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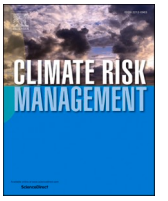

Livelihood diversification among women farmers in Nigeria's flood-resilient drylands

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ABSTRACT

Jigawa State, Nigeria, faces increasing vulnerability to recurrent floods, highlighting the need for alternative socio-economic strategies to enhance livelihood diversification and strengthen the resilience of the most vulnerable groups, particularly women farmers. This study explores the role of livelihood diversification in flood resilience through three key questions: (1) How frequent are floods in northern Nigeria, and what are their perceived impacts? (2) What livelihood diversification strategies do women farmers employ? and (3) What factors enable or hinder the adoption of diversified livelihoods? Data was collected via focus group discussions with women farmers from three communities, supplemented by semi-structured interviews with community leaders and institutional stakeholders, and analysed using coding and content analysis. Results on reported perceptions show that from 2013 to 2023 communities experienced an average of seven flood events, causing significant damage to homes and farmland. Women farmers diversify livelihoods by rotating fast-growing crops (e.g., beans, tomatoes, cassava), planting economic trees, raising livestock, and engaging in off-farm activities like petty trading. Enabling factors include building farmer and institutional stakeholders' capacity, improving climate data access, supporting alternative income activities, strengthening agricultural extension, and providing infrastructural and financial support. However, barriers such as limited access to capital, agricultural insurance, and inequalities in resource distribution among women, along with cultural dynamics and conflicts, hinder progress. Awareness-raising and capacity-building are essential to overcoming these challenges and addressing social barriers. Additionally, limited institutional coordination and inadequate budgetary allocations exacerbate difficulties in achieving effective livelihood diversification for flood resilience. By revealing the factors influencing the resilience and vulnerability of rural women amid recurring floods in dryland Africa, the lessons learned help bridge key knowledge gaps and highlight essential enablers for strengthening adaptive capacities in flood-prone areas.

1. Introduction

Increasingly frequent and higher magnitude weather and climate extreme events have exposed millions of people to several forms of hardship and disaster, with the largest share of such impacts occurring across Africa, Asia, Central and South America, small islands and the Arctic (IPCC, 2023). Amongst these extreme events, flooding – whether caused by natural or human factors – has been defined

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as the most devastating in Africa over the past decade, leading to significant loss of life and severe disruption of livelihoods(Umar & Gray, 2022). In 2020, more than 1 million people were affected by floods in 12 countries in West Africa, where agriculture is the main source of livelihoods of the rural people (Canton, 2021). Flooding devastates infrastructure, destroying houses, displacing communities, and severely disrupting livelihoods (Muhammad & Rilwan, 2020). It also poses significant health risks by contaminating drinking water and spreading waterborne diseases (Abdulmalik et al., 2021). In terms of food security, flooding leads to the loss of crops, agricultural fields, and stored goods, further exacerbating land degradation (Abdulkadir, 2023). These impacts collectively undermine income stability, as affected households struggle to recover from the destruction of assets and reduced agricultural productivity. Addressing these impacts is a building block in attaining a number of Sustainable Development Goals (SDGs), including SDG 1 (no poverty), SDG 2 (zero hunger), SDG 6 (clean water and sanitation), SDG 15 (life on land), and SDG 13 (climate action) (NIHSA, 2023).

Nigeria is one of the West African countries most affected by flooding. In the years 2012 and 2022 the country experienced its worst flood events, affecting 32 and 36 states respectively. The 2012 flood affected more than 7 million people. More than 2 million were displaced, more than 5,000 people physically injured, and over 5,900 houses were destroyed (NEMA, 2013). The World Bank (2022) reported that the 2022 flood led to the loss of 108,392 farms spread over 500,000 ha of land, with 1.4 million people being affected, more than 662 persons killed and thousands of people displaced. The economic loss across all sectors was estimated at US$ 6.68 billion (World Bank, 2022). Between 1996 and 2016, flooding in Jigawa state, located in the drylands of northern Nigeria, accounted for approximately 90 % of all damages caused by natural disasters (Umar, 2016). The widest interval between one flood event and another is estimated at 1.6 years (EMDAT, 2021; Muhammad & Rilwanu, 2020). The 2012 flood event alone affected almost 4 million people and resulted in the death of roughly 400 people, 6,000 injured, and 387,000 displaced in Jigawa State. Guri, Birniwa and Kirikasamma are among the major Local Government Areas that have been devastated by such floods, and therefore require the most urgent attention (Sani, 2023).

In this context, Livelihood Diversification (LD) is defined as the attempts made by individuals and households to undertake diverse income generating activities (both on– and off –farm) over time, to secure survival and improve standards of living, as well as to reduce risk, vulnerability and poverty, and increase income and wealth (Chonabayashi et al., 2020; Memon et al., 2020). LD is considered vital to expand income sources and employment opportunities, particularly for women who are highly dependent on agriculture, with a view to reduce vulnerability to external shocks in times of floods (Ellis, 2000).

Focusing on LD from the perspective of women is essential, as global research consistently shows that women are disproportionately affecteded by climate change due to their socio-cultural roles in traditional households. Women often provide critical labour in agriculture, fishing, herding, commerce, pottery, cloth making, and crafts, positioning them as the backbone of household economic development (Manza et al., 2018; Phuong et al., 2023). Despite their central role in agriculture and food systems, women face persistent challenges in accessing land, labour, markets, and mobility. As a result, they often bear the brunt of climate-related shocks, including flooding, especially in vulnerable and semi-arid regions across Africa (Carr, 2008; Korzenevica et al., 2024). Feminist and gender scholarship has challenged traditional notions of the household as a unitary entity, emphasising instead the gendered nature of resource access, risk exposure, and resilience strategies (Elmhirst, 2011). LD, therefore, is not only an economic response but also a gendered coping strategy shaped by unequal power relations and structural constraints (Kabeer, 1999; Nwokocha and Ezeh, 2020). Significant gender disparities in access to alternative livelihoods and productive assets have been reported in rural Nigeria, Kenya, and Ghana (Loison, 2019; Oyesola & Ademola, 2012; Vercillo et al., 2025). Evidence from Osun State, Nigeria, shows that women who diversify their livelihoods often achieve greater household income gains than men, highlighting the value of women-targeted interventions (Akintunde et al., 2023). Yet, research across sub-Saharan Africa continues to focus disproportionately on male-headed households, often overlooking women's specific experiences and needs (Hegazi & Seyuba, 2024). Integrating gender-responsive perspectives into flood resilience and LD policies is critical for enhancing adaptive capacity and advancing SDG 5 (gender equality), which is foundational for achieving broader development goals (Ha et al., 2023).

