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Adaptive Strategies on the Impacts of Artisanal Mining among Rural Households in Kaduna State, Nigeria

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Abstract

Mining serves as a source of livelihood for many rural communities worldwide. However, it also poses environmental risks that can negatively impact household livelihoods, such as harming farmland and contaminating water supplies. This study explores how households in rural areas of Kaduna State, Nigeria, adapt to the impacts of artisanal mining. Data were collected through Focus Group Discussions, in-depth interviews, and on-site observations. The findings were analysed using descriptive statistics with the aid of Nvivo Version 11.0 software. The study reveals that households employ a range of adaptive measures to mitigate the effects of artisanal mining. These include clearing new land for farming, acquiring or leasing land for cultivation, planting non-native tree species for timber and palm oil, filling mining pits and ponds for agricultural use, and using manure and fertilisers to boost crop yields. Other strategies involve relocating herders and their livestock, securing land specifically for grazing, confining livestock, purchasing animal feed, avoiding polluted water sources, treating water through heating and filtration, digging wells, and using chemicals or treated sachet water for drinking. The study recommends that both households and the government engage in reclaiming degraded land and underground mine areas for agricultural use, as a sustainable measure to combat food insecurity.

Keywords: Artisanal Mining, Adaptation Strategies, Households and Livelihood Vulnerability

Introduction

Artisanal mining remains vital yet environmentally problematic livelihood strategy in the rural communities. It contributes positively to the economy, particularly in rural areas, it also leads to severe geo-environmental consequences such as soil erosion, mercury contamination, water pollution, deforestation, and biodiversity loss, thereby impacting the quality of life of the population [1]. Additionally, health risks, including respiratory issues and HIV prevalence, and socio-economic challenges, including child labor and high school dropout rates, are prevalent in mining regions [2]. Artisanal mining in sub-Saharan Africa serves as both a livelihood lifeline and an environmental stressor for rural households. Frequently driven by agricultural decline and poverty, families increasingly turn to artisanal mining as a "distress-push" strategy to supplement income and secure essentials like fertiliser and food inputs [3]. Thereby increasing inequality among rural households [4]. In Ghana, for instance, rural households faced deteriorating food security, water quality, and land access due to artisanal mining, but over 75% adopted coping strategies influenced by factors like education, off-farm work, and cooperative involvement [5]. In Nigeria, artisanal mining contributes substantially to livelihoods but often operates informally, resulting in land degradation, deforestation, contaminated water, and weakened regulatory oversight [6][7]. Artisanal mining remains a significant livelihood activity across rural communities in Nigeria, particularly in Kaduna State, where it supports local economies despite considerable environmental and socio-economic trade-offs. These extractive practices degrade arable land, reduce vegetation cover, contaminate water sources, and diminish grazing areas, inflicting serious consequences on household food security and livelihoods [8]. Similarly, the environmental impacts of artisanal mining, such as soil erosion, biodiversity loss, and the depletion of grazing land have exacerbated rural vulnerability and poverty, thereby compelling households to adopt various coping strategies [9] [10] [11] [12]. Households coping strategies include livelihood diversification, adjusted planting schedules, and use of organic inputs, land reclamation, and resettlement in other communities [13] [14]. Likewise, community-based adaptation frameworks in Nigerian settings show how integrating traditional knowledge, agroforestry, and local engagement improves resilience to environmental shocks [15].

However, research specifically examining how rural households in Kaduna State adapt to the multifaceted impacts of artisanal mining remains scant. Understanding such responses is crucial for informing sustainable land reclamation, food

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security, and rural resilience policies. This study thus explores the adaptive strategies employed by affected households, uncovering how they navigate environmental degradation and resource scarcity in artisanal mining zones.

