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TABLE OF CONTENTS

<i>About the Journal</i>	iv
<i>Author's Guidelines</i>	v
<i>Editorial Board</i>	vii
<i>Table Contents</i>	viii
Impact of <i>Tamarindus Indica L.</i> on Soil Fertility in Smallholder Agroforestry Systems of Gumel, Jigawa State, Nigeria <i>Abdulmajid, A., Usman Shehu Ahmad & Muhammad, N. D.</i>	1-12
Sociological Analysis of Anti-Corruption in Nigeria: A Study of Independent Corrupt Practices and Other Related Offences Commission (ICPC) <i>Ibrahim Yusuf & Jefferey Onyekachi Okwunwa</i>	13-46
Investigating the Determinants of Domestic Energy Consumption Patterns in Abuja Municipal Area Council (AMAC) Abuja <i>IMANFIDON, Samson Enenhizenan, ILENRE Abraham Ehizojie, & OKHAE Ehiabhi Sunday</i>	47-65
Change in Rainfall and Temperature Patterns as Evidence of Climate Change in Benin-City, Edo, Nigeria <i>Ilenre Abraham Ehizojie, Tashok Y. H. & Abumere Daniel</i>	66-76
Commercialization and Financial Performance: Empirical Evidence from NTA and FRCN <i>Alhaji Abduljalil Wali</i>	77-85
Implications of Climate Change on Seasonal Bush Fires in Ikpoba-Okha Local Government Area, Edo State, Nigeria <i>Abraham Ehizojie Ilenre, Okhae Ehiabhi Sunday & Imanfidon Samson Enenhizenan</i>	86-96
Assessing the Impacts of Extreme Hydrological Events and Flood Vulnerability in Lokogoma Community, Abuja, Nigeria <i>Abubakar SADIQ & Mohammad Abdul-Rahman Muslim</i>	97-111
Comparative Analysis of Soil Physical and Chemical Properties in Bichi and Gaya Farms, Kano State, Nigeria <i>Haris, G. N., Abdulkadir, N. A., Adamu, M. B., Abdulbasir, A., Sufiyanu, S., Amin, M. A., Ahmad, U. B. & Abdullahi, S.</i>	112-121
Assessment of the Level of Flood Vulnerability and Mitigation Strategies in Shiroro Local Government Area, Niger State, Nigeria <i>Waziri, A., M., Adnan, A., Ahmed, Y., Ishaq, A. B. & Usman M. N.</i>	122-133
Indigenous Knowledge, Techniques and Perception on Weather, and Crop Production Practices in Part of Biu and Hawul, Borno State, Nigeria <i>Yahamman I. Usman, Maharazu, A. Yusuf, Afolayan, O. Samuel & Abdulkarim, K. Mohammed</i>	134-147
Effects of Artisanal Mining on Land Degradation in Anka and Maru, Zamfara State, Nigeria <i>Ibrahim Idris Baba, Richard Goji Abel, Telzin Ponsak Bala & Abdulyasar, Idris Baba</i>	148-158
An Analysis of Socio-Economic Variables that enhance the Quality of Life in Rural Kano State <i>Umar Farouk Yahya & Abdulkadir Muhammad Dambazau</i>	159-168

INDIGENOUS KNOWLEDGE, TECHNIQUES AND PERCEPTION ON WEATHER, AND CROP PRODUCTION PRACTICES IN PART OF BIU AND HAWUL, BORNO STATE, NIGERIA

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Abstract

The study explores the use of indigenous/local knowledge, techniques, and perception of weather, and crop production practices in Biu and Hawul Local Government Areas of Borno State, Nigeria. Data were collected through Focus Group Discussions, Key Informant Interviews and open-ended questionnaires across the three villages of Buratai, Viukutha and Yimirshika. The data were analyzed both quantitatively (descriptive statistics) and qualitatively (content analysis). The findings revealed that the farmers employ a variety of indigenous knowledge, techniques, and perceptions of weather, for making decision on crop production to ensure the success of their farming activities. Though these are slowly diminishing due to a variety of socio-economic and environmental factors. The indigenous smallholder farmers rely heavily on their knowledge and experience of the local environment, including the prevailing weather conditions to predict weather for crop farming decision making. In addition, they use indigenous techniques such as observing plants phenology, animal behaviour, atmospheric condition and lunar calendar to predict weather and make decision on farming activities accordingly. The findings also indicated that the farmers have a high degree of local knowledge and understanding of the weather phenomena for enhanced crop productivity. The study recommends that State/local government and NGOs must work together with NIMET to provide downscaled weather information for the local farmers through extension agents and also plan for the integration of the indigenous/local weather forecast/ forecasting indicators with scientific forecast information for enhanced productivity.