Existing knowledge on LD globally has focused on the determinants of LD and related strategies in the face of general hazards (Adepoju and Obayelu, 2013; Amede et al., 2020; Ao et al., 2022; Samal et al., 2016; Shah et al., 2021). Some authors, like Kehinde et al. (2020), laid emphasis on the costs of LD and water provision by arable crop farmers in Nigeria. Lahon and Mahanta (2021) compared flood and non-flood prone areas in India, focusing on how floods drive more intense LD as compared to non-prone areas. However, these studies seldom explore the conditions and actions needed to enhance adopted alternative pathways through an integrated approach that actively involves affected communities, ensuring sustainable livelihood options while aiming to influence policymaking. Similarly, focusing on Nigeria, the existing LD studies commonly lay emphasis on LD as a coping mechanism to reduce food insecurities and poverty among households, but without focusing on flood events (Ahmed et al., 2018; Adejobi et al., 2008; Aminu et al., 2022; Gani et al., 2019; Mamman et al., 2022). For example, Amurtiya et al. (2016) focuses on the socio-economic characteristics of the residents of Adamawa state, in Nigeria along Kiri Dam, showcasing opportunities to diversifying income from the presence of a dam in the locality. Other studies have modelled flood impacts in the northern part of the country, like that by Umar and Gray (2022). Overall, none of these studies have addressed the experiences of women farmers with regard to flood events and LD. This reveals a gap that requires further investigation.

To address this gap, this paper assesses the factors that shape the resilience and vulnerability of rural women in the face of recurring floods, by taking the case of Jigawa State in northern Nigeria as one of the most flood-prone areas in the country. It qualitatively investigates the hypothesis that LD could enhance women's resilience to the negative impacts of floods and improve their socio-economic well-being, by answering the following questions: (1) how frequent are floods in northern Nigeria, and what are their perceived impacts? (2) What LD strategies do women farmers employ? and (3) What factors enable or hinder the adoption of diversified livelihoods? Findings can inform regional to national-level policymakers and institutional stakeholders in Nigeria in

designing more suitable disaster management interventions focused on supporting LD responses to flooding. This requires practical evidence in applying knowledge on the impacts of flood-coping strategies to guide decision-making and shape policies for effective responses. More broadly, the lessons learned are relevant to similar contexts in dryland regions of Africa, particularly in countries facing comparable challenges, where such informed decision-making and policy-shaping are equally critical.

2. Material and methods

2.1. Description of the study area

Jigawa State is one of the 36 states that make up the Federal Republic of Nigeria, located in the north-western region of the country. Jigawa experiences an annual average temperature of 31.2 °C, which is 1.8 % higher than the national average in Nigeria (Kaugama and Ahmed, 2014). The state covers a total land area of approximately 22,410 km^2. The majority of Jigawa lies within the Sudan Savannah biome, with elements of Guinea Savannah in its southern reaches. Jigawa boasts vast fertile arable land that can support the cultivation of nearly all tropical crops, making it a valuable natural resource. Additionally, the Sudan Savannah vegetation zone includes extensive grazing lands suitable for livestock production. However, the state is subject to land degradation and desertification, driven by both climate change and unsustainable land use practices. Its total forest cover falls below the national average of 14.8 % (Murtala & Abdulkadir, 2023). The State has the highest poverty rate in Nigeria, with land degradation worsening due to migration, ongoing conflicts, and the limited recognition of women's rights and roles. Women are disproportionately impacted by poverty and land degradation, given their prominent roles in farming households, and engage largely in unskilled, labour intensive agricultural work, lacking access to finance, training and decision-making. Increasing flooding exacerbates these socio-economic challenges (Tudunwada & Abbas, 2022).

2.2. Research design and methods

Fieldwork was undertaken between September 2023 and April 2024. The research questions were addressed using Focus Group Discussions (FGDs) with women farmers and semi-structured interviews with community leaders, NGOs and policy makers (Table 1). These methods, widely employed in social science research, were selected for their effectiveness in facilitating an in-depth exploration of personal perceptions within small interview samples, leading to the generation of transferable findings (Krueger and Casey, 2000; Kvale, 2007). Due to local cultural dynamics, all community leaders and institutional stakeholders are male.

Three farming communities were selected to investigate women's exposure to flooding and the related LD strategies adopted: i.e., Wareri in Guri Local Government Area, Dilmari in Kirikasanma and Kasabur in Birniwa (Fig. 1).

The communities were selected because they: (i) are located in the Local Government Areas most devastated by floods in the State (Sani, 2023), (ii) the predominant economic activity of the women is farming (Kura et al., 2023), and (iii) the women's livelihoods have been particularly affected by floods (scoping exercise, 2023). Sampling criteria for FGDs included direct targeting of women farmers who are exposed to floods and who are implementing varying forms of LD, based on information derived from a scoping exercise. The exercise was conducted on August 2023, and involved engaging with community leaders to explain the purpose of the research and seek their assistance in identifying women farmers who met the sampling criteria. Community leaders circulated open invitations at the community level prior to organising three FGDs. All women who were willing to participate in the discussions from each community were included in the sample, ensuring no exclusions. This approach led to similar FGD sample sizes across villages, as shown in Table 1. The selected women farmers were aged between 25 and 65 years, ensuring that they had been engaged in crop production for at least 10 years.

Each FGD addressed the local flooding impacts and related LD strategies (Supplementary Material 1). They were facilitated through guided discussions using open-ended questions to encourage participant engagement and explore diverse perspectives, aligning with approaches followed in qualitative research (Nyumba et al., 2018). As regards the semi-structured interviews, a total of n = 3 community leaders, n = 1 NGO and n = 6 policy makers were identified and approached using purposive sampling (Kvale, 2007), with questions expanding the themes covered in FGDs and focusing on the key enabling factors and barriers to adoption of LD (Supplementary Material 2). The sampling size for the semi-structured interviews was determined by the number of relevant institutional stakeholders To ensure qualitative rigor and minimise bias in the purposively selected sample, the study employed triangulation to capture diverse perspectives, used a structured interview guide for consistency (Supplementary Material 2), ensured data saturation, and incorporated member validation to accurately reflect participants' views (Kvale, 2007). The FGDs and semi-structured interviews were audio recorded. The recordings were then transcribed into Microsoft Word and subjected to content analysis using NVIVO software 14 trial version, following six steps (Nowell et al., 2017; Azeem & Salfi, 2012):

Table 1
Summary and sample size of participants used across study sites.

