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Journal of Agricultural Extension
Vol. 22 (1) February, 2018
ISSN(e): 24086851; ISSN(Print); 1119944X
http://journal.aesonnigeria.org
http://www.ajol.info/index.php/jae
Email: editorinchief@aesonnigeria.org

Indigenous knowledge of Rural Communities for Combating Climate Change Impacts in West Central Ethiopia

https://dx.doi.org/10.4314/jae.v22i1.16

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Abstract

The study examined how local knowledge of climate change plays a role in adjusting to changing climate and how these beliefs may influence future decision making about how to go about adjusting to climate change at a local level. The study was conducted in west central Ethiopia at the edge of the Blue Nile. The current indigenous knowledge practiced by the local community in adopting the changing environmental conditions was discussed. Rural communities have local knowledge in areas such as weather and seasonal forecasting (44%), drought forecasting (20.9%), crop pest & disease (47%), and weed (99.7%) control methods to adapt to some of the climate change impacts. Not all households have the same levels and types of indigenous knowledge. Therefore, awareness creation and experience sharing among community members are important in increasing the application of indigenous knowledge for climate change adaptation.

Keywords: *Climate change adaptation, Climate change impacts, Ethiopia, Indigenous knowledge*

Introduction

East Africa is one of the most food insecure regions in Africa due to frequent climate risks (Slegers and Stroosnijder, 2008, Demeke *et al.*, 2011, Gray and Mueller, 2012). Ethiopia faces numerous development challenges that exacerbate its vulnerability to climate change, including food insecurity and ongoing conflict over natural resources such as water and grazing lands. The climate change variables such as an increase in temperature, and rainfall variation lead an increase in crop pest and disease outbreaks and other extreme events like a flood. In Ethiopia, climate change affects agriculture, water, and human health. Local peoples knowledge was acknowledged in the Fourth Assessment Report of the Intergovernmental Panel on Climate Change (IPCC) as 'an invaluable basis for designing adaptation, coping, and natural resource management strategies in response to environmental and other forms of change'(IPCC, 2007, Nakashima *et al.*, 2012).

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Combating climate change impact requires the involvement of many people ranging from communities who experience the effects on a daily basis, to scientists attempting to understand the biophysical and socioeconomic causes and consequences of climate change, to developers and policy makers at all levels. Rural communities in Sub-Saharan Africa developed several adaptation strategies that have enabled them to reduce vulnerability to climate variability and extremes. These local adaptation strategies were to conserve carbon in farming soils using zero tilling in cultivation, mulching, and other soil management techniques(Schafer *et al.*, 1989, Osunade, 1994).

Local farmers largely depend on organic farming, which also is capable of reducing greenhouse gas emissions. It is also recognized that forests play an important role in the global carbon cycle by sequestering and storing carbon(Karjalainen *et al.*, 1994, Stainback and Alavalapati, 2002). Application of mulching regulates soil temperatures and extremes, suppress diseases and crop pests and usd to conserve soil moisture so as to increase the productivity of agricultural land.

Indigenous knowledge refers to the knowledge and know-how accumulated across generations and renewed by each new generation, which guides human societies in their innumerable interactions with their surrounding environment (Nakashima *et al.*, 2012). Communities indigenous knowledge has been defined as institutionalized local knowledge that has been built upon and passed on from one generation to the other by word of mouth(Ajani *et al.*, 2013). Local peoples' knowledge focuses on elements of significance for local livelihoods, security, and well-being, and as a result, it is essential for climate change adaptation strategy. Despite the fact that indigenous knowledge is an emerging area of interest for climate change scientists, the exchange of knowledge between scientists and indigenous peoples dates back to the very origins of science (Nakashima *et al.*, 2012). The importance of local knowledge has been known in the design and implementation of sustainable development projects; little has been done to include this into formal climate change adaptation strategies(Ziervogel and Opere, 2010).Managing climate chanage impcats has traditionally been the responsibility of households, except large extreme weather events and disasters. Improving farmers' knowledge and their capacity to observe and experiment is an essential element in the development of integrated soil fertility management technologies (Deugd *et al.*, 1998, Corbeels *et al.*, 2000, Heltberg *et al.*, 2009). It is also important to establish local systems of knowledge, as they relate to specific locations and are based on experience and understanding of local conditions of production. Therefore, traditional knowledge practices embody local adaptive management to the changing environment and complement scientific research. Besides, the uncertainty associated with climate change demands an approach that prepares people without relying on detailed weather information and climate projections. In the last decades, Ethiopia has been implementing a community level environmental rehabilitation programme that focused on soil and water conservation(Ajani *et al.*, 2013). This is a testimony that climate change impact adaptation policies should be considered part of the sustainable development process and be implemented at the grassroot level. Therefore, having the experience of this indigenous knowledge practices in climate change adaptation is important. The study

