


INDIGENOUS EARLY WARNING IN KARAMOJA, UGANDA:
Application, Validity, and Entry Points for Integration with Conventional Forecasts

November 2022

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ACRONYMS

ACTED	Agency for Technical Cooperation and Development
CAO	Chief administrative officer
CEWS	Conventional early warning system
DDMC	District Disaster Management Committees
DRESS-EA	Strengthening Drought Resilience for Smallholder Farmers and Pastoralists in the Intergovernmental Authority on Development (IGAD) Region
DRM	Disaster risk management
EW	Early warning
EWS	Early warning system
FAO	Food and Agriculture Organization of the United Nations
FGD	Focus group discussion
FEWS NET	Famine Early Warning System Network
IEWS	Indigenous early warning system
IGAD	Intergovernmental Authority on Development
KII	Key informant interview
KRSU	Karamoja Resilience Support Unit
MAAIF	Ministry of Agriculture, Animal Industry and Fisheries
MCF	Modern climate forecast
NECOC	National Emergency Coordination Centre
NGO	Non-governmental organization
OPM	Office of the Prime Minister
TE	Traditional expert
UNMA	Uganda National Meteorological Authority
USAID	United States Agency for International Development
WFP	United Nations World Food Programme

EXECUTIVE SUMMARY

Background

An effective early warning system (EWS) is a prerequisite for timely response to avert and mitigate the impacts of disasters that affect pastoralist and agro-pastoralist communities. Whereas there exist various forms of EWS in Uganda, the main concerns have been whether the early warning information is timely, accurate, accessible, and elicits early action. These questions point at inefficiencies in the conventional EWS in the country and the importance of the indigenous early warning system (IEWS) used by rural communities. These indigenous systems are especially important where conventional early warning information is inaccessible or coarse and therefore not suitable for guiding location-specific decisions.

The Karamoja sub-region in northeast Uganda is a semi-arid area occupied mainly by agro-pastoralist and pastoralist communities. In common with many other African communities, indigenous knowledge and practices are known to exist in Karamoja, but specific information on early warning has not been fully documented. Therefore, it was unclear how IEWS and conventional EWS might be combined to maximize the benefits of each system. This assessment describes indigenous early warning knowledge in Karamoja in detail, how the knowledge is used by communities, and the extent to which it is used. The assessment also covers the validity and reliability of IEWS with reference to known climate events such as droughts or floods, and it makes recommendations on how IEWS and EWS can be better integrated. The findings of this assessment are meant to create awareness among decision makers and provide entry points for integrating the indigenous and conventional early warning systems for enhanced effectiveness.

Assessment Design

The assessment was conducted in Moroto and Napak Districts to represent agro-pastoral livelihoods, and Amudat District to represent pastoralist livelihoods. Information was collected using a literature review, key informant interviews (KIIs), focus group discussions (FGDs), and adapted participatory epidemiology (PE) methods. KIIs included traditional experts (foretellers), and government and non-governmental organization (NGO) staff working on disaster risk management in Karamoja. Focus group discussions involved 8–15 participants and were repeated in 8 villages in the selected districts.

Using this approach, information gathered on IEWS included:

- Climatic trends and corresponding impacts on the availability of foods such as milk, sorghum, and maize;
- Indigenous weather forecast knowledge and practices;
- Community views on the strengths and weaknesses of IEWS;
- Government and NGO staff views on indigenous weather forecast knowledge and practices;
- Reliability of indigenous weather forecasts;
- Decisions made from indigenous weather information.

Information gathered on the conventional EWS included:

- The strengths and weaknesses of EWS;
- Climate information flow;
- Reliability of climate forecasts;
- Decisions made from climate forecasts;
- Community views on the relevance of conventional EWS.

Government and NGO representatives also made suggestions for integrating IEWS and EWS.

Key Findings

Monthly Rainfall, Crop, and Milk Calendar

Rainfall in the districts within Karamoja sub-region follows a more-or-less similar pattern, but with inherent spatial variations. For example, whereas rainfall normally starts in March and peaks in April–May and August in Napak, in Amudat the second peak falls in October. Monthly rainfall was reported to decline to between 10% and 13% in a "bad year," with implications on the availability of sorghum, maize, and milk. The year 2020 was used as an example of a bad year, in which very little rainfall was experienced. Monthly availability of cow milk was reported to closely follow the rainfall pattern, whereas sorghum and maize availability coincided with periods after harvest. These patterns were reported to be increasingly variable by rainfall onset, cessation, and amount each year.

Indigenous Early Warning Information

Both government and NGO staff recognized the role of indigenous early warning information and that communities have relied on their traditional knowledge and practices for generations to guide their livelihood decisions. The IEWS relies on a combination of local people's long-term observations and close interaction with their environment, and real-time monitoring of their surroundings. Communities trust the forecasts from their own experts because these forecasts are generally seen as reliable. They were however in agreement with the government and NGO staff that their own system was subject to unreliability, like the conventional system.

The pastoral and agro-pastoral communities in Karamoja rely on various indicators to predict weather. They study plant phenology, animal behavior, position and movement of stars, position of the sun, and direction of the wind to predict weather. In addition, local experts "dream" to foretell the future, while other specialists read intestines and shoes, and speak to the gourd to foretell climatic conditions and other forms of misfortunes or fortunes. These indicators can be grouped into four main categories, namely: meteorological indicators; biological indicators (both plant based and animal based); astrological indicators; and supernatural/animistic indicators.

A salient feature of the IEWS is its multihazard nature as it not only comprises hydrometeorological indicators, but also indicators for conflict and insecurity (e.g., cattle raids), among a myriad of other misfortunes. Whereas knowledge about meteorological indicators, biological indicators, and astrological indicators is common among the community members and can be learnt from the older generation by anyone, interpretation of some of the supernatural/animistic indicators require special expertise that is only passed down generations through particular families or clans. Traditional early warning information is subjected to verification among experts before forecasts and advice are released to the communities. For example, predictions from intestine readers, shoe readers, and talking gourd experts are referred to the dreamers to verify and advise the community on action to avert any pending misfortune such as drought. Such actions are normally in the form of rituals involving slaughtering specific animal species of specified colors and sources, as directed by the foretellers. Likewise, forecasts from the government are subjected to corroboration by the foretellers.[1] The indigenous knowledge and practices were however mentioned to be under threat from the influence of Christianity, formal education, lack of systematic documentation, environmental degradation and loss of habitat for both plant and animal indicators, and clampdown on foretellers by the government because of their apparent involvement in facilitating cattle raids.

Conventional Early Warning Information

Early warning system preparedness and disaster management are responsibilities of the National Emergency Coordination Centre (NECOC). Climate monitoring is however a mandate of the Uganda National Meteorological Authority (UNMA), which is responsible for collation of climate data from the monitoring stations and modelling to produce the forecasts that NECOC uses, in addition to sectoral information generated at district level by sentinels for disaster risk preparedness and response. NECOC works together with the District Disaster Management Committees (DDMCs) in collecting and analyzing early warning information, validation of the information, and dissemination of it to the communities. Currently EWS is largely supported by non-governmental partners such as Mercy Corps, Food and Agriculture Organization of the United Nations (FAO), and World Food Programme (WFP), and donors such as United States Agency for International Development (USAID). The USAID-funded Famine Early Warning System Network (FEWS NET) mainly produces food security early warning information through analysis of information from various sources/sectors including agriculture production and markets, in addition to climate data. The FAO Pro-Resilience Action (Pro-ACT) project (funded by the European Union) provides institutional capacity building through technical support at NECOC, strengthening of the DDMCs, and district-level EWS. Mercy Corps and Save the Children, through the USAID-funded Food for Peace Activity (Apolou) project, are working with both NECOC and UNMA to integrate indigenous early warning information into the forecasts at district level. UNMA's forecast is however the main source of climate hazard information and uses climate data to generate: 6-hourly (6 a.m.–noon), daily, 5-day, 10-day, monthly, and seasonal climate information that is readily available online, with the radio being reported to be the main channel of dissemination to the communities. The main types of climate information from the forecasts include rainfall onset

1 Intestine readers, shoe readers, talking gourd experts, and dreamers.

and cessation, drought, and floods. The information is normally accompanied with advice.

At community level there are mixed views on the forecasts from government, with most informants treating the information with contempt. However, they respond to the government advice by planting at the right time (when rain delays are expected), planting the right type of crop (if little rain is predicted), as well as preparing for migration to track pasture in case of an extended dry season or drought; they also plan grazing management when plenty of rain is expected. Whereas both the government and NGO staff considered conventional forecasts to be more reliable than the indigenous weather forecasts, they too acknowledged the inaccuracy in the EWS; this inaccuracy was mostly attributed to poor downscaling and distribution of weather monitoring stations.

Integration of Indigenous and Conventional Early Warning Information

Indigenous and conventional early warning systems exist side by side in Karamoja. Discussions with government and NGO staff, as well as with the communities, reveal that both the indigenous and conventional early warning systems have their strengths and weaknesses, and that while communities may accept government advice to some degree, they still subject the conventional forecasts to verification by their own foretellers. This points to the potential for complementarity between the two systems, probably in the form of a hybrid early warning information that is more acceptable, accurate, actionable, and effective. However, the current attempts to integrate the two systems appear to focus more on community validation of the conventional forecast rather than on co-generation of early warning information and joint verification before dissemination of forecasts and advice. It was not clear from the assessment participants which aspects of the two systems are targeted for integration.

Conclusions and Recommendations

Several conclusions and recommendations arise from this assessment with respect to the weaknesses and strengths of the two systems to inform entry points for their meaningful integration. These are listed below.

- Currently, the processes aimed at integration of the indigenous and conventional early warning system seem to seek validation and acceptance of the conventional forecasts by communities rather than involving them in co-generation.
- The findings of this assessment call for co-piloting accuracy of both conventional and indigenous weather prediction indicators to identify the common, most reliable/accurate, and compatible indicators for integration.
- An in-depth analysis and a further documentation of the location-specific weather prediction indicators are necessary given the inherent variability between communities and locations.
- Strengthening the existing district disaster risk management institutional framework and decentralizing the DDMCs further to village level are vital in facilitating integration of the indigenous early warning system and practice with conventional EWS.
- There is a need to improve the climate monitoring infrastructure (distribution of weather stations) and capacity of meteorological personnel in data generation, modelling, and downscaling to provide location-relevant information to enable integration with IEWS.
- Integration of the two systems should focus on co-generation of early warning information, and joint verification involving the community elders/experts and government experts before dissemination of forecasts and advice.
- An effective EWS should not only focus on efficient generation, analysis, and dissemination of timely and accurate information, but also on actionable and user/sector-specific warning to communities, accompanied with support and anticipatory action rather than emergency response.
- Integration of the two systems requires more urgency among stakeholders, preceded by further awareness creation about the role of indigenous weather forecasts and practices in government and NGOs.
- Without peace and security, meaningful interventions on early warning and disaster response will be challenging.

I. INTRODUCTION

An effective early warning system (EWS) is a prerequisite for timely response to avert and mitigate the impacts of climate shocks in the uncertain environments inhabited by pastoralists and agro-pastoralists, like the semi-arid Karamoja sub-region in northeast Uganda. An EWS can be defined as "an interrelated set of hazard warning, risk assessment, communication and preparedness activities that enable individuals, communities, businesses and others to take timely action to reduce their risks" (UNDRR, 2015). An effective EWS should be an "end-to-end" and "people-centered" one that spans all steps, from hazard detection to user- or sector-specific warning. Whereas there exist various forms of EWS in Eastern Africa, and in Uganda in particular, the main concerns have been whether the early warning information is timely, accurate, accessible, and elicits early action to enable communities and sectors to avoid or mitigate the impacts of shocks (Maxwell and Hailey, 2020). The early warning-early action "gap," which has been referred to as "system failure" (Maxwell and Majid 2016, cited in Maxwell and Hailey, 2020), is an indication that most early warning information/analysis is never systematically linked with early action (EA). There is a lack of clear evidence on how the information is translated into an analysis—a forecast or a prediction—and then into action. Other questions surrounding early warning (EW) in Eastern Africa are whether the early warning information is understandable and usable by communities; whether it is effective (does it protect the lives and livelihoods of those at risk?); and whether the projections of EWS are checked against future actual outcomes to allow improvements in the future.

These questions reflect the existing inefficiencies of formal, conventional EWS in the region and indicate why many rural communities rely on indigenous EWS (IEWS) to bridge the gap, especially where conventional early warning information is inaccessible or non-specific and therefore of limited value for guiding location-specific decisions. IEWS is particularly critical among the pastoralist and agro-pastoralist communities inhabiting the arid and semi-arid environments characterized by a highly variable climate. Given that pastoral and agro-pastoral economic activities (extensive livestock production and crop farming) are rain-fed, a reliable and dynamic early warning information system that conforms to the uncertainty of rainfall is key in informing actions aimed at avoiding risks and mitigating the impacts of climatic shocks on lives and livelihoods.

Indigenous knowledge and cultural norms form the basis for decision making for many rural communities in Africa. Indigenous weather information generated through observation of multiple indicators among pastoralist communities is critical in guiding decisions on environmental and resource conservation, livestock and crop husbandry, including planning and preparing for mobility to track pasture and water, herd splitting, grazing management, and when to plant and what type of crops to grow, among other important decisions (Ochieng' et al., 2021; Okonya and Krosche, 2013). The IEWS is therefore prominent among rural communities, especially in the absence of timely, accurate, actionable, and effective conventional EWS (Radeny et al., 2019; Dejene and Yetebarek, 2022). Studies have however shown that IEWS too has its weaknesses, and so there have been calls to seek ways of integrating the strengths of the two systems for better results (Radeny et al., 2019; Ochieng' et al., 2021; Muriithi et al., 2018; Dejene and Yetebarek, 2022; Ayal et al. 2015).

Indigenous knowledge and practice is known to be widespread and important in the Karamoja sub-region (Maxwell and Hailey, 2020; Egeru et al., 2015; Lwasa et al. 2017). Historically the area has been prone to drought, with major impacts on people's survival and livelihoods. During the last 10 years, Karamoja has seen a marked increase in development programs across sectors, but a recent Karamoja Resilience Support Unit (KRSU) review of drought management capacities concluded that Karamoja was ill-prepared to respond effectively and on time to a major drought (Aklilu et al., 2021). Government capacities centrally and locally were weak in terms of drought management, and most non-governmental organizations (NGOs) in Karamoja had not integrated drought management into their development programs. Food and Agriculture Organization of the United Nations (FAO) produces drought early warning bulletins for Karamoja's nine districts, but these efforts are project based; it is unclear how this work will continue when the project ends. With these issues in mind, the KRSU commissioned an assessment of IEWS in Karamoja, to document indigenous early warning knowledge in Karamoja; describe how the knowledge is applied by local communities and the extent of this use; assess validity and reliability of IEWS with reference to known climate events such as droughts or floods; and draw up recommendations on how indigenous early warning knowledge and actors can be better integrated into existing, formal EWS in Karamoja. The findings of this assessment are not only meant to create awareness on IEWS among decision makers, but also provide an avenue for integrating it with the conventional early warning system (CEWS) for enhanced effectiveness.