Materials and Methods

Study Area

Kaduna State is situated in North Central Nigeria, within West Africa. It is one of the 36 states comprising the Federal Republic of Nigeria. Geographically, it lies between latitudes 9°03′N and 11°32′N, and longitudes 6°05′E and 8°38′E, east of the Greenwich Meridian. Covering approximately 46,053 km² about 5% of Nigeria's total land area. Kaduna State shares boundaries with Kano, Katsina, and Zamfara States to the north; Bauchi and Plateau States to the east; Niger State to the west; and both the Federal Capital Territory (FCT) and Nasarawa State to the South. Administratively, the state is divided into 23 local government areas, as illustrated in Figure 1.

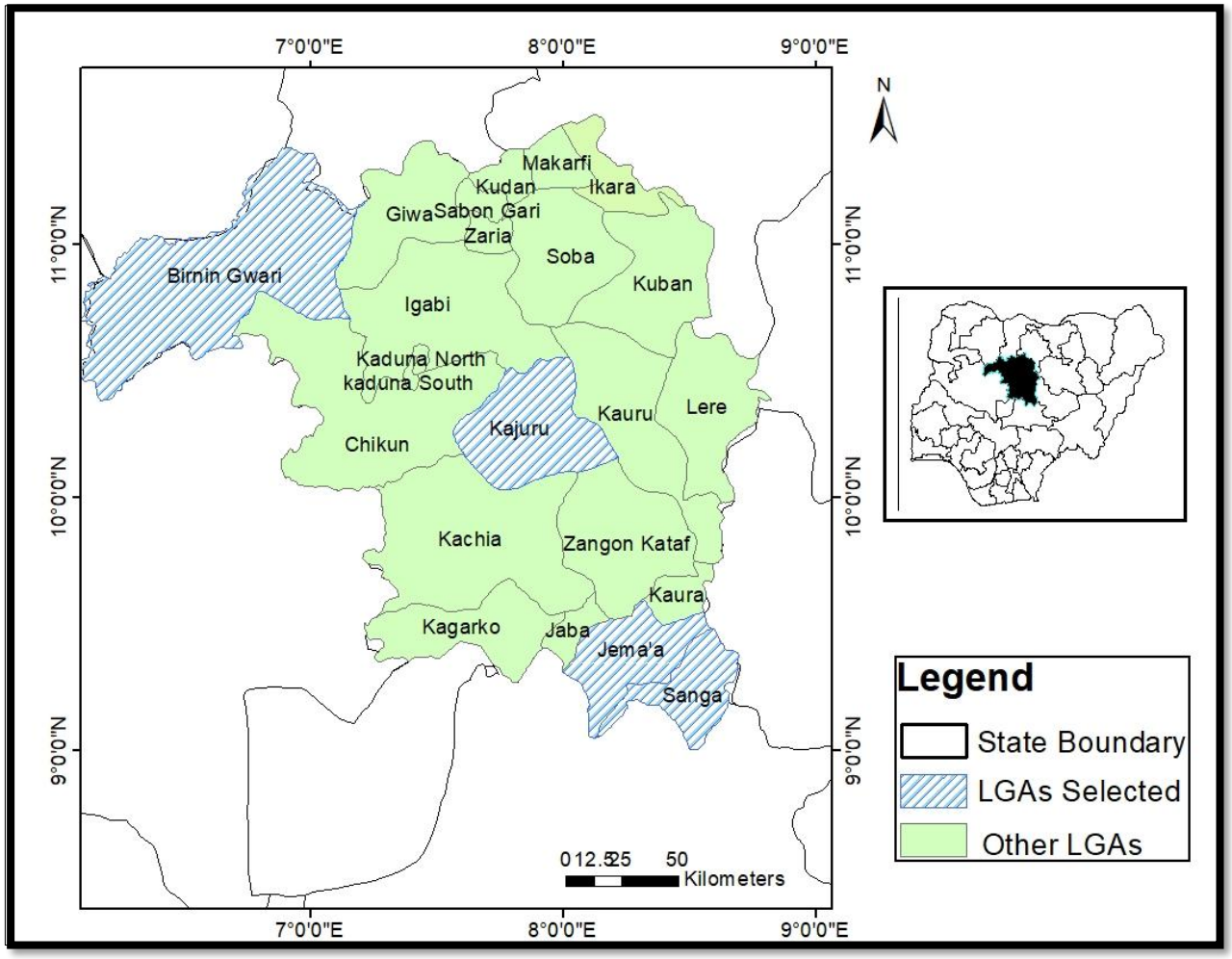

Figure 1: Map of Kaduna State showing the local government Areas selected for the study
Source: GIS Lab, Department of Geography BUK