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therefore was designed to assess the indigenous knowledge of rural communities to combating climate change impacts in west central Ethiopia.

Aim and Objectives of the study

The general aim of the study was to assess the indigenous knowledge of rural communities to combating climate change impacts in west central Ethiopia.

The specific Objectives were to:

1. Explore the current weather and seasonal forecasting knowledge of the rural communities

2. Identify the current soil fertility increment techniques and seasonal food shortage coping methods

3. Identify the current pest, disease, and weed control methods

Methodology

The study was conducted in Dejen district of west-central Ethiopia at a road distance of 335km south of the regional state capital, BahirDar, and 230 km northwest of the capital city of Ethiopia, Addis Ababa. The district lies between longitude 38^{o} 6' E and 38^{o} 10' E, and between latitude 10^{o} 7' N 10^{o} 11' N, with an elevation of 1071 and 3000 meters above sea level (>M.A.S.L). The same to most parts of Ethiopia; it is a mixed production system with both crop and livestock rearing. Crop production is completely rainfed, except in a small number of localities where small-scale water harvesting processes have been recently introduced by the office of Agriculture and Rural Development. In the lowland parts of the district, the combination of moisture stress and poor soil fertility is the limiting factor for agricultural production. The climate of the district is traditionally classified based on altitude and temperature. Annual average temperature and total annual rainfall of the district range between 20^{o}C and 24^{o}C and 800 mm and 1200 millimetres, respectively. The district has been categorised into three traditional climatic zones, 41%, highland,31 % midland, and 28 % lowland(DDFEDO, 2014, DDEPO, 2016).

The data were collected between March to October 2016 in the three agro-ecological settings of lowland, midland, and highland sites of the Nile basin of Ethiopia. This was because climate change affects the rural communities differently in different agro-ecological zones. As a result, communities' knowledge and skill to adapt to the climate change impacts varies from place to place. Stratified and snowball sampling techniques were employed to select a sample of 398 households. The household survey was employed to collect data on households' local knowledge to adapt climate change impacts and time series climate data over the period 1979-2014 was used to triangulate the households' response respectively. Focus group discussions and key informant interviews were used to triangulate households' response on local knowledge of climate change adaptation strategies. Field observations were used to observe biophysical, economic, social, and institutional features of the district. The indigenous knowledge of households was measured using variables such as

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traditional weather forecasting knowledge, knowledge of households in predicting the quality of the coming season (rain or drought),traditional climate change impact coping and adaptation strategies such as water and land resource management, pest control methods, weed control methods, and seasonal food shortage coping mechanisms. Seasonal rainfall is the major determinants of Ethiopian agricultural production. Ethiopia has three seasons; *KIREMT* which is the main rain season (June to September), *BEGA*, characterized by sunny and dry weather situation with occasional falls. It extends from October to January and *BELG* which is the small rainy season that extends from February to May and covers Southern, Central, Eastern and North eastern parts of the country. Hence rain-fed agriculture is highly dependent on rainfall patterns, the rural communities have to make crucial decisions about sowing time and the varieties of crops used. In both agro-ecology of the district, people make these decisions on the basis of their observations of what they call “signs” of the weather forecast.

