Environmental Research and Technology
https://dergipark.org.tr/en/pub/ert
DOI: https://doi.org/10.35208/ert.1593474

Environmental Research & Technology

Research Article

Indigenous knowledge and climate change adaptation in Ghana: Empirical evidence from the Tolon District

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ARTICLE INFO

Article history
Received: 29 November 2024
Revised: 06 January 2025
Accepted: 25 January 2025

Key words:
Indigenous indicators, adaptation strategies, climate change, indigenous knowledge systems, indigenous farmers, Tolon district

ABSTRACT

Reliable local weather predictions are essential for informing indigenous farmers in Ghana about climate change alternatives, as they heavily rely on rain-fed agriculture for their subsistence. The literature highlights numerous examples of how scientific understanding has fallen short in addressing the needs of rural areas over the past century. However, indigenous knowledge has proven invaluable in helping rural farming families adapt to climate shocks and make informed decisions about adaptation strategies. To ensure that indigenous knowledge systems receive the recognition they deserve, there is a pressing need to improve assessment procedures. This study assessed farmers' perspectives on indigenous knowledge of weather forecasting for climate adaptation and evaluated farmers' perceptions regarding climate change in the Tolon district of Ghana. Using a mixed methods approach, the study collected data through questionnaires, interviews and focus group discussions. The findings revealed a range of indigenous indicators used by farmers to forecast weather, including celestial movement (star and moon), emergence of red and black ants, wind movement, flowering and fruit production of some indigenous trees, the behaviour of certain trees (developing tree new leaves of baobab), the croaking of frogs, birds, the appearance of rainbow and lightning. The findings underscore the importance of considering indigenous knowledge network when developing climate change adaptation strategies. Policymakers are urged to educate indigenous communities about the impacts of climate stress and provide support to boost agricultural productivity.

Cite this article as: Abukari A. Indigenous knowledge and climate change adaptation in Ghana: Empirical evidence from the Tolon District. Environ Res Tec 2025;8(4) 986-995.

INTRODUCTION

Climate change negatively influences agricultural activities in global communities; however, the effects are not the same among rural farmers [1, 2]. According to the Intergovernmental Panel on Climate Change (IPCC) [3], local farming systems in Sub-Saharan Africa (SSA) are a vital segment that is greatly influenced by climate change. Climate change impacts the food security of the local population, requiring urgent attention [4]. Bansah et al. [5] stated that rural farmers are particularly affected by the changes in climate, as extreme weather events cause the decline of crops and decrease farmers' subsistence. Reports show that scientific knowledge in recent years has been lacking and is inadequate at the local level in fighting environmental problems [6-8].

Little information is known about merging indigenous knowledge and the knowledge in the scientific community in responding to climate menaces, thus, this research concentrates on local farmers' indigenous knowledge as an approach to responding to climate change. Many researchers have progressively acknowledged that indigenous knowledge is more appropriate, dependable, and readily employed by rural farmers in climate predictions than scientific weather

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data [11-13]. Yua et al. [14] indicated that indigenous knowledge is analogous to scientific data. Many investigations have shown that indigenous knowledge approaches are qualitative while creating a historical databank resulting from observations over a long period from the local environment [1, 15, 16]. Observers are usually indigenous people since their decision is associated with the quality and consistency of their socio-environmental explanations [17]. Alternatively, modern science explanations result from limited indigenous people and ecology knowledge.

According to the IPPC, adaptation is the "adjustment made to the human, ecological or physical system in response to a perceived vulnerability". Adaptation concerning climate menaces is fine-tuning the physical environment in response to climate change's anticipated shocks and effects [18, 19]. Indigenous knowledge in climate science is anticipated to assist indigenous farmers at the local level to adapt strategies concerning unforeseen weather conditions and climate change effectively [3, 10, 20]. Many climatic threat approaches have been employed in Ghana including water harvesting techniques, drought-resistant seed production, diversification of crops and livestock, changing planting dates and early maturing crops [21]. Some studies reveal that indigenous farmers employ indigenous knowledge indicators to forecast the commencement and end of planting periods. For instance, the presence of dark clouds, increased insects and the ground becoming very hot indicates heavy rains to come [22]. Moreover, the appearance of birds such as the white-faced whistling duck, the appearance of frogs and the movement of the wind are employed as indicators for the coming rains [23].

