Journal of Geoscience and Environment Protection, 2021, 9, 55-70
https://www.scirp.org/journal/gep
ISSN Online: 2327-4344
ISSN Print: 2327-4336

The Need of Incorporating Indigenous Knowledge Systems into Modern Weather Forecasting Methods

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How to cite this paper: Irumva, O., Twagirayezu, G., & Nizeyimana, J. C. (2021). The Need of Incorporating Indigenous Knowledge Systems into Modern Weather Forecasting Methods. *Journal of Geoscience and Environment Protection, 9,* 55-70.
https://doi.org/10.4236/gep.2021.92004

Received: January 8, 2021
Accepted: February 7, 2021
Published: February 10, 2021

Abstract

The study was aimed to examine the need of incorporating traditional weather forecasting renowned indigenous knowledge system (IKS) into modern weather forecasting methods to be used for planning farming activities. In addition, not only gap that is not infused by current weather forecasting system with their advanced studies to understand why it is incorporated into existing technical frameworks was regarded, but also the limitation of advanced weather forecasting approach and strength to be elicited by indigenous knowledge system are crucial. Perspicuously, forms and onsite interrogates have been conducted to assess people's beliefs, understanding, and attitudes on the indigenous knowledge system significance on weather forecasting. Therefore, atmospheric and biological conditions, astronomic, as well as relief characteristics were used to predict the weather over short and long periods. Usually, in assessing weather conditions, the conduct of animals and insects were listed as essential. Obviously, in order to predict weather particularly from rain within about short period of time, astronomical characteristics were used. Commonly, there are few peers who know conventional weather prediction approaches. This lowers the reliability of conventional weather prediction. The findings revealed some variables that impact meteorological inaccuracy by scientific methods and help to recognize and evaluate the gap that current meteorological technologies do not achieve and new particulars anticipated to be filled with conventional methods to attain accurate weather prediction. Additionally, the study indicated that both modern and conventional processes have certain positive and limitations, which means that they can be coupled to generate more accurate weather prediction reports for end users.

Keywords

Indigenous Knowledge Systems, Meteorological Technology, End Users, Weather Forecasting

1. Introduction

Currently, global climate change is becoming enormously one of the headache global challenges of the 21st century (Theodory, 2016). However, climate information services are progressing as a way to assist farmers in managing their risks and to create ongoing climate resilience of farming (Hansen, 2017), and poor rural communities will be gravely affected by their dependency on climate-sensitive activities for their livelihoods in developing countries (Yanda & Mubaya, 2011). Some Sub-Saharan Africa countries are one of the most endangered to the change (Niang, Ruppel, & Abdrabo, 2014). In recent decades, there has been growing warming across Africa, which correlates to anthropogenic climate change and has a direct effect on climate-sensitive sectors (IPCC, 2014). Climate change contributes to weather variation and unforeseen weather forecasts that threaten developing countries immensely. Agriculture is a dynamic and difficult activity due to a set of factors such as a disadvantageous economic environment and unstable climate (Osbahr & Allanb, 2003). However, it is a primary source of food and income for rural populations (Bigirimana, n.d.). Weather forecasts are defined as scientific estimating future weather conditions that are expressed as variables such as precipitation, temperature, and wind (Lutgens & Tarbuck, 2010). While information concerning weather is usually provided as seasonal forecasts, which can also be described as the total precipitation expected during the season or over a given period (Ziervogel & Calder, 2003).