The results from surveyed households and focus group discussions revealed, farmers use and rely on indigenous knowledge forecasts than on scientific weather forecasts. This is because of lack of tailored made information as per their understanding and insufficient information from the National Meteorological Agency of Ethiopia. These responses were analysed using statistical product and service solutions (SPSS version20). The household survey questions that used in collecting indigenous knowledge of rural communities were open ended.

Results and Discussion

The results were structured to reflect the local communities’ knowledge of coping and adaptation strategies of climate change impacts.

Weather and Seasonal Forecasting Knowledge

Farmers tend to use a combination of indigenous knowledge and scientific information in their seasonal forecasting, as they primarily rely on indigenous knowledge but are also open to receiving scientific forecasts from their district agricultural office experts.

About 44% of the farmers had forecasting knowledge. Signs (indicators) used to forecast the start and end of rain season and weather forecasts include moisturized wind from North to South (31.9%) which shows onset of short rainy season and sign of heavy rainfall in the coming season, unusual heat increment (11.1%) and lighting towards East (16.1%) indicating to rain within late afternoon. Others include when the sky becomes clean (0.5%), there will be rain within a week period. The sound of Eagle (0.5%) also shows the coming season will be rainy/*Belg* (Figure 1). Previous studies have reported signs such as “winds blow from North to South(Risiro *et al.*, 2012) and feeling of excess heat during the night and day(Risiro *et al.*, 2012, Mahoo *et al.*, 2015)

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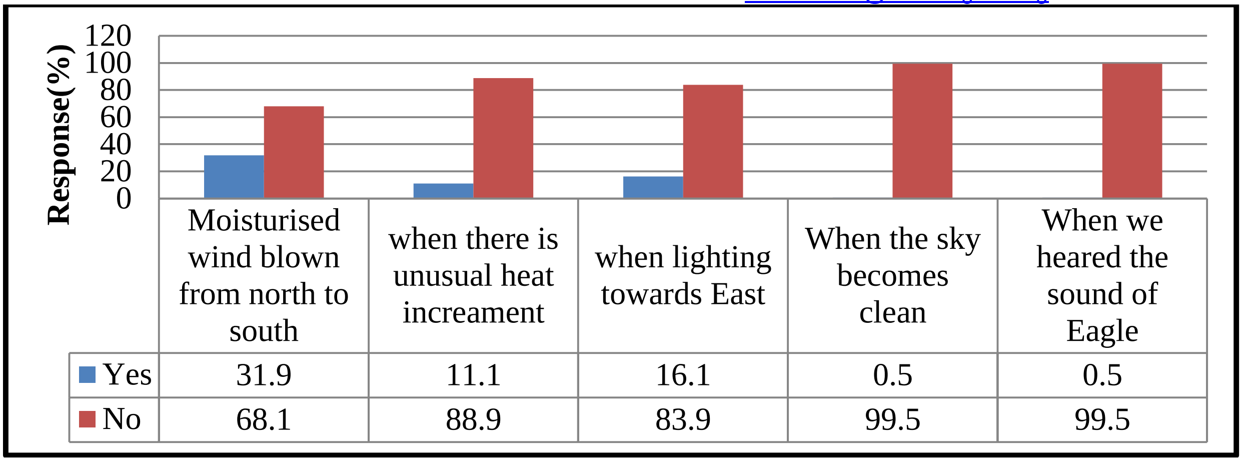

Figure 1: **Households rainfall forecasting knowledge**
Household Survey data, March-October (2016)

The communities have also drought forecasting knowledge. A few (20.9%) of respondents have indigenous drought forecasting knowledge. Identified local knowledge for drought forecast include: there is drought in every four years (2.3%), when there is dry fog (10.1%), North to South dry wind (12.3%) and the wind after some rainy days (0.5%) were indicators for a bad season in the rural communities (Figure 2).
The study communities believe there is a drought in every four years. This result coincides with the focus group discussions, the key informant interviews, and the results of climate data analysis precipitation index (SPI). In the past ten years (2005 to 2014), there were two drought years in every four years. The year 2008 was characterized by severe drought and 2012 extreme drought (see Table1). The table showed 12 months of above and below normal wet and dry seasons from the 36 years. Local communities in Africa have continued to rely on indigenous knowledge to conserve the environment and deal with natural disasters such as drought (Chang'a *et al.*, 2010, Egeru, 2012, Mahoo *et al.*, 2015).