Keywords: *Indigenous Knowledge, Weather, Techniques, Perception and Rainfed Crop Farming.*

Introduction

Indigenous people and their Traditional Ecological Knowledge (TEK) on weather have been considered essential in global efforts to adapt to climate variability and change. Though, indigenous people represent just 5% of the World's population, they inhabit 22% of the Earth's surface and are custodians for 80% of the planet's biodiversity (International Labor Organization, 2017). There is evidence that their land management systems ensure sustainability; their farming practices minimize emissions from deforestation, and thus, their adaptation strategies can be used in coping with current challenges on climate variability and change (Macchi *et al.*, 2008). However, Traditional Ecological Knowledge (TEK) and the resource-based livelihoods of indigenous communities, are themselves threatened by climate variability and extreme environmental events (Nakashima *et al.*, 2012; Mafongoya and Ajayi, 2017). Weather and other climatic variables understanding, prediction anticipating changes and interpretation is very crucial for rural communities whose livelihood rely directly on weather and climatic conditions. Across the world, local communities observe the weather events taking place in their environment which affects their livelihood choices.

Indigenous societies observe bio-physical, animate and inanimate entities to make predictions about future and current weather variables that can sometimes be sensed directly by human senses (Balehegn, *et al.* 2019). Therefore, understanding values attached and local practices by indigenous people about weather events and farming practices are of paramount importance.

Nigerian agriculture is actually characterized by small farm units, fragile soil, rain dependency with minimum inputs. Despite these features, the Nigerian resource-poor farmers have for ages sustained the national food supply through a considerable wealth of environment-related indigenous knowledge in harnessing of natural resources and in the manipulation of socio-economic factors of production (Adedipe, *et al.*, 2004). Indigenous/local weather knowledge on climatic parameters, and crop production practices, are not only relevant in day-to-day decision making in farming communities but continues to be the only accessible and affordable alternative source of climatic information (Chisadza, *et al.*, 2015; Balehegn *et al.*, 2019).

Despite tremendous contribution of Indigenous Knowledge (IK) in crop production by resource poor farmers and considering the recognition of breakthrough by agricultural scientists across the world, there is the need to further strengthen the synergy between IK and modern technologies in farming system, especially subsistence crop production (Adedipe, *et al.*, 2004).

Indigenous small holder farmer communities in Biu and Hawul LGAs of Borno State have been depending on technique and perception of weather using local knowledge to upscale their rainfed cropping seasons. Available Biophysical indicators are observed to predict weather to make decisions to implement on their rainfed crop production. The study inventories the indigenous/local knowledge for weather prediction condition and interpretation and relate same to rainfed crop production practices in the study area.

Methods

Study Area

The study was conducted in part of Biu and Hawul L.G.A, located in southern Borno, Borno State. The area lies between latitudes 10°.18' and 11°.06' and longitude 11°.25' and 12°.30'. It covers an area of about 5,400 Km² (Biu, 3,315 Km² and Hawul, 2,098 Km²). It is bordered to the northeast by Daboa L.G.A, to the west, by Kwaya Kusar L.G.A, to the east, by Askira Uba L.G.A and to the south, by Gombi L.G.A in Adamawa State (Usman, 2015).

The climate of the area is considered most clement in north eastern Nigeria. Its elevated position on the plateau accounts for this. At about 800 meters above sea level, the weather is sharply remarkable on accounts of the hot, humid and semi-arid nature of much of the north east zone. It's often referred to as climatic Oasis of sort in the zone. Dry season is brief and tolerable by the breezy mix of hot and cold weather. It begins in December with harmattan and ends in March, just before the onset of rainy season. The rainy season is from May to October. The rains are characterized by thunderstorm and furious winds, flashes of lightening accompanied by thunder claps. The temperatures are around the hot season ranging from 39°C and 47°C and around 27°C to 32°C during cold seasons (Usman, 2015, and Mayomi, *et al.*, 2017).

Biu local government area had a projected population of 257,500 and Hawul L.G.A had 179,900 as at 2022 (NPC, 2009: City Population 2022). Major ethnic groups are: Babur Bura and very few Hausas and Fulani. Predominantly farmers, major crops grown include cereals (maize, rice and sorghum), legumes (cowpea, groundnut, Bambara nuts), vegetables (tomatoes, okras), cash crops (cotton) and fruits (mango, guava, pawpaw, oranges) livestock found in the area include cattle, sheep and goats, poultries are also reared. Some number of people also engaged in commercial activities such as trading and entrepreneurial ventures and government/nongovernmental jobs (Usman, 2015).

