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RESEARCH

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Indigenous weather forecasting among Gujii pastoralists in southern Ethiopia: Towards monitoring drought

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Abstract

Indigenous weather forecasting (IWF) is practised by various communities around the world. Access to meteorological weather forecasting is limited in eastern Africa's pastoral regions. As a result, pastoralists frequently rely on indigenous weather forecasting indicators. This paper investigates the use of IWF in drought forecasting among Gujii pastoralists in southern Ethiopia. To collect data, household surveys, focus group discussions, and key informant interviews were used. Furthermore, meteorological data were used to determine the frequency of drought events in the area. A comparison was made between IWF and data from the Ethiopian National Metrological Service Agency to ensure consistency of the results of IWF and climatic data. For quantitative data analysis, descriptive statistics was used, while hermeneutic and narrative analyses were used for qualitative data analysis. Pastoralists have used a variety of weather forecasting indicators, such as reading livestock intestines, observing animal and insect behaviours, and interpreting the star and moon alignment. Both the indigenous drought event forecasting result and the drought history result from the meteorological agency indicate the presence of drought in the area. However, several internal and external factors are contributing to IWF's gradual decline. Religious teachings, technology, and education were identified as external factors, while the growing generation gap was identified as an internal factor. Thus, to increase the accuracy of forecasting of weather events and improve pastoralist's prediction capacity, the integration of this knowledge is highly appreciated.

Keywords: Ayyaantuu, Forecasting, Indigenous knowledge, Uuchuu

Introduction

Pastoralists are among those who are most vulnerable to drought. Drought events will increase by more than 20% in most of the world by 2080, with the number of people affected by droughts rising by 9–17% in 2030 and 50–90% in 2080 (Kebede et al. 2012). Several pieces of evidence indicate that Africa has warmed in recent decades, which is coherent with anthropogenic climate change and has a significant impact on climate-sensitive sectors (UNICEF 2012; Balehegn et al. 2019). Drought, unlike other climatic hazards, has a slow onset and a long duration, making effective prediction difficult (Blauhut et al. 2016). In pastoral areas where access to technology is limited and the use of scientific weather prediction is unlikely, taking early action to reduce the risk is seemingly challenging.

Climate change is likely to increase the frequency of extreme events such as droughts and floods, contributing to livestock death and crop production decline (Randall 2015). However, there were significant disparities in the availability of timely, accurate, and user-friendly climate forecast information to farmers and pastoralists (Radeny et al. 2019). Furthermore, scientific weather forecasts are not accessible or usable by pastoralists, making them less effective at the district level (Adu et al. 2018). Unlike urban residents, who can obtain information from

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a variety of sources such as television, radio, newspapers, and social media, pastoralists are limited to the information they share through their indigenous information dissemination channels.

Pastoralists' lives are completely reliant on rain. The availability and spatial distribution of pasture and water are determined by rainfall (Napier and Desta 2011). However, not only is there a shortage of information on climatic risks, but the dissemination and interventions are also inconsistent. Pastoralists suffer difficulties as a result of this and when they are at risk (Martin et al. 2016). The majority of pastoralists make decisions based on indigenous knowledge (IK) for seasonal weather forecasts, in which local-observed indicators and experiences are used to analyse, anticipate, and interpret local weather patterns and climate (Balehegn et al. 2019; Radeny et al. 2019).

Indigenous knowledge can be described as institutionalized local place-based knowledge rooted in local cultures that is frequently passed down through oral traditions from generation to generation (Getahun 2016; Selemani 2020; Ngenga et al. 2021). Many indigenous communities worldwide rely on indigenous weather forecasting to help them cope with or adapt to the impact of climate change-induced extremes in weather events (Nassef & Belayhun 2012). Following several years of inspection, indigenous weather forecasting (IWF) is embedded and entrenched in many African cultures and communities (Khan et al. 2016). Various societies and cultures use various indicators to forecast future weather conditions. This necessitates the use of effective early warning systems to address the impacts from the drought cycle and reduce the negative repercussions of droughts (Leal et al. 2021). In pastoral areas, where modern drought forecasting and information dissemination through radio, television, newspaper, social media, and others are lacking, the contribution of IWF is highly appreciated.

Pastoralists forecast local weather patterns such as the onset, cessation, intensity, and distribution of rainfall, as well as the incidences and magnitude of drought and flood events, by observing living organism behaviour, wind direction, and cloud types (Radeny et al. 2019). Despite its benefits, IK has been criticized for its lack of precision in predicting the magnitude of the effect and the duration of the climatic shock. However, IWF is decisive in assisting endeavour to advance access to climate services in many African communities (German et al. 2013), particularly where meteorological forecasts are not accessible. Pastoralists have a diversity of IK categories that they have used for centuries to address various uncertainties in their daily lives. For example, in rural Tanzania, societies rely heavily on IK to forecast the weather by observing the behaviour of animals, birds, plants, and insects. Approximately half of Borana's households did receive weather forecast information about extreme events, and nearly three-quarters reported receiving weather-related information from indigenous sources (Addisu 2017).

Weather-related disaster early warning systems are not only technically weak among Gujii pastoralists, but the spatial distribution of stations that provide information is also limited. According to Jemai et al. (2016), early warning systems are defined as the rapid and appropriate dissemination of information through identified institutions that enables individuals/communities threatened by a hazard to act decisively, avoid or reduce their risk, and prepare for an effective response. Because of its late and inappropriate early warning, pastoralists in the study area are highly vulnerable to multi-dimensional hazards (Bista 2019; Dare et al. 2014). The majority of interventions are heavily focused on post-disaster relief activities that are carried out to save lives or assist victims in coping. As a result, the objective of this research is to investigate indigenous weather forecasting techniques used by Gujii pastoralists for drought monitoring. Furthermore, indigenous and modern drought forecasting methods were compared. In pastoral areas where modern weather forecasting services are rarely accessible and usable, mainstreaming these two bodies of knowledge is critical to increasing pastoral adaptive capacity.

Research approach and data sources

This particular research followed a mixed research approach. Primary and secondary sources were used as a source so that both qualitative and quantitative data were collected. Data on the status of using IWF, challenges in using it, and its contribution towards drought management were primarily obtained from pastoral households. The other primary data was temperature and rainfall data that was taken from the Ethiopian Meteorological Agency (EMA) which were used to calculate the drought index. In addition, the IWF knowledge that pastoralists developed and used was obtained from *Ayyaantuu* and *Uuchuu*. In addition, IWF demonstration (mainly intestinal reading and star reckoning) takes place. A comparison of indigenous weather forecasting and meteorological data was made to supplement IWF findings with the results of meteorological data. In addition, books, journals, and reports were taken as secondary sources.

