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Assessing Weather Forecasting Needs of Smallholder Farmers for Climate Change Adaptation in the Central Rift Valley of Ethiopia

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Abstract

In Ethiopia, climate change is set to hit the agricultural sector adversely and cause considerable negative impacts particularly for smallholder farmers. Weather information is one of the requirements for effective climate change adaptation in Ethiopia, where Agriculture is the back bone of the economy. This study made during 2011/12 investigates whether smallholder farmers, development agents and organizations in the Central Rift Valley of Ethiopia have access to weather information and consequently use it in their agricultural activities to overcome adverse impacts of climate change. For this study, data were collected and analyzed from 200 randomly selected households, 34 development agents and 18 experts of different organizations in four districts (Meki, Melkassa, Miesso and Ziway) representing the same agro-ecological settings in the Central Rift Valley of Ethiopia. The result revealed that the adaptation capacity of farmers in using weather information are constrained by language problems, difficulty in understanding forecast terminology, absence of a center for coordination and downscaling weather information at local level and inconsistency in the time of information provision were the common problems identified in the study area. A new weather information delivery system is proposed which enables effective and location and purpose specific weather information delivery to farming communities and other stakeholders in the agricultural sector.

Keywords: Central rift valley; Climate change adaptation; Ethiopia; Needs assessment; Smallholder farmers; Weather information

Introduction

Climate change is now a global concern because of its wide-ranging effects on the environment and on socio-economic and other related sectors, including water resources, agriculture and food security, human health, terrestrial ecosystems and biodiversity [1,2]. Changes in rainfall patterns and rising temperatures cause a shift in crop growing seasons and affects food security in low income and agriculture based economies [3]. Agriculture is the main source of the Ethiopian economy that supports 52% of the Gross Domestic Product (GDP) and covers 80% of total employment and produces more than 85% of exports [4]. Despite its high contribution to the overall economy, this sector is the most vulnerable sector to climate variability and change [5]. Thus, adaptation of the agricultural sector to adverse effects of climate change will be imperative to protect the livelihoods of the poor and to ensure food security [6]. Adaptation can greatly reduce vulnerability to climate change by making poor farmers better able to adjust to climate change and variability, moderating potential damage, and helping them cope with adverse consequences [7]. Recent studies by Jotoafrika [8] indicate that smallholder farmers depend on rain-fed agriculture in most of sub-Saharan Africa and that they adjust their planting patterns and farming calendar to the onset, duration and end of rainy seasons. However, with changing rainfall due to climate change, their planting patterns and farming calendar no longer match seasonal rainfall distribution which often lead to crop losses. Seasonal rainfall forecasts are thus crucial for the provision of early warning information to be used by farmers [8]. Bryan et al. [6] reported the accessibility and usefulness of weather information as one factor that affects a farmer's ability to adapt to climate change. In addition, studies show that, climate-related concerns and information have claimed to be among the major factors considered by farmers in their decision-making [9]. The promise of using weather forecasts to better manage agriculture and food security has been part of the rational for sustained investment [10]. It is therefore, important to understand weather forecasts may have considerable potential to improve agricultural management and rural livelihoods. However, constraints related to access, understanding and capacity to respond, have so far limited the widespread use and benefit of weather forecasts among smallholder farmers [10]. In the current study the Central Rift Valley (CRV) is used as the case study area. It is one of the environmentally vulnerable regions in Ethiopia, where rain fed crop production has expanded rapidly over recent decades [11]. The region is highly affected by inter-annual rainfall variability and associated climate risks [12]. This calls for a need for weather information utilization by farmers to adapt the impacts of climate change at local level [12]. Therefore, the objective of this study is to find out how farmers perceive impacts and causes of climate change and whether or not farmers have access to weather information to mitigate potential impacts of climate change in the study areas.

Materials and Methods

Description of the study areas

The areas covered by this study are Meki, Melkassa, Miesso and Ziway which are all found in the Central Rift Valley of Ethiopia. The choice of districts was based on farming systems and representativeness of agroecological settings in the Central Rift Valley of Ethiopia, Figure 1 and Table 1.