Africa's local communities and farmers have built complicated structures for weather convocation, prediction, interpretation and decision-making. They have the awareness and practices required to deal with adverse environmental conditions in their societies (Enock, 2013). IKS is unique and specific to a particular culture. Local communities vulnerable to disaster risk use IKS for micro and macro-level decision-making in their livelihood management (Phiri, Van Nikerk, & Van, 2016; Mbewe & Siyambango, 2019) climate change Researchers have discerned, despite discrepancies between the criteria used by local farmers and scientists to identify seasonal phenomena, there is also considerable overlap between these criteria which can enable climate scientists in tracing change by using indigenous observations. Suggest IKS to provide climate science connections. The information sources that meteorologists use is a variety of components of the indigenous knowledge such as weather observations, historical climate pattern, regional information. In adopting decisions on crops and livestock production, environmental protection and coping with other natural disasters in sub-Saharan Africa, indigenous information application has been successfully employed (Ayal et al., 2015; Egeru, 2012; Luseno et al., 2003), For instance, a study conducted in Zimbabwe revealed that farmers' enthusiasm to solicit seasonal climate forecasts escalated when forecasts are in combination presented and contrasted to the indigenous predictions of local climate (Boko, 2007). Cultural and ritual experts use dreams, visions, and divination to forecast weather in Burkina Faso, apart from viewing animals and plants behaviors (Roncoli et al., 2002). Rainmakers from the NGANYI family in Western Kenya have gotten sacred shrines with indigenous trees, which they use to forecast weather. Their weather forecast was combined with that from Kenya Meteorological Department to generate a more reliable weather report (Foundation, 2012). In Africa, many local farmers in developing countries relied on IKS for weather forecasting (Briggs, 2005). This indicates that strengthening indigenous capacity is essential to enhancing the empowerment and successful involvement of local communities in the development process (Boko, 2007). IKS is not only used in Africa but also in Asia, for instance, In the Philippines farmers and fishers rely on the actions of animals and insects to forecast the arrival of rain and poor weather (Galacgac & Balisacan, 2003). This method is an institutionalized knowledge focused on local locations and is rooted in local traditions, built up and passed on over centuries through oral history (Osunade, 1994; Orlove et al., 2010). Despite the IK weather forecasting interest and significance, the absence of systematic documentation and often passed from one generation to the next through oral history, creating a wide inter-generational divide between IK custodians and the young generation (Radeny et al., 2019). Such prediction accuracy is still penurious (Lutgens & Tarbuck, 2010). In addition, this weather prediction approach has been used since time immemorial, but these conventional approaches have continued to be overlooked with the advent of modern weather prediction methods (Risiro et al., 2012). However, it should be remembered that not all indigenous expertise can provide the correct solution to a specific problem (Ajani et al., 2013). Therefore, before appointing indigenous knowledge, amalgamating it into development programs or dispersing it, Practices like any other technology should be tested for their suitability.

Weather plays a major role in the livelihoods of Rwandan farmers (Irumva, 2021); limited adaptation measures combined with a limited environment and weather instability and change management capabilities have made Rwanda highly vulnerable to negative consequences. This has prompted Government of Rwanda (GoR), in response to the aim set by the Comprehensive Africa Agriculture Growth Progress (CAADP), to increase the budget allocation for agriculture from 4.2 percent in 2008 to almost 10 percent in 2011 (Bizimana & Sonmez, 2015). Changes in weather patterns have a strong impact on people's lives because they cannot deal with changes in weather variability (Mertz et al., 2009). Weather and climate change are predicted to have a rising occurrence and intensity of extreme events including droughts, floods, excessive precipitation, and plant declining (Radeny et al., 2019). Rwandan local communities have established the art of evaluating weather conditions through their generational experience, observation, and cumulative information. This technique, known as IVUBIRO, is largely focused on the keen observation of various systems including the structure and nature of clouds, wildlife, and the flora, Sun, Moon, and Wind. On top of the HURO Mountain, there is a platter like a pot embedded into the ground. The top of the hill was sealed. The elderly in the area stated that weather is forecast for IVUBIRO by viewing Humidity and by decreasing or increasing the water in the pot. When the quantity of water is high, they have already been told that the rainy season is over and they are ready for farming activities and when the quantity is reduced entails that there is no rain. This IKS traditional system operated for centuries as they associate with local lifestyles, frameworks in institutions, and social systems (Mbilinyi et al., 2005). Therefore, this study aimed to investigate the need of incorporating indigenous knowledge systems into modern weather forecasting methods in Rwanda, particularly in MUHONDO sector, Northern Province.