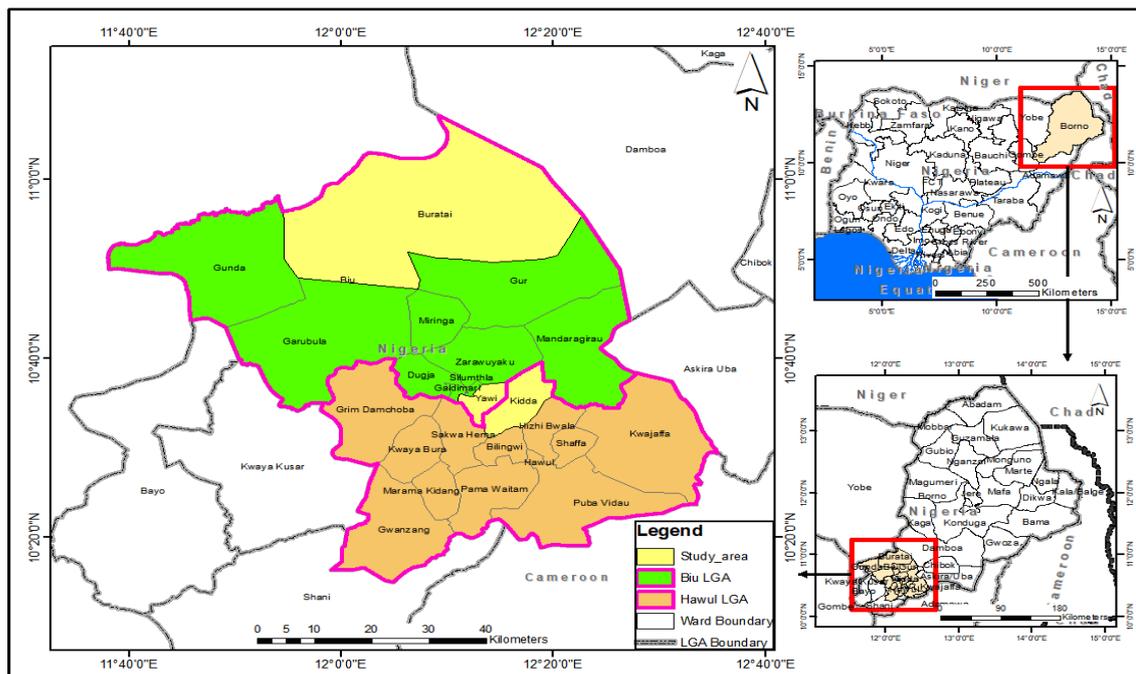


Figure 1: Map of the Study Area

Types and sources of Data

Triangulation approach was adopted in collecting both quantitative and qualitative data and merging the data. This approach was deployed to serve as a vehicle for cross checking the authenticity and validity of the various generated data sets. The primary data was collected through Focus Group Discussion (FGD), Key Informant Interview (KII) and questionnaire from rural farmers, while the secondary data were sourced through documented sources.

Sampling Procedure

The study considered Buratai and Viukutha villages in Biu, while, Yimirshika village was selected from Hawul. All three (3) villages were purposively selected. In all three (3) villages selected, Focus Group Discussions (FGD) were held with men (8 to 10) participants and women of the same number in Yimirshika village. In each of the villages selected; two (2) key Informant Interviews (KII) were conducted. The key informants are elderly persons who have proven to be custodians of the indigenous/local knowledge and whom people consult for advice on the practices and village/ward heads. Sixty (60) respondents were selected using a non-probability snowballing sampling technique for the open-ended questionnaire, by first, using purposive sampling to identify the first respondent.

Data Analysis

The study included both qualitative and quantitative techniques of analysis. Qualitative data obtained using FGD, KII and review of documents were transcribed and analyzed using content analysis based on thematic areas in accordance with objectives. Quantitative data were summarized and presented in percentages, and frequency tables through the use of Statistical Package for Social Sciences (SPSS). All the qualitative data were analyzed through transcription and sorting for specific relevant themes and grouping in the content. Microsoft Word was used to categorize the specific identified themes that were coded and then merged to come up with information for each specific thematic category.

Results and Discussion

Inventory of The Indigenous/Local Knowledge for Weather Prediction, Condition and Interpretation indicated that smallholder farmers use a wide range of indicators to predict the weather for rainfed cropping season. Indicators are used to predict the incoming/beginning of the rainy season, the outlook of the wet season (good/not good farming season), everyday weather for farm-level decision making and the end of the wet season. All predictions are used for deciding rainfed crop production. Most of the indicators are used concurrently to predict the weather.

Table 1: Indicators Used in IK for Weather Prediction

Signs/indicators	Used/Not Used	Frequency	Percentage (%)
Plants behavior	Used	55	91.7
	Not used	05	8.7
Animals' behavior	Used	58	96.7
	Not used	02	3.3
Soil condition	Used	49	81.7
	Not Used	11	18.3
Temperature	Used	58	96.7
	Not used	02	3.3
Wind direction/speed	Used	59	98.3
	Not used	01	1.7
Cloud cover	Used	58	96.7
	Not used	02	3.3
Rainfall pattern	Used	43	71.7
	Not used	17	28.3
Harmattan	Used	48	80.0
	Not used	12	20.0
Astronomic indicator	Used	44	73.3
	Not used	16	26.7
Historical records	Used	32	53.3
	Not used	28	46.7
Others Duration of the cold season Thunder sound Smell/personal perception	Used	10	16.7
	Used	07	11.7
	Used	03	5.0
	Not used	40	66.7

