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THE ROLE OF INDIGENOUS WEATHER FORECASTING KNOWLEDGE SYSTEMS FOR ADAPTATION TO THE EFFECTS OF CLIMATE VARIABILITY ON AGRICULTURE IN KONDOA DISTRICT- TANZANIA

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Keywords: Climate Variability, Indigenous Knowledge System (IKS)

ABSTRACT

Tanzania has been experiencing climate variability extremes such as drought and floods. The spatial distribution and the intensity of these extremes exceed the expected weather events and said to be aggravated by global climate change. Floods and drought are known to affect socio-economic activities.

This study has investigated the role of indigenous agricultural knowledge systems for adaptation to the effects of climate variability in Kondoa district, Tanzania. The study used questionnaires and focus group discussion as basic tools for gathering information. A total of 109 respondents were involved in this study. 94 respondents were involved in questionnaire survey and 15 were key respondents.

The study revealed that local people have both indicators and practices which are used in minimizing key climate based vulnerabilities that are related to agriculture. The common indicators used for forecasting are birds, plants and insects behaviors and thundering. The

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common soil management practice revealed was the use of animal manure. These practices correlate well with modern climatic information gathered in the study area.

This study concluded that indigenous knowledge used by the local people in Kondoa district has significant effect in reducing key climate vulnerabilities in agriculture.

Introduction

Climate change and variability phenomenon is an issue of global concern. The awareness on effects of climate change and variability has resulted into the establishment of the Intergovernmental Panel on Climate Change (IPCC) in 1988 jointly by the World Meteorological Organization and the United Nations Environment Programme. To address climate change vulnerability, mitigation and adaptation globally, the United Nations Framework Convention on Climate Change (UNFCCC) was adopted in New York in 1992 (Wyk, 2010).

Local communities and development in Africa are vulnerable to the effects of climate change and variability (IPCC, 2007, UNFCC, 2008). Studies on vulnerability and adaptation to the effects of climate change in Tanzania clearly indicate that forestry, water and agriculture sectors are among sectors likely to be vulnerable to climate change and variability. (Majule and Mary, 2009).

Africa including Tanzania and other developing countries are mentioned to be highly vulnerable to climate vulnerability impacts due poverty which causes adaptation mechanism to be less effective(IPCC, 2001; Hasternrath;2001).

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Communities livelihoods in Kondoa district are among the most vulnerable societies to the effects of climate variability in Tanzania. This vulnerability is due to nature-dependent livelihoods, which include crop farming and livestock keeping. These livelihood sectors are likely to be affected by frequent drought, increased rainfall variability, and climate-induced crop and animal diseases. The Kondoa district socio-economic survey of 2004 shows that, the district is affected by land degradation and has a semi-arid climate, a situation that adds to its vulnerable nature, leading to reduced crop and animal productivity in the district. These have affected livelihood sustenance in the district in terms of food security and access to social services such as safe and clean water. In the face of climate change, the effects can adversely impact the social and economic development in the area and contribute to increased poverty.

Effective adaptation strategies in agriculture such as practices weather forecasting, are important in order to respond to the effects of climate variability and improve the community livelihoods in Kondoa district. Effective adaptation depends on comprehensive knowledge and participation of local communities in every process of adaptation. This should include taking into consideration Indigenous Knowledge Systems (IKS) in responding to various environmental and socio-economic challenges.

Research Objectives

The specific objectives were:-

i. To identify the factors contributing to agricultural vulnerability to the effects of climate variability in Kondoa district.

ii. To find out how climate variability have affected agriculture activities in Kondoa district.

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iii. To recommend strategies in which IKS related to agriculture can be incorporated in environmental policy and legislation in Tanzania.

Location of the Study Area

The study was conducted in Kondoa district. The district is located in the north of Dodoma region about 160 km from the capital town, Dodoma Tanzania. It lies between latitude 4^0 12'to 5º 38' south, and longitude 35^0 6'to 36^0 2' east. Much of the district is plateau rising gradually from 900m to 2,190m above sea level.