Climate

The study areas have a bimodal rainfall pattern. The first rainy season locally known as Belg extends from the end of February to May

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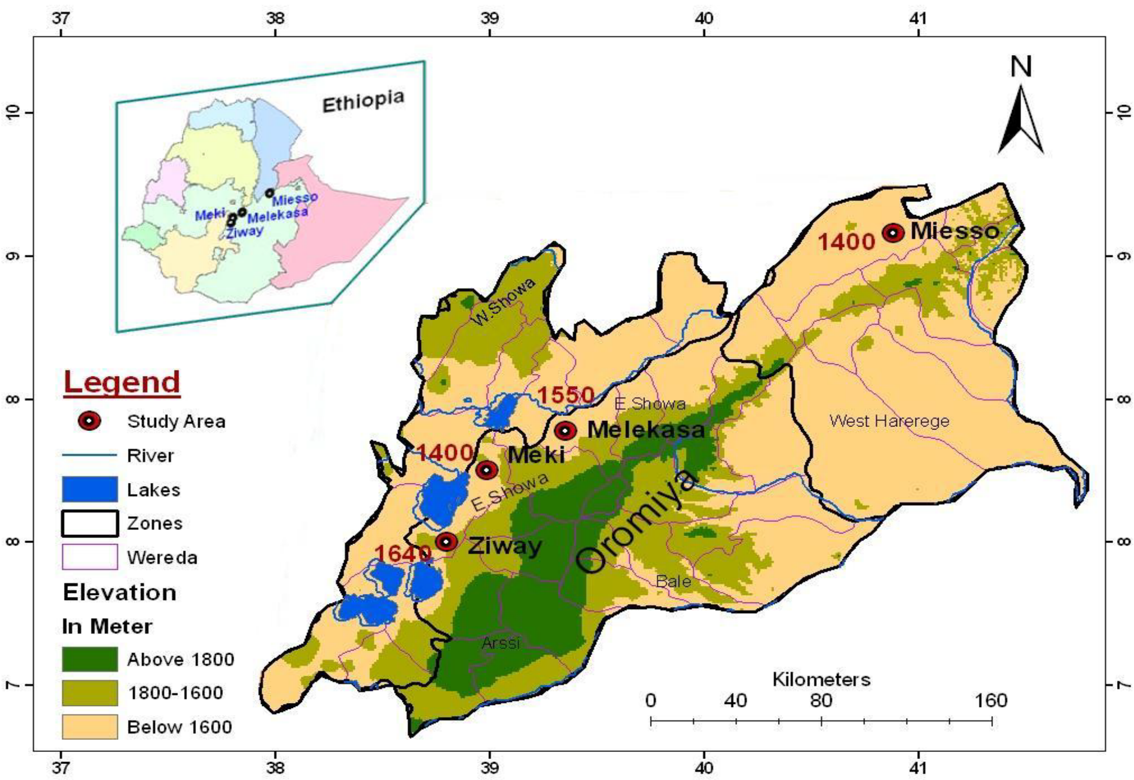


Figure 1: Location map of the study areas in the Central Rift Valley of Ethiopia.

Site	Altitude (m.a.s.l)	Major crops	Soil type
Meki	1400	Teff, Wheat, Sorghum, Barley, Millet, Maize, Fieldpea, Chickpea, Lentils and Horsebean	Shallow depth and has low total nitrogen contents
Melkassa	1550	Maize, Sorghum, Haricot beans and teff	Andosols (dominant), Fluvisols and Lithosols
Miesso	1400	Sorghum, Maize, Common beans, Sesame, and Chat.	Regosols (dominant), Lithosols, Luvisols and Cambisols
Ziway	1640	Maize, Teff, Horse bean, Barley, Wheat, Sorghum, Onion, Tomato, Cabbage	loamy sand, and fertile

Table 1: Altitude, major crops grown and soil type in the study area [13].

and the second rainy season Kiremt extends from June to September. Climate data obtained from the National Meteorological Agency for the study areas shows that the mean annual rainfall of the study area ranges from 719 m (Miesso) to 791 mm (Melkassa). The mean annual maximum temperature of Melkassa, Miesso and Ziway ranges from 26.8-30.6°C and the mean minimum temperature ranges from 13.7-15.0°C. Temperature data was not available for the Meki site. The medium length of the growing period in the study area was found to be 101, 88, 118 and 104 days at Meki, Melkassa, Miesso and Ziway respectively [12].

