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The Relevance and Practices of Indigenous Weather Forecasting Knowledge among the Gabra Pastoralists of Southern Ethiopia

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Abstract: Indigenous weather forecasting is utilized by numerous pastoralist communities throughout the world to take pivotal decisions on how to adapt to volatile ecological conditions. In many pastoral communities in Africa, indigenous weather forecasting knowledge abetted pastoralists to manage their livestock, reduce menace during adverse seasons and maximize prospects during favorable conditions. This study intends to assess the relevance and practices of indigenous weather forecasting knowledge, indigenous rain calendar and various indigenous indicators used to forecast the imminent weather events among the Gabra pastoralists of southern Ethiopia. The study is based on qualitative data gathered through key informant interviews and focus group discussions and the collected data was analyzed using thematic analysis. The findings show that the Gabra pastoralists possess a wealth of indigenous methods of weather forecasting knowledge which they use in their preparation for climate related events such as the inception of rainfalls and droughts. The Gabra pastoralists forecast the imminent weather events based on the keen observation of numerous indigenous indicators such as floras, faunas, wind, clouds, birds chirping, animals' behavior, intestine of slaughtered animals and star assemblages. Despite all the potency of indigenous weather forecasting knowledge, the application of such knowledge systems is challenged by factors such as disappearance of indigenous indicators, climate change, deforestation, religion restriction, culture change and top-down development interventions. In light of the practicality of indigenous weather forecasting knowledge and contemporary challenges outlined, the study suggests a synthesis of indigenous and conventional methods of weather of prediction to provide timely and applicable service to pastoralist communities.

Keywords: Indigenous knowledge, Weather forecasting, Gabra pastoralist, Ethiopia

Introduction

Understanding, predicting and anticipating changes in weather and other climatic variables is vital for rural communities, whose livelihoods rely directly on weather and climate conditions (Balehegn et al., 2019). Indigenous and local communities in Africa and elsewhere in the world that are inclined to disaster threats ably utilized indigenous knowledge as the basis for their decision-making to manage their livestock, natural resources and subsistence livelihoods. According to Johnson (1992) and Steiner (2008) indigenous knowledge is a body of knowledge developed by a group of people through

generations of living in close contact with the natural environment. These knowledge systems represent societies a massed knowledge and conceded on verbally from generation to generation through daily interaction (Ngulube, 2017; Mbewe et al., 2019). Despite, not equipped with scientific instrumentation and analytical tools and techniques, the local communities in Africa have developed the tremendous art of assessing weather conditions using their experience and accumulated knowledge of generations (Luseno et al., 2002; Eyong, 2016).

Indigenous weather forecasting, as understood today, relates to proficiency of measuring weather conditions in advance (Rautela and Karki, 2015). Hence, indigenous weather forecasting provides information and insights that can be used for effective adaptation to climate change as well as for preparedness of rainfall and drought events at the local level (Chisadza et al., 2015). As optimal management regimes in agriculture [crop and livestock production] depends basically on rainfalls (Luseno et al., 2002), indigenous weather forecasting is being developed with the thought that it might help pastoralists mitigate risk more skillfully, thereby helping avert crises (Barrett, 2001). Speranza et al. (2009) stipulated that agro-pastoralists in south-eastern Kenya observes the nature of clouds, faunas, floras, sun, moon, wind, migration patterns of birds and other physical changes in their environments to forecast the imminent weather conditions in their areas. Such indicators of rainfall forecasting, this way, made significant contributions towards more sustainable development (Zuma-Netshiukhwi et al., 2013) through providing early cautionary about possible risks or conceivably a good season that would enable timely planning for optimum productivity (Lwasa et al., 2017). However, many farmers and pastoralists in Africa are likely to suffer the most from direct and indirect climate change, owing to their close connection to the natural world and their condensed socio-ecological resilience (Zuma-Netshiukhwi et al., 2013). In Gaza province of Mozambique, it has been reported that the current irregularity and changes in weather and climate adversely bothered the interpretation, accuracy, and reliability of most of bio-physical indicators, and thus their farming activities (Salite, 2019).

Even though, climate change affects the whole world its impact is generous in least developed countries (Salza, 2019; Kidemu et al., 2020). The Ethiopian case is not different. Climate variability and changes have exerted inconceivable impacts on the livelihoods and well-being of pastoralists who inhabited the arid and semi-arid lowlands of Ethiopia. Despite the fact that, indigenous weather forecasting have been abetted the Ethiopian pastoralists (i.e., Gabra, Borana, Afar, Mursi, Nyangatom, Somali, Hamer, etc.) to deal with multiple threats and to estimably utilize the exceedingly flexible environments, factors such as frequent and severe droughts (Kidemu et al., 2020), lack of systematic documentation and coordinated research (Radeny et al., 2019), disappearance of bio-physical indicators (Ayal et al., 2015), fast pacing economic, political and cultural changes on a global scale (Kimani et al., 2014) had intensely deteriorated the utilization of indigenous weather forecasting knowledge systems. Along this line, numerous authors (Roncoli et al., 2002; Ayal et al., 2015; Kagunyu et al., 2016) have stressed that climate change and associated increase in weather variability have resulted in decrease in the fidelity of many of the indigenous weather forecasting knowledge. Thus, many pastoralists in arid and semi-arid lowlands of Ethiopia are deserting the utilization of indigenous weather forecasting as consequences (Balehegn et al., 2019). As Kimani et al. (2014) put it, the calamity of the imminent disappearance of indigenous weather forecasting is utmost evident to those who have developed it and make a living through this indigenous knowledge. Likewise, the ramification for others can be detrimental as well, when aptitudes, problem solving schemes and custodians are vanished.