Kaduna State falls under the AW climate classification according to Köppen, characterized by two distinct seasons: wet and dry. The wet season is longer in the southern part of the state, particularly around Kafanchan and Kagoro, where it typically begins in April and ends in October. In contrast, the northern areas such as Zaria and Makarfi experience a shorter rainy season, similar to that of the Kano region, lasting from mid-May to September [16]. Rainfall generally peaks once annually, usually in August or September. The seasonal patterns are primarily influenced by the interaction between tropical maritime and tropical continental air masses. Annual rainfall in the State shows a decreasing gradient from South to North, with approximately 1,659.44 mm recorded in Kafanchan (south), 1,245.97 mm in Kaduna (central), and 1,016.66 mm in Zaria (north) [16]. On average, the entire State receives about 1,307.36 mm of rainfall annually, with a mean relative humidity of 56.64%. Average minimum and maximum temperatures are 15.1°C and 35.18°C, respectively. Additionally,

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the orographic influence of the Jos Plateau and Kagoro Hills contributes positively to the climate of the Southern region, enhancing rainfall, moderating temperatures, and increasing relative humidity [17].

The study area is located within Nigeria's Guinea Savanna zone, characterized by relatively high rainfall and limited exposure to frequent bushfires [18]. Geologically, the region is underlain by Pre-Cambrian basement complex rocks, primarily composed of granite, gneiss, migmatite, and quartzite, which support the presence and exploitation of various mineral resources [19]. The dominant economic activities in the area include farming, mining, commerce, animal husbandry, and hunting. The population is culturally diverse, with notable variations in ethnicity, traditions, and social norms. The northern part of the State is predominantly inhabited by Hausa Muslims, while the Southern region is home to a mix of ethnic groups, largely Christian, each with distinct cultural identities.

Data Collection

Data for this study were collected through Focus Group Discussions (FGDs), in-depth interviews, and direct field observations. Households in mining communities were purposively selected, as they are directly impacted by artisanal mining activities and are therefore well-positioned to provide relevant insights and express their concerns. Participants aged 18 and above were included, as individuals at this age are generally considered capable of making independent decisions and participating in both local and national decision-making processes. Four local government areas - Sanga, Jema'a, Kajuru, and Birnin Gwari were purposively selected based on the presence of active artisanal mining operations. Within these areas, participants for the FGDs and in-depth interviews were also purposively chosen from among the local population to ensure relevant and experience-based responses. In each of the four selected local government areas, one Focus Group Discussion (FGD) was conducted with households. Each group consisted of 6 to 10 participants who gathered at a designated location to discuss specific issues and questions relevant to the study. A trained moderator facilitated the discussions, while a note-taker documented participants' responses and operated a voice recorder to ensure accuracy. Additionally, four individual officials associated with local mining activities were purposively selected for in-depth interviews, one from each local government area. These interviews were conducted face-to-face and focused on key topics outlined in the study. Furthermore, the researcher conducted direct field observations to assess the coping strategies adopted by households in response to the impacts of artisanal mining, identify the types of minerals extracted, and observe other related activities within the study area.