Table1: Standardized precipitation index(SPI) values of above and below normal wet and dry years

Years	Annual rainfall(mm)	SPI values	Values Category
1983	1251.4	1.2	Moderately wet
1986	1269.6	1.29	Moderately wet
1987	1363.6	1.71	Moderately wet
1996	1274.94	1.31	Moderately wet
1998	1403.3	1.89	Moderately wet
2002	467.6	-2.35	Extremely dry
2008	713.6	-1.24	Moderately dry
2010	1274.1	1.31	Moderately wet
2011	686.6	-1.36	Moderately dry
2012	536.04	-2.04	Extremely dry
2013	699.6	-1.3	Moderately dry
2014	759.15	-1.03	Moderately dry

Computed from global weather data for soil and water assessment [http://globalweather.tamu.edu/]1979-2014)

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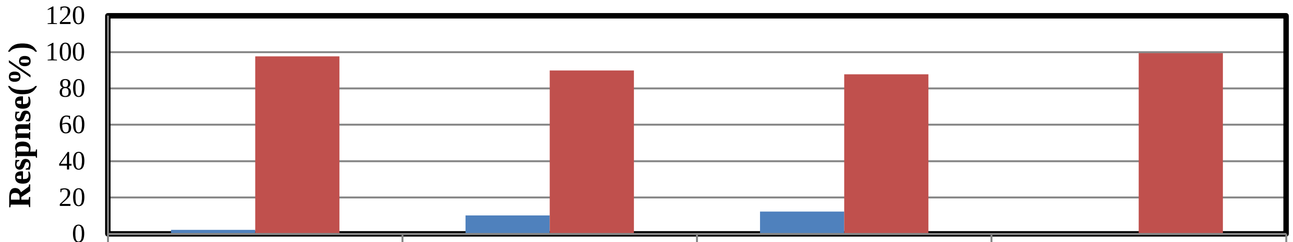
Less than half (44%) of respondents have weather and seasonal forecasting knowledge and only 20.9% of respondents have traditional drought forecasting knowledge. This implies that not all households have the same levels and types of indigenous knowledge. Therefore, awareness creation and experience sharing among community members are important in increasing the application of indigenous knowledge as a climate change adaptation.



	There is drought in every 4yrs	When there is dry fog	North to South Wind	Wind after some rainy days
Yes	2.3	10.1	12.3	0.5
No	97.7	89.9	87.7	99.5

Figure 2: **Drought forecasting knowledge of households**
Household Survey data, March-October (2016)

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Table 2: Weather and drought forecasting knowledge of rural communities

	Responses		Agro-ecology
Discussed issues	Female FGDs	Male FGDs	
weather forecasting knowledge	There is rain when lightning towards East	When there is un usual heat, the rain will come in the late afternoon or evening time of the day	Highland
drought forecasting knowledge	When there is rain at the end of rain season (September 11), it is expected to be good for the coming season and vice versa.	There is drought in every four years	
weather forecasting knowledge	When there is un usual heat, the rain will come There is rain when lightning towards East and vice versa	When we hear sound of Eagle, the rain will come not later than a week When the wind blows from west to East, rain will come	Midland
drought forecasting knowledge	They have no idea	There is drought in every four years	
weather forecasting knowledge	There is rain when lightning towards East	When there is un usual heat, the rain will come There is rain when lightning towards East	Lowland
drought forecasting knowledge	They have no idea	April Rain is a good indicator of good season(*Belg*) When there is left side wind, there will be frost with consequence of crop failure specifically cereal crops and red pepper There is drought in every four years	