In various countries where CCPP is a major problem to goat farming, CCPP vaccine is manufactured locally, including Ethiopia, Kenya, Jordan, Saudi Arabia, Turkey, and China. In Ethiopia, the National Veterinary Institute (NVI), which was organized as a public enterprise by Proclamation No. 25/1992 and Council of Ministers Regulations No. 52/1999, oversees the production of livestock and dog vaccines. In 2019/20, the institute produced vaccine valued at ETB 279.72 million (USD 9.85 million) (76.5% of the plan for the year) and collected ETB 152.41 million (USD 5.37 million) in income.

The DeLiVa Ethiopia Project intends to improve the availability, accessibility and demand for CCPP vaccine and other veterinary products through pilot implementation and testing of a public-private franchise CCPP vaccine delivery model. The overall project aim is to contribute to the improvement of the livelihoods and food security of pastoral communities. The project will examine how to improve the supply of high-quality CCPP vaccines, and improve the cost-effectiveness, technical efficiency and sustainability of vaccine delivery in areas with limited use of CCPP vaccination. It will also generate evidence for policy and institutional change to support private sector vaccine and products delivery in Ethiopia, across its regions and for a variety of livestock disease.

This study examines pastoralists' WTP for CCPP vaccine and evaluates the price range they are willing to accept. By gauging the maximum price that the customer is willing to pay, this study aims to gauge the price of the CCPP vaccine and capture the beneficial price value of the vaccine to the pastoralists while, at the same time, maximizing the profit of potential private sector actors in the vaccine supply chain. Therefore, the study will support the DeLiVa Ethiopia Project by providing information on the current WTP for CCPP vaccine, how much pastoralists are willing to pay, and what factors affect the WTP in Borena Zone.

2. ASSESSMENT DESIGN

2.1 STUDY AREA

The assessment was conducted in three districts in Karamoja sub-region, namely Moroto, Amudat, and Napak (Figure 1) from November 1–13, 2022. The districts were purposively selected to represent the two dominant livelihood types/production systems in the area, namely agro-pastoralism (represented by Moroto and Napak Districts) and pastoralism (represented by Amudat District). The selection also targeted areas where indigenous knowledge is still prevalent, specifically indigenous climate/weather forecast knowledge and practices, as informed by KRSU project experience in the area.

2.2 ASSESSMENT METHODS

The assessment used a combination of qualitative approaches, including a literature review, focus group discussions (FGDs), monthly calendars (an adapted participatory epidemiology (PE) method), key informant interviews (KIIs), and on-the-spot observations. The information solicited on IEWS included: observed climatic trends and corresponding impacts on food (milk, sorghum, and maize) availability; indigenous weather forecast knowledge and practices, and their strengths and weaknesses;

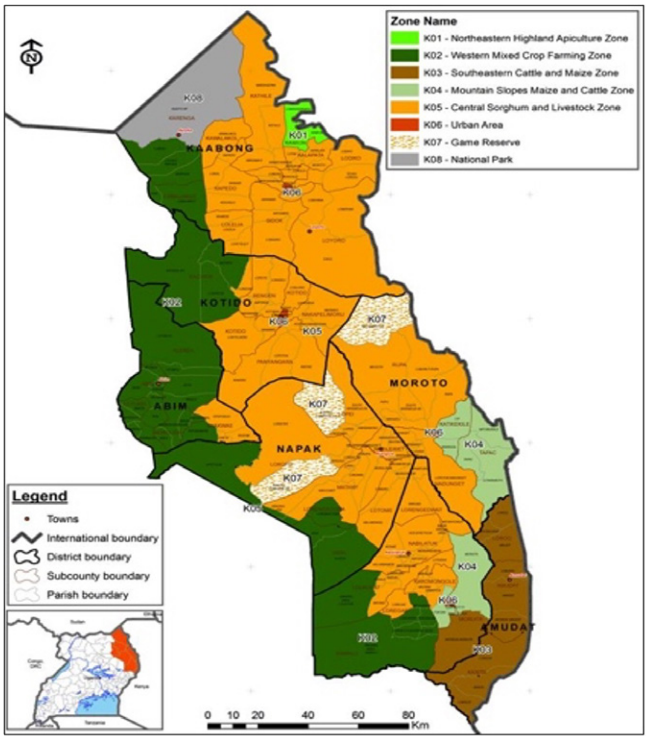

Figure 1 Karamoja sub-region

scientific experts' views on indigenous weather forecast knowledge and practices; reliability of indigenous weather forecasting; and decisions made from indigenous weather information. Information gathered on conventional EWS were: existing conventional EWS and their strengths and weaknesses; climate information flow; reliability of climate forecasting; decisions made from climate forecasting; and communities' views on relevance of conventional EWS. Additional views were collected from the government and NGO representatives on suggestions for integration of indigenous and conventional early warning systems.

The interviews and discussions were conducted in local languages (Ngakarimojong and Pokot), and were facilitated by four research assistants with experience in participatory research approaches, having been trained by Feinstein International Center, Friedman School of Nutrition Science and Policy at Tufts University. The responses were translated for the researchers at intervals to allow follow-up questions before recording.

2.2.1 Literature Review

The fieldwork was preceded by a comprehensive literature review of reports, briefing notes, scientific papers, and other relevant documents. The online review process was guided by key words such as: climate of Karamoja; EWS in Uganda/Karamoja; traditional weather forecast; indigenous early warning system; local knowledge on climate prediction; traditional ecological knowledge; indigenous knowledge of Karamoja pastoralists; drought and pastoral livelihoods in Karamoja; impacts of climate change in Karamoja; and others to elicit information related to the aforementioned areas of focus. The search was widened or narrowed to the specific topics of interest depending on the nature and amount of information.

2.2.2 Focus Group Discussions

Eight FGDs were conducted, one in each of the villages listed in Table 1. The number of participants for each FGD ranged between 8 and 15 people, with a total of 95 participants. The mixed age and gender FGDs involved 51 elderly to middle-aged men; 31 elderly and middle-aged women; and 13 young men and women.

Table 1 Sampled districts, sub-counties and villages

District	Sub-county	Village
Moroto	Lotisan	Atedeoi
	Nadunget	Kachakatom
Napak	Lopeei	Loutakou
	Lokopo	Lolemyek
	Iriir	Kalopiding
Amudat	Achorchor	Lwakei
	Amudat	Chematong
	Katabok	Akayot

The key questions that guided the FGDs sought to understand: climatic trends (rainfall, drought, floods, etc.) in Karamoja and how they impact food (milk, sorghum, and maize) availability; whether the communities are aware of the indigenous/traditional ways of predicting weather (rainfall or drought); and if yes, what the common weather indicators are and how the process of prediction is undertaken; whether the communities have observed any changes in the use of traditional weather forecasting in Karamoja; and if yes, what factors are contributing to the changes; communities views on the use/relevance of IEWS in the future given the observed changes; type of conventional climate/weather information received by the communities from the government or NGOs; whether the communities consider climate information from the government and NGOs useful; and if yes, why and what type of livelihood decisions they make based on such information; and if it is not useful, why and how it can be improved/made better; how the communities compare traditional weather forecasting with conventional weather forecasting; whether it is possible to integrate indigenous weather forecasting with modern climate forecast (MCF); and if yes, how and what would makes it possible (enablers) or difficult (barriers) to integrate the two systems.

2.2.3 Participatory Monthly Calendar

To gain an in-depth understanding of monthly variation in rainfall and associated impacts on communities' livelihoods, monthly calendars were used with FGD participants to show events in a "normal/good" year and a "bad" year. Upon explanation of the objective of the monthly calendar to the participants, the facilitator, in consultation with the participants, drew a line on the ground and marked 12 points representing months of the year on the line in a normal or good year, with the help of symbols. Participants were asked to use a symbol to represent each of the 12 months. The symbols showed a typical activity (agricultural or other household activity) that takes place in the month in that village in a normal/good year. This use of symbols made it easier for participants to remember the particular months. They were then asked to name the months to ensure they were in agreement and fully understood what was presented on the ground. Next, they were given 100 stones. They were told to assume that the 100 stones represented the total amount of rainfall received in a normal year and were asked to distribute the stones among the months to show distribution of rainfall in a normal year. This activity was done in an iterative manner until they all reached a consensus on the quantity of piled stones for each month. The stones were then counted and recorded against each month.

To determine the perceived quantity of annual rainfall received in a bad year, they were asked to choose a proportion of stones out of the 100 that represented the amount of annual rainfall received in a bad year. Upon picking the proportion of stones, they were asked to pile them against the months to show the monthly rainfall distribution in a bad year. The stones were then counted and recorded against the respective months. These two scoring procedures were repeated to determine the participant's perception of milk availability, and sorghum and maize availability, in a good and bad year. Figure 2 illustrates the monthly calendar method. The monthly calendar was used in Lolemyek village, Lokopo sub-county and repeated in Chematong village, Amudat sub-county.

Table 2 presents a monthly calendar of routine farming activities associated with the agro-pastoralist communities in Napak District (Lolemyek village).

Table 2 Main crop production activities by month, agro-pastoralists in Lolemyek village, Lokopo Sub-County in a normal/good year[2]

Month	Activity
January	Clearing of gardens
February	Burning of cleared vegetation
March	Planting by hand
April	Ox-ploughing
May	Weeding
June	Harvesting of fresh beans and wild cucumber
July	Harvesting of fresh maize and scaring of bird pests from crops
August	Harvesting sorghum fallen by frogs and rain
September	Harvesting mature sorghum
October	Threshing and winnowing of sorghum
November	Traditional after-harvest ceremonies, e.g., marriages
December	Cutting of materials (sticks, poles, and grass) for constructing huts

Table 3 Crop production activities by month, agro-pastoralist Pokot community in Chematong village, Amudat Sub-County in a normal/good year[3]

Month	Activity
January	Land clearing
February	Burning of cleared vegetation
March	Land tilling/ploughing for early cultivators
April	Planting of early cultivators
May	Weeding for early cultivators
June	Finalization of weeding for first cultivator and fencing of the farms
July	Weeding for second (late) cultivators; harvesting of beans
August	Eating fresh maize
September	Harvesting of mature maize
October	Building granaries/stores
November	Shelling and storing harvest
December	Cutting of grass and poles for house construction and plastering of huts; traditional ceremonies; paying of dowries

Table 3 presents a monthly calendar for routine farming activities associated with the agro-pastoralist[4] Pokot community in Chematong village, Amudat District.

Livestock and pasture management among the Pokot is organized to ensure that during the farming period, most of the cattle are away in distant pastures. They

2 FGD-5 (Lolemyek village), November 11, 2022, N = 13.

3 FGD-9 (Chematong village), November 12, 2022, N = 10.

4 The Pokot community mainly practices pastoralism but has recently adopted some crop farming.

Figure 2 Scoring monthly rainfall amounts and availability of milk, sorghum, and maize in a normal and a bad year

return in May, a month characterized by high milk availability. During the months of August to October in a bad year, livestock, especially milking animals, are sustained on crop residues since there is little pasture.

2.2.4 Key Informant Interviews

A total of 17 KIIs were conducted with staff of government departments (9) and NGOs (8) undertaking disaster management projects in Karamoja. The consulted institutions/organizations/individuals included: Chief Administrative Officer (CAO) (Moroto); Ministry of Water and Environment (Strengthening Drought Resilience for Small Farmers and Pastoralists in the Intergovernmental Authority on Development (IGAD) Region (DRESS-EA) project); Production Department (Pro-Resilience Action (Pro-ACT) project, focal person) (Moroto); Chairman of District Disaster Management Committee (DDMC) and Acting Deputy CAO (Napak); Chief Administrative Officer (Napak); Principal Assistant Secretary (Amudat); Production Department (Pro-ACT project, focal person) (Amudat); Mercy Corps; FAO; Karamoja Youth Effort to Save Environment (KAYESE); Institute for International Cooperation and Development; World Food Programme (WFP), Pro-ACT project; and Agency for Technical Cooperation and Development (ACTED).

2.2.5 Traditional Expert/Foreteller Interviews and On-the-Spot Observations

Participants of the FGDs were asked to identify traditional experts associated with the mentioned indigenous weather prediction practices, specifically readers of intestines, readers of shoes, and talking gourd experts. In-depth interviews were then conducted with the experts, and the researchers requested a demonstration of how they predict weather. A total of seven traditional seers (two intestine readers, three shoe readers, and two talking gourd specialists) were interviewed in Moroto and Napak Districts.

2.3 DATA ANALYSIS

Collected data were collated and subjected to content and thematic analysis and presented under the various broad thematic areas investigated: observed climatic trends in Karamoja and how they impact food (milk, sorghum, and maize) availability; indigenous weather forecasting (knowledge, indicators, and practices) and its strengths and weaknesses; decisions made from indigenous weather information; suggestions for strengthening indigenous weather forecasting; existing conventional EWS and its strengths and weaknesses; climate information flow; decisions made from climate forecasting; suggestions for strengthening conventional EWS; existing opportunities and entry points for integration of IEWS and conventional EWS.

3. RESULTS AND DISCUSSION

3.1. RAINFALL, MILK, AND CROP AVAILABILITY PATTERNS IN KARAMOJA

Discussions with communities show that rainfall in the districts within Karamoja sub-region follows a more-or-less a similar pattern, but with inherent spatial variability. For example, rainfall normally starts in March, peaks in April–May and August, and ceases in November in Napak District. In Amudat District, the second peak falls in October. The monthly rainfall amounts were reported to decline to between 10% and 13% in a bad year, with implications for the availability of sorghum and milk (Figure 3).

