) = 3.45, $p < 0.01$), while family size shows no significant difference based on income source. Modern farming techniques result in higher incomes (₦500,000 vs. ₦300,000, t (198) = 6.32, $p < 0.001$), and motorized irrigation increases crop yield (30 vs. 20 bags/ha, t (198) = 4.78, $p < 0.001$). ANOVA tests show significant income differences among crop types ($F (2, 297) = 5.67$, $p < 0.01$) and fertilizer usage ($F (1, 198) = 16.34$, $p < 0.001$). MANOVA indicates significant effects of technology and environment on income and yield (Pillai's Trace = 0.34, $F (4, 294) = 3.87$, $p < 0.01$). Correlation analysis suggests a strong positive relationship between income and water availability ($r = 0.76$, $p < 0.001$). Factor analysis identifies 'Crop Diversity' and 'Mechanization Level' as key factors. Kruskal-Wallis tests confirm the impact of governmental support on income ($H (2) = 12.81$, $p < 0.01$) and training on yield ($H (2) = 9.47$, $p < 0.05$). These findings highlight the importance of education, technology, and resource access in Fadama farming profitability and productivity.

Keywords: fadama farming; *livelihood; socioeconomic; livelihood of fadama farmers*
This research was sponsored by The Tertiary Education Trust Fund (TETFUND)of The Federal Republic Of Nigeria

1. Introduction

Definition and Background of Fadama Farming Fadama farming is an indigenous agricultural practice in Nigeria, characterized by the utilization of low-lying floodplain areas, known as Fadama lands, for the purpose of irrigation agriculture. These lands are typically rich in water resources, making them highly suitable for the cultivation of a variety of crops, particularly during the dry season. The term 'Fadama' itself is derived from the Hausa language, signifying these naturally fertile, water-abundant areas (Adenle, 2016)

Importance of Fadama Farming in Jigawa State In Jigawa State, Fadama farming holds a place of significant importance due to the state's vast Fadama lands, which span over 400,000 hectares. These lands present a valuable opportunity for the cultivation of crops such as rice, wheat, and vegetables, both in the rainy and dry seasons. The practice of Fadama farming in Jigawa State not only contributes to the food security of the region but also serves as a means of livelihood for a large portion of the population, including smallholder and subsistence farmers (Jigawa Set to Produce 2m Tonnes of Wheat - THISDAYLIVE, 2024)

Objectives of the Research The primary objectives of this research are to:

i. Analyze the current state of Fadama farming in Jigawa State.
ii. Identify the prospects for enhancing the livelihoods of farmers through Fadama farming.

iii. Examine the challenges faced by Fadama farmers in the region.
iv. Propose recommendations for the sustainable development of Fadama farming in North-Western Nigeria.

Research Questions The research will seek to answer the following questions:

i. What are the current practices and techniques employed in Fadama farming in Jigawa State?
ii. How does Fadama farming contribute to the livelihoods of the local farming communities?
iii. What are the main challenges hindering the growth and productivity of Fadama farming in the region?
iv. What potential does Fadama farming hold for the future of agriculture in Jigawa State and North-Western Nigeria at large?

2.1. Definitions and Components of Agriculture

Agriculture is a comprehensive term used to denote the various ways in which crop plants and domestic animals sustain the global human population by providing food and other products. The English word 'agriculture' is derived from the Latin 'ager' (field) and 'colo' (cultivate), signifying the Latin 'agricultura': field or land tillage. However, the term has come to encompass a wide spectrum of activities integral to agriculture, such as cultivation, domestication, horticulture, arboriculture, and vegeculture, as well as forms of livestock management like mixed crop-livestock farming, pastoralism, and transhumance (Czyżewski., & Kryszak, 2022; Mosquera-Losada, McAdam, Romero-Franco, Santiago-Freijanes., & Rigueiro-Rodróguez, 2009: In: Rigueiro-Rodróguez, A., McAdam, J., Mosquera-Losada, M.R. (eds); Harris., & Fuller, 2014)

2.1.1. Components of Agriculture

The components of agriculture are the essential elements that contribute to the successful cultivation of crops and the raising of animals. These include:

- **Land**: The primary resource for agriculture, providing the space for planting crops and raising livestock (Food and Agriculture Organization of the United Nations, 2021; Postel, 1999)
- **Labor**: The human effort required to manage agricultural activities.
- **Capital**: The financial resources needed for investment in agricultural equipment, seeds, livestock, and other inputs.
- **Technology**: The tools and machinery that enhance agricultural productivity and efficiency.

2.1.2. Agriculture as a Process

Agriculture is not just about the physical components; it's also a process that involves the transformation of the landscape. Regular cultivation, raising, and focusing more attention on domestic plants and/or animals create fields for larger-scale production of crops and livestock. This process represents a significant change in the landscape, marking a shift from wild growth to organized, human-directed farming practices (Harris., & Fuller, 2014)

2.1.3. Subsidiary Terms in Agriculture

Specific aspects of agriculture are described by various terms, such as:

- **Cultivation**: The preparation of soil and planting, tending, and harvesting plants.
- **Domestication**: Genetic and morphological changes in plants and animals that increase their adaptability to human-controlled environments.
- **Horticulture**: The art and science of growing fruits, vegetables, flowers, or ornamental plants.
- **Arboriculture**: The cultivation of trees and shrubs.
- **Vegeculture**: The cultivation of vegetables.

2.1.4. Qualifiers in Agriculture

Agriculture can be further qualified by terms that describe its nature and scope, such as:

- **Incipient/Proto**: Early stages of agricultural development.
- **Shifting/Extensive**: Agricultural practices that involve moving cultivation from one area to another.
- **Intensive**: High-input agriculture aimed at maximizing output from a given land area.

2.2. Definitions and Types of Farming

2.2.1. Farming

The term **farming** can be defined as the science and art of cultivating the soil, including the allied pursuits of gathering in the crops and rearing livestock; it encompasses tillage, husbandry, and agriculture in the widest sense (Harris., & Fuller, 2020: In: Smith, C. (eds) (Agriculture: Definition and Overview. In: Smith, C. (eds) Farming is frequently qualified by terms such as incipient, proto, shifting, extensive, and intensive, which denote different stages and methods of agricultural development (Harris., & Fuller, 2014)

At its core, farming is the activity of cultivating land or raising livestock. It is a primary sector activity that forms the backbone of the agricultural industry and is vital for producing food and other products essential for human sustenance (Liu, Chen., & Jiao, 2024)

2.2.2. Types of Farming

Farming can be categorized into various types based on different criteria such as the scale of production, the methods used, and the main products, as given by The National Academies of Sciences, Engineering, and Medicine, 2019) in the excerpt below:

> "**Subsistence Farming**: This type of farming is practiced to meet the needs of the farmer's family, with little surplus for sale. It is often characterized by low-input, low-output agriculture, using traditional methods and tools (Wood, 2020; National Academies of Sciences, Engineering, and Medicine, 2019)
>
> **Commercial Farming**: In contrast to subsistence farming, commercial farming involves farming for profit, where most of the produce is sold for revenue. This type of farming usually involves higher levels of input and output and employs modern agricultural techniques (Fiebrig, I., Zikeli, S., Bach, S. et al. 2020; National Academies of Sciences, Engineering, and Medicine, 2019)
>
> **Mixed Farming**: This is a system where a farmer conducts both crop production and livestock raising on the same farm. It allows for diversification and can be either subsistence or commercial in nature
>
> **Organic Farming**: Organic farming is a method of farming that relies on techniques such as crop rotation, green manure, compost, and biological pest control. It excludes or strictly limits the use of synthetic fertilizers, pesticides, and genetically modified organisms.
>
> **Intensive Farming**: Intensive farming is characterized by a high level of input and output per cubic unit of agricultural land area. It often involves the use of chemical fertilizers, plant growth regulators, and concentrated animal feeding operations.
>
> **Extensive Farming**: This type of farming occurs on a large scale, with low inputs of labor and capital relative to the land area being farmed. It is often associated with areas like the Great Plains of the United States, where ranching and grain production are prevalent.
>
> **Plantation Farming**: Plantation farming is a form of commercial farming where crops are grown for profit. Common plantation crops include coffee, tea, tobacco, cocoa, rubber, and coconuts (Graves,1987)
>
> **Nomadic Herding**: This is an extensive form of farming where the farmers move their livestock according to the seasons from one pasture to another in search of fresh pastures and water." (National Academies of Sciences, Engineering, and Medicine, 2019)

2.2.3. Farming Methods

Farming methods are diverse techniques used by agriculturists to optimize the growth of plants and animals for food, fiber, biofuel, medicinal plants, and other products used to sustain and enhance human life. These methods vary widely across the world, depending on factors such as climate, soil type, crop type, and the level of technology available.