Focus group discussions (FGDs), August (2016)

Soil Fertility Increment Techniques and Seasonal Food Shortage Coping Mechanisms

Rural communities have their own indigenous knowledge of classifying, describing and characterizing local soil types in their farmlands based on the soils characteristics and its suitability for growing various types of crops. Farmers identified different soil types based on their colour, stony composition, water holding capacity, the capacity of the soil for long-term productivity of crop yield, drainage & manure requirement of the farmland and topographic location (cultivability). The majority (95.7%) of respondents have at least one traditional soil fertility increment techniques such as use of compost, animal waste, frequent ploughing, terracing, crop rotation, leguminous plants, and fallowing (Figure3). Seasonal migration and shift to cheap food items were some of seasonal food shortage coping mechanisms.

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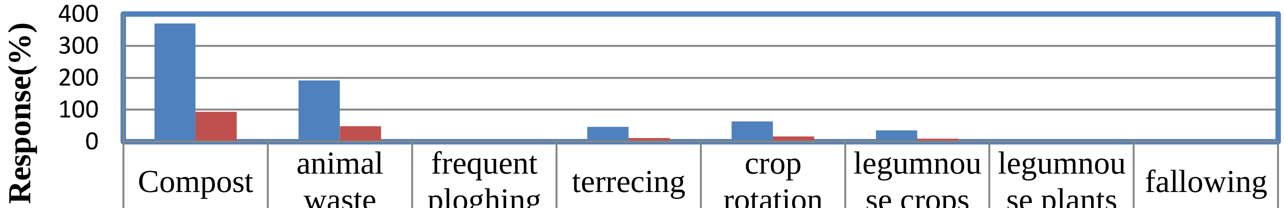
Manure-compost: The majority (92.3%) of farming households and non-farming households who have backyard apply manure-compost to increase their farm/backyard land fertility. Compost is a mix of animal wastes and a variety of organic materials such as leaves, grass clippings, kitchen scraps and yard wastes. As a result, it takes time to prepare and requires labour. The respondents report that composting takes up to six to eight months to get ready for the farm. Whereas, among those who did not use manure-compost, 35.7% of them explained, they did not have skill to make compost, shortage of labour(21.4%), small land/no land at all (39.3%) to apply manure, insignificant numbers of households(3.6%) have doubt on manure-compost to increase soil fertility.
Frequent ploughing: Only 0.8% use frequent ploughing. In the study area, frequent ploughing is not only to increase soil fertility, it also uses to expose to sun light weed residuals and kill crop pests and diseases. The reason for non-use by many farmers was due to it is labour intensiveness and cost.



	Compost	animal waste	frequent ploghing	terrecing	crop rotation	legumnouse crops	legumnouse plants	fallowing
Freq	371	192	3	46	63	35	1	4
%age	93.2	48.2	0.8	11.6	15.8	8.8	0.3	1

Figure 3: **Traditional soil fertility increment techniques**
Household Survey data, March-October (2016)

Terracing: Farmers traditionally constructed terraces (11.6%) to improve soil fertility and productivity. In addition to soil fertility, terracing the low land helps to slow down water runoff and capture sediments. Farmers regard these sediments as fertile soil material and believe that terracing can make an infertile soil more fertile specifically on the hill sides of the study sites.
Crop rotation: About 16% of the respondents practiced crop rotation to increase the fertility of their soil. Major crop rotations practiced by farmers' choice were; barely-what-teff/maize; teff-barely-wheat; barely-chicken pea-barely.
Leguminous crops and plants: A few of the respondents adopted use of leguminous crops (8.8%) and plants (0.3%) as methods of enhancing soil fertility and adapting to climate change. Some of the leguminous crops are beans and peas. Besides soil fertility increment, leguminous plants such as alfalfa were used as fodder for animals. These legumes can increase soil fertility and reduce weeds by conserving organic matters. Ayoade (1983) noted that, legumes and grasses could increase soil fertility and controls weeds with the addition of organic matter and improve the water retention capacity of the soil.
Fallowing: Very few farmers (1%) used this system to increase their soil fertility. Limited extension services and weather information, lack of skills, lack of water,

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shortages of land and land fragmentation have led the insufficient application of traditional soil fertility management practices such as fallowing.

