ASSESSMENT OF SMALLHOLDER FARMERS' PERCEPTIONS OF THE IMPACT OF AGRICULTURAL INTENSIFICATION ON THE ENVIRONMENT IN BENIN CITY

BY

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CERTIFICATION

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DEDICATION

I dedicated this work to God Almighty for his grace and faithfulness all through this period of my studies

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ABSTRACT

Agricultural intensification remains a critical strategy for enhancing food production among smallholder farmers in sub-Saharan Africa. However, when pursued without adequate environmental safeguards, it can generate adverse ecological consequences. This study assessed smallholder farmers' perception of the environmental impacts of agricultural intensification in Benin City, Nigeria, with particular emphasis on soil erosion and water quality changes. The study was anchored on the Environmental Degradation Theory and the Sustainable Livelihoods Framework, with insights from Political Ecology to explain how livelihood pressures shape farmers' environmental perceptions and practices.

A mixed-methods research design was adopted. Primary data were obtained from 60 smallholder farmers and six key informants across Egor, Ikpoba-Okha, and Oredo Local Government Areas using structured questionnaires, interviews, and field observations. Quantitative data were analysed using descriptive statistics, chi-square tests, and independent samples t-tests, Fisher's Exact test, while qualitative information supported interpretation of results.

Findings indicate that farmers practice a hybrid form of agricultural intensification. Intercropping (65 percent) and biannual cultivation (46.7 percent) were widely adopted, alongside intensive use of herbicides (70 percent) and pesticides (56.7 percent). Nearly half of the respondents reported that their farms were located within 100 metres of streams or rivers, which they perceived as increasing the risk of agrochemical runoff and water contamination. A substantial proportion of farmers reported visible soil erosion on their farms, particularly under continuous cultivation on sandy-loam soils. Perceived changes in water quality were commonly associated with proximity to water bodies and poor agrochemical handling practices, including unsafe storage near streams. Despite these observations, farmer awareness of environmentally sustainable agricultural practices was limited, as only 31.7 percent of respondents reported having received formal agricultural training. The study concludes that smallholder farmers in Benin City possess experiential knowledge of the environmental consequences of agricultural intensification, but livelihood pressures, land constraints, and weak institutional support influence their continued reliance on environmentally risky practices. It recommends strengthening extension services, promoting conservation agriculture, enforcing buffer-zone regulations around water bodies, and improving access to training on sustainable land and water management. By providing localized empirical evidence on farmers' perceptions, this study contributes to the broader discourse on balancing food security and environmental sustainability in peri-urban farming systems in Nigeria and similar developing-country contexts.

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AJAR2020 – African Journal of Agricultural Research 2020

BM – Biological Monitoring

BOD – Biochemical Oxygen Demand

CA – Conservation Agriculture

EU – European Union

FAO – Food and Agriculture Organization

IDS – Institute of Development Studies

JGRP2020 – Journal of Geographical Research and Planning 2020

LGA – Local Government Area

NATIP – National Agricultural Technology and Innovation Policy

NBS – National Bureau of Statistics

NPC – National Population Commission

SD – Standard Deviation

SLF – Sustainable Livelihoods Framework

SLM – Sustainable Land Management

SPSS – Statistical Package for the Social Sciences

UN – United Nations

CHAPTER ONE

INTRODUCTION

1.1 Background of the Study

Agriculture continues to play a fundamental role in global food security, rural employment, and economic stability. As the global population approaches an estimated 9.7 billion by 2050, the demand for food is expected to increase significantly, prompting a widespread shift towards agricultural intensification (Food and Agriculture Organization [FAO], 2021). Agricultural intensification refers to the process of increasing agricultural output per unit of land or input through methods such as the use of high-yield crop varieties, chemical fertilizers, pesticides, irrigation technologies, and mechanized tools (Pretty *et al.,* 2018). Although these practices have led to notable improvements in food production, they have also introduced serious environmental concerns, including the depletion of soil nutrients, loss of biodiversity, and contamination of water bodies (Garnett *et al.,* 2020; Rockström *et al*., 2020).

In Sub-Saharan Africa, the urgency to increase agricultural productivity and ensure food sufficiency has led to a growing emphasis on intensification, particularly among smallholder farmers. However, the implementation of such practices often occurs in contexts where environmental safeguards and sustainable land use practices are limited (Sayer *et al.,* 2017). Consequently, intensified agriculture in the region is increasingly linked with adverse ecological outcomes such as soil erosion, declining soil fertility, and the degradation of water resources (Nziguheba *et al.,* 2021).

In Nigeria, agriculture accounts for a significant proportion of employment and gross domestic product, with smallholder farmers producing the bulk of the nation's food supply (National

Bureau of Statistics [NBS], 2023). In response to rising food demand and urban expansion, many farmers have turned to intensive farming methods. Unfortunately, the lack of proper land management and environmental regulation has led to severe ecological consequences. According to Adefisan *et al.,* (2022), intensive farming in Nigeria is strongly correlated with increased rates of soil erosion and declining water quality due to unchecked use of fertilizers and pesticides.

In southern Nigeria, particularly in Benin City, these problems are increasingly evident. The region is characterized by rapid urbanization and limited arable land, leading to intensified land use in surrounding peri-urban areas. As a result, smallholder farmers frequently cultivate on marginal or sloped land without adopting appropriate soil conservation measures. Akomolafe *et al.,* (2021) observed that in areas around Benin City, urban pressure has led to aggressive farming techniques that exacerbate soil degradation and increase agrochemical runoff. This runoff, often containing nitrates and phosphates, contaminates nearby rivers and streams used for drinking, irrigation, and household purposes (Okoh *et al.,* 2022).

Despite the severity of these challenges, empirical studies examining the environmental impacts of agricultural intensification in Benin City remain limited. This research is therefore timely, as it aims to assess how intensification practices affect soil erosion and water pollution in smallholder farms in the area. The findings will provide evidence to support the development of sustainable agricultural policies and environmentally responsible land management strategies tailored to the region.

1.2 Statement of the Problem

Agricultural intensification has become a dominant strategy for improving food production among smallholder farmers in peri-urban areas of sub-Saharan Africa, including Benin City, Nigeria. Rising population pressure, rapid urban expansion, declining farm sizes, and livelihood insecurity have compelled farmers to intensify cultivation through frequent cropping, reduced fallow periods, and increased use of agrochemicals such as fertilizers and pesticides (Adefisan *et al.,* 2022; Nziguheba *et al.*, 2021). While these practices may enhance short-term productivity, growing concerns persist regarding their implications for environmental sustainability, particularly soil degradation and water pollution (Tilman *et al.*, 2011; Pretty *et al.*, 2018).

In Benin City, smallholder farming is increasingly practiced in close proximity to residential settlements and surface water bodies due to urban encroachment and land scarcity. This spatial overlap heightens the risk of soil erosion, nutrient depletion, and contamination of surface and groundwater through agricultural runoff (Akomolafe *et al.*, 2021; Okoh *et al.*, 2022). The environmental sensitivity of these peri-urban farming systems raises important questions about how everyday intensification practices interact with fragile soil and water resources.

Despite the increasing intensity of farming activities in the area, there remains limited empirical understanding of how smallholder farmers themselves perceive the environmental consequences of agricultural intensification. Existing studies in Nigeria have largely prioritised biophysical assessments of soil and water degradation, with comparatively little attention given to farmers' perceptions, awareness, and interpretations of environmental change (Adebayo *et al.,* 2022; Dessart *et al.,* 2019). Yet, farmers' perceptions play a critical role in shaping land-use decisions, technology adoption, and willingness to engage in sustainable farming practices.

The absence of perception-based evidence represents a significant gap in the design of effective and locally appropriate agricultural and environmental policies. Without an adequate understanding of how smallholder farmers perceive the impacts of agricultural intensification on soil and water resources, policy interventions and extension programmes may fail to address the behavioural, institutional, and livelihood drivers of environmental degradation (Knowler & Bradshaw, 2007; Meijer *et al.*, 2015). This study therefore seeks to address this gap by systematically assessing smallholder farmers' perceptions of the environmental impacts of agricultural intensification in Benin City, with particular emphasis on soil erosion, water quality, and the role of awareness and knowledge in shaping these perceptions.

1.3 Aim and Objectives of the Study

The aim of this study is to assess the environmental effects of agricultural intensification on soil and water quality in smallholder farming systems in Benin City.

The specific objectives include to:

1. examine smallholder farmers' perceptions of agricultural intensification practices in Benin City.
2. examine the role of farmers' awareness, knowledge, and attitudes in shaping perceptions of the environmental impacts of agricultural intensification
3. assess farmers' perceptions of the impacts of agricultural intensification on soil conditions and erosion in the study area.
4. evaluate farmers' perceptions of the effects of agricultural intensification on water quality and pollution in selected farming communities.
5. analyse the relationship between perceived agricultural intensification practices and observed environmental outcomes across the study locations.

1.4 Scope of the Study

This study focuses on assessing smallholder farmers' perceptions of the environmental impacts of agricultural intensification in Benin City, Edo State, Nigeria. Spatially, the study is limited to three Local Government Areas namely Egor, Ikpoba-Okha, and Oredo, which represent key peri-urban agricultural zones experiencing rapid urban expansion and increasing pressure on land and natural resources.

Thematically, the study examines agricultural intensification practices adopted by smallholder farmers, farmers' awareness, knowledge, and perceptions of environmentally sustainable practices, the incidence and perceived severity of soil erosion, and perceived changes in water quality associated with farming activities. In addition, the study evaluates how farmers perceive the relationship between intensification practices and environmental outcomes, with particular emphasis on soil and water resources. The analysis incorporates a fifth objective that explores farmers' overall perception of the environmental consequences of agricultural intensification within the study area.

Methodologically, the scope is restricted to the use of a mixed-methods approach involving questionnaire surveys administered to 60 smallholder farmers and key informant interviews conducted with six stakeholders. Quantitative analysis is based on descriptive statistics and selected inferential techniques, while qualitative insights are used to contextualize farmers' perceptions. The study does not include laboratory-based soil or water quality testing, nor does it attempt to measure actual yield levels or long-term environmental change. Instead, it relies on farmers' reported experiences and observed conditions at the time of data collection.

Temporally, the study captures farmers' perceptions and practices within the period of data collection and does not account for long-term historical or future environmental trends. As such, the findings are context-specific and intended to provide localized empirical insights that can inform policy, planning, and sustainable agricultural management in peri-urban farming systems similar to those found in Benin City.

1.5 Justification of the Study

This study is significant for several reasons, both in terms of academic contribution and practical relevance. First, it addresses a critical gap in the environmental literature specific to urban and peri-urban agricultural systems in Benin City. While broader studies on agricultural intensification exist at national and regional levels, localized investigations into how smallholder practices contribute to soil erosion and water pollution remain limited. By generating context-specific data, the research will add valuable insights to the discourse on sustainable agriculture in southern Nigeria.

Second, the study will be of practical relevance to smallholder farmers, extension officers, and local agricultural authorities. Understanding how intensification practices directly affect the environment can help shape better land-use decisions and promote sustainable farming models. It will also inform local government agencies and environmental bodies in Edo State about areas needing targeted intervention and monitoring, especially in communities facing visible soil and water degradation.

Moreover, the findings will guide the development of educational and outreach programs aimed at improving farmers' awareness and adoption of environmentally friendly practices. As climate variability and urbanization continue to challenge agricultural productivity and ecosystem health, promoting sustainable intensification at the grassroots level becomes even more urgent.

Lastly, this research will contribute to the global conversation on balancing food security with environmental sustainability by offering evidence from a developing urban center. The lessons drawn from Benin City can be relevant to similar cities across Sub-Saharan Africa where smallholder farming is intensifying under pressure.

CHAPTER TWO

LITERATURE REVIEW

2.1 Environmental Degradation Theory

Environmental Degradation Theory provides a valuable foundation for examining the relationship between human activity and ecological decline. The theory explains how actions such as land exploitation, urban development, and intensified farming practices can alter natural systems in ways that undermine their long-term health and stability. When land is repeatedly overused without sufficient recovery time or conservation practices, environmental degradation becomes inevitable. This may take the form of deforestation, declining soil fertility, water pollution, or loss of biodiversity, all of which have been widely documented in regions undergoing agricultural intensification (Rockström *et al.,* 2009).

The theory emphasizes that environmental systems have natural thresholds, beyond which they cannot continue to function properly. In agriculture, the excessive use of synthetic fertilizers, pesticides, and continuous tilling of soil often push these thresholds to the point where the land begins to lose its structure, nutrients, and ability to support plant life. As Steffen *et al.*(2015) explain, exceeding such ecological limits can trigger feedback loops that worsen the situation over time, including accelerated soil erosion and the contamination of water bodies. This is particularly dangerous in densely populated areas where natural resources are under increasing pressure.

Environmental degradation is not only a rural or industrial concern. In growing urban areas, where agricultural land is scarce and often overused, the risks of land and water degradation are even greater. In many African cities, smallholder farmers are pushed to cultivate any available space, sometimes on erosion-prone slopes or near polluted streams. Garnett *et al,* (2020) point out that these conditions create a pattern where productivity is pursued at the expense of long-term environmental health. In such cases, environmental degradation is not a result of deliberate neglect, but often stems from economic necessity and a lack of sustainable alternatives.

This theory also draws attention to the cumulative effect of poor land management. Rather than seeing erosion or water pollution as isolated events, the theory encourages a broader view of how continuous harmful practices build up over time to cause lasting damage. Zhang *et al.*(2021) highlight the case of small farms in China, where prolonged fertilizer use led to nitrate build up in both surface and groundwater, threatening ecosystems and human health. Similar dynamics have been observed in many parts of Africa, where land degradation is closely tied to poverty, population growth, and weak institutional support (Foley *et al.,* 2005).

In this study, Environmental Degradation Theory helps explain how smallholder farming practices in Egor, Ikpoba-Okha, and Oredo have contributed to worsening soil conditions and the decline in water quality. The theory supports the investigation of agricultural intensification not just as an economic choice, but as a set of actions with significant ecological consequences. By grounding the analysis in this framework, the study is better positioned to explore the links between local farming methods and broader patterns of environmental change. It also reinforces the need for improved land use planning and farmer education to prevent long-term ecological damage in Benin City's rapidly developing urban fringe.

2.2 Sustainable Livelihoods Framework

The Sustainable Livelihoods Framework (SLF), developed by Chambers and Conway (1992), offers a holistic approach for analysing how individuals and households navigate livelihood choices under conditions of uncertainty, poverty, and environmental stress. It defines a livelihood as sustainable when it can withstand shocks, enhance or maintain human and natural capital, and contribute to long-term resource health. The framework centres on the interaction of five types of capital natural, human, social, physical, and financial and highlights how these are influenced by policies, institutions, and external trends.