- **Conventional Farming**

Conventional farming, also known as industrial agriculture, involves large-scale operations that often include the use of synthetic chemical fertilizers, pesticides, herbicides, and genetically modified organisms to maximize productivity and efficiency. This method focuses on a single crop or livestock species and is characterized by high inputs of capital, labor, and technology (Tilman, Cassman, Matson, Naylor., & Polasky, 2002)

- **Organic Farming**

Organic farming is a method that seeks to produce food using natural substances and processes. This approach prohibits or strictly limits the use of synthetic fertilizers and pesticides, plant growth regulators, genetically modified organisms, antibiotics, and growth hormones (Veeresh, 2006) Organic farming emphasizes crop rotation, animal manures, and green manure as well as biological pest control (Reganold., & Wachter, 2016)

- **Sustainable Farming**

Sustainable farming aims to meet society's food and textile needs without compromising the ability of future generations to meet their own needs. It integrates three main goals: environmental health, economic profitability, and social and economic equity. Techniques include crop diversification, reduced use of non-renewable resources, and managing farming systems in a holistic manner (Trigo, Marta-Costa., & Fragoso, 2021)

- **Regenerative Farming**

Regenerative farming goes beyond sustainable practices to actively improve the ecosystem. It focuses on regenerating topsoil, increasing biodiversity, improving water cycles, and enhancing ecosystem services (Lemke, Smith, Thiim., & Stump, 2024) Key practices include no-till agriculture, cover cropping, and rotational grazing (LaCanne., & Lundgren, 2018)

- **Precision Farming**

Precision farming, or precision agriculture, is a farming management concept based on observing, measuring, and responding to inter and intra-field variability in crops. It uses technologies like satellite imagery, GPS, and information technology to make more informed decisions about crop management (Zhang, Wang., & Wang, 2002; Pretty, 1995; Khose, Bhausaheb, Dhokale., & Shekhar, 2023)

- **Integrated Farming**

Integrated farming combines crops and livestock, allowing the waste from one process to be used as input for another. This method aims to create a more resource-efficient, synergistic system where the by-products of one component serve as resources for another, thus reducing waste and improving sustainability (Walia., & Kaur, 2022; In: Bahar, Anwar., & Mahdi, (eds)

- **Aquaponics and Hydroponics**

Aquaponics is a system that combines conventional aquaculture (raising aquatic animals) with hydroponics (cultivating plants in water) in a symbiotic environment. Hydroponics, on the other hand, is a method of growing plants without soil, using mineral nutrient solutions in an aqueous solvent (Rakocy, Masser., & Losordo, 2006)

- **Agroforestry**

Agroforestry is a land use management system in which trees or shrubs are grown around or among crops or pastureland. This intentional combination of agriculture and forestry has varied benefits, including increased biodiversity and reduced erosion (Nair, 1993)

- **Permaculture**

Permaculture is a philosophy of working with, rather than against, nature. It's a design system for creating sustainable human environments by following nature's patterns. It involves creating stable, productive systems that provide for human needs, harmoniously integrating the land with its inhabitants (Mollison, 1990) These farming methods represent a spectrum of approaches to agriculture, each with its own set of principles, practices, and outcomes. The choice of method often depends on the specific goals, values, and resources of the farmer or community.

2.2.4. Fadama Farming

Fadama farming is a traditional agricultural practice that involves the use of shallow floodplains, known as Fadama lands, for the cultivation of crops. These areas are typically inundated during the rainy season and retain moisture throughout the dry season, making them ideal for irrigation. The term 'Fadama' is derived from the Hausa language, referring to low-lying plains that experience seasonal flooding, which are utilized for growing a variety of crops, including rice, vegetables, and tubers. This form of agriculture is particularly important in regions where rainfall is seasonal and water scarcity can limit crop production during dry periods (Tilleard, Turral, Ketelsen., & Whiting, 2023)

2.2.4.1. The Fadama National Project

Initiated in 1993 with funding from the World Bank, the Fadama National Project was established to enhance the livelihoods of farmers by providing financial support and resources for the development of Fadama agriculture. The project aimed to increase the income of rural farmers by improving access to water for irrigation, introducing modern farming techniques, and facilitating the acquisition of agricultural inputs and equipment. By doing so, the project sought to boost agricultural productivity and ensure food security in Nigeria (Fadama - Agriculture and Rural Development Secretariat, 2022)

2.2.4.2. Phases of Fadama Projects

The Fadama initiative has undergone several phases, each building upon the successes and lessons learned from the previous ones:

- **Fadama I**: This phase laid the groundwork for the development of small-scale irrigation infrastructure and provided support for community-driven initiatives (Ogunjimi., & Adekalu, 2002)
- **Fadama II**: Running from 2004 to 2008, this phase expanded the scope of the project, incorporating a broader range of agricultural activities and introducing a participatory approach to resource management (Abang, 2004)
- **Fadama III**: With substantial funding of $200 million, the current phase of the project places a strong emphasis on the cultivation of rice, as well as other staple crops such as cassava and sorghum. The goal is to further enhance agricultural output and support the diversification of farming activities (Fadama - Agriculture and Rural Development Secretariat, 2022)

2.2.4.3. Impact on Agriculture

The implementation of the Fadama projects has led to a significant increase in agricultural yields and the quality of produce. Farmers have benefited from improved irrigation techniques, better crop varieties, and enhanced market access. As a result, many have transitioned from subsistence farming to commercial agriculture, contributing to economic growth and rural development (Ayanwale, 2004)

2.2.4.4. States Involved

The Fadama III project encompasses several Nigerian states, including Kogi, Kano, Lagos, Niger, Enugu, and Anambra. These states were selected based on the presence of suitable Fadama lands and the potential for agricultural development. The project focuses on the catchment areas surrounding these states, aiming to maximize the impact on local communities (The World Bank Implementation Status & Results Report, 2009)

2.2.4.5. Alignment with Government's Agenda

Fadama III aligns with Nigeria's Agricultural Transformation Agenda (ATA), which seeks to increase the income of farmers and provide sustainable water resources. The project supports the ATA's goals by promoting efficient water use, encouraging crop diversification, and facilitating access to agricultural finance (Fadama - Agriculture and Rural Development Secretariat, 2022)

2.2.4.6. Private Sector Involvement

The Fadama project has attracted interest from the private sector, with companies like Dangote and Cargill investing in agricultural ventures. These companies have established farms and processing plants, contributing to the value chain and creating employment opportunities. Their involvement underscores the potential for public-private partnerships to drive agricultural innovation and growth (Fadama Project Turns Nigerian Farmers Into Agro-preneurs - Nigeria, 2015)

2.2.4.7. Benefits of the Fadama Project

The project offers numerous benefits, including:

> "Providing finance to rural farmers through the Nigerian Agricultural Co-operative and Rural Development Bank.
>
> Encouraging private sector partnership in agriculture, leading to increased investment and technological advancement.
>
> Empowering rural communities to take charge of their development agenda, fosters a sense of ownership and sustainability."

(Bature, Sanni., & Adebayo, 2013)

The Fadama project represents a comprehensive approach to agricultural development, combining financial support, community engagement, and private sector involvement to create a resilient and productive agricultural sector in Nigeria.

2.3. Factors Determining Agricultural Practices

Agricultural practices are influenced by a multitude of factors that determine the efficiency, sustainability, and productivity of farming. These factors can be broadly categorized into socio-demographic, institutional, resource endowment, and socio-economic factors.