Several indigenous farmers in Ghana have employed indigenous climate indicators to forecast the weather and arrived at better farming decisions vital for dealing with climate change [24, 25]. The report from Boafo et al. [26] indicates that indigenous farmers experience extreme weather conditions in Ghana.

Owing to the scarce climate science data, indigenous farmers depend on indigenous knowledge to fight climate change [27, 28].

Small-scale farmers face climate variability and climate change that jeopardize district agricultural production. For instance, introducing new crop varieties, predicting change and executing measures to mitigate negative effects on agricultural output are all part of adapting to climate risk. Though, among indigenous farmers, using scientific models is not cost-effective in offsetting climate menaces in rural areas. Consequently, factors such as no education, absence of climate data and low financial strength influence the indigenous farmers in adapting to smart agricultural practices. Kugara et al. [29] suggested concentrating on indigenous knowledge and assessing how it relates to weather forecasts and climate change. Thus, indigenous farmers in the Tolon district of Ghana exclusively employ IKS as the strategy adapted to forecast the season's commencement and harvesting time through weather indicators.

Notwithstanding, indigenous farmers have restricted access to weather forecasts making climate change adaptation relatively cheap [30].

The response to climate change in the Tolon district of Ghana continues to be at a breakneck speed as the effects of climate variability emerge. Hence, crop production and farmers' subsistence are threatened due to the delay in response to climate menace over the years [1].

Due to climate change impacts, small-scale farmers face major threats to farming activities and crop yields. These impacts are commonly found in the district's semi-arid areas with farmlands receiving less annual precipitation [31]. Major drivers including rainfall variability, high temperatures and unceasing droughts are expected to impact crop production in the Tolon district substantially. Chhogyel et al. [32], observed that weather predictions indicate the incidence and high temperatures intensity, drought rainfall variability and heatwaves negatively influence agricultural production.

Many studies have revealed that indigenous weather indicators, including the appearance of certain plants, movement of the stars and moon, presence of red and black ants and mist cover on mountains, are used by smallholder farmers during the changing weather conditions in SSA [1, 33, 34]. Also, the same weather forecasts are founded on scientific knowledge and climatological indicators such as the movement of the wind and air temperatures are studied as indigenous knowledge by indigenous farmers [1]. Now, many scholars approve of the integration of indigenous knowledge and scientific knowledge. Owing to inadequate strategies for adapting to climate change, indigenous farmers employ indigenous knowledge indicators to reduce climate change and climate threat [31]. Consequently, the responses from indigenous farmers in the study area suggest that they use indigenous knowledge for weather forecasts.

We should be aware that traditional beliefs and the understanding of mythical paths are crucial in rural areas because indigenous farmers firmly believe in the socio-cultural knowledge of their forefathers concerning severe weather conditions and farming output. A compelling case can be made for revising indigenous resilience as the foundation of indigenous knowledge for failing strategies. Hence, educational programmes such as workshops, seminars and radio discussions should be developed for indigenous farmers to obtain climate information in the Tolon district. In many studies, the conservative know-how was employed to challenge the antagonistic weather events which are also executed by indigenous farmers in Ghana [35-37, 38]. This survey was pursued to educate the regional, national and policymakers on how indigenous farmers employ indigenous knowledge indicators as an adaptation strategy to fight climate change in the Tolon district of Ghana, thereby contributing to the achievement of Sustainable Development Goals (SDGs) 1, 2, 5, 8, 10 and 13. This study investigates (i) the extent of indigenous farmers knowledge of climate change indicators (ii) what indigenous knowledge system do farmers employ to deal with climate change? and (iii) what indigenous strategies do farmers use to adapt to climate change? Therefore, the study will allow policymakers and professionals to reinforce adaptation actions and implement and network with indigenous farmers' expertise regarding climate indicators.

MATERIAL AND METHODS

Study Area

The study was conducted in the Tolon district in the Northern part of Ghana, which is situated in the Guinea Savannah agro-ecological zone having boundaries with North Gonja to the West, Kumbungu district to the North, Central Gonja to the South and the East with Tamale metropolis. It lies between latitude 9°43'33" north and Longitude 1°06'67" west (Figure 1).