Sampling techniques

Probability and non-probability sampling techniques were applied to select sample respondents from the target population. First and foremost, the study area

(Burkitu watershed) was chosen on purpose due to the consistent use of IWF knowledge practices. Besides the usage of this knowledge however, pastoralists' livelihoods are not fully transformed and still remain vulnerable to the impacts of different weather- and climatic-related risks. Based on the altitudinal distribution, the kebeles within the watershed are grouped into three strata as outlet, middle, and upper watershed units. Based on this baseline, the most commonly affected Burkitu watershed consisting of Deru Danfile (outlet), Chame Kura and Baya Gundi (middle), Boko Gorobali, Finchawa 01, and Burkitu Magada (upper watershed unit) was chosen as a sample kebele. According to the district report, there were 2282 households in the Burkitu watershed. Therefore, to find sample households from the area, the sample size determination formula of Yemane (1967) was used. Accordingly, approximately 340 sample respondents were identified as sample size. Finally, maintaining population proportionality for each watershed unit, 84, 107, and 149 household head sample respondents were proportionally taken from the outlet, middle, and upper parts of the watershed using simple random sampling.

$$n = \frac{N}{1 + N(e)^2}$$

where $n =$ sample, N is the population size, and no is the sample size.

$$n = \frac{N}{1 + 2282(0.05)^2} = 340$$

In addition, 15 individuals were purposefully chosen for key informant interviews (KIIs), mostly knowledgeable elders, Abbaa Gadaa members, and religious leaders. As a result, the specific numbers of elders (5), Ayyaantuu (2), Uuchuu (2), and Abbaa Gadaa (3) were purposefully identified (i) for the special knowledge they have concerning IWF and (ii) to identify challenges in using IWF and the status of its continuity. In addition, 3 Christian religious leaders were interviewed to discover how they view IWF. Three rounds of FGD were also held with selected pastoral households, with each FGD session averaging 7–12 participants. Participants in the FGD were chosen on purpose based on their long-term residency in the area, which was obviously 15 years or more. The FGD was planned with consideration of how pastoralists use IWF, the challenges in its use, and the accuracy of knowledge in weather forecasting. Furthermore, the IWF's trends and continuity were evaluated during the FGD. Ayyaantuu and Uuchuu provided information on how indigenous weather forecasting is used in the Gujii community.

Methods of data analysis

Quantitative data was analysed using descriptive statistics mainly frequencies and percentages. Data obtained from focus groups were thematically analysed using a hermeneutics approach. Hermeneutics derives from the Greek word *Hermeneuin*, which means to express, explain, translate, or interpret a message (Drummond et al. 2004). Hermeneutics is a credible, rigorous, and creative strategy for addressing aspects of professional practice that must be flexible, adaptable to specific needs, and justifiable in both evidence-based and client-centred settings (Paterson & Higgs 2005). The reasoning process of data analysis evolved through the study phases in the hermeneutics approach (Viera 2017), where an initial recognition of the need for additional knowledge resulted in the identification of the research purpose.

Furthermore, in qualitative research, the hermeneutic approach is a credible and rigorous research approach for investigating practical reasoning and its communication (Guillen 2019). Thus, in this study, we used an interpretive (hermeneutical) research paradigm, with the primary goal of contextualizing how pastoralists use indigenous weather forecasting for weather event monitoring and pastoral resilience in general (Fig. 1). Similarly, the difficulties and persistence of using indigenous weather forecasting in the pastoral area were widely discussed. As a result, it includes an examination of the usability, continuity, and prospects of knowledge over time. In addition, data obtained from EMA was analysed using Drinc software. Thus, the index produced was used as an input to compare with IWFK. In addition, the data obtained from household surveys were analysed using descriptive statistics mainly frequencies and percentages.

Gujii pastoralists have relied on indigenous weather forecasting knowledge for centuries to adapt to extreme weather events and recurring droughts. They have been interpreting insect behaviour, flowering plant characteristics, and animal behaviour during grazing and sleeping time as local weather indicators. Furthermore, their experience in interpreting the alignment of the stars and moon in the sky assisted them in forecasting weather events as well as other fortunes and misfortunes in the area. However, due to a number of challenges, the use of IWF appears to be declining, and its future is ostensibly uncertain. Thus, using a hermeneutic approach, the type of IWF that has been used, its usability status, and challenges in knowledge continuity were thoroughly discussed.

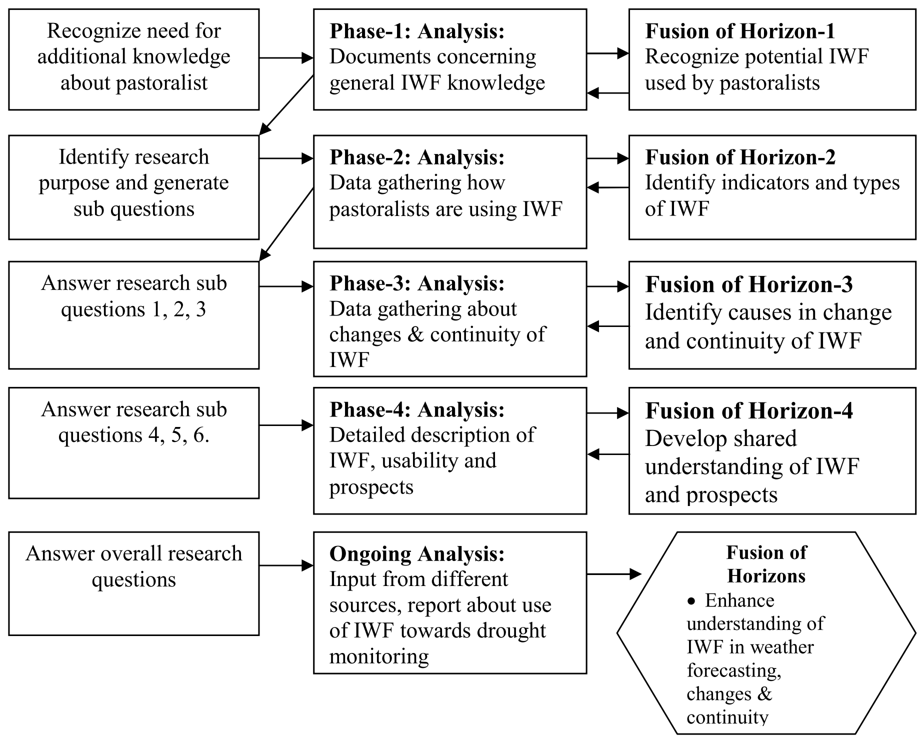

Fig. 1 The hermeneutic spiral approach. Adapted from Paterson and Higgs (2005)

Results and discussion

Acquisition of indigenous weather forecasting knowledge

In pastoral areas, various indigenous knowledge (IK) systems are used in pastoralists' daily lives. From the response during the FGD session, indigenous knowledge can be generally grouped as (i) communal and (ii) personal. However, both types of knowledge serve the pastoral community in the same way. Communally owned IK includes, but is not limited to, knowledge such as resource management (forest, soil, pasture livestock, human health, etc.), food preparation, conflict resolution, and the creation of material cultures. However, most knowledge, such as ethno-veteran, weather forecasting, and traditional healing, is solely owned by a few elders who have been trained or have experience with the knowledge.

Pastoralists divide IWF knowledge into three major categories based on its source. The first is *Uuchuu*[1] knowledge, the second is *Ayyaantuu*[2] knowledge, and the last is communal knowledge (which is held and known by all). Most of this IWF is sometimes excoriated for various reasons. Some scholars, for example, argue that IWF lacks precision and certainty. Indigenous forecasters are constantly questioned (Ayal et al. 2015) and have been sturdily compromised by the public in recent years. Others claim that IWF is rarely documented, making retrieval of historical events impossible (Radeny et al. 2017). In reality, IWF like all modern methods of weather forecasting has flaws and is not always perfect.

According to Gujii's experience, pastoralists have some unique techniques for commemorating incidents that occurred in their environment. They excel at attaching any weather events to the *Gadaa system*[3], where retrieval is simple. And pastoralists describe how they gained this knowledge. The majority (42.9%) of respondents stated that indigenous weather forecasting (IWF) is obtained naturally from Waaqa (supernatural God), while approximately 25.3% stated that the knowledge is obtained from family as a result of long-term experience. Even though it is uncommon, there are occasions when some knowledge is passed from father to son after proper ceremonial activities. However, pastoralists claim that this is rarely practised and is unevenly distributed even within Gujii territory.