Method	Wareri	Dilmari	Kasabur	Total (n =)
Focus group discussion	17	18	13	48
Semi-structured interviews (community leaders)	1	1	1	3
Semi-structured interviews (NGOs and policy makers)				7
Total number of participants				57

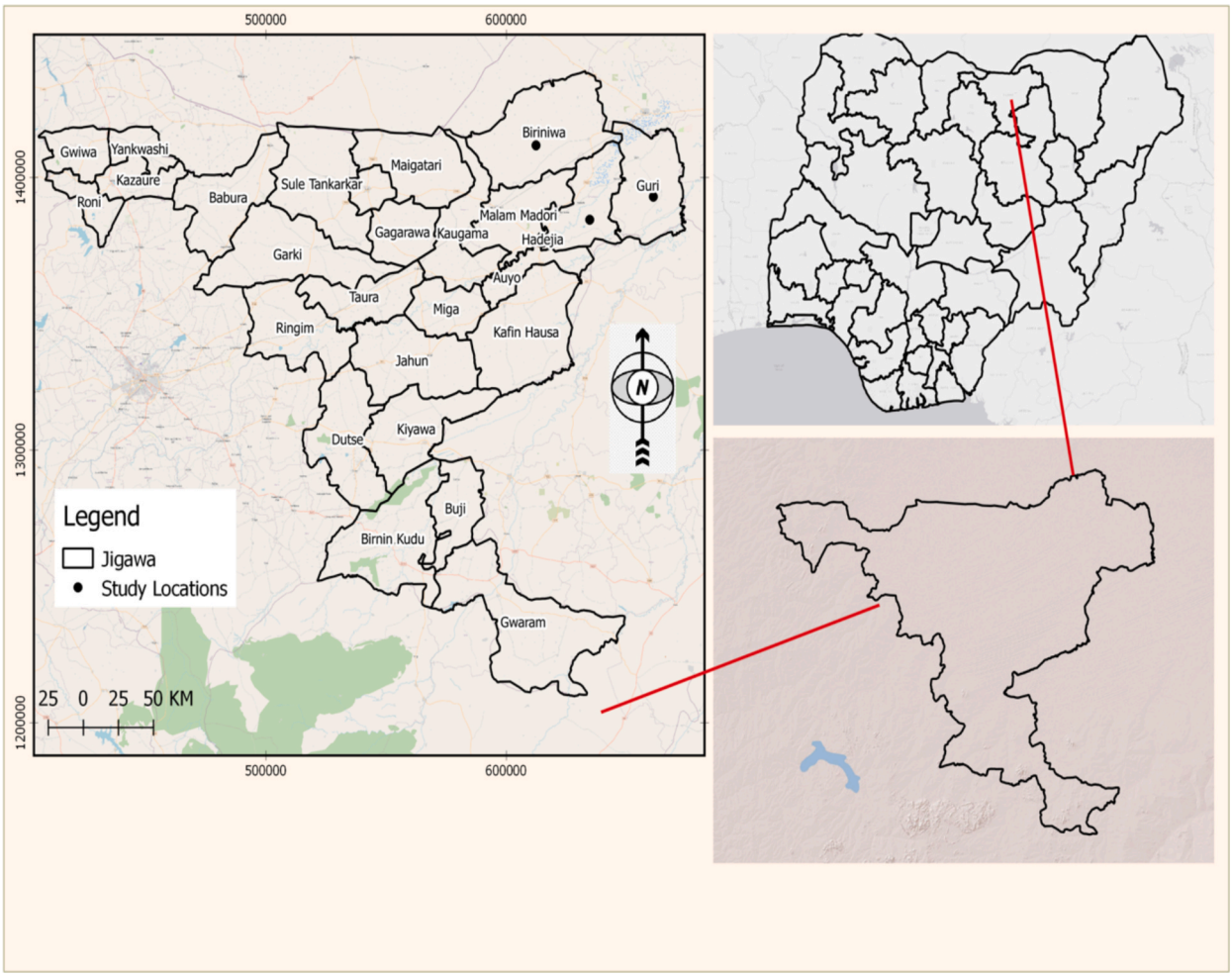

Fig. 1. Map of Jigawa State, Nigeria, and location of study sites (drawn by Yusuf A. Yusuf, 2024).

(i) Transcripts were imported into NVivo;
(ii) Codes reflecting the three research questions were created;
(iii) Nodes were created to address the specific themes of each research question: flooding impacts, livelihood diversification strategies, enablers, and barriers;
(iv) The transcripts were coded by assigning specific portions of the text to relevant nodes;
(v) The data was queried by using NVivo's query tools, such as text search, to explore key patterns in LD responses and the related challenges in coping with flooding across the study sites;
(vi) The coded data is presented in Section 3.

This research was conducted in accordance with the ethical policies of Bayero University Kano, where formal ethical clearance is not required for non-invasive social research. However, all ethical considerations were observed, including obtaining informed consent, ensuring confidentiality, and upholding voluntary participation. The study posed no risks to participants and adhered to established ethical guidelines for social science research.

3. Results

The results are organised according to the research questions, presenting rural women's perceptions of flood occurrence and impacts in northern Nigeria, the reported LD strategies, and the corresponding enabling factors and barriers affecting LD among rural women farmers.

3.1. Rural women's perceptions of flood occurrence and impacts in northern Nigeria

According to the reported perceptions, from 2013 to 2023 all three communities have experienced floods at least 7 times i.e., 8 times in Wareri (years 2013, 2014, 2015, 2016, 2017, 2018, 2019 and 2020), 8 times in Dilmari (years 2013, 2014, 2015, 2016, 2017, 2018, 2019 and 2020), and 7 times in Kasabur (years 2013, 2014, 2015, 2016, 2017, 2018 and 2019). The floods are most severe in August, when rain is usually the heaviest in the peak of the rainy season. However, in 2022 and 2023, the amount of rainfall received severely reduced, leading to drought particularly in Kasabur community: *"We have had about 7 occurrences of flood events in the last 10 years. But these few years, the rain is not much, there is drought instead"* (FGD, Kasabur). Construction of drainage and clearing of *Typha* grass (Kachalla, in Hausa) from water bodies are reported to reduce flood impacts: "*Also in the last 2 years, the drainage built and the removing of Typha grass (kachalla) in the rivers by the state government, allowed the water to flow through its natural course without causing floods*" (FGD, Dilmari). Conversely, the topography of these communities exacerbates the rate at which the excess water floods and destroys their homes and farmlands, as most of them are located in low-land valleys: *"The month of August is when the floods are most severe. That is when we experience loss of houses and farmlands, due to the fact that the places do not get to dry up and then more rains set in, crumbling our houses and farms"* (FGD, Wareri).