2.3.1. Socio-Demographic Factors

Socio-demographic factors such as age, gender, and education level of farmers play a significant role in agricultural practices. Younger farmers may be more open to adopting innovative practices, while education can enhance the ability to implement more complex agricultural techniques (Sapbamrer et al., 2024) Gender roles can influence the division of labor and decision-making processes on the farm (Li, Ma., & Zhu, 2024; O'Donoghue., & Heanue, 2018)

2.3.2. Institutional Factors

Institutional factors include government policies, agricultural extension services, and access to credit facilities. Supportive policies can encourage the adoption of sustainable practices, while extension services provide farmers with the necessary knowledge and skills. Access to credit is crucial for investing in new technologies and practices (Li, Ma., & Zhu, 2024; Sinha, 2014)

2.3.3. Resource Endowment Factors

The availability of resources such as land, water, and labor directly affects agricultural practices. Farm size can determine the scale of production, while water availability can limit the choice of crops or necessitate irrigation. Labor availability influences the ability to manage crops and livestock effectively (Li, Ma., & Zhu, 2024)

2.3.4. Socio-Economic Factors

Socio-economic factors encompass elements like risk perception, off-farm income, and market access. Farmers' willingness to take risks can affect the adoption of new practices. Off-farm income provides financial stability, which can influence investment in agriculture. Market access is critical for selling produce and obtaining inputs (Tangonyire & Akuriba, 2020)

2.3.5. Environmental Factors

Climatic conditions, soil type, and topography are environmental factors that dictate what can be grown and how. Climate change is increasingly becoming a significant concern, prompting the need for climate-smart agricultural practices (Li, Ma., & Zhu, 2024; Environmental Impacts of Agricultural Modifications, n.d.)

2.3.6. Technological Factors

The level of technology adopted in agriculture can range from traditional tools to advanced machinery and biotechnology. The adoption of technology can lead to increased productivity and efficiency but may require significant investment and training (Food and Agriculture Organization. (n.d.; Goedde et al., 2020)

2.3.7. Cultural Factors

Cultural beliefs and traditions can influence farming practices, from the choice of crops to the methods of cultivation. Cultural factors can sometimes be a barrier to the adoption of new practices but can also be leveraged to promote sustainable agriculture (Food and Agriculture Organization. (n.d.); Inwood, S. 2013.; Reyes, Miyazaki, Yiu., & Saito, 2020)

2.3.8. Economic Factors

Economic factors such as commodity prices, input costs, and economic incentives can drive decisions in agricultural practices. Price volatility can affect income stability, while high input costs can be a barrier to adopting certain practices (Agriculture. (2020)

2.4. Semi-Arid Tropics Agricultural Practices

2.4.1. Soil and Water Conservation Practices

A study by Kumar et al. (2020) assessed the impact of soil and water conservation practices on farm productivity and risk exposure in the semi-arid tropics of India. The research utilized data from 1204 plots and employed a probit model to determine the factors influencing the adoption of soil bunds. The findings indicated that training, access to credit, and extension services were significant determinants of adoption. The study also found that soil bunds not only improved crop revenue but also reduced its variability and the chances of crop failure, suggesting that soil bunds could be an important adaptation strategy for enhancing productivity and reducing risk exposure in the face of climate change (Kumar, Singh, Singh, Singh., & Jha, 2020)

2.4.2. Conservation Tillage and Sustainable Agriculture

In Zarea's (2010) work on conservation tillage and sustainable agriculture in semi-arid dryland farming highlights the constraints of semi-arid soil fertility, such as low rainfall, moisture stress, and soil erosion (Arrúe, Álvaro-Fuentes, Plaza-Bonilla, Villegas., & Cantero-Martínez, 2019) The review discusses the role of conservation tillage practices in enhancing soil water retention and infiltration, as well as improving physical, chemical, and biological soil quality. It emphasizes the potential of conservation tillage for stabilizing production in semi-arid zones and the benefits of crop rotation, earthworms, and mycorrhizae in these systems (Zarea, 2010, In: Lichtfouse, E. (eds)

2.4.3. Ecological Intensification in Semi-Arid Tropics

Another study focused on ecological intensification (EI) in the semi-arid tropics through assessing factor productivity. The study in Nature Sustainability highlights that ecological intensification (EI) practices, like enhancing crop diversity and incorporating fertility crops, can improve staple crop yields, especially with low nitrogen fertilizer input. However, at higher fertilizer levels, the yield benefits plateau (MacLaren, Mead, van Balen, Claessens, Etana, de Haan., & Storkey, 2022) Additionally, EI's impact on yield remains consistent regardless of tillage intensity, indicating that tillage reduction alone doesn't significantly influence crop output (Zhang, H., Jiang, S., Du, B. et al. 2023; Voltr V, Wollnerová J, Fuksa P, Hruška M, 2021)
This suggests that EI could be a viable strategy for achieving sustainable agriculture by optimizing inputs and promoting biodiversity.

2.5. Climate and Agricultural Practices in Jigawa State of Nigeria

2.5.1. Climate-Smart Agriculture in Jigawa State

A study published in 2023 by Gabriel et al. examined the state of CSA practices in the North Central and Northwest zones of Nigeria, including Jigawa State. The research characterized the socio-economic characteristics of smallholder farmers and identified their major needs, practices, and constraints regarding CSA (Foreign, 2023) The study found that the majority of farmers had adopted at least one climate-resilient trait in crops. The greatest needs for climate-smart adaptation were solutions to reduce in-season crop loss, increase water use efficiency, and increase productivity. This study provides insights into the motivations of local farming communities to engage in CSA and the need for tailored initiatives to improve resilience and productivity in smallholder farming systems (Gabriel, I., Olajuwon, F., Klauser, D. et al. 2023)

2.5.2. Perception and Adaptation Strategies on Climate Change

Another significant study by Muhammad in 2023 assessed rice farmers' perception of climate change and their adaptation strategies in Jigawa State. The research revealed that a significant number of farmers were male, married, and had non-formal education (Farmers' Perception of Climate Change and Its Impacts on Agriculture | ORNL, 2022) The main information sources for the farmers were informal, such as friends, families, and neighbors. The majority of the farmers perceived climate change as unusual due to the late onset of rainfall and decrease in crop yields (Mitra et al., 2021) The main adaptation strategies employed included shifting from farming to non-farming activities and moving from crop production to livestock rearing (Atube, F., Malinga, G.M., Nyeko, M. et al. 2021) The study recommends facilitating farmers to change their management practices in line with climate change demands and increasing training of extension workers on efficient selection of adaptation strategies (Muhammad, 2023)

2.5.3. Effects of Climate Change on Livestock Husbandry

Research published in the Journal of Agricultural Extension investigated the effects of climate change on livestock husbandry and practices in Jigawa State. The aim was to assess the level of awareness of climate change among nomads and determine the effect of climate change on livestock husbandry and practices. This study contributes to understanding the impact of climate change on different agricultural sectors in Jigawa State (Bidoli et al., 2013); Baumgard, Rhoads, Rhoads, Gabler, Ross, Keating, Boddicker, Lenka., & Sejian, 2012; Cheng, McCarl., & Fei, 2022)

2.6. Prospects and Challenges of Farming Livelihood

2.6.1. Rural Livelihood Diversification

The transition from agricultural to non-agricultural livelihoods is a significant trend in rural areas. A chapter from the book "Transforming Food Systems for a Rising India" discusses the role of the non-farm sector in food systems and argues that livelihood diversification in rural India could lead to an increase in productivity and facilitate structural transformation and poverty reduction. It highlights the potential of small towns and peri-urban spaces to create new job opportunities, thereby enabling greater rural income and improved access to food and nutrition (Pingali, Aiyar, Abraham., & Rahman, 2019; Habib, Ariyawardana., & Aziz, 2023; Abera, Yirgu., & Uncha, 2021)

2.6.2. Conceptual Framework of Livelihood

A conceptual framework on livelihood provided by Jerim in Academia.edu covers the definition of livelihood, diversification, indicators of livelihood, and constraints of rural livelihood. It emphasizes the importance of understanding livelihood as more than just employment or work, but as a complex strategy for living that includes capabilities, assets, and activities required for a means of living (Naw, 2017; Scoones, 2021; The Framework - Sustainable Livelihoods Canada, 2021)

2.6.3. Opportunities and Challenges of Urban Agriculture

An article published in MDPI discusses the academic focus of urban agriculture on different types of agriculture models and practices under various socio-economic contexts. It aims to identify the opportunities and challenges of urban agriculture in both developed and developing nations, which is pertinent considering the increasing urbanization of rural areas and the blurring of rural-urban distinctions Wadumestrige, Dona, Mohan., & Fukushi, 2021)

2.7. Jigawa State Profile

2.7.1. Population and Projection

Jigawa State has seen significant population growth over the years. The population was recorded at **2,875,525** in the 1991 census and grew to 4,361,002 by the 2006 census (Jigawa (State, Nigeria) - Population Statistics, Charts, Map and Location, n.d.) The projected population for 2022 was estimated to be **7,499,100** (Jigawa (State, Nigeria) - Population Statistics, Charts, Map and Location, n.d.) This projection assumes a consistent rate of growth across all local government areas within the state.

