Chapter 8

Revisiting Indigenous Biotic and Abiotic Weather Forecasting for Possible Integration with Scientific Weather Prediction: A Case from the Borana People of South Ethiopia

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Additional information is available at the end of the chapter

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Abstract

This study assesses how Borana herders make weather forecast using abiotic and biotic indicators. Survey questionnaire, observations, focus group discussions, and key informant interview were employed to obtain data. Field data were analyzed and interpreted using appropriate analytical tools and procedures. The result revealed that the Borana herders have time-tested weather forecasting experience of using astrological, intestinal, plant, and animal body language indicators. Astrological and intestinal readings that need special training and local expertise are known as *Urgii Elaltus* and *Uchuu*, respectively. Forecast information is disseminated using the Borana sociocultural institutions. Based on the disseminated forecast information, the Borana herders take measures such as strengthening enclosure, storing hay, migrating with animals, destocking, and changing schedules of social and cultural festivities such as wedding. The precision and credibility of traditional weather forecast steadily declined and led to repeated faulty predictions. Poor documentation and knowledge transfer system, influence of religion and modern education, premature death of forecast experts, and expansion of alcoholism were identified as causes undermining the vitality of Borana indigenous weather forecast. It is high time that the tenets of indigenous weather forecasting be assessed scientifically and be integrated into the modern science of weather forecasting before they vanish.

Keywords: weather forecasting, indigenous knowledge, abiotic, biotic

1. Introduction

Indigenous weather forecasting system is dynamic and is built on observation and long years of experience [1]. The importance of indigenous knowledge transcends the culture from which it is born and offer exciting insights to scientists and others who seek to assist the development of local people [2]. Agricultural decisions, such as the timing of planting, indigenous ranch management, herd composition, and number, are highly interlinked with anticipated weather phenomenon [3, 4]. Hence, the capacity of people to be drought resistant is highly related to the precision and credibility of their indigenous weather forecasting systems [5–8].

Different cultures make use of biotic and/or abiotic indicators to forecast about the future weather conditions. For example, atmospheric conditions and astronomic, plant, human, and animal indicators are used in Zimbabwe for weather forecasting [9, 10]. Besides, traditionally, the behavioral changes of some animals and birds, change of wind directions, and phonological changes in plant species are used to make weather forecast in Ethiopia, Nigeria, and Kenya [1, 3, 11, 12]. Astrology is also cited in Kenya. The ritual observation of the Pleiades alignment is used for weather forecast in Peru and Bolivia [13]. Cultural and ritual specialists in Burkina Faso observe plant and animal behaviors for the same purpose [14]. In Uganda indigenous weather forecasting is made based on cloud color, features of vegetation, the cycle and shape of the moon, and seasonal calendar [15], while in Swaziland, reading animal behavior and environmental clues are the sources of weather forecasting indicators. In western Ethiopia indigenous experts have a sophisticated indigenous knowledge of weather forecasting by way of reading and interpreting astrological phenomena [16]. The list goes on and is too much to mention all, and much commonality is shared in different cultures. History shows that over the last 400 years, the Peruvian and Bolivian Andes people were able to forecast El Nino years based on indigenous weather forecasting.

However, studies show that in recent years the vitality of indigenous weather forecasting mechanisms is declining. Among many factors the disappearance of biotic indicators and the influence of religion and modern education [10, 17], poor documentation and knowledge transfer mechanism [9, 18], generation gap, poor finance, and passing away of skilled persons [15] are identified as causes for the gradual weakening of the precision and acceptance of indigenous knowledge of weather forecasting. In addition to examining how the reality of the study area feeds into the short survey made above, this study extends the discussion to forecast dissemination systems and reaction of the herders to the forecast information.

Most related studies are highly descriptive (of the view of indigenous people) and lack critical appraisal on how to determine the validity of indigenous weather forecasting system. In a bid to address that lacuna, this book chapter assesses the relative merits and demerits of different indigenous weather forecasting systems and their level of acceptance by the people. It is hoped that it would make significant contribution as to what policy directions should be followed vis-à-vis agricultural development programs. Attempt is made to distinguish aspects of indigenous weather forecasting that could be readily dismissed as superstitious from those that merit appreciation for scientific validation.

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2. Study area and research methodology

2.1. Study area

Borana zone is found in Oromia Regional State of Ethiopia between 3°36'–6°38' N and 36°43'–41°40' E [20]. The zone covers a total area of 35,000 km^2 [19]. The study site experienced semiarid climatic condition and has four distinct seasons. These are small rainy season, hot dry season, main rainy season, and cool dry season that roughly cover from September to November, December to January, March to May, and June to August, respectively. The rainfall amount decreases toward south, and annual rainfall amount ranges between 400 and 600 mm. The study site receives 59 and 27% of its rainfall during the main rainy season and small rainy season, respectively. There is no perennial river which crosses the study site [20]. In the study site, pastoralism is the dominant way of life. This study was conducted in Yabello and Arero *woredas* (districts) of CCAFS 30 × 30 block learning site.

2.2. Research methodology

2.2.1. Study site, sample size, and sampling technique

Dida Hara PA in Yabello and Alona PA in Arero of CCAFS learning site were purposefully selected for the study. For questionnaire survey 200 herders were selected using simple random sampling technique. A total of four focus group discussions (FDG) having 12 participants in each session were organized. Eight indigenous astrologists, eight indigenous intestinal readers, four veterinarians, four botanists, and two astrologists were also interviewed.

2.2.2. Sources and data collection methods

In this research flexible and eclectic research approaches which combine participatory rural appraisal (PRA) (as a tool in overt observation, FGD), key informant interview and survey questionnaire were used to collect data from different stakeholders. Overt observation and diagnostic approach were used as a complementary approach to understand how technical skills of indicators sign interpretation. Data was also gathered through in-depth interviews and questionnaire. The quantitative method deals mainly with herders' socioeconomic preparations following the forecast and perceptions on the status of the Borana weather forecast. Metrological data was also collected at National Meteorological Agency.

2.2.3. Data analysis technique

For the qualitative data which was collected using observation, interview, and focus group discussions, thematic content analysis was applied. Paraphrasing, identification, and characterization of the recurring themes were carried out in the analytical procedure. The household survey was analyzed using simple descriptive technique, i.e., percentage. Drought assessment method which was developed by [21] was adopted to identify drought and normal years within the last 27 years.

3. Results and discussions

3.1. Participants' background information

Table 1 provides background information of herders who were approached to gather data for this research. Illiteracy is rampant, and attendances of primary school's first- and second-cycle education were 3.5 and 0.5%, respectively. Predominant majority of them (80%) adhere to the indigenous religion called Wake Feta followed by Islam and Christianity. Indigenous weather forecast system was the source of weather information for 96.5% of the respondents, while the rest had access to modern meteorological weather information. Herders have limited modern mass media weather information.