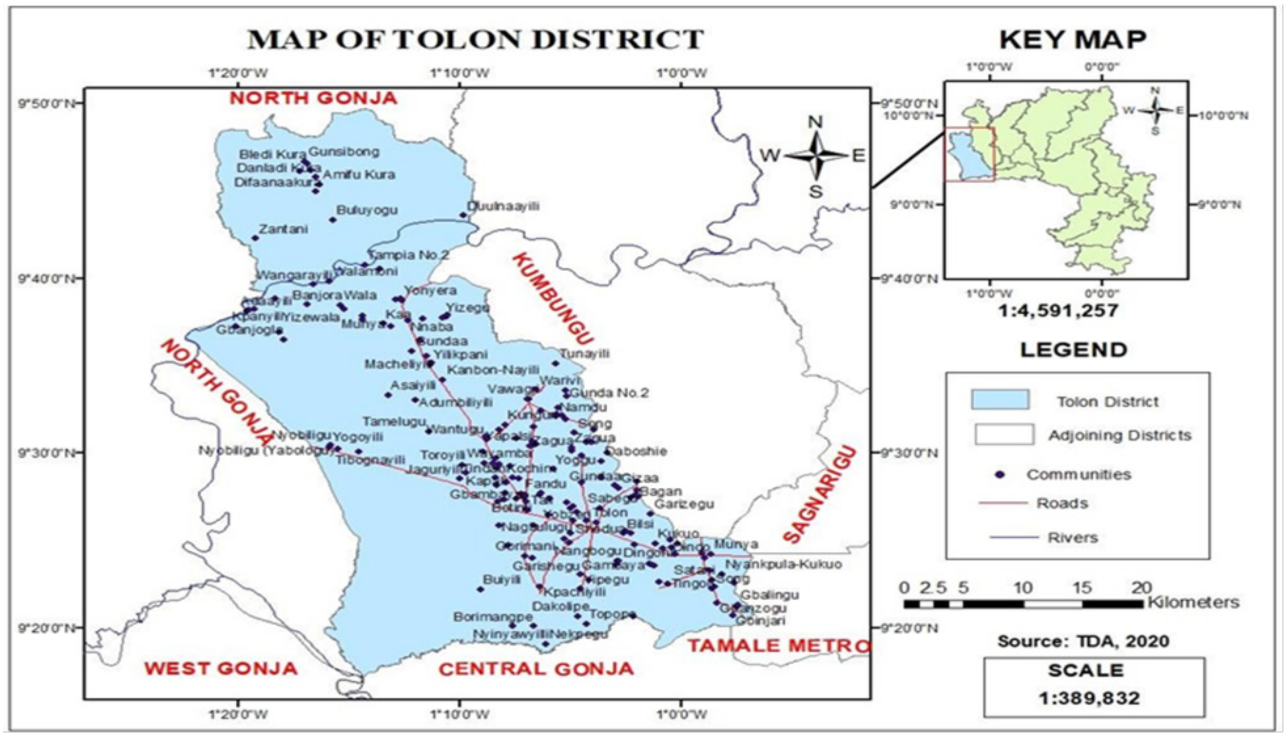

Figure 1. Location of study communities

The Tolon district experiences wet and dry seasons. Generally, the wet season commences in May and wraps up in September with varying rainfall from 800 mm to 1100 mm per year. The wet season is further defined by heavy rainfall, most common in August and September. The dry season is the longest with temperatures of 15° C and 35° C respectively during the night and day and is common from October to April.

The Tolon district primarily consists of grassland vegetation and some drought-resistant scattered Guinea Savannah woodlands such as Vitellaria paradoxa, Acacia longifolia, Adansonia digitata, Parkia biglobosa, Azadirachta indica, Mangifera indica. These trees contribute to the indigenous people's subsistence owing to their economic value.

Agriculture is the primary revenue generator in the area and the majority (90%) of the indigenous people participate in small-scale farming. The district's agricultural system is determined by agro-ecological factors notably the unimodal rainfall trend. Farmers cultivate annual crops such as maize, groundnut, rice, sorghum and vegetables plus raising livestock including poultry, cattle, goats and sheep in the district. The majority of the female population is involved in dawadawa and shea butter production, collection of firewood and charcoal production [39].