For numerous generations, the Gabra pastoralists have developed the expertise of measuring forthcoming weather events using their know-how and zealous observation of various indigenous indicators. As many pastoralist areas of Ethiopia comprising the

Gomole district where the Gabra pastoralists mainly lives, don't have the access to scientific weather forecasting center that can deliver them with proper information facilities, indigenous weather forecasting was the sole sources of climatological information for preparation and alleviation against imminent risky climatic incidents. Notwithstanding their efficiency, the Gabra pastoralist's indigenous weather forecasting knowledge have not been scientifically documented in written form and thus are not reachable to researchers, development practitioners and other pertinent stakeholders. In addition, numerous indigenous indicators and custodians are at the margins of disappearances. Despite, numerous studies were previously piloted on the indigenous weather forecasting knowledge of the pastoralists and agro-pastoralists that dwelled in southern Ethiopia (i.e., Borana and Guji), the indigenous weather forecasting knowledge of Gabra pastoralists has not noticed adequately by the researchers. Hence, documenting and propagating as well as utilizing indigenous weather forecasting knowledge of the Gabra pastoralists in research and development programs will provides a rich ground for the development of the pastoralists in southern Ethiopia. Therefore, this research systematically investigated the indigenous weather forecasting knowledge of Gabra pastoralists and proposes the fundamental role of indigenous weather forecasting in sustaining pastoralist's resilience strategies. The objectives of this article were to explore the relevance of indigenous weather forecasting knowledge in adaptation to climate change; to identify the practices and various indigenous indicators used by the Gabra pastoralists to forecast the imminent weather conditions; and lastly, to illustrate the challenges presently faced by indigenous weather forecasting knowledge of the Gabra pastoralists in Gomole district of southern Ethiopia.

The article is organized into four sections. Below this brief introduction, materials and methods (incorporating the study area context) are discussed. While section three deals with results and discussions, the last section concludes and suggests the way forward.

Material and Methods

Study area

Gomole district is situated in the Borana Zone, Oromia National Regional State, Ethiopia. It lies between 20° 17′ to 16° 35′ north latitude and 29° 30′ to 30° 19′ east longitude. It is located at 40 km from Yabello, capital of Borana zone. It shares its boundary with Fincawa district to the north, Yabello district to the south, Arero district to the east and Elwaye district to the west (Figure 1). Gomole district comprised of 14 Kebeles (smallest administrative unit beneath the district administration) namely Surupha-magala, Kella-qufa, Haro-bake, Abbunu, Buya, Surupha-badiyya, Bildim, Tulla-wayyu, Dasse-gora, Dambala-saden, Harboro, Tullu-qobo, Selle and Dhaka-barru. Gomole district is home to groups of pastoralists and agro-pastoralists comprising Gabra, Borana and Guji. Out of 14 Kebeles that were inhabited by these three Oromo tribes, five Kebeles *i.e.,* Surupha-magala, Haro-bake, Buya, Surupha-badiyya and Tullu-qobo, were purposively selected for this study as they were mostly inhabited by the Gabra pastoralists. The Gabra are members of the larger Oromo speaking camel pastoralists occupying southern Ethiopia and northern Kenya. The Gabra in southern Ethiopia and in northern Kenya are called Gabra Migo and Gabra Malbe, respectively (Soga, 2006). The Gabra pastoralists is organized according to patrilineal descent and its basic unit is *gosa* (clan). There are about twelve clans in the Gabra society (i.e., Kabarkal, Jiriwa, Adotile, Lossa, Qoowa, Doliyo, Artiwina, Magale, Allamalo, Sukubtire, Uchota and Darawa), comprising of 43 *mana* (lineage). The division goes-up to a single family in which mana is divided in to *balbala* (minimal lineage) and *worra* (extended family). Another basic categorization vital to

understand Gabra pastoralist social structure is the twofold exogamous division of the society in to *Jiblo* and *Lossa* moiety. Hence, all aforementioned clans belong to either of the two moieties.

Traditional animal husbandry has been the prevailing economic activities of the Gabra pastoralists for centuries. They are usually pastoralists relying on camels, goats, sheep and a petty number of cattle. However, the Gabra are predominantly camel herders, and all their relations are strengthened by the common doctrines and codes of conduct involved in nursing after their camels. In addition to pastoralism, the Gabra pastoralists also have practiced trivial livestock trade to supplement their means of subsistence livelihoods.

The Gabra pastoralists are interleaved in toughest environments, where resources like grassland and water are erratically available. According to Ethiopian Metrological Agency (2021) the mean maximum and minimum temperatures of Gomole district is 31°C and 13°C respectively and has semi-arid weather conditions with rainfall fluctuating between from 300 mm to 500 mm per annum. Rainfall is bimodal with the long rainy season of *ganna* commence from March continuing to the end of May and the short rainy season of *hagayya* from September lasting to the end of November.