Interviews and Survey Procedure

Sampling procedure

A multi-stage purposive sampling procedure was followed to select East Shewa and West Hararghe, administrative zones. These zones were selected on the basis of their vulnerability to climate related risks including high temperatures, erratic rainfall distribution and onset date variability. Once the zones were selected, the same procedure and selection criteria were used to select the study districts, namely Meki, Melkassa, Miesso and Ziway. The districts are highly affected by inter-annual rainfall variability and associated climate risks including high variability of onset date [13]. Peasant associations (kebeles) were selected using a purposive random sampling procedure based on their vulnerability to climate change using the information obtained from the district Bureau of Agriculture and Rural Development. Following the selection of the peasant associations (kebeles), 50 sample farmers were randomly selected in each of the four districts on the basis of probability, proportional to size of the household.

Data collection

A total of 200 individual interviews with farmers were used to collect quantitative and qualitative data on impact and causes of climate change, and climate information needs in the area. In addition, participatory research tools, such as semi-structured and key informant interviews, were used to collect relevant data from 34 development agents and 18 experts of different organizations in order to understand their access, importance of weather information and their service provision on climate change adaptation mechanisms in the area. Some of the organizations included in this study were the Ministry of

Agriculture on district and zonal levels, Melkassa Agricultural Research Center (MARC), National Meteorological Agency Branch Office, Rift Valley Children and Women Development Organization, Sustainable Environmental Development Action, International Livestock Research Institute (ILRI), Disaster Prevention and Preparedness Agency (DPPA), Pastoral Community Development Project (PCDP) and Agricultural Sector Support Project (ASSP). A structured questionnaire was prepared and pre-tested before the actual implementation of the interview. Primary data were collected from respondents on the cause and effect of climate change, the role of weather forecasts, access of weather forecasts for climate related adaptation. To be able to make an in-depth analysis leading to conclusive results, qualitative information was gathered from all those who, in one way or another, are involved in using weather information for climate change adaptation. Farmers' field observations were also made as part of the qualitative information appraisal procedure. Secondary data were also obtained from various sources, such as research centers, district agricultural, finance and economic development offices. Weather forecast service delivery models for the study area were developed based on the gaps perceived by farmers, development agents and institutions on accessing weather information.

Data analysis

After data collection, the data were coded and entered into SPSS (Statistics Package for Social Sciences) software and descriptive statistics was generated and interpreted.

Results and Discussion

Demographic characteristics of sample farmers

Household heads' demographic composition is an important determinant of decisions in agricultural production. Out of the total sample households, 82% were male-headed and 18% were female headed. This could be attributed to various reasons, which could be the problem of economic position of female headed households, including limited access to information and cultural reasons. With regard to marital status, 96% of total sample respondents were married; although, all the sample respondents in Meki and Miesso were married household heads. Age is one of the demographic factors useful to describe households and provide a clue about the age structure of the sample and the population. Age is usually considered in adaptation studies because older people have more farming experience which enables them to easily identify adoptable new technologies. However, age is also related to a conservative risk management nature of an individual farmer. About 78% of the total respondents fall between the age of 46 to 55 years, see Table 2 below. In this age group, the highest (86%) and the lowest (66%) age was found in Ziway and Miesso, respectively. The rest (22%) of total respondents fall between 56 to 75 years of age. The role of education is believed to influence household heads income, adoption of technologies, and as a whole the socioeconomic status of the family. Among the sample farmers, 38% were illiterate, while 5% had adult education and 57% received formal education. The family size of the households in the study area ranged between 8 and 10 members, and 53% of them speak the Afan Oromo language.

Causes of climate change as perceived by farmers

As indicated in Table 3, 66% of all respondents across the districts believe that the environment has been changing over the years due to deforestation for fuel, housing, and furniture, as well as bush burning particularly in Ziway (80%), Melkassa (66%) and Meki (64%). Similarly, farmers in Borana area experience that tree cutting for fire wood and charcoal production aggravates desertification [14]. In addition, Aklilu et al. [15] indicate that destruction of forests and consequent soil erosion are frequently described as exacerbating factors for climate change in Ethiopia. More than one-third of the respondents in Ziway suggest that release of chemicals from greenhouse has increased due to the expansion of private flower farms. Floriculture is one of the dominant components of the agricultural sector in the area. Farmers