In addition to farmland and house loss, commonly reported flood impacts include increasing hunger and poverty, widespread dampness and slippery soils: *"The floods affected everywhere, we lost 2/3 of the lands. This led to killing the grains completely. As a result of the floods, we are facing hunger"* (FGD, Dilmari). House flooding hampers the capacity to practice religious rituals at home and generates conflicts among women and the farming communities: *"When our houses and farms get flooded, we have nowhere to go, even ablution [*i.e., *religious rite] we perform it in our rooms. It also brings about conflict among us, because your neighbor would not want you to squat with her, because she does not have enough space for her family either"* (FGD, Dilmari).

The floods are reported to decrease crop production and soil fertility, and increase pest infestations: "*The sesame, beans, sorrel, and millet were all affected by pest infestation. We lost everything" (FGD,* Kasabur). Flooding affects the choice of crops used to diversify and limits the capacity of women to benefit, socially and economically, from their harvest. While peppers and tomatoes are easier and quicker to grow in comparison to grains, they are theoretically more suitable to grow in the face of flood risks. However, it was stressed that their harvest is commonly controlled by men, who benefit from their sales without giving any financial reward to the women who have grown these products: "*When we harvest the peppers, our husbands don't allow us to keep that at home, they take the peppers to the market and sell and pocket the money*" (FGD, Dilmari). Conversely, when women grow grains, their husbands allow them to set aside a share of the harvest, which is saved and used to feed the household: *"That is why we prefer to cultivate crops like millet or sorghum, where our husbands do not have a choice but to leave enough in the house to last us throughout the year"* (FGD, Wareri).

3.2. Livelihood diversification strategies

In Wareri and Dilmari communities, the LD strategies reported by women farmers fall into two categories: on-farm and off-farm activities. As regards on-farm activities, women engage in growing watermelon, rice, tomatoes, beans and early maturing variety of maize (masara yar tarye). These are considered more economical activities than growing millet and sorghum, which used to be cultivated more extensively before the floods occurred regularly: *"We plant rice, wheat, guinea corn, maize, sesame seeds, beans, tomatoes, peppers, onions (yar rani). Guinea corn is resistant, it can still survive after the farm has been flooded. When the water recedes, we utilise it for beans and tomatoes… Our hope and what we would rather do though is still crop cultivation"* (FGD, Wareri). Another form of diversification includes planting economic trees like mango, guava, cashew, lemon and *Hibiscus sabdariffa*. Their produce is used both as food and sold within their local markets, to relieve some of the hardships caused by the floods. *"We plant trees like mango, guava, cashew, lemon. We had to resolve to these, to adapt to the floods, since we cannot grow our usual crops"* (FGD, Dilmari). In Kasabur community, the women only reported alternative crop cultivation as a means of on-farm LD. This is owed to the women's lack of capital to engage in any other economic activity. Thus, the Kasabur women heavily rely on economic trees like *Moringa oleifera* and *Lawsonia inermis* (henna), which are sold to improve household income: *"We plant Moringa oleifera and Lawsonia inermis (henna), because we can sell the produce and get some money"* (FGD, Kasabur). At best, they use the residual moisture for growing *Citrullus lanatus* (Guna), from which they derive oil and sell. In this community, only men have the option of rearing cattle, which are considered more resistant to floods. However, women are eager to explore other livelihood opportunities to diversify their income sources.

Regarding the off-farm activities, the women engage in petty trading, rearing of animals, selling of cooking ingredients and cooked food such as *danwake* (i.e., local food made from beans, wheat and cassava flour), *shinkafa da wake* (cooked rice and beans), *kosai* (bean cake), *taliya* (local spaghetti made from flour) and *gumin shinkafa* (steamed rice). They also produce local hand fans and mats. It was reported that the most viable alternative income is generated by the rearing of small ruminant animals, revenues from which are used to pay for the labor and are also invested in other small businesses: *"Rearing of animals is the major alternative to crop cultivation… When we sell the livestock, we are able to augment our needs. We also use part of the money to dig wells so that we can engage in irrigation farming"* (FGD, Dilmari). It was noted that during floods small ruminant animals are often relocated and kept at the outskirts of the community.

3.3. Enabling factors and barriers to livelihood diversification for rural women farmers

The factors enabling and hindering livelihood diversification are outlined below and summarised in Table 2 at the end of this section.

3.3.1. Enabling factors to livelihood diversification

The enabling factors to LD are categorised into the following thematic areas: climate data, social networks, support for alternative income-generating activities, material assistance, extension and agricultural support, and financial aid for livelihood diversification.

3.3.1.1. Climate data. Access to weather forecasts and disaster warning information helps women farmers to cope with sudden climate shocks: "*We [women farming group] conduct an annual local review… we look at the pattern of rainfall, flood events and crop performance of the previous year*" (FGD, Wareri). Semi-structured interviews with the Nigerian Meteorological Agency (NIMET) and the National Emergency Management Agency (NEMA), highlight that information on seasonal climate prediction, including floods, is periodically

Table 2
Summary of key livelihood diversification strategies, enablers and barriers identified across three flood-affected case study communities in Northern Nigeria.

