International Journal of Weather, Climate Change and Conservation Research, 9 (2),44-59, 2023
Print ISSN: ISSN 2059-2396 (Print)
Online ISSN: ISSN 2059-240X (Online)
Website: https://www.eajournals.org/
Publication of the European Centre for Research Training and Development -UK

Indigenous Knowledge and Forecasting systems in coping with Climate challenges in Lare Woreda, Gambella National Regional State, Ethiopia

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doi: https://doi.org/10.37745/ijwcccr.15/vol9n24459 Published December 08, 2023

Citation: Monyjok C.K. and Guek B.C. (2023) Indigenous Knowledge and Forecasting systems in coping with Climate challenges in Lare Woreda, Gambella National Regional *State, Ethiopia, International Journal of Weather, Climate Change and Conservation Research*, 9 (2),44-59

ABSTRACT: *This paper summarizes the current status of weather forecasting and climate prediction in Lare woreda. The characteristics and requirements of modern weather forecast operations are described briefly and the significance of numerical weather prediction for future development is emphasized. The critical tasks for short term climate prediction that covers the extended range (1530 days), monthly, seasonal, inter-annual and inter-decadal time scales are projected. The author found that Indigenous knowledge, traditional stories and prediction relating to lightning, wind direction, cloud formation, rains, drought, birds migration, animal, trees, mitigation, response, and effects of climate on crops are realistic in a contemporary environment from Nuer farmers in the woreda. The research was conducted more or less through the qualitative research methodology where Indigenous knowledge has remained the focus of anthropological study. It looks at the traditional way of life in understanding about nature, environmental conditions and effective use of resources. The overall objective of the study was to identify indigenous knowledge indicants and how they help in seasonal forecasting in the face of changing climatic conditions. The research result shows that People in the woreda acquired this perception to cope with natural stresses and solve their own problems. Recent studies indicate that the value of indigenous knowledge is becoming recognized by scientists, managers and policy makers. The various affirmation of the aged and young people claim that the scientific knowledge is more authentic and powerful than indigenous knowledge whereas in some areas, the indigenous people said that scientific knowledge is harmful based on religious background.*
KEYWORDS: indigenous knowledge, forecasting, climate challenge

INTRODUCTION

The climate of Africa is warmer than it was 100 years ago and changing climate; puts additional stresses on water resources, whether or not futurity rainfall is significantly altered (Hulme et al., 2001). Climate change could reduce total agricultural production in many developing countries by up to 50% in the next few decades, particularly South Asia and sub-Saharan Africa (Hoffmann, 2011). According to Cooper, 2004, large portion of Africa’s crop production depends directly on rainfall, where about 89% of cereals in sub-Saharan Africa are rain-fed. Rainfall is highly variable in Africa and it is important to have a reliable forecast so as to enable farmers, of whom the majority is small-scale, to plant crop types that produce good yield under the forecast conditions. Due to the unrecorded rate in which climate variability is occurring globally, there are concerns that IKS will become unreliable to predict future weather events accurately, which compromise the ability for farmers to secure their livelihoods. Nonetheless, some scholars are optimistic that if farmers rely on seasonal climate forecast (SCF), it will facilitate the adoption of planned and more efficient adaptation strategies, thereby ensuring that they continue effectively in food production. While most countries in sub-Saharan Africa have been investing in meteorology, farmers still rely heavily on IKS. Seasonal forecasts are probabilistic and rain is often forecasted as the probability of being ‘above normal’, ‘below normal’ or ‘near normal’. The forecast is usually issued for a period of one, three or six months and suggests the total amount of rainfall expected over that period, but not the distribution of rainfall within that period (Githungo et al., 2009). Studies show that indigenous knowledge could contribute to fill gap in formal seasonal forecasts, focusing on rainfall amount rather than on its timing which is of greatest importance to the farmers (Luseno et al., 2003). According to Warren et al. (1995), local knowledge needs to be integrated with research-generated information and technology in efforts to improve rural livelihood. A combination of high dependence on rain-fed agriculture while rainfall is highly variable with recurrent droughts and floods leaves the community vulnerable to food shortages (Muhonda, 2011). For the period of 1988 to 2011, rainfall had a coefficient of variation of 162%; resulting in output being significantly reduced. This leads food security to remain a challenge in the Sub-Saharan regions because of recurrent drought and flood (Bosongo, 2011). The extent to which indigenous knowledge is used in forecasting weather in Gambella region in general and in Lare woreda in particular is not known; making the situation danger of being doomed because it is the elderly who possess it and has not been recorded, but merely passed from one generation to the other orally. Therefore, this study addresses the need for traditional knowledge scheme of meteorology and examines the scientific basis for farmers’ weather folklore. It further determines areas of possible desegregation between scientific and traditional knowledge systems and analyzes associated challenges.