Variable	Indicator	Meki	Melkassa	Miesso	Ziway	Average
Sex of HH head (%)	Male	88	64	94	80	82
	Female	12	36	6	20	18
Marital status (%)	Single	0	2	0	8	3
	Married	100	98	100	90	96
	Divorced	0	0	0	2	1
Age of HH head (years)	46-50	54	38	24	44	40
	51-55	24	44	42	42	38
	56-60	6	0	8	2	4
	61-65	2	8	14	2	6
	66-70	8	0	4	6	5
	71-75	6	10	8	4	7
Education level	Illiterate	8	46	68	32	38
	Adult education	0	10	4	4	5
	Grade 1-4	78	26	14	32	38
	Grade 5-8	14	18	14	24	17
	Grade 9-12	0	0	0	8	2
Family size	<5	14	24	8	10	14
	5-7	22	48	18	32	30
	8-10	38	26	60	42	42
	>10	26	2	14	16	14
Language	Afan Oromo	22	46	88	54	53
	Amharic	0	4	2	2	2
	Both	78	50	10	44	45

Table 2: Demographic characteristics of respondents (n=200) at four study sites in the Central Rift Valley of Ethiopia.

Perception on causes	Response (%)				
	Meki	Melkassa	Miesso	Ziway	Average
Increased greenhouse gases released in to the atmosphere by industrial countries	12	8	8	34	16
Deforestation	64	66	54	80	66
Use of inappropriate crop and animal management practices	2	0	2	16	5
Population growth	6	38	42	22	27
Waste products of industries	0	2	2	8	3
Investment expansion	0	0	4	12	4
God's will	38	28	44	24	34

Table 3: Perceived causes of climate change by respondents (n=200) in the Central Rift Valley of Ethiopia.

in the district claim floriculture industries which grow cut flowers in greenhouses expose laborers to dangerous pesticides, and damage the environment through over use of natural resources. In addition, the most visible impact of floriculture industries on the environment mentioned by farmers is the depletion of the soil through the intensive usage of fertilizers and chemical, as well as the waste disposal of cut flowers which affects the availability and quality of Lake Ziway. Studies made by Hengsdijk and Jansen [16] clearly indicate that in Ethiopia most greenhouses are built in close proximity to water which has negatively impacted the water resource. According to Graichen [17] many of the lakes in the Great Rift Valley are endorheic, meaning they are end points of watersheds that do not drain, and these lakes are highly susceptible to damage from the floriculture industry because of the agricultural residue discharges that regularly flow from the greenhouses into the lakes [18]. Moreover, Getu [19] shows that pesticides have a capacity of contaminating organisms, soil and water. Due to it's highly volatility nature, it is estimated that only 0.1 % of the total applied pesticide attain its intended goal but the rest, 99.9 % remain an air pollutant. On the other hand, 34% of the all respondents are convinced that the vagaries of the climate are a sign of divine anger. Those in Miesso (44%) and Meki (38%) offer a philosophical explanation thus: "there are many sinners in our midst and God is trying to punish us through climate hazards such as drought and floods which have serious consequences". Similarly, a study conducted in Borana, South Ethiopia [14] farmers reported that disobedience and unfaithfulness to God's rules, failure to glorify him and divergence from the age-old Boran tradition have led to divine punishment, especially drought events. In addition, Rao et al. in their study in semi-arid Kenya [20] report that farmers believe climate is an act of God over which they have no control. This spiritual perspective is widespread in Africa [21,22]. About 27% of all respondents, particularly those in Melkassa (38%) and Miesso (42%) think that population pressure is another factor causing climate change in the region. The respondents' perception is in line with a NAPA report [5] which indicates high population pressure as a key underlying cause of Ethiopia's vulnerability to climate change. Similarly, Aklilu et al. [15] point out that population growth has been linked to the decline in forests, and is considered as one of the most important causes of climate change in Ethiopia. Moreover, a study conducted by Haile [23] indicates that the Ethiopian population is exploiting degraded lands and desert areas without any irrigation facilities or efficient water harvesting strategies, which are more likely to fire back as climate change continues unabated.