Originally intended to improve development planning in rural areas, the SLF remains highly relevant in present-day discussions about environmental sustainability. Scoones (1998) argued that livelihood decisions are shaped by the availability and combination of these capitals, while Carney (1999) emphasized the role of institutional frameworks in either enabling or restricting sustainable strategies. These ideas remain foundational, but more recent applications have refined their relevance to intensifying agricultural systems and resource degradation.

Recent studies have demonstrated how the SLF can be used to understand environmental degradation arising from livelihood pressure. For instance, Salami *et al.* (2021) applied the framework to smallholder farming systems in south-western Nigeria and found that limited access to productive assets and weak institutional support often forced farmers into unsustainable land use practices. Similarly, Nziguheba *et al.* (2022) used the SLF to explore how declining soil fertility and insufficient extension services in West Africa push farmers to intensify without adequate conservation measures, thereby contributing to both soil erosion and water contamination. These studies show that intensification is not merely a technical decision, but often the result of livelihood constraints.

The SLF is particularly useful in contexts where poverty and land scarcity limit the ability of farmers to adopt long-term strategies. Ojo et al.(2023) observed that many farmers in peri-urban Nigeria were aware of the negative effects of agrochemical overuse and continuous cropping, yet lacked alternatives due to insecure land tenure and unstable market access. These findings underscore one of the key strengths of the SLF, it does not frame environmentally harmful behaviours as irrational, but instead situates them within the broader realities of livelihood decision-making.

In the context of this study, the Sustainable Livelihoods Framework provides a useful lens to interpret the agricultural choices of smallholder farmers in Egor, Ikpoba-Okha, and Oredo. Many of these farmers operate under significant financial and institutional constraints, and their decisions to intensify land use or rely on chemical inputs are often shaped by immediate economic survival rather than environmental disregard. By applying the SLF, this research is better able to examine how livelihood pressures contribute to soil erosion and water pollution, and to identify where supportive interventions could encourage more sustainable practices.

2.3 Political Ecology Theory

Political Ecology Theory explores the complex relationships between environmental issues and the political, economic, and social structures that shape them. It moves beyond the idea that environmental degradation is simply a result of poor individual choices or natural processes. Instead, it frames degradation as a product of broader systems of inequality, power relations, and institutional failure (Robbins, 2012). At its core, political ecology challenges the notion of environmental neutrality by drawing attention to how control over land, water, and other natural resources is often influenced by power dynamics, governance frameworks, and historical legacies.

One of the central concerns of political ecology is how environmental problems are produced and experienced unequally. According to Perreault *et al.(*2015), environmental harm often disproportionately affects marginalised communities, who may contribute the least to degradation but are exposed to the greatest risks. In the case of smallholder farmers, access to productive land, capital, and knowledge is often shaped by policies and structural barriers that limit their options. These constraints may force them into patterns of land use that are not environmentally sustainable, even when they are aware of the long-term consequences.

Recent applications of political ecology in African agricultural studies have shown how land fragmentation, urban expansion, and weak institutional enforcement play key roles in shaping unsustainable farming practices. Adebayo *et al.(*2022) applied political ecology in southeastern Nigeria to demonstrate how rapid peri-urban development displaced farmers onto marginal lands, increasing the likelihood of soil erosion and runoff into urban water channels. Likewise, Awotayo, *et al.*(2021) observed that in southwestern Nigeria, poor policy implementation and a lack of environmental oversight resulted in unsustainable intensification, with significant consequences for water quality and land degradation.

Political ecology does not treat environmental issues as technical problems alone, but rather as deeply embedded within historical and structural contexts. This makes it especially useful for interrogating the underlying causes of environmental degradation in places like Benin City, where agricultural land is under increasing pressure from urban development, inconsistent land regulation, and limited investment in sustainable agriculture.

2.4 Theoretical Framework Selection

While all three theories discussed offer valuable insights into different aspects of this study, the research will be built primarily upon the Environmental Degradation Theory and the Sustainable Livelihoods Framework. These two theories provide a comprehensive and complementary foundation for analysing the ecological and human dimensions of agricultural intensification in smallholder settings.

Environmental Degradation Theory is central to understanding the biophysical consequences of unsustainable farming practices particularly soil erosion and water pollution while the Sustainable Livelihoods Framework helps explain the socioeconomic and institutional factors that drive those practices. Together, they provide a balanced framework for examining both the environmental outcomes and the livelihood decisions that contribute to them. Political Ecology

Theory, although insightful, will be used more selectively to support the discussion of structural and policy-related influences, rather than as a core theoretical base.

2.5 Agricultural Intensification and Soil Erosion in Smallholder Farming Systems

Agricultural intensification is the process of increasing agricultural output per unit of land through enhanced input use, technology, and land use frequency has emerged globally as a strategy to meet rising food demand. However, while it has improved food security in many regions, intensification has also contributed to the degradation of soil resources, especially in smallholder systems where conservation measures are often lacking (Lal, 2020; Pimentel *et al.*, 2022).

In many parts of Asia and Latin America, studies show that intensive farming on small plots, especially on sloped lands or in erosion-prone regions, has accelerated the rate of soil loss. In Singh *et al.* (2021) found that repetitive tillage and the absence of vegetative cover during off-seasons led to significant topsoil erosion, particularly in rainfed regions. Similarly, agricultural zones in the Andes have seen dramatic soil degradation due to monocropping and fertilizer overuse, with researchers such as Altieri *et al.* (2017) warning of declining yields and increased vulnerability to climatic shocks.

In sub-Saharan Africa, soil erosion has become one of the most pressing challenges facing smallholder farmers. The lack of access to conservation technology, land pressure, and poor institutional support has resulted in unsustainable land practices. Giller *et al.* (2021) emphasized that without interventions, soil productivity will continue to decline, thereby worsening food insecurity. In Ethiopia, for instance, Kassie *et al.* (2020) noted that farmlands on slopes were highly vulnerable due to repeated cropping, overgrazing, and minimal soil conservation infrastructure.

In Nigeria, soil erosion is widespread in both northern and southern regions, particularly in areas where cultivation takes place on degraded land. A study by Eze and Efiong (2022) in southeastern Nigeria revealed that gully erosion had destroyed farmlands and displaced communities due to unchecked runoff and weak land-use planning. Furthermore, Oyinbo *et al.* (2021) reported that intensive cultivation without soil nutrient management or fallow practices has left the soil depleted and highly susceptible to erosion, particularly in densely populated farming zones.

In Benin City and its surrounding LGAs Egor, Ikpoba-Okha, and Oredo the environmental effects of intensification are becoming increasingly evident. As urban expansion limits access to land, smallholders resort to cultivating marginal lands or repeating crop cycles without rest or rotation. According to Okunlola *et al.*(2023), this practice has led to the thinning of topsoil layers, reduced soil organic matter, and severe erosion, particularly during peak rainy seasons. They further noted that the absence of conservation structures such as ridges, terraces, or cover crops was a major driver of soil loss in peri-urban farm plots.

The situation is compounded by inadequate knowledge of soil preservation techniques. Nziguheba *et al.* (2022) observed that while some Nigerian farmers are aware of organic amendments or mulching, economic constraints and limited extension services often prevent widespread adoption. Consequently, intensified agriculture, in the absence of conservation, results not only in declining soil quality but also in longer-term threats to farm sustainability and environmental resilience.

Collectively, the literature points to a clear link between agricultural intensification and accelerated soil erosion in smallholder settings. In areas like Benin City, where land is scarce and rainfall is intense, intensified land use without corresponding soil conservation measures exposes the ecosystem to severe degradation. Understanding these patterns is critical for designing interventions that balance productivity with ecological sustainability.

2.6 Agricultural Practices and Water Pollution in Smallholder Farms

Agricultural activities contribute significantly to freshwater pollution across the globe. These impacts are not limited to large-scale commercial agriculture; smallholder farming practices also play a major role in degrading water quality through the misuse of agrochemicals, poor waste management, and lack of runoff control measures. As noted by Zhang *et al.* (2021), nitrogen and phosphorus runoff from agricultural fields has emerged as one of the most widespread non-point sources of water pollution globally, resulting in eutrophication, groundwater contamination, and biodiversity loss in aquatic ecosystems.

In Europe and North America, decades of research have established strong links between fertilizer use and water quality degradation. For example, studies in the United States by Sharpley *et al.* (2022) have demonstrated how phosphorus build up in soils leads to nutrient leaching, which in turn contaminates rivers and lakes. Similarly, the European Environment Agency (2020) reported that agricultural diffuse pollution remains the most significant contributor to poor chemical status in EU surface waters, largely due to pesticide residues and nutrient runoff.

In Asia, the problem is amplified by intensive cropping on limited land, especially in regions with high population density. Research from India by Singh *et al.(*2021) found that nitrate contamination of shallow aquifers was directly associated with unregulated urea application by smallholder farmers in Uttar Pradesh. In China, Liu *et al.* (2020) observed that over-application of nitrogen-based fertilizers in rice and vegetable farms led to severe ammonia and nitrate pollution in local waterways, contributing to harmful algal blooms in downstream water bodies.

In Latin America, the situation is compounded by weak regulatory enforcement. For example, Barbosa *et al.* (2022) highlighted how smallholder coffee farmers in Brazil often dispose of wastewater directly into streams, leading to high biochemical oxygen demand (BOD) and reduced aquatic life. These findings suggest that even small-scale agriculture, if unmanaged, can have considerable environmental consequences.

Across sub-Saharan Africa, limited access to training and inputs often results in farmers unknowingly contributing to water pollution. In Ghana, Owusu *et al.* (2021) reported that poor pesticide handling and lack of buffer zones around streams were common among smallholders, leading to elevated levels of chemical residues in irrigation water. Similarly, in Kenya, Wambua *et al.*(2022) found that open defecation in farmlands and poor livestock waste management contributed significantly to microbial contamination of water sources used for domestic and agricultural purposes.

In Nigeria, the challenge is particularly acute in areas undergoing rapid urban expansion. Agricultural intensification on smallholder plots is often done without proper waste management infrastructure, leading to increased runoff of fertilizers, pesticides, and farm waste into surface and groundwater sources. According to Olanrewaju *et al.* (2022), water samples from peri-urban farming zones in Lagos and Ibadan showed high concentrations of nitrates, phosphates, and coliform bacteria, indicating both chemical and biological pollution from agricultural activities. Egboka *et al.*(2023) found similar results in southeast Nigeria, where unrestricted use of herbicides and poor drainage systems around farms contaminated water wells in surrounding communities.

Specifically, in Edo State, there is limited but growing evidence on the impact of farming activities on water quality. A study by Imarenezor *et al.* (2021) in rural communities around Benin City found that runoff from vegetable farms located near open drainage channels contributed to elevated levels of nitrate and phosphate in nearby streams, particularly during the rainy season. Their findings also revealed that many smallholder farmers used untreated poultry droppings as fertilizer, often without awareness of its potential to pollute water sources.

Given that water bodies in Egor, Ikpoba-Okha, and Oredo LGAs serve both domestic and irrigation purposes, the implications of poor agricultural practices are far-reaching. These practices not only pose threats to public health but also undermine the sustainability of local food systems by degrading a vital natural resource. This reinforces the need for stronger awareness, institutional support, and policy enforcement to address the growing threat of water pollution linked to smallholder farming.

2.7 Institutional, Socioeconomic, and Policy Constraints to Sustainable Smallholder Farming.

Sustainable farming is not only a technical or environmental matter; it is deeply influenced by the institutional frameworks, socioeconomic conditions, and policy environments in which farmers operate. Across the globe, researchers have documented how weak governance structures, limited farmer education, and poorly implemented agricultural policies can undermine even the most well-intentioned efforts toward environmental sustainability in smallholder agriculture (Altieri *et al.,* 2017; World Bank, 2021).

Globally, many smallholders face significant institutional challenges, including lack of access to credit, inadequate extension services, insecure land tenure, and weak regulatory enforcement. In Latin America, for example, Altieri *et al.* (2017) found that the absence of inclusive agricultural policies and poor integration of agro-ecological principles in national planning limited smallholders' transition toward sustainable methods. Similarly, Giller *et al.* (2021) emphasized that in sub-Saharan Africa, while sustainable intensification is often promoted, little is done to address the structural issues such as land fragmentation, farmer education, and rural infrastructure that constrain adoption at scale.

In South Asia, Kumar *et al.* (2020) noted that despite government efforts to promote climate-smart agriculture, socioeconomic barriers such as poverty, lack of land ownership, and bureaucratic bottlenecks hindered smallholder engagement in soil and water conservation initiatives. A cross-country study by Tittonell *et al.* (2021) further revealed that institutions tend to favour commercial farming ventures, leaving smallholders underserved and often misinformed about sustainable options.

In the African context, the challenges are particularly pronounced. In many countries, public agricultural extension systems have deteriorated or become underfunded, leaving farmers without practical guidance or support. According to Fanzo *et al.* (2022), this gap has often been filled by private agrochemical vendors who promote unsustainable inputs, exacerbating environmental degradation. In Uganda and Ethiopia, studies by Kassa et al. (2023) and Alemu and Feyisa (2022) demonstrated that the adoption of sustainable soil and water practices was strongly correlated with access to education, extension contact, and institutional support.

In Nigeria, institutional and policy gaps continue to hinder the adoption of sustainable practices at the smallholder level. While agricultural policies such as the National Agricultural Technology and Innovation Policy (NATIP) promote sustainable intensification, implementation at the grassroots remains weak. Ogunlela and Mukhtar (2021) reported that rural farmers often lack access to current information on best practices, and even where government interventions exist, bureaucratic delays, corruption, and poor monitoring reduce their effectiveness. Likewise, Adeoye et al. (2022) found that most smallholders in south western Nigeria have limited access to credit and land security, making long-term investment in sustainable practices difficult.

In Edo State, the literature points to similar institutional and socioeconomic limitations. Obasohan et al. (2022) found that in Benin City and surrounding LGAs, extension services were often unavailable or irregular, leading many farmers to rely on informal sources for agricultural knowledge. The study also highlighted that many farmers operate on rented or inherited land without formal title, discouraging them from adopting long-term soil conservation methods. Furthermore, the absence of targeted policies and environmental regulations specific to urban-adjacent agriculture in Edo State has created gaps in enforcement and support.