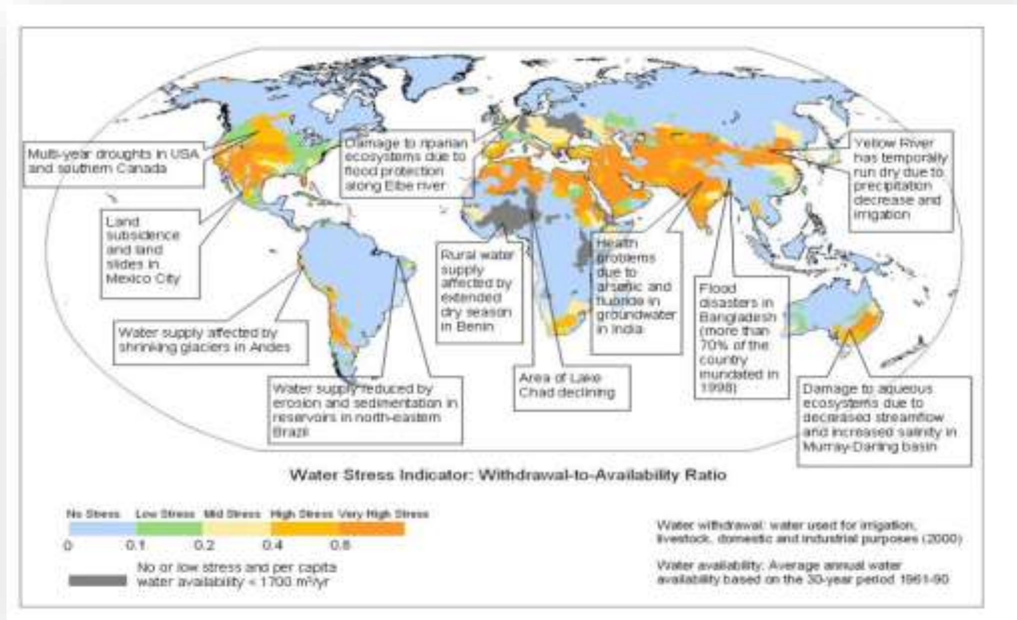


Figure 1: Global water stress due to climate changes
Water stress (Source: IPCC 2007)

MATERIALS AND METHODS

Sampling procedures

Data was collected in twelve (12) with each kebele composting of ten using purposive sampling; by selecting ones affected by overflows of the Baro-River. The selection was made based on the shared common boundaries, similar environmental characteristics and indigenous knowledge systems as localized knowledge domains.

Data collection methods

During the study, four (4) instruments were employed; questionnaires for government officials, Business agencies and the local community, observation of the physical environment, Structured and non-structured interviews and Focus Group discussions/FGDs to collect both quantitative and qualitative data. In addition, Rainfall data and seasonal forecasting information for the 2020/2021 rainfall season were collected from the Meteorological Agency and the Agricultural and Regional Livestock Bureaus. Participants in FGDs and KII were selected based on: overview of the flooding, drought and dry spell situation in communities, Indigenous early warning indicators for floods, droughts and dry-spells, action taken based on IK signs and systems for message sharing, Reliability of indigenous warning, and accessibility to official warning information, consultation with the community-leaders (e.g. village chiefs) who helped by reaching out to the individuals., living in the village for most of their lives (30 years and above), Over the age of 55 and no upper age limit, Up to 2 participants from a different age category, known to be affected by flooding, Extensive experience with flooding and Known in the community for having IK related to disasters.

Rainfall data

Rainfall data for the years 2011-2020 for Lare station was collected from the Meteorological Services Department (MSD), Daily rainfall data for the period of ten years was also collected from the same source. In addition, Seasonal forecast information for the 2020/2021 season was collected.