Kondoa district is characterized by semi-arid to sub-humid conditions. The mean maximum and minimum temperatures are 29°C and 16°C respectively, and mean annual rainfall varies between 500 and 900 mm. Natural vegetation consists of miombo woodland, with *Brachystegia* being the most common woody genus. This vegetation has declined during the past century and often deteriorated into vegetation consisting mainly of thickets or widely spaced clumps of thorn bush with bare ground in between. The decline was associated by timber production in the 1970s that accelerated deforestation (Dejene et al, 1997). Also the traditional tsetsefly eradication programs through massive tree felling during colonial era which were initiated in 1927 and continued until 1949 to combat *trypanosomiasis* led to wholesale clearing of vegetation which resulted in long-term reduced vegetation cover (Mbegu and Mlenge, 1983). The main soil types are those rich in iron (ferric acrisols). The study was conducted at three villages found at different height above sea level namely Tampori, Ntomoko and Bereko.

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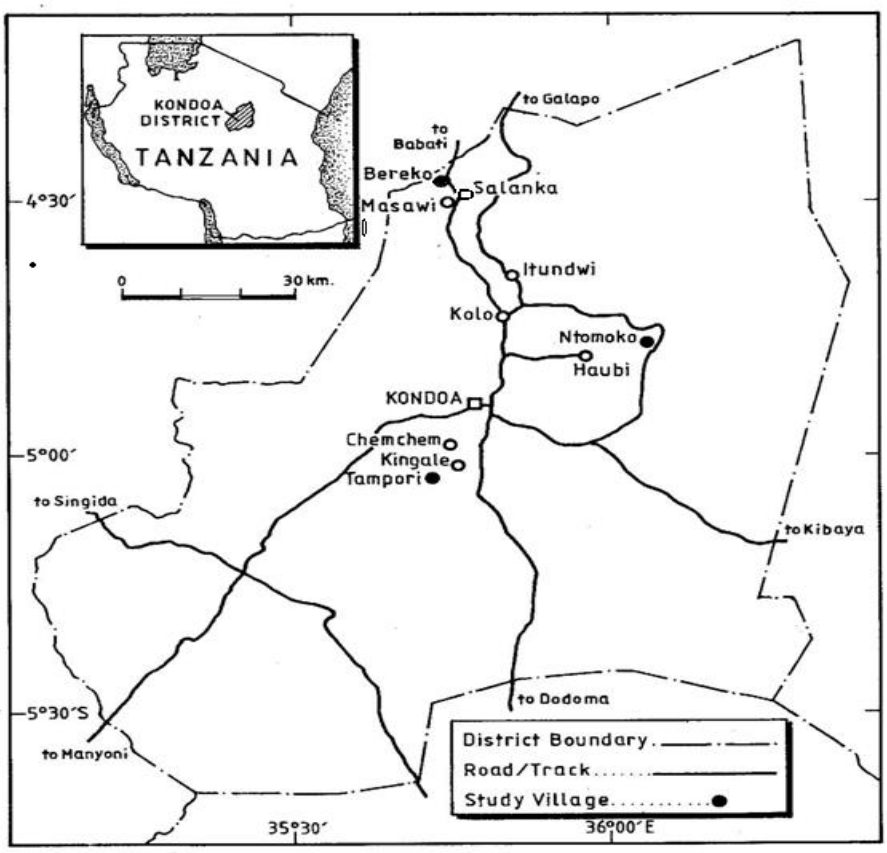

Figure 1: Map of Kondoa district showing location of study villages
Source: Cartographic Unit, University of Dar es Salaam (2013)

Methodology

Research Design

This study uses survey design with quantitative and qualitative methods for data analysis. Three villages from the district were purposefully selected due to their characteristics. The main consideration was geo ecological gradient. The sample for household survey was 10% of the total household in the selected study villages.

Both simple random sampling and purposive sampling were employed in this study. Purposive sampling were used to select study villages as well as key informants involved in the study while simple random sampling were used to select households involved in the study.

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Sources of Data

Social Economical Survey

Social economical survey were used to collect primary data. The questionnaires were used to collect data from household survey on the indigenous knowledge available that are used by the community in the study area. The meteorological data was used to indicate the historical timeline for incidences of climatically vulnerability and agricultural productivity in the area. Data collected using questionnaires were analysed using SPSS. Descriptive and inferential statistics were used to determine course effects relationship and occurrences of variables. Direct observation was also employed to depict ground actions such as various indigenous knowledge systems used for agriculture from the time of farm preparation to the time of harvest.

Results and Discussion

Based on the information from the study area the following results were found; Section 1 presents findings on the factors that contribute to community vulnerability to the effects of climate variability in Kondoa district. Section 2 present Information on the effects of climate variability to the livelihood of the local people in the study area. Section 3 present findings on the IKS related to agriculture such as IKS in weather forecasting, IKS in soil fertility management, IKS in crop and animal management and IKS in water resources management.