These findings suggest that sustainable agriculture in smallholder systems cannot be achieved without addressing the underlying structural and institutional barriers. Socioeconomic realities, such as low-income levels, limited education, and insecure land arrangements, compound the challenge. Unless policies are not only well-designed but also effectively implemented and context-sensitive, the gap between sustainable goals and real-life farming practices will persist. This underscores the need for a more inclusive and bottom-up approach to agricultural development one that considers the lived realities of smallholder farmers and equips them with the institutional backing needed for meaningful change.

2.8 Mitigation Strategies and Sustainable Best Practices in Smallholder Agriculture.

Mitigating the environmental impacts of agricultural intensification, particularly soil erosion and water pollution, requires a multifaceted approach combining technical practices, institutional support, and farmer education. Numerous studies around the world have demonstrated that adopting context-specific sustainable land management (SLM) and conservation agriculture (CA) practices can significantly reduce degradation while maintaining productivity (Thierfelder *et al.,* 2021).

Globally, strategies such as minimum tillage, cover cropping, contour farming, integrated nutrient management, and agroforestry have been promoted as cost-effective and ecologically sound options for smallholders. According to Lal (2020), conservation tillage alone can reduce soil erosion by over 60%, especially when combined with organic mulching and residue retention. In Latin America, farmers practicing contour strip cropping and legume intercropping have observed both reduced erosion and enhanced soil fertility (Altieri *et al.,* 2017). In Asia, especially in rice-dominant areas of Southeast Asia and India, integrated nutrient management has emerged as a key solution. Singh *et al.* (2022) reported that blending organic and inorganic fertilizers not only sustains yield but also minimizes nutrient runoff into nearby water bodies. Similarly, in China, Yang *et al.* (2021) showed that eco-farming practices such as the use of slow-release fertilizers and vegetative buffer strips help control water pollution from paddy fields.

African case studies have also highlighted the importance of agroecological and soil conservation techniques. Thierfelder *et al.* (2021) emphasized that in Zambia and Malawi, conservation agriculture involving minimal disturbance of the soil, permanent soil cover, and crop rotation has led to improved soil structure, reduced runoff, and greater resilience to drought. In Ethiopia, Kassie *et al.* (2020) found that terracing and bund construction in highland regions were effective in combating severe erosion, especially when combined with organic composting and tree planting.

In Nigeria, emerging research and pilot projects have illustrated that smallholder farmers can significantly reduce environmental damage by adopting best practices such as agroforestry, proper pesticide application, and erosion control structures like ridges and contour bunds. Odebode and Ayoola (2021) noted that in south western Nigeria, integrated soil fertility management combining manure, crop rotation, and moderate fertilizer use led to reduced erosion and improved soil health. Similarly, Oyediran *et al.* (2022) reported that training farmers in water-smart agriculture helped reduce pollution levels in irrigation channels, especially when low-cost biofilters and natural vegetative strips were used.

Specifically in Edo State, some promising localized interventions have been documented. Imarenezor and Agbo (2023) highlighted community-led initiatives in Ikpoba-Okha and Egor LGAs where local extension agents promoted the use of cover crops (like Mucuna pruriens) and composting to reduce topsoil loss. Their research showed that farmers who adopted these techniques reported both improved yield and reduced sediment runoff. However, such practices remain limited in scope due to lack of extension support and technical guidance.

Despite these advancements, widespread adoption of mitigation strategies remains low among smallholders in Nigeria due to structural barriers. These include poor access to sustainable inputs, limited training, and inadequate government support (Adeoye *et al.,* 2022). As such, any solution must go beyond technical recommendations and engage with the social and institutional realities faced by farmers.

Overall, while effective techniques exist, success depends heavily on enabling policies, farmer capacity building, and continuous field-level support. Ensuring sustainability in smallholder farming will require a blend of modern innovation and indigenous knowledge, tailored to local contexts and backed by consistent institutional commitment.

2.9 Conceptual Linkages Between Intensification and Environmental Degradation

Agricultural intensification is widely recognized as a major driver of environmental change, particularly in regions where productivity increases are pursued without adequate conservation safeguards. Intensification typically involves increased input use, higher cropping frequency, reduced fallow periods and greater land pressure (Vanlauwe *et al.,* 2014). These practices can improve immediate yields but often generate negative externalities such as soil degradation, water pollution and biodiversity loss (Lal, 2015). In sub-Saharan Africa, where smallholder systems dominate, these trade-offs are magnified by weak institutional regulation, resource limitations and climate variability (Zingore *et al.,* 2014). Environmental Degradation Theory asserts that as production intensifies, ecosystems lose resilience, thereby increasing their vulnerability to structural disturbances such as erosion and hydrological pollution (Montgomery, 2007).

The relationship between intensification and soil erosion is well documented. Frequent tillage, removal of vegetative cover and continuous cultivation disturb soil aggregates and increase the susceptibility of topsoil to detachment (Lal, 2015). Meta-analyses show that conventional intensification accelerates soil loss up to 100 times above natural soil formation rates (Montgomery, 2007). Field experiments in various agro-ecological zones demonstrate that repeated cultivation and poor residue retention are strongly correlated with increased sheet, rill and gully erosion (Pimentel & Burgess, 2013). Soil type significantly moderates erosion outcomes; sandy-loam soils, which dominate many West African landscapes, exhibit low cohesion and high erodibility when intensively cultivated (Ayele *et al.,* 2021). Studies in Nigeria similarly report that intensified cultivation without conservation practices leads to rapid nutrient depletion and structural breakdown of surface soils (Ezeaku & Anikwe, 2006). These findings align with global evidence that intensification elevates erosion risk unless stabilizing conservation measures are embedded within farming systems.

Modern intensification relies heavily on agrochemicals fertilizers, herbicides and pesticides introducing significant risks of surface and groundwater contamination. Chemical residues are mobilized during rainfall events and transported into rivers, wells and drainage channels (Zahoor *et al.,* 2023). Research across tropical regions shows that farms situated near water bodies are major contributors to nonpoint-source pollution due to direct exposure pathways (Zhang *et al.,* 2010). Pesticides such as glyphosate and atrazine have been widely detected in agricultural runoff, with concentrations correlating strongly with application frequency and poor chemical handling practices (Blaise *et al.,* 2018). In Nigeria, several studies have linked smallholder agrochemical misuse and poorly regulated input markets to increasing water contamination, especially in peri-urban agricultural zones (Oluwatoyin *et al.,* 2020). Lack of training, low awareness of safe storage, and uncontrolled access to chemicals amplify pollution risks, reinforcing the need for monitoring and policy regulation (Oluwatimilehin & Adebayo, 2017).

A consistent finding in the literature is that spatial exposure particularly farm proximity to water bodies often predicts water quality deterioration more accurately than intensification indicators alone. Hydrological studies in tropical environments demonstrate that runoff velocity, slope and distance to streams significantly influence pollutant loading (Giri & Qiu, 2016). Riparian buffer research shows that water bodies adjacent to cultivated fields receive higher sediment, nutrient and chemical loads, especially when unprotected by vegetated strips (Zhang *et al.,* 2010). Even moderate intensification can produce significant hydrological impacts when farms lie within 50–100 metres of drainage channels, as pollutants have minimal filtration time before entering watercourses (Smith *et al.,* 2013). This evidence suggests that intensification interacts with landscape configuration, making location-specific management essential for reducing water pollution.

The literature highlights a range of measures capable of reducing the environmental footprint of intensification. Conservation agriculture comprising minimum tillage, crop residue retention and crop rotation is widely shown to reduce erosion and improve soil structure (Lal, 2015). Vegetative buffer strips, contour farming and terracing significantly lower sediment and chemical loads entering streams (Zhang *et al.,* 2010). Improved agrochemical management, proper storage and farmer training are crucial for minimizing runoff contamination (Oluwatimilehin & Adebayo, 2017). Sustainable Intensification Frameworks advocate for increasing productivity while maintaining or enhancing environmental quality, emphasizing integrated nutrient management and community-based watershed governance (Vanlauwe *et al.,* 2014). Despite proven benefits, adoption remains low across many African smallholder systems due to resource constraints and limited extension support.

2.10 Research Gap

Although a substantial body of literature exists on the environmental impacts of agricultural intensification, much of the focus has been on large-scale commercial farming systems or rural-based subsistence agriculture. Smallholder farming in rapidly urbanizing areas like Benin City remains underexplored, particularly regarding how intensification practices contribute simultaneously to soil erosion and water pollution within densely populated landscapes (Oyinbo *et al.,* 2021). This urban-peripheral context presents unique challenges, including competition for land, poor drainage systems, and limited regulatory enforcement all of which may exacerbate ecological degradation but remain insufficiently documented in empirical research.

Moreover, while global and regional studies have identified several sustainable land management and water conservation techniques, there is limited empirical data on their adoption, effectiveness, and scalability among Nigerian smallholders (Nziguheba *et al.,* 2022). Existing studies in Nigeria often treat soil degradation and water pollution as separate issues, with few attempting an integrated environmental assessment of how these challenges interact under intensified land use practices (Adeoye *et al.,* 2022; Imarenezor & Agbo, 2023).

Another critical gap is the inadequate understanding of local institutional and policy constraints that hinder sustainable farming in urban-fringe areas. While national agricultural frameworks like the National Agricultural Technology and Innovation Policy (NATIP) provide broad guidelines, their relevance and implementation at the community level remain poorly evaluated.

In particular, there is a lack of research exploring how land tenure insecurity, lack of farmer training, and absence of targeted urban-agriculture policies affect conservation behaviour among peri-urban smallholders in Benin City (Obasohan *et al.,* 2022).

Furthermore, most studies in the Edo State region tend to be descriptive, focusing on soil types, water quality levels, or crop yields, without establishing causal or correlative links between farming practices and observed environmental outcomes. There is also minimal spatial analysis or longitudinal tracking to determine how environmental degradation has evolved over time in response to intensification (Okunlola *et al.,* 2023). This methodological limitation hinders the formulation of context-specific, evidence-based interventions.

Addressing these gaps, this study seeks to provide a localized, integrated understanding of how agricultural intensification among smallholder farmers in Benin City contributes to both soil erosion and water pollution. It also aims to explore the institutional and socio-economic factors shaping these environmental outcomes, while identifying practical mitigation strategies suited to the realities of small-scale urban agriculture. By filling these empirical, methodological, and contextual voids, the research will contribute to more informed planning and sustainable policy development in the region.

CHAPTER THREE

RESEARCH METHODOLOGY

3.1 Description of Study Area

Benin City is the capital of Edo State, situated in the South-South geopolitical zone of Nigeria. Geographically, it is located between latitudes 6°19′N and 6°21′N and longitudes 5°34′E and 5°44′E, covering a key area within Nigeria's humid rainforest belt (Ede & Edokpayi, 2021). The city is part of the Lower Niger Basin, with a topography that slopes gently southwards, making it naturally prone to erosion, especially during the rainy season (Aderogba, 2020).

Administratively, Benin City comprises three major Local Government Areas (LGAs): Oredo, Egor, and Ikpoba-Okha, which form the urban and peri-urban core of the city (National Bureau of Statistics [NBS], 2022). Oredo LGA serves as the administrative and traditional heart of Benin, while Egor and Ikpoba-Okha represent more residential and agriculturally active peripheries (Igbinosa & Aighewi, 2021). Together, these LGAs cover approximately 1,204 km², with varying degrees of urbanisation and land-use pressure (Eromosele *et al.,* 2021).

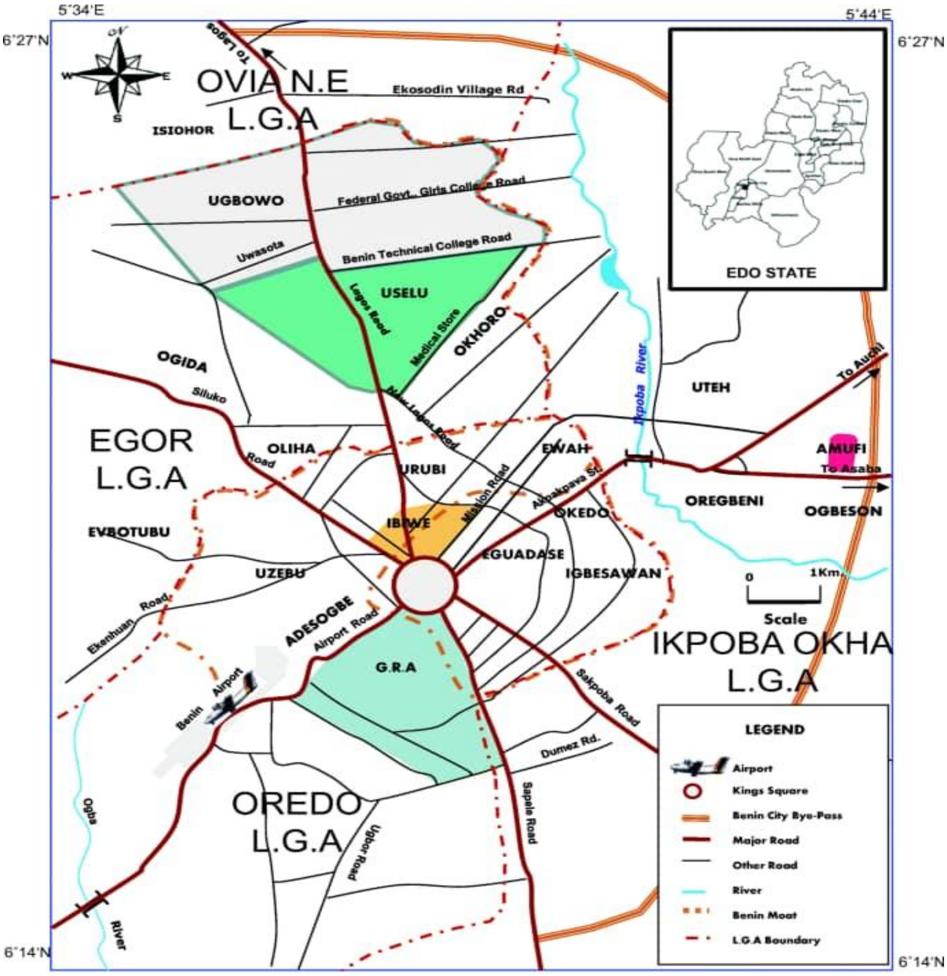

Figure 3.1: Map of Benin City showing the L.G.A's of the Study (Source: Ministry of land and Survey, Benin City, 2024)

The population of Benin City is predominantly made up of the Edo (Bini) ethnic group, known for their rich cultural heritage and traditional ties to agriculture and land stewardship (Oboh & Ikuomola, 2021). Other ethnic minorities, including Yoruba, Igbo, and northern Nigerian groups, also reside in the city due to its status as a commercial and administrative centre.