Data Analysis

Data for the study were analysed using descriptive statistics with the aid of NVivo Version 11.0, a software tool designed for qualitative and mixed-methods research. NVivo is particularly effective for analysing unstructured data such as text, audio, video, and images. It enables the organisation and condensation of large volumes of qualitative data such as those obtained from interviews, focus group discussions (FGDs), in-depth interviews, and participatory rural appraisals into manageable textual formats. The software allows for efficient transcription, coding, and categorisation of data based on participants' opinions and perceptions, reducing extensive qualitative input into concise, meaningful insights. The results of the analysis were presented in tabular format for clarity and ease of interpretation.

Presentation of Results

Adaptation Strategies to Cope With Shortage of Farmlands due to Mining in Kaduna State

Households in Kaduna State adopt various strategies to boost agriculture on mining-damaged lands, including land clearing, renting farmland, surface mining, planting exotic trees, refilling pits for cultivation, and using fertiliser and animal manure to improve soil fertility (Table 1).

Clearing of abandoned lands for Crop Production

The study found that households in mining communities clear long-abandoned fallow lands for crop production, as their original farmlands have been degraded by mining pits and ponds. This supports findings by [20] and [21], which show that households use non-mined lands to sustain agriculture. These fallow lands, having regained soil nutrients over time, require minimal fertiliser application to enhance crop yields, making them suitable for cultivation and helping households adapt to the impacts of artisanal mining. This is what one of the FGD participants has to say:

> "Our farmlands are now mining pits, so we returned to previously abandoned, low-fertility lands. After years of rest, the soil

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regained nutrients. We cleared and cultivated them, which has greatly helped us feed our families."

Households now travel long distances to cultivate crops, often relocating to hilly areas, as seen in Gidan Waya and Godo-Godo, due to mining damage to flat lands. This aligns with [22], who observed farmland resettlement into marginal areas. However, hilly terrains experience high surface flow, leading to rapid nutrient loss, reduced soil fertility, and negative impacts on vegetation and wildlife. Additionally, daily removal of watershed areas lowers the water table and increases land exposure to intense sunlight, accelerating evapotranspiration. These environmental changes pose serious challenges to sustainable agriculture in the affected communities.

Table 1: **Adaptation Strategies to cope with the effect of Artisanal Mining in the Study area**

Strategies to cope with shortage of farmlands	**Strategies to cope with shortage of grazing land**	**Strategies to cope with shortage of water for domestic uses**
➢ Clearing of abandoned land for crop production, ➢ Acquisition/renting of land for crop production, ➢ Adoption of surface mining, ➢ Planting of exotic tree species, ➢ Filling up of mining pits and ponds for crop production and ➢ application of fertiliser and animal dropping to improve crop yield	➢ Relocation of herders to new areas, ➢ Filling up of mining pits and ponds, ➢ Acquisition of land mainly for grazing, ➢ Caging livestock, and acquisition of feed for the livestock and ➢ Avoidance of contaminated and polluted water	➢ Heating and filtering of water, ➢ Avoiding polluted and contaminated water, ➢ Provision of wells, and ➢ Treatment of water with chemicals

Source: Field Survey, July, 2021

Table 1 shows different adaptation strategies to cope with the effect of artisanal mining in the mining communities of Kaduna State. *Acquisition/renting of Land for Crop Production*

Many participants noted that households in mining communities often rent or acquire land in non-mining areas for crop production, especially those who have completely lost their farmlands. Some also secure land from neighbours whose land remains unaffected. In certain cases, miners with income from mining activities invest in farming by renting land either within or outside their communities. To cope with the impact of mining, households engage in farming, trading, and labour supply, with mining proceeds often supporting small-scale agriculture [23] [24]. However, mining disrupts agriculture, increasing household vulnerability to hunger and malnutrition due to land loss. Acquiring farmland in distant communities also raises transportation costs. Additionally, some of the land accessed in non-mining areas has poor soil fertility, forcing households to spend more on farm inputs such as fertilisers to improve crop yield, further straining their resources and resilience.