Factors that contribute to community vulnerability to the effects of climate variability in Kondoa district

Communities in the study area depend much on farming activities as a main source of food and income. The findings show that, 99% of the respondents depend on agriculture to earn income for their living. However, 37.2% of respondents involved in agriculture claimed that the activity gave them low income while 30.9% of the respondents involved in the activity pointed out that

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the activity recently has increased poverty in their family and 15.9% affirmed that they get enough income. Similarly the Kondoa district socio-economic report describes that, agriculture in the area is characterised by low productivity resulting from low and erratic rainfall in the area. Generally, about 85% of the annual rainfall in the study area falls between December and March. The field study noted that there is existence of agricultural practices that are related with clearance of forest in the area. Among others 73.5% of the respondents pointed out that deforestation is still practiced in the area, also 29.9% pointed out that shifting cultivation is practiced.These activities have contributed to the decrease of the amount of rainfall in the area over time by reducing atmospheric moisture resulted from evapotranspiration from plants which are important for rainfall formation. The study also revealed that 68% of the respondents pointed out that the trend of rainfall in the study area has been decreasing if compared with 2000 levels while 16% denied and suggested that rainfall in the area has been increasing, 13.8% affirmed that rainfall trends from 2000 to 2012 has been in the same trend (table 1 and table 2).

Table 1: Responses on the Rainfall Trend in the Study Area Since 2000

Responses	Percent
Decreasing	(64)68%
Increasing	(15)16%
Same as Before	(13)14%
Not Sure	(2)2%
Total	**(94)100%**

Source: Field Survey

Table 2: Causes of Decline of Vegetation in the Study Area

Responses	Percent
Deforestation	(56)59.6%
Shifting Cultivation	(15)16.0%
Deforestation, livestock population, shifting cultivation	(1)1.1%
Deforestation, shifting cultivation	(12)12.8%
Total	**(94)100%**

Source: Field Survey

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The extent to which climate variability have affected agriculture activities in Kondoa district

The main crops grown in the area include maize, millet, sorghum and cassava. Others are bananas, peas, beans, groundnuts, sunflower and sweet potatoes. Majority of the population in the study area keep cattle, goats and donkeys. Climate variability has caused reduction of crop and animal productivity in both lowlands and highland areas.

These findings are similar to the district survey on the production trend from the year 2005 to 2010 which revealed decrease of production in some of the crops. The findings noted that the production of common grown grains (maize, sorghum, millet and rice) has been decreasing at different rates depending on the nature of the crop. The decreasing rate for maize production was significant at the rate of 0.518 tones while millet was 0.5409 tones and sorghum was 0.6006 tones. Moreover, the rate of production of rice was decreasing at the rate of 0.4956 tones (figure 2).

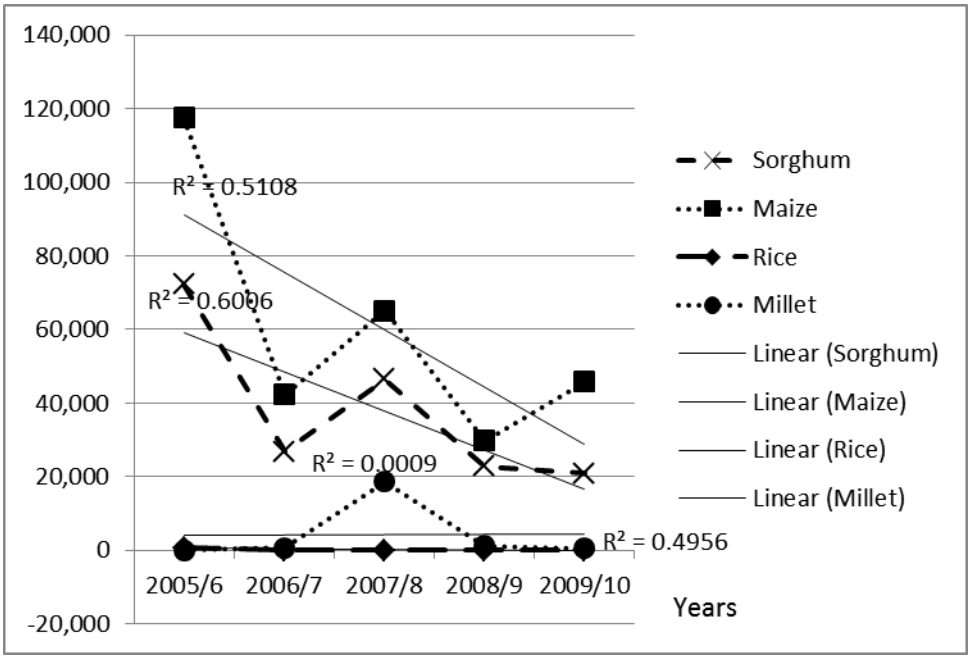

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Figure 2. Production Trend of Some Grains Crops from 2005-2010 in Tones
Source: DALDO Kondoa (2012)