Data Analysis about Climatic Parameters

The qualitative collected data was analyzed using thematic analysis; one of the most common approaches for data analysis in qualitative research; bases on a process in which collected data is thoroughly examined for identifying recurring theme in the text. Initially, data was coded followed by the process in which codes were merged. After the process of coding and theme identification, the final study findings write-up was done in which, general themes were generated based on the interview guides and a coding scheme was developed and applied to data transcriptions.

Data Analysis about Climatic Parameters

During the research writing phase, participants' quotations were used in order to fully depict the in-depth information gathered and provide contextualized results. Quantitative data from questionnaires were analyzed using frequencies, relationships and levels of significance by the help of the Statistical Package for Social Science (SPSS). Moreover, Rain fall data was analyzed by applying GEOCLIM Analysis Model. For climatic parameters, the researcher analyzed local climate data from the selected kebeles from **2011-2020** G.C. Climate data were examined for the last ten (10) years including; temperature, rainfall, humidity and wind speed. During the research period, analysis was made with the help of Pearson correlation coefficients was determined for relevant climate parameters. Significance levels for correlation between temperature and rainfall were analyzed using the model.

RESULT AND DISCUSSION

Indigenous ways of seasonal weather forecasting associated with common disasters

The study results showed the gradually decreasing trend of cattle population due to some practically observed threats like trans-boundary diseases and animal transaction in the region.

FGDs from elders indicate that several disease outbreaks usually kill large number of cattle at all age groups and consequently disturbing the livelihood pillars of many households. This problem usually exacerbates the situation badly as it is mostly attached with insufficient veterinary services and drug supply including the open Ethio-South Sudan border. The prediction for the loss of cattle was due to frequent drought, both disease prevalence and feed shortage which become very critical and bring socio-economic instabilities in the study area.

Traditional Methods in coping with Natural Disasters

Flooding during summer season & Drought during the dry season are most of the times being mentioned by the elders as the most common natural disasters predicted in the region. Overflows of Rivers such as Baro, Jikow, Nyandera and Koikoye each year was found as serious problem. People were displaced, crops were damaged, and property destroyed. Floods resulted in deaths, drowning, communicable diseases and malnutrition caused interruption of health services due to the damage to the health infrastructure. The current coping strategies in the study area include Afforestation incentives and programs, construction of walls and channel gates and shelters.

Weather Information based on raw data

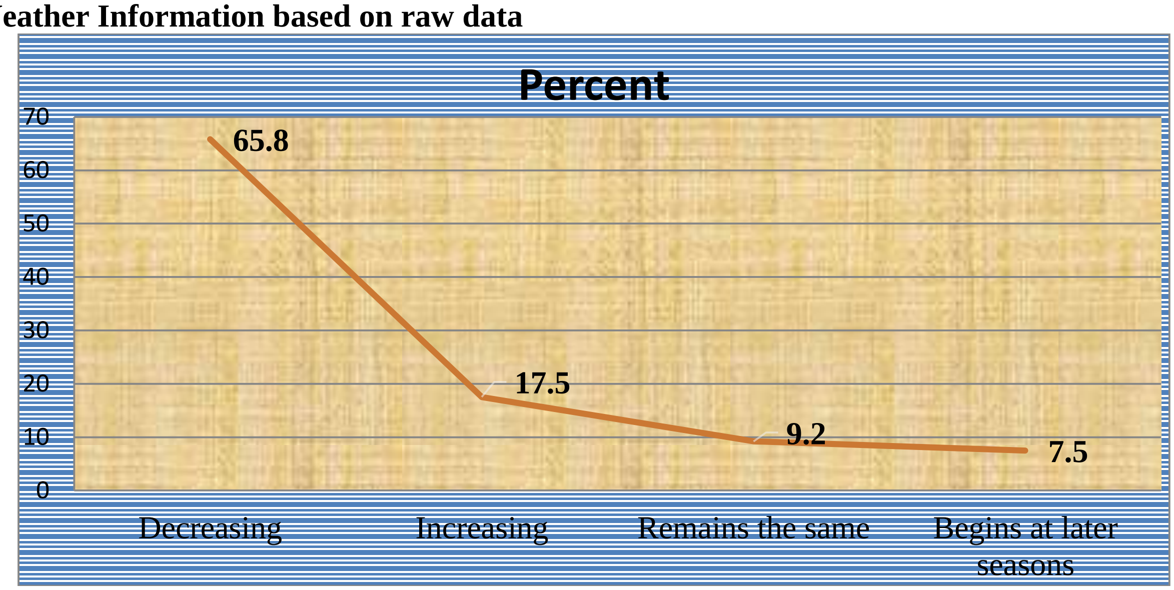


Figure 2: Change in Rainfall and Temperature patterns
Source: Field survey results, 2020