Monthly availability of cow milk was reported to closely follow rainfall patterns, whereas sorghum and maize availability coincided with periods after harvest. These patterns are however becoming increasingly unpredictable. Onset, cessation, and amount of rainfall have varied considerably in recent years: "*It used to rain February/March, but now the rains come in April/May, and there is a long dry spell between rains, unlike before. With enough rains, especially towards the end of the year, we used to have Ejojo [sorghum ratoon], but not nowadays.*"[5]

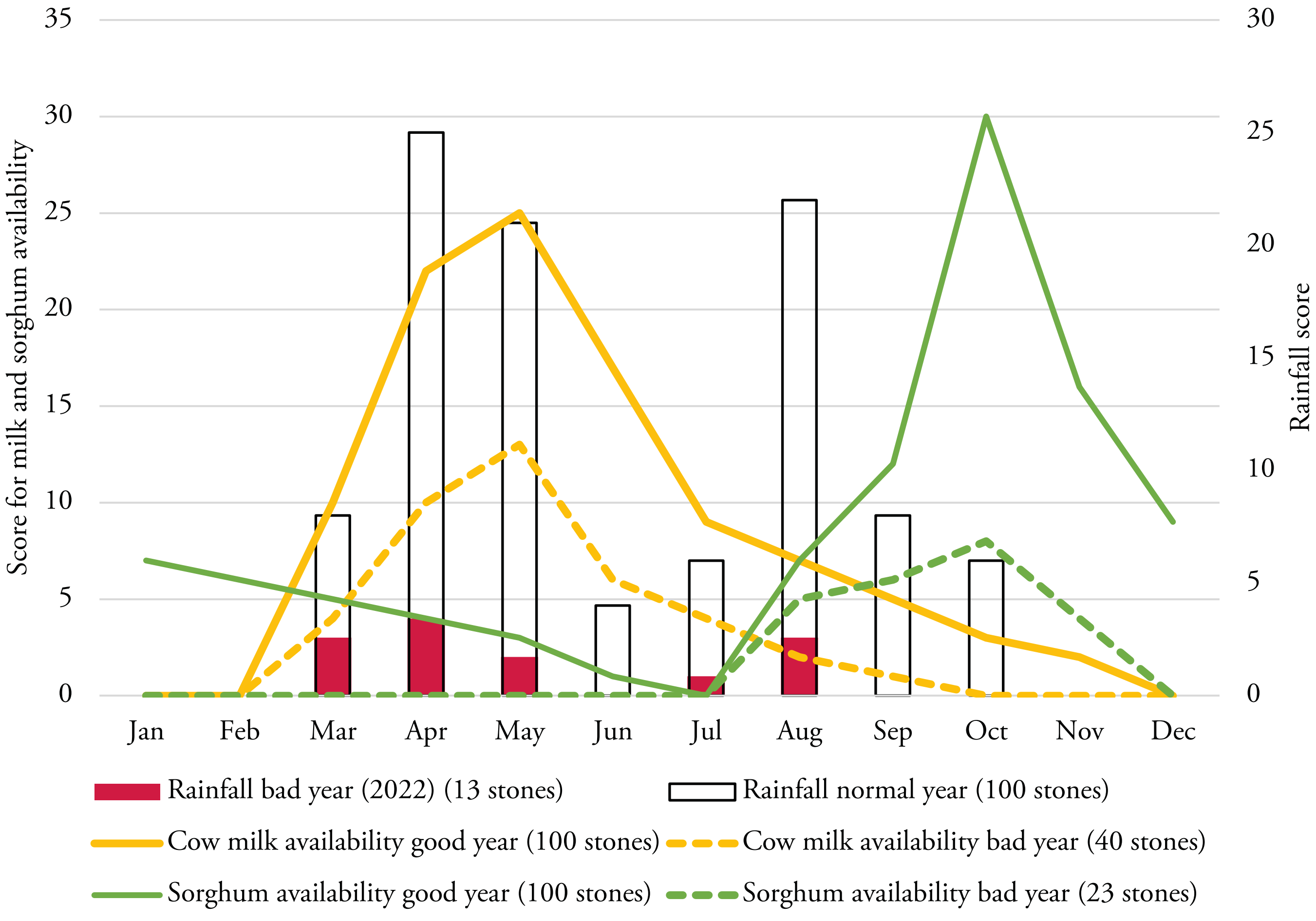

Figure 3 Monthly cow milk and sorghum availability in good and bad years[6]

Note: The monthly calendar was derived from proportional piling with 13 community participants comprising 5 elderly men and 2 young men; 5 elderly women and 1 young woman.

5 FGD-3 (Nadunget village), November 4, 2022

6 FGD-5 (Lolemyek village), November 7, 2022, N = 13.

3.1.1 Rainfall, Milk, and Sorghum Monthly Availability Pattern in Napak District

Figure 3 shows the monthly rainfall pattern in a good and a bad year in Napak District and presents monthly availability of milk and crop (sorghum) as perceived by the agro-pastoralist community based on the proportional piling of stones. The year 2022 was used as an example of a bad year, in which there was very little rainfall. Rainfall onset was in March as expected, but only 13% of the amount expected during the year fell, with early cessation occurring in August instead of November.

Availability of cow milk in a good year was reported to closely follow the rainfall pattern, with the peak coinciding with the months of April and May owing to abundance of quality pasture. On the other hand, the availability of milk in a bad year drops to about 40% of the annual amounts expected in a good year. The availability of sorghum in a good year was reported to be highest in the months of September to November, which coincides with the harvesting season. The pattern was reported to be similar in a bad year but with only about 23% of availability recorded during the months of August to November, and none for the remaining months of the year.

3.1.2 Rainfall, Milk, and Maize Monthly Availability Patterns in Amudat District

Figure 4 presents monthly rainfall, milk, and maize availability patterns in a normal and a bad year in Chematong village, Amudat District as perceived by the community. The perception of the community is that rainfall onset is in March, with peaks in April and May and October. In a bad year (2022), as little as 10% of the expected rainfall was received. Maize availability is normally highest between October and December, just after harvest, and lowest between April and August. Although a similar trend in maize availability is depicted in the bad year, the quantities expected in the bad year drop by about 20%.

3.2 COMMON HAZARDS

The assessment shows that rainfall is the main determinant of livelihood activities in the area, and therefore reduced rainfall is a hazard for crop and livestock production. Drought and insecurity were reported to be the top hazards, followed by livestock pests and diseases, crop pests and diseases, and flash floods and fire, in descending order of importance (Table 4). Security was mentioned as a key determinant of the effectiveness of government/

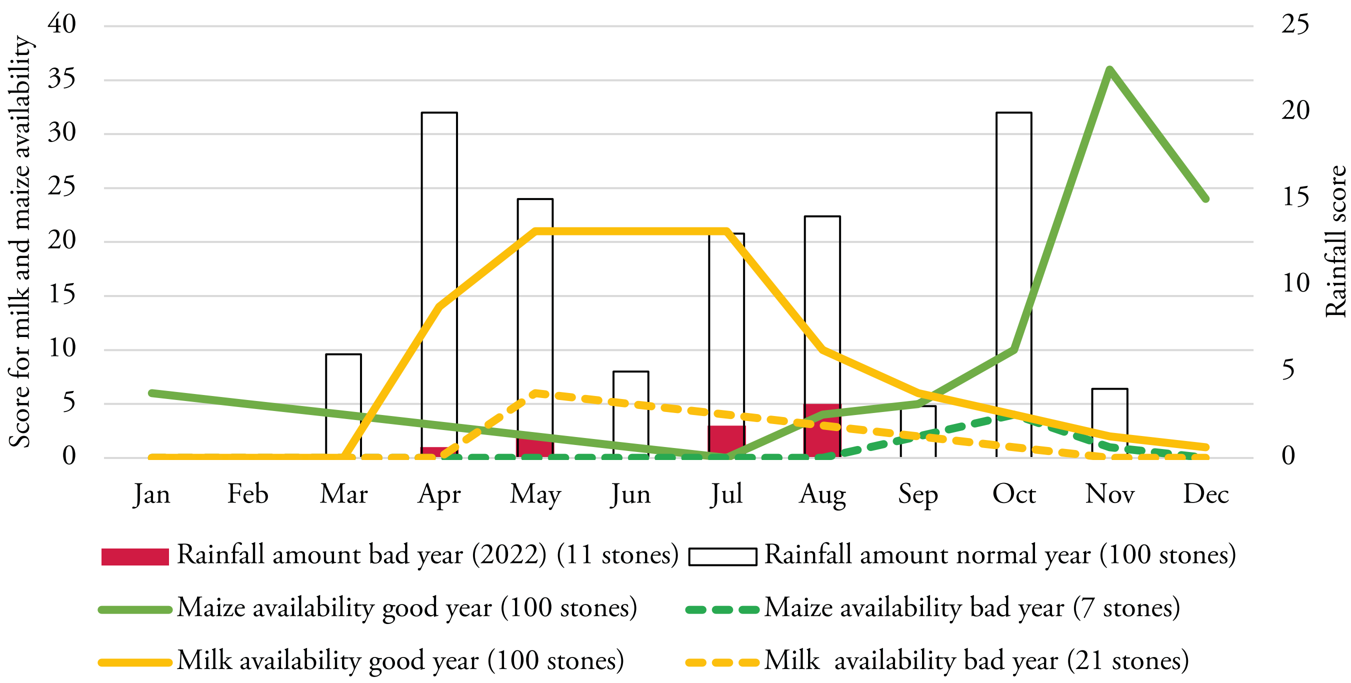

Figure 4 Monthly calendar for Pokot agro-pastoralists in Chematong village, Amudat District[7]

Note: The monthly calendar was derived from proportional piling 10 community participants comprising 5 elderly men and 2 young men; 2 elderly women and 1 young woman.

7 FGD-9 (Chematong village), November 12, 2022, N = 10.

Table 4 Common hazards in Karamoja[8]

Hazard	Average rank (in descending order of importance)
Drought	1
Insecurity/conflicts	1
Livestock pests and diseases	2
Crop pests and diseases	3
Flash floods	4
Fire	

Prediction Using Indicators

- Meteorological
- Biological
- Astrological
- Supernatural/ animistic

Triangulation and Interpretation

- Interpretation by dreamers/seers
- Production of forecast and advisory

Forecast and Advice

- Dissemination of forecast by messengers of the seers

Action

- Ritual to avert misfortune

Figure 5 Indigenous early warning system of the Karamojong and Pokot in Karamoja

NGO and community responses to disasters. Insecurity compounds the situation by making it difficult for communities to exercise their traditional disaster risk management strategies, such as migration. Insecurity also hinders government interventions. Peace provides an enabling environment for sustainable coping and adaptation to drought and climate change.

3.3 INDIGENOUS EARLY WARNING SYSTEM IN KARAMOJA

3.3.1 Indigenous Knowledge and Practices in Karamoja

Indigenous weather forecasting is widely used to guide livelihood decisions in Karamoja. People make use of a combination of astronomical, meteorological, and biological (animal and plant) indicators based on their observations and experience arising from close interaction with their environments. This finding corroborates research by Radeny et al. (2019) among various communities in Uganda, Tanzania, and Ethiopia. Besides the common environmental indicators, weather predictions are done by traditional experts who may be trusted and respected spiritual leaders/heads of shrines and decision makers, in addition to their role foretelling fortunes and misfortunes.

The communities indicated that they trust forecasts from their own experts because their predictions come true most of the time. They were however in agreement with the government and NGOs staff that their own system was as subject to unreliability as the conventional system.

3.3.2 Indigenous Early Warning Information Processing and Action

Figure 5 presents the end–to-end IEWS among the interviewed Karamojong communities. The process of generation of indigenous early warning information starts with observation of the plant indicators and animal behaviors, patterns and movement of the stars, wind direction, and reading of intestines whenever an animal is slaughtered, among others. The dreamers are then consulted to verify and interpret the observed indicators, as well as provide guidance to the communities. Predictions from shoe readers and talking gourd experts, as well as those from conventional forecasts, are also subjected to verification by the dreamers. The community trusts these experts (the traditional seers).

8 FGD-1 (Atedeoi village), November 1, 2022, N = 14; FGD-2 (Kachakatom village), November 2, 2022, N = 12; FGD-3 (Loutakou village), November 2, 2022, N = 13; FGD-5 (Kalopiding village), December 2, 2022, N = 13.

3.3.3 Indigenous Weather Prediction Indicators

The pastoral and agro-pastoral communities in the assessment areas rely on various indicators to predict weather. They study plant phenology, animal behavior, the position and movement of stars, the position of the sun, and wind direction to predict weather. In addition, experts with supernatural powers dream to foretell the future, while other specialists read the intestines and shoes, and speak to the gourd to tell future climatic conditions or other misfortunes or fortunes (Tables 5–9). These indicators can be grouped into four main categories, namely: meteorological indicators, biological indicators (animal based and plant based), astrological indicators, and supernatural/animistic indicators. A salient feature of the IEWS in the area is its multihazard nature given that it not only comprises hydrometeorological predictions, but also predictions of conflict, disease, and insecurity (e.g., cattle raids), among others. Whereas knowledge about meteorological indicators, astrological indicators, and biological indicators is common amongst the community members, and can be learnt from the older generation by anyone, interpretation of the supernatural/animistic indicators requires special expertise that is only passed down through the generations in particular families or clans.

Another salient feature of IEWS is that the information is subjected to verification amongst experts before forecast and guidance is released to the communities. For example, predictions from intestine readers, shoe readers, and talking gourd experts are referred to the dreamers for verification. The community is then advised about action to take to avert any pending misfortune such as drought. Such actions are normally in the form of rituals involving slaughtering of animals of a specific species, color, and source as directed by the traditional seers. Likewise, forecasts from the government are subjected to corroboration by the traditional seers. KIIs mentioned that indigenous knowledge and practices are under threat from the influence of Christianity, formal education, lack of systematic documentation, environmental degradation and loss of habitat for both plant and animal indicators, and clampdown on traditional seers by the government because of their involvement in facilitating cattle raids. Changing aspirations among both the old and youth was mentioned alongside technology as a key threat to indigenous knowledge and practice: "*We learnt about indigenous practices from our forefathers and used to trust them, but now the youth believe in the church/Christianity.*"[9] "*The obsession with modernity, technology, education, and Christianity may undermine the role of indigenous knowledge system, as people largely view traditional ways of doing things as retrogressive. The gap between IEWS and formal EWS is that of misunderstanding, especially when scientists are not willing to learn from the communities.*"[10]

Several studies in East Africa report the relevance of indigenous early warning indicators (Radeny et al., 2019; Dejene and Yetebarak, 2022; Pratt, 2002). Use of animal and plant-based indicators has been reported among the Gabra of southern Ethiopia (Dejene and Yetebarak, 2022); Gujii from southern Ethiopia (Guye et al., 2022); and the Borana from southern Ethiopia (Radeny et al., 2019). Similarly, use of astrological indicators such as the pattern and movement of stars is common among the Borana and Gujii of Ethiopia (Radeny et al., 2019). None of these studies have however documented the reading of shoes and the talking gourds reported among the Karamoja and the Pokot of Karamoja sub-region.

3.3.3.1 Detailed Description of Selected Indicators

Reading of Intestines (Akirip ngamaliteny, in Ngakarimojong)

When stars and other indicators point to a long dry spell or drought ahead, elders gather in a dry riverbed, slaughter an animal, and read the intestines. If predictions confirm that a bad year (drought—*Akolong*—or extended dry season) is pending, then they agree on a ritual to bring the rains. This ritual normally entails slaughtering an animal and prayers by special/spiritual leaders. The leaders will offer prayers on a dry riverbed or under a ficus tree (*Ebobore* in Ngakarimojong; *Mokongwo* in Pokot) for about two weeks until they see signs of rain. During prayers, they sprinkle water from the livestock water trough in all directions, using twigs. Prayers for divine intervention have also been reported by Pratt (2002) in a study conducted among the pastoralist communities in northeastern Kenya, where the community reaction to a drought forecast is to come together and pray for intercession by Allah.