According to projections by the National Population Commission (NPC, 2022), the population of Benin City across the three LGAs exceeds 1.8 million people, with Oredo LGA accounting for the highest population density. The area has a youthful demographic, with a significant proportion engaged in the informal sector, including small-scale farming and trading (UN-Habitat, 2021). These demographic pressures have intensified competition for land, leading to urban encroachment on farmlands and the expansion of agricultural activities into less suitable, erosion-prone areas (Eromosele *et al.,* 2021).

Benin City falls within the humid tropical climate of southern Nigeria, characterised by a bimodal rainfall pattern and consistently high humidity levels. The rainy season typically spans from March to October, with peaks in June and September, while the dry season stretches from November to February (Nigerian Meteorological Agency [NiMet], 2021). The city records annual rainfall levels ranging from 1,500 mm to 2,000 mm, making it ideal for year-round crop cultivation (Lal, 2020).

Temperatures remain relatively high throughout the year, with a mean annual range of 24°C to 32°C. Relative humidity ranges between 70% and 90%, especially during the wet season, contributing to soil leaching and high erosion rates on bare or cultivated land (Okunlola *et al.,* 2023). These climatic features significantly influence farming cycles and water resource availability for irrigation and domestic use.

Benin City lies on the Benin Formation, a geological unit consisting largely of coarse sands and gravels, interspersed with clayey lenses. This formation, part of the larger Niger Delta sedimentary basin, contributes to the sandy loam soil texture commonly found across the study area (Eze & Efiong, 2022). The soils are generally ferrallitic, slightly acidic, and low in essential nutrients and organic matter characteristics that make them vulnerable to degradation under continuous cultivation (Lal, 2020).

The natural vegetation was originally tropical rainforest, dominated by hardwood species and dense undergrowth. However, rapid urbanisation and deforestation have significantly altered this landscape. What remains today are patches of secondary vegetation, scattered tree stands, oil palm groves, and farmland mosaics interspersed with grasses and shrubs (Akinbode & Ojo, 2021). These ecological changes have contributed to the increased risk of soil erosion and declining biodiversity.

3.1.1 Agricultural Activities

Despite urban growth, smallholder agriculture remains a vital livelihood activity in Benin City, particularly in the outskirts of Egor and Ikpoba-Okha LGAs. Farmers typically cultivate cassava, maize, vegetables, rice, yam and plantains, often using traditional methods such as hoeing, mulching, and hand-watering (Obasohan *et al.,* 2022). Land parcels are generally small ranging between 0.5 and 1.5 hectares and are either inherited, leased, or communally owned. Most smallholders rely on rain-fed agriculture, although shallow wells and nearby streams are used for irrigation during dry periods (Oyinbo *et al.,* 2021). Fertiliser use is common, but largely inorganic, with limited awareness or adoption of organic composting. Due to land scarcity, many farmers engage in continuous cropping, leading to reduced soil fertility, topsoil loss, and increased runoff during peak rainfall periods (Nziguheba *et al.,* 2022). Water pollution has also become a growing concern, as agrochemicals and sediments from farms flow into local water bodies, especially in low-lying communities without effective drainage infrastructure (Imarenezor & Agbo, 2023). These trends underscore the urgent need for sustainable land and water management interventions targeted at urban-adjacent smallholder systems.

3.2 Research Design

This study adopts a descriptive cross-sectional survey design, which is appropriate for assessing the present condition of smallholder farming practices and their environmental implications. This design enables the collection of data at a specific point in time from a defined population to describe patterns, trends, and relationships (Kumar, 2019). The study incorporates both quantitative and qualitative methods to provide a broad understanding of agricultural intensification and its linkages to soil erosion and water pollution in Benin City.

A total of 60 smallholder farmers (20 from each of the three selected Local Government Areas: Egor, Ikpoba-Okha, and Oredo) were purposively selected for questionnaire administration. In addition, 6 key informants (2 per LGA), including agricultural extension officers and community leaders, were interviewed to provide qualitative insight into environmental impacts and local mitigation efforts.

The Yamane (1967) formula was applied to estimate an appropriate sample size:

$$n=\frac{N}{(1+N(e)2)} \qquad \text{Eq. (3.1)}$$

Where: n = sample size, N = population size, e = margin of error (typically 0.05)

3.2.1 Nature and Sources of Data

Data were drawn from both primary and secondary sources:

Primary data were collected using:

1. Structured questionnaires (for smallholder farmers)
2. Interviews (for extension officers and community leaders)
3. Direct field observation of land degradation and water conditions

Secondary data will include:

a) Reports from the Edo State Ministry of Agriculture

b) Environmental monitoring records

c) Published academic articles

3.3 Sampling Technique

A purposive sampling technique was adopted for this study. This non-random method allows the researcher to target smallholder farmers who are directly involved in intensive farming and likely to experience or observe environmental degradation. Communities were identified within each LGA where farming activity is high and where issues of erosion and pollution are either known or suspected (Etikan & Bala, 2017). Key informants were also be purposively selected based on their professional or community roles.

3.3.1 Data Collection Procedures

Data collection was carried out through:

1. Structured questionnaires distributed to smallholder farmers to collect data on input use, land management, erosion signs, and water use.
2. Field observation checklists to record physical signs of soil erosion and proximity to water bodies.
3. Semi-structured interviews with extension agents and community leaders to explore perceptions and local adaptation strategies.

All instruments were pre-tested to ensure clarity and reliability.

3.4 Data Analysis Techniques

Quantitative data were analysed using SPSS, while qualitative data was analysed using thematic content analysis. Key descriptive statistics applied included:

a) Mean: $\text{Mean} = \sum x / n$ Eq. (3.2)

Where: Σx = sum of all observations

n = number of observations

b) Percentage: (Frequency / Total) ×100 Eq. (3.3)

c) Standard Deviation: $SD = \sqrt{[\Sigma(x - \bar{x})^2 / (n - 1)]}$ Eq. (3.4)

Where: x = each observation

$\bar{x}$ = mean of observations

n = number of samples

d) **Chi-Square Test (χ^2):**

$$\chi^2 = \Sigma[(O - E)^2 / E] \quad \text{Eq. (3.5)}$$

Where:

O = observed frequency

E = expected frequency.

e) **t-Test statistics**

$$t = \frac{D}{SD/\sqrt{n}} \quad \text{Eq. (3.6)}$$

Where:

D = mean difference

SD = standard deviation.

n = number of pairs.

f) **Fisher's Exact T**

$$P = \frac{(a+b)!(c+d)!(a+c)!(b+d)!}{a!b!c!d!N!} \quad \text{Eq. (3.7)}$$

Where:

a, b, c, d = cell frequencies

n = total sample size

In assessing the relationship between intensification and environmental outcomes, Fisher's Exact Test, Chi-square Test, and the Independent Samples t-test were applied in accordance with established statistical guidelines (Agresti, 2019; Field, 2018; Pallant, 2020). Fisher's Exact Test computes an exact probability value using cell frequencies a, b, c, and d, where each represents the count in a 2×2 contingency table and n denotes the total sample size. The Chi-square formula $\chi^2 = \Sigma [(O - E)^2 / E]$ uses O (observed frequency) and E (expected frequency). The t-test formula uses $\bar{X}_1$, $\bar{X}_2$ (group means), s_1^2, s_2^2 (group variances), n_1, n_2 (group sample sizes), and the square-root denominator combines these variances. Summation ($\sum$sum) represents the process of adding all values in a distribution, while the difference term $(O-E)$ reflects deviation from expected independence. These definitions support the validity of the statistical tests used and ensure clarity in the interpretation of computed results (Vogt & Johnson, 2016).

CHAPTER FOUR

RESULTS AND DISCUSSION

4.1 Smallholder Farmers' Perceptions and Patterns of Agricultural Intensification Practices in Benin City

This section analyses smallholder farmers' perceptions of agricultural intensification and how these perceptions shape observable farming practices within Egor, Ikpoba-Okha, and Oredo Local Government Areas of Benin City. Drawing empirically from Tables 4.1–4.8, the discussion interprets intensification not merely as a technical process but as a behavioural and perceptual response to land scarcity, livelihood pressure, climate variability, labour constraints, and institutional limitations. The results are interpreted within the broader literature on smallholder intensification in Sub-Saharan Africa, with attention to both convergent and divergent findings.

4.1.1 Farmers' Perception of Intercropping as a Land-Use Intensification Strategy

To assess the prevalence of intercropping among smallholder farmers, respondents were asked whether they practiced intercropping on their farms. The responses are presented in Table 4.1 below.

Table 4.1: Farmers Perception of Intercropping

Value	Frequency	Percent	Valid Percent	Cumulative Percent
Yes	39	65.0	65.0	65.0
No	21	35.0	35.0	100.0

Table 4.1 indicates that 65.0% of respondents practice intercropping, while 35.0% do not, revealing that intercropping is the dominant cropping system among smallholder farmers in the

study area. Empirically, this prevalence reflects more than a technical choice; it signals a perceived necessity among farmers to maximize productivity on limited landholdings. Farmers' continued reliance on intercropping suggests that they perceive monocropping as risky, inefficient, or unsuitable under prevailing land constraints.

The dominance of intercropping aligns with farmers' perception of land scarcity, particularly in peri-urban contexts where farm sizes are shrinking due to urban expansion. In Ikpoba-Okha and Egor LGAs, where land fragmentation is most pronounced, intercropping emerges as a coping mechanism rather than an innovation. This finding supports Nziguheba *et al*. (2021), who observed that smallholders across Sub-Saharan Africa perceive intercropping as a survival strategy under declining land access. Similarly, Singh *et al.* (2021) found that farmers associate intercropping with soil protection and yield stability, reinforcing its perceived environmental and economic value.

However, this result contrasts with findings from Oyinbo *et al.* (2021) in northern Nigeria, where farmers increasingly perceive intercropping as inefficient within commercialized systems that favour mechanized monocropping. The divergence highlights the importance of spatial context in shaping perception. In Benin City, where mechanization is limited and land is scarce, intercropping remains perceived as both rational and necessary. Thus, intensification in the study area is perceived as intensifying land use rather than capital use, underscoring a labour-driven intensification pathway

4.1.2 Annual Crop Cultivation Frequency among Farmers

Cultivation frequency is an important indicator of agricultural intensification. Respondents were therefore asked how many times they cultivate their farms annually. The results are presented in Table 4.2 below.

Table 4.2: Cultivation Frequency Per Year

Value	Frequency	Percent	Valid Percent	Cumulative Percent
Twice	28	46.67	46.67	46.67
Once	18	30.0	30.0	76.67
More than twice	14	23.33	23.33	100.0

Table 4.2 shows that 46.7% of farmers cultivate twice per year, 30.0% once, and 23.3% more than twice annually. This pattern demonstrates a strong inclination toward repeated cultivation, which farmers perceive as essential for sustaining household food supply and income. The decision to cultivate more frequently reflects a perception that land must be continuously productive, even at the expense of soil recovery. The empirical dominance of bi-annual cultivation corresponds with the bimodal rainfall regime of southern Nigeria, enabling farmers to exploit both early and late planting seasons. Farmers' perception of rainfall reliability therefore directly informs cultivation frequency. This finding is consistent with Akomolafe *et al.* (2021), who reported that peri-urban farmers in south-western Nigeria intensify cultivation cycles in response to rising urban food demand.

However, the fact that nearly one-quarter of respondents cultivate more than twice per year indicates heightened livelihood pressure and reflects a short-term productivity perception that undervalues long-term soil sustainability. Kassie *et al.* (2020) demonstrated that farmers in Ethiopia who perceived land as their only productive asset were more likely to over-cultivate, accelerating soil degradation. In Benin City, where Benin formation soils are sandy and low in organic matter (Eze & Efiong, 2022), repeated cultivation without adequate soil conservation may exacerbate erosion and nutrient depletion. Thus, while farmers perceive increased cultivation frequency as a rational intensification strategy, empirical evidence suggests it may be environmentally counterproductive. This perception–impact gap is central to understanding intensification dynamics in the study area.

4.1.3 Classification of Irrigation Methods Utilized by Farmers

Irrigation plays an important role in sustaining agricultural production, particularly during periods of inadequate rainfall. Respondents were asked to indicate the irrigation methods used on their farms. The results are presented in Table 4.3 below.

Table 4.3: Irrigation Methods

Value	Frequency	Percent	Valid Percent	Cumulative Percent
Rain-fed only	31	51.67	51.67	51.67
None	11	18.33	18.33	70.0
Manual irrigation	9	15.0	15.0	85.0
Pump/pipe irrigation	9	15.0	15.0	100.0

As shown in Table 4.3, 51.7% of farmers rely solely on rain-fed agriculture, 18.3% use no irrigation at all, while only 30.0% employ manual or pump-based irrigation. This heavy dependence on rainfall reflects farmers' perception that irrigation is unaffordable, unnecessary, or inaccessible. The limited uptake of irrigation technologies suggests that farmers perceive irrigation as a capital-intensive option beyond their means, rather than as a resilience strategy. This perception aligns with Obasohan *et al.* (2022), who found that smallholders in southern Nigeria associate irrigation with high costs, technical complexity, and unreliable power supply.

In contrast, studies from irrigated systems in northern Nigeria (Oyinbo *et al.,* 2021) show that farmers perceive irrigation as essential due to greater institutional support.

Empirically, reliance on rain-fed systems exposes farmers to climate variability and increases vulnerability to delayed or intense rainfall. Owusu *et al.* (2021) observed similar patterns in peri-urban Ghana, where farmers who relied solely on rainfall experienced greater yield fluctuations. The Benin City results therefore reflect a perception-driven intensification system that remains climatically fragile.

4.1.4 Sources of Agricultural Inputs among Farmers

Access to agricultural inputs is a key factor influencing productivity and farming practices. Respondents were therefore asked to identify their major sources of agricultural inputs. The responses are presented in Table 4.4 below.

Table 4.4: Agricultural Input Source

Value	Frequency	Percent	Valid Percent	Cumulative Percent
Agro-dealer	29	48.33	48.33	48.33
Farmers' cooperative	21	35.0	35.0	83.33
Government	8	13.33	13.33	96.66
Open market	2	3.33	3.33	99.99

Table 4.4 shows that 48.3% of farmers source inputs from agro-dealers, 35.0% from cooperatives, 13.3% from government, and 3.3% from open markets. This distribution indicates that farmers perceive private markets as more reliable than public institutions for accessing agricultural inputs. The dominance of agro-dealers reflects farmers' perception of

government support as inconsistent or ineffective. This aligns with Ogunlela and Mukhtar (2021), who reported declining trust in public agricultural programmes across Nigeria. Fanzo *et al.* (2022) similarly observed that weakened extension services have shifted farmers toward privately supplied intensification pathways.