The interpretation of the above figure is supported by David D. Breshears, Neil S. Cobb, Paul M. Rich, Kevin P. Price, Craig D. Allen, and Randy G. Balice in 2005 who stated that regional vegetation die-off in response to global-change-type drought. The scholars added that this global climate change is projected to yield increases in frequency and intensity of drought occurring under warm temperatures. If this prove is integrated with that of Lare woreda, the future drought is projected to occur as climate change progresses and yet quantitative assessments of the causes and potential extent of drought-induced vegetation die-off remain critical uncertainties in assessing climate-change impacts. Moreover, the author prompted that there could be an incidence of regional-scale mortality of long life plants, which rapidly alters ecosystem type and land surface conditions for decades. The patterns in which rainfall occurs has recently become to decline as compared to the previous years. This means that the recent drought was warmer than the previous sub continental drought of the 1950s.

Indigenous weather forecasts using local indicators

It is traditionally believed that indigenous knowledge is often passed on from one generation to the other but not widely documented. A combination of plants, animals, insects, meteorological, and astronomical indicators were commonly used for assessment and prediction. The most common IK indicators in the study area are birds (swallows, hornbills, owls and golden orioles), animals (hyena, monkeys, and antelopes), insects (ants, bees, locusts and butterflies), shrubs and trees. In conducting this research, over 90% of the respondents indicated that they were aware of the indigenous weather and climate forecasts for estimation in planning their agricultural works.

Local knowledge based on birds and animals

The behavior, appearance and movement of some birds in the study area are frequently used by the local people to predict the future weather condition in their communities. The monitoring of the behavior of birds is done informally with time and experience where; the local people use to recognize the unique features of some birds.

Table 1: Local knowledge based on birds and animals

Local name	Events related to the rainy season (N=120)
Swallows, hawk & Crow	Flocks of swallows roaming from West to East in the area; indicates the beginning of summer rains
Owl	When owl sits on top of a house during day light; is an indication of a problem
Wild bird	Loud singing out of wild birds; is an indication of the heavy rains
Fox	When fox cries loudly is a sign of fight in a village
Eagle	Flying down of eagle directly from the sky; is a sign of some dead animals on the ground
Hyena	When rain is raining while sun rises; is a sign that hyena is giving birth

Source: Field survey results, 2020

Indicators based on insects and amphibians

Results from the household interviews and focus group discussions show that various insects and some amphibians are used by the local communities to predict weather and climate. The most commonly used ones were army ants, butterflies, locusts, grasshoppers and frogs.

Table 2: Indigenous indicators based on insects and amphibians

Local name	Events related to the rainy season (N=120)
Butterflies	Appearance of butterflies in large number; is an indication of early onset of rains and also gives a prospect of a floods
Frogs	Frogs starting to make a lot of noise; is an indication of rainfall
Ants	When ants occur in large numbers almost everywhere even inside the houses and appear to be celebrating; is an indication of beginning of wet season
Locusts	Presence of many army locusts; is an indicator of the drought and hunger
Bees	Bees appearing in big groups; indicates germination of new flowering plants as rain is predicted
Grasshoppers	Appearance of green grasshoppers in large numbers in the fields; indicate the beginning of rainfall

Source: Field survey results, 2020

Table 3: Indicators based on the moon, sun and wind

Sign	Characteristics related to the rainy season (N=120)
North-South wind direction in April-May	Indicates onset of wet season and in most cases a sign of heavy rainfall.
Moon surrounded with heavy clouds	A sign of a good rainfall season
Halo moon (yellowish ring around the moon)	An indication of onset for both Wet and dry seasons