Reading of intestines is a routine practice whenever an animal is slaughtered. Mesenteric veins full of brown fluid (blood) with a long flow and side pockets

9 FGD-8 (Achorchor village), November 11, 2022, N = 10.

10 KIING-6 (IICD), November 3, 2022.

Table 5 Meteorological indicators[11]

Category of weather prediction indicators	Description
Cloud	• When clouds appear over Mt. Iriir, it rains the same day. • Appearance of dark clouds are signs of rain, while clear skies depict dry conditions. • When straight clouds with a big bulb-like appearance at the tip (*Akapet*; *Erot Angapesur*; *Aroo tipin*) are seen at night moving from Kadam towards Lodwar, it is a sign of a good year. When they appear west of Moroto and with a small *Akapet*, it indicates a bad year (little rain).
Lightning	• When lightning is seen from Loima mountains (Turkana); Chau Mt. (Morukomol); Morungole Mt. (Dodoth); Nangolebwel Mt. (Nyakwae); Longor water pan (Jie); Napak Mt. (Bokora); Yelele Mt. (Turkana); Koteen Mt. (Matheniko); Nabwel Arengan (water pan in Matheniko area), it rains the same day. • When there is lightning in Mt. Moroto, there will be no rain in Matheniko area, but it will rain in Bokora, Jie, Kumam, and Teso areas. However, nowadays this lightning could be accompanied with no rains at all. • Lightning seen from Mt. Lowokowok, Lomee (at the foot of Mt. Moroto), Mt. Nangolebwel in Abim, Mt. Kirik in Teso, and Mt. Kapchorwa is a sign that it will rain the same day. (Source: FGD-4). • Lightning and thunderstorms are signs of rain, while a calm atmosphere shows that it is about to rain.
Wind	• Strong winds in the middle of a dry period indicates there will be an extended dry season, and the households start to reinforce the fences and other structures within the homesteads, and to preserve food.
Dew	• Dew on stone for grinding grains is a sign that it will rain.
Temperature	• Increased temperatures at night are a sign of rains.

(extensions) indicate enough/a lot of rains. When there is only clear fluid and no ingesta or blood in the intestines, drought is expected. Intestines can also be read to predict raids and insecurity. For example, small white particles moving along the veins when pressed, revealing a map of enclosures and the gates through which animals get in or out, is a sign of a fortune (successful raid or raided cows are about to be brought home). Readings of intestines have been reported among the Gujii pastoralists in southern Ethiopia (Guye et al., 2022) and the Gabra pastoralists in southern Ethiopia (Dejene and Yetebarak, 2022).

Normally, the intestines of the first three animals slaughtered are checked to confirm the prediction. If found to be consistent, a dreamer is sent for and told what the intestine reader has predicted. He will then be given time to dream about the forecast and advise the community on what to do to avert the misfortune. The dreamer is *Lo Irujae* in Ngakarimojong and *Werkoyon* (prophet) in Pokot. In Pokot, they are also described using coded names such as *Poyon* (respected elder), *Moning* (the child), or *Kokonyon* (old woman). The dreamer will advise the community to slaughter an animal as a ritual. He specifies the type of livestock, color, age, sex, class (whether castrated or not), homestead from which to get it, and whether people should eat the meat or alternatively smear their bodies with the blood. In this regard, the rank of the dreamer in the hierarchy of experts is higher than the intestine reader. "*Everything depends on* Emuron, *he is so powerful, he brings lightning and rain. We trust the* Emuron *more because what they predict always happens and they live with us here, we do not know how the government makes their predictions.*"[12]

11 FGD-3 (Nadunget village), November 4/11, 2022, N = 14; FGD-5 (Lolemyek village), November 7, 2022, N = 16; FGD-4 (Loutakou village), November 5, 2022, N = 13; FGD-10 (Akayot village), November 12, 2022, N = 10; FGD-1 (Atedeoi village), November 1, 2022, N = 14; FGD-2 (Kachakatom village), November 2, 2022, N = 12; FGD-5 (Kalopiding village), December 2, 2022, N = 13; FGD-8 (Achorchor village), November 11, 2022, N = 10.

12 FGD-3 (Nadunget village), November 4, 2022.

Table 6 Biological indicators[13]

Category of weather prediction indicators	Description
Phenology of trees	• Flowering and fruiting of *Ngitopoj*, *Ngibeyo* (Balanites), *Ekadelwae*, and *Ngakaalio* trees during the dry season show the rains are nearing or are an indication of a good year. • Shedding of leaves (*Arara*) is associated with a dry spell. • Flowering of *Eregae* tree towards January–March is a sign of a bad year since the tree normally flowers in April/May/June, when white ants appear. • Flowering of *A. mellifera* (*Panyarit* in Pokot) around November/December is an indication that of a lot of rain can be expected. • Fresh growth of twigs (leaves and fruits) (*Akimukokin*) of trees such as *Etopojo*, *Ekorete*, *Ekalweit* (*Ekaale*), *Epeduru*, *Ekadelwae*, *Ekamongo*, *Elamae*, *Epongae*, *Ebobore*, *Ebei*, *Etirir*, *Engomo*, and *Edome* (in Ngikarimojong) in the dry season is a sign of rain. Fruits of *Edome* (Balanites spp.) is an indicator of expected good harvest.
Birds and other wild animals	• Calling of a certain bird (*Elele* in Ngakarimojong or *Alele* in Pokot), *ki ki ki*, at dawn (5 a.m.) is a sign that rains are about to come. When the call is extended at dawn (*ki ki ki ki ki ki ki ki*), it is a sign that it will rain in the afternoon or evening. If it calls at midnight or in the evening, it is a sign that the rains are still far. When *Alele* calls/laughs towards the east while shaking its tail in the morning, it signifies a lot of rain, while when *Alele* calls during the day, it predicts a raid. When *Alele* flies westwards/southwards, there is no rain/bad year. • Calling of *Akidodok* (frog) at dawn indicates that the rains are near. • When the head of *Anakanak* (monitor lizard) is facing down while perching on a tree, it means rains are about to come. • When the head of *Anakanak* is facing up while perching on a tree, it means rains are far (extended dry season). • Calling of Etula (owl) at dawn means rain is coming. • When certain birds, *Ngabanga* (ducks), *Ngataparkitela*, *Ngabongia*, and *Ngikopokipi* migrate from the west (water bodies/wetlands) to the east, it is a sign of a good year. This was last seen in 2019, which was the only good year in the recent past. • When *Owal* (cranes) fly from the west (water bodies/wetlands), after rains (during weeding), it will be a good year. • When *Ngabatae* (ducks) dance at home, it rains the same day. • *Iluru/Lobeleny* (*Quil* in Ngikarimojong) calling is a sign that there will be enough rain and a bumper harvest. It is a heads-up for communities to start preparing land for planting. • Croaking of frogs indicates that rain is about to fall. • Appearance of snakes is a sign of rain. • Appearance of white ants (*Ngikong*) and butterflies indicates rain.

13 FGD-3 (Nadunget village), November 4, 2022, N = 14; FGD-5 (Lolemyek village), November 7, 2022, N = 16; FGD-4 (Loutakou village), November 5, 2022, N = 13; FGD-10 (Akayot village), November 12, 2022, N = 10; FGD-1 (Atedeoi village), November 1, 2022, N = 14; FGD-2 (Kachakatom village); November 2, 2022, N = 12; FGD-5 (Kalopiding village), December 2, 2022, N = 13; FGD-8 (Achorchor village) November 11, 2022, N = 10.

Table 6 Biological indicators (continued)

Domestic animals	• When male goats become restless and sexually active, the rain is about to fall. • Excitement of calves indicates rain is about to fall. • Rutting of male camels is a sign that it will rain in the next 1–2 days. • Cows flapping their ears (*Ipokipokete ngaki*) indicates a good year. • Cows gnashing their teeth (*Eriabete Ngikial*) shows a bad year. • Cows defecating while lying down (*Ibobonete Eperete*) is a sign of a bad year and famine. • Cows urinating while lying down is a sign of a good year, signifying a lot of rain, river flows (FGD, Akayot village, Katabok sub-county, Amudat District, November 12, 2022). • When cows moo (uuugh,uuugh, uugh), it is a sign of good rains.

Table 7 Astrological indicators[14]

Category of weather prediction indicators	Description
Pattern of stars	• When *Lomoroko* (a group of stars forming a star-like head and smoky tail) appears from the east, it signifies a pending drought or conflict. • *Tapogh* ("female star" in Pokot): When the big star rises and moves with the sun, it is a sign of no rain. When it rises from the east before the sun, it is a sign of rain. When the sun rises from the east and *Tapogh* rises from the west in the evening, it indicates no rain. "Right now it is rising with the sun, that is why there is no rain." (FGD-8 (Achorchor), November 11, 2022, N = 10). • When *Tapogh* overlaps the sun, there is no rain, and when it produces a calf (accompanied by a small one), livestock give birth (high productivity of livestock), and there is a lot of rain. When it moves without a child, it signifies little or no rain. • When *Sitagh* ("a group of stars of different sizes" in Pokot) moves and gets to the north in March, it rains. When *Sitagh* appears in the south, it signifies a dry season. • *Rupkwapaugh* (cloud-like star) is seen at night in the northwestern direction (dry season) and southeastern direction (wet season). When it is small, it signifies little rain. When it is large, it signifies a lot of rain. When it disappears and appears in the northeast direction, it signifies high productivity, while when its appearance in the northeast is delayed, it is a sign of little or no rain. • *Ngiramatom* (A group of seven stars) signify the wet (March to September) and dry season (October to February) months. They move from East towards Northern direction. *Ngimarakalo* (A group of four stars) appear to signify beginning of dry season and move following a small cloud-like circle from the southeast to the southwest from October to June.

14 FGD-3 (Nadunget village) November 4, 2022, N = 14; FGD-5 (Lolemyek village), November 7, 2022, N = 16; FGD-4 (Loutakou village), November 5, 2022, N = 13; FGD-10 (Akayot village), November 12, 2022, N = 10; FGD-1 (Atedeoi village), November 1, 2022, N = 14; FGD-2 (Kachakatom village), November 2, 2022, N = 12; FGD-5 (Kalopiding village), December 2, 2022, N = 13; FGD-8 (Achorchor village), November 11, 2022, N = 10.

Table 7 Astrological indicators (continued)

Position of the sun	• The sun rises at different positions to indicate the month, while the onset of rains indicates whether it is a good year or a bad one. In a good year, rainfall starts from April–December, while in a bad year rainfall starts from July–November and there is no rain in December. • Position of the shadow, which is linked to the position of the sun: when facing east and the shadow goes to the right, it indicates a wet season. When facing east and the shadow goes to the left, it indicates a dry season. When the shadow is right under the body (January), it means a dry season. • When the sun is surrounded by a red, green, or yellow ring (*Alokaki akolong*), it is as a sign of good rains.
Position of the moon	• When facing *Kuju* ("source of the river" in Ngakarimojong), it will rain shortly. • When facing *Kwap* ("mouth of the river" in Ngakarimojong), it is a sign of a dry season. • When the moon is enclosed by a red, green, or yellow ring (*Alokaki Elap* in *Ngakarimojong*), it is an indicator of good rains.

Table 8 Supernatural/animistic indicators[15]

Category of weather prediction indicators	Description
Reading of intestines (*Akirip ngamaliteny*)	• Used to predict misfortunes and fortunes. Reading of intestines is an expert practice done by traditional seers with supernatural powers, *Emuron*. They are also known as *Ikoku* (the child), *Enyait* (the grass), or *Itwan* (the person) as a way of concealing their identity. • Reading of intestines is done in a regular manner for most animals slaughtered. • The *Emuron* invites either close friends/confidants or relatives to witness the reading of intestines and later convenes a meeting to give the predictions/forecasts. There are normally three people present at the reading of intestines: the senior reader and one or two juniors/helpers whose work is simply to witness/observe. They do not point at or touch the intestines.
Dreaming (*Akiruja*)	• There are experts who dream (*Irujae*) about fortunes and misfortunes and give guidance on how to avert the misfortunes. • Dreaming is done once in a while. Dreamers normally give information at the beginning, middle, or end of the month. They also dream by themselves when not requested to interpret and advise on a forecast. • The predictions from intestine readers are normally shared with the dreamers, who sleep over the forecasts and give advice back to the community through chosen individuals. The advice is mainly aimed at averting misfortunes and takes the form of rituals, e.g., *Emunyen* (a ritual that involves smearing the body with mud) or *Ajulot* (a ritual that involves slaughtering of animals). These are performed using healthy specified livestock species of a particular age, sex, and color. *Emunyen* and *Ajulot* are done both in combination and separately. The next time the expert reads the intestines, he will use the type of animal recommended by the dreamer.

15 FGD-3 (Nadunget village), November 4, 2022, N = 14; FGD-5 (Lolemyek village), November 7, 2022, N = 16; FGD-4 (Loutakou village), November 5, 2022, N = 13; FGD-10 (Akayot village), November 12, 2022, N = 10; FGD-1 (Atedeoi village), November 1, 2022, N = 14; FGD-2 (Kachakatom village), November 2, 2022, N = 12; FGD-5 (Kalopiding village), December 2, 2022, N = 13; FGD-8 (Achorchor village), November 11, 2022, N = 10.

Table 8 Supernatural/animistic indicators (continued)

Reading of shoes (*Akirip Ngamuk*)	• The reading of shoes is accompanied by items of value, namely milk, tobacco, money, or local brew, to appease the spirits/gods to tell the future. These items of value are either put on the shoe or on the sides during the exercise. • The shoe reader (Loa Ngamuk) tells misfortunes and fortunes by putting a pair of traditional sandals together and dropping them on the ground, after which he observes their orientation to predict whether a bad or a good thing will occur. Reading shoes and reading intestines serve the same purpose.
Talking gourd	• The traditional gourd experts, mainly women, shake the gourd as they talk to the spirits to make predictions on various matters brought before them by the community members. • Like shoe reading, consultations of the gourd are accompanied with offer of tobacco, money and local brew to appease the spirits to talk.

Table 9 Other weather prediction indicators[16]

Category of weather prediction indicators	Description
Other indicators	• Trapping of rats is an indicator of a bad year. When drought sets in, the communities increasingly burn pasture to smoke out rats. They sell the bush meat in order to conserve the little grain and livestock they own. Burning of pastures is also traditionally done in expectation of regeneration during the rainy season. Trapping of rats is also a common practice every dry season. • When people start eating wild fruits (fruits of Balanites), it is an indicator of a bad year. • Increased cattle theft and stealing of household items indicate hunger and can form part of the multihazard early warning system in Karamoja.