[1] Knowledgeable elders that have knowledge of reading animal intestine and interpret it in line with the weather events

[2] Indigenous astrologers who are highly skilled in observing position celestial bodies mainly stars and moon for weather forecasting

[3] An egalitarian indigenous system of governance where power is transferred every 8 years

Fig. 2 Intestine reading session, 20 August 2021

Most indigenous knowledge that someone owes is referred to as a natural gift in Gujii society. It is rarely perceived this knowledge is 'learned' or 'formally obtained' from another source or experiential stimuli. Thus, whatever knowledge or indicators are used to solve communal problems is thought to have been passed down from Waaqaa to their forefathers. Knowledge is then shareable and can be experienced once it is given to someone from Waaqaa. However, the manner in which knowledge is shared or experienced varies greatly from one knowledge type to the other. For example, weather forecasting knowledge gained through reading animal intestine (Uuchuu) is practised. However, in the case of Gujii pastoralists, this research has not proven that, and the respondents argued that intestinal reading knowledge can be acquired through long-term experience. They went on to explain that in order to be an expert in reading intestines and obtaining weather forecasting knowledge, one must closely observe the entire procedure while Uuchuu undergoes the forecast. Most of the time, this type of knowledge is gained through careful observation of how experts slaughter, slaughtering procedures, separation of readable organs, and time of slaughter.

There is an oral tradition in Gujii about how the Gujii community began to use intestine reading as a knowledge that helped them solve multi-faceted public

Table 1 Acquisition of IWF and mode of sharing weather information

	Frequency	Percent
Source of IWF knowledge		
From experience	17	5.0
It is inherited from the family	85	25.0
Informal education at home	6	1.8
Gift from God	146	42.9
Gift as a blessing from family	86	25.3
Total	340	100.0
Mode of sharing weather information		
From elders' gatherings	200	58.8
In the place of herding	58	17.1
Abbaa Gadaa announcements	15	4.4
Information from religious institutions	29	8.5
Observation and realization	38	11.2
Total	340	100.0
Pastoralists' perceived period for drought frequency		
Every year	3	.9
2–4 years	188	55.3
5–7 years	88	25.9
8 years and above	61	17.9
Total	340	100.0

problems (Fig. 2). According to one of the interviewees (Ayyaantuu), God previously gave three holy books to the Gujii society and all human ancestors, the books being the Holy Bible, Holy Quran, and Gujii scripture (Kitaaba Gujii). However, elders claim that the Gujii Book was eaten by a cow in the herding field one unfortunate day. Then, God informed the elders about the tragedies, and the Book that the cow ate was safely stored in the ruminant livestock's intestinal parts. Then, on God's advice, the elders then directed personnel to slaughter the cow immediately so that the Book could be removed. However, they were unlucky to refind the book, and since then, as directed by God, they have begun to read the intestine, which they believe contains information about human fortunes, misfortunes, past history, and prospects.

It was learned from the interview that animals slain for intestinal reading are not slaughtered at night. Pastoralists feel that the content of blood and food in the gut is not fairly distributed at night and thus may affect forecasting accuracy. Elders also state that women are not permitted to kill (slaughter) animals while a man is present. There is a tradition that men, especially seniors, are responsible for slaughtering animals for intestinal reading. The Ayyaantuu is a person with knowledge of a constellation or a time reckoning system based on interpreting the alignment of stars and moons in the sky during a specific month or season. This type of knowledge is thought to be naturally given to a few groups within the Gujii. Borana also considers Ayyaantuu knowledge to be a gift from God to certain Borana families (Ayal et al. 2015). As a result, not everyone is equally gifted to be an Ayyaantuu, and knowledge is rarely trained. Other indigenous weather forecasting techniques, such as interpreting events from animals, birds, and plant behaviour, can be learned through experience or through day-to-day life activities.

Weather event information obtained from individuals (indigenous experts) or groups can be disseminated to users (community) via various means (Table 1). The primary source is elder gatherings (58.8%). Pastoralists stated that elders will occasionally organize a communal gathering when they believe misfortunes have occurred or are about to occur in their community. They reveal what has occurred and clarify what is about to occur at the gathering. In contrast, information can be exchanged at the herding location (17.1%), through observation and realization (11.2%).

During the focus group, the researcher discovered how the commemorative knowledge system operates. For instance, the drought incidence of 1972–1974 caused the death of large numbers of livestock and people in the Gujii area. The Gujii people called that event the Bule Dabasa's drought where Bulé was the 1970s Abbaa Gadaa (Robson 2021). However, aside from the historical scenario of every climatic disaster being linked to Abbaa Gadaa's leadership time, the Gujii people never had an Abbaa Gadaa named Bule Dabasa. Girjaa Jiloo was the name of Abbaa Gadaa, who ruled from 1968 until 1975. Furthermore, according to Jamjam and Dhadacha (2011), the 1970 drought, which was the second most catastrophic after the 1984/1985 drought, impacted several regions of the Gujii area. Thus, the drought of 1984–1985 in Gujii was dubbed 'Oolaa Godaanaa' (Godana's drought), after Abbaa Gadaa 'Godaanaa Kattaa', who ruled Gujii from 1984 to 1991. Furthermore, based on their reminiscence capacity, the majority (55.3%) of pastoralists claim that at least one drought occurrence occurs in the district every 2–4 years, (25.9%) every 5–7 years, and just (0.9%) every year.

Another feature of IWF is its flexibility to the changing environmental conditions over time. Pastoralists frequently notice and forecast the causes and implications of changes in their environment. Indigenous weather forecasting knowledge is created, accumulated, and transmitted in a dynamic process (Balehegn et al. 2019). Pastoralists said they relied on IWF for daily, weekly, and seasonal weather forecasts, as well as the interpretation of local weather conditions using locally observed indicators. Several indicators are taken into account while forecasting weather events. This finding is consistent with the research of Behnke and Kerven (2013), Ayal et al. (2015), and Radeny et al. (2019). They stated that weather conditions are observed and forecasted using local indicators and experiences. What they observe is aimed at identifying if the weather condition of an area has already changed or is changing and about to change any time possible (Balehegn et al. 2019; Khan & Gomes 2019).

Indigenous weather forecasting indicators

The Gujii pastoralists claimed to have developed centuries-old experiential knowledge of weather forecasting. This knowledge enabled the pastoral community to forecast the occurrences, duration, and likely effects on their environment, livestock, or people. IWF is frequently referred to as 'divine revelation'. The concept of divine revelation is straightforward, and claiming of help of IWF is not validated following scientific procedures. However, in practice, IWF is beyond this scenario for it is practically experienced and formally used by the pastoralists. IWF is practicable and utilized in pastoralist's daily life (Mbilinyi 2020). Moreover, it was been helping a large number of pastoral households across the globe although the system of knowledge production, dissemination, and usability may vary from one region to the other. In the same token, pastoralists are not passive observers of what is happening to their environment. They are exceedingly