3.2. Mode of acquiring the skill of weather forecast among the Borana herders

Not all Borana herders possess the skill of different modes of indigenous weather forecasting, and there are different ways of acquiring the skill. Those who make astrology-based weather forecasting, known as *Urgii Elaltu*, teach the skill to their eldest son as they received it from their fathers, and the process goes on. A trainee masters the skill at about adolescent age and starts to read the alignment of celestial bodies for weather forecast. Thereafter, the title of *Urgii Elaltu* will be bestowed to him. The skill being highly guarded with secrecy, the possibility for others to acquire it is closed, although there are few individuals who reported to have acquired the skill from friends. In most cases, however, the skill of astrology-based weather forecasting is inherited from their own fathers.

Item		**Participants (N = 200)**			
Educational level	Illiterate	M	F	Total	%
	1–4	167	25	192	96
	5–8	7	0	7	3.5
	9–10	0	0	0	0
Religion	Wake Feta	142	17	159	79.5
	Christian	10	0	10	5
	Muslim	23	8	31	15.5
	Others	0	0	0	0
Source of weather information	Indigenous	168	25	193	93.5
	Development agent	52	0	52	26
	Relatives/friends	165	21	186	93
	Radio	21	0	21	10.5
	TV	0	0	0	0

Table 1. Participants' education, religion, and access to weather information.

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Learning the technique of weather forecasting based on reading of animal intestine takes up to 2 years of training. A person who completed the training and started to make weather forecast based on intestinal reading is known as *Uchuu*. Intestinal exploration is used to forecast about the timing and intensity of drought, peace, conflict, the time of livestock mass death, and the timing and the place where good pasture will be available. In the study site, there were no female experts in astronomy and intestine reading. The result is cognate with previous findings in other parts of the world, i.e., indigenous knowledge is gendered and obscured the contribution and interest of women [22]. Weather forecasting based on a reading of the behavior and body language of animals and plants or observation of weather conditions is largely known by many people and is almost a tradition. For that reason, no special title is used to designate a person who makes weather forecast from the observation of weather conditions and the body conditions and behavior of the cattle. The same applies to the skill of weather forecasting based on observation of plant conditions. As is the case in some other cultures, vertical and horizontal skill transmission takes place orally which impedes seamless transfer of indigenous knowledge from generation to generation especially when experts die untimely [23]. The accurate transmission of oral indigenous knowledge of weather forecasting across generation is also influenced by both the teacher and capability skill receiver.

3.3. Types of indigenous weather forecasting

Among the Borana herders, indigenous weather forecasting was made based on (1) a reading of alignment of celestial bodies, (2) a reading of the conditions of animal intestine, (3) a reading of plant and animal body languages, and (4) observation of local weather phenomena and shape and color of celestial bodies. How such traditional mechanisms and technical know-hows are used are discussed below.

3.3.1. Reading of celestial body alignment

In Borana, some stars' alignment with the moon, stars' apparent movement and location, and decent and cessation of some stars were used for weather forecasting purposes. Like other indicators of weather forecasting, there was no special ritual activity or any food or sexual restrictions. Celestial bodies, indigenous astrol *Urgii Elaltus* were able to forecast the upcoming rainfall onset, cessation, and volume at different time scales, i.e., ranging from a week to 3 years. The detailed techniques of the know-how are presented as follows.

3.3.1.1. Reading of the alignment of celestial bodies using the Geda calendar

Based on the alignment of celestial body reading, *Urgii Elaltus* claim to be able to make weather forecasts 6 months or more in advance of the timing, duration, and amount of rainfall or drought. Weather forecast based on stars' position and their alignment with the moon is considered to be the most effective method for weather forecasting. *Urgii Elaltus* reported that there are seven stars (individual or in groups) known locally as *Lemi* (believed to be the mother of all and very important for forecasting), *Busan*, *Soresa*, *Algajama*, *Arba-Gadu*, *Walla*, and *Bassa*. The different alignments of such stars in relation to the position of the moon provide data for weather forecasts. There are a maximum of seven star-moon alignments,

but observing only the Lemi-moon alignment is enough for weather forecasting. Unlike the claims of [10], this study found that astrological features are used for long-term weather prediction.

Among the Borana herders, observation of star-moon alignment for weather forecast is made partly in reference to the lunar Borana calendar. The association is partial in the sense that *Urgii Elaltus* use months of the Borana calendar to choose the timing of observing star-moon alignment. The Borana calendar divides the year into 12 months. The first and the last months of the year in Borana calendar are *Amajjii and Abrassa*, respectively. For the purpose of weather forecasting, *Urgii Elaltus* divide months of the year in the Geda calendar into two groups each comprising 6 months. The first group comprises the months of *Birra*, *Ciqqa'a*, *Sadassa*, *Abrassa, Amajjii*, and *Gurandhala*. The first 3 months represent the short rainy season, while the last 3 months are the hot dry season. It is only during *Birra* that *Urgii Elaltus* calculate star-moon alignment for weather forecast. The second group of months comprises *Biouttessa*, *Chamissa*, *Buufa*, *Waxxabaji*, *Obora-Gudda*, *and Obra-Teka.* The first 3 months represent the main rainy season, while the last three are months of the cold dry season. Of the 6 months, it is only during *Biouttessa* which *Urgii Elaltus* can calculate in terms of star-moon alignment for weather forecasts.

In Borana observation of the constellation of celestial bodies takes place in the month of *Birra* (September) on the fourteenth and fifteenth moon day at 9:00 p.m. in order to predict the weather for the main rainy season (*Biouttessa*, *Chamissa*, *Buufa*). The small rainy season weather forecast is made in the month of Biouttessa (March) on the first and second day of the moon at 09:00 p.m. When asked to elaborate the rationale behind the specific date for forecasting, the *Elaltus* were unable to justify their choice.

Weather forecasting for the main and small rainy season is made through observation of star-moon alignment in the months of *Birra* (September) and Biouttessa (March), respectively. However, it is not clear why *Urgii Elaltus* use *Birra* and *Biouttessa* even the date and time to forecast the prospect of rainfall. They were asked to elaborate the rationale behind, but they were unable to justify their choice. *Urgii Elaltu* makes forecast for the small and main rainy seasons as follows.

Figures 1 and **2** show the seven star-moon alignments as described by *Urgii Elaltus*, which they used for observation during the months of *Birra* and *Biouttessa*:

I. If the first alignment (moon and *Lemi*) is observed in the month of *Birra*, it signifies that 14 days have elapsed since the first appearance of the moon. This *Ayana* (year) is known locally as *Gonchera.* The alignment is interpreted as an indicator of a delay in the onset and early cessation for the next main rainy season.

II. The second moon-*Lemi* constellation is referred to as *Gobana* and predicts that the next main rainy season will be normal and be a time of abundance, peace, and love.