The *Emuron's* advice is always heeded by the communities for fear of consequences: "A *while back, the expert predicted the invasion by the Army and the community was advised to slaughter a donkey in specified two villages, but one village disregarded the advisory, and soon after a prominent personality (Local Council 3) was shot dead by the Army*."[17]

Reading of Shoes (Akirip Ngamuk in Ngakarimojong)

Reading of shoes is normally done to predict both bad and good things. Besides prediction of weather, shoe reading is used to locate lost children, property, or a stolen animal, or predict snake bites, conflicts/raids, persons to be killed in the raids, and when the raiders are coming (and the route they will follow). Its demand rises during periods of conflicts. Experts use telepathy to foretell the future and perform shoe reading before communicating the results to the community. Reading of shoes is accompanied with tobacco, money, or local brew to appease the gods to tell the truth. Figures 6 and 7 illustrate the orientation of sandals (shoes) during *Akirip Ngamuk* and the meaning.[18] The shoe reader holds the pair of sandals together in his hands, then drops them on the ground and studies the orientation of the shoes to come up with his predictions. When the pair of shoes land on the ground open and facing up, it is a sign of drought (Figure 6a); when they face down, it is a sign of rain

16 FGD-3 (Nadunget village) November 4, 2022, N = 14; FGD-5 (Lolemyek village), November 7, 2022, N = 16; FGD-4 (Loutakou village), November 5, 2022, N = 13; FGD-10 (Akayot village), November 12, 2022, N = 10; FGD-1 (Atedeoi village), November 1, 2022, N = 14; FGD-2 (Kachakatom village), November 2, 2022, N = 12; FGD-5 (Kalopiding village), December 2, 2022, N = 13; FGD-8 (Achorchor village), November 11, 2022, N = 10.

17 FGD-1 (Atedeoi village), November 2, 2022.

18 Key informant interview (KII), traditional expert (TE)-2 (shoe reader), November 8, 2022.

(Figure 6b); when one shoe is open and facing up with the other on top it predicts a successful raid (raided animals coming home) (Figure 7a); when one shoe is facing up and another is at a tangent but facing down, it signifies enemies spying around the homestead with the intention of raiding animals (Figure 7b).

Talking Gourd

Upon consultation by members of the community, experts (who are normally women) shake the gourd while talking to the spirits/gods (*Ngikasukou* in Ngakarimojong). Talking gourd experts acquire the status by first becoming possessed/sick. If the individual cannot be treated, the family traces their lineage back to find out if any ancestors had such talents. Then the individual is cleansed and initiated/introduced to the practice of talking to the gourd; and they become well. The expertise/skill is passed down through generations and is unique to a specific family or clan. The gourd experts deal with people with health problems such as infertility, but they can also predict rain, drought, conflicts, and death. It is a preserve for the women because of the nature of the practice such as fetching local brew for the spirits,

Figure 6 Shoe forecast:[19] drought (a) and rain (b)

Figure 7 Raided animals coming home[20] (a) and enemy spying to raid animals (b)

19 KII, TE-2 (shoe reader), November 8, 2022.

20 KII, TE-2 (shoe reader), November 8, 2022.

which men don't want to be associated with. Like shoe reading, consultations of the gourd are accompanied with tobacco, money, local brew, or *Emuna* (in Ngakarimojong, a food mixture of meat, local fruits, fats for the drought periods) to appease the gods to tell the truth. Local brew is sprinkled on the gourd, the seer tastes/sips the brew, and passes it to the helpers, while the seer watches closely. The role of the helpers is to carry the gourd, local brew, and tobacco, and to communicate the predictions to the community. There are normally at least three because of the various roles they need to play. The helpers are usually related to the forefathers, but close friends can also be used as helpers. This is a way of protecting the expertise and keeping the skills with a given clan or family. During the exercise, the expert shakes the gourd and speaks out loudly to the spirits and relays the responses from the gods to the client (Figure 8). *Ngikasukou* provide advice on how to avert the predicted tragedies.[21]

Dreamers (Werkoyon in Pokot)
Dreamers are special people who possess a special gift that runs in a family/clan. They dream about rain, drought, diseases, conflict, and harvest. Good dreamers give solutions that specific elders in a given age category then have the responsibility of passing on to the community. Dreamers specify the type of animal, the particular homestead, where to sacrifice, how exactly to conduct the ritual, which parts to eat, and what to do with the rest of the carcass. When a bad dream comes without a solution, dreamers are forced to flee in fear of consequences; it is a sign that the dreamer is about to die or his family is about to be destroyed.[22]

Reading the Stars
A group of seven stars (*Ngiramatom* in Ngakarimojong), with four forming the head and three making the tail, normally appears to signify the beginning the dry season (Figure 9). They usually appear in October and November at 4 a.m. and move from the east towards the northwest. The stars start to disappear one by one as rain starts and progresses; by April only three can be seen, while in May there are only two left. Finally, they all disappear by June at the peak of rainfall. Readings of stars is a common practice among the pastoralist communities in the eastern Africa (Guye et al., 2022; Radeny et al., 2019; Dejene and Yetebarak, 2022).

Figure 8 Talking gourd[23]

Another group of stars is the *Ngimarakalo* (in Ngakarimojong). They are four in number (in two pairs following a small cloud-like circle (*Akai Amosing* in Ngakarimojong)). They appear and move from the southeast to the southwest. All four stars usually appear from October through June.

Ranking the Sources of Indigenous Weather Predictions
The communities ranked dreamers as the most trusted source of indigenous weather prediction, followed by intestine reading, shoe reading, the big star, birds, position of the sun, tree phonological indicators, cows' behavior, and movement of a group of stars, in that order. In terms of frequency of receiving predictions, intestine readers provided information most frequently, followed by shoe readers and dreamers (Table 10).

21 KII, TE-8 (talking gourd expert), November 9, 2022; FGD-7 (Nadunget village), November 9, 2022.

22 FGD-8 (Achorchor village), November 11, 2022, N = 10.

23 KII, TE-8 (talking gourd expert), November 9, 2022.

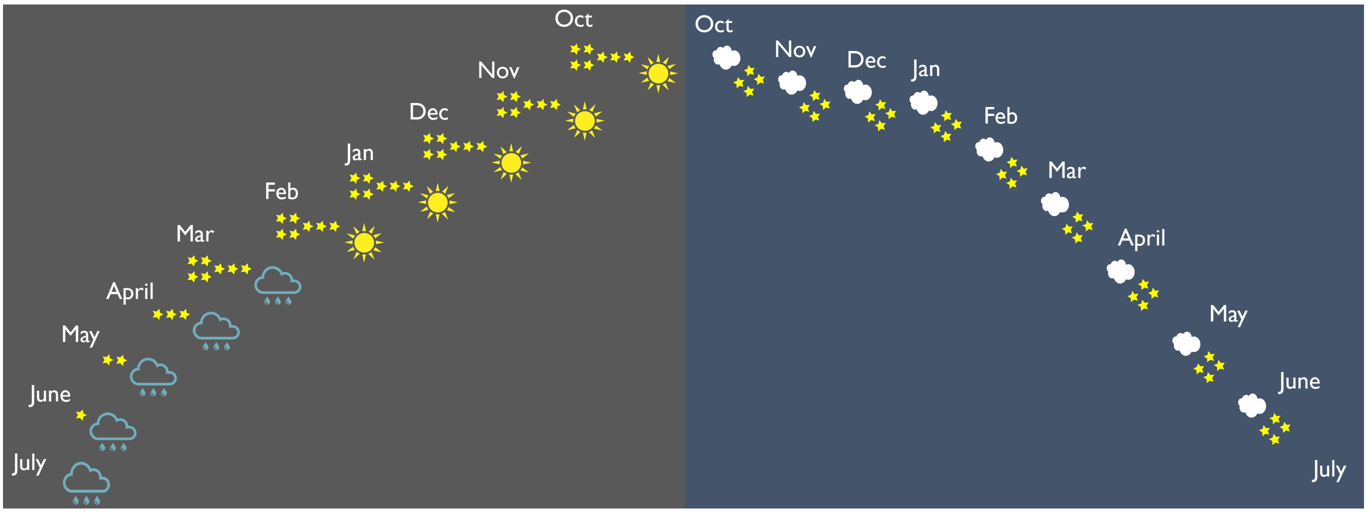

Figure 9 Movement patterns of stars[24]

Note: The group of seven stars on the left (Ngiramatom) signifies the wet (March to September) and dry season (October to February) months. The group of four stars on the right (Ngimarakalo) appear from October to June.

Table 10 Ranking sources of indigenous weather prediction indicators[25]

Trust (ranked in descending order)	Frequency of receiving predictions from sources (ranked in descending order of frequency)
1. Dreamers	1. Reading of intestines
2. Intestine readers	2. Reading of shoes
3. Shoe readers	3. Dreamers
4. Big stars' (*Tapogh* in Pokot) pattern/ movements	
5. *Alele* (a bird)	
6. Sun's (*Asis*) position as it rises	
7. *Acacia reficiens* (*Eregae*) flowering	
8. Cows, when they urinate while lying down	
9. Group of stars (*Sitagh* in Pokot) pattern/movements	

3.3.4 Communities' Responses to Indigenous Weather Forecasts

The various types of community responses to indigenous weather forecasts are presented in Table 11.

3.3.5 Strengths, Opportunities, and Challenges of IEWS

3.3.5.1 Strengths and Opportunities as Perceived by Key Informants

Strengths of IEWS mentioned by KIIs included:

- Indigenous early warning information is easily understood, accepted, and trusted by the communities.
- IEWS is contextualized, because it's location specific, making it have good precision in Karamoja's highly variable climate.
- Collection and verification process of the IEWS is participatory. The communities own the information. They are the managers of the system, and there is trust in the traditional system's capacity. "*Indigenous early warning information is readily available and accessible to*

24 FGD-3 (Nadunget village), November 4, 2022.

25 FGD-10 (Akayot village), November 12, 2022, N = 10.

Table 11 Community responses to indigenous early warning information[26]

Forecast	Community responses to forecast
Predicted rains	Start preparing land for planting
Enough rain	Plant variety of crops
Too much rain	Perform rituals to reduce the rainfall intensity to avoid destruction of crops, pasture, houses, and drowning
Little rain	• Plant variety of crops and see what survives. • Plant beans (*Loter/Lodwe*), green grams, pumpkin, sim sim, short maturing sorghum (Serena/*tinyi tinyi*), short maturing Karamoja maize (multicolored maize) • Farm in the lowlands/wetlands, and see the outcome
Little or no rain	Seek *Emuron's* advice/perform rituals to appease the gods/spirits to release more rain.
Little or no rain	Plan and migrate to seek pasture and water.
Little harvest	Sell livestock to buy cereals/grains.
Strong winds	When observed in the middle of a dry season, it is a sign of a bad year. Households start to reinforce the fences and other structures within the homesteads and start to preserve food.

the entire community, unlike the conventional early warning system whereby, if you do not have data bundles for internet, you cannot access conventional climate information even if it is readily available online; you need at least Ugandan shillings 2,000 to buy bundles, and even the district administrators need internet to access the information."[27]

- IEWS is multihazard. Besides climate indicators, it has indicators and prediction of conflicts/security situations, diseases, and other problems. "*Indigenous early warning experts have been predicting rains and always accurately. How they manage to do it, no one knows. A year before COVID-19 pandemic, they already predicted it and advised communities to slaughter donkeys; they knew about the desert locust invasion too and assured communities to just leave them alone, since they are harmless and will soon go.*"[28]
- Indigenous early warning is normally subjected to verification/triangulation among traditional experts before forecasts and advice are released to the communities. IEWS brings together a multiskilled team that constitutes the verification process: dreamers/spiritual leaders, intestine and shoe readers, talking gourd experts. These individuals play different roles in eventually producing cross-verified information to be communicated to the communities.
- Indigenous advice emphasizes anticipatory action, mainly to avoid the predicted weather condition or misfortune, often in form of a ritual to bring rain or avert a disaster.
- Many indigenous early warning indicators are biological, which provides incentive to conserve plant and animal diversity.
- Indicators from birds normally give lead time of weeks to months. They therefore constitute good warning of pending weather situations.
- IEWS is consistent in its prediction of climatic events and the timing of those events.
- Many indigenous early warning indicators are meteorological; for example, the direction of wind: westerly winds are normally associated with the moist Congo air mass that brings rainfall to the Karamoja, Jie, Matheniko, Pokot areas, while easterly winds indicate dry conditions. It is easy to cross-validate such indicators. Likewise, the plant changes are linked to changes in humidity that influence phenology e.g., flowering, fruiting, and flourishing of new foliage can be cross validated. In addition, as a sign of coming rain, animals can smell from afar the earthy scent of fresh rain (geosmin, which is a chemical compound behind the scent of moistened dry soil), which

26 FGD-6 (Kalopiding village), November 8, 2022; FGD-10 (Akayot village), November 12, 2022, N = 10.

27 KII NGO (NG) (IICD)-6, November 3, 2022.

28 KIIG-9 (Amudat village), November 10, 2022.

brings excitement after a long dry season. Also, the change in sexual activity linked to hormonal influence, among other behaviors of animals in anticipation of rain/moisture and therefore plenty of pasture, can be conventionally proven.
- Traditional weather forecasts are accompanied by advice on how to avert the tragedies as opposed to how to simply mitigate the impacts, as with conventional forecasts.
- Indigenous expertise will not completely disappear because it is passed from one generation to another within certain lineages.

KIIs indicated the following as weaknesses of IEWS:
- Validation of some indigenous indicators may pose a challenge to scientists because they may be difficult to perceive or measure, and therefore there is a need for co-evaluation.
- Some indigenous weather forecasts are long term. They may not have a clear lead time, as is the case with conventional EWS.
- Some indicators are becoming inaccurate due to climate change, changes in plant and animal habitats, and disruption of plant phenology. Some animals and plants are becoming less common and are even disappearing.
- There is limited documentation and limited indigenous knowledge transfer since most of the knowledge is tacit knowledge transferred verbally from one generation to another and experience built through hands-on practice. Indigenous early warning skills are normally held by the elderly. Those who have these skills are becoming rare because the experts die with the information and skills; the younger generation is less interested in the indigenous practices.

KIIs listed the following as challenges faced by IEWS:
- Disappearance of particular wild animals, which are used as weather indicators.
- Formal education does not emphasize indigenous knowledge, and those who have gone to school look down upon traditional knowledge.
- There is a government clampdown on traditional seers for their involvement in providing advice to cattle raiders.
- Religion/Christianity is not always compatible with the indigenous practices. Most who have embraced Christianity are women; this is why the talking gourd, a specialty of women, is no longer in use in certain areas.
- It emerged during the KIIs that in some areas Christianity has a significant influence on indigenous systems, with a portion of the communities disassociating themselves from traditional practices, which they describe as "un-godly." Such was the case in Kalopiding village of Iriir sub-county where respondents indicated that about two-thirds of the community members are born-again Christians (*Mulokole* in Ngakarimojong and *Wakristin* in Pokot) who do not engage in or rely on indigenous practices.[29] This case is an isolated one, as most of the communities, for example in Amudat District, who have embraced Christianity still rely to a large extent on indigenous knowledge and practices to guide important decisions in their lives. "*For example, if the traditional experts identify a bull for rituals, even the Christians volunteer to donate for rituals.*"[30] But Christianity definitely has a significant influence on the cultural practices: "*This year is bad, if it were not for the church, we could have already conducted the rituals by now. These Wakristin tell us to kneel down and pray, yet the Karamojong raid our animals; before we would predict and perform rituals to avert such misfortunes; now we sit back and watch to see if that god of theirs will help.*"[31] The *Mulokoles/Wakristin* believe that Christianity is superior to both science and indigenous systems, and that Christian dreamers and foretellers exist and have replaced the traditional ones (*Ekadwaran*). They have their own vision seers, who can be seen as a continuum of traditional knowledge/skills/gifts, through Christianity and belief in the New Testament.[32] If there is a prediction from the *Emurons*, Christians normally cross-check it with their god. Likewise, traditional experts do not trust Christian predictions, and if predictions come from Christians they will cross-check with their own gods. Some Christians (such as members of the Church of

29 FGD-6 (Kalopiding village), November 8, 2022; FGD-8 (Achorchor village), November 11, 2022.

30 FGD-8 (Achorchor village), November 11, 2022, N = 10.

31 FGD-8 (Achorchor village), November 11, 2022, N = 10.

32 FGD-6 (Kalopiding village), November 8, 2022.

Uganda, the Catholic Church) and Muslims can accept what traditional experts say. For example, the group of elders in the Catholic Church no longer engage in indigenous practices but listen to indigenous forecasts. But *Mulokoles/Wakristins* (e.g., members of PAG, End-Time Message Church, Full Gospel, Agape, AGC, Lutheran, Dini ya Roho) do not accept the traditional experts. It became apparent that Christians and indigenous knowledge and practice believers are ready to work with the government independently but not together with each other. *Mulokoles/Wakristins'* priority is on Christianity; conventional predictions come second. Radeny et al. (2019) in their study among communities in Eastern Africa and Pratt (2002) in a study conducted in northeastern Kenya reported religion as one of the threats to indigenous knowledge and practices.