Seasonal migration: In Ethiopia labours often move to in another place for seasonal work and destinations and work vary by community members. Young people and some household owners often seek alternate and seasonal sources of income especially during crop failure and other shocks. However, seasonal migration in the government extension package is not included as adaptation strategies in the study area. Each year during the dry season following harvest people from many communities in rural Ethiopia travel for temporary work. On the contrary, the majority (67.4%) of the surveyed households were reluctant to leave their locality even for a day period. This was due to their family love and cares each other in the nearby (67.4%) and culturally (6.2%) did not want to travel outside their locality as they think it as migrant. Others explain the shortage of labour (14%) to travel seasonally and work, do not have skills and information (11.4%) about where and how to travel and work. Insignificant numbers of households (0.8%) explain the lack of money for transportation.

Shift to cheaper food items: The other seasonal food shortage coping mechanism was changing household consumption to cheap food items. During climatic shocks 71.8% of the surveyed households shift their daily consumption to less expensive items. In Ethiopia *Teff* is the major food crop and that used as household food consumption in urban and rural communities. As a result, the communities take as a culture and relying on it. The same to this, among those who did not change (28.2%) their food items to cheaper food crops during the bad time or drought shocks, explained that it is because of the culture of consumption (77.7%) of households relying on one or two food crops. Others (22.3%) did not have information about changing /shifting to cheap food items.

Pest, Disease, and Weed Control Techniques

About 47% have at least one type of traditional crop pest and disease control technique. Climate change could have positive, negative or no impact on each pest. There is a need for better models to assess their global impact as most pest population prediction models have different spatial and temporal scales than global models (Reijntjes *et al.*, 1992, Ajani *et al.*, 2013). Crop pests are usually controlled by cultural practices, natural enemies, host plant resistance, biopesticides, and synthetic pesticides. However, many of these control methods are highly sensitive to the environment and climate change may render them less effective. For example, there were indications that stem rot (*Sclerotium rolfsii*) resistance in groundnut is temperature dependent, while in Kenya resistance to sorghum midge(*Stenodiplosis sorghicola*) breaks down under high humidity and moderate temperatures (Ajani *et al.*, 2013). The traditional techniques used for pest control include application of livestock urine and wood ash(31.4%), mix of different leaves(14.3%) such as clematishirsuta (*Yeazohareg*),crotonmacrostachyus (*Bisana*) Eucalyptus leaves, flooding over the affected land(0.8%),spraying boiled water(0.3%), frequent ploughing (0.8%),burning of crop residuals (2.5%),clearing of leaves around farmland (1.8%),disturb the pests

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using stick manually (4.5%), removing affected plants(0.8% and covering seeds with leaves and wood ash(0.5%) can be used to kill crop pests and diseases(Table3).

The majority (99.7%) of households have at least one traditional weed control methods. 99.5% used hand weeding, a few (9.3%) used burning of residuals, frequent ploughing (20.6%) and use of improved seeds (2.3%) (Figure 4). Burning of residuals after harvest can reduce the surface seed banks and destroy weed seeds. However, burning of crop residuals has the potential to increase greenhouse gases which has a great contribution for climate change(Amare, 2014). Thus, before adopting such indigenous knowledge practices need to be examined for their appropriateness just as any other technology. Both the soil fertility increment, pest and disease control techniques are in line with results obtained from focus group discussions (Table4). Scott *et al.* (2014) noted that, the main drivers for climate change impacts on plants, including weeds are a change in temperatures and rainfall, altered frequency and intensity of extreme weather events and climate change exacerbate both the threat to biodiversity and the cost of agriculture weeds.