N=60 Source: Field Survey, 2022

The study result in Table 1 reveals farmers used biological indicators in form of plant behavior (90%), animal behavior (97%), and soil condition (82%). The study also shows the use of meteorological indicators by local farmers including temperature (97%), wind direction/speed (98%), cloud cover (97%), rainfall pattern (72%), and Harmattan (80%). Other responses are the duration of the cold season (17%), thunder sound and direction (12%), and smell/personal perception (5%) respectively. Smallholder farmers also use Astronomical indicators to predict the weather, which includes observation of the Moon, Sun and Stars (73%). Use of historical records have been recorded at (53%). This includes keeping records of the time of rainfall commencement, planting dates, and rainfall cessation.

The analysis in Table 2 showed indicators such as plants/tree phenology like bearing new leaves/shoots, sprouting of some shrubs and grasses, changing of leaves color, flowering and flowers blossom and intensity of fruiting are used to predict the onset as well as the outlook of

the season. Animal's behavior, especially migratory pattern of birds like *Abdim stork* and *Horn bill*, movements of Ants are also used. Soil condition like moistening/softening used to predict the onset of the season. Wind direction, speed, moisture content and temperature of the air are very much relevant in the forecasting practice utilized by the indigenous farmers. Other indicators used include cloud cover, early season's rainfall pattern, harmattan and records of the seasonal rainfall commencement and cessation dates in the area. Number of indicators are used simultaneously to make forecast and plan accordingly for rainfed crop production for the season.

According to the FGD respondents:

“We use plants phenology and migratory behavior of Abdim (Shaduwar/Shamuwa) and Hornbill (Talipaku/tsuntsun Kaho). These birds are predominantly use to predict the onset and cessation of the rainy season. For everyday rainfall, we observe the wind, cloud and temperature behaviors to tell whether it will rain or not. Harmattan and duration of the cold season indicate how good the rainy season will appear.” (FGD respondent in Viukutha, 2022).

Table 2 compiles a detailed description of weather forecasting indicators used in indigenous/local knowledge. The indicators' description of the weather forecast concurred with description indications responses to the questionnaire. The content analysis of the table above is emphasized because the FGD and KII participants are more elderly with vast experience and knowledge of indicators used, thus, are very certain of their assertion.

In the analysis, the most widely used indicators for predicting the onset rainy season are the biological indicators, principally, plant phenology, migratory behavior of birds and soil condition. Local farmers observe some tree plants like flamboyant, Baobab, Climbing Lily among others as they begin to produce new shoots and leaves after shedding old ones. This is in response to heat/warmth building up and influx of moisture that is raising atmospheric humidity. Birds like *Abdim stork* arrival prior to the first rain also signals the rainfall season about to commence. For the outlook of the season, the FGD/KII participants emphasized the use of harmattan and the duration of the cold season as well as high yield of wild edible fruits including mango. These phenomena determine the length/duration the rainy season will last and the distribution pattern of the season's rainfall. As for the everyday weather forecast (short term), the local farmers majorly rely on wind direction and strength, feeling of the moisture content of the air, temperature of the air as well as the nature, color, cover and position of the cloud to predict rainfall. The most common indicators used to predict rainfall cessation are biological and meteorological indicators. Change in leaves color of some tree plants like Frankincense, flowering of some weed. Migration of *Horn bill* from north to south and overwhelming appearance of spider webs in nooks and crannies of compound, tree branches and other common places. The physiology of some tree plants responds to changing air and moisture dynamics of both the atmosphere and soil of the transition period by changing leaves color from green to yellow or orange. The *Horn bill* moves with the rain and migrate along the receding rainfall direction (north to south). Spiders are moisture abhorrent and thrive favorably when moisture reduced appreciably. The use of historical records is much recognized even though, the locals mostly use lunar calendar, it has been established that the rain commences in April and ceases in October. However, the distribution pattern, amount and intensity differ across seasons.

Below are some indicators use to forecast rainfall as narrated by veteran indigenous farmers

“When trees like Baobab, Flamboyant, and Gutta-percha have developed fresh leaves, be assured that the rainy season is near, some weeks or month away. As such, you may start preparation for the farming season like farm clearance and rearrangement of terraces”. (KII respondent in Yimirshika, 2022).