Sampling Techniques and Sample Size

The study implemented the multi-stage sampling technique to select farmer households. The initial stage was to select a district in the Northern region of Ghana given that it was unachievable to survey all the farmers practicing small-scale farmers in the region. The subsequent stage randomly selected five district communities: Gundu, Dalingbihi, Munya, Lungbunga and Warivi. Finally, small-scale farmer households were randomly selected. To arrive at the final samples the communities were divided into smaller intersecting areas with some of these areas chosen randomly. The total population of the five communities was 1100. 285 rural farmers were selected from five communities in the district. The Krejcie & Morgan [40] table was employed to determine farmers' sample size in the communities.

The purposive sampling was done to select knowledgeable and experienced farmers in indigenous knowledge indicators regarding climate change. The research obtained detailed information from farmers by employing sampling methods. The study compiled voluminous details on indigenous knowledge and opinions concerning climate change. The exploratory approach was employed to acquire information about rural households and allow the investigator to comprehensively understand indigenous knowledge and climate problems while uncovering novel perspectives. Furthermore, this approach was employed to elicit clarifications from participants regarding climate change and approaches employed by indigenous farmers in the district.

Methods of Data Collection

The information was gathered from both main and supplementary references. The main data was obtained through surveys, semi-structured interviews, focus group talks, transect observations, and oral narratives, while the supplementary information was collected from journal papers, symposium papers, and books.

To collect comprehensive data questionnaires were administered to most indigenous farmers who are household heads. The adaptive strategies and the perception of indigenous farmers on the variations in their environment to fight climate change were obtained during the interview. The focus group discussion was used to gather information about household demographic attributes (years of farming experience, gender, household income levels of farmers and educational level of farmers). The indigenous farmers' perception and knowledge of climate indicators regarding climate change were split from the questionnaires during the group discussions and face-to-face interviews. To obtain detailed qualitative information concerning the experiences, attitudes and perceptions of the indigenous farmers focus group discussions were employed. The focus group discussions used 4-8 indigenous farmers including male and female traditional leaders. The researcher and three research supporters who understood the local language hosted the discussions. The focus group discussion used a checklist on farmers' retorts, local climate indicators, farmers' perception of climate change and the effects on crop yields. Conversely, three (3) research supporters who understood the local language were trained for 3 days aimed at enhancing their ability to communicate with farmers. Additionally, there was a greater concentration on purposefully interviewing the indigenous farmers who have adopted the indigenous approach for more than 20 years to cultivate crops against climate change in the Tolon district. These aspects were used to understand farmers' perceptions of climate change and indigenous farming practices in the district. The investigation emphasized indigenous farmers who were at least 50 years old or endured farming in the district for at least 20 years. The age restriction attracted indigenous farmers who could accurately account for climate change over an extensive period. After receiving consent each interview lasted for 45 minutes and was recorded.

The University for Development Studies ethics board was consulted for ethical approval for this study (approval no. UDS IRB0036) on 30/06/2022. This guaranteed that the study followed all the required ethical standards, guaranteeing that participants were not disadvantaged.

Ghana has gone through major attempts to adjust to and deal with environmental changes and climatic highlights resulting from increasing temperature, drought, and meagre rainfall. Local farmers in the Tolon district of Ghana have grown a variety of crops that resist adverse weather conditions and often complement such through trading and shea butter making. Indigenous farmers in the district adopt practices such as climate-resistant crops, adjusting planting dates, employing a native variety of plants and eventually migrating to the cities when they are unsuccessful.

The engagement of indigenous farmers was completely optional and a written consent form was completed before collecting the information. From November 2022 to March 2023, the investigator and research assistants collected the information through questionnaires. The Tolon district of Ghana is extremely in peril of climate occurrences. Regardless of this, indigenous farmers are employing IKS-based approaches to subsist to alleviate the adverse impact of climate patterns on their farming operations.