Adoption of Surface Mining

The study participants revealed that in some areas, surface mining is adopted as a strategy to cope with limited agricultural land. This method allows farmers to return to the land after a few years, once soil nutrients are restored. Surface mining involves extracting minerals from the land's surface without digging deep pits, ensuring future agricultural use is not hindered. Prior to mining, agreements are made with miners to avoid creating holes that would obstruct farming. This approach enables landowners to resume crop production after the land recovers. A notable example is in Igboh Ngat, Zankan-Nindem, where surface mining was practiced, and after some years, residents returned to cultivate the land. The method has become a viable option for many households, balancing short-term economic benefits from mining with long-term agricultural use. Surface mining has a lower impact on agricultural lands than underground mining because it avoids creating deep pits that hinder farming. This allows households to continue cultivating their land, enhancing crop production for both personal benefit and the country's food supply. The findings of this study support [25], who highlighted that surface mining can serve as a short-term land use that, with proper reclamation, can be converted back into productive farmland. Surface mining is commonly practiced in hilly, rough terrains where underground mining is not feasible.

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Planting of Exotic Tree Species

The study found that households in Kaduna State mining communities planted exotic tree species such as *Elaeis guineensis*, *Pterocarpus mildbraedii* (Ameme), *Gmelina arborea*, and *Tectona grandis* to restore soil nutrients, especially in areas affected by surface mining (see plate 1). These trees also serve as income sources for families. For example, *Elaeis guineensis* produces fruits that can be consumed or sold. Additionally, G*melina arborea* and *Tectona grandis* yield timber and electric poles, which are harvested and sold to generate income. As one participant explained:

> "Sometimes we plant trees like palm, Ameme, Gmelina, and Teak on damaged land to restore it and generate income by selling timber, electric poles, leaves, and oil. These areas then provide us with oil for cooking and timber for roofing our homes."

In Nisama and Kanufi communities, residents planted trees like *Elaeis guineensis*, *Gmelina arborea*, and *Tectona grandis* on land affected by mining to reclaim the soil and generate income. These plantations now provide significant earnings and oil for the owners. This aligns with [26], who noted that farmers diversify into non-farm and off-farm activities to sustain income in mining areas. Although mining land may no longer be suitable for traditional farming, the trees serve as a long-term resource for future generations. They provide income, timber, and materials to build homes, benefiting even those yet to be born.

Plate 1: Exotic Tree Species Planted in Mining-Affected Areas for Land Reclamation and Income Generation in Kaduna State

Source: Field Survey, January, 2022

Filling up of Mining Pits and Ponds for Crop Production

Some FGD participants observed that in certain mining communities in Kaduna State, households reclaim mined lands by filling pits and ponds for crop production once the soil regains its nutrients. This aligns with [22], who noted that households often restore degraded land post-mining for agricultural use. In areas like Godo-Godo and Gidan Waya, where mining is intensive, farmers and miners sometimes agree beforehand that the pits will be refilled after extraction. Compensation is occasionally paid to farmers, who then hire workers to fill the pits, or miners do it themselves. However, some miners prefer paying others to handle reclamation, as filling pits may delay access to new mining sites. This view was well illustrated by one of the discussants:

"Agriculture sustains humanity, so when mining occurs on our farmlands, we agree with miners to either refill the pits they create or pay us to hire labourers. This ensures the land is reclaimed for farming and other productive uses after mineral extraction".

To restore land for future crop production, many households in Godo-Godo and Nisama refill mined areas, allowing soil nutrients to recover. This supports [25], who noted that reclaiming degraded mine lands boosts agricultural productivity, narrows crop yield gaps, and promotes food import substitution, especially for staples like rice and wheat.