2. Materials and Methods

2.1. Description of the Study Area

The high elevation of Rwanda renders the climate temperate with 1212 mm/year of average precipitation (FAO, 2016). In the northern parts of Rwanda, the mountainous topographic character is largely dominant. In the VIRUNGA Volcano chain in the northwest, the highest peaks are located, including Mount KARISIMBI, the highest point in Rwanda (Ndayisaba, Guo, Bao, Guo, Karamage, & Kayiranga, 2016). This makes the land more fertile and reliable for Agriculture. The study was carried out in MUHONDO sector, one of nineteen sectors of GAKENKE district forming the Northern Province of Rwanda. GAKENKE district is divided into sectors namely BUSENGO, COKO, CYABINGO, GAKENKE, GASHENYI, MUGUNGA, JANJA, KAMUBUGA, KARAMBO, KIVURUGA, MATABA, MINAZI, MUHONDO, MUYONGWE, MUZO, NEMBA, RULI, RUSASA, RUSHASHI and MUHONDO sector locates on Latitude: 1˚49'40"S and Longitude: 29˚50'33"E, and is inhabited by 20,125 populations (Rwanda (NISR), 2012). Therefore, the sector is largely rural and people are generally dependent on land cultivation and crop production, such as maize and beans. As a source of livelihood and significant socio-economic activity, they are also involved in animal husbandry, especially cattle farming.

2.2. Data Collection and Analysis

This part entails two research methods: a literature review includes a systematic desk review of all indigenous weather and climate prediction information studies. In view of this, a significant secondary source of the research was a wide variety of journal papers, books, thesis, newspaper articles, and scholarly articles, which are applicable to the research. The authors also used a descriptive survey in conducting questionnaires and interviews, Two-hundred adult participants spread over in MUHONDO sector were issued with questionnaires. The authors applied purposive sampling as a strategy in which particular events, informants or settings are selected deliberately in order to provide relevant information. (Irumva & Twagirayezu, 2020). The questionnaire sought to elicit information on the different aspects such as, Major Cause of Weather Forecasting Inaccuracy, Identification of the IK on The Quality of a Season, Local community's perspective on the prediction of weather and recommendation to improve the weather forecasting. Limitation of age used to ensure that only respondents with good indigenous knowledge were interviewed. This helped to ensure both validity and reliability of collected data. Therefore Microsoft Excel and Origin 2018 are used for Data analysis.

3. Results

Two hundred people of ages above sixty years were interviewed to elicit information on their indigenous methods of the weather forecast. The nature of the study dictated that the elder people were preferred as research respondents. This is since their age meant that they had accumulated knowledge and experience over time; and that makes them, in all probability, custodians of indigenous knowledge, since this ensured the acquisition of authentic information about traditional knowledge of weather forecasting. The respondents believed that Weather is changing. Their indicators are low rainfall being received, change in planting season from September to late November or early December, and late rains, rising temperatures, the disappearance of very cold winters, erratic rainfall distribution, and drying of wetlands. The responses are in agreement with Rwanda Meteorological Agency (METEO-Rwanda). **Figure 1** shows the number of indigenous people interviewed per their respective ages; whereby informants aged between 71 - 80 years, 25% were male while 12.5% were female. 61 - 70 years, 12.5% were male, 25% were female while informants aged over 80%, and the percentage were all equal (12.5%).

3.1. Weather Forecast and Fluctuating Precipitation

Since agriculture is the most important economic sector in Rwanda, the forecast of potential weather events is extremely important for daily farming decisions (planting, spraying, or fertilizing) and long-term farm planning and agribusiness decisions (for the private sector). Under the Ministry of Natural Resources (MINIRENA), the Rwandan Meteorological Agency (METEO-Rwanda) is mandated to provide weather and climate information and products for various sectors, including agriculture and Supported by institutions of government. METEO-Rwanda offers predictions: daily projections, 5-day, 7-day, 10-day, monthly projections, and decadal projections. It has been noted that the use of conventional signs to predict the start of the rainy season is influenced by recent