LD strategies	Enablers	Barriers
• Growing watermelon, rice, tomatoes, beans and early maturing variety of maize) instead of millet and sorghum (FDGs, Wareri and Dilmari); • Alternative crop cultivation of sesame, beans, millet and *Citrullus Lanatus* (FDG, Kasabur).	• Provision of early maturing crop varieties by the state government and NGOs (semi- structured interview, policy maker); • Availability of agricultural insurance (semi-structured interview, policy maker); • Research on crops and soil science (semi-structured interview, policy maker); • Collaborations with international development agencies for alternative livelihood support (semi-structured interview, policy maker); • Availability of weather forecasts & efforts towards moving to impact-based forecasts – i.e., ACReSAL digital climate change laboratories; (semi-structured interview, policy maker); • Provision of community revolving funding for purchasing early maturing flood resilient crop varieties (semi-structured interview, policy maker); • Increasing farmers' access to markets & financial institutions (semi-structured interview, policy maker);	• Appropriation of cash crops harvests by men – women do not benefit from cash crops and prefer growing grains (FDG, Dilmari); • Stealing of harvests by Fulani herders is a recurrent threat (FDG, Wareri); • Skepticism towards accepting agricultural insurance (semi-structured interview); • Pest infestations destroy the alternative crops (FDG, Kasabur); • Solely reliant on rainfed farming (FDG, Kasabur); • Extreme droughts kill the crops (FDG, Kasabur).
• Planting economic trees like *Mangifera indica* (mango), *Psidium guajiva* (guava), *Anacardium occidentale* (cashew) and *Citrus limon* (lemon) (FDGs, Wareri and Dilmari) • Planting economic trees like *Moringa Oleifera* and *Lawsonia Inermis* (FDG, Kasabur)	• Training on pesticide application and business proposal writing for selling harvests (semi-structured interview, policy maker); • Donating of fruit/economic trees, agrochemicals and fertiliser by state government (semi-structured interview, policy maker); • State ecological funds to restore degraded lands & preventive measures against natural disasters (semi-structured interview, policy maker); • Encouraging economic tree planting by allocating land and extension workers for orchard establishment (semi-structured interview, policy maker);	• Lack of training on tree growing techniques, value addition and storage (FDG, Kasabur); • Lack of agricultural insurance (FDG, Kasabur).
• Rearing of animals (FDGs, Wareri and Dilmari)	• Availability of grazing land (semi-structured interview, policy maker); • State government's support via donation of goats, rabbits, chickens – i.e., livestock productivity and resilience support project (semi-structured interview, policy maker); • Restoration government programmes via ACReSAL and community revolving funds (semi-structured interview, policy maker).	• Stealing of reared small ruminant animals by youths (FDG, Dilmari); • Only male farmers can afford animals and engage in rearing (FDGs, Dilmari and Kasabur); • Lack of capital (FDG, Kasabur).
• Pursuing off-farm activities (petty trading, selling cooked food, rice steaming, making local hand fans and mats, making soaps and detergents) (FDGs, Wareri and Dilmari) • Making vegetable oil from *Citrullus lanatus* (FDG, Kasabur)	• Training on rice steaming, pomade, soap and detergent making by NGOs (FDG, Dilmari); • State-run women empowerment programmes: donating grinding machines for rice milling and groundnut oil making, sewing machines, and seed capital (semi-structured interview, policy maker); • Drilling of boreholes and provision of water pumping machines (semi-structured interview, policy maker); • Training in energy efficient rice steaming & parboiling (FDG, Dilmari).	• Capacity building training and government incentives are unequally distributed: Kasabur did not receive any training (FDG, Kasabur); • Lack of capacity, training personnel & understanding of state emergency management agencies, with scattered responsibilities (semi-structured interview, policy maker); • Lack of synergy among institutional stakeholders (semi-structured interview, policy maker); • Inadequate funding and budgetary allocations (semi-structured interview, policy maker); • Difficulty in local collaborations and partnerships among competing government agencies (semi-structured interview, policy maker)

made available to the general public through radio stations, social media platforms, community leaders and their emirates. Through engagement with the International Fund for Agriculture (IFAD) and Human and Environmental Development Agency (HEDA), and the United Nations International Children's Emergency Funds (UNICEF), NIMET has co-developed national and state contingency plans aimed at building the resilience of flood-prone communities that face natural disasters in Jigawa: *"We have the national contingency plan… a plan for initial action to be taken in case of any natural disaster, flood inclusive"* (semi-structured interview, NEMA).

FGDs in both Wareri and Dilmari reveal that belonging to community groups is critical to enable women farmers access information on weather forecasts, disaster preparedness plans and awareness raising campaigns. The findings also highlight that community cohesion not only facilitates access to weather information, but it also forms part of a broader livelihood diversification strategy aimed at enhancing flood resilience.

In light of the need to provide women with more readily accessible and usable climate data, the interview with NIMET stressed the need to move towards impact-based forecasting: *"We are moving towards impact-based forecasting, going beyond what the weather will be, and focusing on where it is likely to experience floods, on their impacts, and on the ways of mitigating them"* (semi-structured interview, Nimet). Aligned with this goal, our semi-structured interview with the State Ministry of Environment revealed a current commitment to develop digital climate change laboratories that will serve as early warning systems for detecting floods, which will collect climate data across the 27 LGAs and transmit directly to the state government's server. It nevertheless remains vital that this information is passed on in good time to the farming communities.

3.3.1.2. Social networks. Through a cooperative system where members contribute financially, the community is able to collectively purchase and share sacks used to build local embankments during floods. Additionally, the cooperative supports education by covering costs such as school materials, and it can be used to purchase grinding tools or provide small loans: "*We have a cooperative to help one another in times of need… We contribute money and even assist our husbands when necessary*" (FGD, Dilmari). Findings highlight that while community groups in Wareri are often male-dominated and tend to restrict women's livelihood opportunities, the strong cohesion among women farmers in the face of flooding positively impacts the livelihoods of male members within the household.

3.3.1.3. Enabling alternative income-generating activities. Wareri and Dilmari communities have received capacity building training on rice steaming, making detergents, soaps and pomades from various non-governmental organisations. Women in both communities acknowledge that such training has expanded their knowledge and enhanced their income generation capacity: "*We had some NGO come in and taught us how to prepare the rice better than the way we used to*" (FGD, Dilmari). They are therefore keen to engage in similar training in the future: *"We would want to get some more of these trainings to strengthen our capacity to be able to engage in other activities outside farming"* (FGD, Wareri). As confirmed by the interview with the State Ministry of Environment, wider community training was implemented under the FAO's rural access & agricultural market project (RAAMP) to strengthen the business management skills of small-scale farmers: *"Both male and female farmers were trained on how to develop a business plan to increase income and resilience"* (semi-structured interview, Ministry of Environment).

Through the "Livestock Productivity and Resilience Support" project implemented by the State government in 2020, LD was supported through donation of chickens, rabbits, goats, animal feeds, animal cages, and livestock health treatments. To further boost women farmers' off-farm economic activities, Wareri and Dilmari communities were given seed capital, sewing machines, grinding machines, groundnut oil machines and rice milling machines. The State government also supported the planting of economic trees by distributing fruit tree seedlings to plant on irrigated farms. Interviews with government officials stressed that while it was not feasible to reach out to all the villages across the state, the most vulnerable communities were prioritised: *"Chickens, rabbits & goats were given to women, identified through vulnerability mapping*" (semi-structured interview, Senior Advisor, state government).