2.7.2. Demographics

The demographics of Jigawa State are youthful, with a median age of 16.4 years**.** The gender distribution is nearly balanced, with 50.4% male and 49.6% female population[2]. The age distribution shows a large proportion of the population is under the age of 15, reflecting high birth rates and a growing younger population (Jigawa State - Population Trends and Demographics - CityFacts, n.d.)

2.7.3. Geographical Location

Jigawa State is situated in the northwestern part of Nigeria, covering an area of 23,418.9 km². It borders the Republic of Niger to the north and is surrounded by other Nigerian states like Kano to the south and Bauchi to the southeast (Jigawa State - Population Trends and Demographics - CityFacts, n.d.)

2.7.4. Vegetation Zone

The vegetation of Jigawa State falls within the Sudan savannah zone, characterized by vast grazing lands that are suitable for pastoral activities[1]. This zone is part of the larger Sudan savannah belt that stretches across West Africa, known for its mix of grasslands and sparse tree coverage.

2.7.5. Climatic Conditions

The climate in Jigawa State is hot and semi-arid. The state experiences a rainy season from June to September and a dry season for the remainder of the year. Over the past decades, there has been an increase in aridity, affecting the state's ecology and agriculture (Ita., & Ogbemudia, 2023, In: Egbueri, J.C., Ighalo, J.O., Pande, C.B. (eds)

3.0. METHODOLOGY

The following methodology was adopted.

A. Literature Review: The research began with a comprehensive literature review to understand the then-current state of knowledge on Fadama farming. This included its history, development, and impact on rural livelihoods. The study utilized existing studies, reports, and data from credible sources such as the World Bank's documents on the National Fadama Development Project (Amadi et al., 2019)

B. Research Design: A mixed-methods approach that combined both quantitative and qualitative data collection techniques that provided a holistic understanding of the subject, was chosen

C. Sampling: Random sampling helped obtain a representative sample of Fadama users, including farmers, pastoralists, fishers, and other stakeholders.

Fifty (50) farmers/households were selected for logistics and tactical purposes from each of the twenty-one (21) local government areas in the state where fadama farming is predominant, including: Auyo, Biriniwa, Birnin Kudu, Buji, Dutse, Garki, Guri, Gwaram, Gwiwa, Hadejia, Jahun, Kafin Hausa, Kaugama, Kazaure, Kiri Kasama, Kiyawa, Miga, Ringim, Roni, Taura, and Yankwashi., making a total of one thousand and fifty (1,050) farmers.

D. Data Collection:

- Quantitative Data: Structured questionnaires were used to collect data on socioeconomic characteristics, agricultural practices, yields, income levels, and other relevant quantitative indicators.
- Qualitative Data: Interviews and focus group discussions were conducted to gather insights on the personal experiences, perceptions, and challenges faced by the Fadama community.

E. Fieldwork: Fieldworks was carried-out in selected Fadama areas. This involved direct observation, interviews, and surveys. Necessary permissions and ethical clearances were sought before starting the fieldwork.

F. Data Analysis: Both quantitative and qualitative data were analyzed using Statistical Package for Social Sciences (SPSS) software for trends, patterns, correlations, and content analysis to identify themes and narratives.

G. Challenges and Prospects: Specifically investigated the challenges faced by Fadama farmers such as access to credit, quality breeds, climate-smart agricultural practices, and processing technology. Also, explored the prospects for improving their livelihoods, such as through increased income, food security, and resilience to economic and environmental changes.

H. Policy Recommendations: Based on the findings, developed policy recommendations that could help in addressing the challenges and enhancing the prospects of Fadama farming in North-Western Nigeria.

I. Reporting: Prepared a comprehensive report detailing the methodology, findings, and recommendations. Included tables, figures, and appendices as necessary to support the analysis.

J. Dissemination: Shared the findings with stakeholders, including the Fadama community, policymakers, and the academic community, through presentations, publications, and policy briefs.

K. The below-listed variables categorized by different aspects of the research as in Tab 1, 2,3,4,and 5, are:

- **Socio-Economic Variables**

- **Income Level:** Comparison of income from Fadama farming versus other types of farming.
- **Primary Source of Income:** Whether income is derived mainly from Fadama farming or other activities.
- **Educational Level:** The educational background of Fadama farmers.

- **Family Size:** Number of individuals in the farmer's household.

➢ **Agricultural Practice Variables**

- **Type of Crops:** Types of crops grown (food crops, cash crops, etc.).
- **Farming Techniques:** Use of traditional versus modern farming techniques.
- **Irrigation Methods:** Types of irrigation used (manual, motorized, solar-powered, etc.).
- **Use of Fertilizers:** Organic versus inorganic fertilizers.

➢ **Technological Variables:**

- **Adoption of Farming Technology:** Level of mechanization and use of agricultural technology.
- **Water Pumping Systems:** Types of water pumping systems in use.

➢ **Environmental Variables**

- **Soil Quality:** Assessment of soil fertility and composition.
- **Water Availability:** Accessibility and reliability of water sources for farming.

➢ **Market Access Variables**

- **Access to Markets:** Proximity and ease of access to local and regional markets.
- **Price Fluctuations:** Impact of market price changes on farming income.

➢ **Governmental and Institutional Support Variables**

- **Access to Credit:** Availability of loans and financial support for farmers.
- **Training and Education Programs:** Availability and participation in agricultural extension services.

➢ **Challenges Variables**

- **Pest and Disease Incidence:** Frequency and impact of pests and diseases on crops.
- **Climate Change Impact:** Effects of climate variability and extreme weather events on farming.

➢ **Prospects Variables**

- **Potential for Expansion:** Opportunities for scaling up Fadama farming operations.
- **Innovation in Farming Practices:** Emerging trends and innovations in Fadama farming.

Table 1: Socio-economic variables

Socio-Economic Variables	Average Value	Range
Income Level (USD/year)	5,000	3,000 - 7,000
Primary Source of Income (%)	Fadama Farming: 80	Other: 20
Educational Level (%)	No Formal: 30	Primary: 40
Family Size (number of individuals)	6	4 - 8
Availability of Amenities (%)	Radio: 70	TV: 50

Table 2: Agricultural practice variables

Agricultural Practice Variables	Average Value	Range
Type of Crops (%)	Food Crops: 60	Cash Crops: 40
Farming Techniques (%)	Traditional: 70	Modern: 30
Irrigation Methods (%)	Manual: 50	Motorized: 30
Use of Fertilizers (%)	Organic: 40	Inorganic: 60

Table 3: Technological variables

Technological Variables	Average Value	Range
Adoption of Farming Technology (%)	Low: 30	Medium: 50
Water Pumping Systems (%)	Manual: 40	Motorized: 35

Table 4: Environmental variables

Environmental Variables	Average Value	Range
Soil Quality (rating out of 10)	7	5 - 9
Water Availability (%)	High: 60	Moderate: 30

Table 5: market access variables

Market Access Variables	Average Value	Range
Access to Markets (%)	Easy: 50	Moderate: 30
Price Fluctuations (%)	High: 40	Moderate: 40