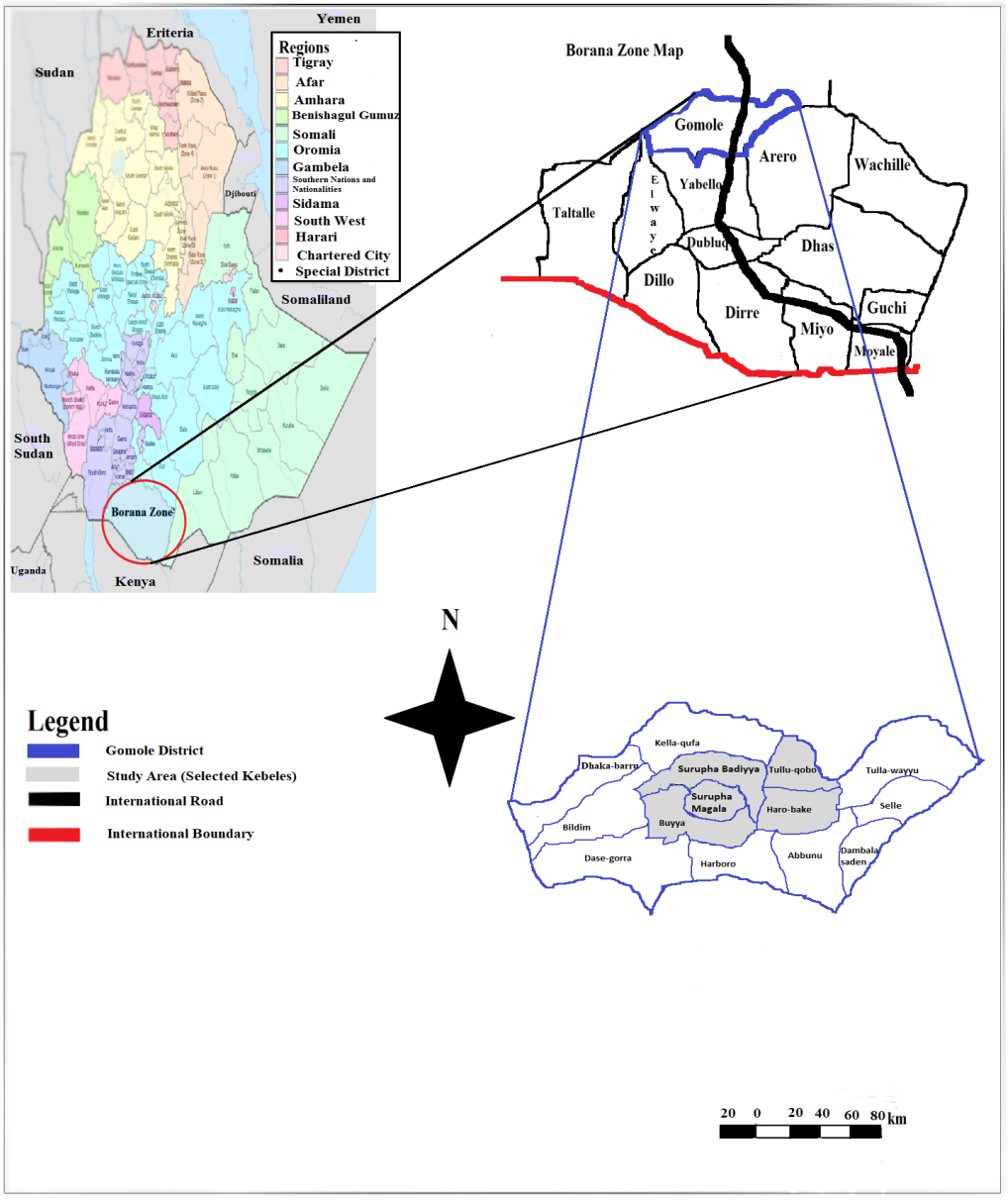

Figure 1 – Map of the study area

Data Collection

The study was conducted in Gomole district of Borana zone administration, Oromia National Regional State, Ethiopia, from February 10 to April 1, 2020. Qualitative methods of data collection such as key informant interview and focus group discussion were used to access participant's interpretations and opinions in their natural scenery. Qualitative data collection methods play a substantial role by providing information useful to understand the processes behind observed results and assess changes in people's perceptions of their actuality.

While selecting participants for key informants' interviews and FGDs, purposive sampling was used. Purposive sampling is the most common sampling strategies, that help the researcher decides what needs to be known and sets out to find people who can and are willing to provide the information by virtue of knowledge (Bernard, 2002).

The subsequent research questions were drawn to achieve the main objectives of the study:

a. What is the relevance of indigenous weather forecasting knowledge in adaptation to climate change?
b. What are the practices and indigenous indicators used by the Gabra pastoralists to forecast the forthcoming weather conditions?
c. What are the challenges presently faced by indigenous weather forecasting knowledge?

Key Informant Interviews

Key informant interview under the semi-structured interview method allows flexibility for the researcher throughout the interview progression to explore new ideas and issues that have not been expected in planning study. Two early warning experts from Gomole District Disaster and Risk Prevention Office (GDDRPO) were selected for key informant interviews on their basis of their affiliation to the subject under the investigation. Key informants from the community were selected by the eminence of their role within the community, knowledge, willingness, and information. Hence, five key informant interviews were piloted with the knowledgeable elders who have lived there and had potential insights on the indigenous weather forecasting methods. In sum, seven key informant interviews were conducted with government office specialists and well-informed elders to acquire the precise facts about the indigenous weather forecasting knowledge of the targeted society.

Focus Group Discussions

According to Mishra (2016) focus group discussions (FGDs) are used for generating data on collective views and the meanings that lie behind those views. Five FGDs, one in each selected Kebeles (i.e., Surupha-magala, Surupha-badiyya, Buya, Haro-bake and Tulu-qobbo) having seven to eight participants per-sessions which involved knowledgeable Gabra elders, local communities and aged women (ranging from 54 to 83 years of age), were conducted to confer on the relevance of indigenous weather forecasting in adaptation to climate change, indigenous rain calendar, practices and indigenous indicators of impending weather events and the challenges presently faced, freely with guidance from the researcher. Out of the five FGDs, two were conducted with women to represent their views. According to Mishra (2016) the ideal size for FGD ought to be 6 to 8 participant's per-session. For this inquiry, sample size for FGD was acclimatized by two factors: the group must be small enough for everyone to participate and more manageable in contrast

to the larger group, typically is stiffer for a researcher to control. A total of 38 informants were participated in the five FGDs.