Data Analysis

The qualitative study involved evaluating indigenous farmers' opinions on climate change through focus group discussions and interviews. The Microsoft Excel 2019 statistical package was implemented to analyze quantifiable data. The content and ethnographic methods of analysis were used in this study and both suggested analyzing the information gathered from focus group discussions. Thematic content analysis was used to collect and analyze data from in-depth interviews with indigenous farmers, focus group discussions and observation. The interviews and focus group discussions were audio- recorded and subsequently transcribed into written text. A coding framework was developed to identify and categorize the climate change indicators mentioned by farmers such as changes in temperature and precipitation patterns, shifts in seasonal cycles and increased frequency of extreme weather events. The theme identification was conducted to uncover patterns and themes related to the climate change indicators including observation of changes in weather patterns, indigenous knowledge and practices for adapting to climate change. The themes were refined through a rigorous process of reviewing the coded data, checking for consistency and ensuring that the themes accurately reflected the data. Ethnographic techniques were employed to gain insight into the behavioural patterns and life styles of indigenous farmers. Participant observation was conducted with indigenous farmers to gain a deeper understanding of their daily practices and knowledge related to climate change adaptation. Detailed field notes were taken on observations, conservation and interviews with farmers. A detailed description of farmers practices and knowledge related to climate change adaptation was developed including indigenous farming practices and techniques, local knowledge of climate change and the adaptation strategies. Patterns and themes were identified in the data such as the use of indigenous indicators like changes in plant phenology to predict weather patterns. The findings were contextualized within the broader cultural, social and historical context of the indigenous farming communities.

RESULTS AND DISCUSSIONS

Indigenous Farmers' Knowledge and Perception of Climate İndicators

This study employed indigenous farmers' perceptions as an aspect of their daily and ongoing interactions. Understanding indigenous knowledge depends not only on the indigenous farmers' identities but their lifestyles, environment and the connection between the two factors [1, 41].

The study revealed that 44% of the indigenous farmers showed a very high level of indigenous knowledge regarding climate change, 46% of the indigenous farmers also showed a high level of indigenous knowledge while 6% of the indigenous farmers showed a very low level of indigenous and only 4% of the indigenous farmers showed a low level of indigenous knowledge (Figure 2).