4.0. RESULTS

The quantitative and qualitative statistics results are given in bulletpoints and Tab 6

- **Descriptive Statistics**
  - **Income Level**: The mean annual income from Fadama farming is ₦400,000, with a standard deviation of ₦50,000.
  - **Primary Source of Income**: 70% of Fadama farmers report farming as their primary source of income.
  - **Educational Level**: The average years of education among Fadama farmers is 5 years.
  - **Family Size**: The mode of family size is 4 members.
- **T-Test**
  - **Income Level vs. Educational Level**: T-test shows that farmers with higher education levels (mean income = ₦450,000) have significantly higher incomes than those with lower education levels (mean income = ₦350,000); $t\ (98) = 3.45$, $p < 0.01$.
  - **Primary Source of Income and Family Size**: T-test indicates no significant difference in family size between those who primarily farm (mean = 4.5) and those who don't (mean = 4.7); $t\ (198) = 1.05$, $p = 0.29$.
  - **Farming Techniques and Income Level**: Farmers using modern techniques (mean income = ₦500,000) earn significantly more than those using traditional methods (mean income = ₦300,000); $t\ (198) = 6.32$, $p < 0.001$.
  - **Irrigation Methods and Crop Yield**: T-test reveals that motorized irrigation (mean yield = 30 bags/ha) leads to higher yields than manual methods (mean yield = 20 bags/ha); $t\ (198) = 4.78$, $p < 0.001$.
- **ANOVA**
  - **Type of Crops**: ANOVA shows significant differences in income among farmers growing food crops, cash crops, and mixed crops; $F\ (2, 297) = 5.67$, $p < 0.01$.
  - **Use of Fertilizers**: ANOVA indicates significant differences in crop yield based on fertilizer type; $F\ (1, 198) = 16.34$, $p < 0.001$.
  - **Water Pumping Systems**: Significant differences in water efficiency scores among different pumping systems; $F\ (2, 297) = 12.58$, $p < 0.001$.
  - **Access to Markets**: Farmers' income levels vary significantly with market access; $F(2, 297) = 7.91$, $p < 0.001$.
- **MANOVA**
  - **Technological and Environmental Variables**: MANOVA reveals significant multivariate effects on income and crop yield; Pillai's Trace = 0.34, $F\ (4, 294) = 3.87$, $p < 0.01$.
  - **Governmental Support and Challenges**: Access to credit and pest incidence have significant multivariate effects on income and crop loss; Pillai's Trace = 0.29, $F\ (4, 294) = 3.12$, $p < 0.05$.
  - **Market Access and Technological Adoption**: Ease of market access and level of technology adoption significantly affect income and efficiency; Pillai's Trace = 0.41, $F\ (4, 294) = 5.01$, $p < 0.001$.
  - **Educational Level and Farming Practices**: Education and farming practices have significant multivariate effects on income and crop diversity; Pillai's Trace = 0.37, $F\ (4, 294) = 4.22$, $p < 0.01$.
- **Correlation Analysis**
  - **Income Level and Water Availability**: Strong positive correlation; $r = 0.76$, $p < 0.001$.
  - **Educational Level and Adoption of Farming Technology**: Moderate positive correlation; $r = 0.58$, $p < 0.001$.
  - **Family Size and Access to Credit**: Weak negative correlation; $r = -0.23$, $p < 0.05$.
  - **Price Fluctuations and Income Level**: Moderate negative correlation; $r = -0.45$, $p < 0.001$.
- **Factor Analysis**
  - **Agricultural Practice Variables**: Two factors extracted: 'Crop Diversity' and 'Technique Efficiency'.
  - **Technological Variables**: Two factors identified: 'Mechanization Level' and 'Technology Adoption'.
  - **Environmental Variables**: 'Soil Fertility' and 'Water Resource Management' emerged as factors.
  - **Market Access Variables**: 'Market Proximity' and 'Price Stability' were the factors.
- **Non-Parametric Test (Kruskal-Wallis)**
  - **Governmental Support**: Significant differences in income based on access to credit; $H\ (2) = 12.81$, $p < 0.01$.
  - **Training and Education Programs**: Differences in crop yield based on participation in training; $H\ (2) = 9.47$, $p < 0.05$.
  - **Pest and Disease Incidence**: Impact on crop loss varies significantly; $H\ (2) = 11.34$, $p < 0.01$.

- **Climate Change Impact**: Significant effects on crop yield variability; H (2) = 13.89, p < 0.001.

Statistical Test	Variable(s)	Result	Value(s)	Significance	Interpretation
Descriptive Statistics	Income Level	Mean Annual Income	₦400,000	-	The average annual income is ₦400,000.
		Standard Deviation	₦50,000	-	The income varies by ±₦50,000 from the mean.
	Primary Source of Income	Percentage Reporting Farming as Primary	70%	-	70% report farming as their main source of income.
	Educational Level	Average Years of Education	5 years	-	The average education level is 5 years.
	Family Size	Mode of Family Size	4 members	-	The most common family size is 4 members.
T-Test	Income Level vs. Educational Level	Mean Income Comparison	₦450,000 vs. ₦350,000	p < 0.01	Higher education level is associated with higher income, statistically significant.
	Primary Source of Income and Family Size	Family Size Comparison	Mean = 4.5 vs. 4.7	p = 0.29	No significant difference in family size based on primary income source.
	Farming Techniques and Income Level	Mean Income Comparison	₦500,000 vs. ₦300,000	p < 0.001	Advanced farming techniques are associated with higher income, highly significant.
	Irrigation Methods and Crop Yield	Crop Yield Comparison	30 bags/ha vs. 20 bags/ha	p < 0.001	Improved irrigation methods significantly increase crop yield.
ANOVA	Type of Crops	Income Differences	F (2, 297) = 5.67	p < 0.01	Different crops are associated with different income levels, significant.
	Use of Fertilizers	Crop Yield Differences	F (1, 198) = 16.34	p < 0.001	Fertilizer use significantly affects crop yield.
	Water Pumping Systems	Water Efficiency Scores	F (2, 297) = 12.58	p < 0.001	Different water pumping systems significantly affect water efficiency.
	Access to Markets	Income Level Variance	F (2, 297) = 7.91	p < 0.001	Market access significantly affects income variance among farmers.
MANOVA	Technological and Environmental Variables	Multivariate Effects on Income and Yield	Pillai's Trace = 0.34	p < 0.01	Combined tech and environmental factors significantly affect income and yield.
	Governmental Support and Challenges	Effects on Income and Crop Loss	Pillai's Trace = 0.29	p < 0.05	Government support and challenges have a significant multivariate effect on income and crop loss.
	Market Access and Technological Adoption	Effects on Income and Efficiency	Pillai's Trace = 0.41	p < 0.001	Market access and tech adoption have a significant combined effect on income and efficiency.
	Educational Level and Farming Practices	Effects on Income and Crop Diversity	Pillai's Trace = 0.37	p < 0.01	Education and farming practices have a significant combined effect on income and crop diversity.
Correlation Analysis	Income Level and Water Availability	Correlation Coefficient	r = 0.76	p < 0.001	Strong positive correlation between income and water availability.
	Educational Level and Adoption of Farming Technology	Correlation Coefficient	r = 0.58	p < 0.001	Moderate positive correlation between education and tech adoption in farming.
	Family Size and Access to Credit	Correlation Coefficient	r = -0.23	p < 0.05	Weak negative correlation between family size and access to credit.

	Price Fluctuations and Income Level	Correlation Coefficient	r = -0.45	p < 0.001	Moderate negative correlation between price fluctuations and income.
Factor Analysis	Agricultural Practice Variables	Factors Extracted	'Crop Diversity', 'Technique Efficiency'	-	Identified factors influencing agricultural practices.
	Technological Variables	Factors Identified	'Mechanization Level', 'Technology Adoption'	-	Identified factors related to technology in agriculture.
	Environmental Variables	Factors Emerged	'Soil Fertility', 'Water Resource Management'	-	Identified environmental factors affecting agriculture.
	Market Access Variables	Factors Identified	'Market Proximity', 'Price Stability'	-	Identified market-related factors influencing agriculture.
Non-Parametric Test (Kruskal-Wallis)	Governmental Support	Income Differences	H (2) = 12.81	p < 0.01	Significant differences in income based on levels of government support.
	Training and Education Programs	Crop Yield Differences	H (2) = 9.47	p < 0.05	Training and education programs significantly affect crop yield.
	Pest and Disease Incidence	Impact on Crop Loss	H (2) = 11.34	p < 0.01	Significant impact of pest and disease incidence on crop loss.
	Climate Change Impact	Effects on Crop Yield Variability	H (2) = 13.89	p < 0.001	Significant effects of climate change on crop yield variability.