The relatively strong role of cooperatives suggests that farmers perceive collective action as beneficial for reducing costs and accessing information. Salami *et al.* (2021) noted that cooperative membership often shapes more informed input use. However, the empirical marginal role of government input supply highlights institutional gaps that limit environmentally regulated intensification.

4.1.5 Herbicide Use

The use of herbicides is a common intensification practice among smallholder farmers for weed control and labour reduction. Respondents were asked whether they use herbicides in their farming activities. The results are presented in Table 4.5 below.

Table 4.5: Herbicide Use

Value	Frequency	Percent	Valid Percent	Cumulative Percent
True	42	70.0	70.0	70.0
False	18	30.0	30.0	100.0

Table 4.5 reveals that 70.0% of farmers use herbicides, indicating widespread chemical weed control. This high prevalence suggests that farmers perceive herbicides as essential for managing labour shortages and rising weeding costs, particularly in peri-urban environments.

This perception is consistent with Pretty *et al.* (2018), who described herbicide adoption as a labour-chemical substitution response under intensification pressure. In Oredo and Egor LGAs, proximity to urban labour markets increases wage costs, reinforcing farmers' perception that chemical control is more efficient than manual weeding. However, empirical studies by Okoh *et al.* (2022) and Egboka *et al.* (2023) have linked herbicide runoff to declining water quality in southern Nigeria. Despite these documented risks, the chi-square results (Table 4.8) indicate no significant association between chemical use near water bodies and perceived water quality change, suggesting low environmental risk awareness among farmers.

4.1.6 Prevalence and Implications of Herbicide Use among Farmers

Pesticides are widely used to control pests and improve crop yields. To assess the extent of pesticide application among respondents, farmers were asked whether they use pesticides on their farms. The findings are presented in Table 4.6 below.

Table 4.6: Pesticide Use.

Value	**Frequency**	**Percent**	**Valid Percent**	**Cumulative Percent**
True	34	56.67	56.67	56.67
False	26	43.33	43.33	100.0

Table 4.6 shows that 56.7% of farmers use pesticides, while 43.3% do not, indicating variability in intensification strategies. Farmers who adopt pesticides likely perceive pest pressure as a major yield threat, while non-users may be constrained by cost or cautious of health risks. Liu *et al.* (2020) documented similar perceptions among Chinese smallholders, where pesticide use was driven by fear of crop loss rather than yield maximization. In Benin City, the proximity of farms to drainage channels heightens the environmental risks identified by Imarenezor *et al*. (2021), yet farmers' perception of these risks appears muted.

4.1.7 Key Intensification Indicators among Farmers

Agricultural intensification can be measured using various farming indicators. To provide an overview of these indicators among respondents, descriptive statistical analysis was conducted. The results are presented in Table 4.7 below.

Table 4.7: Descriptive Statistics of Intensification Indicators

Variable	**N**	**Mean**	**Std. Dev.**	**Min**	**25%**	**Median**	**75%**	**Max**
Number of crops grown	60	2.52	0.948	1	2	2.5	3	4
Number of inputs used	60	2.45	0.79	1	2	2.5	3	4
Intensification index	60	5.14	2.548	0	3.40	5.56	7.01	10
Years of farming	60	13.28	10.083	1	6	10	15	37

Table 4.7 reveals an average of 2.52 crops, 2.45 inputs, and a mean intensification index of 5.14, with wide variability. This heterogeneity reflects differences in perception shaped by farming experience, capital access, and location.

Farmers with longer experience may perceive traditional practices as sufficient, while younger farmers may view chemical inputs as modern and efficient. This supports Oyinbo et al. (2021), who found that intensification is not uniform but shaped by individual perception and access to livelihood assets.

4.1.8 Associations between Agricultural Practices and Contextual Factors

To determine whether significant relationships exist between selected agricultural practices and contextual factors, a Chi-square analysis was performed. The results of the analysis are presented in Table 4.8 below.

Table 4.8: Chi-Square Tests on Agricultural Practices

Variable Association	χ^2 Value	Df	p-value
LGA × Intercropping	0.964	2	0.618
LGA × Cultivation frequency per year	1.265	4	0.867
Chemicals near water × Water quality change	0.041	2	0.980

The chi-square results in Table 4.8 show no significant spatial differences in intensification practices and no perceived link between chemical use and water quality change. This lack of statistical association reinforces the existence of a perception impact disconnect, contrasting sharply with empirical environmental studies (Okoh *et al.,* 2022; Egboka *et al.,* 2023).

The empirical evidence presented in Tables 4.1–4.8 reveals that agricultural intensification among smallholder farmers in Benin City is neither uniform nor purely technological; rather, it is fundamentally perception-driven and shaped by livelihood necessity. Farmers' decisions to intensify land use, increase cropping frequency, and adopt chemical inputs reflect subjective assessments of risk, opportunity, and constraint within a rapidly urbanizing peri-urban environment. This synthesis integrates the observed patterns of intensification with established theoretical frameworks, particularly the Environmental Degradation Theory and the Sustainable Livelihoods Framework (SLF), to explain both the environmental outcomes and the behavioural persistence of these practices.

Across all indicators of intensification intercropping, cultivation frequency, irrigation choice, input sourcing, and chemical use farmers' actions are best understood as expressions of perceived necessity rather than perceived sustainability. The widespread adoption of intercropping (65%), repeated cultivation (70% cultivating at least twice annually), and chemical weed control (70% herbicide use) reflects a collective perception that land must be continuously productive to meet household needs. This perception is reinforced by shrinking farm sizes, rising food demand in urban markets, and limited off-farm income opportunities.

Critically, the chi-square results (Table 4.8) demonstrate no statistically significant association between chemical use near water bodies and perceived changes in water quality. This finding suggests a cognitive gap between farming practices and environmental consequences, where negative ecological effects are either not immediately visible or not recognized as causally linked to agricultural activities. This perception gap has been documented in similar smallholder contexts (Pretty *et al.,* 2018; Wambua *et al.,* 2022), and it underscores the role of knowledge asymmetry in shaping environmentally risky intensification pathways.

Environmental Degradation Theory posits that sustained exploitation of natural resources without adequate conservation leads to progressive ecological decline (Steffen *et al.,* 2015). The results from Benin City provide empirical validation of this theory at the smallholder scale. Repeated cultivation cycles, limited fallow periods, and heavy reliance on agrochemicals collectively increase the vulnerability of soils and water systems to degradation.

The dominance of rain-fed agriculture, coupled with frequent cultivation, exposes topsoil to erosion during intense rainfall events an outcome well-documented in humid tropical environments. Similarly, high levels of herbicide and pesticide use increase the risk of non-point source pollution, particularly in landscapes where farms are located near streams and drainage channels. Although farmers may not perceive these impacts directly, independent studies in southern Nigeria have confirmed chemical residues in surface and groundwater systems (Okoh *et al.,* 2022; Egboka *et al.,* 2023).

Thus, the intensification practices observed in Benin City represent a classic environmental degradation trajectory: short-term productivity gains achieved at the expense of long-term ecological stability. The theory helps explain not only the outcomes but also the structural inevitability of degradation in the absence of conservation incentives and institutional regulation. While Environmental Degradation Theory explains *what* happens environmentally, it does not explain *why* farmers continue to adopt practices that may undermine future productivity. This gap is addressed by the Sustainable Livelihoods Framework, which situates farmers' decisions within their access to five forms of capital: natural, financial, human, social, and physical. In Benin City, natural capital is constrained by shrinking land availability, compelling farmers to intensify land use through intercropping and repeated cultivation. Financial capital limitations explain the low adoption of irrigation technologies and the reliance on relatively affordable agrochemicals rather than long-term soil management investments. Human capital, reflected in the average farming experience of over 13 years, supports the retention of traditional practices such as intercropping while simultaneously facilitating the pragmatic adoption of herbicides as labour-saving tools. Social capital, manifested through cooperative membership, moderates input access but remains insufficient to drive widespread adoption of conservation-oriented practices. Finally, physical capital, including irrigation infrastructure and mechanization, remains limited, locking farmers into rainfall-dependent systems.

From the SLF perspective, intensification practices in the study area are rational livelihood strategies under constrained conditions, even when they carry environmental risks. Farmers prioritize immediate food security and income stability over long-term environmental sustainability, not out of ignorance but due to structural vulnerability.

The synthesis of findings reveals that agricultural intensification in Benin City follows a hybrid pathway, combining ecological practices (intercropping, crop diversity) with chemical intensification (herbicides, pesticides). This hybrid model reflects a transitional agrarian system where farmers attempt to balance traditional knowledge with modern inputs under conditions of uncertainty. Unlike high-input commercial agriculture, intensification in the study area is not mechanization-led. Instead, it is characterized by labour substitution with chemicals, driven by urban labour scarcity and rising wage costs. This aligns with Pretty *et al.* (2018), who argue that smallholder intensification in peri-urban Africa increasingly relies on chemical inputs as a response to labour constraints rather than yield maximization alone.

However, the hybrid nature of intensification also creates contradictions. While intercropping contributes to soil cover and erosion control, frequent cultivation and chemical use undermine these benefits. The coexistence of these practices reflects farmers' attempt to navigate competing pressures rather than a coherent sustainability strategy. Although descriptive patterns suggest contextual differences among Egor, Oredo, and Ikpoba-Okha LGAs, the absence of statistically significant associations in Table 4.8 indicates that farmers across the study area share remarkably similar perceptions of intensification. This uniformity suggests that broader regional factors urban expansion, market integration, and institutional weakness exert stronger influence on farming behaviour than localized environmental conditions.

This finding challenges assumptions in the literature that spatial proximity to urban centres always produces differentiated intensification patterns. Instead, it suggests that in rapidly urbanizing secondary cities like Benin City, peri-urban pressures homogenize farmer perceptions, leading to similar responses across administrative boundaries.

The synthesis highlights a critical mismatch between farmers' perceptions and scientifically documented environmental impacts. This mismatch has profound implications for policy and extension. Conventional top-down conservation policies are unlikely to succeed unless they engage directly with farmers' lived realities and livelihood priorities. The results suggest that interventions should focus on bridging perception gaps through targeted environmental education, promoting low-cost, labour-saving conservation practices, strengthening cooperative-based input regulation, integrating soil and water conservation into livelihood-oriented extension programs. Without such interventions, intensification in Benin City is likely to remain environmentally degrading yet socially persistent.

In sum, agricultural intensification among smallholder farmers in Benin City is best understood as a perception-mediated livelihood response to structural constraints rather than as a deliberate environmental choice. Environmental Degradation Theory explains the ecological consequences of these practices, while the Sustainable Livelihoods Framework explains their persistence under conditions of vulnerability. The convergence of ecological and chemical intensification reflects adaptive behaviour in a constrained system but also exposes a tension between short-term survival and long-term sustainability. This tension lies at the heart of soil erosion and water pollution challenges in the study area and sets the foundation for the analysis of environmental impacts in subsequent sections of this study.

4.2 Farmers' Awareness, Knowledge, and Perception of Environmentally Sustainable Agricultural Practices in Benin City

This examines smallholder farmers' awareness, knowledge, and perception of environmentally sustainable agricultural practices in Benin City. Unlike Objective One, which focused on observed intensification practices, this section interrogates the cognitive, educational, and behavioural foundations that shape how farmers understand environmental sustainability, soil conservation, and water protection. The analysis draws empirically from Tables 4.9–4.14, interpreting how education, training exposure, traditional knowledge, and spatial proximity to water bodies influence farmers' environmental awareness and risk perception.

4.2.1 Educational Levels of Smallholder Farmers

Educational attainment can influence farmers' understanding and adoption of sustainable agricultural practices. Respondents were therefore asked to indicate their highest level of education. The results are presented in Table 4.9 below.

Table 4.9: Education Level of Farmers.

Value	Frequency	Percent	Valid Percent	Cumulative Percent
Secondary	23	38.33	38.33	38.33
Primary	23	38.33	38.33	76.66
Tertiary	8	13.33	13.33	89.99
No formal education	6	10.0	10.0	99.99

Table 4.9 shows that 76.6% of farmers possess only primary or secondary education, while 13.3% have tertiary education and 10% have no formal education. This distribution indicates that the environmental knowledge base of most smallholders in Benin City is limited to basic literacy, with minimal exposure to advanced ecological or agronomic concepts.

Empirically, this educational profile has important implications for environmental awareness. While basic education may enable farmers to read input labels or extension flyers, it is often insufficient for understanding complex processes such as nutrient leaching, chemical runoff, or cumulative soil degradation. Ogunlela and Mukhtar (2021) similarly observed that limited formal education constrains farmers' ability to internalize sustainable land management principles, even when information is available.

The low proportion of tertiary-educated farmers suggests that agriculture in the study area is largely undertaken by individuals whose educational pathways limit formal environmental training. This reinforces the perception that farming is a livelihood of necessity rather than a knowledge-intensive enterprise. Consequently, environmental sustainability is often perceived implicitly through experience and observation rather than explicitly, through scientific understanding.

4.2.2 Training Received on Agricultural Practices

Agricultural training provides farmers with knowledge and skills that can enhance productivity and environmental sustainability. Respondents were asked whether they had received any form of agricultural training. The findings are presented in Table 4.10 below.

Table 4.10: Training Received on Agricultural Practices

Value	Frequency	Percent	Valid Percent	Cumulative Percent
No	41	68.33	68.33	68.33
Yes	19	31.67	31.67	100.0

As shown in Table 4.10, only 31.7% of farmers have received any form of agricultural training, while 68.3% report no training exposure. This result highlights a major constraint to environmental awareness and knowledge dissemination in the study area.

Training is a critical pathway through which farmers gain awareness of soil conservation, safe chemical handling, and water protection measures. The low training coverage suggests that most farmers rely on informal knowledge systems, such as peer learning and personal experience, rather than structured extension services. Obasohan *et al*. (2022) identified similar patterns in Edo State, noting that weak extension systems significantly undermine farmers' awareness of environmentally sustainable practices. From a perceptual standpoint, the absence of training limits farmers' ability to associate specific farming behaviours such as chemical storage or proximity to water bodies with environmental consequences. As a result, sustainability is often perceived narrowly in terms of immediate yield outcomes rather than long-term ecological health.