Circular shaped Moon	Is an indication of onset rainfall & moon with different colors like rainbow indicates onset of volcanic rains
Red moon	Indicates onset of dry rains with heavy wind
Sun	Sun hitting without wind indicating rains

Source: Field survey results, 2020

Table 4: Indicators based on air temperature, clouds and wind

Weather	The sign used to relate to the rain (N=120)
High Temperature	Most of the time indicates the onset of rains is near
High temperature during night time	Is an indication that it will rain the next day
Strong and swirl winds	Indicate pending rain onset
White clouds appearing in the evening	Indicates the prospect of rain the next day
Repeated lightning in the evening during the dry season	Is an indication of onset of rain
Cold wind with no rain	Is usually an indication of rain in other places
High temperature together with blowing wind	Is an indication of rain

Source: Field survey results, 2020

Effect of Natural Disasters on the environment and animals

According to the observation made by the researcher, the natural disasters, which hit Lare Woreda in 2020 has also impacted human population, crops, fisheries, livestock, households, roads and educational and religious institutions. The study area's river side was observed as yearly affected by natural disaster like floods during the summer season. According to DPFSA, in 2020, the region was affected by numerous spells and heavy rainfall which were reportedly to displace more than ten thousand people and affected two thousand households in the study area. According to the report, numbers of affected families were positively increased due to the heavy rainfall rather than other impacts such as death, handicapped and wounded. Within the selected kebeles of the woreda, about 10ha cropping area was fully (100%) destroyed by the natural disasters (flood and drought). Similarly, 3,674.05ha area were partially (50%) affected by tropical winds and heavy storms. In addition, 5ha of arable land was damaged as a result of flood, heavy storms and drought (Lare woreda Agriculture and Natural resource Office, 2020).

Fish and livestock are important food resources that have a direct benefit to human health. Unfortunately, these food sources are declining due to increased commercial farming, livestock trading and raiding intensity in the region of Gambella. Fish in riverine and pond ecosystems were affected due to the intrusion events that accompanied the flooding and land degradation. As a result of this, 500metric tons of fish were lost by this natural disaster. According to the observation results, flooding in Lare woreda during the year of 2020 destroyed approximately 120 tons of livestock feed. Records indicate that 2 dairy farms and 1 poultry farms were severely damaged. Accordingly, cattle, goat and chicken were found more injured than other livestock due to the tropical disasters of floods. The number of chicken was found highly injured due to drought also. The figure below shows the photo of a dead cow during the natural disaster of floods. Figure 3: Dead animal due to natural disasters during May, 2020

Source: Field survey results, 2020

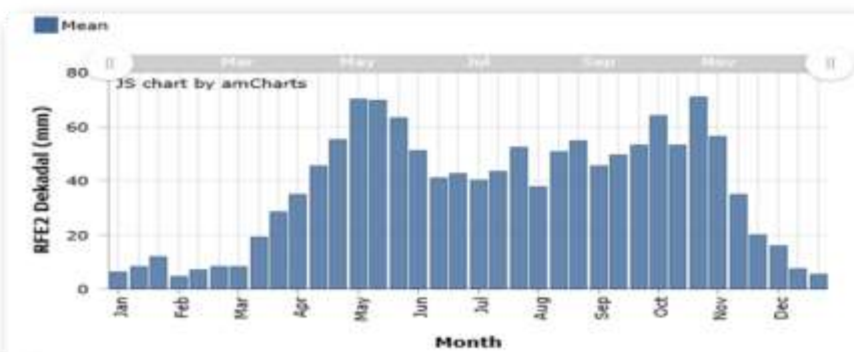
Existing Coping Strategies for Natural Disasters

- Afforestation incentives and programs,
- Construction of walls and channel gates, and the
- Construction of shelters.
- Increased public awareness of disaster plans achieved through education and outreach which include implementation of first aid training programs, search and rescue training, and cultural demonstrations of natural disasters through drama, folk songs, public rallies and school feeding.
-

Scientific Weather forecasting in the woreda

Rainfall amount received compared with NDVI in the region (from 2007-2016)