III. If the first moon-Lemi alignment, known locally as *Bita-Dura* or *Kera,* is observed in the month of *Biouttessa*, it is considered to be a sign of a coming season of drought and famine during the small rainy season.

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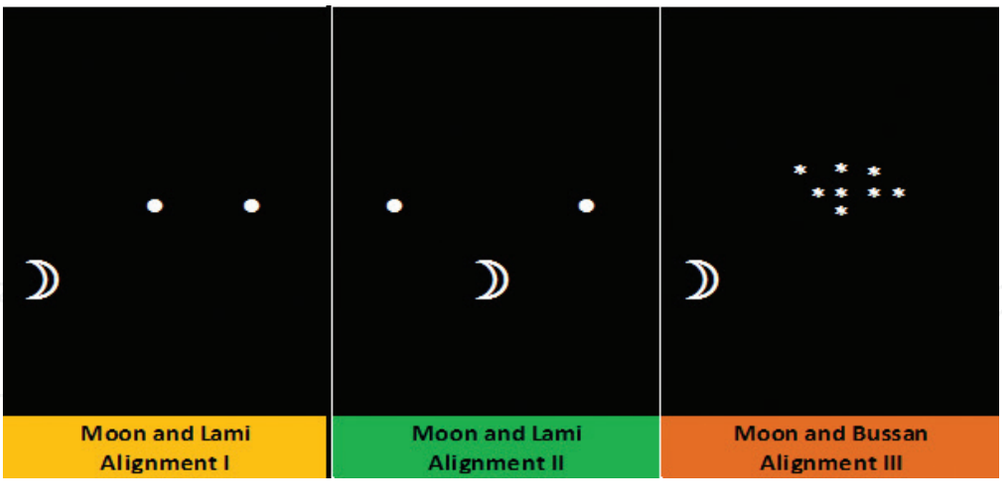

Figure 1. The first three moon-star alignments. Sources: Diagram sketched based on the description of *Urgii Elaltu*.

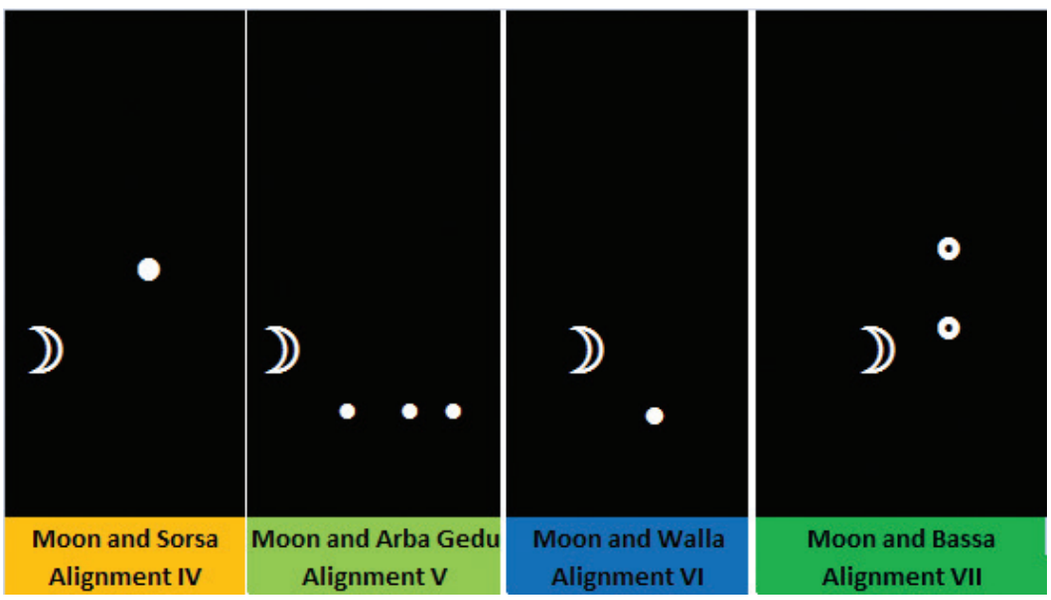

Figure 2. The four moon-star alignments. Sources: Diagram sketched based on the description of *Urgii Elaltu*.

IV. On the other hand, the second moon-Lemi alignment signifies that the next season would be Beta-*Bella*, in which a timely and optimal rainfall is expected.

Whether the reported moon-star alignments actually occur in reality during the specific months, informant mentioned is not of interest to this study. Equally, the meteorological consequence of those alignments on earth is difficult to negate or confirm. However, modern science has reached a stage where the movement, position, and speed of celestial bodies in different times and ages are certainly known. It is established beyond a shadow of doubt that the alternating constellations of celestial bodies caused by their differential rotation and movement are very regular. If *Urgii Elaltus'* perception about the impact of moon-star alignment were true, then we would naturally expect to experience drought and normal year in

a very regular succession, and if changes to that regularity are to happen, it would only be possible in thousands of years. Hence, the actually experienced drought seasons being very erratic than regular, and knowing that the alignment changes are very regular, indigenous experts' claim does not tally with the reality. This must account for the discrepancy between their forecasting and the actual phenomena.

3.3.1.2. The apparent movement duration of Bekalcha Bari or Bekalcha Gulchu

The morning star known locally as *Bekalcha Bari* (star at dawn east direction) and *Bekalcha Gulchu* or *Ahiha* (in the west) is used to forecast extreme drought conditions. If it is seen in the west 70 days after it has been observed in the east, and if it is seen in the east 7 days after its appearance in the west, it assumed that the prospective season will be normal. However, if it is not observed in the east on the seventh day after its appearance in the west and is observed again in the west after 140 days, it is regarded as an indicator of future extreme drought.

3.3.1.3. Geometrical alignment of celestial bodies

In Borana the alignment of the moon with the *Busan* is also used to forecast the upcoming weather. If the *Busan* is observed in the west by a man milking a cow at 08:00 p.m. under the cow belly, then it is regarded as an indicator of the arrival of the main rainy season. On the other hand, if it is seen in the east to a person milking a cow at night at 08:00 p.m. under the cow belly, it indicates the arrival of the small rainy season. The informants could not explain why the observer should be in a milking position with a cow in such a way that he/she should observe *Busan* in the east or west. If it is supposed to imply any geometrical value, for example, to calculate the impact of that constellation on earth, unfortunately that is out of the scope of this study to prove. Here, it is interesting only to say that this observation is not made to forecast the likelihood of normal rainfall or drought, but to simply know the arrival of the main and small rainy seasons.

3.3.1.4. The apparent size of the stars

A star locally known as *Kormi Mado* is located in the southern hemisphere. It moves in a clockwise direction and never moves to the north of a perceived line of the equator (see **Figure 3**). The position of *Kormi Mado* is used to make forecasts both for the long and short rainy seasons. The forecasting is based on the size of the star at the time of observation. If it is observed in the month of *Birra* and seemingly smaller in size at the 14th day of the moon at 09:00 p.m., the forecast for the upcoming main rainy season would be drought. On the other hand, if the star is observed, on the same month, day, and time, with a seemingly greater size to normal, a rainy season is expected. The star is also used to make weather forecasts for the small rainy season. While the interpretation of the size of the star is the same, for the small rainy season, the timing of observation is in the month of *Biouttessa* on the 1st day of the moon and at 09:00 p.m. local time.