Table 3: Crop pest and disease control techniques used by rural households

Responses (%)	Mix of livestock urine &wood ash	Mix of different leaves	Flooding over farmland	Spraying boiled water	Frequent ploughing	Burning of residues	Clearing of leaves	Disturb by stick	Removing affected plant	Covering seed with leaves & wood ash
Yes	31.4	14.3	0.8	0.3	0.8	2.5	1.8	4.5	0.8	0.5
No	68.6	85.7	99.2	99.7	99.2	97.5	98.2	95.5	99.2	99.5

Household Survey data, March-October (2016)

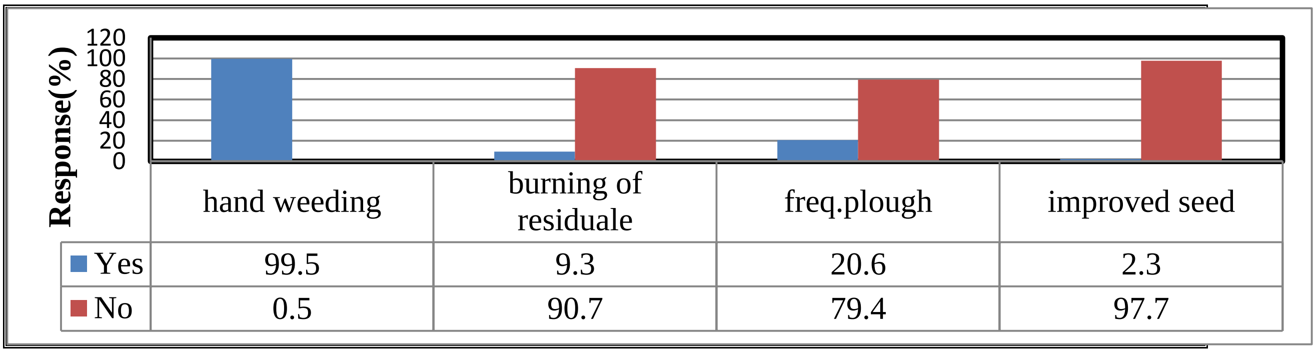

Figure 4: **Crop weeds control techniques**
Household Survey data, March-October (2016)

The focus group discussions reveals that grass/vegetation strip along with conservation tillage and hoeing improves crop yields by reducing run-off and top soil erosion (Table4). Studies conducted by Zhang *et al.* (2004) and Zhang *et al.* (2009) in hilly areas of the Sichuan Basin where manual hoeing is a predominant tillage method

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demonstrated that, tillage erosion rates by contour tillage were reduced by 77%, compared to those for down slope tillage. Tillage erosion is the downslope movement of soil by tillage. That means during tillage, soil is lifted and gravity moves soil downslope. This implies, grass/vegetation strip has a role in reducing erosion for the downslope farming locations. Besides, changing other types of seed produced from another farm and sowing seeds in mud farm are weeds control techniques in the study area. Farmers believe that seeds from another farmland have a strong adaptive capacity to weeds for the new farmland.

Religion plays a role in local adaptation strategies. Old age and being the religious head is an important determinant to understand and interpret indigenous knowledge to climate change impacts. In bad years /season, communities come together in church or the mosques and pray for better rains. Praying and spraying holy water on the farmland is believed to control crop weeds, pests, and disease. People view climatic change as acts of God and believe in God's intervention as traditional adaptation strategy(Batta *et al.*, 2013).