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Application of Fertiliser and Animal Dropping

The study found that households in Kaduna State's mining communities apply fertiliser and animal droppings (cow and poultry manure) to boost crop yields. Many of these farmlands have been cultivated for generations and have lost essential nutrients over time. To restore soil fertility, farmers supplement with organic and chemical inputs. This aligns with findings by [27] and the [28], which show that fertilisation and organic inputs improve soil properties, including available phosphorus levels, thereby increasing crop productivity. These efforts have helped households grow more food and cash crops, contributing to food security and supporting their livelihoods. Some individuals used their earnings from mining to purchase farm inputs, such as fertilisers, to enhance crop production in the study area. Additionally, some farmers invited herders to settle their livestock on their farms, allowing animal waste to naturally enrich the soil, thereby improving fertility and supporting increased agricultural output. As noted by a discussant: Due to land shortage and poor soil fertility, I improved crop yield by applying fertilizer, cow and poultry manure, or allowing a herder to graze livestock on my farm temporarily. These methods have significantly enhanced the productivity of the land I cultivate.

Adaptation Strategies to Cope with Shortage of Grazing Land due to Mining in Kaduna State

Households adopted various adaptation and coping strategies to address the shortage of grazing land for livestock. These included relocating herders to new areas, refilling mining pits and ponds, acquiring land specifically for grazing, caging livestock, purchasing animal feed, and avoiding the use of contaminated or polluted water sources.

Relocation of Herders to New Areas

The study shows that livestock owners, especially herders in Kaduna State's mining communities, relocate to areas free of mining pits to protect their animals. In places like Godogodo, Gidan Waya, and Bakin Kogi Kaninkong, mining pits and ponds block livestock movement, forcing herders to migrate. This relocation helps prevent livestock losses and allows animals to graze freely in unaffected areas. As a result, herders can sustain their livestock in safer environments, ensuring continued production of meat and milk, which are important protein sources for the country.

Herders move to areas with abundant vegetation to feed their livestock. This study supports findings by the [29] and [9], linking mining impacts on herder livelihoods to their relocation away from mining pits. Although relocation can lead to competition and conflict over resources in crowded new areas, it allows herders to protect their livestock by moving to safer grazing grounds. One of the participants shared the following insight:

"Because of mining pits, we relocate our livestock to safer areas without wells or ponds to prevent accidents. These new grazing lands have abundant grass, allowing our animals to feed well and move freely, helping us maintain a healthy livestock population".

Filling up of Mining Pits and Ponds

The study revealed that many livestock owners, especially herders in mining communities, fill mining pits and ponds to create more grazing land. Often working through unions like Miyetti Allah or hiring others, they restore these areas to ensure free movement for their livestock. This reclamation effort has required significant financial investment across the study area. In some mining communities, households near mining sites refill pits to prevent losing livestock like pigs, goats, and chickens. Refilling allows their animals to move freely and safely. Livestock provide both income and food, so protecting them is essential. This finding aligns with [9] which noted herders refill mining pits to expand grazing areas and support their livelihoods.

Acquisition of Land mainly for Grazing

The study reveals that some households in Kaduna State's mining communities acquire land specifically for livestock grazing to prevent mining activities in these areas. This strategy helps avoid irregular surfaces caused by mining, ensuring free movement of livestock and reducing the risk of animals falling into pits. Mainly herders with large cattle and sheep herds adopt this practice, as maintaining safe and accessible grazing land is essential for sustaining their livelihoods [30]. For example, Fulani settlements in Bayya and Tafan Gidan Waya have secured land where mining is prohibited, allowing livestock to graze safely. Grazing is their primary livelihood, so they actively protect these areas from encroachment by mining activities. Such adaptive land-use strategies have been observed in other parts of northern Nigeria, where pastoralists respond to environmental and human-induced land degradation by securing alternative grazing spaces to ensure

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herd survival [31]. While this helps maintain their herds, herders sometimes still face challenges when moving livestock through mining-affected lands with uneven terrain, risking injury or loss of animals. This highlights the broader impact of artisanal and small-scale mining on pastoral systems, as land degradation and surface instability continue to pose risks to livestock mobility and safety [32].