3.3.1.5. Apparent movement of the star

Turban is located only in the northern hemisphere moving in a clockwise direction. The position of *Turban* is not used to forecast the starting and cessation time of rainfall as well as the

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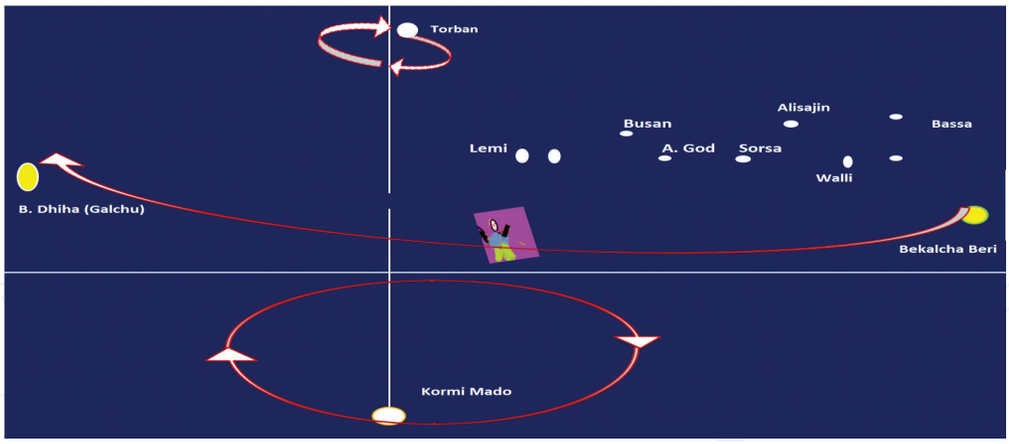

Figure 3. Significant moon positions used for weather forecast. Sources: Diagram sketched based on the description of *Urgii Elaltu*.

volume of the rain. When it is observed on the position shown in **Figure 3**, experts realize that the rainy season is approaching. When *Turban* is observed near to the extreme North Pole, *Urgii Elaltus* believe that the small rainy season is approaching. Conversely, when *Turban* moves from its southern path into the northern path of rotation, it is believed that the main rainy season will arrive within 2 weeks.

3.3.1.6. Other indicators used to validate star-moon alignment weather forecasting

The Borana herders use data from the condition of weather and climate elements such as sunlight, cloud cover, temperature, and wind necessary not only to forecast weather but also to strengthen forecasts based on other biotic and abiotic indigenous weather forecasting systems. If, at the time of star observation, the sun is surrounded with what is locally called *Muna Garti*, herders conclude that drought will occur in the next season. If, on the same day, a solar radiant with reddish color is observed at sunrise, experts believe that the next season will have normal rainfall. A dull and white sky at sunrise is equated to the future drought. When people notice that their locality experiences a strong and fast wind blowing from east to west, they expect that drought is forthcoming. However, if the wind blows slowly raising the dust upward, people expect normal rainfall at the right time. The appearance of a whitish feather-like column of cloud (in a vertical position) in the sky is regarded as indicative of rainfall which is about to fall. If the sky is dominantly covered by light cloud, herders do not expect rainfall shortly.

3.3.2. Reading of animal intestines

Uchuus claim that intestinal features that are used for weather forecast are mirrors of the future weather conditions. This stems from a dictum that the future weather and sociopolitical conditions of an area are encoded in animals' intestines where the sex and age of the animal do not matter, although an informant indicated the females and older ones preferably. The intestines of cattle, sheep, and goats are used to forecast about the magnitude, severity, and duration of drought, drought-affected places, disease outbreak, the prospect of peace, and/or conflict.

Like astrological weather forecasting, intestinal forecasting system is full of secrecy. *Uchuus* read and interpret slaughtered animal organs such as the large intestine (*Kechuma*), small intestine, lymph node (*Kabello*), and blood vessels (veins) to forecast the upcoming season (see **Figure 4**). *Uchuus* infer the amount of food substance in the intestine, color and amount of blood, and lymph node size to forecast the small and main rainy season drought condition. For instance, the more the amount of food substance in the small intestine and large intestine, the forecast translates into normal rainfall season. But, the drought season will be expected if they observe small amount of food substance in the digestion process in the small intestine and large intestine. The intestinal weather forecasting system also used to predict the magnitude of drought. Mild, moderate, severe, and extreme drought conditions are forecasted when *Uchuus* see small, smaller, and very small food subsistence in both the small intestine and large intestine

When *Uchuus* observe uniform lymph node thickness entirely and the node is covered by darker color tissues, normal rainfall season is forecasted, and rainfall onset will begin on the right time. Forecast for drought is made if a thin and very thin lymph node is observed. A very thick lymph node and large intestine are signs to predict that rainfall will commence in 2 weeks time and 2 months, respectively. Regardless of its thickness, if a marked protrudes is observed at the end of the lymph node that is regarded as the right sign to forecast an outbreak of livestock disease. In Borana, intestinal reading of weather forecasting system is used only for short-term weather forecasting, i.e., from 2 to 3 months. This system of forecasting enables to identify the village and peasant's association level of drought severity. These help herders to send scout to areas which will not affect by drought.

The amount and color of blood in the blood vessel on different parts of the intestine are also indicators for weather forecasting (see **Figure 4**). If the blood filled tauten the vessel and its color