Perception of the effects of climate change

Climate change is perceived to have adverse ecological, social and economic impacts. This study shows that smallholder farmers in the study area face numerous risks to their agricultural production. 95% of respondents opine that there is frequent crop failure over the areas due to erratic distribution and dwindling rainfall quantum (Table 4). According to many of the respondents, lack of feed and shortage of water for animals, frequent death of animals, reduction of forest cover and degradation of natural resources, and shortage of food for households are some common problems associated with climate change. For instance, in Miesso, 90% and 82% of respondents claim that due to lack of feed and shortage of water for animals, respectively, there has been frequent death of animals in the past few decades. Moreover, increased incidence of plant, animal and human diseases (48%) and shortage of food for the household (54%) were indicated as major consequences of climate change in Miesso district. Similarly, Bewket, in his study in the central highland of Ethiopia [24] reports increased incidence of agricultural pests and diseases as one of the manifestation of climate change. Farmers in Melkassa and Ziway districts also stated that shortages of forage and water result in weakness of animals and oxen mortality. A recent study conducted by Abate [25] on climate change impact on livelihoods, vulnerability and coping mechanisms in West Arsi Zone indicates that drought and delay in the onset of rain leads to poor grass regeneration and forage deficit, water shortage and heat stress on livestock, and consequently increases the mortality of livestock, vulnerability to diseases and physical deterioration due to long distance travel for water and pastures. In contrast, despite lack of feed for animals (94%), the problem of shortage of water is not serious (14%) and as a result reported death of animals is low in Meki district as compared to the other districts. Farmers in the study area indicted loss of traditional crops being replaced by other crops, particularly in Miesso (24%).

Weather forecast needs of farmers

Climate science and meteorology provide valuable sources of information that can help, not only in predicting future weather and climate, but also in developing understanding and skills in managing uncertainty [8]. Results show that, on average, more than half of all respondents are aware of the weather information service in their respective areas (Table 5). Those respondents, who have access to weather information, use radio except a few model farmers (i.e., known for their high productivity, familiar with new technologies and with a relatively better income) in Ziway who are using both radio and television since 1997. Studies in Sub-Saharan Africa indicate newspaper, radio and television are traditional mechanisms for transmitting current weather observations and weather forecasts to the general public, including agricultural stakeholders, and they have played a prominent role in disseminating weather forecast information. The study also indicates relative importance that the various forms of media varies greatly by region and country, but radio receives most attention as the key means for delivering climate information to rural communities [10]. Reportedly farmers have been accessing the daily weather forecast occasionally. According to respondents, they have only accessed the weather information when they switch on their radio and television (few model farmers) while listening to news, music and other programs. Farmers do not look for climate information deliberately and regularly. Farmers in the study areas believe that they know what they do and have a lot of experience and knowledge regarding agricultural activities. Moreover, respondents assert that, even if they get weather information through the radio, they do not rely on and trust the weather forecast. The farmers' reason for this is that the forecast given is vague and it targets the entire region and not their specific vicinity. There

Effect perception	Response (%)				
	Meki	Melkassa	Miesso	Ziway	Average
Frequent crop failures	100	92	94	94	95
Lack of feed for animals	94	74	90	68	81
Replacement of one crop by another one	4	6	24	14	12
Reduction of ground water level	0	0	20	16	9
Frequent death of animals	12	22	56	26	29
Increased incidence of plant, animal and human disease	2	12	48	14	19
Reduction of forest cover	10	10	20	10	12
Shortage of water for animals	14	36	82	32	41
Shortage of water for drinking	0	16	14	22	13
Shortage of food for the household	10	18	54	34	29

Table 4: Effect of climate change as perceived by respondents (n=200) in the Central Rift Valley of Ethiopia.

Questions	Response (%)				
	Meki	Melkassa	Mieso	Ziway	Average
Access to climate information					
Yes	58	60	50	76	61
No	42	40	50	24	39
Climate information service					
1977s	2	0	0	4	1
1987s	4	2	2	4	3
1997s	24	42	10	28	26
since 2007	28	16	38	40	31
Type of climate information					
Daily weather forecast	56	46	32	64	50
Ten day weather forecast	2	14	14	10	10
Monthly weather Forecast	0	0	0	0	0
Seasonal weather forecast	0	0	4	2	1
Sources of climate information					
Television	6	4	0	4	4
Radio	52	48	40	46	46
Development Agents (DAs)	0	0	2	2	1
Neighbors	0	2	2	4	2
Village leaders	0	4	0	2	1
TV, Radio & DA	0	0	0	18	5
Radio, DA & Sharing with neighbors	0	2	6	0	2
Reason for not accessing climate information					
Not aware of climate information services	0	10	6	4	5
Do not know about the role of climate information	0	6	0	0	2
Do not believe that climate information can be helpful in improved decision	6	0	0	0	2
Do not believe that climate can be forecast	16	14	34	4	17
The information given is not credible	16	16	12	14	15
There is no center to be contacted	4	0	0	0	1
TV= Television DA= Development Agent					