The findings revealed that the production of some common grown leguminous crops was characterized by both increasing and decreasing trends. For example, figure 3, shows that the rate of decrease in production of beans was low at the rate of 0.0002 tones while for cow peas the production decreased at the rate of 0.5747 tones from the year 2005 to 2009. However, it was revealed that seed crop production was decreasing at insignificant rate based on type of crop, for example sunflower decreased at 0.0016 tones, groundnuts 0.2719 tones, and 0.5409 tones for simsim. These fluctuations in production have a relationship with variation in rainfall trends.

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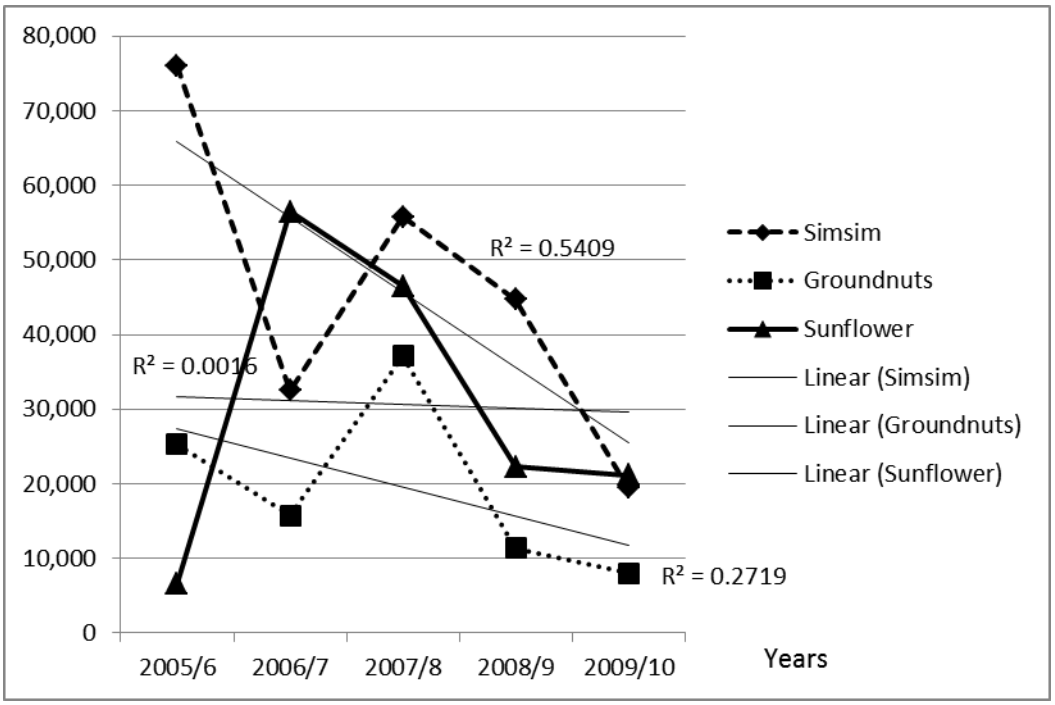

Figure 3: Production Trend of some Tuber Crops from 2005-2010 in Tones
Source: DALDO Kondoa (2012)

The findings noted that rainfall variation trends have significant impacts on crop production. The years where in low yields were recorded are associated with rainfall variation. The year 2006/7 had low yield due to the fact that during the planting season, in November, the rainfall was moderate. The abrupt increase of rainfall retards and weakens plant growth the situation that reduced yields (Figure 4). Also the year 2008/9 recorded low yields. Rainfall trends show that in the end of 2008 in November the rains were enough to plant crops. In December when the planting had been done the rains fell below 50mm, a situation that caused many of the plants to die and resulted into low yields (Figure 4). So, the general rainfall trends have been varying from year to year. Rainfall has been decreasing in 2007, 2008 and 2010 at decreasing rates of 0.3634mm, 0.3296mm and 0.1186mm respectively . The findings showed that rainfall trends in the years 2006 and 2009 had been increasing at the rates of 0.0652mm and 0.0111mm respectively.