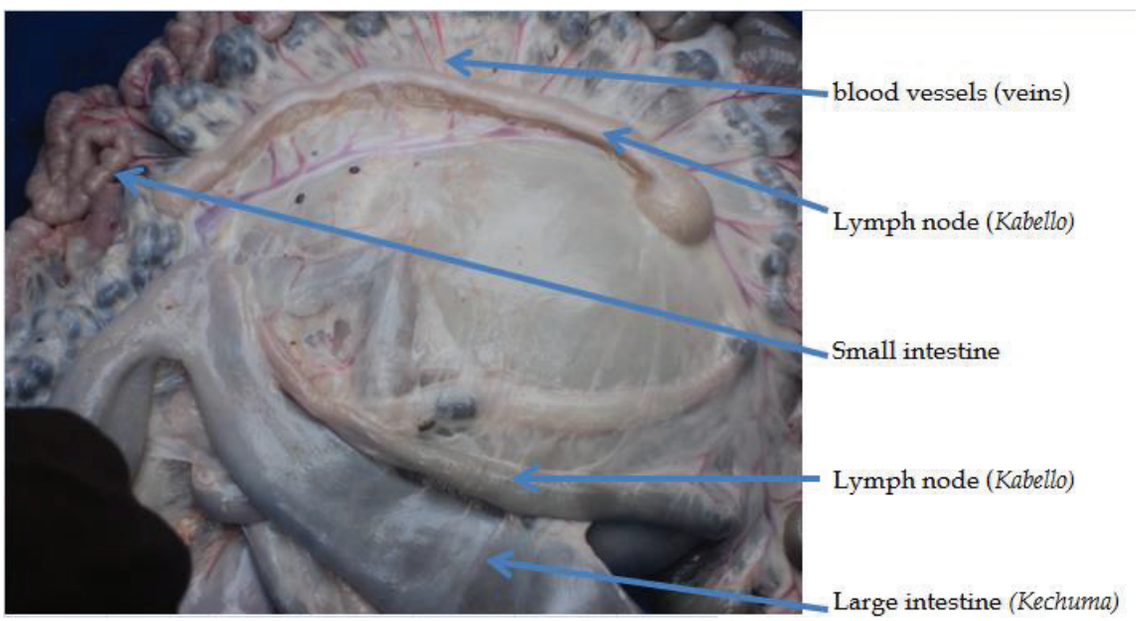

Figure 4. Parts of the intestine used for weather forecasting. Source: Photo taken during data collection when *Uchuu* interprets the intestine.

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is darker, *Uchuus* forecast drought for both small rainy season and main rainy season. But if the blood is smaller and yellowish in color at the junction of blood vessel in the small intestine and large intestine, the forecast for the next season would be normal rainy season. The severity of the drought is inferred in indirect proportion to the amount of blood contained in the vessel; if the amount of blood in the blood vessels is small and yellowish in color, normal year is predicted. However, the absence of blood in the vessels is an indication of extreme drought condition.

In the diagnostic data collection sessions, the researcher confirmed that *Uchuus* used the same signs and sign interpretation procedure and made similar forecast. In three diagnostic sessions, six of *Uchuus* forecasted accurately the 2015 main rainy season. Likewise, all weather forecasting systems made accurate forecast for the 2014 main rainfall season. However, faulty weather forecast was made for the 2015 small rainy season. The timely onset of rainfall was forecasted by *Uchuus* and *Urgii Elaltu*, which foresaw drought. The *Urgii Elaltus* rightly forecasted the 2014 small rainy season. It may mislead to comment the reliability of intestinal weather forecasting system by single right forecast and faulty forecast. Hence, I argue that since meteorological forecast has its own limitations, repeated diagnostic and astrological observation is compulsory to reach a conclusion on the precision of Borana indigenous forecasting system.

The researcher tried to substantiate *Uchuu* signs and interpretations with the experience of veterinarians. Veterinarians have different positions on the intestinal indigenous weather forecasting signs and interpretations. Those who have research experience on indigenous knowledge have positive attitude to indigenous weather forecasting system, whereas others connect the amount of food substance in the small intestine and large intestine with the amount of food taken, laying position of the animal at the time of slaughtered and the color of the blood with the effect of disease or toxic grass. They emphasized that the blood color variation might be the effect of disease or toxic grass that is mostly encountered during times of environmental stress. Proper red color simply reflects the good health status of the animal rather than to be a code for the future of rainfall.

The view of veterinarians holds that the inequality in the amount of waste found in the right and left blood vessel of intestines could vary depending on the age, sex, pregnancy, and health conditions of animals and is not necessarily linked with future climatic events, peace/war, conflict, etc. However, the researcher observed the similarity of interpretations made on the intestine of three goats by different readers. In both cases, normal year was forecasted, and the amount of waste, color blood, and shape of the blood vessel are found similar. However, this could be attributed to the similarity and harmony with which fathers train their sons and does not necessarily lend the craft of intestinal reading a force of scientific truth, and we know myths told even in distant cultures show high degree of consistency.

It suffices here to point out that indigenous intestine observation is not impure to superstition. Hence, it may make too big claims in forecasting the range from the fate of the animal owner to that of local weather information and world peace and conflict. It looks as if the practice is an archaic form of early warning system for socioeconomic, political, and security threats of the people. At any rate, it is very difficult and misleading to entirely disregard the craft as it might risk perpetual loss of valuable cultural heritage, and rigorously thus scientific validation should take place.

The same assumptions apply to forecast about the prospect of peace, conflict, starvation, mass death of livestock, etc., from a reading of the intestine. The prospect of conflict (including at the global level) can be deciphered if the section of the intestine that bears "the map" is observable beneath the matter that envelops it. Intestinal reading is also used as to who would come to visit them or even where guests would park their car, not only the belief that intestinal feature give clue to forecast the rain time but also when the owner of the animal would die.

3.3.3. Reading of animal behaviors and body conditions

The informants believed that particular body conditions and behaviors of cattle during abundant resources are signals for future weather condition. Cattle behaviors that are interpreted as signs of a future drought are calmness, sleeping in the zoo very close to one another, being unwillingness to go to the nearby pasture, reluctance to go away from water points after drinking, and poor appetite for grass and salt. Besides, the bull would isolate himself from the herd, goes to forest, and refuses to return to the zoo. Cattle body conditions that are considered as indicators of a future drought are loss of body weight, erection of skin hair, and swollen bellies, which do not get raised even when they have eaten much, urinating and defecating while sleeping and diminishing of dung amount even when they eat enough and lack of desire for mating.

On the other hand, informants believe that in view of a prospective normal rainy season, cattle lick each other's body, roam around villages, eat any bone found, leave water points immediately after drinking, show a relaxed mood, and amuse them with frenzy wriggling around. Besides, the bull mounts on any cows in a short period of time. In other words, they think that the future weather conditions of the area find expression in animals' external behavior to a degree that warrants weather forecasts. Such views are endorsed by scholars who said that animals detect the incoming weather conditions, and that is an essential component of their survival strategy. Veterinarians also agreed with the view of herders in that animals have natural ability to sense the future precisely than human-made technology. They believed that sensing the future and making behavioral changes are essential features of their instinctual knowledge. Behaviors such as reduced appetite for food and mating prepare cattle to withstand incoming harsh condition. Some of the cattle body conditions and behaviors mentioned by study participants such as looking hungry is similar with a study result in Kenya but contradicts with the assertion that cattle fight over food [12].

Some of the above body conditions and behaviors of cattle used by herders as harbingers of the future weather conditions could lead to misinterpretation. In science, things like lack of appetite for mating and food are caused by sickness than the influence of the future weather phenomenon. The cattle behaviors that are said to be indicators of a future drought are in fact typical conditions of animals during actual drought time and may not necessarily be indicators of a future drought. Likewise, the cattle behaviors interpreted as indicators of normal rainy season are actually conditions that can be seen in time of abundant resources rather than the effects of what would happen during the next season.