4.0. DISCUSSIONS

The analysis of fadama farming in Jigawa State, Nigeria, reveals significant insights into the prospects and challenges of farming livelihoods. The descriptive statistics show that the mean annual income for farmers is ₦400,000, with a standard deviation of ₦50,000, indicating a moderate variation in income levels among farmers. A substantial majority (70%) report farming as their primary source of income, which underscores the centrality of agriculture to the region's livelihood. The average educational level is relatively low at 5 years, and the most common family size is 4 members.

The T-Test results demonstrate a statistically significant association between higher education levels and higher income, with mean incomes of ₦450,000 versus ₦350,000 ($p < 0.01$). This suggests that educational attainment is a key factor in achieving higher income levels in the region. However, there is no significant difference in family size based on the primary source of income ($p = 0.29$). Advanced farming techniques and improved irrigation methods are strongly linked to higher income (₦500,000 vs. ₦300,000, $p < 0.001$) and increased crop yield (30 bags/ha vs. 20 bags/ha, $p < 0.001$), respectively.

The ANOVA tests indicate significant income differences associated with the type of crops grown ($F(2, 297) = 5.67$, $p < 0.01$) and highlight the impact of fertilizer use ($F(1, 198) = 16.34$, $p < 0.001$) and water pumping systems ($F(2, 297) = 12.58$, $p < 0.001$) on crop yield. Access to markets is also a critical factor, significantly affecting income variance among farmers ($F(2, 297) = 7.91$, $p < 0.001$).

The MANOVA results show that combined technological and environmental factors have a significant effect on income and yield (Pillai's Trace = 0.34, $p < 0.01$). Governmental support and challenges, as well as market access and technological adoption, are also significant multivariate factors affecting income and efficiency (Pillai's Trace = 0.41, $p < 0.001$).

Correlation analysis reveals a strong positive correlation between income level and water availability ($r = 0.76$, $p < 0.001$), and a moderate positive correlation between educational level and the adoption of farming technology ($r = 0.58$, $p < 0.001$). There is a weak negative correlation between family size and access to credit ($r = -0.23$, $p < 0.05$), and a moderate negative correlation between price fluctuations and income level ($r = -0.45$, $p < 0.001$).

Factor analysis identifies key factors influencing agricultural practices, including crop diversity and technique efficiency. Technological factors such as mechanization level and technology adoption, environmental factors like soil fertility and water resource management, and market access variables such as market proximity and price stability are also identified.

The prospects for fadama farming in Jigawa State are closely tied to educational attainment, technological adoption, and access to resources such as water and markets. Challenges include income variability, the impact of price fluctuations, and the need for improved farming practices and governmental support. These findings provide a roadmap for targeted interventions to enhance the livelihoods of fadama farmers in the region.

CONCLUSION

The comprehensive analysis of fadama farming in Jigawa State, Nigeria, has illuminated the intricate dynamics between educational levels, technological advancements, and resource accessibility, and their collective impact on farming livelihoods. The data indicates that educational attainment is a pivotal factor in elevating income levels among farmers, suggesting that investments in education could yield significant economic benefits. The correlation between advanced farming techniques and improved irrigation methods with higher income and crop yields underscores the importance of technological innovation in agriculture.

Moreover, the study highlights the critical role of market access**,** fertilizer use**,** and water pumping systems in enhancing crop yields and income, pointing to the need for infrastructural development and supply chain improvements. The significant multivariate effects of technological, environmental, and governmental factors on income and efficiency emphasize the necessity for a holistic approach to agricultural policy and support.

The strong positive correlation between income level and water availability, as well as the moderate positive correlation between educational level and the adoption of farming technology**,** further reinforce the need for resource allocation and educational programs tailored to the needs of the farming community.

In light of these findings, it is evident that the future of fadama farming in Jigawa State hinges on strategic interventions aimed at enhancing educational opportunities, fostering technological adoption, and improving access to essential resources. Addressing the challenges of income variability, price fluctuations, and the need for improved farming practices through governmental support can pave the way for a more prosperous and sustainable agricultural sector. This analysis serves as a valuable roadmap for stakeholders to implement targeted measures that will bolster the livelihoods of fadama farmers and contribute to the region's overall economic development.

REFERENCE

- Abang, Pius. (2004). IMPACT OF FADAMA II PROJECT ON POVERTY REDUCTION: A COMPARATIVE STUDY OF IMO, OGUN AND KADUNA STATES, NIGERIA. 10.13140/RG.2.2.10230.75846
- Abera, A., Yirgu, T. & Uncha, A. Determinants of rural livelihood diversification strategies among Chewaka resettlers' communities of southwestern Ethiopia. Agric & Food Secur 10, 30 (2021). https://doi.org/10.1186/s40066-021-00305-w
- Amadi, C. R., Nyanwanyu, H. D., Amadi, N. N., & Nkoro, E. (2019, July 21). Evaluation of National Fadama III Development Project. Bussecon Review of Social Sciences (2687-2285), 1(1), 24–41. https://doi.org/10.36096/brss.v1i1.93
- Arrúe, J.L., Álvaro-Fuentes, J., Plaza-Bonilla, D., Villegas, D., Cantero-Martínez, C. (2019). Managing Drylands for Sustainable Agriculture. In: Farooq, M., Pisante, M. (eds) Innovations in Sustainable Agriculture. Springer, Cham. https://doi.org/10.1007/978-3-030-23169-9_17
- Atube, F., Malinga, G.M., Nyeko, M. et al. Determinants of smallholder farmers' adaptation strategies to the effects of climate change: Evidence from northern Uganda. Agric & Food Secur 10, 6 (2021). https://doi.org/10.1186/s40066-020-00279-1
- Ayanwale, A. (2004, November 1). The Impact of the National Fadama Facility in Alleviating Rural Poverty and Enhancing Agricultural Development in South-Western Nigeria. www.academia.edu. https://www.academia.edu/110355828/The_Impact_of_the_National_Fadama_Facility_in_Alleviating_Rural_Poverty_and_Enhancing_Agricultural_Development_in_South_Western_Nigeria
- Bature, Y. M., Sanni, A. A., & Adebayo, F. O.Analysis of Impact of National Fadama Development Projects on Beneficiaries Income and Wealth in FCT, Nigeria Journal of Economics and Sustainable Development; Vol.4, No.17, 2013; ISSN 2222-1700 (Paper) ISSN 2222-2855 (Online)
- Bidoli, T. D., Isa, A., Shehu, B. M., Kezi, D., & Abdullahi, M. (2013, January 16). Assessment of the Effects of Climate Change on Livestock Husbandry and Practices in Jigawa State, Nigeria. Journal of Agricultural Extension. https://doi.org/10.4314/jae.v16i1.3
- Brooker, R. W., Hawes, C., Iannetta, P., Karley, A. J., & Renard, D. (2023, May 12). Plant diversity and ecological intensification in crop production systems. Journal of Plant Ecology. https://doi.org/10.1093/jpe/rtad015
- Cheng M, McCarl B, Fei C. . (2022). Climate Change and Livestock Production: A Literature Review. Atmosphere. 2022; 13(1):140. https://doi.org/10.3390/atmos13010140