Table 5: Access and source of weather information by farmers (n=200) at four sites in the Central Rift Valley of Ethiopia.

is a significant gap between the information needed by farmers for their decision making and the weather forecasts given by the National Meteorological Agency (NMA). While farmers are heterogeneous and their information needs vary in different areas, they reported that they are able to respond to the weather forecast information when it is downscaled and interpreted locally in terms of onset and cessation of the rainy season, agricultural impacts and management implications [26,27]. Some of the respondents also pointed out that the forecast is inapplicable to their specific localities. For example, farmers from Melkassa district recalled the instance of replanting their farms after their crop had failed to grow due to following an inaccurate rainfall forecast. Farmers in the study area also mentioned the difficulty in understanding weather forecast information. The reason given is the probabilistic manner, such as 'above normal', 'normal' and 'below normal', which are not clear to them. The probabilistic nature of weather forecasts presents a significant challenge not because farmers have difficulty making decisions in the face of uncertainty, but because formal probability formats must be mapped onto their mental models for dealing with uncertainty [10]. Unlike farmers response, studies in Burkina Faso, Zimbabwe, Kenya and including Ethiopia show that, with some help, smallholder farmers are able to understand and incorporate probabilistic forecast information into their decision process [28-31]. Moreover, some farmers observed that the time of weather broadcast/telecast is not fixed and not broadcast in their mother tongue. Thus, this indicates farmers in the study area wish to receive weather forecast information dissemination through their own local language. On the other hand, 39% of farmers who do not have access to weather information due to lack of awareness, lack of knowledge about the role of weather information, disbelief in weather forecasts, and lack of credibility of the information (Table 5).

Access to weather information by development agents (DAs)

The survey results show that the DAs have access to weather information such as seasonal cropping practice and seasonal climate forecasts. The sources of weather information cited by respondent DAs are local media, district agricultural offices and NMA (Table 6). On average, more than half of the respondents receive information on seasonal cropping practice from their district agricultural offices and from their regular meetings. Most of the information they received is in the form of hard copies. Table 6 shows 59 % of the respondents mentioned that the information they get is not clear and easy to understand. For instance, DAs from Miesso district said that "the probabilistic forecast says normal to above normal rainfall could be anticipated for pocket areas of the eastern part of Oromia region" which was difficult for them to interpret, as it is difficult to identify the exact areas that would receive the forecasted rainfall. Therefore, they mentioned that it is difficult to use the weather forecasts they receive for agricultural decision making.

Role of institutions in offering weather information

There are different governmental and nongovernmental organizations (NGOs) working in the districts. The major services provided by these organizations include agricultural services, technology transfer, research, agrometeorological information, health, water and sanitation, education, relief and natural resource conservation (Table 7). Most of the surveyed organizations are involved in agricultural services followed by technology transfer and research (Table 7).

Weather information use by institutions

Table 7 shows how governmental and NGOs in the study areas use climate information for their activities. The weather information used by these organizations include seasonal, monthly and daily forecasts. Seasonal forecasts are the most commonly used weather information by the organizations (Table 8). The main sources of weather information cited are the National Meteorological Agency (NMA) website, regional

Questions	Response (%)
Where do you get climate information	
NMA	3
District Bureau of Agriculture	37
Television, radio, newspaper & meeting	60
Kind of information you get	
Seasonal forecast for 4 months	6
Daily weather event and forecasts	42
Information about seasonal cropping practice	52
Climate information clear and easy to understand	
Yes	41
No	59

Table 6: Access to weather information by development agents in the Central Rift Valley of Ethiopia.

and zonal meteorological branch offices, Melkassa Agricultural Research Center (MARC), mass media and agricultural offices. Most respondents justify reasons for using seasonal forecasts by stating that they are helpful in making appropriate agricultural decisions during the rainy and dry seasons. As shown in Table 8, 50% of the organizations provide weather advisory services to users, 39% provide services on agriculture and above 20% use the weather information for research, planning aid requirements and health services (e.g., malaria control).