Availability of and accessibility to grazing land plays a role in enabling women farmers to rear their animals and keep them safe during floods. Rearing of animals has been identified as one of the major LD strategies, which also generates animal dung that can be used as a source of organic manure on farmlands: *"We have grazing land where we take our animals towards the north. The rearing of animals enables us to meet up our needs, from the shortfall of lost harvest…. and we take the animal dung to our farms to revive the farms"* (FGD, Dilmari). Improving the management of grazing land and strengthening women's access to the land is perceived as a major enabler to allow them to diversify their livelihoods. The interview with the Ministry of Environment revealed that increasing focus is being placed on addressing the pressing priority to improve currently degrading land and make it available for livelihood diversification: "*We are already working towards restoring 8,000 ha of degraded grazing land, in collaboration with the FAO and ACReSAL, and we have already identified a number of grazing lands across the Jigawa State*" (semi-structured interview, Ministry of Environment). They have also collaborated with the Livestock Productivity and RESilience Support project (LPRESS), in order to boost livestock rearing.

3.3.1.4. Material support. Infrastructural interventions provided by the government during flood events are reported to help cope with the immediate impacts of flooding, e.g., through provision of fuel for pumping the excess water out of the communities: "*Like last year, when the flood came, we fuelled the vehicles (petrol-powered engines) in order to draw out the water, so when our local government chairman heard about it, they came and fuelled the vehicles until all the excess water was drained out"* (FGD, Dilmari). In line with these forms of support, the Hadejia Jama'are River Basin Development Authority (HJRBDA) maintains the river systems and sustains agricultural capacity in irrigation, while also providing facilities such as water pumps. Interviews reported that funding received from the Islamic Development bank (IDB) was key in enabling HJRBDA deliver these interventions.

3.3.1.5. Extension and agricultural support. Semi-structured interviews with the Ministry of Environment indicate that research on

crops and soil science undertaken through government programmes, e.g., the Jigawa Agricultural and Rural Development Agency's (JARDA) degraded land restoration programmes, ACReSAL, and the livestock shelter establishment programmes, help enhance crop production and animal rearing: *"There are a number of livestock shelters to encourage animal rearing as another source of income around the state, in places like Gumel, Birniwa, Sule tankarkar, Kila, Gwaram and Malam Madori"* (semi-stuctured interview, Special Advisor, Jigawa state government). Through donation of economic trees and agrochemicals, the government has engaged extension workers to diffuse agroforestry best practices. Some women have reported LD benefits generated by the government programmes, through acquisition of 0.5–1 ha of land for orchards, and fertiliser, where boreholes were drilled and pumping machines were installed to ensure water supply: *'The extension workers have helped us with establishing the orchards'* (FGD, Wareri). The government aims to enable LD, in collaboration with ACReSAL, also by training women on bio-briquette production from farm residues: "*Women farmers will be trained in bio-briquettes production from farm residues like rice husks and Typha grass, and on climate smart agricultural practices"* (semi-structured interview, Ministry of Environment).

3.3.1.6. Financial support to livelihood diversification. Semi-structured interviews highlight the importance of Community Revolving Funds (CRFs) as LD enablers. The CRF is a further initiative of the ACReSAL World Bank funded project. Through the project, 10 community clusters are able to utilise the funds to sustain agricultural investments, including the purchase of flood-resilient and early-maturing crop varieties: *"The CRF connects the farmers to markets and financial institutions like the Nigeria Incentive-Based Risk Sharing System for Agricultural Lending (Nirsal)* [Nirsal is a Non-Bank Financial Institution under the Central Bank of Nigeria (CBN) created to tackle agribusiness-related credit risks in the country]… *we cater for flood resilient crop varieties"* (semi- structured interview, Ministry of Environment). It was noted that wider safety nets are available for the farmers through national-level disaster management funds, state-level ecological funds, and the Agricultural Insurance Programme implemented by the Nigerian Insurance Commission to help farmers cope with disasters such as floods. Among the enabling factors identified, certain initiatives are specifically tailored for women farmers, such as capacity-building programs and the provision of small ruminant animals, groundnut oil processing machines, and sewing equipment. Other opportunities and interventions, including climate monitoring, infrastructural support, agricultural extension services, and financial assistance, are designed to benefit both male and female farmers in Jigawa State.

3.3.2. Barriers to livelihood diversification

The identified barriers to LD fall into the following key areas: limited access to capital and agricultural insurance, theft of harvests and ruminant animals, inequalities among women farming communities and restricted access to information and resources, institutional constraints, inadequate budgetary allocation, and cultural barriers to diversification.

3.3.2.1. Access to capital and agricultural insurance. Lack of capital and limited access to agricultural insurance are major barriers identified in FGDs across the three communities: *"We do not have savings… If there is insurance in place, that would mean that we would be compensated for our losses"* (FGD, Wareri). Interviewees in Dilmari reported that the LD capacity building training received in the village remains limited in its scope and it should be expanded for more concrete impacts to be delivered: *"The financial assistance received from government is not that much, because some may receive it and some may not, that poses a challenge"* (FGD, Dilmari). Both women's groups in Wareri and Dilmari agreed that there is need for more widespread training and financial support to sustain agricultural practices in the face of flooding.

3.3.2.2. Thefts of harvests and ruminant animals. The Wareri women reported that recurrent thefts of their farm produce by Fulani herders poses serious threats to their livelihoods: *"Whenever we plant and our produce is ready for harvesting, the Fulani herdsmen go into our farms and steal everything and leave"* (FGD, Wareri). FGDs reveal that a sense of fear and vulnerability is generated by this situation, particularly as it stressed that the legislative and justice structures prove inefficient to deal with the problem, due to a lack of enforcement: "*We tried taking them to court, but because they are financially stronger than us, they always win the case and we do not have money to appeal. Thus, it has become order of the day. If there is anything bothering us more than the floods it is the Fulani herders"* (FGD, Wareri). Similarly, the Dilmari community faces thefts of ruminant animals, often by the youths from their own community, especially in households where the women are the household heads and do not have an adult male child in the house: "W*hen the animals have grown and ready to be sold, thieves get into our homes and steal the animals…that really is now a major issue in this community"* (FGD, Dilmari). This suggests that vulnerability of women as a social group limits their LD capacity in the face of floods.