While selecting participants for FGD sessions, the issues of age and gender were pondered in order to attain a comprehensive data. Because FGD is a good way to gather people from similar backgrounds or experiences to discuss a specific topic of interest (Mishra, 2016). These assemblages were proposed to make FGD participants liberally to confer and express their knowledge and opinions with group members (Mishra, 2016).

Data processing and analysis

The data collected from key informant interviews, FGDs and secondary sources were systematized and interpreted in relation to the research intents. This was followed by identifying, analyzing, and reporting themes within the data to develop categories and sub-themes. These themes encompassed the relevance of indigenous weather forecasting; detail practices comprising the observation of various indigenous indicators of imminent weather events; and the challenges faced by indigenous methods of weather forecasting. Thus, the collected data were analyzed in a similar way based on a three-stage procedure suggested in the literature: preparing the data for analysis by transcribing reducing the data into themes through a process of coding and representing the data.

Results and Discussion

The relevance of indigenous weather forecasting in adaptation to climate change

The Gabra pastoralists have utilized their indigenous weather forecasting knowledge since ancient time to manage scanty pasture and water resources, to adapt looming weather events and forecast the destiny of imminent season. Due to the truancy of modern weather prediction in the study area, indigenous weather forecasting is the merely available source of imminent weather events that utilized to sustain the livelihoods under progressively variable climate conditions. As pastoralism is extensively rain-fed production system, weather prediction particularly rainfall and information sharing is vital for the Gabra pastoralists adaptation to climate change. Likewise, a study by Shoko and Shoko (2013) indicates that indigenous weather forecasting is fundamental to any planning process at the lowest level and enables local communities to act in a timely way.

Historically and to date, indigenous and local communities in different parts of the world have sustained to rely on indigenous knowledge to conserve their environment and deal with natural disasters (Chang'a et al., 2010). According to the findings of this study, indigenous weather forecasting was applied for preparation and mitigation against perilous climatic events and survival during the events. The basic strategy implemented by the Gabra pastoralists in curtailing vulnerability to climate change jeopardies is the application of early cautionary system. In Tanzania, Chang'a et al. (2010) observes that rural communities, predominantly those in droughts prone areas have generated a vast body of indigenous knowledge on disaster hindrance and alleviation through early warning. Early cautionary systems have been ascertained to be indispensable in preparing for weather related events such as the inception of rainfalls and droughts. As informants stated, once receiving alert from indigenous weather forecaster regarding the imminent risky drought events the Gabra pastoralists utilized various risk aversion strategies such as livestock mobility, herd splitting and herd diversification to sustain their livelihoods and the livestock as well. In Gomole district the shortening of drought cycles and its prevalence, have forced the Gabra pastoralists adeptly to practice livestock mobility in order to withstand the impacts of climate change and to ease forage shortage during the lingering drought periods.

A key informant elucidated the subsequent, vis-à-vis the correlation between weather prediction and livestock mobility:

> *Once perilous weather events forecasted [delay in rainy season predicted] usually we migrate our livestock (specifically camels) to the neighbouring Soyama special district in Southern Nation, Nationalities and Peoples Regional State and sporadically to Arero district. Soyama special district is the utmost preferable ephemeral grazing area for us owing to its swampland and catchment scrublands that are suitable for our camels. Correspondingly, we migrate back to our main camp in early Jibor jiddu (October) and Sooma (March) when the imminent rainy season is anticipated to perform well.*

Similar evidence (for example, Speranza et al., 2009) in Kenya has shown that understanding the degree to which local people perceive drought risk and vulnerability to be controllable is crucial for designing mitigation measures to reduce vulnerability to drought. In addition to livestock mobility, the Gabra pastoralists also have practiced herd splitting and diversification as a risk alleviation strategy as each livestock species adapts differently to drought incidents and thus, these customary practices certify that there were stayers in whatever climatic events. This robust role of indigenous weather forecasting knowledge abetted the Gabra pastoralists to adapt to climate change exposure to a great magnitude.

Traditional rain calendar of Gabra pastoralists

In order to help evaluate and monitor imminent incidents, the eco-chronology of the pastoralists must be recorded and updated by the indigenous expert's professional in specific knowledge bases (Salza, 2019). An approach to this activity lies in dubbing of the seasons and years in the indigenous rain calendar of the Gabra pastoralists. Customarily, the Gabra pastoralists have four seasons in a year *i.e., hagayya (*short rainy season), *bonna* (long dry season), *ganna* (long/main rainy season) and *addollessa* (relatively colder season) (see Table 1 for the detail). Among the Gabra pastoralists, each day, months, seasons and years are linked with particular weather arrays, the truancy or a good rainy season and natural resources prosperity.