Proposed organogram for weather information flow

Weather and weather-related information is very important for farming communities. NMA provides weather forecasts in different types and formats. The agency uses television, radio, faxes, postal services and websites to disseminate the forecasts and bulletins to users. As shown by the survey results presented above, there is a gap in accessing weather information in the study areas as the majority of the farming communities use radio as a source of weather information (though not deliberately) except those model farmers who get information from both radio and television. Only a few farmers receive weather information from their neighbors and/or development agents. Another important gap identified from this survey is that farmers do not access weather information regularly and intentionally and do not use the information for their agricultural decision making in most cases. The reason for this is that the forecast given is too general (for region) and not area specific. Farmers also indicated the difficulty in understanding the forecast details and terminologies used. Other problems mentioned by farmers in accessing weather information are the irregularity on the time of broadcasts/telecasts and language used. In addition, lack of awareness of weather information services, lack of knowledge about the role of weather information, and absence of centers that coordinate and downscale weather information at local level were mentioned as common problems in the study areas. Therefore, in order to address the above mentioned issues, a new organogram of weather information delivery is proposed (Figure 2). It proposes establishing regional weather forecasting and weather information service providers. The main objective of these regional bureaus should be to downscale the weather forecast given by NMA and even by international forecasting institutions and make the forecast location and purpose specific. The NMA shall provide national weather information at a scale of day, decade, month and season that are of interest at a national and/or regional level using national media, websites and print media. The NMA needs to build the capacity of the RBM through infrastructure and human resource development. The RBM should collaborate with NMA and need to refine their weather information and services using better facilities and human resource available at the NMA. The RBM shall collect, analyze, interpret, package and repackage relevant local weather information using regional local language at a time scale of daily, weekly, monthly and season, and disseminate the same to local media, district BoA, and local government and NGOs. The district BoA in turn dispatches the information it receives from the RBM to DAs located in different peasant associations (*Kebeles*) and deliver the weather information to the farming communities. The DAs are expected not only to deliver weather information to the farming communities but also to advise them on making the right farming decisions based on the weather forecast provided. In this direction providing short/long-term training in weather data handling and delivery to DAs is essential to get the best out of the proposed weather information delivery organogram. The RBM can also reach farmers and DAs through local mass media, which usually broadcast in regional languages. Local institutions can also disseminate weather information to DAs and farming communities depending on the calendar of agricultural activities. The organogram also contemplates exchange of weather information among local and national institutions and media. Those DAs and farming communities who have access to mass media can also obtain large-scale weather information from the NMA, through national mass media although the usefulness of such information may be limited due to language variation, area coverage and clarity. Although not agro-climatic specific, the NMA is trying to establish regional weather coordination offices in different parts of the country. However, these regional offices are not yet engaged in local weather information service delivery except collecting and sending weather data to their headquarters. The proposed chart, therefore, encourages the initiative of NMA so that it strengthens its regional offices by considering agro-ecology as the criteria for location of the offices and equipping and staffing them.