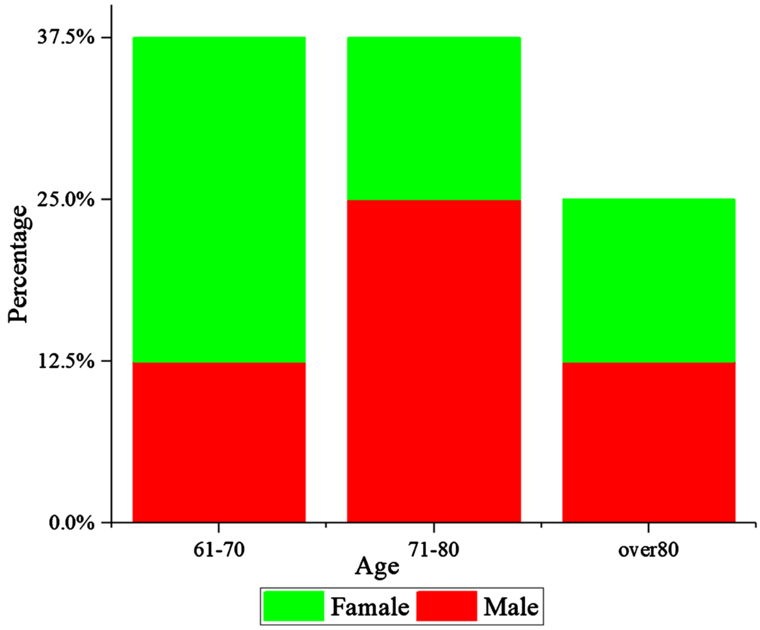

Figure 1. Indigenous people with their ages.

climate fluctuations. Farmers will also benefit from modern weather forecasts issued by government bodies. This will give farmers the opportunity to make sound decisions about how the seasonal distribution of rainfall can be completely utilized to increase and stabilize crop yields. However, when weather forecasting diverges from reality and conventional predictions, for reasons which fit well with the community, the farmer is inclined towards indigenous knowledge and is tested and tested over many years, and in a language that the farmers believe (Makwara, 2013). There is an uneven distribution of precipitation in Rwanda (any area in the north) which changes significantly from year to year, and region to region. The distribution of the rains is graded according to the total season of rainfall in two groups, above and slightly above the rainfall. One is above average when precipitation exceeds or equals 430 mm and another approximately normal is labeled at [370 mm - 430 mm]. Since Rwandan weather is largely based on the patterns of rainfall. Thus, the country's climate is characterized by a four-season alternation, two rainy, and the other two dries. The long-wet season from March to May, marked by heavy rainfall (World Bank Database, 2016). and the short-wet season (October-November) alternates with long-dry (June-July-August) and short-dry seasons (December-January-February). They are controlled primarily by regional atmospheric circulation (Ilunga et al., 2004; Kizza et al., 2009). However, it should be noted that annual rainfall in the North province varies throughout the region, with the highest amounts available. Over the years, farmers' knowledge of indigenous communities has been conveyed orally for centuries to combat climate change and variability. However, reports indicate that the strategy of coping with the increasingly unreasonable climatic instability and the quick speed of other drivers of change might not be successful (Nyasimi, Radeny, & Hansen, 2017). With numerous initiatives to promote the adaptation of farmers to climate change and variability, Government of Rwanda and other development agencies have reacted. These organizations include financial institutions, seed companies, insurance firms, and non-governmental organizations. With the increasing devastating effect on agricultural production, farmers and other stakeholders necessitate climate services that include high-quality meteorological data, risks, edaphic conditions and vulnerability assessments, insurance products and agro-advisory information (Hewitt et al., 2012).