Seven years cycle

The Gabra pastoralists record a precise sequential history by involving the utmost important incident of the year in the community to the 7-year cycle. According to the findings of this study, a *wagga* (year) comprised 360 days with 12 lunar months in a year (Table 2). Each week has seven days, termed as follows:

1. Alasnin – Monday
2. Talada – Tuesday
3. Arba –Wednesday
4. Kamisa – Thursday
5. Gumata – Friday
6. Septi – Saturday
7. Ahada – Sunday

Each of these days has a year dubbed after it and thus, after every seven years it is supposed that life will made one episode. To tell one from the other, after a cycle of 7 years a nickname is added. Dubbing the years in this manner echoes which events are considered most important by the Gabra pastoralists. Hence, New Year's Day as well as the last, day

of the lunar year always fall on the same day of the week, and the subsequent year begins on the next day of the week (Soga, 2006). For instance, if the year *Talada* (Tuesday) materializes to be a year of plentiful rain, in the subsequent cycles it is supposed that this incident will reappear itself after seven years. Thus, *Talada* year was dubbed as *Talada* year of the plentiful rain. Through this dubbing system, all pivotal ecological and climatological figures is propagated and retained for imminent generations. As a result, the appellation of years is vital to indicate all climatological sequences as well as subsequent incidents.

The task of unfolding imminent weather events based on calendar sequence is performed by traditional weather forecaster and disseminated to the local communities through customary leaders (*i.e., abba olla*/village chiefs, *jaarsaa gosa*/clan leaders, and *jaarsaa*/elders) and other pertinent individuals. Therefore, comprehending the traditional rains calendar is a fundamental part of Gabra pastoralist's indigenous weather forecasting knowledge and related livelihoods management.

Table 1 – Traditional Gabra pastoralist's portrayal of rainy seasons

TAXONOMY OF THE SEASONS	MONTHS AND DURATION OF THE SEASONS	DESCRIPTION OF THE SEASONS
Hagayya	September - November	The Gabra pastoralists considered *hagayya* rainy season as the second utmost vital rainy season, next to the *ganna*. The extent of *hagayya* rain is exceedingly slight. Thus, the Gabra pastoralists used *hagayya* rain as a transitory to the main rainy season of *ganna*. Meanwhile, a trivial *hagayya* rainy season is not plentiful to sustain all livestock; the Gabra pastoralists exhaustively utilized available water and rangeland resources till *ganna* rainy season begins.
Bonna	December - February	*Bonna* (all months falling between December and February) is a hot and dry period following the petty rainy season of *hagayya*. *Bonna* season is characterized by hot weather, dusty wind and no discernable cloud in the sky.
Ganna	March - May	*Ganna* is the main rainy season that fall between the months of March and May. The *ganna* rainy season commences as light rain during late March and reaches its climax during the month of April and decreases during early May. The Gabra pastoralists deliberated *ganna* rainy season as a season of plenty of livestock products. Because the *ganna* rainy season is the merely season in which the Gabra pastoralists abundantly attain rangeland and water resources to their livestock.
Addollessa	June - August	*Addollessa* is a designation given to a generally cold season falling between the months of June and August. During the season of *addollessa* there is no rain, but there is occasionally small precipitation and hazy sky. *Addollessa* season is characterized by relatively colder or lower temperatures.

Table 2 – Indigenous months of Gabra pastoralists

LOCAL VERNACULAR	ENGLISH NAME
Jibor qara	January
Jibor jiddu	February
Jibor ege	March
Somder qara	April
Somder ege	May
Sooma	June
Furana	July
Sikittal	August
Arafa	September
Daka	October
Ragara	November
Mawlida	December

Traditional calendar of guyya dhibbaa (100 days)

Typically, the Gabra pastoralists recounted 90 days of *bonna* season between the last day of *hagayya* rainy season and the beginning day of *ganna* rainy season. Accordingly, once the *bonna* period ends after approximately 90 days, the Gabra pastoralists conceivably added 10 days for the *ganna* rains to fall in line with the weather prediction. If rain doesn't fall within the 10 days, additional 30 days are added as a transitory period before a succeeding forecast. Thus, rains are anticipated to fall within the waiting epoch of 30 days. Comparably, Roncoli *et al.* (2002) also noted similar perception among Burkina Faso farmers who predict "the onset of rains by counting 182 days from the beginning of the cold-dry period. That is, farmers count 91 days for the cold-dry period plus 91 days for the hot-dry period before the next season should start (p. 414)."

The practices of indigenous weather forecasting by Gabra pastoralists

The Gabra pastoralists forecast the imminent weather events based on the observation of various indigenous indicators such as floras, faunas, wind, clouds, animal behaviors, birds chirping, intestine of slaughtered animals and star constellations. Thus, the subsequent section briefly describes on the indigenous practices and bio-physical indicators that were used by the Gabra pastoralists to forecast the imminent onset of rainfalls and droughts events.

Flora indicators

Traditionally, the Gabra pastoralists observe the maturing and blossoming of some flora species to forecast the destiny of imminent weather events. The local floras that were used by the Gabra pastoralists to forecast the imminent weather events begins flowering and their leaves were turned into intensely green during the proximate onset of *ganna* rainy season. Informants stated that the budding and blossoming of certain floras species during the culmination phase of *bonna* season is associated with the imminent inception of rainy season. The floras that blossom in the anticipation of approaching *ganna* rainy season were *Dhaddacha* (Acacia tortilis) and *Burquqe* (Acacia nilotica). Likewise, when floras locally called *Handada* (Entada leptostachya), *Bisduga* (Kirkia burgeri), *Burra* (Acacia goetzei) and *Rukessa* (Combretum molle) leaves profoundly turned into green during the month of *Somder ege*, a good rainfall is predicted for imminent ganna rainy season. These heralds

are usually witnessed within one month before the *ganna* rainy season pledges. Key informant and FGD participants unveil that unusual tumbling and drying of these floras before their plentifully maturing and blossoming periods are considered as a herald of drought incidence in the imminent season.