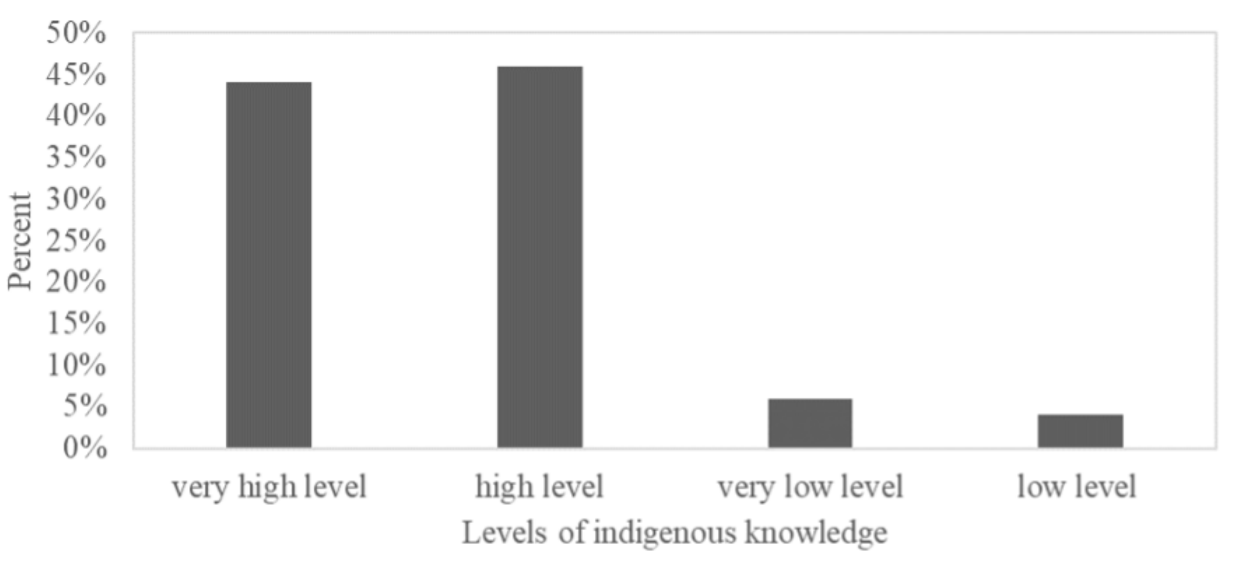

Figure 2. Levels of indigenous knowledge on climate change

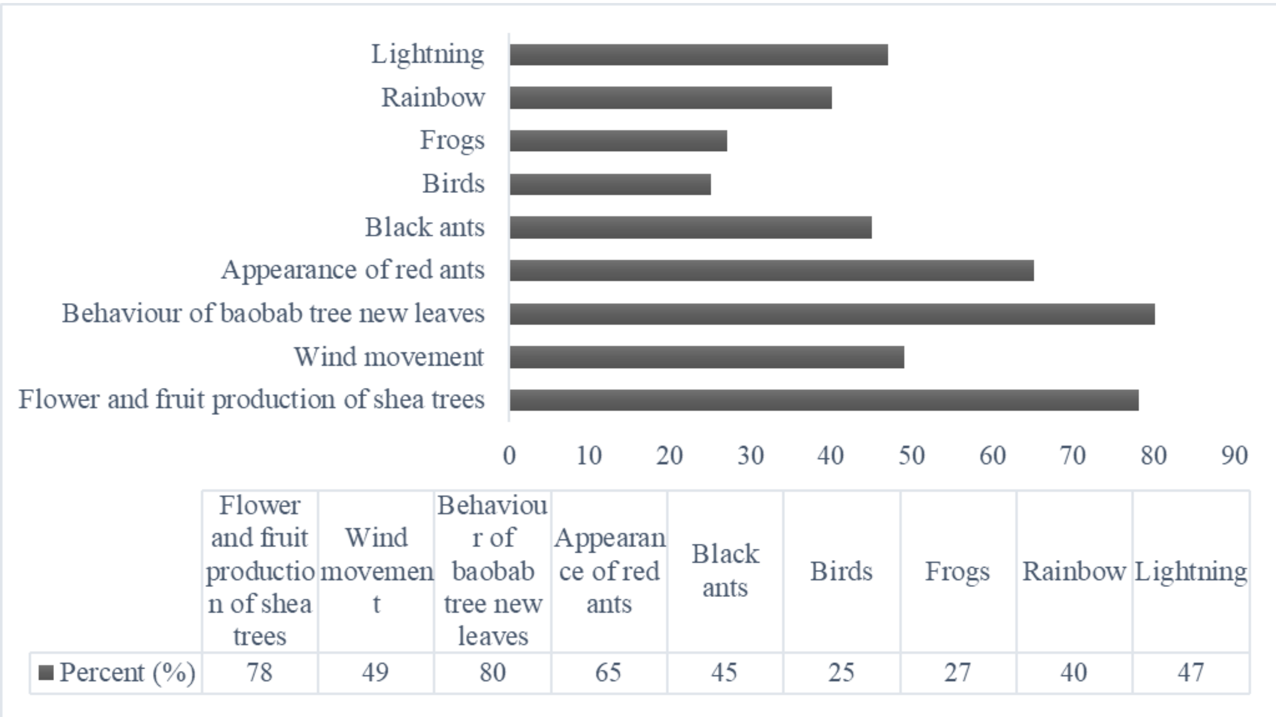

Figure 3. Climate indicators employed by indigenous farmers in making decisions

The indigenous understanding of weather prediction is a vital aspect of the theory of ethno-meteorology. It is founded on indigenous environmental knowledge passed down from one generation to the next generation [42]. It was understood in focus group discussions that indigenous farmers historically utilized numerous indigenous climate indicators based on their socio-cultural, environmental, social and cultural beliefs.