Caging Livestock

The study shows that households in Kaduna State's mining communities cage their livestock to prevent accidents in mining pits that could cause injury or death. This finding highlights how local herders respond to environmental risks introduced by mining through practical and protective measures. Herders use iron nets or barbed wire to confine animals at night, protecting them from falling into pits and from cattle rustlers, while some also tie the animals' legs to keep them from escaping. These strategies reflect a deliberate effort to minimize both physical and economic losses, enabling herders to continue operating within mining areas with reduced vulnerability and greater confidence in the safety of their livestock [33]. This practice allows herders to stay in mining areas without fear of losing livestock, demonstrating its importance as a livelihood-sustaining mechanism. Additionally, many households build pigpens to cage pigs, further indicating a broader adaptation toward controlled livestock management in hazardous environments. Overall, caging helps families maintain larger herds safely, ensuring their livestock's protection and supporting their livelihoods despite the challenges posed by mining activities. Such adaptive practices underscore the resilience of rural households and their capacity to adjust traditional livestock systems to changing environmental conditions [34].

Acquisition of Feed for the Livestock

The study reveals that rural households in Kaduna State acquire livestock feed to prevent animals from wandering into mining areas. They often purchase maize or cowpea chaff (crop residues) to keep animals like chickens, goats, pigs, and sheep safely at home. Herders also adopt this practice, especially during the dry season when bushfires destroy grasses. To manage this, they store feed from the harvest period for use during food scarcity. This aligns with [35], who noted that crop residues are a key feed source for smallholder livestock farmers. Without stored feed, livestock may roam into abandoned mining sites in search of grazing, risking injury or death from falling into pits. By providing feed, households reduce such risks and better manage their animals, ensuring both safety and productivity despite environmental challenges caused by mining. The practice of acquiring livestock feed is common even in non-mining communities, especially during periods of scarcity. Rural households buy or gather feed to keep animals confined and safe, as free roaming can lead to theft, poisoning, or accidents, including falling into pits. To cope with feed shortages, farmers adopt various strategies such as switching feed types based on availability and cost, bulk purchasing, using crop or food waste, harvesting naturally growing forage, and reducing herd size [36]. These measures help protect livestock and sustain production during challenging times.

Avoiding Contaminated and Polluted Water

The study reveals that rural households in Kaduna State's mining communities avoid letting their livestock drink polluted water from rivers and streams, which may contain harmful chemicals like mercury used in mining. To protect their animals' health, herders take precautions, as livestock are vital to their livelihood. If animals accidentally drink contaminated water, they are given medical treatment upon return. Some herders also provide potash to aid digestion and maintain livestock health. These practices help reduce disease and death among animals, allowing households to sustain their herds with fewer challenges despite the environmental risks posed by mining activities. This was further emphasised by one of the participants: "We avoid polluted or contaminated water to keep our livestock healthy. If they happen to drink such water, we provide immediate treatment once they return from the field. Additionally, we use potash to aid their digestion and ensure their overall well-being."

Adaptation Strategies to Cope with Shortage of Water for Domestic Uses in Kaduna State

Water pollution affects rural households relying on natural sources like rivers and streams. In Kaduna State's mining communities, households adapt by heating and filtering water, avoiding polluted sources, digging wells, and using chemical treatments to ensure safe water for domestic use despite contamination and scarcity.

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Heating and Filtering of Water

The study shows that rural households in Kaduna State's mining communities heat and filter water from rivers and streams for drinking and cooking due to pollution caused by mining. As most communities lack access to clean, potable water, residents rely on traditional methods like boiling and filtering to ensure water safety and protect their health. Many households walk long distances to fetch water, highlighting the scarcity of safe water sources. This finding aligns with [37], who reported that traditional hygiene practices remain common in rural areas with limited access to improved water supply systems. Many households collect water from streams and rivers but often dig shallow holes beside the stream channels to reduce contamination risk. However, during flooding, the streams overflow, contaminating these sources. Heating and filtering remain effective water treatment methods, helping households access safer water for drinking and other domestic needs. One discussant clearly illustrated this point, stating: Since mining has contaminated most of our water sources and alternatives are lacking, we heat and filter the water before use to prevent illness. Without doing so, we risk contracting diseases from consuming untreated water.