According to the scientific weather result; with the help of GEOCLIM model, the highest rainfall amount was received during the Month of May (67.33mm) followed by 62.33mm in October and comes September with 49mm respectively. The interpretation here means that winter season was the time with higher and longer time in amount of rain though the highest rain was recorded in May (autumn). To correlate this with Indigenous knowledge, wetter season in the study area covers more than seven months. This means that scientific climate forecasting is associated with Indigenous knowledge of farmers in Lare woreda. In addition, higher NDVI (0.771) in the ten years period was recorded in the month of September with average rainfall amount of 49mm while smaller NDVI (0.366) was recorded in the month of March with average rainfall of 18.33mm (below figure). This means that the higher the amount of rain receives, the higher the normalized difference of vegetation index was recorded in Lare woreda during the ten years period. In other words, NDVI was low for drier months, for instance March with 0.366 NDVI and only 18.33mm.
Figure 4: Decadal RFE2 Average (mm) in the region Climatic RFE2 (mm)-Last 10 years & Mean Median (2007-2016) Annual eMod's NDVI C6.



Source: GEOCLIM data, January-December 2020)

Agro-Climatology assumptions for Scenario Development; Ethiopia, Gambella

Print ISSN: ISSN 2059-2396 (Print)
Online ISSN: ISSN 2059-240X (Online)
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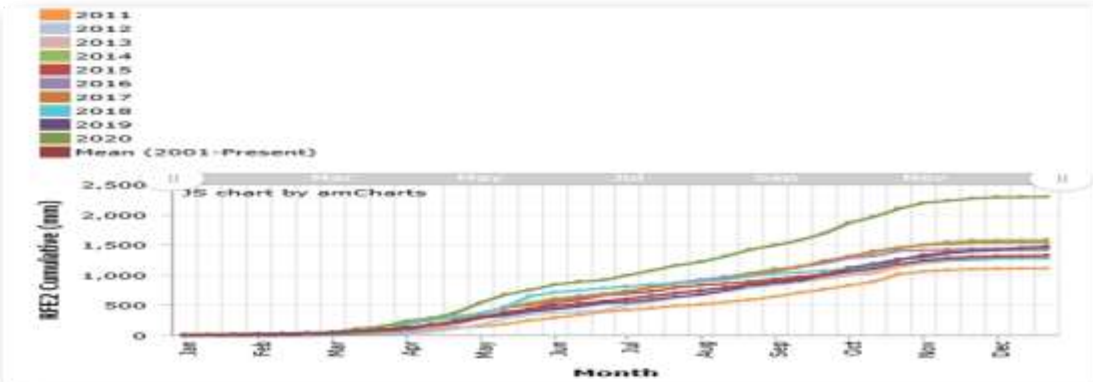
Publication of the European Centre for Research Training and Development -UK

The data extracted from GEOCLIM model indicates that higher amount of rainfall shows arithmetic increase from May up to December (below graph). If the traditional knowledge of Lare woreda farmers is matched with these assumptions, there is high correlation because the questionnaire results bring the same scenario which equated the model.

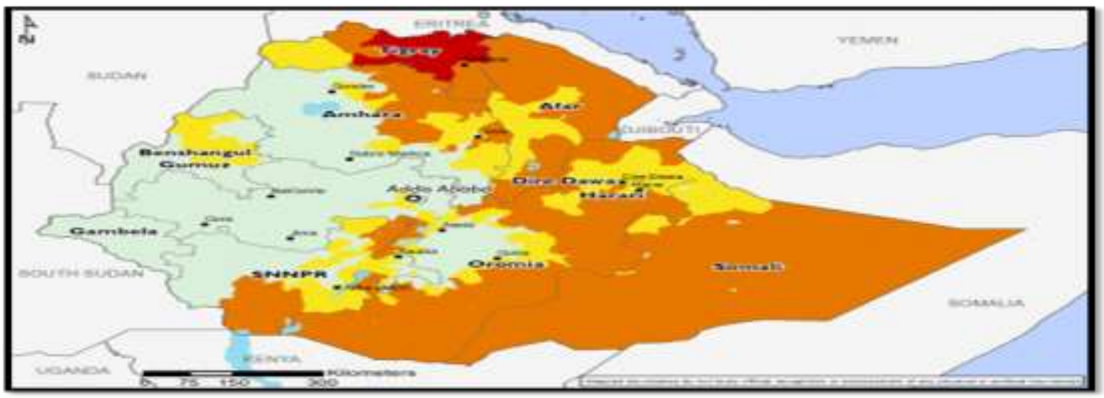


Source: GEOCLIM data, (January-December 2020)