3.2. Major Cause of Weather Forecasting Inaccuracy by Modern Meteorological Technology

The respondents had known all the indigenous weather and climate forecast practices by their own experiences, among 200 informants interviewed, they have shown (Figure 2) a Shortage of Weather Data (SWD), Few Weather Station at the ground and upper air station (FWS), Poor Telecommunication (PT), Insufficient Understanding of Atmospheric Processes such pressure and wind (IUAP), Lack of Information about the composition of the atmosphere (LI), Unstable Atmospheric Composition and air motion in the atmosphere (UAC), Unexpected Natural Disasters (UND), Poor Maintenance (PM), Less Skilled Staff (LSS), Less Sophisticated Instruments (LSI) and Financial Means (FM) to acquire weather forecast equipment as the major cause of weather forecasting inaccuracy.

Respondents gave different reasons for the question saying "What do you think should be the causes of the gaps Unachieved by current meteorological technology?" the financial means to acquire weather forecasting equipment 16. (6%), the shortage of weather data (30.33%), unstable atmospheric composition and air motions in Atmosphere (0.33%) and poor maintenance (6%) are the main causes of that inaccuracy whereas fewer weather Stations at the ground and upper air station (16.66%), unexpected natural disasters (4%); less sophisticated instrument (6.33%) and the poor maintenance (6%) and less skilled staff do intervene in causing the gaps Unachieved by modern weather forecasting method.

3.3. Local Community's Perceptive on IK Indicators

Since the cessation of rains is Key to the timing of most farm activities in Rwan-

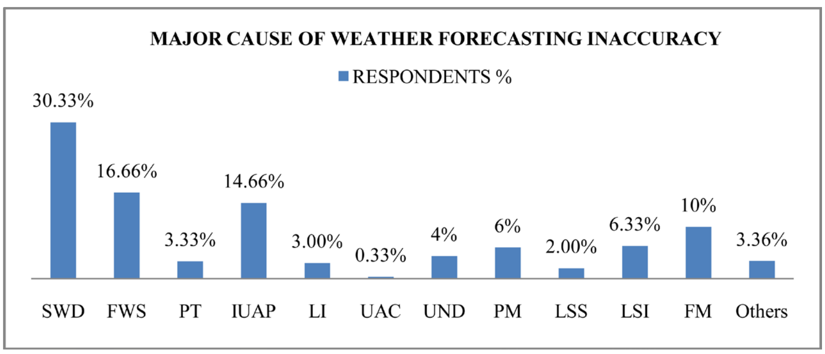

Figure 2. The causes of gap unachieved by current meteorological technology in weather forecasting.

da. There are several IK indicators currently being used to predict the onset of the rainy and dry seasons in the study area. According to the respondents as shown in Table 1, the most predominant indicators in MUHONDO Sector; Heavy dark cloud formation and prevailing Westerly wind which blows from west to East. The respondents emphasized that unusual increase in temperature, and trees sprouting/gaining leaves and flowering, termites flying in the evening hours, frogs crocking in the chorus is followed by a shower, Ants shifting their eggs to a safe place, foretells the occurrence of rain. When dragonflies fly low, it may rain. If rain in any of the day, there will be no rain in that particular month, a ring around the moon is an indication of rain to be followed. Dense fog in the early morning indicates no rain. More black clouds during the winter season increase the pest and disease incidence. Continuous drizzling indicates more pest and disease incidence. High sweating in the day time foretells rainfall in the night. Morning cloud and evening thunder indicate the occurrence of rain. Rainbow in east direction indicates an absence of rain are the Indigenous believes/practices of weather and climate forecast. Indigenous rainy and dry season indicators for the area of research including trees, animals, and the atmosphere for the preparation of farming activities as fed mainly in sub-Saharan African farming practices is rain (Chikaire et al., 2018). Descriptive statistics were used to scrutinize data collected from by questionnaire. This includes use of mean, presented in the table to achieve the objectives of the study, Objectives will be achieved on a three-point Like-type scale of strongly agree, agree, and disagree assigned weight of 3, 2, and 1. Any value of less than 2 was regarded as not signs for weather forecasting (disagree). The value 2 was regarded as agreeing while values of 2.5 and above were taken as strongly agree. The Majority of respondents accepted that heavy dark cloud formation in the atmosphere (M = 3), Wind movement (M = 2.81), unusual increased temperature (M = 2, 75), and thunder and lightning (M = 2.80) are the main indicators used to predict the

Table 1. IKS Indicators for predicting the onset of the rain season and the start of the dry season.