3.3.2.3. Inequalities among women farming communities and limited access to information and resources. Social dynamics of inequality between men and women are key determinants of LD. While grazing land is more accessible to women farmers in Kasabur, they do not get involved in rearing animals as this is a privilege only owned by men. Conversely to Wareri and Dilmari, the Kasabur community has very limited access to weather forecast information: *"There are no sensitization or warning signals towards floods by any government body. When it comes it comes; it is then that we look for ways to reduce the impact"* (FGD, Kasabur). Also, alternative livelihood off-farm opportunities in Kasabur remain limited, as the farmers are solely reliant on rainfed crop cultivation, which makes them extremely vulnerable to extreme weather events or increasing pests and diseases: *"If the rain is favourable then there is a good harvest, if not then there is nothing. The only option is to wait for the onset of the next rainy season, hoping it would be flood-free"* (FGD, Kasabur). Lack of access to capacity building and other forms of support in Kasabur leaves the community behind their counterparts in the Wareri and Dilmari: *"There is no agricultural insurance. We do not have trainings… once the crops are infested by pests, we lose everything and we do not have money to buy pesticides to spray on our farm"* (FGD, Kasabur).

3.3.2.4. Institutional bottlenecks. Interviews with the National Emergency Management Agency (NEMA) stress that lack of expertise and know-how about how to design LD-focused disaster management responses remains a major challenge: *"The staff force of the state emergency management agencies is not based on specialisation, rather pulled from the pool of service based on transfers…they lack capacity, training, personnel, and understanding of our responsibilities"* (semi-structured interview, NEMA). A paradigm change in delivering support is needed, particularly as difficulties were reported in advancing towards measures that reduce longer-term vulnerability, rather than just providing short term relief: "*We are supposed to do more risk reduction, rather than relief, but states do not understand this. They are still waiting for the damage to happen, then they respond"*. Overlapping mandates, conflict amongst different institutions or departments, combined with lack of effective coordination and communication among stakeholders and end-users, exacerbate the difficulties in designing and pursuing shared goals: *"Getting collaborations and partnerships is difficult, because everyone believes you want to take their jobs. So, every organisation is doing their own thing, creating overlaps and disconnects among us, the disaster management agencies. This gives rise to poor response to forecasts information"* (semi-structured interview, NEMA).

3.3.2.5. Inadequate budgetary allocation. As noted in semi-structured interview with the Nigerian Meteorological Agency (Nimet), inadequate budgetary allocation to disaster management agencies, including the Nigeria Hydrological Services Agency (NIHSA), results in limited delivery of awareness raising workshops and dissemination of information by the agencies: *"The major challenge is that the funding and budgetary allocations are not enough for NIMET and NIHSA, leading to poor forecasts and dissemination"* (semi-structured interview, Nimet). It was also found out that most of the institutional stakeholders do not have a monitoring and evaluation system nor a department to keep track of disaster occurrences, flood monitoring, trends, impacts and interventions. Agencies like Hadejia Jama'are River Basin Development Authority and the Ministry of Environment completely rely on Nimet's periodic reviews: *"We rely on Nimet for reports… we have no periodic reviews. The Ministry of Environment normally updates the periodic reviews"* (semi-structured interview, HJRBA).

3.3.2.6. Cultural barriers to LD. The FGD in Wareri pointed out that communities' skepticism towards agricultural insurance arises from cultural beliefs, ignorance, and a low educational level. This attitude is also extended to information on weather forecasts, towards which many people remain suspicious: *"There are sensitization campaigns, but our people do not take these warnings seriously, till they can see the danger"* (semi-structured interview, Community leader, Wareri). The need for awareness raising to break such cultural barriers is more than ever evident and urgent to avoid further damage and loss, as observed by a Nimet official: *"Nonchalant attitudes of the communities towards responding to warning signs from weather forecasts information has resulted in poor responses to forecast information and huge economic losses. For example, in 2022, lack of response to warnings from weather forecasts led to a loss of 1.6 billion US dollars in about 34 states of the country"* (semi-structured interview, Nimet). These barriers outlined are common to both male and female farmers in the study area, except for the theft of small ruminant animals, mostly prevalent among women headed households.

Findings from the FGDs and semi-structured interviews are summarised in Table 2. These reveal a strong convergence in most LD strategies adopted in Wareri and Dilmari, likely due to their geographical proximity, as well as notable similarities with those observed in Kasabur.

4. Discussion

The lack of empirical studies examining LD as a coping strategy to increasing floods across Africa, particularly for women farmers as a highly vulnerable group, demands urgent attention. Our findings indicate that LD enhances women's resilience to the adverse impacts of floods and improves their socio-economic well-being in Northern Nigeria, a region that has experienced recurring floods and droughts since the early 2000 s, as confirmed by both literature and interview results (Umar & Gray, 2022). Diversifying on-farm activities – such as growing cash crops and fast-growing varieties instead of millet and sorghum – proves to be a valuable LD strategy across all study communities, aligning with similar regional efforts (Aminu et al., 2022; Mamman et al., 2022). FGDs reveal that awareness-raising, particularly around training women in suitable cash crops, economic trees, value addition, and access to climate and weather forecast data, is crucial to adjusting agricultural practices under volatile conditions.

Across Africa, it has been demonstrated that utilising weather and climate information services significantly improves the adoption of effective coping strategies (Djido et al., 2021), while the key role of capacity building and knowledge sharing in fostering climate resilient development in flood prone areas has been highlighted more widely across continents, e.g., with similar examples from Asia (Akter et al., 2023). A novel insight from our study is that cultural acceptance plays a foundational role in the success of LD strategies, which, as evidenced in the results, are often constrained by skepticism toward improved practices and cultural resistance to change.

Research across Africa shows that women's climate adaptation and LD strategies are often oriented toward fulfilling basic household needs, with adoption patterns shaped by the gendered socio-cultural dynamics of their communities (Huho and Asokan, 2024). Applying a feminist political ecology lens reinforces the importance of designing LD support strategies that are grounded in these intersecting social and ecological contexts, shaped by persistent gender norms and structural inequalities (Nwokocha and Ezeh, 2020). This study challenges the assumption that technical training alone is sufficient to improve livelihood outcomes. Instead, findings suggest that meaningful change requires broader cultural shifts that empower women and recognise the influence of local norms. This is particularly evident in Wareri and Dilmari, where male control over the sale of cash crops restricts women's ability to store food or reinvest in household welfare (Memon et al., 2020). In Kasabur, limited access to productive assets, reinforced by discriminatory customs, reflects a wider trend of married women's exclusion from decision-making across the Global South, where men are often seen as household heads (Eastin, 2018; Van Aelst and Holvoet, 2016). This study emphasises that while male-dominated

structures constrain women's livelihood options, the adaptive strategies employed by women continue to support and stabilise household well-being. LD interventions must therefore be culturally sensitive and designed with these complexities in mind.