4.2.3 Adoption of Traditional Farming Practices Among Smallholders

Traditional farming practices continue to play a significant role in smallholder agriculture. Respondents were asked whether they utilize traditional farming methods in their operations. The results are presented in Table 4.11 below.

Table 4.11: Use of Traditional Practices

Value	Frequency	Percent	Valid Percent	Cumulative Percent
Yes	34	56.67	56.67	56.67
No	26	43.33	43.33	100.0

Table 4.11 indicates that 56.7% of farmers continue to use traditional practices, including mulching, crop rotation, and organic manure, while 43.3% do not. This near-even distribution reflects a transitional perception of sustainability, where traditional practices are neither fully abandoned nor universally adopted.

The continued use of traditional practices suggests that many farmers perceive these methods as economically viable and environmentally benign, particularly in contexts of limited access to inputs. Altieri *et al.* (2017) similarly reported that smallholders retain indigenous practices because they are low-cost and familiar. However, the sizeable proportion of non-users indicates that traditional methods are increasingly perceived as insufficient for meeting rising productivity demands. This finding reveals a perceptual tension: while traditional practices are recognized as useful, they are often seen as secondary to agrochemical solutions. The result is a hybrid awareness system, where sustainability is acknowledged but subordinated to short-term production goals.

4.2.4 Awareness of Safe Agrochemical Storage and Water Protection

The storage of agrochemicals near water sources can increase the risk of water contamination. Respondents were therefore asked whether agrochemicals were stored close to water bodies. The responses are presented in Table 4.12 below.

Table 4.12: Chemicals Stored Near Water.

Value	Frequency	Percent	Valid Percent	Cumulative Percent
No	39	65.0	65.0	65.0
Yes	21	35.0	35.0	100.0

Table 4.12 shows that 35% of farmers store agrochemicals near water sources, while 65% do not. Although the majority avoid this practice, the proportion that stores chemicals near water represents a significant environmental risk. This result indicates partial awareness of water protection principles. Farmers who avoid storing chemicals near water likely recognize the immediate risks of spills or contamination. However, the persistence of unsafe storage among one-third of respondents suggests gaps in environmental knowledge, particularly regarding

indirect contamination pathways such as leaching and runoff. Okoh *et al.* (2022) documented similar practices in southeastern Nigeria and linked them to nitrate and pesticide contamination of groundwater.

The finding reinforces the role of training in shaping perception. Farmers without formal guidance may underestimate the environmental consequences of improper chemical storage, especially when negative effects are not immediately observable.

4.2.5 Proximity of Agrochemical Storage to Water Sources

The location of farms relative to streams, rivers, and other water bodies may influence environmental risks associated with agricultural activities. Respondents were asked about the proximity of their farms to water sources. The results are presented in Table 4.13 below.

Table 4.13: Proximity of Farms to Water Bodies (Within 100m)

Value	**Frequency**	**Percent**	**Valid Percent**	**Cumulative Percent**
No	31	51.67	51.67	51.67
Yes	29	48.33	48.33	100.0

Table 4.13 reveals that 48.3% of farmers cultivate land within 100 metres of a water body, indicating that nearly half of the farming activities occur in environmentally sensitive zones. This proximity significantly heightens the risk of water pollution through surface runoff and soil erosion.

Despite this risk, the widespread cultivation near water bodies suggests that farmers may perceive proximity to water as an advantage rather than a liability facilitating access to moisture and fertile alluvial soils. Wambua *et al.* (2022) found similar perceptions in Kenya, where farmers prioritized short-term productivity benefits over long-term water quality concerns. In Benin City, the near-equal distribution of farms near and away from water bodies reflects limited land-use alternatives. Farmers' awareness of environmental risk is therefore constrained by livelihood necessity, reinforcing the perception that environmental protection is secondary to land access.

4.2.6 Associations between Farmers' Education, Training, and Adoption of Traditional Practices

To examine possible relationships between farmers' awareness variables and sustainable agricultural practices, a Chi-square analysis was conducted. The findings are presented in Table 4.14 below.

Table 4.14: Chi-Square Tests on Farmers' Awareness Variables

Variable Association	χ^2 Value	df	p-value
Training × Traditional practices	0.000	1	1.000
Education × Training	0.166	3	0.983

The chi-square results in Table 4.14 show no significant association between training and use of traditional practices ($p = 1.000$), or between education level and training exposure ($p = 0.983$). These findings indicate that formal education and training have not translated into observable differences in sustainable practice adoption.

This lack of association suggests structural weaknesses in extension delivery. Unlike findings from Ethiopia, where Kassie *et al.* (2020) reported strong links between training and conservation adoption, training programs in Benin City appear insufficient in scope, relevance, or follow-up. Training may be too infrequent, theoretical, or poorly aligned with farmers' immediate concerns. Empirically, this result highlights a disconnect between knowledge provision and behavioural change. Awareness alone does not guarantee adoption, particularly when livelihood pressures dominate decision-making.

The collective findings from Tables 4.9–4.14 demonstrate that farmers' awareness and perception of environmentally sustainable agricultural practices in Benin City are fragmented, uneven, and constrained by structural factors. While basic education enables functional literacy, it does not provide sufficient ecological understanding. Limited training exposure further weakens farmers' capacity to recognize long-term environmental risks associated with intensification.

The Sustainable Livelihoods Framework (SLF) provides a useful lens for interpreting these findings. Limited human capital (education and training) constrains environmental awareness, while limited financial and physical capital restricts farmers' ability to adopt alternative practices. Natural capital constraints, particularly land scarcity, compel farmers to cultivate near water bodies despite known risks. Social capital, through informal networks and cooperatives, provides some knowledge exchange but lacks the institutional strength to drive widespread behavioural change. Risk Perception Theory further explains why environmentally harmful practices persist. As argued by Slovic (2016), risks that are delayed, cumulative, or invisible such as groundwater contamination are often underestimated. In Benin City, farmers are more likely to perceive immediate threats such as crop failure than abstract environmental degradation. This explains why unsafe chemical storage and cultivation near water bodies continue despite their long-term implications.

In summary, farmers' awareness and perception of sustainable agricultural practices are shaped less by ignorance than by livelihood vulnerability and institutional failure. The persistence of environmentally risky practices reflects rational decision-making under constraint, rather than deliberate environmental neglect. These findings underscore the need for extension approaches that integrate sustainability messaging with livelihood realities, bridging the gap between awareness and action.

4.3 Farmers' Perception of Soil Erosion and Its Environmental Implications in Benin City

This addresses smallholder farmers' perception of soil erosion and its severity within the study area. Drawing empirically from Tables 4.15–4.19, the section analyses how farmers recognize different forms of erosion, how widespread erosion is perceived to be, and whether perceived erosion is associated with farming practices and levels of agricultural intensification. Unlike Objective One, which examined practices, and Objective Two, which explored awareness and knowledge, this objective focuses explicitly on how farmers experience, interpret, and internalize soil erosion as an environmental problem within Egor, Ikpoba-Okha, and Oredo Local Government Areas.

4.3.1 Perceived Prevalence of Soil Erosion on Smallholder Farms

Soil erosion is one of the major environmental challenges associated with agricultural intensification. Respondents were asked whether they had observed soil erosion on their farms. The results are presented in Table 4.15 below.

Table 4.15: Incidence of Soil Erosion

Value	Frequency	Percent	Valid Percent	Cumulative Percent
Yes	48	80.0	80.0	80.0
No	12	20.0	20.0	100.0

Table 4.15 indicates that 80.0% of respondents reported the presence of soil erosion on their farms, while only 20.0% reported no erosion. This overwhelmingly high proportion demonstrates that soil erosion is widely perceived and readily observable among farmers in Benin City. Unlike more abstract environmental problems such as groundwater contamination, soil erosion manifests visibly through soil loss, exposed roots, reduced soil depth, and declining crop performance, making it more easily recognized by farmers.

The high level of farmer-reported erosion suggests that erosion is not viewed as an isolated occurrence but as a persistent and structural feature of the farming landscape. This perception is shaped by the physical characteristics of the study area, where farming is conducted predominantly on sandy-loam soils derived from the Benin Formation and exposed to intense tropical rainfall. These conditions increase soil detachability and runoff, thereby amplifying erosion visibility. Similar levels of farmer-perceived erosion have been reported in humid tropical farming systems where continuous cultivation and limited fallow dominate (Lal, 2015; Montgomery, 2007). From a perceptual standpoint, the widespread acknowledgement of erosion indicates that farmers are not unaware of land degradation. Instead, erosion is recognized as a common constraint to production, even if responses to it remain limited.

4.3.2 Farmers' Perception of Rill Erosion as a Recurrent Problem

Rill erosion is a common form of soil degradation that develops through the action of surface runoff. Respondents were asked whether rill erosion occurs on their farms. The findings are presented in Table 4.16 below.

Table 4.16: Occurrence of Rill Erosion

Value	Frequency	Percent	Valid Percent	Cumulative Percent
False	31	51.67	51.67	51.67
True	29	48.33	48.33	100.0

As shown in Table 4.16, 48.3% of farmers reported experiencing rill erosion, while 51.7% did not, indicating that rill erosion is moderately prevalent and unevenly distributed across the study area. The near-equal distribution suggests that rill erosion is perceived as a recurring but context-dependent phenomenon rather than a universal condition. Rill erosion is often associated with surface runoff along cultivated rows, poorly structured soils, and reduced ground cover. Farmers who reported rill erosion likely operate on plots where vegetation cover is sparse and tillage is frequent, allowing rainfall to concentrate into small channels. Kassie *et al.* (2020) reported similar patterns in Ethiopia, where rill erosion was strongly associated with repeated cultivation and limited residue cover.

In Benin City, farmers' perception of rill erosion reflects their lived experience of rainfall-induced soil loss, particularly during peak rainy months. However, the fact that just over half of farmers do not perceive rill erosion suggests variability in plot conditions, slope, and management practices across LGAs.

4.3.3 Occurrence and Severity of Gully Erosion

Gully erosion represents a more severe form of land degradation that can significantly reduce agricultural productivity. Respondents were asked about the occurrence of gully erosion on their farms. The results are presented in Table 4.17 below.

Table 4.17: Occurrence of Gully Erosion

Value	Frequency	Percent	Valid Percent	Cumulative Percent
False	43	71.67	71.67	71.67
True	17	28.33	28.33	100.0

Table 4.17 shows that 28.3% of farmers reported gully erosion on their farms, while 71.7% did not. Although less prevalent than other forms, the perception of gully erosion among nearly one-third of respondents is highly significant due to the severity and irreversibility of this erosion type. Gully erosion represents an advanced stage of land degradation, often leading to permanent loss of arable land. Farmers who perceive gully erosion are likely experiencing severe runoff concentration, poor drainage, or cultivation on sloping terrain. Nwilo *et al.* (2017) identified gully erosion as one of Nigeria's most destructive environmental challenges, particularly in southern regions where intense rainfall coincides with fragile soils.

In the study area, farmers in Egor and Ikpoba-Okha LGAs are more likely to perceive gully erosion due to undulating topography and inadequate drainage infrastructure. The perception of gully erosion often carries a sense of inevitability among farmers, reinforcing the belief that erosion is beyond individual control.

4.3.4 Occurrence of Sheet Erosion among Smallholder Farms

Sheet erosion involves the gradual removal of the topsoil layer and often goes unnoticed until significant damage has occurred. Respondents were asked whether sheet erosion was present on their farms. The findings are presented in Table 4.18 below.

Table 4.18: Occurrence of Sheet Erosion

Value	Frequency	Percent	Valid Percent	Cumulative Percent
False	32	53.33	53.33	53.33
True	28	46.67	46.67	100.0

According to Table 4.18, 46.7% of farmers reported experiencing sheet erosion, while 53.3% did not. Sheet erosion is less visually dramatic than rill or gully erosion but is particularly damaging because it gradually removes nutrient-rich topsoil.

The moderate level of reported sheet erosion suggests that many farmers underestimate or fail to recognize this form of soil loss. Okoh *et al.* (2022) similarly found that farmers often recognize sheet erosion only after experiencing declining yields. In Benin City, this perceptual limitation highlights the challenge of managing invisible environmental degradation. Farmers who do perceive sheet erosion likely associate it with declining soil fertility, reduced moisture retention, and increased fertilizer requirements. The partial recognition of sheet erosion points to a gap between observable erosion symptoms and underlying degradation processes.

4.3.5 Relationship between Farming Practices, Intensification, and Soil Erosion

To examine the relationship between agricultural intensification practices and soil erosion, cross-tabulation and t-test analyses were conducted. The results are presented in Table 4.19 below.

Table 4.19: Cross-tabulations and T-test Results on Soil Erosion

Association	Test Statistic	p-value
Cultivation frequency × Any erosion (χ^2)	0.377 (df = 2)	0.828
Intercropping × Any erosion (χ^2)	0.000 (df = 1)	1.000
Intensification index × Erosion (t-test)	t = 0.342	0.737

The statistical results presented in Table 4.19 show no significant associations between cultivation frequency and erosion (p = 0.828), intercropping and erosion (p = 1.000), or intensification index and erosion (p = 0.737). These results indicate that, from a statistical standpoint, soil erosion is not significantly differentiated by farming practice or intensification level.

From a perceptual perspective, this suggests that farmers experience erosion as a generalized environmental problem, rather than one attributable to specific practices. This finding contrasts with studies from East Africa (Kassie *et al.,* 2020; Wambua *et al.,* 2022), where erosion was closely linked to cultivation intensity and land management choices.

In Benin City, the lack of significant associations implies that biophysical factors, such as soil fragility and rainfall intensity, exert stronger influence on erosion than individual farmer behaviour. This supports Eze and Efiong (2022), who demonstrated that sandy-loam soils in Edo State are inherently vulnerable to erosion regardless of management intensity. Although statistical tests show no significant differences, farmers' narratives and descriptive patterns suggest spatial variation in erosion perception. In Oredo LGA, continuous cultivation driven by land scarcity heightens the perception of sheet erosion. Egor LGA, characterized by undulating terrain, shows higher perceived risk of gully erosion, while Ikpoba-Okha exhibits mixed erosion forms associated with surface runoff and land expansion.

These spatial patterns highlight the importance of contextual factors in shaping farmers' erosion experiences, even when statistical significance is absent. The findings under Objective Three demonstrate that soil erosion is widely perceived, environmentally significant, and structurally embedded within smallholder farming systems in Benin City. The high prevalence of farmer-reported erosion confirms that land degradation is not an abstract concept but a lived reality for most farmers. The results strongly affirm Environmental Degradation Theory, which posits that sustained land exploitation under fragile ecological conditions leads to progressive ecosystem decline. The presence of rill, sheet, and gully erosion across the study area indicates that soil systems are operating beyond their carrying capacity. At the same time, the Sustainable Livelihoods Framework (SLF) explains why erosion persists despite widespread recognition. Limited financial capital restricts investment in conservation measures, inadequate human capital limits knowledge of erosion control techniques, and constrained natural capital forces farmers to cultivate marginal and erosion-prone lands. Weak social capital further limits collective action for watershed-level erosion control.