Indicators for predicting onset of rain season	Mean (M)	indicators for predicting the start of the dry season	Mean (M)
Westerly Wind (Blowing from West to East)	2.81	Clear sky/White clouds	2.9
Heavy dark cloud formation	3	Presences of Butterflies	2.5
Unusual increased temperature (hot at night)	2.75	Drop in Temperatures at night/coldness at night	2.6
Plants/trees start flowering	2.55	High temperature during the day/Hot morning	2.5.9
Red/black ants movements uphill	2.45	Hot morning sunshine	2.7
Migratory birds fly over to the community	2.65	Bright /clear moon	2.65
Animals become restless	2.5	Earthquake /earth vibration	2
Thunder/Lightening	2.80	Appearance of rainbows	2.55
Joint pains felt by some elders	2.1	Morning star appearing in the east	2.58
termites flying in the evening hours	2.8		

onset of the rainy season. While the predominant IK indicators currently being used by communities to predict the onset of the dry season found to be Clear sky/White clouds (M = 2.90), Hot morning sunshine (M = 2.7), Bright/clear moon (2.65) Drop-in temperatures at night/Coldness at night (M = 2.60) and High temperature during the day/Hot morning sunshine (M = 2.59), are predominant indicators used to predict the start of the dry season.

3.4. Indigenous Knowledge System Indicators on the Quality of the Season

MUHONDO farmers could be using many IKS indicators as a responsive measure to minimize risks in drier years and maximize opportunities in a wet season. The indicators being used by farmers are different depending on the weather and climatic condition, natural resources available, cultural/traditional and social backgrounds of an area (Ziervogel & Opere, 2010) also noted that IKS forecasts are conducted based on local biophysical and mystical knowledge that has been gained through many decades of experience in a specific area. However, some indicators may be common and the interpretation of these indicators in use is almost the same amongst the different farmers in a different region. Therefore as shown (**Table 2**) in MUHONDO sector, The Weather indicators that are used to predict include clouds, wind temperature, moon, trees, birds, and Aunts.

4. Discussion

The present daily observation of the atmosphere and what had happened in the past is the basis of modern weather forecasts and the comments will then be taken into account in the future (Buckle, 1996). The technique employs high technology such as satellites and radar (radio detection and ranging). Rwanda's meteorological department did this in Rwanda (METEO-Rwanda). It's costly because high-technology and expertise are required. It is a problem for developing countries like Rwanda. Therefore, for the short or long term, modern weather forecasts can be done. Forecasting of very short distance will last up to 12 hours and can be used in cyclone prediction. Short-range forecasts cover times from 12 hours up to a few days (Lutgens & Tarbuck, 2010). Medium range forecasts scope from few days up to two weeks.

Notably, Farmers in MUHONDO sector agree on the similarity and usefulness of the meteorological forecasts to their IKS evaluations. However, they argued that while scientific meteorological forecasting is not disseminated in due course, it is not useful compared with IKS forecasts. To have an effect on farmers for seasonal climate forecasts, they must be accurate, timely, well-designed, and readily available (O'Brien & Vogel, 2003). The meteorological predictions are not the case. The IKS is observed at the beginning of the season while the weather department is sometimes able to disseminate the predictions before the season has begun. This makes farmers even more optimistic about the IKS pro-

Table 2. Indicators to predict the start of rain and dry season.