3.4 CONVENTIONAL EARLY WARNING SYSTEM

3.4.1 Flow of Early Warning Information and Actors in Uganda

Early warning, preparedness, and disaster management are the responsibility of the National Emergency Coordination Centre (NECOC). Climate monitoring is however a mandate of the Uganda National Meteorological Authority (UNMA), which is responsible for the collation of climate data from monitoring stations and modelling to produce the forecasts that NECOC uses, in addition to sectoral information generated at district level by sentinels for disaster risk preparedness and response. Figure 10 presents the existing EWS in Uganda. NECOC works together with the DDMCs in collecting and analyzing early warning information, and in validation and dissemination to communities. Currently, the EWS is largely supported by non-governmental partners such as Mercy Corps, FAO, and WFP, and donors such as United States Agency for International Development (USAID). The USAID-funded Famine Early Warning System Network (FEWS NET) mainly produces food security early warning information through analysis of information from various sources/sectors including agriculture production and market, in addition to climate data.

FAO, through the EU-funded Pro-Resilience Action (Pro-ACT) project, provides institutional capacity building through technical support at NECOC, strengthening the DDMCs and district-level EWS. Pro-ACT works in nine districts in Karamoja and partners with the Office of the Prime Minister, Ministry of Karamoja Affairs, local administrations, UNMA, Ministry of Agriculture, Animal Industry and Fisheries (MAAIF), Ministry of Water and Environment, and Production Departments. FAO has early warning staff based in the nine districts working with the district focal person for Pro-ACT and the DDMC. "*Pro-ACT collects early warning indicators in five sub-counties, particularly on drought as the main hazard, and intends to incorporate multihazard indicators from December 2022.*"[33] Pro-ACT relies on the information generated by the sentinels, parish chiefs (gathered from communities), and sectoral data. In addition to meteorological data from UNMA, the information is analyzed to produce early warning phase classification, which informs the monthly bulletins that contain information on livestock, livelihoods, water, crops, health, and socioeconomics.

3.4.2. Climate Data Collection, Processing, and Dissemination

Climate data are collected using tablets by parish chiefs, staff of MAAIF, Ministry of Water and Environment, and Production Departments, supervised by FAO staff. The data are verified before being relayed by the Pro-ACT focal person or the FAO staff at district level to the central server at the Office of the Prime Minister (OPM). Data collected every month are analyzed in addition to climate information from UNMA and used to calculate Standard Precipitation Index (SPI), which depicts the severity of drought. This information is used to produce a drought early warning bulletin. The report is either presented by focal person/FAO staff or by DDMC members to DDMC for validation. Indigenous weather information is normally not included but its inclusion has been suggested in several workshops.
Mercy Corps and Save the Children, through the USAID-funded Food for Peace Activity (Apolou) project, are working with both NECOC and UNMA to integrate indigenous early warning information in the forecasts at district level. The IGAD-funded DRESS-EA project provides technical support. The project aims to strengthen regional early warning systems in Uganda. The implementation is led by UNMA in partnership with the Ministry of Water and Environment. The EWS has a District-Specific Forecast Platform that

33 KIING-2 (FAO), November 2, 2022.

produces forecasts in March (for March to May); June (for June and July), and September (for September to December). DRESS-EA addresses EWS infrastructure, e.g., improving the distribution and functionality of the climate monitoring stations, and dissemination of early warning information in Karamoja.

UNMA's forecast is however the main source of climate hazard information and uses climate data to generate: 6-hourly (6 a.m.–noon), daily, 5-day, 10-day, monthly, and seasonal climate information that is readily available online; otherwise, radio was reported to be the main channel of dissemination to the communities. Other dissemination methods include: village meetings; district platforms; agro-dealers; extension agents (through resilience action teams); and One Health Units.[34] The main type of climate information in the forecasts is rainfall onset and cessation, drought, and floods. The forecasts are normally accompanied with advice. "*To guide improvement of climate monitoring infrastructure and efficiency of the EWS, a study has already been conducted by UNMA to determine the status of existing weather stations; perceptions of farmers/pastoralists on the conventional climate information and challenges; and documentation of indigenous knowledge and how it can be integrated with conventional climate forecast.*"[35]

3.4.3 Community Views on the Conventional EWS

There are mixed communities' views on the weather forecasts from the government, but most treat the information with contempt. They however indicated that they respond to government advice by planting at the right time (if delayed rains are expected) and the right type of crop (if insufficient rain is predicted), preparing for migration to track pasture in case of extended dry season or drought, and planning grazing management if plenty of rain is expected (Table 12). Similar types of climate information from the government have been reported among the Boran of southern Ethiopia; Hoima of southwest Uganda; Rakai of southeastern Uganda; and the Lushoto community of northeastern Uganda (Radeny et al., 2019). Whereas both the government and NGO staff considered conventional forecasts to be more reliable than indigenous weather forecasts, they too are in concurrence with communities in acknowledging the inaccuracy of conventional forecasts, which is mostly attributed to poor downscaling and distribution of weather monitoring stations. Discussions with the communities revealed the reason for their mistrust of government forecasts: "*The government sometimes gives false information; some time back they announced over the radio that we shall only receive two and not six jerricans of rainfall (there will be depressed rainfall), and therefore we should not plant, but because we do not trust their forecasts, I went ahead and planted and ended up harvesting three granaries of sorghum from my farm. However, sometimes when they say it will rain, predictions come true for some areas and not others. For example, we once received information from the government that there will be rain in the months of April and May so we should prepare land for planting, and it indeed rained but only here but not elsewhere.*"[36] The usefulness of conventional forecasting was also confirmed by NGOs working in Karamoja: "*In September they predicted early onset of rains in Nakapiripirit, which helped the communities to prepare to accommodate Pokot pastoralists from Kenya. An advance team was sent to negotiate for access to pasture ahead of the herds' arrival. Host communities provide space for kraal and make plans for sharing of grazing resources, and, if this is enhanced through deliberate efforts, it helps maintain peace.*"[37] The message from communities and other actors in Karamoja is that climate information/weather forecasts are not useful when they are not accurate and when not accompanied by support from the government, e.g., relief food in case of drought, or mitigation plans and action. The communities even alluded to poor climate monitoring infrastructure as the probable cause of the reported inaccuracies: "*It may be that the government machines (weather stations) are not capable of telling whether it will rain or not, because when they predict rain, it only occurs in some places and not others….This could be the reason why they are now coming back to us [referring to UNMA's recent interest in indigenous early warning system].*"[38]

It was reported that there other uncertainties that make it difficult for communities to reduce disaster risk,

34 These comprise a multisectoral/multidisciplinary team including nurses, vets, nutritionists. Activities include vaccination, screening for malnutrition, COVID-19 vaccination, and sharing of other relevant information.

35 KII Government (G)-10 (UNMA), November 15, 2022.

36 FGD-1 (Atedeoi village), November 1, 2022.

37 KIING-10 (ACTED), November 10, 2022.

38 FGD-1 (Atedeoi village), November 1, 2022.

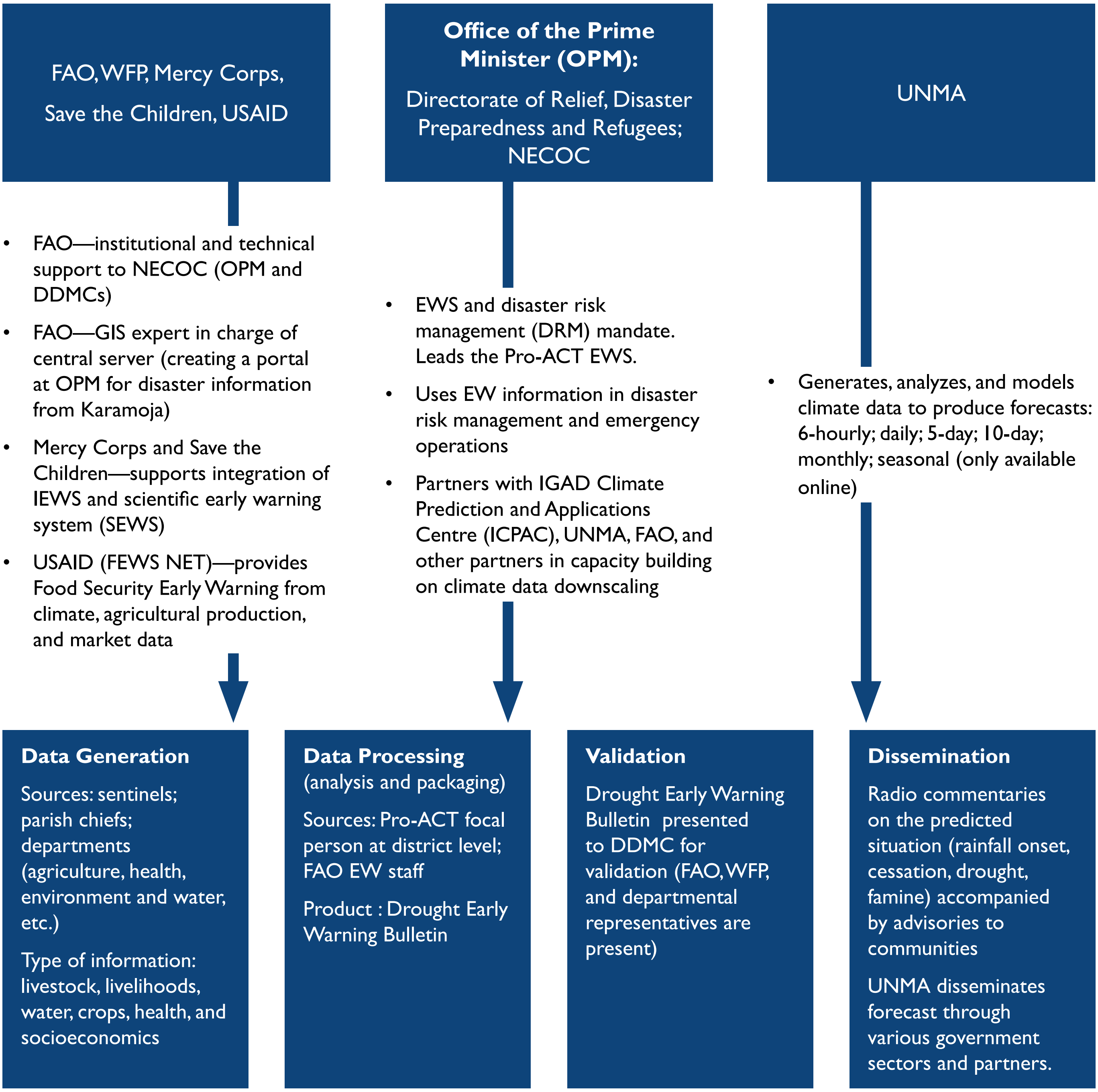

Figure 10 Climate information flow chart[39]

besides rain failure: "*Some crops recommended by the government do not grow well in Karamoja, and even if they grow, rain failure, crop diseases, and pests are a big challenge. A while back, I was arrested over insecurity and while in Kampala (prison) we grew tomatoes, onions, brinjals [eggplant], and so when I was released I tried to grow them here; the first time the rains failed and when I tried again the African armyworms cleared all the crop. I thought I would now settle and cease to engage in cattle raiding, but this did not work.*"[40]

39 KIING-2 (FAO), November 2, 2022.

40 FGD-3 (Nadunget village), November 4, 2022.

Table 12 Formal climate forecasts and associated advice, and actions by communities[41]

Type of climate information	Advice	Actions	Dissemination channel
1. Onset of rainfall	Plant early in anticipation of the rains	• Land preparation for planting • Elders meeting to plan grazing pattern	• Radio • Government and NGO agents • Village meetings • District platforms, agro-dealers • Extension agents and through resilience action teams • One Health Units
2. Cessation of rainfall		• Plant early-maturing crops • Dry planting (sowing early to maximize on the short duration of rain)	
3. Amount of rain	Plant short-maturing crops if there will be little rain	• Splitting herds into two (home-based and away herds) in a good year • Dry planting (sowing early to maximize on limited moisture when it rains)	
4. Drought	Do not plant or plant short-maturing crop varieties	• Planning for migration: in a bad year, all animals remain in mobile camps • Organizing for herding labor • Negotiating for grazing access with neighboring communities (done by communities and government)	
5. Floods (flash floods)	Avoid areas prone to flooding	• Relocation and avoidance of dry riverbeds/waterways	
6. Hunger	Avoid food wastage	• Food preservation	

3.4.4 Strengths, Opportunities, and Challenges of Conventional EWS

3.4.4.1 Strengths and Opportunities

UNMA already has linkages with the communities (via their traditional seers[42]) through the district-level forecast platforms. Some communities are already using the government advice, e.g., on when and what crops to plant, as well as when to harvest sorghum following weather bulletins. In addition, partners such as Catholic Relief Services (CRS) and DRESS-EA are keen on building on the initiative by Mercy Corps that entails working with both NECOC and UNMA in an attempt to integrate indigenous early

41 FGD-3 (Nadunget village), November 4, 2022, N = 14; FGD-5 (Lolemyek village), November 7, 2022, N = 16; FGD-4 (Loutakou village), November 5, 2022, N = 13; FGD-10 (Akayot village), November 12, 2022, N = 10; FGD-1 (Atedeoi village), November 1, 2022, N = 14; FGD-2 (Kachakatom village); November 2, 2022, N = 12; FGD-5 (Kalopiding village), December 2, 2022, N = 13.

42 The true traditional seers cannot easily be accessed directly. They are accessed through their messengers. They are not called by their true names but using coded names such as *Ikoku* (child), *Enyait* (grass), *Itwaan* (person).

warning information in the forecasts at district level. In addition, FAO, through the Pro-ACT project, is focusing on EWS institutional capacity building at both national and district level through the focal persons in Production Departments, and working towards producing multi-hazard EWS and providing the possibility for an entry point for integration of the multi-hazard indigenous EWS.