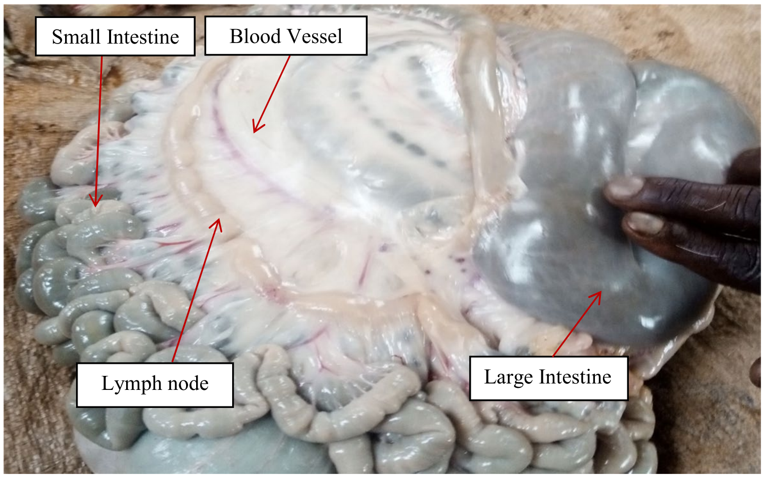

Fig. 3 Organs in the intestine reading. The photo was taken by the first author, 20 August 2021

intelligent in sensing and informally collecting the situational indicators which help them generate knowledge and make a decision. Thus, hence it is practically applied in their day to day activities and obviously helped them at large, there is no reason to call the knowledge a mere divine revelation.

Biological indicators

From the response of FGD, biological indicators can have different forms. For instance, the ability to observe the behaviour of birds, plants, animals, and insects is increasingly widely known, although only a few are specialized and advanced in this kind of knowing. Based on pastoralists' responses, it was noticed that one of the biological indicators is observing animal behaviour. Animal behaviour was employed by 53.5% of pastoralists as an indicator, which is mostly used to analyse how cattle urinate and leave dung in the kraal/pen when sleeping.

Elders constantly keep a watchful eye on their cows, and if one urinates or dumps dung while sleeping, they expect a long dry season ahead. Furthermore, pastoralists claim that animals are recognized to have intrinsic abilities to sense and detect the occurrence of tiny changes in their surroundings. This finding agrees with the finding of Balehegn et al. (2019), who discovered that animals can sense what is going on in their localities. According to an interview conducted with livestock health expert[4], animals such as cows, camels, and goats have a great ability to detect weather inconsistencies. In the months of January to March, for example, if a camel puts its mouth in the sand or begins scratching the ground, the onset of rain during the spring season is delayed. Pastoral elders also said that when there is a good chance of rain in the near future, cows and goats express sexual urges and jump. When animals are startled and grow restless in their enclosures, or when bulls refuse to mate, it is a sign that the bad season is approaching.

Pastoralists take standard precautions to help themselves survive the effects of the intended risks based on the symptoms displayed by animals. For example, based on the symptoms described above, pastoralists relocate their cattle to a location where they feel safe, most likely to the highlands where water and pasture are plentiful. Besides, they sell overweight animals in order to save money for future use in difficult times. Moreover, they divide herds into satellite and home, where relatively drought-resistant livestock (goats, camels, and healthy cattle) may be forced to move long distances while weak and lactating cows may remain at home-based grazing areas to avoid the effects of the expected drought. Pastoralists may also notice that rain appears to be missing when calves or heifers move restlessly. Hence, it is an indication of the apparently happening drought, and they start storing pasture for later use, either by searching for it in the farm yard, collecting leaves from the forest, or buying it from the market.

The reading of animal intestines is the other biological indicator (Fig. 3). Uuchuu is the exclusive owner of the knowledge of intestinal reading, and they are branded with information that forecasts weather, fortunes and misfortunes, peace, and conflict conditions in the society. Experts in intestinal reading were able to predict not only the future weather but also the prospects for peace and conflict, as well as the fortunes of humans and animals (Howell 2003; Ayal et al. 2015).

[4] Aged 49, at Dugda Dawa. Interviewed on 23 March 2021

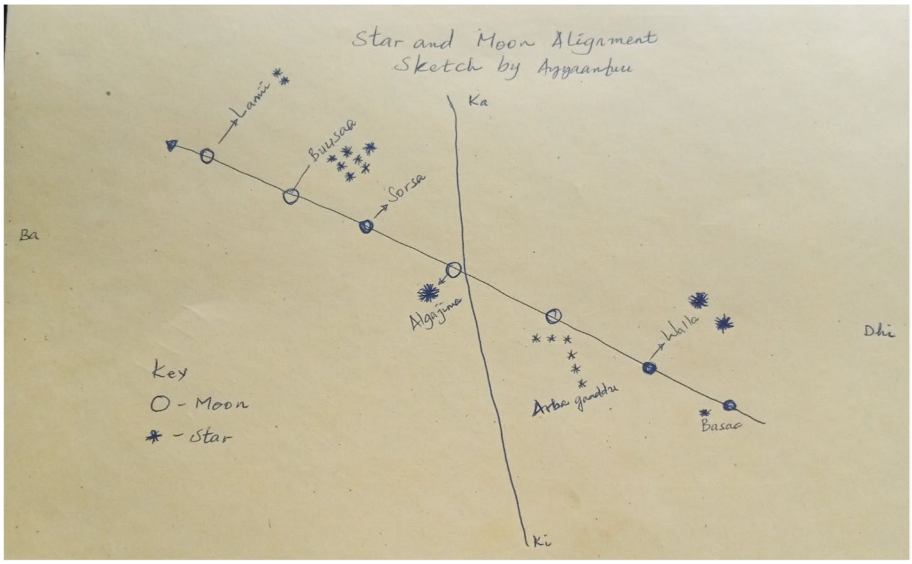

Fig. 4 Position of star and moon drawn by *Ayyaantuu*

Because it is disfavoured by some religious teachings, this knowledge is eroding, and just a few Gujii elders are practising it.

The researcher has invited two different Uuchuus to a single intestine one after the other to see if the procedures of reading the intestine and the information they delivered were the same. One expert read for an average of 20–30 min. According to the experts, delaying intestinal reading for more than 1 h after slaughter is not recommended because nodes, blood vessels, and the intestine may shrink and impair reading quality. Both Uuchuus have displayed the same information and named the same intestinal parts as an indicator of weather events. Both of them revealed that domestic animals such as old cows, goats, and sheep are slaughtered in proportion to their age for weather forecasting. They argue that the intestines of old-age animals (e.g., old cows and goats) provide more accurate forecasting.

Despite the fact that different parts of the slaughtered animal intestine are used for different purposes, the most commonly used parts for IWF are the large (*madhumaan guddoo*) and small intestines (*madhumaan diqqoo*), blood vessel (*hidda dhiigaa*), and lymph node. During the reading period, Uuchuu observes various key signs that help them forecast the weather as well as other fortunes and misfortunes. For example, if the amount of food available in the large intestine, small intestine, and lymph node is very small (nearly empty), it indicates that the worst season has begun, and vice versa. The finding is similar to that of Ayal et al. (2015) and Ngenga et al. (2021), who argue that if the food substance in the small and large intestines is small and large, respectively, forecasts for drought and a normal rainfall season will be made. In contrast, if the intestine of a freshly slaughtered animal appears black, it indicates that a good season or normal rainfall is forecasted. The greyness, whiteness, or nearly reddish colour of the intestinal part under read, on the other hand, indicates severe weather events, most notably the onset of a long dry season.

They have also commented, saying that the length and thickness of gut organs predict weather patterns. When the big intestine or lymph nodes are too short or thin, it signals the start of a terrible season, and vice versa. Most of the time, Uuchuu[5] narrates this type of intestinal reading that verifies the start of the severe drought. If one or more lymph nodes become displaced from their usual alignment and are separated from the rest of the lymph nodes, it indicates that war will break out in the near future. The change in colour of blood vessels from red to brilliant yellow or grey suggests that rain will be arriving soon. However, unlike (Ayal et al. 2015) who suggested the amount of blood within the vessel utilized to anticipate the weather. However, this research was unable to vindicate any proof of this reality.