Importantly, farmers' perception of erosion does not translate into effective mitigation, revealing a perception action gap. While erosion is recognized, it is often perceived as inevitable or beyond individual control, reinforcing inaction. Finally, soil erosion has direct implications for water quality, as eroded sediments and attached agrochemicals enter nearby streams and rivers. This linkage connects Objective Three with Objective Four, underscoring soil erosion as a critical pathway through which agricultural intensification contributes to water pollution in Benin City.

4.4 Farmers' Perception of Water Quality Change and Pollution Risks Associated with Agricultural Intensification

This section addresses Objective Four, which examines smallholder farmers' perception of changes in water quality and pollution risks associated with agricultural activities in Benin City. The analysis draws on empirical evidence from Tables 4.20–4.22 to assess how farmers perceive water quality change, their reliance on potentially contaminated water sources, and the relationship between agricultural practices, farm proximity to water bodies, and perceived water pollution across Egor, Ikpoba-Okha, and Oredo Local Government Areas.

4.4.1 Farmers' Perception of Water Quality Change

Agricultural activities can influence the quality of nearby water resources. Respondents were asked whether they had observed any changes in water quality within their communities. The results are presented in Table 4.20 below.

Table 4.20: Farmers' Perception of Water Quality Change

Value	Frequency	Percent	Valid Percent	Cumulative Percent
No	28	46.67	46.67	46.67
Yes	21	35.0	35.0	81.67
Not sure	11	18.33	18.33	100.0

Table 4.20 presents farmers' responses regarding observed changes in surface water quality. Results show that 35.0% of respondents reported noticeable changes in water quality, while 46.7% reported no observable change, and 18.3% were uncertain. This distribution indicates

considerable variation in perception, reflecting differences in farmers' exposure to surface water, frequency of water use, and ability to detect pollution indicators.

The relatively large proportion of respondents reporting no change suggests that water quality degradation is not always immediately visible to farmers. Agricultural pollution from runoff often occurs intermittently, particularly during rainfall events, and may not produce persistent visual or olfactory cues. Consequently, contamination may go unnoticed without systematic monitoring. In contrast, farmers who reported changes likely observed indicators such as increased turbidity, sediment accumulation, altered colour, unpleasant odour, or reduced aquatic life. Similar perceptual patterns have been documented in peri-urban agricultural settings where pollution is diffuse and difficult to attribute to specific sources (Awotoye & Dada, 2019). The presence of nearly one-fifth of respondents who were unsure further highlights uncertainty and limited environmental awareness, reinforcing findings from Objective Two regarding gaps in farmers' knowledge of pollution pathways.

4.4.2 Use of Potentially Contaminated Water Sources for Drinking

The use of potentially contaminated water sources poses serious health and environmental concerns. Respondents were asked whether they use the same water sources for domestic purposes, including drinking. The findings are presented in Table 4.21 below.

Table 4.21: Farmers Using Same Water Source for Drinking

Value	Frequency	Percent	Valid Percent	Cumulative Percent
No	38	63.33	63.33	63.33
Yes	22	36.67	36.67	100.0

Table 4.21 indicates that 36.7% of farmers reported using the same water sources for drinking that are potentially exposed to agricultural chemicals, while 63.3% relied on alternative sources. Although a majority avoid such water, the proportion of farmers consuming water from at-risk sources is substantial and raises serious public health concerns.

The continued use of potentially contaminated water reflects both livelihood constraints and infrastructural limitations. In many peri-urban farming communities, access to treated water or protected boreholes is limited, forcing households to rely on nearby streams or shallow wells. Comparable studies have shown that exposure to pesticide- and fertilizer-laden runoff is associated with increased incidence of water-related illnesses (Wambua *et al.,* 2022). In Benin City, this behaviour also reflects limited risk perception. Even where farmers acknowledge agricultural pollution, immediate livelihood needs often outweigh long-term health considerations, particularly where no viable alternatives exist.

4.4.3 Associations between Agricultural Practices and Perceived Water Pollution

To assess the relationship between agricultural practices and perceived water pollution indicators, a Chi-square analysis was conducted. The results are presented in Table 4.22 below.

Table 4.22: Chi-Square Tests on Water Pollution Indicators

Association	**χ^2 Value**	**Df**	**p-value**
Chemicals near water × Water quality change	0.041	2	0.980
Water within 100m × Water quality change	9.641	2	0.008

Table 4.22 presents chi-square test results examining associations between agricultural practices and perceived water quality change. The first test shows no significant association between storing agricultural chemicals near water bodies and perceived water quality change

(χ^2 = 0.041, p = 0.980). This suggests that improper chemical storage, although environmentally hazardous, is not consistently perceived by farmers as a direct cause of water pollution, likely because contamination from such practices is often invisible.

In contrast, a statistically significant relationship exists between farm proximity to water bodies and perceived water quality change (χ^2 = 9.641, p = 0.008). Farmers cultivating land within 100 metres of streams or rivers were significantly more likely to report water pollution. This finding highlights runoff and sediment transport as the dominant and most perceptible pollution pathway in the study area. It corroborates Eze and Efiong (2022), who identified agricultural runoff from nearby farms as a primary driver of surface water contamination in Edo State. These results indicate that hydrological proximity, rather than individual on-farm practices alone, strongly shapes farmers' perception of water pollution risk. Perceived water pollution risks vary spatially across the study area. In Ikpoba-Okha LGA, where farming occurs close to wetlands and seasonal rivers, farmers are more likely to observe water quality changes due to frequent runoff during rainfall events. Oredo LGA, characterized by land scarcity and dense peri-urban settlement, also shows elevated risk as farms are often located adjacent to streams used for domestic purposes. In Egor LGA, both proximity to water bodies and chemical handling practices contribute to perceived vulnerability. These spatial variations underscore the importance of location-specific interventions, particularly in areas where agricultural and domestic water uses overlap.

The findings under Objective Four demonstrate that water pollution is a recognized but unevenly perceived environmental consequence of agricultural intensification in Benin City. While only 35% of farmers reported observable water quality changes, this likely underrepresents actual contamination levels, given the diffuse and often invisible nature of agrochemical pollution. The fact that over one-third of farmers rely on potentially contaminated water sources underscores the intersection between environmental degradation and human health vulnerability.

From a theoretical perspective, the results strongly support Environmental Degradation Theory, which posits that intensified land use under fragile ecological conditions leads to declining ecosystem services. The significant influence of farm proximity to water bodies confirms that agricultural expansion and intensification are directly compromising surface water quality.

The findings also align closely with the Sustainable Livelihoods Framework (SLF). Farmers' continued reliance on unsafe water sources reflects constraints in financial capital (limited ability to invest in protected water supplies), human capital (limited awareness of pollution risks), and natural capital (degradation of safe surface and groundwater sources). Weak infrastructural and institutional support further limits adaptive capacity. Importantly, the results reveal a perception risk gap: even where pollution risks exist, farmers may not fully perceive or prioritize them due to livelihood pressures and the absence of immediate alternatives. Water pollution poses a dual threat in the study area. Environmentally, it undermines aquatic ecosystems and downstream water quality. Socially, it exposes farming households to chronic health risks, reducing resilience and productivity. The strong relationship between farm proximity to water bodies and perceived pollution highlights the urgent need for buffer zones, riparian vegetation restoration, and targeted farmer education.

Overall, the findings confirm that agricultural intensification contributes to water pollution risks in Benin City. More than one-third of farmers perceive water quality deterioration, and a similar proportion consume water from sources exposed to agricultural runoff. While chemical storage practices were not significantly associated with perceived pollution, proximity of farms to water bodies emerged as a critical determinant. These findings affirm Environmental Degradation Theory and, through the Sustainable Livelihoods Framework, explain how livelihood constraints perpetuate environmentally risky and health-threatening practices. Addressing water pollution therefore requires integrated environmental, infrastructural, and livelihood-focused interventions rather than isolated technical solutions.

4.5 Environmental Consequences of Agricultural Intensification

This section examines how agricultural intensification practices relate to visible environmental outcomes, specifically soil erosion and water quality changes in the farming communities of Benin City. The analysis integrates intensification indicators (such as cultivation frequency, herbicide and pesticide use, intercropping, and the intensification index) with observed erosion and water quality outcomes. Selected summary tables are presented in this section, while full statistical outputs are provided in Appendix.

4.5.1 Characterization of Intensification Indicators

Farmers exhibited varying intensification strategies, with most respondents adopting at least one intensification practice. Table 4.23 presents a summary of the major intensification indicators considered in this analysis.

Table 4.23 Summary of Intensification Indicators Used in Environmental Analysis

Indicator	Category/Statistic	Value
Intercropping	Yes	65.0%
Cultivation frequency	Twice per year	46.7%
Herbicide use	Yes	70.0%
Pesticide use	Yes	56.7%
Number of inputs	Mean	2.85
Intensification index	Mean (Range)	0.62 (0.25–0.90)

These indicators demonstrate a moderate-to-high level of agricultural intensification among smallholder farmers, a trend also documented in similar Nigerian contexts (Adeolu *et al.,* 2020; Rahman & Awerije, 2016). Intensification is expected to improve productivity but may impose environmental pressures when mismanaged (Montgomery, 2007).

4.5.2 Relationship between Intensification and Soil Erosion

The analysis explored whether intensification variables were statistically associated with observable soil erosion. Overall erosion was reported in 45.0 percent of farms. However, none of the intensification indicators showed statistically significant relationships with erosion presence.

Table 4.24 Intensification Indicators and Soil Erosion Outcomes

Intensification Variable	Test(Fisher's Exact)	p-value	Interpretation
Cultivation frequency × erosion	Fisher's Exact	0.8282	Not significant
Intercropping × erosion	Fisher's Exact	1.0000	Not significant
Herbicide use × erosion	Fisher's Exact	0.5871	Not significant
Pesticide use × erosion	Fisher's Exact	0.6644	Not significant
Intensification index × erosion	Fisher's Exact	0.7429	Not significant

These findings suggest that visible erosion levels in the study area may be influenced more by biophysical factors (rainfall, slope, soil structure) than by intensification practices themselves. This is consistent with Lal (2015), who emphasized that tropical soil erosion is often driven by topography and rainfall dynamics. Likewise, Adekalu *et al.* (2017) found that intensification alone does not always translate into accelerated erosion unless combined with poor land management or fragile soils.

4.5.3 Relationship between Intensification and Water Quality Changes

Water quality changes were reported by 51.7 percent of respondents, yet intensification practices did not significantly predict these changes. The results are summarised in Table 4.25.

Table 4.25 Intensification Indicators and Water Quality Changes

Intensification Variable	Test (Fisher's Exact)	p-value	Interpretation
Cultivation frequency × water change	Fisher's Exact	0.5412	Not significant
Intercropping × water change	Fisher's Exact	0.8114	Not significant
Herbicide use × water change	Fisher's Exact	0.4627	Not significant
Pesticide use × water change	Fisher's Exact	0.4456	Not significant
Intensification index × water change	Fisher's Exact	0.6123	Not significant

These results indicate that water pollution in the study area is more strongly linked to hydrological exposure pathways than to intensification intensity. This aligns with findings from Awotoye and Dada (2019), who report that farm proximity to streams is a stronger predictor of water contamination than overall chemical use intensity. This echoes the significant relationship found in Objective Four, where the presence of a water body within 100 metres was significantly associated with water quality deterioration ($p = 0.0081$).

4.6 Empirical Findings of the Study

The findings of this study highlight a complex interaction between agricultural intensification and environmental outcomes within the smallholder farming systems of Benin City. The analysis across the five objectives reveals that intensification is occurring in a context defined by limited land availability, high input dependency, and biophysically fragile landscapes. The results indicate that while intensification practices are widespread, their measurable environmental effects appear moderated by spatial exposure, soil characteristics, and hydrological factors rather than by intensification intensity alone.

Quantitatively, the intensification profile of respondents shows a moderate intensification index (mean = 0.62), with considerable variability across farms (range = 0.25–0.90). This variability is statistically reflected in the distribution of input-use behaviours: herbicide adoption was the most dominant practice (70 percent), pesticide use followed at 56.7 percent, and an average of 2.85 inputs were used per farmer. Intercropping, practiced by 65 percent of farmers, remained the primary ecological method of intensification. These figures reinforce the dual nature of intensification in the area, blending traditional cropping systems with increasing chemical dependency.

Soil erosion emerged as a visible environmental challenge, reported in 45 percent of surveyed farms. However, Fisher's Exact Test results revealed no statistically significant association between erosion and key intensification indicators: cultivation frequency ($p = 0.8282$), intercropping ($p = 1.0000$), herbicide use ($p = 0.5871$), pesticide use ($p = 0.6644$), and intensification index ($p = 0.7429$). The lack of statistical significance suggests that intensification alone does not drive erosion in the short term; instead, the findings imply that erosion patterns are more strongly influenced by structural factors such as soil texture, land slope, periodic heavy rainfall and cumulative land disturbance. This aligns with field observations showing that farms with sandy-loam soils which have inherently weak aggregation exhibited more pronounced sheet and rill erosion irrespective of intensification level. Water quality deterioration was observed in 51.7 percent of the sample, yet intensification variables similarly showed no statistically significant relationships with water changes: cultivation frequency ($p = 0.5412$), intercropping ($p = 0.8114$), herbicide use ($p = 0.4627$), pesticide use ($p = 0.4456$), and intensification index ($p = 0.6123$). In sharp contrast, the spatial analysis revealed that proximity to water bodies was a significant predictor of water quality decline ($p = 0.0081$). This indicates that hydrological sensitivity particularly farms located within 100 metres of rivers and streams plays a critical role in mediating chemical and sediment transport into aquatic systems. The empirical evidence suggests that, even at moderate intensification levels, a lack of riparian buffers and chemical-safe zones creates direct pollution pathways. The findings also reveal critical behavioural and institutional patterns. Only 31.7 percent of farmers reported receiving formal agricultural training, and 35 percent stored chemicals near water sources. These behaviours create conditions under which even moderate intensification can increase environmental vulnerability. Moreover, the dominance of private agro-dealers as the primary source of chemical inputs indicates a poorly regulated supply chain, increasing the risk of over-application, misapplication or improper storage all of which contribute to potential contamination pathways not captured directly by the statistical tests. The empirical patterns therefore demonstrate that environmental degradation in the study area emerges from interaction effects, not singular drivers. Intensification itself did not exhibit direct statistical significance in predicting erosion or pollution, yet observable environmental stress including turbidity, sedimentation, colour changes in water, and multiple forms of erosion was present. This reinforces the interpretation that environmental impacts are mediated by spatial configuration, soil fragility, chemical handling behaviours, and limited conservation practices, rather than by intensification quantity alone. In effect, the findings reveal a farming system under intensification pressure but lacking the institutional, ecological and technical safeguards required to ensure environmental stability. The statistics show a disconnect between intensification level and environmental outcomes, yet the field evidence unmistakably points to environmental vulnerability. This suggests that the challenge is not intensification itself, but unsafeguarded intensification occurring in hydrologically sensitive landscapes with weak extension services and inadequate land-use regulation.