Of course, it is not difficult to explain some of the cattle behaviors and body conditions. Forecasts of rainfall are made during the dry season where resources are scarce. By then cattle have very little to eat, and their bellies would not rise up and hence would have defected

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diminished dung. In fact, this is indirectly admitted by informants who said that if the future is to be drought, the palatability of grass decreases which reduces the amount of grass consumption of animals below the normal years. On the other hand, if animals show behaviors and body conditions that are believed to be indicators of good rainy season, it could be because they are not hard-hit during the dry season for various reasons such as herders have had stored enough forage. Moreover, it is odd to believe that cattle would demonstrate behaviors and body conditions that are typically observed during the time of resource abundance while living during the dry season. Hence, without disregarding a possibility that specific body languages and behaviors could be signs of future weather conditions, it would be difficult to distinguish those signs from those caused by sickness and hunger.

In addition to cattle, in Borana weather forecast is made using the behavior of other wild animals. If ground squirrels (*Tuka*) are busy digging holes, the ants' movement along a course of nearly a straight line, a normal rainy season is expected and vice versa, while drought is forecasted if squirrels are passive and ants are dispersed in search of food. The migration of bees during the time of resource abundance season in their locality from north to south is regarded as a signal for a future drought, while normal rainfall will be forecasted if they migrate in the reverse direction. In Kenya the same activity of ants and bee migration are interpreted similarly for weather forecast [12]. The termites' activity 2 months before the small and main rainy season commence is also other indicator for the forthcoming season. When termites are actively engaged in gathering and storing of food, building hills is regarded as normal rainy season. In the contrary, if termites did not show any activity to gather and store food and build their home, drought will be expected. It seems clear that the above behaviors and activities of animals confirm that the forecast is derived from a belief that those animals act in a way that ensure their survival in the face of forthcoming season. Among the Borana herders, the varying screaming hyenas' tones and songs of birds are employed to make forecasts about different things. But it is a daunting task to describe the musical or vocal scale of different voices of hyenas and birds here. This result is in line with previous study in Borana [24].

3.3.4. Reading of plant body languages

In Borana, the phonology of Tedecha (acacia flowering tree with narrow leaves and black fruit pods, *Acacia tortilis*) (see **Figure 5**) and Ret (aloe tree, a plant with fleshy-toothed leaves) (see **Figure 6**) is used to forecast the main and small rainy season rainfall situation. In both cases, herders expect rainfall a month after the date of flowering of these trees. If the trees have small amount of flower and shed it early, that is regarded as a sign for a future drought. Botanists corroborate the claims of herders. They elaborated that to survive or withstand the incoming harsh conditions, plants respond through different ways: by restricting their growth (which can be observed at the tree ring), shading their flower before pollination to minimize their fruit, and minimizing their flower to reduce the food intake. All such strategy helps them minimize the loss of energy in times of scarcity. Otherwise, the plant would perish (see also similar scientific arguments from [12, 25]. Shukurat et al. [12] discovered partially conflicting result with the Borana plant observations and botanists in that forecasting is made busing same tree spices fruits. In the contrary, other botanists claimed that plant body conditions are reflections of the conditions they live in rather than the future weather phenomenon.

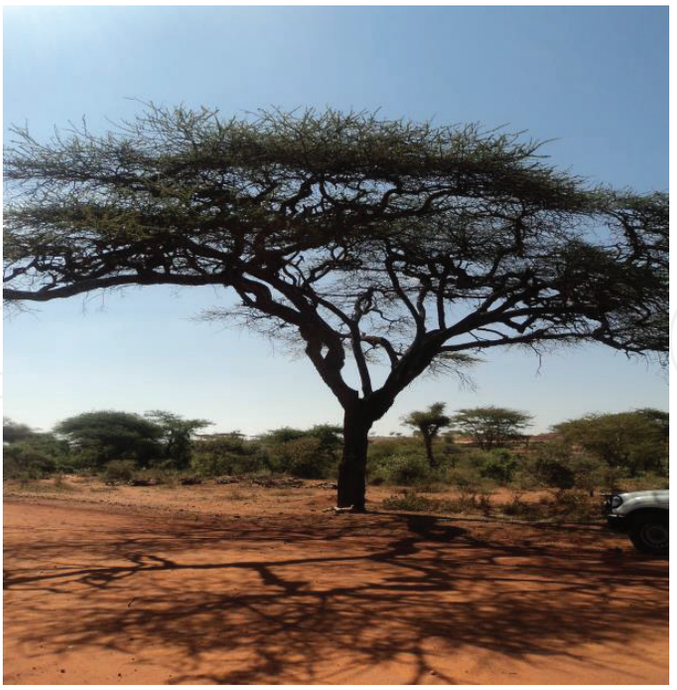

Figure 5. *Tedecha*/acacia tree. Source: Photo taken during data collection.

If herders observe a less number of locally growing green leaf plants such as *Hamesa* (*Commiphora africana*), Agarsu (*Commiphora erythraea*), *Dakkara* (*Boswellia neglecta*), and *Sukela* (*Delonix elata*) during *Obra-Teka* (August) and *Amajjii* (January), the forthcoming small rainy season and main rainy season are forecasted as drought. In the contrary

Figure 6. *Ret*/aloe tree. Source: Photo taken during data collection.

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when the density of the aforementioned tree leaves increased, normal year is predicated. *Bisduga* (*Kirkia burgeri*) tree provides more precise forecast information than the above tree types. However, the observation and interpretation system is the same with the rest of the plants. Unlikely, our finding [9] observed plants that are used for long-term weather forecast. The variation could be due to biophysical (e.g., climate, topography, soil, tree type) differences.

On the other hand, there is something discomforting about herders' explanations. They say that the tree flowers and leaves before the onset of the rainy season and the flowering and lavishness by itself are not sufficient to make weather forecasts; it is the amount of the flowers and leaves as well as its early fall. If the flowers and/or the leaves are small and drop early, it could be because of the actual moisture stress felt by plants rather than in anticipation of drought. Like cattle behaviors, it is hard to distinguish plant body conditions that are caused by actual drought, disease, etc. from those natural signs caused by the perceived drought. To make a conclusive argument about the true cause for the smallness of the flowers and leaves and their early fall, it is imperative to make experimental research such that a group of trees would be continuously watered since the time of flowering while leaving the other group with no water. If both groups shed their flowers and leaves early than the usual time and then drought follows, herders claim would make good sense. But that is not the scope of this study. Herders expect that rain follows a month after the starting date of flowering and lavishness of the leaves. If their analogy is correct, their ability to make weather forecast depends on how early or late the trees drop their flowers and leaves. At any rate, they do not seem to be able to make forecast for drought before about 2 weeks, a time too small to make adequate preparation. In summary, scientists have not reached consensus about the implication of plant body conditions, and it is very difficult to downplay the claims of tradition. A more conclusive answer awaits for in-depth scientific investigation.