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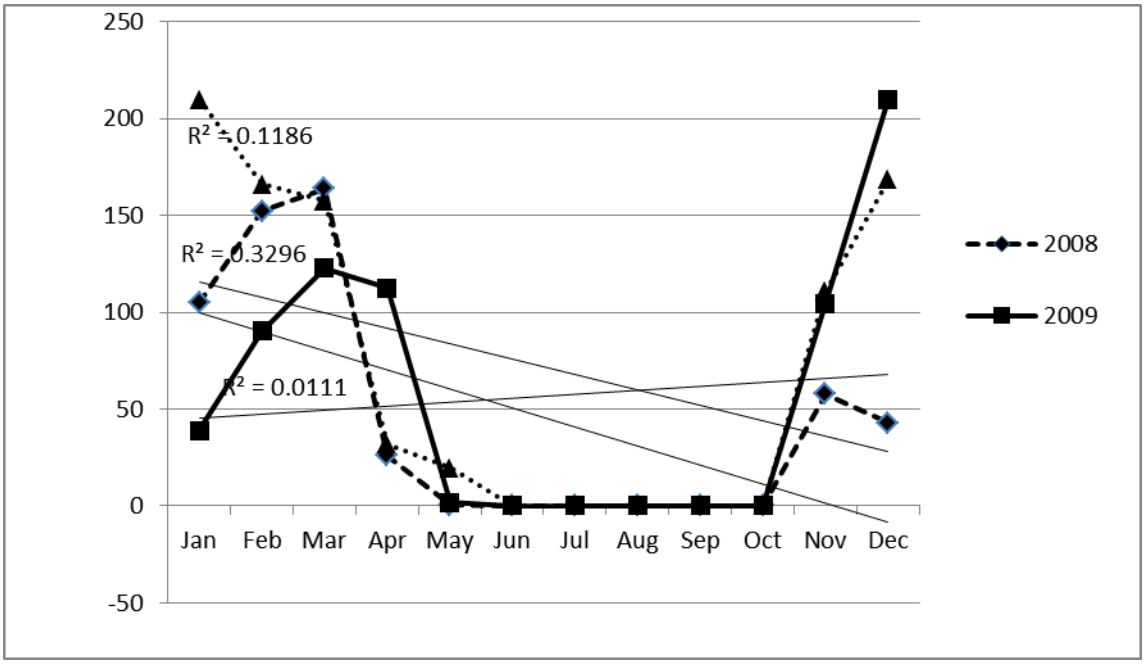

Figure 4: Production Trend of some Tuber Crops from 2005-2010 in Tones
Source: DALDO Kondoa (2012)

Indigenous Knowledge Systems for Adaptation to the Effect of Climate Variability on Agriculture

Agriculture in the study area is affected by several factors including unreliable rainfall, drought, crop and animal disease and environmental degradation. Farmers in the study area have developed various IAKS strategies for coping and adapting to the effects of climate variability on agriculture. IAKS developed include knowledge in weather forecasting for crop farming.

IKS in Weather Forecasting

Climate variability in the study area has necessitated local people to develop knowledge on the understanding of the beginning and ending of rain seasons. These knowledge on rainfall forecast have been developed through experiences gained while interacting with the environment in performing different economic activities particularly agriculture. Rain-fed agriculture dominates

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the rural economy of most of the people in the study area. Changes and variation of rainfall in the study area has a probabilistic nature in predicting when to start agriculture activities. The study found out that the sources of information in the study area about weather forecast depends on indigenous knowledge (61.7%), media (37.2%) and 1.1% weather reports from village stations (Table 3.). This findings shows that the community in the study area have been relying in the IKS due to its availability in the area and efficiency of the community to transfer this knowledge from one generation to another. However minimal use of other ways to get information about weather forecast increase the risk of being insecure from unforeseen climate extremes which rely on the use of scientific predictions such as El Nino.