Table 2 Detail description of rainy season weather forecasting indicators

Season/time	Indication Description	Indicator category
Beginning/incoming rainy season	<ul style="list-style-type: none"> Some plants develop new leaves, flowers blossom and bear fruits. Trees like a Climbing lily (<i>Kamda/Baure</i>), Acacia Faidherbia (<i>Minta/gaarwoo</i>), (shed leaves), Gutta-percha (<i>Bwala/Ganji</i>), Ficus thonningi (<i>Durumi/Chediya</i>), Locust bean (<i>Nnona/Doorawa</i>), Baobab (<i>thiva/Kuuka</i>), and Flamboyant (<i>Balankache</i>) will be putting new leaves while, Mango (<i>Mangoro</i>), Black plum (<i>Shika/Dinyaa</i>), Blood plum (<i>Nursha/Jan Dinyaa</i>), Spiny plum (<i>Tsonzura/Tsaada</i>), Shea fruit (<i>Fumwa/Kadanya</i>), Jujube (<i>Huhui/Magaryaa</i>) and Neem (<i>Doogon yaaroo</i>) will be fruiting. Some weeds would be sprouting close to the onset of the rainy season. Arrival of Abdim stork bird (<i>Shadhuwar/Shaaamvaa</i>) to build its nest. The soil will become soft, if a stagnant stone is rolled, one will discover damp moisture like sweat beneath (<i>Di Akwa birta</i>). 	Biological indicators
	<ul style="list-style-type: none"> The wind will be blowing in circles for some days before it gradually changes direction to south/west. Intense heat/warmth and profuse sweating especially at night. The wind is not dry but damp. Patches of isolated dark/grey clouds will appear high in the sky, though, it may not rain 	Meteorological indicators
	<ul style="list-style-type: none"> The position of the Sun at Sunrise changes to more eastern or north-eastern direction as observed about some designated hills. Group of four stars usually located in the south migrate north 	Astronomical indicators
	<ul style="list-style-type: none"> The rain usually comes around April and planting commences in May/June 	Historical
Outlook of the season (Good farming season)	<ul style="list-style-type: none"> High/overwhelming yield of wild edible fruits like Black plum (<i>Shika/Dinyaa</i>), Blood plum (<i>Nursha/Jan Dinyaa</i>), Spiny plum (<i>Tsonzura/Tsaada</i>), Shea fruit (<i>Fumwa/Kadanya</i>), Jujube (<i>Huhui/Magaryaa</i>), A Odina Barter (<i>Thnyi/Faaruu</i>) including Mango indicate that any crop planted that season will bring good yield Appearance, consistency, duration and cessation of Harmattan give a clear picture of the season. The time of appearance, Early December means early-onset, (April). Consistency and breaks portray the distribution (Dry/Wet spell), and cessation, around Feb/March indicates rainfall cessation around (October). Harmattan thickness and intensity indicate plenty of rainfall. However, others described the cold season rather than harmattan as the determinant of the rainy season. Overwhelming appearance of spider webs across cracks on soil indicates the good rainy season Early season's morning rainfall pattern for like 5-8 times means there will be a dry spell in that season. 	Biological/Meteorological indicator
Everyday weather prediction	<ul style="list-style-type: none"> Gentle wind blowing to the east, especially in the morning, it later ceases and heat/warmth envelops the ambience that results in profuse sweating. Little later, the cloud begins to form. For the rain to be expected, the cloud normally forms from the eastern or northeastern horizon (<i>Viukutha and Buratai</i>), south/south-eastern (<i>Yimirshika</i>), takes time to form, except in August, usually, dark/grey and overwhelming. As it advances from east to west, the upper part may become ash/grey and the rear, dark or vice versa. Wind blowing from east to west must not be cold. If there is a thunder sound before the rain begins, it sounds at some interval not so close. Any change, the rain is least expected. Ants' movement with their eggs or earthworm sighted crawling on the surface during the day, rainfall is expected. 	Meteorological indicator
End of the rainy season	<ul style="list-style-type: none"> Leaves of some tree plants will turn red/orange like the Frankincense tree, (<i>Debiro/Ararrabi</i>). Some weeds will produce flowers and leaves rolled up once rain touches them. Migration/departure of Hornbill birds (<i>Talipaku/Tsuntsun Kaho</i>) from North to South Prevalence of Spider webs across tree branches, nooks and crannies of a compound. 	Biological indicators
	<ul style="list-style-type: none"> The wind will blow in circles, roll and gradually changes to a North-East direction. It is dry. Brighter sunshine even after it rained during the day. Frequent localized rainfall variation Appearance of haze/fog smoke, especially, in the morning and along streams. The temperature of the rainwater will be very cold. Historical records showed that the rain ends in October. 	Meteorological indicators

Source: FGD/KII Survey, 2022

Many farmers use combinations of indicators simultaneously to predict weather conditions to prepare for farming activities of the season.

“I used trees that bear new leaves, the arrival of Abdim stork bird and soil condition to be certain that the rains are about coming and schedule my movement and farming season preparation”. (KII respondent in Viukutha, 2022)

The outlook of the season is determined by four (4) major indicators as explained by the participants in the FGD and KII. These are Harmattan, Rainfall pattern, duration of the cold season and good yield of wild edible fruits. The time for commencement, intensity, duration and cessation of harmattan and cold season indicates the time for commencement, intensity, duration and cessation of rainfall, (Adequacy and distribution of rainfall).