3.4.4.2 Weaknesses and Challenges

Districts lack a policy framework to guide local government in early warning and disaster risk management. Early action is still a challenge as the responses from government and partners are often not timely. There is a weak linkage between NECOC and DDMC because the EWS is donor/partner-driven, and there is no local NECOC office to closely engage on early warning at the district level. Both UNMA and NECOC are centralized, with limited coordination between them. This centralization makes it difficult to disburse contingency funds to district level to facilitate quick response. Forecasts from UNMA are often inaccurate due to poor distribution of climate monitoring stations. "*Only weather stations at Kotido and Napak were functional, and Apolou project has rehabilitated five stations to improve accuracy*."[43] "*There is little trust in conventional weather/disaster forecast. For example, in June/July 2022, UNMA predicted floods in Mbale District but because of lack of trust and previous incorrect forecasts, the communities did not take action based on the government advisory, and many people lost their lives and property when floods actually occurred*."[44] The inaccuracy in forecasts was reported to arise from the zoning of districts with highly variable climates into one zone and poor infrastructure of the weather stations. Sustainability of the aid-funded EWS initiatives is a concern in the absence of resource allocation from the government when partner-funded projects end. It not clear whether the recently developed District Contingency Plans (CPs), supported by WFP, will receive funding for implementation.

3.4.5 Suggestions for Strengthening the Existing Conventional Early Warning System

- There is dire need for improvement of climate monitoring infrastructure to enhance accuracy and ensure location-specific actionable early warning information. Improvement of the infrastructure requires capacity building in climate collection, modelling, and downscaling to make forecasts relevant to local contexts.
- Advice should be provided in languages that communities speak and in ways that communities can relate to, e.g., pictorial presentation is key for improving action-based forecasting.
- Further downscaling of climate data to village level is necessary to ensure the forecasts are relevant to the local contexts. However, the challenges are the clustering of the forecasts into smaller resolutions and the poor distribution of the weather monitoring stations.
- Programming of pastoral projects should incorporate crisis modifiers for handling emergencies when they occur; timely use of crisis modifiers depends in part on adequate early warning.
- There is a need to consider anticipatory action components to accompany the advice arising from a multi-hazard EWS. For example, anticipation of disease outbreak to enable early action and weekly DDMC meetings is necessary to help address livestock disease surveillance, and vaccination of livestock against foot and mouth disease (FMD) and contagious bovine pleuropneumonia (CBPP) in the disease hotspots.
- Agro-pastoralist field schools can be used to engage communities in participatory identification and priority interventions, e.g., training of pastoralists in strategic deworming of livestock, for example in October just after the heavy infestations that are expected during the rains.
- It is necessary to mobilize funds at national level to support disaster risk management (DRM) at district levels, as well as to support advocacy, which should be accompanied by scaling-up of best practices.

3.5 INTEGRATION OF FORMAL AND INDIGENOUS EARLY WARNING SYSTEMS

3.5.1 The Rationale for Integration

Integration of indigenous and formal early warning systems seems to be the logical option since pastoral and agro-pastoral systems rely on indigenous technical

43 KIING-1 (MC), November 1, 2022.

44 KIING-1 (MC), November 1, 2022.

knowledge, practices, and beliefs (ecological, cultural, and spiritual) to guide decisions concerning resource use and management, as well as responses to shocks.

The role of the indigenous knowledge system is acknowledged by NGO staff in Karamoja: "*We recognize and appreciate indigenous knowledge because it is such knowledge and practices that have kept the community going. Various departments now encourage use of indigenous knowledge, for example in the use of traditional health information and use of traditional plant medicine in treatment of various ailments. The latest one being the ongoing research on use of Warbughia ugandensis in the treatment of COVID-19.*"[45] There is concurrence among government experts, NGO staff, and communities on the potential of the indigenous early warning system: "*If conventional data relies on historical data to model and predict the future, then IEWS can as well work effectively given that it is a tried-and-tested system that combines historical experiences and real-time observations, which communities have been relying on from time immemorial.*"[46]

IEWS and formal EWS coexist, but in parallel; both are used by communities, as also reported by Pratt (2002) in northeastern Kenya. As observed by Zinyeka et al. (2016), there are overlapping perspectives, with both shared and unique tenets between science and indigenous knowledge. At present there seem to be tensions and confusions in interpretation and application of the early warning information generated by the two systems, as well as a need for more acceptable, reliable, and effective forecasts. The integration of formal indigenous early warning was supported by Dejene and Yetebarak (2022) in their study among the Gabra of southern Ethiopia; Okonya and Kroschel (2013) in their study on indigenous knowledge of seasonal weather forecasting in selected regions of Uganda; Ochieng' (2018) in a study conducted in Baringo County of Kenya; as well as in the UNESCO (2012) summary of IPCC Fifth Assessment Report for Policymakers.

The IEWS and CEWS have both unique characteristics and shared features. Some of the unique characteristics of IEWS are: use of multi-hazard indicators (meteorological, biological, astrological, animistic indicators); continuous, localized, areal time monitoring of weather indicators; multistage corroboration of predictions to produce validated forecasts; participatory and consultative process; short lead time for warning; sociocultural and spiritual interconnection and interdependence of weather and climate prediction; basis in tacit knowledge and inherited skills/expertise. The conventional early warning system, on the other hand mainly uses meteorological data that are gathered both locally and remotely; relies on modelling of historical data for verification and forecasting; produces forecasts at specified times; has a longer lead time; uses technical skills learned through formal learning; and is divorced from an epistemic framework in the search for universal validity. The two systems however have common features that include: use of meteorological indicators; combination of current and historical information in forecasting; and both seek to inform critical decisions on use, management of resources, and strategies to evade or mitigate against impacts of shocks (Figure 11).

3.5.2 Framework for Integrating IEWS and CEWS

The Sendai Framework for Disaster Risk Reduction 2015–2030 indicates that it is important "to ensure the use of traditional, indigenous and local knowledge and practices, as appropriate, to complement scientific knowledge" (UNDRR, 2015). The framework mainly provides guidelines at the high level, but with no tangible direction on how exactly to integrate indigenous knowledge. Different process frameworks have been proposed to achieve the goal of incorporating IEWS with CEWS. For example, Chand et al. (2014), in a case based on disaster response practices, suggests a four-step participatory rural appraisal framework: identify priority communities; develop an infrastructure for collection; conduct recording and monitoring; integrate indigenous and scientific forecasts; and disseminate consensus forecasts. In another case, Kniveton et al. (2015) suggests two innovative approaches: knowledge timeline, which compares indigenous knowledge and conventional weather information; and participatory downscaling, which translates national and regional weather information to enable local-level action. These approaches, as noted by Liang (2017), appear rather theoretical and hardly address other critical integration details. It has also been noted that attempts to integrate indigenous and conventional knowledge systems face the diverse needs and priorities that characterize

45 KIIG-1 (CAO), November 2, 2022.

46 KIIG (PD)-3 (PD–Pro-ACT), November 3, 2022; KIIG-4 (DDMC), November 8, 2022.

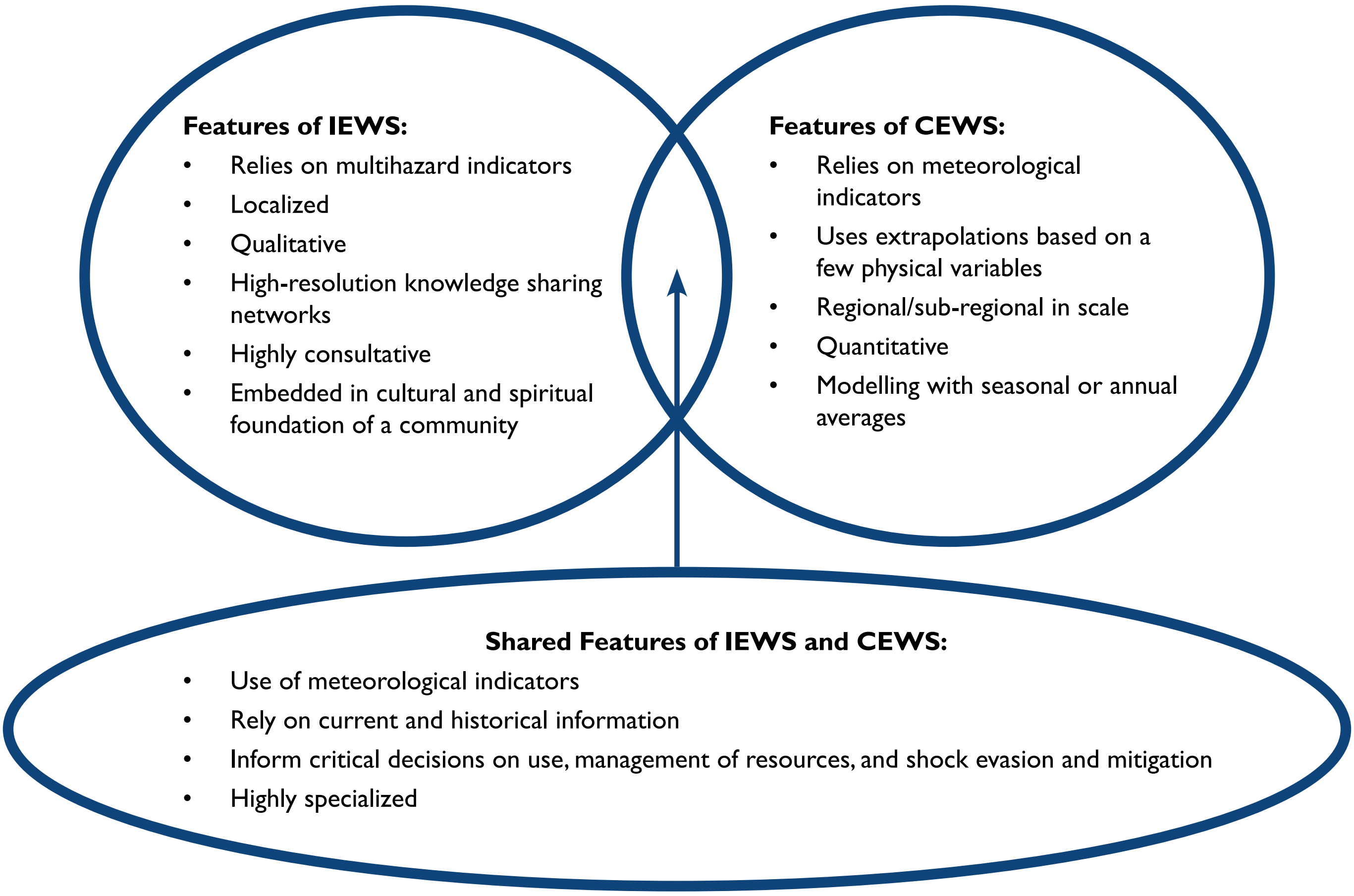

Figure 11 Unique and shared features of the conventional early warning system and indigenous early warning system

participatory approaches (Thomalla and Larsen, 2010). Therefore, while a framework may be key in guiding integration of the two systems, the processes have to be contextualized to suit various institutional, sociocultural, and political situations. Figure 12 presents a generalized framework based on the current assessment. The steps in the framework are detailed below.

Step 1: Generating evidence
A meaningful integration process requires concrete evidence on the nature, practice, and role of IEWS among communities. This process calls for community engagement and detailed studies to investigate and document indigenous early warning information and practice, and the value of that information.

Step 2: Sensitization of decisions makers
Equipped with advocacy tools generated from the evidence of studies, sensitization and awareness creation among the relevant government organs, decision makers, and development agencies on the role of IEWS are critical.

Step 3: Institutional and policy framework
Buy-in and good will from the government and other stakeholders set the stage for development of institutional and policy frameworks for mainstreaming of IEWS (at national and local levels). Doing so involves modification of existing institutions or creation of new ones, and identification of community actors (traditional experts) and institutions.

Step 4: Resource mobilization
Supportive policy and an institutional framework provide the basis for technical support and resource allocation to implement mainstreaming activities.

Step 5: Implementation strategies and guidelines
There needs to be development of strategies and guidelines for integration of the two systems. This requires development of the modalities of integration informed by the identified common climate prediction indicators between IEWS and CEWS, and iterative evaluation to guide the composition of the hybrid early warning system. Structures should be developed for community engagement and co-generation, co-processing, and joint dissemination of climate forecasts.

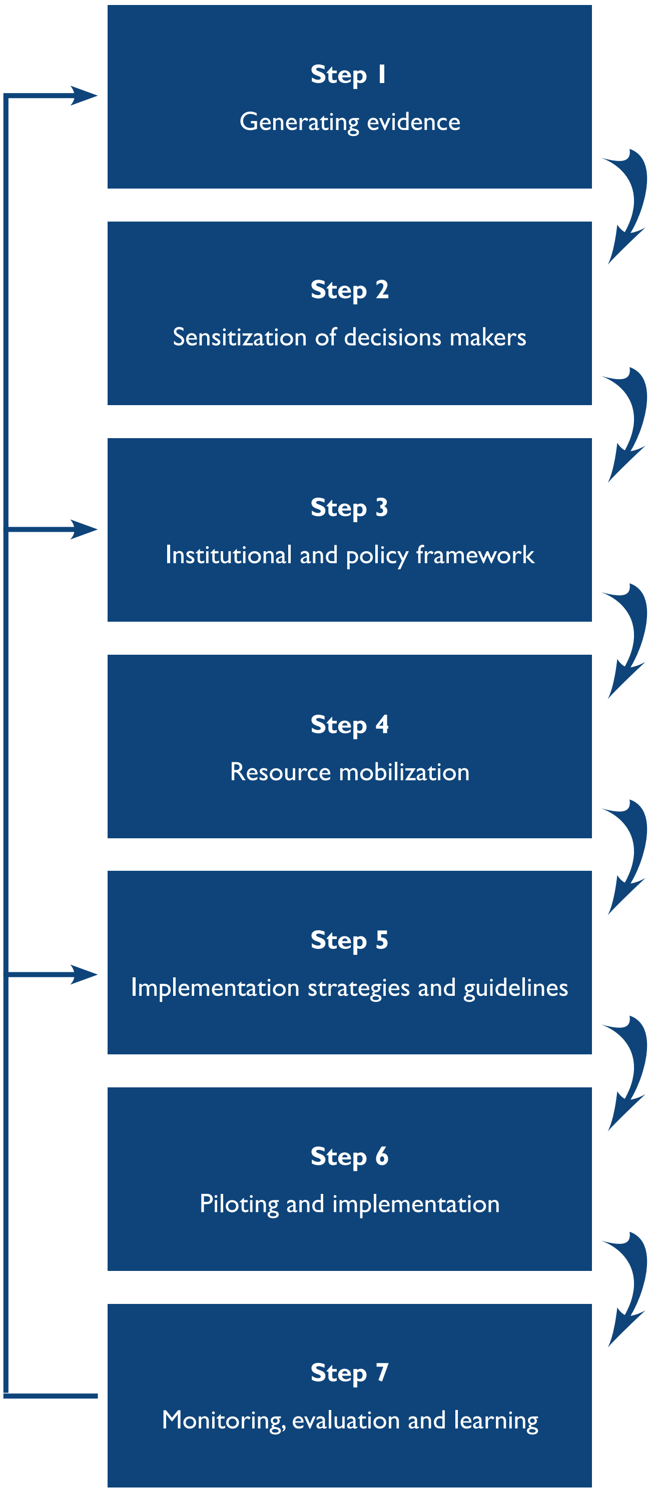

Figure 12 Proposed framework for integration of IEWS and CEWS

Step 6: Piloting and implementation
Piloting of the developed hybrid system, review, and implementation are necessary.