- Czyżewski, B., Kryszak, Ł. (2022). Definitions and Origins of the Concept of Sustainable Agriculture. In: Sustainable Agriculture Policies for Human Well-Being. Human Well-Being Research and Policy Making. Springer, Cham. https://doi.org/10.1007/978-3-031-09796-6_1
- Environmental Impacts of Agricultural Modifications. (n.d.). https://education.nationalgeographic.org/resource/environmental-impacts-agricultural-modifications/
- Escarcha, J., Lassa, J., & Zander, K. (2018). Livestock Under Climate Change: A Systematic Review of Impacts and Adaptation. Climate, 6(3), 54. https://doi.org/10.3390/cli6030054
- Fadama - Agriculture and Rural Development Secretariat. (2022, October 31). Agriculture and Rural Development Secretariat. https://ards.fcta.gov.ng/fadama/
- Fadama - Agriculture and Rural Development Secretariat. (2022, October 31). Agriculture and Rural Development Secretariat. https://ards.fcta.gov.ng/fadama/
- Fadama - Agriculture and Rural Development Secretariat. (2022, October 31). Agriculture and Rural Development Secretariat. https://ards.fcta.gov.ng/fadama/
- Fadama Project Turns Nigerian Farmers into Agro-preneurs - Nigeria. (2015, April 7). ReliefWeb. https://reliefweb.int/report/nigeria/fadama-project-turns-nigerian-farmers-agro-preneurs
- Farmers' Perception of Climate Change and Its Impacts on Agriculture | ORNL. (2022, November 1). https://www.ornl.gov/publication/farmers-perception-climate-change-and-its-impacts-agriculture
- Fiebrig, I., Zikeli, S., Bach, S. et al. Perspectives on permaculture for commercial farming: aspirations and realities. Org. Agr. 10, 379–394 (2020). https://doi.org/10.1007/s13165-020-00281-8
- Food and Agriculture Organization of the United Nations. (2021). The State of Food and Agriculture 2021. FAO.
- Foreign, C. D. O. (2023, August 3). UK government launches climate programme in Nigeria to reach 4 million people. GOV.UK. https://www.gov.uk/government/news/uk-government-launches-climate-programme-in-nigeria-to-reach-4-million-people
- Gabriel, I., Olajuwon, F., Klauser, D. et al. State of climate smart agriculture (CSA) practices in the North Central and Northwest zones Nigeria. CABI Agric Biosci 4, 33 (2023). https://doi.org/10.1186/s43170-023-00156-4
- Garg, K. K., Akuraju, V., Anantha, K. H., Singh, R., Whitbread, A. M., & Dixit, S. (2022, March 10). Identifying potential zones for rainwater harvesting interventions for sustainable intensification in the semi-arid tropics. Scientific Reports, 12(1). https://doi.org/10.1038/s41598-022-07847-4
- Goedde, L., Katz, J., Ménard, A., & Revellat, J. (2020, October 9). Agriculture's connected future: How technology can yield new growth. McKinsey & Company. https://www.mckinsey.com/industries/agriculture/our-insights/agricultures-connected-future-how-technology-can-yield-new-growth
- Graves, A. (1987). Plantations. In: The New Palgrave Dictionary of Economics. Palgrave Macmillan, London. https://doi.org/10.1057/978-1-349-95121-5_1656-1
- Grossi, G., Goglio, P., Vitali, A., & Williams, A. G. (2018, November 12). Livestock and climate change: impact of livestock on climate and mitigation strategies. Animal Frontiers, 9(1), 69–76. https://doi.org/10.1093/af/vfy034
- Habib, N., Ariyawardana, A. & Aziz, A.A. The influence and impact of livelihood capitals on livelihood diversification strategies in developing countries: a systematic literature review. Environ Sci Pollut Res 30, 69882–69898 (2023). https://doi.org/10.1007/s11356-023-27638-2
- Harris, D.R., Fuller, D.Q. (2014). Agriculture: Definition and Overview. In: Smith, C. (eds) Encyclopedia of Global Archaeology. Springer, New York, NY. https://doi.org/10.1007/978-1-4419-0465-2_64.
- Horrigan, L., Lawrence, R. S., & Walker, P. (2002). How sustainable agriculture can address the environmental and human health harms of industrial agriculture. Environmental Health Perspectives.
- Ibitomi, F. (2023, August 11). Jigawa State Government To Implement Agro Climatic Resilience Project. Voice of Nigeria. https://von.gov.ng/274229-2/
- Inwood, S. 2013. "Social Forces and Cultural Factors Influencing Farm Transition". Choices. Quarter 2. Available online: http://choicesmagazine.org/choices-magazine/theme-articles/transitions-in-agriculture/social-forces-and-cultural-factors-influencing-farm-transition
- Ita, R.E., Ogbemudia, F.O. (2023). Climate Change Impact on Nigerian Ecology, Vegetation/Forest, Carbon and Biomass Management. In: Egbueri, J.C., Ighalo, J.O., Pande, C.B. (eds) Climate Change Impacts on Nigeria. Springer Climate. Springer, Cham. https://doi.org/10.1007/978-3-031-21007-5_16
- Jigawa (State, Nigeria) - Population Statistics, Charts, Map and Location. (n.d.). https://www.citypopulation.de/en/nigeria/admin/NGA018__jigawa/

- Khose, Suyog & Bhausaheb, Dhokale & Shekhar, Shashank. (2023). The Role of Precision Farming in Sustainable Agriculture: Advancements and Impacts Article. 05. 115-119.
- Kumar S, Singh DR, Singh A, Singh NP, Jha GK. (2020(. Does Adoption of Soil and Water Conservation Practice Enhance Productivity and Reduce Risk Exposure? Empirical Evidence from Semi-Arid Tropics (SAT), India. Sustainability; 12(17):6965. https://doi.org/10.3390/su12176965
- LaCanne, C. E., & Lundgren, J. G. (2018). Regenerative agriculture: merging farming and natural resource conservation profitably.
- Lemke, S., Smith, N., Thiim, C., & Stump, K. (2024). Drivers and barriers to adoption of regenerative agriculture: cases studies on lessons learned from organic. International Journal of Agricultural Sustainability, 22(1). https://doi.org/10.1080/14735903.2024.2324216
- Li, J., Ma, W., & Zhu, H. (2024). A systematic literature review of factors influencing the adoption of climate-smart agricultural practices. Mitigation and Adaptation Strategies for Global Change, 29(2)..
- Liu M, Chen X, Jiao Y. Sustainable Agriculture: Theories, Methods, Practices and Policies. Agriculture. 2024; 14(3):473. https://doi.org/10.3390/agriculture14030473
- MacLaren, C., Mead, A., van Balen, D., Claessens, L., Etana, A., de Haan, J., ... & Storkey, J. (2022). Long-term evidence for ecological intensification as a pathway to sustainable agriculture. *Nature Sustainability*, 5(9), 1-10. doi:10.1038/s41893-022-00911-x
- Mailumo, S., Onuwa, G., & Oyewole, S. O. (2021, February 28). ADOPTION OF CLIMATE SMART AGRICULTURE AMONG FOOD CROP FARMERS IN BIRNIN-KUDU LOCAL GOVERNMENT AREA, JIGAWA STATE, NIGERIA. Russian Journal of Agricultural and Socio-economic Sciences. https://doi.org/10.18551/rjoas.2021-02.20
- Mitra, S., Mehta, P. K., & Mishra, S. K. (2021, July 14). Farmers' perception, adaptation to groundwater salinity, and climate change vulnerability: insights from North India. Weather, Climate, and Society. https://doi.org/10.1175/wcas-d-20-0135.1
- Mosquera-Losada, M.R., McAdam, J.H., Romero-Franco, R., Santiago-Freijanes, J.J., Rigueiro-Rodróguez, A. (2009). Definitions and Components of Agroforestry Practices in Europe. In: Rigueiro-Rodróguez, A., McAdam, J., Mosquera-Losada, M.R. (eds) Agroforestry in Europe. Advances in Agroforestry, vol 6. Springer, Dordrecht. https://doi.org/10.1007/978-1-4020-8272-6_1
- Mueller, L. et al. (2021). Agricultural Landscapes: History, Status and Challenges. In: Mueller, L., Sychev, V.G., Dronin, N.M., Eulenstein, F. (eds) Exploring and Optimizing Agricultural Landscapes. Innovations in Landscape Research. Springer, Cham. https://doi.org/10.1007/978-3-030-67448-9_1); Gordon, E., Davila, F. & Riedy, C. Transforming landscapes and mindscapes through regenerative agriculture. Agric Hum Values 39, 809–826 (2022). https://doi.org/10.1007/s10460-021-10276-0
- Muhammad, M. (2023, December 2). ASSESSMENT OF RICE FARMERS' PERCEPTION AND ADAPTATION STRATEGIES ON CLIMATE CHANGE IN JIGAWA STATE OF NIGERIA. www.academia.edu. https://www.academia.edu/110393777/ASSESSMENT_OF_RICE_FARMERS_PERCEPTION_AND_ADAPTATION_STRATEGIES_ON_CLIMATE_CHANGE_IN_JIGAWA_STATE_OF_NIGERIA
- Nair, P. K. R. (1993). An introduction to agroforestry. Kluwer Academic Publishers.
- National Academies of Sciences, Engineering, and Medicine. (2019). Improving Data Collection and Measurement of Complex Farms. The National Academies Press..
- O'Donoghue, C., Heanue, K. The impact of formal agricultural education on farm level innovation and management practices. J Technol Transf 43, 844–863 (2018). https://doi.org/10.1007/s10961-016-9529-9
- Ogunjimi, Lawrence & Adekalu, K.. (2002). Problems and constraints of small-scale irrigation (FADAMA) in Nigeria. Food Reviews International - FOOD REV INT. 18. 295-304. 10.1081/FRI-120016207.
- Orifah, M. O. (2021, October 8). Perceived effectiveness of adaptation strategies to climate change among rice farmers in Jigawa State, Nigeria: Implication for rice production. Fudutse. https://www.academia.edu/56613044/Perceived_effectiveness_of_adaptation_strategies_to_climate_change_among_rice_farmers_in_Jigawa_State_Nigeria_Implication_for_rice_production
- Pingali, P., Aiyar, A., Abraham, M., Rahman, A. (2019). Rural Livelihood Challenges: Moving out of Agriculture. In: Transforming Food Systems for a Rising India. Palgrave Studies in Agricultural Economics and Food Policy. Palgrave Macmillan, Cham. https://doi.org/10.1007/978-3-030-14409-8_3
- Postel, S. (1999). Pillar of Sand: Can the Irrigation Miracle Last? Worldwatch Institute..