3.4. System of disseminating weather information

The *Uchuu*, *Urgii Elaltu*, and Ayantu (Borana calendar experts) are in charge of forecasting weather and disseminating information, but do not have obligation to do so and are not paid. The *Uchuu*, *Urgii Elaltu*, and Ayantu communicate their weather forecast information to community elders and heads of Geda who would then disseminate it by summoning the people for urgent meetings. Alternatively, the information is provided to people in market places, water points, and village settlements. Moreover, interested people could go to the houses of weather forecasters and personally ask for weather information. Individuals who receive weather information also inform others. The development agents, local administrators, and NGOs participate in the dissemination of forecasted information by *Uchuu*, *Elaltu*, and Ayantu. Besides, they are responsible for disseminating modern weather information by translating it to local language to influence herders to make appropriate preparations. In Alona *kebele*, an NGO called Action for Development (AFD) provides early warning and preparation service by registering the observation of *Uchuu* and *Urgii Elaltu* every 15 days. AFD also disseminates the information to concerned government and nongovernment authorities.

3.5. Public attitude about the vitality of indigenous weather forecasting

Table 2 illustrates that only *Wake Feta* religion followers believe that the traditional weather forecasting systems are not contradictory to the belief in God and contend that God himself has given them the wisdom of weather forecasting, and, hence, they are happy to share their information. They emphasized that their herd management and other cultural activities are guided by forecast information. In general, they think that devoid of traditional weather forecasting systems and their livelihood would collapse. Muslims believe in traditional weather forecasting practices as the right way to cope with the changing weather condition. This could be the fact that Islam is old in the area and followers may not comply with the tradition. Hence, Muslims in Borana consider indigenous weather forecasting as a source of weather information. In the contrary, the traditional practices of weather forecasting are repudiated by Christians who deem it incongruent with the rules of God. For them, the traditional practices are nothing more than magic in which evil spirits are involved. Christians stick to a view that the fortune in every season is determined by God and is blasphemous to consult alternative authorities' information. Borana, which observed in Zimbabwe the expansion of Christianity religion, had a negative impact on the acceptance of indigenous weather forecast practices in the study area [10].

Religion	Wrong practices against God		Right practices	
	No. of replies	%	No. of replies	%
Wake Feta	2	1.25	157	89.75
Christian	10	100	0	0
Muslim	7	22.5	24	77.4

Table 2. Herders' belief on indigenous weather forecasting practices by religion.

Different indigenous weather forecasting systems have varying level of acceptance depending on their reliability [12]. This also applies to the Borana experience where the perceived reliability and acceptance of abiotic and biotic weather forecasting depends on precision of the forecasting system. Astrology-based forecasts are the most reliable indicators followed by intestine reading, animal body language, plant body language, and temperature and wind conditions (see **Table 3**). Astrological indicators also enable them to make weather forecast as long as 3 years, while other methods are effective only to make weather forecast no longer than 3 months. In Kenya weather conditions are found to be the most reliable indicators [12]. However, it should be stressed that all indigenous astrologists are not equally respected and only a person called *Kalicha Qoncher* commands high respect, possibly for his spiritual authority since the *Kalicha Qoncher* was mostly a spirit medium whom people visit for many reasons. Informants also reported that the number of indigenous astrological and *Uchuu* experts has decreased over time in their localities. Key informants and FGD participants stressed that herders are increasingly losing confidence in all methods of indigenous weather forecasting which has led to the decline in the number of *Urgii Elaltu* and *Uchuu*. The precision and popularity of indigenous weather forecasting have declined particularly for

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Indicators	Most reliable indicator	
	Total no. of participants = 200	
	No. of replies	%
Astrology reading	150	75
Intestinal reading	60	30
Animal body language reading	46	23
Plant body language reading	20	10
Temperature and wind condition observation	4	2

Table 3. Herders' response on the most reliable traditional weather forecasting indicator.

the past one decade. However, it is reported that few individuals with exceptional weather forecast skill indicate the timing and nature of rainfall more accurately. There has been a strong public reaction to the negative consequences people suffered due to the faulty indigenous weather forecasting. Most importantly, people are frequently affected when forecasting shows a normal rainy season, but drought comes without preparation. The Borana indigenous experts repeatedly failed to tell the exact timing and intensity of rainfall and drought. Since the last one decade, it is not uncommon to experience abundant rainfall while the forecast indicated drought and vice versa. They also said that there are occasions when they do not receive rainfall although they could see clouds. The people are usually caught unprepared in situations when the weather forecast shows normal rainy seasonal, while the actual weather condition turned out to be drought.

The decline in accuracy of indigenous weather forecasting systems, reported by informants above, is also corroborated by comparative historical analysis. Comparisons of the forecasting made over the last 27 years using all modes of indigenous weather forecasting were compared with Standardized Precipitation Index (SPI) as an indicator. For the purpose of comparison, the instrumental record was computed using Standardized Precipitation Index where results below zero were taken to represent a condition of drought. Besides the inconsistency of forecasts within different modes of indigenous weather forecasting systems, glaring discrepancy exists with the actual instrumental record. For instance, there is about 79% mismatch within the four main types of indigenous weather forecasting systems which means that in most cases herders received contradictory weather forecasts. The degree of mismatch between the forecasts of indigenous experts on the one hand and instrumental records on the other is about 60% (see **Table 4**). Even in the case of astrology-based weather forecast, which is believed by the people as the most reliable indicator, the degree of mismatch with instrumental records is 50% which means that no system of indigenous weather forecasting is reliable enough as to advise herders to base their decision on indigenous weather forecasts. What accounts for the decreasing vitality of indigenous weather forecast systems?

Given that plants and animals naturally undergo behavioral transformation parallel with the global weather change, it is highly possible that indigenous experts may not be able to observe body languages and behaviors that had been used hitherto. In the absence of the commonly

Year	Astrology		Intestinal		Plant body language		Animal body language		Standardized precipitation anomalies		Count of match and mismatch between different forecasts		
	No. of replies	%	No. of replies	%	No. of replies	%	No. of replies	%	SPA	Drought level	Mach/ mismatch	Mach/ mismatch	Mach/ mismatch
1985	15	7.5	51	26	23	12	19	9.5	0.42	Normal	*	***	x
1986	6	3	134	67	169	85	23	12	1.59	Normal	**	****	x
1987	85	43	74	37	58	29	93	47	1.01	Normal	*	***	x
1988	173	87	42	21	25	13	86	43	1.14	Normal	**	****	xx
1989	161	81	51	26	36	18	103	52	1.22	Normal	**	****	xx
1990	16	8	51	26	39	20	27	14	0.35	Normal	*	***	x
1991	144	72	124	62	150	75	164	82	−1.2	Moderate	**	***	x
1992	129	65	123	62	168	84	170	85	0.23	Normal	**	****	xx
1993	23	12	65	33	37	19	32	16	0.08	Normal	*	***	x
1994	190	95	119	60	33	17	186	93	−1.7	Extreme	**	****	x
1995	13	6.5	72	36	22	11	18	9	−0.8	Mild	**	***	xx
1996	178	89	109	55	45	23	166	83	−0.3	Mild	**	****	x
1997	17	8.5	81	41	41	21	29	15	1.37	Normal	*	***	x
1998	150	75	63	32	33	17	102	51	−0.6	Normal	**	****	x
1999	11	5.5	52	26	26	13	24	12	−1.6	Moderate	**	***	xx
2000	182	91	38	19	22	11	77	39	−1	Moderate	**	****	x
2001	7	3.5	158	79	173	87	83	42	−0.5	Mild	**	****	xx
2002	22	11	53	27	15	7.5	100	50	−0.7	Mild	**	****	xx
2003	11	5.5	8	4	11	5.5	11	5.5	−0.2	Mild	**	***	xx
2004	164	82	121	61	50	25	150	75	0	Normal	**	****	x
2005	6	3	32	16	178	89	137	69	0.44	Normal	*	****	x