Avoiding Polluted and Contaminated Water

The study reveals that households in Kaduna State's mining communities often avoid using contaminated river and stream water by sourcing cleaner water elsewhere. Instead of spending time boiling polluted water, many prefer collecting water from nearby communities with open wells or boreholes. This approach helps save time and reduces health risks. Some households, especially those with motorcycles or vehicles, transport water back home for drinking, cooking, and washing. During the dry season, they also dig shallow pits near cleaner stream channels to collect water. This finding aligns with [38], who observed that women adopt coping strategies such as sourcing water from safer neighboring communities, differentiating water use for specific purposes, and harvesting rainwater. These efforts highlight how households adapt to water contamination challenges by finding safer and more practical alternatives to meet their domestic water needs.

Provision of Wells

The study shows that households in Kaduna State's mining communities cope with water shortages by providing wells and boreholes for domestic use. In communities like Godo-Godo, residents collectively taxed themselves to fund borehole installation. Others locate nearby areas with underground water to dig open wells for communal use. Some households also dig wells on their farms to access water for consumption and for spraying herbicides and insecticides. These efforts reduce reliance on polluted water sources. Additionally, boreholes provided by politicians during election campaigns have improved water access in some areas, easing the struggle for safe domestic water. This finding reflects the broader situation in rural Nigeria, where communities rely heavily on self-help and local adaptation strategies to address water scarcity and pollution, especially in mining-affected areas [39]. The collective effort seen in Godo-Godo highlights the importance of community participation in providing basic infrastructure where government support is limited. Moreover, the dependence on wells and boreholes shows a shift away from contaminated surface water sources, which are often affected by mining activities. However, the use of farm wells for both domestic and agricultural purposes may pose risks of contamination from chemicals and mining pollutants. Studies have shown that mining activities in Kaduna State contribute significantly to water pollution, thereby forcing households to seek safer alternatives such as groundwater sources [8]. The role of politicians in providing boreholes during election campaigns also suggests that access to water infrastructure can be influenced by political factors rather than sustainable planning. While such interventions improve access in the short term, they do not fully address the long-term challenges of water supply in these communities. Overall, the strategies identified in the study demonstrate resilience among households but also reveal ongoing challenges in achieving sustainable and safe water access.

Treatment of Water with Chemicals

Some FGD participants reported that households in Kaduna State's mining communities treat water with chemicals like alum to improve its quality before consumption. Pollution and water shortages have forced them to adopt this method to remove impurities and reduce harmful germs, lowering the risk of diseases such as typhoid and cholera. The use of water treatment appliances supports improved water supply [37]. However, the amount of chemicals used is often unregulated

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due to a lack of proper treatment facilities, posing potential health risks. Additionally, some households skip water treatment because they cannot afford the chemicals, increasing their vulnerability to waterborne illnesses.

Conclusion

Artisanal mining significantly impacts various aspects of household life, compelling many families to seek alternative sources of livelihood. These activities pose serious threats, including the loss of agricultural land and domestic water sources, destruction of vegetation, and increased risk of injuries or fatalities. Social consequences such as school dropouts, early pregnancies, and child marriages are also prevalent. In response, households in affected communities have adopted a range of coping strategies. These include saving money, starting small businesses, building houses for personal use or rental income, and cultivating economically valuable trees such as *Elaeis guineensis, Gmelina arborea, and Tectona grandis* for future benefit. Additional strategies involve avoiding polluted water sources by using sachet or treated water, relocating herders, reclaiming mining pits and ponds, and steering clear of underground mining during the rainy season. These adaptive measures have enabled many households in mining communities of Kaduna State to endure the adverse effects of artisanal mining. The study recommends that both households and government authorities actively engage in land reclamation and the rehabilitation of underground mining sites for agricultural purposes as a long-term strategy to enhance food security and ensure environmental sustainability.

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