The study revealed that indigenous farmers employ key indicators to predict climate and climate change. The aforementioned indicators were taken into account to determine the indigenous farmers' options regarding the time for planting crops and the type of crops they choose for their farming activities. These choices could be determined by unpredictable evidence employed during the initial planting stage. Nevertheless, farmers acknowledge that the initial rainfall at the commencement of the wet season gives them an idea of how the growing season's remaining months will progress. As the dry season continues, unpredictable rainfall could lead to misleading information and deception among indigenous farmers. For instance, Parkia biglobosa flowering and leaf development are regarded as an indication of the wet season. Furthermore, the brightness of stars, moon, and sun is closely noted at the beginning of September, signifying the commencement of a new season [43, 44]. In the lack of conventional climate prediction, indigenous farmers in the study area can discern climate indicators through the behaviours of specific plants. Moreover, one of the indigenous farmers in the Lungbunga community stated that their ancestors passed on to them the explanation of using certain plants and animals as climate condition indicators during the focus group discussions. Thus, this indigenous knowledge passed down from ancestors who understood the agricultural system is centuries-old and has demonstrated climate prediction understanding that has been advantageous to indigenous farmers. This study corroborates the study by Kom et al. [1] who found that stars relocating from west to east during the night in the skies indicate that rain is expected in a couple of days.

The majority of the resolutions adopted by the indigenous farmers in the Tolon district of Ghana are centered on the indigenous farmers' own experiences attributed to the surging climate and the unpredictability of the initial rains. According to the survey data, a majority (89%) of indigenous farmers used IKS to predict the condition for the season of planting to arrive at reasoned agricultural options and address crops in the context of changing climate conditions. Figure 3 shows that 78% of the indigenous farmers employed flowering and fruiting of some indigenous trees such as the shea tree to predict the climate condition when opting for the planting seasons [45, 46], 49% of the indigenous farmers employ wind movement to predict the possibility of rain in the coming days. This finding is consistent with those of Bauer et al. [47] and Adanu et al. [48], who employed indigenous climate predictions in eastern Ethiopia. 65% of the indigenous farmers used the appearance of red ants as possible indicators for the dry season while 45% of them employed black ants as excellent climate predictors at the commencement rainy season indicating that farmers ought to prepare for planting. Also, 25% of the participants used the flapping of the wings of ducks in dry and wet places to indicate drought and pending rainfall while 27% of the participants used the croaking of frogs in June to indicate heavy rains. 40% and 47% of the participants use lightning and rainbow to indicate the rainy time is near the end of the rainy season respectively. The findings of this study collaborate with Alemayehu & Hizekeal [49], who found that black cloud formations indicate, the impending arrival of heavy rain.

IKS Employed in Dealing with Climate Change

The theoretical and scientific method fails to clarify how indigenous farmers perceive climate change adequately. The indigenous people in the district prefer indigenous indicators as climate data systems. The traditional knowledge of the weather circumstances in the district might have affected how the majority of rural farmers reacted toward the various consequences of variability in the climate.

The findings highlight the importance of indigenous knowledge practices in climate change approaches. Indigenous farmers possess a limited understanding of variability in the climate, despite having witnessed and experienced the changes including declined rainfall, the untimely end of rainfall, surging temperatures, periodic drought and reduced planting periods. The majority of the indigenous farmers (89%) applied IKS climate prediction to cultivate crops and implement a particular agricultural activity according to the environmental indicators in the district. This result corresponds to that of Kom et al. [1], who found that climate change is based on empirical data compared to the perceptions of indigenous farmers.

Regardless of the huge difficulties posed by climate change, indigenous farmers continue to use indigenous knowledge methods to deal with and adjust to their environment. Contrary, they are extremely prone to the impacts of climate change and have limited adaptive ability [50]. These indigenous farmers have come up with an array of socioeconomic strategies that have constituted the foundation for their ability to respond to climate change. Therefore, a compelling case is to be presented for revitalizing indigenous-based resilience as a foundation for managing and adapting techniques.

The results showed that indigenous knowledge is important in climate prediction and growing crop options. This agrees with the findings of Kugara et al. [29], Ankrah [51] and Limpo et al. [52]. Furthermore, the findings demonstrated that the prevalence of early morning clouds indicates excellent rains in the coming days, so farmers prepare their fields for the sowing of crops. These findings are in line with Salum et al. [53]. Indigenous farmers revealed in the focus group discussions, that insect behaviours occasionally anticipate the possibility of crop disease outbreaks in certain planting seasons. Thus, there is a need for indigenous farmers to employ an array of IKS measures to organize and regulate agricultural production practices.