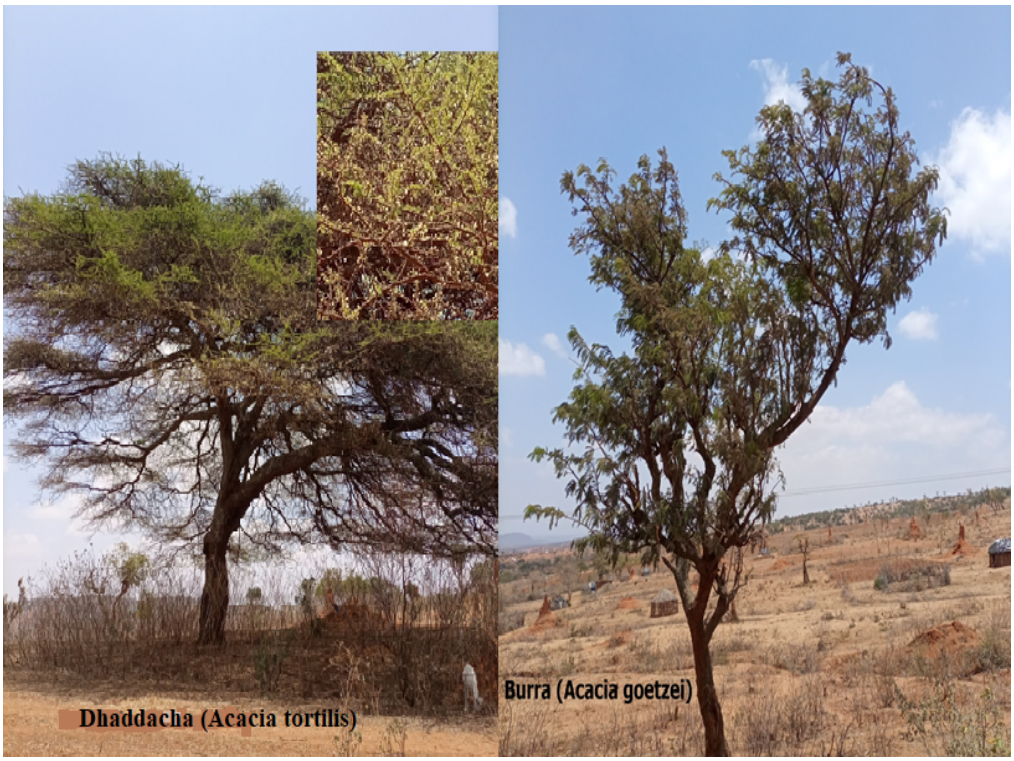

Figure 2 – Showing blossomed Dhaddacha tree on the left side and Burra tree on the right side that deeply turned into green during the approaching main rainy season of ganna

The effective utilization of aforementioned indigenous indicators is decisive with regard to the promotion and viable conservation of natural environments. Thus, the utilization of these robust indicators alludes to the necessity to preserve and protect the plants bearing these indicators (Jiri et al., 2016).

Animal behavior indicators

The Gabra pastoralists envisage the imminent weather events based on the observation of alterations in animal behaviors at certain phases of time. The Gabra pastoralists customarily thought that the specific conducts of animals during the near onset of rainy season would give implications about the imminent weather events. According to informants' interpretations, a good ganna rains would be predicted if camels show the subsequent behaviors:

- When camels showed unanticipated habit of searching for bones and nibbling it like foliage, it is assumed that good rains are anticipated to fall in the imminent ganna rainy season, approximately in less than one or two weeks.
- When camels refuses to drink water at a water point and expose themselves to hot mid-afternoon sun during the month of *sooma*, it is predicted that heavy rain will fall in less than one week period.

- Usually, camels urinate by splitting their rear legs; however, if camels intertwine their rear legs while urinating, it supposed to indicate imminent rainfall onset and a good rainy season ahead.
- Few days before the inception of either *ganna* or *hagayya* rainy season, camel refuses to enter and congregated in front of their *moona* (pen). The repudiation to enter into their *moona* is considered as a herald of imminent good rainy season. This comportment was construed that if the camels discerned the rains falling hastily, they envisage the *moona* would be swamped and muddy, thus inappropriate for them to enter into their *moona*. Because they have instinctively smelled rains, and trying to elude being swept away by flood.

To the contrary, when camels continuously *olola* (howled) for long time while they were in their *moona* and lactating camels refused to feed breast their calf. When they refused to go and browse in a proximate pasture while favoring to stay nearby water point after drinking are considered as heralds of drought incidence in the imminent season. In addition, when cattle defected and urinated while they are napping in their *moona* is also regarded as a herald of drought incident in the forthcoming season.

There are also wild animals whose behaviour is witnessed to forecast imminent weather conditions. According to the informants, when *worabessa* (hyena) yawed early in the morning or late in the afternoon around 4 or 5 am and cannot eat when they find the remnants of dead animal, unlike hitherto, it is considered as an indication of near rainfall onset. Similarly, when *jedala* (fox) yelled near the village for two or three consecutive days, it is assumed that rains shall fall in a short period of time.

Bird indicators

Among the Gabra pastoralists, the singing and twittering of particular birds are anticipated to be a valuable indicator for the inception of the rains and season quality. According to informants, there are three birds that are commonly used by Gabra pastoralists to forecast the imminent rainy season onset and their magnitude *i.e., Bararato*, *Alikima* and *Gurgudde*. When *Bararato* and *Alikima* birds keep singing at mid-night during the month of sooma they are assumed to indicate the imminent onset of good ganna rains. Conversely, *Bararato* and *Alikima* birds would not sing if there is a delay in rainy season or calamitous drought ahead. A key informant stated that while singing at midnight *Gurgudde* bird makes two types of sounds to signify the extent of imminent rainy season. Accordingly, when *Gurgudde* bird sings for long time it signifies imminent rainfall onset and prospect for good season. The Gabra pastoralists consider this to be reliable as they will not be seen either day time or night, however merely sound to be heard.