“An overwhelming yield of wild edible fruits including Mango means every crop planted that season will bring a good yield, (bumper harvest)”. (FGD respondent in Yimirshika, 2022)

As indicated earlier in Table 1 & 2, respondents largely agree on the use of harmattan to forecast the outlook of the rainy season and plan farming activities accordingly.

“When harmattan commences early, (early December), means early rainfall, thick harmattan means wet spell or dry spell as the case may be and duration/ cessation time (March) means late cessation or as the case may be. Harmattans tell how good the season will be”. (FGD respondent in Buratai, 2022).

These indicators that the local farmers solely depend on can be influenced by deforestation, overhunting and environmental change. Extinction of the biological indicators or sudden change of the meteorological indicators as a result of environmental change would leave the farmers stuck in predicting weather to make decisions.

These findings are in consonance with Magoro, (2020) in his exploration of the role of indigenous weather and climate knowledge in crop production in Limpopo province who reported overwhelming reliance on plant phenology like bearing new shoots and leaves of some tree plants to forecast the onset of the rainy season. The use of migratory birds like the Abdim stork, changing wind direction, increase in heat as well as historical records of the commencement of the rainy season coincided with study report of (Adanu, *et al.*, 2021; Eromose and Simatele, 2017 and Green *et al.* 2010).

Regarding the outlook of the season, study report by Nkuba *et al.*, (2020) and Enock, (2013) both asserted that the most widely relied upon indicator for good rainfall are the timing, intensity and duration of cold temperature during winter season and also flowering and fruiting intensity of certain tree as indicative of good amount of well distributed rainfall in the coming season. In his submission, Enock, (2013), dwelled on density of Spider webs indicating very wet season. However, study findings by Eromose and Simatele, (2017) contradicts the finding on the Harmattan variable, in his report, the longer the Harmattan stays, the shorter the rainfall duration. The pattern of the early rainfall of the season determines the outlook of the rainy season corroborated findings of (Suiven, *et al.*, 2019).

Prediction of every day weather, findings by Amare, (2018); Chikaire, *et al.*, (2018); Enock, (2013), agree with the assertion that when there is moisturized wind blowing to the east, unusual heat and the formation of dark/grey low clouds (nimbus/cumulonimbus) the chance of rainfall occurrence is high. The report further buttress that ants are hyperactive and when seen carrying their eggs or food to the ditch, expect there might be rain coming that day or soon.

Maren *et al.*, (2019) study report revealed that change in wind direction, frequent lightning and thunder when it will rain, a lot of mist in the morning, very cold mornings and evenings appearance of rainbow and frequent drizzle as indicators of rainfall cessation and also concurs on Horn bill migration with the rain.

Relationship of the Indigenous Knowledge on Weather, Soil Condition with Agricultural Practices

Farming activities engaged by the local farmers upon perception/forecast of a particular weather event are broadly categorized into four (4): Incoming rainy season/onset forecast, the outlook forecast, everyday weather event forecast and end of the rainy season/cessation forecast.

Table 3: Farming Activities Engaged based on IK Weather Forecast

Rainy Season/Activities	Engaged/Not Engaged	Frequency	Percentage (%) Response
Incoming rainy season/Onset			
Farm clearing and burning	Engaged	57	95.0
	Not engaged	3	05.0
Convey organic manure and compost to farmlands	Engaged	23	38.3
	Not engaged	37	61.7
Tillage and planting	Engaged	29	48.3
	Not engaged	31	51.7
Rearrangement of terraces	Engaged	24	40.0
	Not engaged	36	60.0
Assemble and sharpen farm implements	Engaged	28	46.7
	Not engaged	32	53.3
Thresh seed variety stored for the season	Engaged	35	58.3
	Not engaged	25	41.7
Source for money through the sale of some farm produce	Engaged	28	46.7
	Not engaged	32	53.3
Outlook of the season			
The decision regarding the time for planting	Engaged	40	66.7
	Not engaged	20	33.3
The decision regarding crop type/variety to plant	Engaged	36	60.0
	Not engaged	24	40.0
The decision about ploughing the soil	Engaged	28	46.7
	Not engaged	32	53.3
Expand/reduce farm size/number of farms	Engaged	28	46.7
	Not engaged	32	53.3
Everyday weather/season proper			
Planting decisions based on the weather forecast	Engaged	42	70.0
	Not engaged	18	30.0
Weeding/second ploughing	Engaged	58	96.7
	Not engaged	02	3.3
Other farm operations	Engaged	32	53.3
	Not engaged	28	46.7
End of the season forecast			
Harvesting/cutting into heap some crops	Engaged	53	88.3
	Not engaged	07	11.7
Engaged in weeding	Engaged	22	36.7
	Not engaged	38	63.3
Engaged in planting	Engaged	20	33.3
	Not engaged	40	66.7
Engaged in transplanting	Engaged	36	60.0
	Not engaged	24	40.0