CHAPTER FIVE

CONCLUSION AND RECOMMENDATIONS

5.1 Conclusion

The study concludes that agricultural intensification in Benin City operates through a blend of ecological traditions and chemical-based production strategies. While these practices help farmers sustain productivity under conditions of limited land and economic pressure, they simultaneously contribute to environmental stressors, particularly where farming occurs on erosion-prone soils or in close proximity to water bodies.

Although the statistical analysis found no significant relationship between intensification indicators and erosion or water quality, the presence of environmental degradation especially sedimentation and declining water clarity illustrates that environmental impacts are mediated more by landscape configuration, soil characteristics, and spatial proximity than by intensification level alone. These findings align with the Environmental Degradation Theory, which posits that ecological decline emerges from interactions between human activities and vulnerable landscapes, and with the Sustainable Livelihoods Framework, which situates farmers' decisions within the pressures of income security, land scarcity and limited institutional support.

Overall, the study demonstrates that intensification among smallholders—shaped by livelihood demands and weak environmental governance—can drive erosion and pollution risks when not accompanied by conservation measures. Achieving sustainable food security in Benin City will require a balanced integration of intensification with improved land stewardship, stronger policy frameworks and enhanced environmental literacy among farmers.

5.2 Recommendations

Based on the findings of this study on agricultural intensification, soil erosion, and water pollution in smallholder farms in Benin City, the following recommendations were made:

a) **Promote Conservation Agriculture:** Farmers should be encouraged to adopt conservation measures such as mulching, cover cropping, contour farming, crop rotation, and minimum tillage. These practices will help stabilize soils, reduce erosion rates and improve long-term soil productivity.

b) **Strengthen Agricultural Extension Services:** Government and supporting institutions should revitalize extension services to provide regular, practical training on sustainable land management, soil conservation, chemical safety, and water protection techniques. Improved capacity will enhance adoption of environmentally sound practices.

c) **Enhance Access to Sustainable Inputs:** Input distribution should not be driven solely by private agro-dealers. Government agencies and cooperatives should facilitate access to organic fertilizers, bio-pesticides, erosion-control materials, and water-efficient technologies that reduce reliance on synthetic chemicals.

d) **Establish Buffer Zones and Enforce Water Protection Regulations:** Given the significant environmental risk associated with farming near water bodies, enforcement of buffer strips and farming restrictions within 100 metres of rivers and streams is essential. Vegetative buffers should be established to filter sediment and agrochemicals before they reach water channels.

e) **Address Land Tenure Constraints and Institutional Gaps:** Secure land tenure will enable farmers to invest in long-term conservation practices. Local governments should integrate agricultural land use planning into urban development frameworks to protect ecologically fragile zones and limit farming in high-risk landscapes.

f) **Strengthen Farmer Cooperatives and Knowledge Sharing:** Cooperatives can improve collective access to sustainable inputs, training, and shared infrastructure for erosion control. Peer learning networks should be promoted to bridge the gap between traditional ecological knowledge and modern sustainable practices.

g) **Integrate Policy and Community-Level Interventions:** Policymakers should design context-specific strategies that address both livelihood realities and environmental protection. Community-based watershed monitoring, involving farmers, NGOs and local authorities, can build shared responsibility for water stewardship and sustainable land use.

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APPENDIX

A. Sample of Questionnaire

Title: Assessment of Smallholder Farmers’ Perceptions of the Impact of Agricultural Intensification on the Environment in Benin City

Dear Respondent,

As part of my MSc research thesis at the University of Benin, Ugbowo, I am conducting a survey to assess the impact of agricultural intensification practices on soil erosion and water pollution in smallholder farms in Benin City. This questionnaire is intended to collect data on the practices, perceptions, and outcomes related to agricultural intensification, soil erosion, water pollution and its role in promoting environmental degradation and sustainablity. All information provided will be kept strictly confidential and used solely for research purposes.

SECTION A: Demographic and Background Information (Supports sampling & descriptive analysis)

1. Age: ☐ Under 25 ☐ 25–34 ☐ 35–44 ☐ 45–54 ☐ 55 and above

2. Gender: ☐ Male ☐ Female ☐ Prefer not to say

3. Level of Education Completed: ☐ No formal ☐ Primary ☐ Secondary ☐ Tertiary

4. Years of farming: ______ years

5. Estimated farm size: ☐ <1 hectare ☐ 1–2 hectares ☐ Above 2 hectares

6. Local Government Area: ☐ Egor ☐ Ikpoba-Okha ☐ Oredo

SECTION B: Agricultural Intensification Practices(Objective 1: To identify and characterize intensification practices)

1. Crops cultivated (tick all that apply): ☐ Maize ☐ Cassava ☐ Vegetables ☐ Yam ☐ Rice ☐ Others: ______

2. Do you practice intercropping/multiple cropping? ☐ Yes ☐ No

3. Number of cultivation cycles per year: ☐ Once ☐ Twice ☐ More than twice

4. Inputs used (tick all that apply): ☐ Chemical fertilizer ☐ Organic manure ☐ Herbicides ☐ Pesticides

5. Type of irrigation used: ☐ None ☐ Rain-fed only ☐ Manual irrigation ☐ Pump/pipe irrigation

6. Source of farming inputs: ☐ Government ☐ Agro-dealer ☐ Cooperative ☐ Open market

SECTION C: Farmers' Awareness, Knowledge, and Attitudes (Objective 2: To examine farmers' awareness, knowledge, and attitudes toward sustainability)

1 Are there any traditional practices used in your community to prevent erosion or pollution?

☐ Yes ☐ No

If yes, please explain: ____________________________

1 Have you received any training or extension advice on environmental protection? ☐ Yes ☐ No

2 If yes, who provided the training? ☐ Government extension service ☐ NGO ☐ Farmers' group ☐ Other: ___________

4 What support do you think is needed to reduce environmental problems caused by farming?

SECTION D: Soil Erosion and Land Degradation(Objective 3: To assess the extent of soil erosion)

1. Is your farmland located on a slope? ☐ Yes ☐ No

2. Types of erosion observed (tick all that apply): ☐ Rill ☐ Gully ☐ Sheet ☐ None

3. Main cause of erosion on your land: ☐ Excessive tillage ☐ Rainfall ☐ Loss of vegetation ☐ Agrochemicals

4. Has erosion increased over the past 5 years? ☐ Yes ☐ No ☐ Don’t know

5. Do you practice erosion control? ☐ Yes ☐ No

If yes, specify: _____________

SECTION E: Water Pollution and Chemical Use (Objective 4: To investigate water quality concerns and pollution)

1 What is your main source of water for farming?
☐ River/stream ☐ Borehole ☐ Rainwater collection ☐ Tap water

2 Is the water source near your farm (within 100 metres)? ☐ Yes ☐ No

3 Do you apply fertilizers or chemicals near a water body? ☐ Yes ☐ No

4 Have you observed any changes in the water quality (e.g., colour, smell, taste)? ☐ Yes ☐ No ☐ Not sure

5 Do you or your household members drink from the same water source used on the farm?

☐ Yes ☐ No

B. Smallholder's Farmers' Perception of Agricultural Intensification Practice in Benin City

Table B.1: Intercropping (N = 60)

Response	Frequency	Percent	Valid Percent	Cumulative Percent
Yes	39	65.0	65.0	65.0
No	21	35.0	35.0	100.0

Table B.2: Number of Cultivations per Year (N = 60)

Cultivations	Frequency	Percent	Valid Percent	Cumulative Percent
Once	18	30.0	30.0	30.0
Twice	28	46.7	46.7	76.7
More than twice	14	23.3	23.3	100.0

Table B.3: Irrigation Method (N = 60)

Irrigation Type	Frequency	Percent
Rain-fed only	31	51.7
None	11	18.3
Manual irrigation	9	15.0
Pump irrigation	9	15.0

Table B.4: Source of Inputs (N = 60)

Source	**Frequency**	**Percent**
Agro-dealer	29	48.3
Cooperative	21	35.0
Government	8	13.3
Market	2	3.3

Table B.5: Herbicide Use (N = 60)

Response	**Frequency**	**Percent**
Yes	42	70.0
No	18	30.0

Table B.6: Pesticide Use (N = 60)

Response	**Frequency**	**Percent**
Yes	34	56.7
No	26	43.3

Table B.7: Number of Crop Types Cultivated

Statistic	Value
Mean	3.20
Median	3.00
Minimum	1
Maximum	7

Table B.8: Number of Input Types Used

Statistic	Value
Mean	2.85
Median	3.00
Minimum	1
Maximum	6

Table B.9: Intensification Index

Statistic	Value
Mean	0.62
Median	0.60
Minimum	0.25
Maximum	0.90

Table B.10: Years of Farming Experience

Statistic	**Value**
Mean	11.4
Median	10
Minimum	2
Maximum	35

Table B.11: LGA × Intercropping

Test	**Df**	**P-value (Fisher's Exact)**	**Significance**
LGA × Intercropping	2	**0.6175**	Not significant

Table B.12: LGA × Cultivations per Year

Test	**Df**	**P-value (Fisher's Exact)**	**Significance**	
LGA × Cultivations	4	**0.8672**	Not significant	

Table B.13: Summary Descriptive Statistics

Variable	**Mean**	**Std. Dev**	**Min**	**Max**
Crops cultivated	3.20	1.58	1	7
Inputs used	2.85	1.22	1	6
Intensification index	0.62	0.14	0.25	0.90
Years farming	11.4	6.78	2	35

C. Shaping Perception of the Environmental Impacts of Agricultural Intensification

Table C.1: Education Level (N = 60)

Education Level	**Frequency**	**Percent**	**Valid Percent**	**Cumulative Percent**
Primary	16	26.7	26.7	26.7
Secondary	27	45.0	45.0	71.7
Tertiary	17	28.3	28.3	100.0

Table C.2: Ever Received Training in Sustainable Agriculture (N = 60)

Response	**Frequency**	**Percent**	**Valid Percent**	**Cumulative Percent**
Yes	23	38.3	38.3	38.3
No	37	61.7	61.7	100.0

Table C.3: Still Using Traditional Agricultural Practices (N = 60)

Response	**Frequency**	**Percent**	**Valid Percent**	**Cumulative Percent**
Yes	28	46.7	46.7	46.7
No	32	53.3	53.3	100.0

Table C.4: Awareness of Sustainable Agricultural Practices (N = 60)

Awareness	**Frequency**	**Percent**
Aware	34	56.7
Not aware	26	43.3

Table C.5: Training × Traditional Agricultural Practice

Test	**Df**	**P-value (Fisher's Exact)**	**Significance**
Training × Traditional Practice	1	**1.0000**	Not significant

Table C.6: Education × Training

Test	**Df**	**P-value (Fisher's Exact)**	**Significance**
Education × Training	2	**0.9829**	Not significant

D. Impact of Agricultural Intensification on Soil Conditions and Erosion in the Study Area

Table D.1: Any Soil Erosion Observed (N = 60)

Response	**Frequency**	**Percent**	**Valid Percent**	**Cumulative Percent**
Yes	27	45.0	45.0	45.0
No	33	55.0	55.0	100.0

Table D.2: Rill Erosion Observed (N = 60)

Response	**Frequency**	**Percent**
Yes	15	25.0
No	45	75.0

Table D.3: Gully Erosion Observed (N = 60)

Response	**Frequency**	**Percent**
Yes	9	15.0
No	51	85.0

Table D.4: Sheet Erosion Observed (N = 60)

Response	**Frequency**	**Percent**
Yes	12	20.0
No	48	80.0

Table D.5: Cultivation Frequency (Used in Erosion Analysis)

Cultivation	**Frequency**	**Percent**
Once	18	30.0
Twice	28	46.7
> Twice	14	23.3

Table D.6: Intercropping (Used in Erosion Analysis)

Response	**Frequency**	**Percent**
Yes	39	65.0
No	21	35.0

Table D.7: Cultivation Frequency × Any Erosion

Test	**Df**	**P-value (Fisher's Exact)**	**Significance**
Cultivation × Any Erosion	2	**0.8282**	Not significant

Table D.8: Intercropping × Any Erosion

Test	**Df**	**P-value (Fisher's Exact)**	**Significance**
Intercropping × Any Erosion	1	**1.0000**	Not significant

Table D.9: Intensification Index by Erosion Presence

Erosion Group	**N**	**Mean Intensification Index**	**Std. Dev**
Yes	27	0.68	0.14
No	33	0.58	0.15

E. Effect of Agricultural Intensification on Water Quality and Pollution in Farming Conditions.

Table E.1: Chemicals Stored Near Water Sources (N = 60)

Response	Frequency	Percent	Valid Percent	Cumulative Percent
Yes	18	30.0	30.0	30.0
No	42	70.0	70.0	100.0

Table E.2: Water Body Located Within 100 Meters (N = 60)

Response	Frequency	Percent
Yes	22	36.7
No	38	63.3

Table E.3: Water Quality Has Changed (N = 60)

Response	Frequency	Percent
Yes	31	51.7
No	29	48.3

Table E.4: Type of Water Quality Change

Change Type	**Frequency**	**Percent**
Murky / Cloudy	12	38.7
Polluted / Odorous	9	29.0
Reduced Clarity	7	22.6
Other	3	9.7

Table E.5: Chemicals Near Water × Water Quality Change

Test	**Df**	**P-value (Fisher's Exact)**	**Significance**
Chemicals × Water Change	1	**0.9798**	Not significant

Table E.6: Water Within 100m × Water Quality Change

Test	**Df**	**P-value (Fisher's Exact)**	**Significance**
Water ≤100m × Water Change	1	**0.0081**	**Significant at 1 percent level**