Conversely, when *Gurgudde* bird sings for a short time (two or three times) it is regarded as an indication of imminent drought incidences (scanty rains). Divergent to the Gabra pastoralists the tradition among the Borana pastoralists of northern Kenya envisages that "when *Lo Laase* bird makes sound only once or twice it predicts the coming of the rain in a short time. When it makes a prolonged call, it predicts that the rain may not fall as God had refused to hear its cry (Luseno et al., 2002, p. 78)."

Wind indicators

The Gabra pastoralists observe the direction and magnitude of winds that blows at different seasons to forecast the imminent rainfall onset and drought incidents. According to informants, when a dusty fast wind blows from west to east, it is considered as a virtuous indicator of imminent rains that likely falls within days. On the contrary, when fiercely wind continuously blows from east to west direction during the near onset of rainy season is considered as an indication of drought or delay in the imminent rainy season. Mbewe et

al. (2019) also reported similar perception among the Mukonchi Chiefdom of Zambia who considered that when wind blows from west to east, then good rain is expected to fall within an hour and divergent results from Chengula and Nyambo (2016) in Tanzania.

In sum, the Gabra pastoralists witness the blowing of winds from west to east during the months of *Somder ege* and mid *Sooma* for *ganna* rainy season and from *Jibor qara* and conversely in early *Jibor jiddu* for hagayya rainy season, to forecast the extent of imminent rainy season.

Cloud indicators

The configuration and advent of heavily dark clouds on the *illa boru* (east direction) signifies the incidence of good rains is near to commence. FGD discussants revealed that, when dark clouds proceeded by ferocious winds, it is considered to indicate the interruption or likelihood of trivial rains coming in an hours. Because the Gabra pastoralists thought that ferocious winds avert the likelihoods of attaining rainfalls from area to the others through a blowy weather.

According to the Gabra herders, there are two types of cloud formations, namely *dumessa rooba* (rainy cloud) and *dumessa rooba hin ta'in* (non-rainy cloud). *Dumessa rooba* is the types of cloud formation which is stable and dark in colour and it is considered as a good indicator of rains to befall within hours. *Dumessa rooba hin ta'in* is also the types of cloud formation which hastily move with imprecise colour from east to west direction and it is considered to indicate the interruption of imminent rainfall season. Hence, where the cloud appearance is related to the coming of rains, also this indigenous impending weather indicator could be kept being related to scientific reasoning.

Intestines reading

In contrast to plant based weather forecasting, merely a few indigenous experts, called *uchu*, are considered to have the skill of reading different signs of animal intestines to forecast imminent weather events (Ichiro, 1982). While most domestic animals (*i.e.,* cattle, goats, sheep and camel) intestines were used to forecast the imminent weather events; the Gabra pastoralists predominantly used sheep and goat intestines to forecast the imminent weather and climatic incidents. The Gabra pastoralists assumed that both sheep and goat bowels is the most reliable to forecast the upshot of imminent rainy season quality. Among the Gabra pastoralists the practice of intestine reading is not merely utilized for rainfall forecast but also utilized to forecast imminent incidents like war and fortunes.

According to informants' interpretations once slaughtering was done, intestine would be detached and placed on an apparatus locally called *moyye* (container traditionally used to pound maize and other grains) to forecast imminent weather events based on the distribution of intestine structures. The practice of intestine interpretations would take place as follows:

- When darker spots are witnessed on the intestine swathe, it signposts that there will be plentiful rainfall in the coming rainy season. Because the dark spot is considered as equivalent to dark cloud.
- When more blood spotted in the interior parts of intestine, it is considered as an indicator of near rainfall inception and a virtuous rainfall season ahead.
- When the blood veins unevenly seen on the exterior parts of the intestine, it means that there will be trivial rainfall in the imminent rainy season.
- The prediction for imminent drought will be made if blood is not seen in the vessel and intestine look bright; thus, it is anticipated that the subsequent season will be affected by drought.

Star constellations

The practice of forecasting imminent weather events based on the orientation and assortment of stars discernable in the nocturnal sky is habitual among the Gabra pastoralists. Star gatherings and the time of their appearance signpost rainfall patterns and sequences for predictable rainfall events and mark key points in relation to the imminent season. Typically, the Gabra pastoralists witnessed three stars *i.e., torban*, *busana* and *bakalcha* to forecast imminent weather events. All of them navigate from the east to west direction. Usually, these clusters of stars merely appear when the rainy season of *ganna* is near to commence. Instances, of interpretations are:

- The *torban* stars are a group of seven stars situated in set of 3 and 4 respectively. When the two stars among the seven of torban stars descend below the western horizon late at night around 5 or 6 pm, it is anticipated that the ganna rains will fall likely within the span of a week. However, the prediction for drought will be made when the stars of *torban* appear in the western horizon and rains are not rained within the expected days. Thus, it is predicted that there will be a shattering drought ahead.
- When *busana* (the group of seven stars) appears in the eastern horizon and slope in the western horizon, the ganna rainy season will commence approximately within a week. Nevertheless, the prediction for drought will be made if busana stars are not descended below the western horizon. In addition, during the ending phase of ganna rainy season there is a heavy rain that locally called *booka busana bussu* (a rainfall that downed *busana* stars to eastern horizon); thus, it is believed that ganna rainy season will be terminated once this heavy rain is showered.
- If *bakalcha* star slopes in the eastern horizon and resurfaces in the western horizon within seven days, it indicates imminent rainfall inception and a good rainfall season. However, if bakalcha star slopes in the eastern horizon and resurfaces in the western horizon within 70 days, slight rain is predicted to fall.