Indicators to Predict the Onset of Rain	Implications	Indicators to Predict Onset of The Dry Season	Implications
Westerly winds (blowing from west to East)	Whenever strong winds blow from west towards East, then this is an indication of the rainy season soon approaching	Clear sky/White clouds	Clear sky (blue sky) is a clear indication of no rain while white clouds mean very little or no rain, when this is observed then it clearly showed the onset of the dry season.
Heavy dark cloud formation	When dark clouds form in the sky, the rain will certainly fall	Presences of Butterflies	Whenever butterflies are seen in the numbers, this indicates that there will be no rain.
Unusual increased temperatures (hot at night)	An unusual increase in temperature especially at night is a clear indication of the onset of rains especially around January through March.	Drop-in temperatures at night/Coldness at night	Whenever there is an unusual drop in temperature characterized by coldness at night, this shows that the dry season is soon starting.
Plants/Trees start flowering and gaining leaves	Usually, big trees are expected to shed their leaves from around January and by March the trees will be completely bare, devoid of any leaves. When the leaves of the trees commence sprouting then the rainy season is near.	High temperature during the day/Hot morning sunshine	When there is hot sunrise, with high temperatures during the day these indicate no rains and also mean that dry season is soon approaching.
Red/Black Ants movement's uphill and highland	The appearance of red ants moving up-hill in lines indicates the onset of rain. The same applies to when ants are seen moving downhill to low area/streams it's an indication of very little or no rainfall at all.	Bright/clear moon	When the moon is looked to be clear with no yellowish rings around it, this is a clear indication that it won't rain season and hence an onset of the dry season.
Animals become hyperactive/restless (especially cattle)	When the rainy season is soon approaching, animals are seen to be super excited this includes cattle.	Earthquake	Whenever earthquakes are felt especially at certain known periods in the year, this indicates of onset of dry seasons.
Migratory birds fly over to the community	When the migratory birds fly into the community in their numbers, it is an indication that the rainy seasons are near.	Irregular rain	Whenever rain begins getting irregular especially during the rainy season, this is an indication of an end to the rainy season and hence an onset of the dry season.

jections than weather projections. The farmer employs conventional rainfall forecast, prediction methods and indicators. The dynamism, adaptability, special existence, and creativity of indigenous knowledge are evident in the production of indigenous knowledge by localities or regions (Mapara, 2009). This is typically special and conducive to their continued life and longevity in a specific culture (Warren, 1991).

4.1. Indigenous Knowledge System versus Modern Weather Forecasting System

Generally, the principal importance of IKS and conventional weather forecast information to the community is guiding to preparation for farming and other related activities, Technical monitoring, Communication, and dissemination of warnings (preventing risks). Besides their importance, based on their perception, the respondents in Table 3 mentioned the difference between Indigenous Knowledge and conventional weather forecast system including their uses and challenges.

Table 4 offers a summary of experience from different regions about the adoption of IKS, Modern or coupling both methods in weather forecasting.

4.2. Solution to the Challenges of Weather Forecast

By referring to the interviewed indigenous people summarized in Figure 3, the main solution to the challenges of weather forecast is the adoption of scientific methods (37%), while (25%) of all respondents, preferred the use of IKS as the solution to the weather forecast problems regardless of its unreliability. In addition, a significant proportion (38%) of respondents preferred to use both methods.

It is found that a great number of informants preferred to use both IKS and Modern forecasting Method (38%), Therefore, This implies that Indigenous methods are seen as complementary rather than a contradiction to western-based methods (Modern weather forecasting). Consequently, the study revealed that outcomes of indigenous knowledge-based researches should be utilized and integrated with development processes.

Table 3. Comparison between IKS and Conventional weather forecast.

IK weather forecast information	Conventional weather forecast information
Guiding to preparation for farming and other related activities by emphasizing on the involvement of local community. Knowledge for IKS is embedded in the community so the people become the custodians of the knowledge infrastructure.	The knowledge for the conventional system runs from Meteorological Agency to the communities therefore there is more precise information that would prepare a response in a manner that would reduce the risk and save the lives and livelihoods.
Communication networks are oral (not reliable) Acts as early warning signs/one can prepare to deal with harsh weather conditions such as droughts, floods Local community get Daily updates of weather reports Via the observation of the weather changes.	Communication networks are reliable. The conventional system for technical monitoring and warning services provides more accurate information on the risks with clarity on procedures.
Helps in knowing the period to store crops or seeds (in anticipation for dry season), it provides better planning and dependability and avoidance of disaster risks. Therefore, can easily be mobilized to appreciate the range of risks and encourage them to prepare for action by taking the warnings seriously.	For conventional warning systems, the information can be easily transmitted; but Meteorological Agency (METEO-Rwanda) should make sure that weather reports reach the remotest parts of the rural areas and in a language that is not familiar.
Continuous disappearance of IK indicators due to man-kind activities such as deforestation can leads to Unpredictability due to change in weather over time. IKS lacks a formalized database.	A formalized database with the Accessibility of documents provides tremendous potential for an early warning system with the likelihood to substantially reduce the risk of exposure to disasters However, there is a need to develop easily accessible materials for use.