Cumulative Rainfall for ten years in Gambella region (2011-2020) in mm

As indicated in the map below and the above charts, Kiremt rainfall in the region was expected to start on time in June with above-average rainfall most likely; and predictable to facilitate household engagement in agricultural activities. However, some disruption to typical drought as well as flooding constrained access to cultivation for the Meher harvest. Assuming some agricultural activities occur and the forecast for favorable kiremt rainfall holds, continued large-scale assistance is needed through at least September, after which households were likely to start consuming food from own production. Although households are unable to engage in agricultural activities for the 2020 season, large-scale agricultural inputs are needed in the concerned woreda to sustain beyond the projection period. According to remote sensing imagery, cumulative Belg rainfall in the region was only 25 to 50 percent of average in some areas indicating that; there is an increased risk of crop failure and minimal pasture development. While some improvement in pasture and water availability is anticipated with the start of the winter, pasture was expected to remain low with the forecast below-average rainfall. This is expected to lead to higher-than-normal livestock migration immediately following the summer and persisting from August to September. With this, the unusual livestock migration is assumed to likely drive a decline in livestock body conditions and milk production. Due to consecutive poor seasons and continued below-normal livestock as well as crop productivity and below-average purchasing power, this leads to crisis among many poor households in the woreda.

The following figure indicates the dry conditions prevailed across much of Ethiopia in early April, with below-average *belg/gu/genna* rainfall across most bimodal areas, which is driving below-average area planted in bimodal cropping areas. In addition, in March 2021, weather shocks, and poor macroeconomic conditions drive persistent high needs.



Legend
1: Minimal
2: Stressed
3: Crisis
4: Emergency
5: Famine

Figure 5: Dry conditions prevailed across much of Ethiopia, 2021
Source: GEOCLIM data, (January-December 2020)

CONCLUSION AND RECOMMENDATIONS

Conclusion

Indigenous knowledge played a key role in conserving agriculture with strong positive relationship with livestock & land holding, farm labor and perception of traditional technology. The findings of this paper also illustrate that flood frequency and magnitude has increased rapidly in the last decade in Gambella region. This is a result of climate change as well as land-use change (particularly deforestation) following resettlement of people from other drought-affected regions of Ethiopia. The main impacts of flooding on human health in the area are deaths, malaria, and diarrheal diseases. Despite these impacts, it was found that the current coping strategies against flood-related health risks in the region show three major weaknesses: lack of flood-specific policy, little risk assessment and weak institutional capacity. At last, we emphasize the need for additional research to identify the role of indigenous knowledge on other dimensions of conservation agriculture in addition to the one investigated here. Further research using much larger sample size and in different locations should be conducted to gain more insight into the role of indigenous knowledge in conservation agriculture.

Recommendations

Due to the weak management of natural as well as man-made disasters initiated by climate change, the impacts on human health are often hampered. Therefore, it is imperative that the current challenges in the coping strategies should be effectively tackled in order to sustainably address the impact on socioeconomic development in the study area with the following recommendations points:

- The government should put in place policies that specifically address flooding and the management of flood-related impacts. In preparing such policies, government has to encourage the participation of all stakeholders including flood-affected communities, NGOs, community-based organizations and religious leaders working in the area, that are either affected or work with the flood-affected communities.
- The government should strive to strengthen institutional capacity in terms of training flood watch monitors and escape route supervisors as a short-term measure. These volunteers can be employed as first aid workers in the event of flooding. In the long term, qualified health professionals need to be attracted to the area through the provision of incentives.
- To reduce the health impacts of flooding, the government and other development partners should work to provide a complete basic infrastructure including telecommunications, roads and health facilities. All these are directly or indirectly important for flood disaster management, particularly for early warning, evacuation and recovery.
- Collaborations between climate scientists, health researchers, policy-makers, as well as the disaster community, are essential for jointly developing adaptation strategies.
- Climate change should not be addressed in an isolated manner as it has significant connectivity with natural disasters.
- There has to be a platform that will continue to develop as new datasets as a means of sharing forecasting techniques and best practices between disasters forecast centers.
- Further research is needed in natural disaster risk assessment in the region that should be incorporated in identifying systems at risk and for policy interventions

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