Access to capital and credit has been associated with greater opportunities for LD (Aminu et al., 2022; Kassa, 2019). Our findings suggest that awareness campaigns are essential for educating farming communities on the availability and benefits of agricultural insurance schemes and funding mechanisms, such as community revolving funds and ecological funds. Capacity-building workshops for institutional stakeholders can foster collaboration and ensure that training programs and resources are tailored to the actual needs of the farmers. The broader literature on co-benefit analysis in climate-resilient development underscores that access to finance and technology, along with effective knowledge dissemination, are key pillars of long-term adaptive capacity (Favretto et al., 2020). This research adds to this view, emphasising that adaptive capacity in flood-prone areas of Northern Nigeria can be strengthened by rethinking community engagement, particularly through a gendered perspective. Engagement should not be seen merely as a pre-requisite for funding access but should position communities as key players in setting project goals and forging sustainable livelihood alternatives. This aligns with the critical perspective that participation should go beyond mere community consultation and move towards genuinely empowering beneficiaries (Cornwall, 2008). While agricultural insurance may be available institutionally, farmers' knowledge of these options, their reluctance to engage with them, or the limited capacity of women to access these mechanisms remains a barrier, underscoring the importance of training and awareness in resilience building.

Research across Africa underscores the vital role of land access in sustaining rural livelihoods, particularly for women smallholders who often lack secure land tenure (Addaney et al., 2022; Makhetha, 2024). While our findings show that rearing small ruminants is an effective LD strategy for many women, access to grazing land remains a persistent challenge. As observed, this is frequently shaped by both localised conflict and intra-household dynamics, where men may restrict women's agricultural activities. In Wareri and Dilmari, ongoing farmer-herder conflicts have emerged as a major threat to women's livelihoods, with several accounts of harvest theft by herders. In Dilmari, livestock theft, particularly targeting female-headed households, has also been reported, often carried out by local youth. These findings highlight the need to embed gender-responsive LD strategies within a broader understanding of the structural inequalities and power imbalances that shape rural livelihoods. The lack of effective law enforcement further compounds these issues, as land and resource disputes are frequently resolved in favour of wealthier or more influential actors, such as herders (Brottem, 2021; Akintunde et al., 2023; Vercillo et al., 2025). Addressing these challenges requires LD interventions that account not only for ecological and economic variables, but also for the complex gendered dynamics that influence access to and control over critical resources. For example, our findings stress that while training in cost-effective livestock management has improved women's economic status in Nigeria, it is crucial for government and institutional stakeholders to secure women's access to land and resources, particularly in light of the reported conflict.

While government programs that provide livestock and land donations contribute to LD, addressing cultural barriers and reducing conflict are, once again, deemed as essential to sustaining these practices for women and their households. Simultaneously, promoting off-farm LD activities, such as petty trading, local food production, or crafting, offers women valuable pathways to diversify livelihoods, especially in flood-prone communities. These activities are expanding in response to increasing flooding, as they enable women to participate in income-generating work that is less dependent on land-based resources. This reflects a broader trend across Sub-Saharan Africa since the early 2000 s, where an increasing proportion of households have shifted toward off-farm livelihoods (Adamseged et al., 2019). Building on observations by Mashi et al. (2019), this research finds that the absence of a national emergency management system, with actionable plans and risk management strategies, hinders the state government's dual objectives of enhancing LD by restoring land and supporting business skill development – such as through World Bank-funded initiatives like ACReSAL. Government officials emphasise the need for robust monitoring and evaluation systems aligned with climatic data to improve intervention outcomes.

Overall, our findings support the hypothesis that LD strengthens women's resilience to the negative impacts of floods on socio-economic well-being in Nigeria. However, it is vital to address cultural barriers, conflict dynamics, and resource access to develop support systems that enhance women farmers' resilience to increasing floods. Understanding the unique characteristics of different communities, as well as their enablers and barriers to LD, is key to promoting long-term adaptation and reducing vulnerability to future disasters (Ao et al., 2022). Disparities in access to training and aid programs across communities (with Wareri and Dilmari prioritised and Kasabur left out) highlight equity concerns in how state support is delivered. The LD strategies, barriers, and enablers identified in this study offer valuable insights for sustaining LD in flood-prone regions and tailoring interventions to the specific needs of different communities, geographies, and systems.

5. Conclusion

This paper explores the role of LD in enhancing the resilience of women farmers in Northern Nigeria to floods and other climate-related shocks. It highlights the lack of empirical studies on this topic, particularly concerning vulnerable groups like women, who face compounded challenges due to both environmental risks and cultural barriers. Findings indicate that LD strategies – such as shifting from millet and sorghum to cash crops and livestock rearing – have been effective in boosting women's resilience. Additionally, off-farm activities like petty trading provide alternative income sources less reliant on land. However, cultural dynamics significantly influence the success of these strategies, as men often control key resources and decisions, limiting women's capacity to manage their livelihoods fully. Conflict between farmers and herders further exacerbates women's vulnerability. This study highlights the importance of awareness-raising campaigns and capacity-building initiatives to educate communities about funding opportunities and sustainable practices. These efforts should be designed through gender-responsive approaches that strengthen adaptive capacity in flood-prone areas. Institutional support and the active inclusion of women in decision-making processes are also essential for long-term

resilience. This underscores the need for existing policies to promote inclusion, participation, and empowerment. We acknowledge that the study's exclusive focus on women farmers omits the experiences of male counterparts. While this gender-specific lens is effective in revealing the unique vulnerabilities faced by women, it limits broader comparative insights into how gender dynamics shape flood resilience. Additionally, the case study's geographic and institutional scope constrains generalisability. Future research would benefit from adopting a comparative, longitudinal, and intersectional perspective to better understand gendered adaptation practices across diverse African contexts and over time, particularly in light of growing climate variability. Nonetheless, this study provides valuable empirical evidence to inform policy and guide targeted, gender-sensitive flood resilience strategies across dryland regions in Africa.

CRediT authorship contribution statement

Ummi Khalthum Mohammed: Writing – original draft, Investigation, Formal analysis, Conceptualization. **Nicola Favretto:** Writing – original draft, Supervision, Methodology, Funding acquisition, Formal analysis, Conceptualization.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Appendix A. Supplementary material

Supplementary data to this article can be found online at https://doi.org/10.1016/j.crm.2025.100708.

Data availability

The data that has been used is confidential.

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