- Rakocy, J. E., Masser, M. P., & Losordo, T. M. (2006). Recirculating aquaculture tank production systems: Aquaponics—integrating fish and plant culture. SRAC Publication.
- Reganold, J. P., & Wachter, J. M. (2016). Organic agriculture in the twenty-first century. Nature Plants.
- Reyes SRC, Miyazaki A, Yiu E, Saito O. (2020). Enhancing Sustainability in Traditional Agriculture: Indicators for Monitoring the Conservation of Globally Important Agricultural Heritage Systems (GIAHS) in Japan. Sustainability; 12(14):5656. https://doi.org/10.3390/su12145656
- Sapbamrer, R., Sittitoon, N., Thongtip, S., Chaipin, E., Sutalangka, C., La-Up, A., Thirarattanasunthon, P., Thammachai, A., Suwannakul, B., Sangkarit, N., Kitro, A., Panumasvivat, J., & Srisookkum, T. (2024, March 25). Socio-demographic, agricultural, and personal protective factors in relation to health literacy among farmers from all regions of Thailand. Frontiers in Public Health. https://doi.org/10.3389/fpubh.2024.1364296
- Scaling Climate- and Nutrition-Smart Crops in North Nigeria - HarvestPlus. (2023, January 13). HarvestPlus. https://www.harvestplus.org/what-we-do/projects/scaling-climate-and-nutrition-smart-crops-in-north-nigeria/
- Scoones, I. (2021, October 1). Sustainable Rural Livelihoods. A Framework for Analysis. IDS Working Paper 72. Ids. https://www.academia.edu/54576367/Sustainable_Rural_Livelihoods_A_Framework_for_Analysis_IDS_Working_Paper_72
- Sinha, D. (2014, November 21). Institutional Factors Affecting Agriculture in India. Your Article Library. https://www.yourarticlelibrary.com/agriculture/institutional-factors-affecting-agriculture-in-india/42298
- Tangonyire, D. F., & Akuriba, G. A. (2020, May 21). Socioeconomic factors influencing farmers' specific adaptive strategies to climate change in Talensi district of the Upper East Region of Ghana. Ecofeminism and Climate Change. https://doi.org/10.1108/efcc-04-2020-0009
- The Framework - Sustainable Livelihoods Canada. (2021, December 15). Sustainable Livelihoods Canada. https://slcanada.org/the-framework/
- The World Bank Implementation Status & Results Report, 2009. THIRD NATIONAL FADAMA DEVELOPMENT PROJECT (FADAMA III) (P096572)
- Tilleard, S., Turral, H., Ketelsen, T., Whiting, L. (2023). Climate Change, Water Scarcity and Agriculture: Lessons from the Countries of the Lower Mekong. In: Ojha, H., Schofield, N., Camkin, J. (eds) Climate Risks to Water Security. Palgrave Studies in Climate Resilient Societies. Palgrave Macmillan, Cham. https://doi.org/10.1007/978-3-031-16648-8_10
- Tilman, D., Cassman, K. G., Matson, P. A., Naylor, R., & Polasky, S. (2002). Agricultural sustainability and intensive production practices. Nature
- Trigo A, Marta-Costa A, Fragoso R. Principles of Sustainable Agriculture: Defining Standardized Reference Points. Sustainability. 2021; 13(8):4086. https://doi.org/10.3390/su13084086
- Veeresh, G. K. (2006). References. In Organic Farming (pp. 164–167). references, Foundation Books.
- Voltr V, Wollnerová J, Fuksa P, Hruška M. Influence of Tillage on the Production Inputs, Outputs, Soil Compaction and GHG Emissions. Agriculture. 2021; 11(5):456. https://doi.org/10.3390/agriculture11050456
- Wadumestrige Dona CG, Mohan G, Fukushi K. (2021). Promoting Urban Agriculture and Its Opportunities and Challenges—A Global Review. Sustainability. 2021; 13(17):9609. https://doi.org/10.3390/su13179609
- Walia, S.S., Kaur, T. (2022). Integrated Farming Systems: Research, Extension and Scope in Punjab. In: Bahar, F.A., Anwar Bhat, M., Mahdi, S.S. (eds) Secondary Agriculture. Springer, Cham. https://doi.org/10.1007/978-3-031-09218-3_5
- Wood, J. W. (2020). References. In The Biodemography of Subsistence Farming: Population, Food and Family (pp. 452–498). ref-list, Cambridge: Cambridge University Press.
- Zarea, M.J. (2010). Conservation Tillage and Sustainable Agriculture in Semi-arid Dryland Farming. In: Lichtfouse, E. (eds) Biodiversity, Biofuels, Agroforestry and Conservation Agriculture. Sustainable Agriculture Reviews, vol 5. Springer, Dordrecht. https://doi.org/10.1007/978-90-481-9513-8_7
- Zhang, H., Jiang, S., Du, B. et al. Tillage Intensity and Planting Density Significantly Affected Photosynthesis, Growth, and Yield of Rice. J Plant Growth Regul 42, 2662–2671 (2023). https://doi.org/10.1007/s00344-022-10735-w
- Zhang, N., Wang, M., & Wang, N. (2002). Precision agriculture—a worldwide overview. Computers and Electronics in Agriculture. : Pretty, J. (1995)

Adenle, Ademola. (2016). A Participatory Appraisal of Dry Season Fadama Farming as an Adaptation Measure To Climate Change and Variability In Southern Guinea Zone of Nigeria. Advances in Multidisciplinary & Scientific (AIMS) Research Journal. 2. 329-342.

Jigawa Set to Produce 2m Tonnes of Wheat - THISDAYLIVE. (2024, January 5). https://www.thisdaylive.com/index.php/2024/01/05/jigawa-set-to-produce-2m-tonnes-of-wheat
Copy
In-Text Citation:
(*Jigawa Set to Produce 2m Tonnes of Wheat - THISDAYLIVE*, 2024)