Step 7: Monitoring, evaluation, and learning
Participatory monitoring, evaluation, and a learning system will allow tracking of performance and incorporation of learning to improve efficiency.

3.5.3 Opportunities for Integration of the Two Systems

- As reported by Mercy Corps: "*A journey for a better functioning weather information system for pastoralism for Karamoja has been developed and, together with the efforts to integrate the two systems, provides a basis for further collaboration with the government on the integration process.*" "*We normally organize a validation exercise before the season begins, where UNMA invites the traditional seers of the communities and together produce a joint forecast. Elders and UNMA make announcements over radio in a joint documentary.*"[47]
- UNMA has already conducted a study on indigenous indicators to identify common weather indicators for both modern and traditional weather prediction. Some of the common indicators include winds, clouds, plants, and birds. These will be harmonized based on areas of convergence to improve modelling.[48]
- The existence of the National Policy for Disaster Preparedness and Management, as well as the Directorate of Relief, Disaster Preparedness and Refugees under the Office of the Prime Minister, and existing district platforms and DDMC, provide an institutional platform for further decentralization of EWS.
- The observed interest from the government and traditional seers (increasing demand for consultation with relevant government agencies by community representatives) is critical for integration of the two systems. As expressed by communities, "*We want the tree to be one*" (*Ekitoe toruwor epei*, in Ngakarimojong).[49]

47 KIING-4 (MC), November 3, 2022.

48 KIING-1 (MC), November 1, 2022.

49 FGD-2 (Kachakatom village), November 4, 2022.

3.5.4 Challenges in Integration

- At present there seems to be no realistic integration of the indigenous and formal early warning systems in Karamoja: "*There is no integration because the experts involved in the two systems are different. The government officers understand nothing about the traditional weather forecast. The advice from the two systems differs—whereas the government would advise us, for example, to plant certain crops in view of pending little rains, our traditional seers prescribe rituals to bring the rains.*"[50]
- There are no structures for the integration of the two systems, and MCFs tend to overshadow the traditional practices: "*Indigenous knowledge and practices need to be integrated but the question is at what level. NECOC level? EW level? Community level?*"[51]
- There is no clear policy and institutional framework for mainstreaming the IEWS. It is not clear how districts in Karamoja can deal with disasters because disaster policy is a national mandate of OPM, with no budgetary allocation to the districts. With no budget for early warning and DRM at district level, the district contingency plans are rarely implemented in a timely manner, since acquisition of funds from the national government is a lengthy process. This lengthy process renders early warning information ineffective: "*Recently, the contingency funds (which is 3% of national budget) were only activated during COVID-19, recent floods in Mbarara, and desert locust invasion.*"[52]
- Currently, the two systems operate independently: "*The two systems are like two separate meeting trees, and unless integrated do not add much value.*"[53] "*The* Emuron *and the government are two separate entities, each believe in their own capabilities, and the* Emuron *does not know what the government does, and government does not understand the ways of* Emuron."[54]
- Inaccuracies and weaknesses are common in both systems, and neither can accurately predict spatial variability in rainfall: "*How can you combine inaccuracies?*"[55] "*While scientists may predict rain or drought and it never occurs, our traditional seers may also predict a good year and it never rains; this is why the indigenous early warning information is normally corroborated amongst various traditional experts before a forecast and an advisory is released to the community.*"[56]
- While communities believe that traditional rituals are the most effective for evading disasters, they also act on advice from the formal EWS, even if they are not sure about the quality of this advice.
- Currently, international NGOs and UN agencies seem to be fully in charge of the EWS in Uganda, with government playing a rather passive role. It is therefore unclear how the existing initiatives will be sustained.

50 FGD-3 (Nadunget village), November 4, 2022.

51 KIIG-1 (CAO), November 2, 2022.

52 KIING-5 (Ministry of Water and Environment (MWE)), November 3, 2022.

53 FGD-3 (Nadunget village), November 4, 2022.

54 FGD-5 (Lolemyek village), November 7, 2022.

55 FGD-5 (Lolemyek village), November 7, 2022.

56 FGD-3 (Nadunget village), November 4, 2022.

4. CONCLUSIONS AND RECOMMENDATIONS

Several conclusions and recommendations arise from this study with respect to the weaknesses and strengths of the two systems to inform entry points for their meaningful integration.

- Currently, the processes aimed at integration of the indigenous and formal EWS seem to seek validation and acceptance of the conventional climate forecasts by communities rather than involving them in co-generation.
- The findings of this assessment call for a better understanding of the accuracy of both conventional and indigenous weather prediction indicators to identify the common, most accurate, and compatible indicators for integration. There is need to identify and fully involve the parliament of elders (*Akiriket* in Ngakarimojong) to support the process of integration of the two systems.
- An in-depth analysis and a further contextualized documentation of the location-specific weather prediction indicators are necessary given the inherent variability between communities and locations. There should be monitoring to know whether the indigenous early warning practices do exist, and whether they are still in use, as well as whether they still work and are likely to work in the future to help the integration process.
- The communities proposed the need for piloting the indigenous and conventional weather indicators side by side for a couple of seasons, to monitor them and see their accuracy, divergences, and convergences in order to appropriately guide the integration process.
- Strengthening the existing district disaster risk management institutional framework and decentralizing the disaster risk management committees further to village level are vital in facilitating integration of IEWS and practice with the formal early warning system.
- There is need to improve the climate monitoring infrastructure (distribution of weather stations) and capacity of meteorological personnel in data generation, modelling, and downscaling to provide location-relevant information to enable integration with traditional early warning information.
- Strengthening of coordination between NECOC and partners involved in generation of drought bulletins is critical for the integration of the two systems. This coordination should focus on strengthening capacity of the sentinels and strengthening village disaster risk management committees.
- Integration of the two systems should focus on co-generation of early warning information, and joint verification involving the community elders/experts and government experts before dissemination of forecasts and advisories. Focus should be on parallel presentation of the two forecasts, piloting the accuracy, and harmonizing the common indicators rather than just seeking community's acceptance and validation of conventional forecasts.
- An effective EWS should not only focus on efficient generation, analysis, and dissemination of timely and accurate information, but also on actionable and user-/sector-specific warning to communities, accompanied with support and anticipatory action rather than emergency response.
- Integration of the two systems require creation of urgency among stakeholders, preceded by further awareness creation about the role of indigenous weather forecasting and practice among government and non-government agencies.
- NGO programming should address the policy and institutional framework to ensure an enabling environment and provide a basis for sustainability and mainstreaming of the indigenous early warning system.
- Without peace and security, meaningful interventions on early warning and disaster response, including the associated advisories, will be challenging. Peace and security are also critical in integration of the two systems.

REFERENCES

Aklilu, Y., E. Okori, and R. L. Arasio. 2021. Drought Risk Management in Karamoja: A Review of Functionality and Capacity. A Report for the Karamoja Development Partners Group. Karamoja Resilience Support Unit, Feinstein International Center, Friedman School of Nutrition Science and Policy, Tufts University, Kampala. **https://karamojaresilience.org/wp-content/uploads/2021/09/TUFTS_2143_KRSU_Drought_Capacity_V2_online.pdf**

Ayal, D. S., G. Gebru, J. Kinyangi, J. Recha, and M. Radeny. 2015. Opportunities and Challenges of Indigenous Biotic Weather Forecasting among the Borena Herders of Southern Ethiopia. SpringerPlus 4 (1): 617.

Alemayehu Dejene, Hizekeal Yetebarek. 2022. The Relevance and Practices of Indigenous Weather Forecasting Knowledge among the Gabra Pastoralists of Southern Ethiopia. Journal of Agriculture and Environment for International Development 116(1): 59-76.

Chand, S. S., Chambers, L. E., Waiwai, M., Malsale, P. and Thompson, E. 2014. Indigenous knowledge for environmental prediction in the Pacific Island countries. Weather, Climate, and Society 6(4): 445-450.

Egeru, A., O. Wasonga, J. Mburu, E. Yazan, M. G. Majaliwa, L. MacOpiyo, and Y. Bamutaze. 2015. Drivers of Forage Availability: An Integration of Remote Sensing and Traditional Ecological Knowledge in Karamoja Sub-Region, Uganda. Pastoralism 5:1. **https://doi.org/10.1186/s13570-015-0037-6**

Guye, M., Legesse, A. and Mohammed, Y. 2022. Indigenous weather forecasting among Gujii pastoralists in southern Ethiopia: Towards monitoring drought. Pastoralism 12: 43. **https://doi.org/10.1186/s13570-022-00258-0**

Kniveton, D., Visman, E., Tall, A., Diop, M., Ewbank, R., Njoroge, E., and Pearson, L. 2015. Dealing with uncertainty: integrating local and scientific knowledge of the climate and weather. Disasters, 39 Suppl 1(s1), S35–S53. **http://doi.org/10.1111/disa.12108**

Liang, S. 2017. Incorporating Indigenous Knowledge in the Local Government's Early Warning System: A Case Study from Baringo County, Kenya. MSc. thesis, Lund University, Sweden.

Lwasa, Sh., B. Ambrose, and N. Benon. 2017. Weather Forecasts for Pastoralism in a Changing Climate: Navigating the Data Space in North Eastern Uganda. Data Science Journal 16:50. **https://doi.org/10.5334/dsj-2017-050**

Maxwell, D., and P. Hailey. 2020. Towards Anticipatory Information Systems and Action: Notes on Early Warning and Early Action in East Africa. Feinstein International Center, Friedman School of Nutrition Science and Policy, Tufts University, Boston and Centre for Humanitarian Change, Nairobi.

Maxwell, D., and N. Majid. 2016. Famine in Somalia: Competing Imperatives, Collective Failures. 2011–2012. London and New York: Hurst Publishers/Oxford University Press.

Muriithi, G. M., D. O. Olago, G. O. Ouma, and S. O. Oriaso. 2018. Reliability of Indigenous Traditional Knowledge and Conventional Weather Forecasts in the Face of Climate Change and Variability in Baringo County, Kenya. International Journal of Recent Scientific Research 9 (7(F)): 28136–28141. DOI: **http://dx.doi.org/10.24327/ijrsr.2018.0907.2401**

Ochieng' R. 2018. Use of Seasonal Climate Forecast and Drought Effects on Livestock Assets in Baringo County, Kenya. PhD Thesis, Egerton University, Kenya. **https://www.r-library.egerton.ac.ke**

Ochieng', R., C. Recha, and B. O. Bebe. 2021. Living with Climate Change in ASALs: Integrating Scientific Forecasts with Indigenous Knowledge. In: Handbook of Climate Change Management, eds. Leal Filho et al. Springer Nature Switzerland. DOI: 10.1007/978-3-030-22759-3_240-1.

Okonya, J. S., and J. Kroschel. 2013. Indigenous Knowledge of Seasonal Weather Forecasting: A Case Study in Six Regions of Uganda. Agricultural Sciences 4 (12): 641–648. **http://dx.doi.org/10.4236/as.2013.412086**

Pratt, C. 2002. Traditional Early Warning Systems and Coping Strategies for Drought among Pastoralist Communities, Northeastern Province, Kenya. Working Paper No. 8., Feinstein International Famine Center, Medford

Radeny, M., A. Desalegn, and D. Mubiru. 2019. Indigenous Knowledge for Seasonal Weather and Climate Forecasting across East Africa. Climatic Change 156: 509–526. **https://doi.org/10.1007/s10584-019-02476-9**

Thomalla, F., and Larsen, R. K. 2010. Resilience in the context of tsunami early warning systems and community disaster preparedness in the Indian Ocean Region. Environmental Hazards 9(3): 249-265.

UNESCO. 2012. Weathering Uncertainty: Traditional Knowledge for Climate Change Assessment and Adaptation. IPCC Fifth Assessment Report Summary for Policymakers. Review by UNESCO-LINKS and UNU for Authors of the IPCC 5AR

United Nations Office for Disaster Risk Reduction (UNDRR). 2015. Proposed Updated Terminology on Disaster Risk Reduction: A Technical Review Facilitated by the United Nations Office for Disaster Risk Reduction. **https://www.undrr.org/terminology/early-warning-system**

United Nations Office for Disaster Risk Reduction (UNDRR). 2015. Chart of the Sendai Framework for Disaster Risk Reduction.

Zinyeka, G., G. O. M. Onwu, and M. Braun. 2016. A Truth-Based Epistemological Framework for Supporting Teachers in Integrating Indigenous Knowledge into Science Teaching. African Journal of Research in Mathematics, Science and Technology Education 20(3): 256–266.

APPENDIX I: SAMPLE FRAME

District	Livelihood	Key informant interviews (Government and NGOs)	Number	Focus group discussions	Number	Traditional experts (Traditional seers)	Number
Moroto	Pastoral	1. Chief Administrative Officer (CAO) 2. Mercy Corps 3. FAO 4. Ministry of Water and Environment (DRESS-EA project) 5. Production Department (Pro-ACT project, focal person) 6. Karamoja Youth Effort to Save Environment (KAYESE) 7. Institute for International Cooperation & Development 8. WFP, Pro-ACT Project	1 1 1 2 1 2 1 2	1. Atedeoi village, Lotisan sub-county 2. Kachakatom village, Nadunget sub-county	14 (9M; 3MY; 2 F) 12 (8M; 4F)	1. Intestine reader 2. Shoe reader	2 2
Napak	Agro-pastoral	1. Chairman DDMC, Acting Deputy CAO 2. County Administrative Officer	1 1	1. Loutakou village, Lopeei sub-county 2. Lolemyek village, Lokopo sub-county 3. Kalopiding village, Iriir sub-county	13 (7M; 6F) 16 (9M (3 MY); 4F) 13 (3M (2MY); 7F (1FY)	1. Shoe reader 2. Talking gourd expert	1 2

Amudat	Agro-pastoral	1. Principal Assistant Secretary 2. FAO focal person	1 1	1. Lwakei village, Achorchor sub-county 2. Chematong village, Amudat sub-county 3. Akayot village, Katabok sub-county	10 (7M; (1MY); 2F) 7 (2M; 3F (2FY) 10 (6M (1MY); 3F	
*Nakapiripirit (visited specifically to meet ACTED staff)	Agro-pastoral	1. ACTED	1			
Kampala	Data officer	2. UNMA	1	-	1 M	
Total	119		17		95	7