Table 4. Local community's experiences about different weather forecasting methods.

Country	Recommendation	Source
NGANYI/ KENYA	From Sept 2008, Kenyan Meteorologists and NGANYI Local community (Indigenous knowledge forecasters) met together with the help of the Intergovernmental Authority on Development Climate Prediction and Applications Centre (ICPAC) to produce a consensus forecast for the local Area. The Agreement reached on coupling IK and Modern forecasting methods.	(Ogallo, 2015)
NORTHERN TANZANIA	Tanzania Local farmers have favored Indigenous Knowledge based on their environment, it has been recognized that with Tanzania Meteorological Authority (TMA), farmers would benefit most from seasonal forecasts that are reliable and timely. Therefore, several stakeholders in LUSHOTO District of Northern Tanzania attempted to systematically integrate Indigenous system and Tanzania Meteorological Authority (TMA) Forecasts. After combining, weather prediction results were found to be reliable.	(Mahoo et al., 2013)
UGANDA	Ugandan farmers use IK to predict the occurrence of rainfall by monitoring the behavior of biological and physical features. The farmers claimed Ugandan Meteorological Service (UMS) forecasts timing is not reliable, Therefore The research was undertaken to develop a statistical model that combined the Indigenous knowledge system and UMS forecasts.	(Waiswa, 2007)
MBERENGWA DISTRICT/ ZIMBABWE	The research findings revealed that Local residents in most cases do not understand the meteorological forecasts; This implies the need to utilize the indigenous weather forecasting systems to augment the conventional weather forecasts from the meteorological department. So, the immense benefits can be realized if the IKS and meteorological department (weather prediction data) are combined.	(Makwara, 2013)
ZAKA DISTRICT/ ZIMBABWE	Local people emphasis on the lack of documentation which bring some inaccuracies of relying on indigenous forms of forecasting. Some of farmers reported that the modern approaches work with measurement errors and statistical computations.	(Plotz et al., 2017)

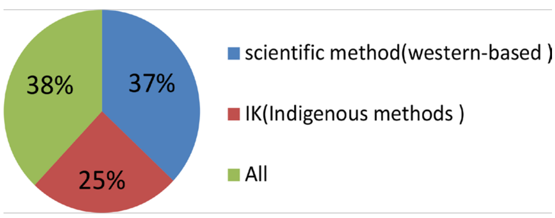

Figure 3. Farmers perception of the system to be used in weather prediction.

5. Conclusion

The study focused on the need of incorporating indigenous knowledge systems into modern weather forecasting methods. Respondents mentioned the main causes of inaccuracy/unreliability and the prediction indicators of both methods, it was clearly remarked that Traditional methods have indicators ranging from biological, atmospheric, relief, and astronomical characteristics. In addition, these are the same parameters used by the meteorologists to predict the scientific seasonal forecast which implies IKS to be complementary to modern system. the local people acknowledged that both indigenous knowledge and scientific method of forecasting had challenges mainly concerning their accuracy/reliability, Moreover, The study revealed that coupling the conventional and current methods could generate more accurate weather prediction reports for the end users. Therefore, local communities, Meteorological Agency (METEO-Rwanda), and governmental institutions in charge of Agriculture need to sensitize the modern and traditional weather forecasters to work together for incorporating IKS into modern system to produce a comprehensive weather forecast that meets the needs of local communities.

Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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