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Table 4: Soil fertility increment and pest and disease control methods

Discussed issues	Responses: Female FGDs	Responses: Male FGDs	Agro -ecology
			Highland
Soil fertility increment	Crop rotation	Crop rotation	
	Changing other types of seed produced from another farm	Terracing to deposit sediment soil	
	Frequent ploughing	Using compost	
	Using compost	Planting legume trees on farm	
Crop pest control	Spraying holy water on the crop farm	Spraying holy water on the crop farm	
	using a mix of wood ash and leaves	Using livestock urine	
	Using smoke, Clearing farmlands and its round		
Crop weed control	Hand weeding	Hand weeding	
	Frequent ploughing	Frequent ploughing	
	Flooding to the farm (watering more water to kill pests)	Clearing farmlands and its round	
	Sowing seeds in mud farm		
Soil fertility increment	Planting legume crops	Crop rotation (legume crops)	Midland
	Using compost	Livestock urine, compost	
	Immature weed (green manure)	Frequent ploughing	
	Terracing to deposit organic sediment	Planting legume plants on farm	
		Terracing, Grass strips	
Crop pest control	Using livestock urine to kill locusts	Clearing farmland and its round	
crop weed control	Hand weeding	Hand weeding	
	Sowing seeds in mud farm	Frequent ploughing	
	Clearing farmland and its round		
Soil fertility increment	Using compost	Crop rotation, Livestock urine	lowland
	Using livestock urine	Using compost, Immature weed (green manure)	
Crop pest control	Spraying holy water on the crop farm and Hoeing	Spraying holy water on the crop farm, and using livestock urine	
Crop weed control	Hand weeding	Hand weeding	
	Frequent ploughing	Frequent ploughing	
	Hoeing	Clearing farmland and its round	

Focus group discussions (FGDs) data, August (2016)

Journal of Agricultural Extension
Vol. 22 (1) February, 2018
ISSN(e): 24086851; ISSN(Print); 1119944X
http://journal.aesonnigeria.org
http://www.ajol.info/index.php/jae
Email: editorinchief@aesonnigeria.org

Conclusion and Recommendations

Weather and seasonal forecasting, soil fertility increment techniques, pest, disease, and weed control methods and food shortage coping methods like seasonal migration and shift to cheap food items were some of the indigenous knowledge used by rural communities. However, it is important to know that not all indigenous practices are sustainable and not all local knowledge can provide the right solution for a given problem. For example, burning of residuals which was one of the traditional weed control techniques in the local community has contribution to enhance climate change. Therefore, before adopting such indigenous knowledge, integrating it into development programs, practices need to be examined for their appropriateness just as any other technology.

Not all households have the same levels and types of indigenous knowledge to combat the changing environment rather the knowledge is at community level. Therefore, institutional supports, as well as increased access to information, awareness creation through environmental education, and experience sharing among community members are important in increasing the application of indigenous knowledge to combat climate change impacts.
Except manure-compost, all other methods of indigenous knowledge practices were not supported by government and other stakeholders who are working on the agriculture sector. Participatory community consultations through government extension agents could help to develop sustainable alternatives to replace ineffective or unsustainable adaptation practices. Thus, bottom-up participatory approach should be implemented to encourage the highest level of community participation in combating climate change impacts. This bottom-up approach provides valuable insights into how rural communities interact and share ideas and allows developing the skills and practices necessary to frame their own path and increase their agricultural production in a sustainable way. Incorporating local knowledge into climate change policies can lead to the development of effective and sustainable adaptation strategies that are cost-effective and environment friendly.

Acknowledgments

This study was sponsored by the Pan African University (PAU) a continental initiative of the African Union Commission (AU), Addis Ababa, Ethiopia. The author acknowledges Professor Johnson O. Ayoade, Dr. Ibidun O. Adelekan and, Dr. Menberu Teshome Zeleke for their contribution to supervise the project from inception to end. Further, the author thanks the University of Ibadan for hosting the programme.

Competing interests

The author declares he has no competing interests

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Abstracted by: EBSCOhost, Electronic Journals Service (EJS), Google Scholar, Journal Seek, Scientific Commons, Food and Agricultural Organization (FAO), CABI and Scopus

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Vol. 22 (1) February, 2018
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Vol. 22 (1) February, 2018
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