Challenges faced by indigenous weather forecasting knowledge of Gabra pastoralists

Meanwhile, indigenous weather forecasting methods have evolved over long periods of time to fit site specific patterns, pastoralists perceive these methods as reasonably accurate (Luseno et al., 2002). Obviously, indigenous weather forecasting knowledge is embedded in culture, known by all and can easily be practical whenever necessary. Indigenous weather forecasting knowledge has been used in the study area for climate change adaptation strategies. The utilization of adaptation strategy is decidedly dependent on time and place as they are subjective to indigenous observations and indicators at the local level. Despite all the potency of indigenous weather forecasting knowledge in the study area, presently their application is facing tormenting challenges owing to numerous factors that deteriorated their practicalities. According to the findings of this study, the notable challenges that was encountered by indigenous weather forecasting knowledge of the Gabra pastoralists in Gomole district include the disappearance of indigenous indicators, climate change, deforestation, recurrent drought, religion restriction, culture change and top-down development interventions.

The disappearance of indigenous indicators in Gomole district owing to climate change, deforestation and recurrent drought have accelerated the decay of indigenous

methods of weather forecasting. Local floras such as *Dhadacha*, *Rukessa*, *Handada*, *Burquqe* and birds such as *Gurgudde* and *Alikima* that were frequently used as indigenous rainfall indicators by the Gabra pastoralists are currently at the verges of disappearance. Moreover, as the Gabra pastoralists are the follower of Islam religion, some members of the communities considered the application of indigenous weather forecasting as sorceries and commanded by irreligious spirit that strictly forbidden by Islamic faith. Soga (2006) unveiled that Islam regained a hold in the Gabra society in the early 1950s under the influence of the Somali political movement. Consequently, the conversion of Gabra pastoralists from indigenous religion to Islam has prompted a significant change to their culture, comprising changes in indigenous weather forecasting knowledge into the pathways through which cultural change affected overall indigenous weather knowledge practices.

Moreover, a key informant and FGD participants commonly itemized that presently the guardians of indigenous weather forecasting knowledge of the Gabra pastoralists are dwindling at an alarming rate. Although the Gabra elders continued to propagate their weather forecasting knowledge to all interested individuals; the younger members of the communities are unenthusiastic to partake in sustaining the expertise. In addition to the demise of custodians and living organisms such as plants and animals are also promptly disappearing owing to climate change as well as a lack of adequate documentation in Gomole district. Balehegn et al. (2019) attested that despite the weakening of indigenous weather forecasting knowledge, there is also a minimal alteration towards the use of conventional weather forecasting and climate information systems among many African pastoralists. A key informant from Gomole District Disaster and Risk Prevention Office reported that, even though, conventional climatological forecasts were sporadically disseminated to the Gabra pastoralists twice a year since 2017 ... they continued to worth indigenous methods of weather forecasting and utilize them for authentication of conventional methods of weather prediction. This is mainly due to the many limitations of modern weather forecasting and climate change information when it comes to its application and use in pastoral societies (Balehegn et al., 2019).

Nevertheless, with increasing rendezvous of governmental and non-governmental organizations in climate change adaptation and application of indigenous weather forecasting, the integration of local community's knowledge is not considered. In Gomole district, numerous generations of top-down development interventions purposely evaded indigenous knowledge on the grounds that modern models were superlative. Alemayehu and Doda (2020) indicated that development interventions such as adaptation to climate changes, conservation of natural resources and others, have variant implications for local knowledge. As a result, any plan to improve the quality of life of the local people will be vain if it doesn't confess the knowledge of the local communities. This study indorses that it is fundamental to use a synthesis of indigenous and conventional weather prediction methods to provide timely and applicable services to pastoralist communities.

Conclusion

In conclusion, the Gabra pastoralists have utilized their indigenous weather forecasting knowledge since ancient times to determine the grazing configurations, seasonal livestock mobility and acclimate to impending weather events. The Gabra pastoralists forecast the impending weather incidents based on the observation of various indigenous indicators such as floras, faunas, wind, cloud, birds chirping, animals' behavior, intestine of slaughtered animals and stars constellations. Notwithstanding all the effectiveness of indigenous weather forecasting knowledge in the study area, presently, its applications is under jeopardies owing to various factors that deteriorated their viabilities. This paper demonstrates that efforts ought to be made to protect indigenous indicators (i.e.,

floras, faunas and other pertinent natural resources) as fundamental elements of our ethos in the course of weather forecast.

Conventional and indigenous weather forecasters can work together to produce a comprehensive climatological information that meets the needs of local communities. Even though, growing engagements of governmental and non-governmental organizations in climate change adaptation initiatives, the integration of indigenous knowledge is not paid adequate consideration. The application of indigenous knowledge in climate change adaptation would provide appropriate mechanisms for a participatory approach, which is a foremost requirement for the sustainability of every project at the grassroots level. Any intended development interventions in climate change adaptation and management of scarce water and rangeland resources will be futile if it does not recognize the knowledge and participation of the local communities. Hence, this study concluded that weather prediction and propagation must be incorporated into a joint strategy that ensures collaborative mechanisms among the modern and indigenous knowledge in order to produce a more precise and socially applicable weather forecasting system.

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