N=60 Source: Field survey, 2022

(a) Incoming Raining Season/Onset Forecast:

This refers to weather prediction based on some indicators of onset or the arrival of the first rain for the year's rainfed crop farming season. Indicators like arrival of the Abdim stork bird, some plants developing new shoots and leaves, increase in heat, soil becoming moistened and change in wind direction and other characteristics. The result from table 7 indicates that for the incoming season forecast, indigenous farmers engaged in farm clearing and burning residue (95%). This includes cutting shrubs, trimming foliage and gathering debris of stalks and chaff from previous harvests (ones that have not been eaten by cattle) to burn. The local farmers believed that burning will control pests (especially), disease, weed seeds and also the ash add nutrients to the soil. Only 38% responded to have been engaging in conveying organic manure in form of cattle and poultry droppings and compost to the farmland. This is because many farmers allow Fulani herdsmen to settle on their farmland after the harvest, hence, seeing no need to look for organic manure again. Most of the farmers who convey the manure are livestock keepers like cattle fattening and poultry farming. In a village like Yimirshika of Hawul Local Government, some farmers till the soil and plant crops like maize, rice, and sorghum weeks before the first rain comes (*Bwaltha*) 48%. However, some from Viukutha do till the soil but allow the rain to come before planting their crops. Considering the undulating terrain and rocky surface of the area, some farmers (40%) engage in rearranging terraces. Farmers use the terraces for soil erosion control and farm boundary demarcation, see Plate 1 below:



Plate 1: Terracing on Flat and Sloppy Terrain
Source: Field Survey, 2022

From left, terracing on a seemingly flat surface and from right on sloppy terrain to curb water soil erosion as well as demarcate farm boundaries.

After harvest, cattle usually walked the areas to graze, thus displacing the terraces that necessitate the farmers to rearrange before tillage and planting. Some farmers, (47%) reported assembling and sharpening farm implements, this includes hoe, sickle, cutlasses, and axed among others. Many indigenous farmers select and keep crop varieties for the upcoming season, and 58% responded to have been engaging in threshing seed varieties mainly, Maize, Sorghum, and Groundnut. Others use cultivars purchased from vendors. As some farming activities will require some money, 47% of the local farmers sold some farm produce to get some money to supplement the labour. However, some farmers do nothing until after it rained couple of times in the beginning of the season before commencing farming activities as indicated in Table 3.

(b) Outlook Forecast:

Here, local farmers through the interpretation of some indicators like timing, duration and intensity of harmattan or cold season, availability of wild edible fruits, the pattern of early season's rainfall among others to predict how good or otherwise the season will be and planned accordingly to maximize yield and reduce weather/soil related risk in crop production. Farming activities engaged based on the outlook forecast of the season centered around decision making regarding time for planting (67%). Here, the farmers hinged their decision on the time the harmattan season started, the pattern of the early season's rainfall and the use of historic records. Regarding the decision on varieties to plant, 60% of the respondents agree to have used the outlook forecast to decide which crop type and varieties to plant. For instance, if heavy rainfall or a wet spell is anticipated, some farmlands will better be used for rice instead of maize or sorghum and vice versa. seldom, drought resistant and early maturing cultivars are preferred. This also applies to some farmlands where the decision to plough the soil is based on the season's outlook. About 47% of the farmers admit ploughing the soil only when they forecast the rainfall to be moderate that will not inundate and erode the soil (depends on the topography and nature of the soil). While others plough irrespective of the forecast because of the believe that it makes the soil soft and fertile. The outlook also determines for 47% of the respondents whether to expand/reduce farm size and/or the number of farms. If the season is forecasted to be good, they expand or add a number of farms and if forecasted otherwise, the reverse is the case.

(C) Everyday Weather Forecast:

This is a short-term weather forecast that farmers made based on interpreting indicators like the nature of the cloud, wind direction and characteristics, air temperature, thunder sound and behaviors of some animals. The prediction here is not more than a day (based on certain times of the day). Farming activities that involve everyday weather when plantings have started, (70%) of the farmers make decision about going to the farm and plant based on the prevailing weather (cloud and rainfall). Farmers have to make sure that they will get enough moisture for the crop to germinate before they plant. Also, the decision about weeding/second ploughing, 97% of the respondents considers the weather, usually rain break to weed/ second plough so that the weeds could die off and dry.

According to FGD respondent:

“Weeding when there is a high soil moisture is not suitable and could affect the growing crops negatively, but if the weeds are taller, you pull them out” (FGD respondent in Yimirshika, 2022).

Other farm operations engaged based on the weather forecast about 53% of the respondents responded to make decision about going to the farm and applying pesticides, herbicides and fertilizer.