We have detected the Gujii Uuchuus have anticipated the incidence of the drought of 2021–2022 along with its apparent subsequent consequences as early as November 2020. On August 20, 2021, a goat was slaughtered to test the accuracy of the Uuchuu reading and forecasted fitness to the rain condition of the autumn season (Galgalo

[5] 56 of age

Table 2 Indigenous weather forecasting indicators

Indicators	Fre	%	Source of IWF	Special characteristics
Cows urinate	106	31.2	Public/Uuchuu	*When a cow urinates while sleeping, it indicates drought is about to happen*
Cow dung	75	22.1	Public/Uuchuu	*When a cow drops dung while sleeping, it indicates a long dry season is coming*
Birds' and fox sound	28	8.2	Public	*Sounds of foxes and birds like Urdudde, Sololiya, Laakkama, Gaarrisa, and Qottoo are transliterated*
Intestine reading	10	2.9	Uuchuu	*Conditions of the blood vessel and large and small intestines are transliterated*
Insect behaviours	6	1.8	Public	*Time and direction of the move of the swarm of insects are transliterated*
Plant flower	31	9.1	Public	*Flowering and leaf shading of the tree can be attached to seasons*
Stars and moon	75	22.1	Ayyaantuu	*Position of the star and moon in the sky used as a reference to weather condition*
Animal thirsty	9	2.6	Public	*When cattle drink too much water, it is an indication of the upcoming dry season*
Total	340	100.0		

and Mekuria 2021). Based on the reading, both Uuchuus predicted the onset of the 2021 autumn (short rainy season), stating that 'most of the regions under study area in particular and southern Ethiopia in particular would face early cessation of rain'. The early cessation would have been followed by severe drought (Oolaa jabaa), threatening the availability of pasture and water. They have responded that the slight reddish blood vessel and low food content in the small intestine indicate drought (Fig. 4).

Cognizant to the forecast by Uuchuu, a report from (FEWSNET 2021) indicates, the poor rain during October to December 2021 in southern and south-eastern pastoral areas brought compounding impacts which have limited pasture and water availability. Similarly, IGAD (2016) reported autumn of the year 2021 was drier in Uganda, southern Ethiopia, eastern Kenya, south Somalia, and Tanzania. To compare weather forecasting knowledge of the Ayyaantuu[6] with that of Uuchuu, an interview was made with Ayyaantuu. One of the Ayyaantuu provided his testimony about the short rainy season of 2021 (September–November) in Gujii by saying:

> *'Lamiin rooba kakatteerti, dugda Gujitti galteerti, roobi Birraa dhufuu hineeggamu, yoo roobelle turee uummata dhaqqaba, akkas taanaan uummati hin miidhama' says the narrator. It literally means that there will be no rain in the upcoming season (autumn), with Lamii not indicating the likelihood of rain in the Gujii land. If we do get rain, it will most likely arrive late in the day. That appears to be a bit of a challenge for our community.*

The other Ayyaantuu[7] responded that there is a possibility of an early cessation of rain in autumn, which would be followed by severe drought (oolaa). The meteorological evidence also revealed that the 2021 short rainy season, which lasted from September to November, was significantly delayed (Negash 2021), poorly distributed (Gebre et al. 2021), and cumulatively far below average (50%) in eastern Africa, particularly in southern and south-eastern Ethiopia (Juma 2009).

On September 20–21, 2019, a workshop facilitated by CIFA and CARE in collaboration with a consortium member brought together Uuchuu, Ayyaantuu, and modern meteorological experts in Mega town for Participatory Scenario Planning (PSP) Workshop, with the goal of determining whether conjoint weather forecasting is possible. As a result, the 2019 *Hagayya* (autumn) rain forecasted by both Ayyaantuu and Uuchuus and they have indicated the possibility of sufficient rain for livestock and rejuvenate grasses. During the meeting, a group from the Ethiopian Meteorological Agency, based in Hawassa, presented their rain prediction for the same season, confirming that 30%, 45%, and 25% of the rainfall was above normal, normal, and below normal, respectively. From the scenario, it can be generalized that most of the rain forecasted by IWF and meteorological personnel matched.

A variety of animal behaviours are also used to forecast the weather. For example, Afar pastoralists forecast particular weather based on changes in animal behaviour, especially bird plumage, camel reproductive and browsing behaviour, and insect, fox, and other wildlife behaviour and movements (Bouabdelli et al. 2022). Similarly, Borana pastoralists refer to the drought and rain that would occur in the area if an army of ants moved in a nearly straight line and then dispersed in search of food (Ayal et al. 2015).

Some animal and insect behaviours used by Gujii pastoralists to forecast the weather are listed below. For example, when brown ground squirrels dig several holes in different locations, it indicates the impending arrival of heavy rain. Squirrels dig holes that will protect them from flooding. They have responded, and the weather forecast

[6] Aged 72, *Ayyaantuu* from Deru Danfile, interview date: August 18, 2021

[7] Aged 65, *Ayyaantuu* from Boko Gorobali, interview date: August 18, 2021

Table 3 Naming of months and seasons in Gujii

No	Seasonal characteristics	Seasons in English	Name of months in Gujii	Conventional names of months
1	Long dry season	Winter	Arfaasaa, Sadaasaa, and Qaamuu	December, January, and February
2	Long rainy season	Spring	Badheessa, Bitdotteessa, and Caamsaa	March, April, and May
3	Short dry season	Summer	Ella, Wocabajjii, and Adoolessa	June, July, and August
4	Short rainy season	Autumn	Hageyya, Birraa, and Onkoleessa	September, October, and November

can be predicted by observing bird behaviour. Some birds' key signs of behaviour are embedded in the sound they make, their feather appearance, and the direction of their movement. For example, the bird Bararaxxuu is known locally as oolaa dhoottuu (drought blinker). The movement of Bararaxxuu from east to west and back again, producing 'ba...ra...ra...ra', indicates the absence of rainfall.

In contrast to the Bararaxxuu, when a local bird known as Urduddee chants in mass and repeatedly makes the sound 'bekke...kko...bekke...kko', the rain is approaching and the season is favourable for people and livestock. Pastoralists employ the behaviour of insects as an IWF (Table 2). According to pastoralists, a long dry season or drought is predicted when a shoal of black ants moves in a scattered mood carrying a piece of chopped leaf. In contrast, when they appeared to move densely in a straight line by sticking together, it indicates that there is a good chance of rain. The sudden invasion of a swarm of butterflies indicates the arrival of rain.

They also observe plant traits in order to develop weather forecasts. However, most of the time, weather event forecasting based on particular plants' primary signals is seasonally limited. This is because a single tree's flowering cycle, leaf shading, colour change, and other behaviours seldom last longer than a season. This finding is consistent with Speranza et al. (2010) and Masendeke and Shoko (2013), who claimed and stated that the time of leaf shading is a predictor of future dryness. In the early months of April, new growth of tree species such as *Commiphora erythraea* (Agarsu), *Lanne arivae* (Handaraku), and *Commiphora africana* (Ammeessa) produces green leaves, indicating the start of the major rainy season. According to Ayal et al. (2015), the loss of old leaves in two wet seasons signals the start of the dry season. *Acacia bussie* (Halloo), *Acacia etbaica* (Alqabeessa), *Acacia tortilis* (Dhaddacha), and *Acacia mellifera* (Saphansa Gurraacha) trees have flowers that are often utilized as weather indicators. If these trees have budding flowers with a deep white colour during the short dry season, it means the rainy season has begun.