Indigenous Strategies for Adaptation

The findings demonstrated that indigenous farmers employ several adaptation strategies to fight climate change and unpredictability. These strategies includee the modification of planting schedules, using drought-resistant crops, applying diversified indigenous crops and practicing local irrigation.

The indigenous farmers recommended in the focus group dialogue that rainwater harvesting and building small local dams for irrigation to mitigate the extended drought could be employed as an adaptive approach to the climate threats. The introduction of short-season crops as opposed to long-season ones as a means of adapting to the changing seasons constituted one of the approaches employed by the indigenous people. For instance, indigenous farmers usually planted maize in April and May owing to climate change issues the planting period has shifted from June to July.

This result is consistent with the work of Kandegama et al. [54] who found that variations in climate contributed to the unpredictability and changes in cultivation schedule and indigenous farmers tend to choose crops that are resilient to local droughts. Also, the findings showed that indigenous farmers cultivated annual crops such as maize, groundnuts and cowpea which proved to be more resilient to long-term drought compared to other crops. Kom et al. [1] observed that indigenous farmers who practice crop diversification as a local approach to reduce climate threats experience increases in crop yields. Indigenous farmers have increased the number of livestock as one of the adaptation approaches to reduce the effects of climate threats and improve income diversification compared to the preceding years. These results concur with the findings reported by Bekuma et al. [55] who conducted a similar investigation in the East Wollega Zone of Oromia, Ethiopia.

CONCLUSIONS AND POLICY IMPLICATIONS

In this study, indigenous farmers in the Tolon district of Ghana were interviewed about applying IKS for climate prediction and adaptation to mitigate the adverse effects of climate change. These indigenous farmers implemented the movement of the wind, the presence of black and red ants, the development of flowers and fruits of indigenous trees to forecast the climate situation.

Furthermore, the perceptions of indigenous farmers on climate change include climate indicators, continued droughts, the upsurge of temperature, decline in rainfall and heatwaves. Also, this research showed how indigenous knowledge was instrumental in the development of methods for adapting to various climate-stressful events like cultivating crops that are resistant to drought, cultivating short-season crops instead of long-season crops, modifying planting schedules, using local methods of irrigation and cultivating native crop varieties. As the majority of indigenous farmers lack access to scientific-methodical forecasting services and are equipped with little to no understanding concerning how to analyze climate data, the utilization of indigenous knowledge systems for weather forecasting approaches significantly enhances the capacity for adaptation in the area. This study makes significant scientific contribution to the field of climate change adaptation by exploring the vital role of indigenous knowledge in enhancing resilience and sustainability, demonstrating the importance of incorporating indigenous knowledge into climate change adaptation strategies and providing a nuanced understanding of climate change impacts and adaptation strategies in specific cultural and environmental contexts. The study bridges the gap between indigenous knowledge and scientific research empowering indigenous communities by recognizing the values of their knowledge and developing context-specific climate change adaptation strategies that incorporate indigenous knowledge, thereby enhancing their effectiveness and sustainability. Despite the accepted value of IKS as a mitigation approach, national institutions and local authorities need to offer assistance through climate policy and programmes.

National institutions, such as the Ministry of Forestry and Environment and local authorities such as district governments should provide technical and financial assistance to support the development and implementation of indigenous knowledge-based climate change mitigation and adaptation strategies. This assistance can be provided through:

1.Capacity-building programmes for local communities and indigenous knowledge holders

2.Funding for climate-resilient agriculture and natural resource management projects.

3.Development of climate policies and programmes that incorporate indigenous knowledge and practices.

Specifically, the Ministry of Forestry and Environment can provide technical guidance and support, while district government can provide funding and logistical assistance. Local communities and indigenous knowledge holders can be involved in the planning, implementation and monitoring of these initiatives.

DATA AVAILABILITY STATEMENT

The authors confirm that the data that supports the findings of this study are available within the article. Raw data that support the finding of this study are available from the corresponding author, upon reasonable request.

CONFLICT OF INTEREST

The author declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

USE OF AI FOR WRITING ASSISTANCE

Not declared.

ETHICS

There are no ethical issues with the publication of this manuscript.

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