(d) End of the Rainy Season/Cessation Forecast:

This is the interpretation of some indicators like plant phenology, migratory behavior of some birds, prevalence of mist in the mornings and pattern/intensity of the rainfall among others to predict the end of the year's rainy season for rainfed crop production. Farming activities engaged upon forecasting the end of rainfall cessation/season are harvests of some crops like maize, rice, soyabeans and groundnut stated by 88% of the respondents. The farmers cut down and make heaps of maize stalks, rice, and soyabeans. This is because if the rains are still plenty, the maize will rot in the heap. As for rice, the rain of high intensity will thresh/destroy the seed yield once it has matured. Groundnut pulling also requires some moisture in the soil for easy harvest (pulling). Small number of farmers (37%), reported to have been engaging in weeding even after forecasting the end of the season. You weed to destroy and prevent seeds of the weeds be

deposited on the soil so that the farms will not be “weedy” (with too much weed) next farming season. Some farmers (60%) engaged in planting (Cowpea) a variety known as *Banjiram* and transplanting of tomatoes, pepper, garden eggs and the likes near the end of the season. They believe that the crops require more dew than rain.

Activities engaged by farmers upon forecasting the onset of the rainy season include farmland clearing, fertilizer sourcing and seed/cultivar selection. Local farmers use cutlasses, hoe and axe to prune shrubs and later use rake to assemble residue that littered the farmland after cattle have fed on and set ablaze. Farmers believe that burning of the residue add nutrients to the soil, control weeds as well as pest and diseases. Decision regarding time for planting, seeds/cultivars selection as well as ploughing the soil are hinged on outlook forecast of the season. Local farmers, based on the indicators of the outlook forecast, decide on what to plant when and where. The farmers are aware that different crop varieties/cultivars respond differently to rainfall and soil dynamics. Thus, timing, duration/length, intensity and distribution pattern are variables considered in the outlook forecast to make decision.

In the absence of weather information from meteorological stations/services, the farmers depend solely on the environmental indicators to predict weather for rainfed cropping season. These indicators respond to environmental (soil, human and animal, physiological disturbances) and other meteorological changes. Thus, the indicators may not be consistently dependable for a medium-term forecast like the outlook of the weather for the season. Abrupt weather changes that indigenous indicators failed to respond or capture accordingly means the indigenous smallholder farmers would be confused or may end up making a wrong decision that will have negative consequences in their crop productivity. Should there be agricultural extension services/agent(s) that convey down scaled weather and other climatic information to complement the indigenous weather information the better for the rainfed crop farming.

The study findings by Mamman and Folorunsho, (2016) concurs that inadequate knowledge of crop residue reuse value and utilization is one of the major problems facing the people and lack of awareness on health hazards related to burning of agricultural crop residue in some communities makes it very easier for them to burnt their waste in the farm. Also Report by Tania *et al.* (2021) had it that the onset forecast guide general rainfed crop farming preparations such as farmland clearing, sourcing of fertilizer, seeds/cultivars and some necessary farm tools. It is interesting and unique finding in this study that some farmers practice tillage and planting prior to the first rainfall of the season. This, the farmers believe that the soil is soft to till and will make more nutrients available to the crops like maize that will be planted in anticipation of the first rainfall (*Birne*), a form of early planting practiced by some local farmers. This will also minimize the risk/effect of drought/dry spell on the crops. This finding is supported by study report of Magoro, (2020), that indigenous farmers’ decision on crop production is guided by their forecast of the season’s outlook. For instance, if they forecast drought occurrence, crops like Millet, Sorghum Cowpea and drought/ heat tolerant varieties are favored and will go ahead to plant.

Conclusion and Recommendations

The study concludes that smallholder farmers in indigenous remote villages use multiple indicators from the environment to predict the weather for farm-level decision making. The indicators have proved useful and fairly reliable in meeting rainfed crop farming requirements. The indigenous weather forecasting indicators are the only available and accessible source of weather information in the remote areas studied. The local farmers use weather focused information in their daily rainfed crop production activities. Therefore, the following recommendations were made:

1. State/local government and NGOs must work together with NIMET to provide downscaled weather information for the local farmers through extension agents and also plan for the

integration of the indigenous/local weather forecast/ forecasting indicators with scientific forecast information for enhanced productivity.

2. Ministries/Departments/Agencies of agriculture in the state should collate the indigenous/local knowledge of weather prediction information, and juxtaposed it with scientific/meteorological weather information at their disposal to correlate and advise farmers accordingly.
3. In the face of the current climate variability and environmental change, the local farmers are challenged with their indigenous/local techniques and perception especially, in crop cultivar adoption, time for planting and pests and disease control, thus, government and NGOs have to assist to empower farmers with information and resources to enable them to cope better with the situation.
4. Some of the plants/trees used as indicators are gradually disappearing as a result of deforestation. Authorities like village heads, vigilante groups and concerned individuals need to work together to ensure the preservation of the plant species.

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