Astrological indicators

Ayyaantuu is an astrologer who does astrological forecasting. They are those who know how to reckon celestial bodies, mostly the moon and stars, based on their alignment, the pattern of stars and moon (Greene 2008), and the placement of stars in months and days. According to pastoralists, the Gujii people's calendar is based on a 12-month calendar with four distinct seasons. And rather than solar cycles, the art of time reckoning is based on lunar cycles. Pastoral and agro-pastoralists of Gujii place the first months of the year slightly in different ways. Gujii pastoralists regard August as the first month of the year, whereas agrarians and agro-pastoralists regard September as the first month of the year (Table 3). The alignment of the stars and moon is used to predict weather and seasons. Ayyaantuu forecast weather events using seven main castellation stars. Lamii (Binary Stars), Buusan (Pleiades), Sorsa (Aldebaran), Algajima (Bellatrix), Arba-Gaadduu (Central Orion), Walla (Saiph), and Basaa are the seven castellation stars (Sirius).

Lamii (binary stars)

In the system of seven constellation stars, Lamii (binary stars) is the starting point for weather forecasting. When the night is cloud free, the observation of star-moon alignment begins during the months of Hageyya (September) and Bitdotteessa (April). As a result, forecasting begins in the season of the autumn. If Lami (binary stars) is observed on the 15th night of September from 09:00 to 10:00 pm, it indicates the uncertainty of the upcoming short rainy season. Similarly, if Lamii's alignment is observed slightly above the moon in the north-east direction in mid-September at 9:00 pm, they forecast the next long dry season of the winter to be normal (Figs. 4 and 5). If the constellations of the moon with Lamii are observed on the first day of the month of Bitdotteessa (April), at 09:00 pm, slightly below the moon in the south-east direction, the short dry season will last longer than expected. Ayyaantuu, on the other hand, can forecast the weather by observing cloud-moon and star alignment. If a cloud covers both the moon and some of the constellation's stars, primarily Lamii and Arba-Gaadduu, in late October or early November, it indicates that the short rainy season has ended.

Buusaa (Pleiades)

Buusaa is referred to as seven sisters in several literatures. When Buusaa is seen (with vivid colour) in December in north-western and above the moon, Ayyaantu suggests

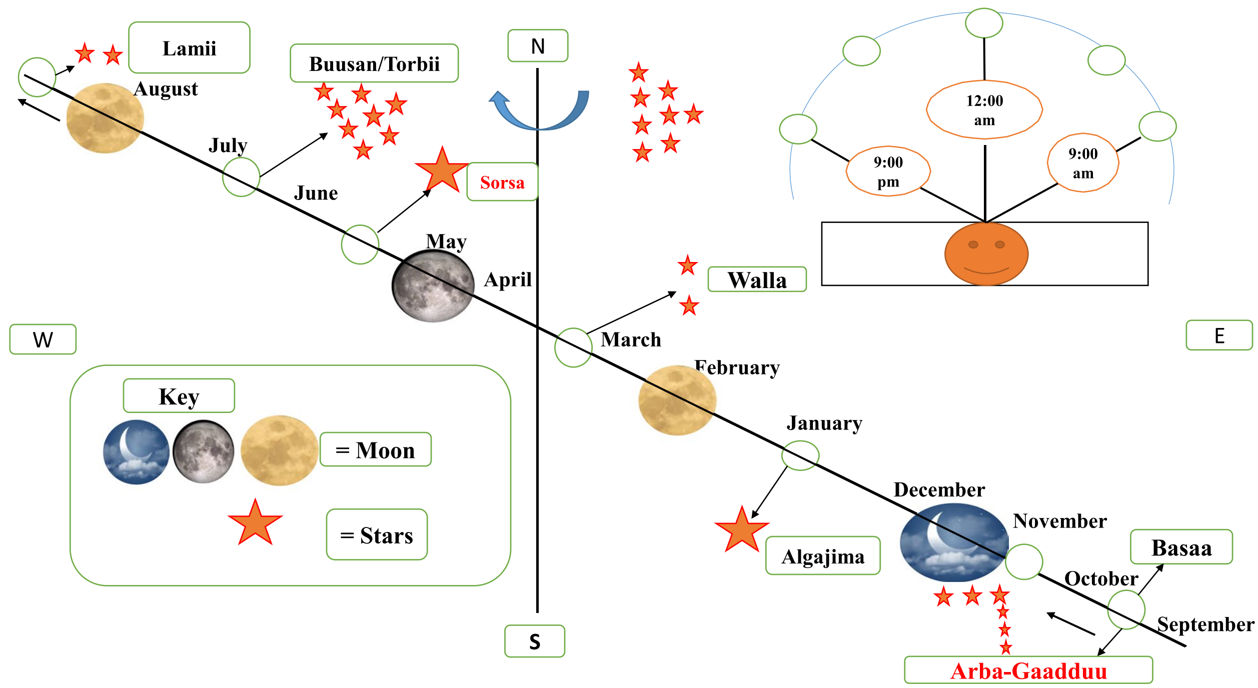

Fig. 5 Position of star and moon drawn by Ayyaantuu

that the rainfall will be normal. The Pleiades visible in the sky during autumn is a marker of the commencement of the coldest nights in Australia, according to Speranza et al. (2010). However, this is not often taken as a very promising indicator for it is highly limited to seasonal. Hence, it is limited to telling the rain of March, and pastoralists do not often consider it for forecasting weather conditions at an annual timescale.

Basaa (Serius)

The *Ayyaantuu* explain that Basaa is most common during the months of August to October. They claim that observing Basaa in the south-west direction, slightly above the moon between 7:00 pm and 9:00 pm would exemplify the extension of the short fall of the rainy season by one or more months. However, if the Basaa star lies below the moon in the same month, the extended dry season would be severe, with the possibility of drought event to occur. The Egyptians, on the other hand, are persuaded that the observation of Serius in August is a sign of Nile River flooding (Saruni 2016).

Ayyaantuu, on the other hand, can evaluate the location of alignment (vertical or horizontal), size, brightness, and pattern of stars in the sky over the course of several months. For example, while Algajima and Sorsa appear to be the same size, they occur at various months of the year and are bright and pale in hue indicating some rain characteristics. The brightest and most widespread apparition of Algajima between the 1st and 5th of December at night between 10:00 pm and 6:00 am indicates that the long rainy season will begin early, with strong prospects of rainy days. The beginning of the short dry season is predicted when the Wallaa (Saiph) star is seen in the upper part of the sky in the north-east position during the first 5 days of March, around 8:00 pm–9:00 pm. If it appears in the south-west direction on the same night, it indicates the likelihood of rain during the main rainy season.