Year	Astrology		Intestinal		Plant body language		Animal body language		Standardized precipitation anomalies		Count of match and mismatch between different forecasts		
	No. of replies	%	No. of replies	%	No. of replies	%	No. of replies	%	SPA	Drought level	Mach/ mismatch	Mach/ mismatch	Mach/ mismatch
2006	176	88	103	52	24	12	176	88	1.2	Normal	**	****	xx
2007	188	94	4	2	91	46	122	61	0.1	Normal	**	****	xx
2008	14	7	114	57	0	0	0	0	−0.8	Mild	**	****	xx
2009	8	4	13	65	0	0	0	0	−1.2	Moderate	**	***	xx
2010	190	95	164	82	102	51	148	74	1.94	Normal	**	***	x
2011	92	46	123	62	164	82	112	56	0.47	Normal	**	****	x
2012	29	15	29	115	113	57	29	15	−0.9	Moderate	**	****	xx
Count of mismatch											22	17	14
Percentage of mismatch											78.5	60.5	50

*Mach of forecast b/n traditional methods and instrumental records of drought condition.

**Mismatch of forecast b/n traditional methods and instrumental records of drought condition.

***Match of forecast within traditional methods.

****Mismatch of forecast within traditional methods.

xMatch of forecast b/n astrology and instrumental record value of drought condition.

xxMismatch of forecast b/n astrology and instrumental record value of drought condition.

Table 4. Comparison of forecasting and the level of mismatches within indigenous methods and instrumental records.

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used signs, indigenous weather forecasters can hazard misinterpretation. Hence, indigenous experts are unable to update their science in view of changed environmental and ecological conditions that directly impact the stimulus-reaction pattern displayed for ages. On the other hand, it is very difficult to excuse the ever dwindling efficiency of astrology-based forecasts since the movement of celestial bodies and their constellations hardly change over brief span of time. Two possible explanations may be forwarded. First, in the past, the occurrence of drought had a more or less regular pattern, recurring once in a decade. Working on understanding of the observed regular pattern of the occurrence of drought might have deluded indigenous astrologists as having been correct in their forecasts. In recent years, however, global weather change has considerably distorted the old pattern of climate conditions with the effect that the forecasts of astrologists would not match with the reality. This means that from the outset, the knowledge claims of astrologists are found on pseudo-epistemology. This seems to be the reason for the failure/unwillingness of astrologist to explain why they read and interpret certain celestial alignments and constellations the way they do.

Secondly, the younger generation seems to have lacked fascination with the wisdom of forefathers, thereby undermining curiosity to learn the difficult technique of weather forecasting. As pointed out above, the expansion of alien ideas through education and monotheistic religions would stand negatively to the prestige and acceptability of indigenous experts, thereby inducing them to shy away from their indigenous practice. The bottom line is that people are no longer ready to seriously subscribe to indigenous forecasts. It would be impudent to argue that people should abandon their tradition at a time when science cannot provide a viable substitute. The best suggestion seems that indigenous experts should disclose their secrets to scientists so that a hybrid of climate forecasting system could be designed in ways that would make consideration of new biologist and animist signs as valid indicators of future weather phenomenon. It should not be difficult for indigenous experts to disclose their secrets as it would not represent any material lose since they are not paid for their service in the first place. They should be convinced that harmonious blend of indigenous and innovation has been inalienable prerequisites for survival and prosperity, as the history of human civilization attests.

3.6. Socioeconomic preparations in view of expected drought

Indigenous knowledge-based weather forecasting is the main source of weather information in Borana where access to modern weather information is limited. In Borana weather forecast is disseminated using well-organized cultural network. In view of drought forecast, herders take different preparations: they stop sawing crops for a while, strengthening enclosure through community bylaw, saving water and grass, preparing livestock medicine, storing hay, migrating with animals, destocking, and changing schedules of social and cultural festivities such as wedding. In Borana, indigenous weather forecasting is becoming unreliable, and herders were victimized by incorrect prediction. However, still herders prefer indigenous weather forecast information than modern forecast information. They were reluctant to heed development agents' advice about modern weather information. This shows that integration of herders' skill and knowledge with the modern weather forecasting system and dissemination should be a topical issue.

Migrating with animals where water and pasture are available areas is widely practiced as a coping strategy to drought. However, in the event of seasonal migration caused by drought,

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people suffer from many problems. There is a high risk of attack on cattle by wild animals, and many incidents of cattle raiding occur that would lead to conflict. They may be exposed to conflict over water and pasture. En route, they have to endure the effects of cold and hot temperature due to problems of shelter which exposes them to health risks such as diarrhea and malaria and other animal contagious diseases that mainly affect the foot and mouths of cattle. Socioeconomic complications breed clan conflict that may lead to the loss of human and animal lives. People often find it difficult to maintain contact with their family members who stay behind and suffer from extreme food shortage. Sustaining the livestock resources in drought times requires heavy workload since owners need to treat their ailing cattle extensively which among other things requires fetching water from long distances, cutting and carrying cattle feed, etc. These complications in turn lead to school dropout for children and inability to fulfill basic needs such as clothing for the family.

4. Conclusion

The study shows that indigenous weather forecasting has its own merits and demerits. The main quality of indigenous weather forecasting lies in the longer temporal horizon it covers. Whereas modern meteorology could offer a probable weather scenario for weeks and a few months, traditional weather forecasting offers probable weather scenario for a longer period. The degree of accuracy of traditional weather forecasting varies depending on the quality of experts, the base of the forecasting, and the complexities caused by climate change. Currently, the acceptance of indigenous weather forecasting is decreasing because of cultural assault perpetrated by the expansion of Islam, Christianity, and modern education. The intrinsic merits of traditional weather forecasting have not been a subject of serious scientific scrutiny. It is a high time that the tenets of indigenous weather forecasting be assessed scientifically and be integrated into the modern science before they vanish. This could improve the performance of weather forecasting for a better climate change adaptation.

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