Conclusion

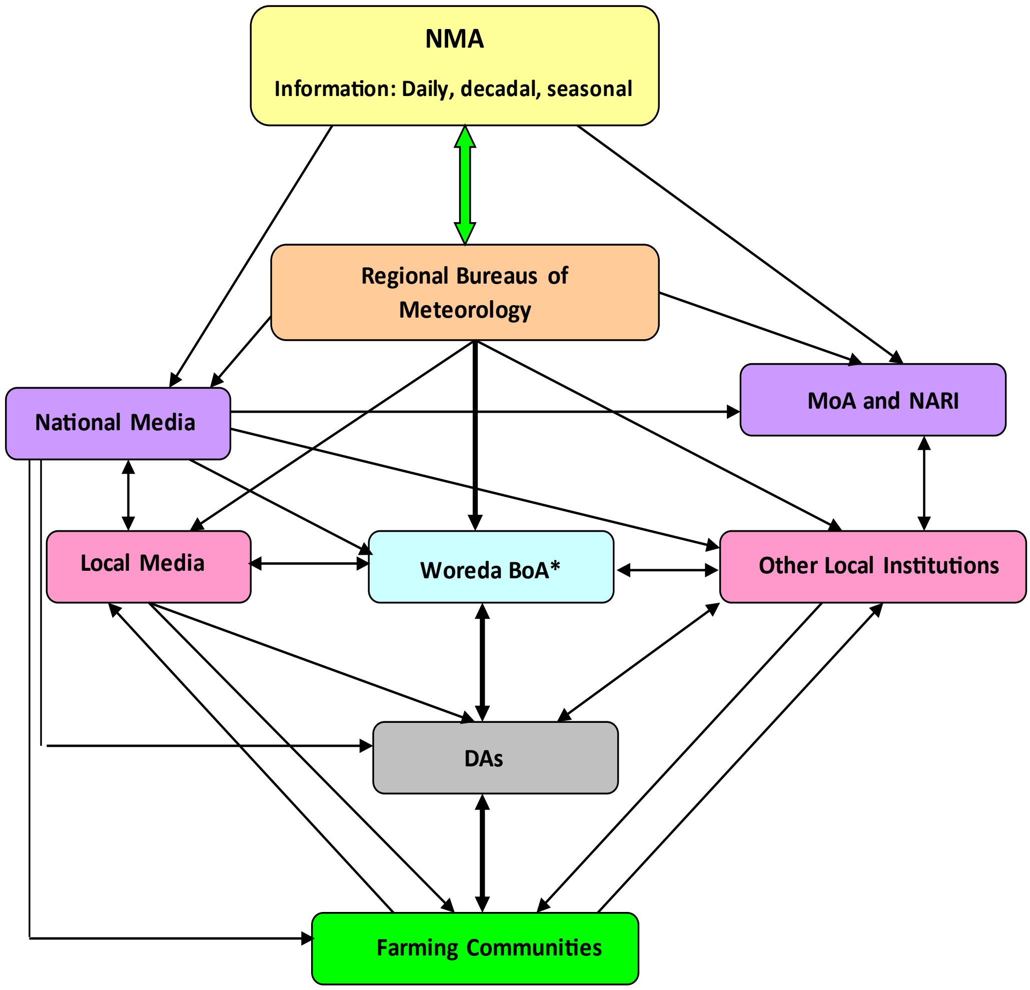
Weather information need assessment in the study areas has shown that, most farmers, development agents and different governmental and NGOs have access to weather information as compared to 39% of farm households who do not have access to climate information due to lack of awareness, lack of knowledge on the role and use of weather information, and lack of trust regarding forecasts. Those farmers who have access to weather information most commonly use radio as the communication medium, except for a few model farmers who use both television and radio. The need for weather information as an adaptation strategy for climate variability and change has been emphasized by farmers, DAs and institutions working in the study areas. However,

Services	Response (%)
Technology transfer	56
Relief	6
Agro-meteorological information	17
Agriculture	72
Research	39
Health	11
Water and Sanitation	11
Education	6
Natural resource conservation	6

Table 7: Respondents views on services provided by institutions (n=18) in the study areas of the Central Rift Valley of Ethiopia.

Issues considered	Response (%)
What kind of weather information do you use	
Daily forecast	17
Monthly forecast	33
Seasonal forecast	61
Source of weather information	
NMA website	44
Regional/zonal meteorological branch offices	11
MARC	22
Media	23
Agricultural Office	22
Purpose of weather information	-
Planning agricultural activities and services	39
Planning health services	22
Planning aid requirements	22
Research works	28
Providing advisory services to different communities	50

Table 8: Weather information used by institutions (n=18) in the Central Rift Valley of Ethiopia.



*BoA = Bureau of Agriculture, DAs= Development Agents, NMA = National Meteorology Agency, MoA= Ministry of Agriculture, NARI= National Agricultural Research Institute

Figure 2: Organogram for weather information flow to farming communities and Agricultural institutions in the Central Rift Valley of Ethiopia. The thickness and continuity of lines indicate the degree of information flow.

difficulty in understanding the weather forecast terminology and details, lack of representativeness of the forecast, inconsistency in the time of information provision and language problems are mentioned as major barriers in accessing and using weather information for climate change adaptation. Therefore, based on the major findings of this research the following recommendations are forwarded: (i) weather forecasts should be downscaled into regional level and should be location specific (ii) disseminate the weather forecast through local media in local languages (iii) the forecast should include additional agriculturally important variables such as start and duration of rainfall season, dry spell period, crop water requirement, crop pest and disease) (iv) probabilistic nature of seasonal forecasts should be given with technical guidance to help farmers interpret easily and respond to the forecast (v) The NMA should follow the new organogram of climate information service delivery in order to provide accurate and tailored forecasts to the farming community and other users (vi) weather information delivery should be one major component of the agricultural extension service delivery. This requires upgrading the knowledge and skills of existing development agents in climate, climate change, climate risk management and climate information management through short-term training and exposure to field visits. Finally, in order to make informed decisions at different levels, advanced research on quantitative analysis of vulnerability of climate risks, climate change impacts and community adaptation mechanisms needs to be encouraged.

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