Comparison of IWF knowledge and meteorological data

The average response to the various IWF systems was calculated over a 23-year period to compare the system's matching status and score with data from the meteorological centre. Respondents were asked to tally the level of drought they remembered, ranging from no drought to extreme drought, using the Gadaa age grade as a point of reference. For better comparison, the researcher assisted pastoralists in categorizing drought incidences and extreme events that they experienced over the five Gadaa administrative years. One Gadaa administrative cycle lasts 8 years. Our data completely covered the administration time of two Abbaa Gadaas, totaling 16 years. And we have taken 6 years from the administration of the first Abbaa Gadaa (Godaanaa Kattaa) and only

Table 4 Comparison of drought events using IK and meteorological data

Gujii Abbaa Gadaa	Year ruled	Ave. HR IWF	%	Perceived drought level	Annual RDI	Drought level	Match level
Godaanaa Kattaa (1994–1999)	1994	234	68.8	OD	0.26	No drought	***
	1995	302	88.8	OD	0.51	No drought	**
	1996	284	83.5	HJ	0.11	No drought	***
	1997	189	55.5	HJ	1.08	No drought	***
	1998	200	58.8	OD	−0.06	No drought	**
	1999	291	85.5	OK	−1.79	Severe	**
Aagaa Xenxenoo (2000–2007)	2000	180	52.9	OGG	−0.06	No drought	*
	2001	160	47.05	HJ	0.64	No drought	***
	2002	211	62.05	OGG	−0.54	Mild	**
	2003	170	50	HJ	−0.26	No drought	***
	2004	143	42.5	HJ	0.43	No drought	***
	2005	269	79.1	HJ	0.59	No drought	***
	2006	209	61.4	OGG	−1.24	Moderate	***
	2007	301	88.5	OK	−2.55	Extreme	***
Waaqoo Duubee (2008–2015)	2008	269	79.1	OJ	−1.03	Moderate	**
	2009	211	62.05	OD	−0.57	Mild	***
	2010	212	62.3	OGG	−0.77	Moderate	***
	2011	201	59.1	OGG	−0.19	No drought	*
	2012	270	79.4	HJ	0.26	No drought	***
	2013	224	65.8	HJ	0.87	No drought	***
	2014	179	52.6	HJ	1.77	No drought	***
	2015	199	58.5	OD	1.25	No drought	**
Jiloo Maandoo (2016–2024)	2016	189	55.5	OD	0.31	No drought	**

Drought categories: *HJ* HinJiru (no drought), *OD* Oolaa diqqaa (mild), *OGG* Oolaa Giddu-galeessa (moderate), *OJ* Oolaa Jabaa (severe), *OK* Oolaa Kutaa (extreme)

*Not matching, **low matching, and ***high matching

1 year from the administration of the last Abbaa Gadaa (the current ruler Jiloo Maandhoo) (Table 4). The intention was to make public understanding correspond to the outcome of meteorological data. Over the course of the 23-year study, the majority of pastoralists' responses to the drought event and the results of the meteorological agency indicated the persistence of the drought in the area.

Pastoralists have excellent recall when it comes to their Gadaa system. For example, approximately 85.5% of respondents claimed that the final year of Godaanaa Kattaa and the first 2 years of Aagaa Xenxenoo was devastating, leaving them hopeless after losing various groups of livestock. They all agree, however, that unlike most of his predecessors, the Gadaa of Aagaa Xenxenoo was the safest ever. They claim that in his Gadaa, we never faced war or other natural disasters. Pastoralists responded that the final year of Godaanaa Kattaa was hit by Oolaa Jabaa (severe), which was similar to the results of the 1999 meteorological report. Pastoralists' reactions to the 2007 drought were strikingly similar to the meteorological report. However, the reports of drought in the year 2000 and 2011 were not matching. It is assumed that the accuracy of the IWF can be affected by a variety of externalities.

The first 2 years under Waaqoo Duubee were a nightmare for pastoralists in the hot lowlands and agro-pastoralists who rely on the spring season for crop cultivation. However, they responded that it was not so bad and that they had managed to survive primarily because most of the NGOs in the area significantly worked on capacity building and provided technical assistance on how to harvest water. The accuracy of the IWF prediction and data from the meteorological agency show a very strong relationship. For example, IWF of the drought incidence prediction under Godaanaa Kattaa administration and meteorological data show a high matching record, while 20% show a low matching record. In addition, 80% of the IWF recorded under the administration of Aagaa Xenxenoo highly match with the prediction record from the meteorological data.

In general, pastoralists have benefited more from IWF information than meteorological information. Pastoralists are rarely advantageous in accessing information about extreme events or early warning from meteorological centres due to a lack of technical familiarity or

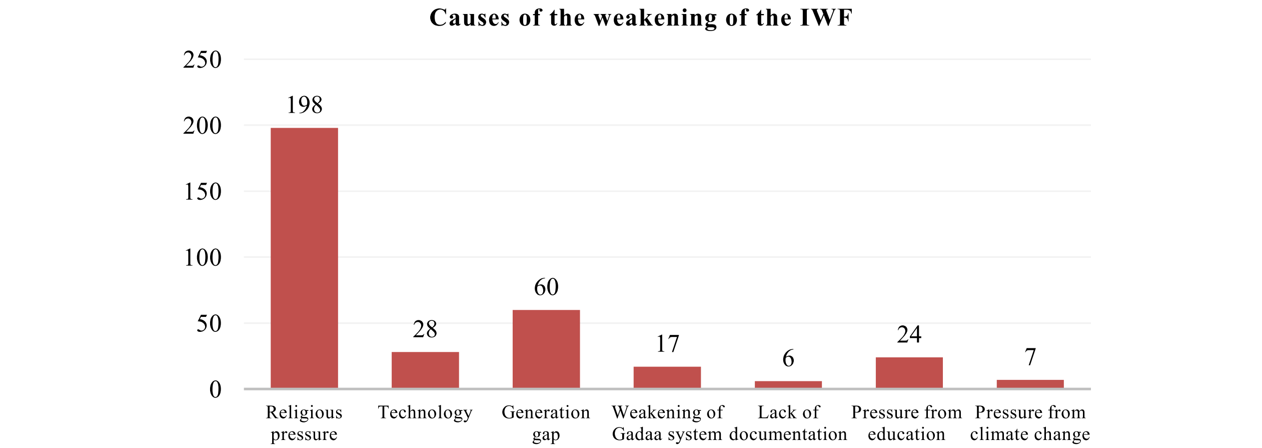

Fig. 6 Causes of the weakening of the Gujii IWF

insufficient availability. They believe IWF is adaptable and easily used to the local level. The creation of indigenous knowledge by the community demonstrates the dynamism, adaptability, unique existence, and creativity of indigenous knowledge (Mahoo et al. 2015). The majority of pastoralists are still forced to use while the climate is changing and the dynamism is becoming unpredictable. According to Shoko and Shoko (2017), pastoralists trust indigenous forecasts because of their familiarity and accessibility. Moreover, forecasting is a simple task and easy going (Shoko 2012), and communicating with people is possible. Indigenous forecasting methods typically focus on predicting the onset of rains and the spatial coverage of rain at a specific time. However, they are unsure of the duration and season of the rainy days. However, IWF knowledge, particularly intestinal weather forecasting, has an advantage over other indigenous weather forecasting techniques in that it can specifically indicate areas at the micro-level based on the amount of rainfall or drought (Speranza et al. 2010).

Changes and continuity of IWF

Despite its numerous benefits to the pastoral community, IWF's usability is gradually deteriorating. For several centuries, primarily since the fifteenth century, when the Gadaa system is thought to have begun formal administration, the Gujii society has relied heavily on indigenous knowledge to successfully lead daily socio-economic activities. Despite the fact that several IK have different functions, they have been using IWF to forecast some weather events until now. However, as time passes, several factors contribute not only to the weakening of this knowledge, but also to the reduction of knowledge production and usability. Approximately 58.2% of respondents stated that religious teaching pressures are the primary cause of IWF's gradual decline (Fig. 6). As evidenced by one of the interviewees, intestine reading is not a Godly practice and is thus Biblically condemned. He went on to say that God taught the Christians in Exodus 7:11, Leviticus 23:23, 1st Chronicles 33:6, 1st Kings 21:6, and Isaias 47:12 that the work of vaticination from any divine source is Biblically disregarded.

With the region's reasonable rate of Christian expansion, this type of teaching sparked the emergence of two most overlapping but distinctively perplexing scenarios concerning the use of IWF. To begin with, some religious leaders teach youths that reading their intestines to predict a weather event is an evil practice that goes against God's will. They assert that 'God created human beings reasonably and let them not be concerned about tomorrow'. According to the other Bible teacher (pastor), God's will for humans is revealed in the books of Matthew 6:34 and Luke 12:22, which states, 'do not worry about tomorrow, for tomorrow will worry about itself'. As a result, the youths who attend this type of teaching appear to be skeptical of the reality in IWF and the function embedded in IWF. Second, many people begin to believe that believing in God makes them immune to extreme weather events. As a result, most IWF knowledge related to intestine reading and constellation of stars and moon is rarely practised by Christians, and only a few non-Christian elders continue to practise it. In Borana, indigenous weather forecasting is widely condemned by Christians as idol worship, and they even refer to them as 'witchdoctors', who are guided by evil spirits and cannot predict or change the future, which is determined and known only by God (Speranza et al. 2010).

The other challenge is the important role that modern education and technology have played in widening the generational gap. Nowadays, pastoral youths have access to technologies such as television, the Internet, and social media. Technology makes life easier, but not all of it is significantly useful. The response of pastoralists during FGD confirmed that access to school provides their youth with scientific knowledge; however, most of its philosophical teachings are rarely applied at the local level. As a result, pastoral children fail to complete secondary and tertiary education due to high dropout rates. Oromia regional state has the highest annual dropout rate (18.6%), with 40% of this occurring in the pastoral area (MoA 2014). Therefore, the students are vulnerable to obtaining a fragmented knowledge that would not help them successfully solve the problem at the local level.

When compared to 50 years ago, the likelihood of sending children to school has been growing. Pastoralists state that their children spend most of their time at school, primarily in the local town, and that they rarely visit family because schooling can take up to 10 months in a year. However, due to this circumstance, children did not have enough time to learn how to apply IWF in real life. Elders sadly predict and contend that 'we are at a cross road; neither our youth bring a science that can save our livelihood, nor IWF has assisted us in becoming self-sustaining'. Pastoralists responded in the FGD session that modern education is good as long as it allows our children to compete and work with the domestic and international communities; however, modern weather forecasting rarely helped improve the local-level difficulty that all households are exposed to. Several pieces of IWF knowledge were lost due to a complete lack of documentation. According to USAID (2008), IWF is deteriorating at an alarming rate in the absence of adequate documentation. Poverty, a lack of clear transferring knowledge, and poor documentation all contribute to indigenous weather forecasting skills' precarious survival in many places (Shoko 2012). In the absence of strong documentation and management, knowledge's accuracy declines as it passes from one generation to the next, and the most important attributes may be lost. As a result, some IWF knowledge is rarely used, and it is possible that it would be forgotten or used less frequently in the long run. In addition, some of the skills require extensive training and it being delivered orally can hinder a full-bodied knowledge transfer from one generation to the other (Elia et al. 2014).

Another challenge is the influence of climate variability on the spatial distribution of tree and insect species, which pastoralists use as an indicator for weather forecasting. With the fast and unpredictable pace of climate change, some of the plant species used by pastoralists to forecast weather appear to be becoming scarce. Plant and animal behaviour forecasts are thus highly challenged. Pastoralists responded by losing some of the plant species, animals, and birds that helped them predict flooding, heavy rain, and severe heat stress, the continuity of some IWF indicators is frightening. For instance, nowadays, insects such as the yellow butterfly (*Billaacha boora*), which indicates the coming of rain, are now becoming less seen in the area.

Pastoralists believe that 'the movement of a swarm of yellow butterflies from north to south indicates that rain will fall within a week'. Similarly, when they see a swarm of ladybugs flying around in search of shelter, they claim that cold weather is on its way. However, these insects are currently uncommon in the area. It is cognizant to the finding of Ayal et al. (2015) which states that some of the species used for weather forecasting are declining as a result of climatic weather variability and ecosystem disturbance.

In terms of continuity, despite all of the challenges, the majority of the IWF are still operational, and its future looks promising due to the relatively revitalizing practices of the Gadaa system. Youth in the Gadaa system are taught how to use and conserve knowledge for the common good. Despite the fact that the Gadaa system is under various pressures, the system's philosophy of community protection and knowledge production is paramount. Its role in resource management (plants, soil, water, and other wildlife) is strongly influential. The other promising condition is the 'pastoralism' way of life itself. Pastoralists have a tradition of leading communal life, with communal social networks that have helped them survive. Pastoralists consider indigenous weather forecasting knowledge to be a gift from 'God' to them (Ayal et al. 2015), and they are extremely cooperative in disseminating IWF knowledge to others. They have come to believe that the viability of their livelihood is inextricably linked to indigenous weather forecasting.

Conclusions

The research was carried out among Gujii pastoralists and focused on the state of indigenous weather forecasting, challenges, and knowledge continuity in the area. Several weather forecasting indicators are in use, each based on a different set of signs. The use of indicators such as biophysical and meteorological indicators is prevalent. Despite the fact that access to modern weather information services is critical for improving pastoral decision-making and increasing pastoralists' capacity to adapt to weather and climatic dangers, Gujii pastoralists rarely have it. As a result, pastoralists have relied on couples of indicators to forecast various weather phenomena. IWF has made a significant contribution to their livelihoods in decision-making, particularly when it comes to the coping aspect of climate risks such as drought and its consequences. Pastoralists prefer IWF to modern approaches because of its ease of use and educational simplicity. Frequently, the method of disseminating information is also simple and inexpensive. In the other case, they prefer IWF due to there is limited access to contemporary weather forecasts in the area. According to pastoralists' responses, IWF expertise can potentially make a big difference in areas where meteorological data is scarce. As an indigenous weather forecasting source of knowledge, various indications are used. Religion-related pressures, a lack of documentation, a persistent generation gap, and availability to some technologies that ignore knowledge have all contributed to the IWF's slow weakening. As a result, it is critical to enhance IWF by trying to reduce external constraints and revitalize knowledge. In addition, if the system of IWF co-production and meteorological forecasting is smoothed for higher weather prediction accuracy, it would be much welcomed by all stakeholders and policy-makers. The finding of this research indicates the result of IWF and modern drought indicating the persistence of drought events. Therefore, mainstreaming IWF expected to be policy priority when ensuring pastoral resilience is a matter of great concern. Thus, it is better if IWF is given attention in the way it is included in the curriculum so that best practices can be taken into consideration when planning for pastoralist development trajectories and formulating pastoral policy.

Abbreviations
CARE: Cooperative for Assistance and Relief Everywhere; CIFA: Central Institute of Freshwater Aquaculture; FEWSNET: Famine Early Warning Systems Network; FGD: Focus group discussion; IEW: Weather early warning systems; IK: Indigenous knowledge; IWF: Indigenous weather forecasting; KII: Key informant interview; MoA: Ministry of Agriculture; UNICEF: United Nations International Children's Emergency Fund; USAID: United States Agency for International Development.

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MG made substantial contributions to the conception, design, and drafting of the paper. AL and YM provided technical support, commented, and added to the draft. All authors approved the final draft for publication.

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Not applicable

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