Table 3: Sources of Rainfall Information Common in the Study Area

Sources of rainfall data	**Percent**
Indigenous knowledge	(58)62%
Media	(35)37%
Village weather report	(1)1%
Total	**(94)100%**

Source: Field Survey (2012)

The IKS on rainfall forecast varies across the district. The study found out that, some IKS are most common in one village and less common in another. The common knowledge identified in the study area as indicators for beginning of the rain season included; cloud and thundering (26.6%), emergency of new tree leaves (50%) and counting 7 to 8 months after the rain season in April (13.8%). Other IKS seemed to be common in some areas and less common in others include birds following cattle (7.5%), not common in the lowlands of Tampori and more

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common in the highlands. The observation of cold and warm condition (2.1%) is more common in Bereko highlands and less common in Ntomoko and Tampori areas (Table 4.)

Table 4: Indicators of the Beginning of the Rain Season in the Area

IKS indicators for beginning of rainfall	Villages Ntomoko	Tampori	Bereko	Total
Bird following cattles	(4) 4.3%	(0) 0%	(3) 3.2%	7 (7.5%)
Cloud and thunder	(7) 7.4%	(6) 6.4%	(12)12.8%	25(26.6%)
New tree leaves	(6)6.4%	(8) 8.5%	(33)35.1%	47(50%)
Warm/cold	(0)0%	(0)0%	(2)2.1%	2(2.1%)
Counting months	(3)3.2%	(3)3.2%	(7)7.4%	13(13.8%)
Total	**(20)21.3%**	**(17)18.1%**	**(57)60.6%**	**94(100%)**

Source: Field Survey (2012)

However, different IKS are used to ascertain the end of rain season in the study area. Like in the beginning of the rain season the IKS on the end of rain season varies over time and space. The widely used IKS across the study area as indicators for the end of rain season is showering rain which carries a total of 43.6% of the respondents. Key respondents reported that when there is no rainfall during a day and there is occurrence of light rainfall during night hours in April and May, this indicates the end of rain season. Other IKS have been observed to apply in some areas and not in others. Emergency of red aunts which carries 11.6% of the respondents seem to be common in Tampori which is in the lowland and Bereko which is in the highland. Counting months and observation of the clear sky during night hours where many stars are seen is common knowledge in the highlands area. Flowering of plant species especially sisal seemed to be the knowledge that is used both in highland and lowland areas and carries 13.8% of the respondents (Table 4).

Table 4: Indicators of the Ending of Rain Season in the Study Area

IKS indicators for the end of rain season	Villages Ntomoko	Tampori	Bereko	Total

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Cold condition	(1) 1.1%	(0)0%	(1) 1.1%	2 (2.1%)
Showering rains	(11)11.7%	(9) 9.6%	(19)20.2%	39(41.5%)
Flowering of some plant species	(0)0%	(1) 1.1%	(1)1.1%	2(2.2%)
Mountainous rains	(0)0%	(0)0%	(7)7.5%	7(7.5%)
Mountainous rain, flowering of plant	(0)0%	(0)0%	(6)2.1%	2(2.2%)
Counting months	(3) 3.2%	(0) 0%	(6) 6.4%	9(9.6%)
Clear sky	(5) 5.3%	(0)0%	(7) 7.5%	12(12.8%)
Flowering of plants, counting months	(0) 0%	(1) 1.1%	(6) 6.4%	7 (7.5%)
Warm condition	(0)0%	(0)0%	(1) 1.1%	1(1.1%)
Emergency of insect(aunts)	(0)0%	(2)2.1%	(5) 5.3%	7(7.4%)
Emergency of insect, mountainous rain	(0) 0%	(2) 2.1%	(2)2.1%	4(4.2%)
Showering rains, flowering of plants	(0)0%	2(2.1%)	(0)0%	2(2.1%)
Total	**(20)21.3%**	**(17)18.1%**	**(57)60.6%**	**94(100%)**

Source: Field Survey (2012)

Discussion

Communities in the study area are vulnerable to the effects of climate variability due to less degree of foreseen adaptive capacity. Key respondents reported that most of the community members have low income due to their dependency on agriculture which is the main economic activity in the area. This has resulted into failure to access basic infrastructures such as energy, transport and adequate water supply for irrigation, domestic use and sanitation.

These indicators are important to farmers in doing their activities. For example it is common to harvest grain crops after the end of rain season but if farmers do not see any sign indicating the end of the rain season, they harvest when it is still raining to avoid grain to rot in the field, this was experienced in 2007 when the rain season continue up to June in steady of May. During the shift from rain season to winter the rains in the area are not strong the air is cold, local people use these signs as indicators for the end of rain season. TMA (2011) data shows that for the past five

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years, five months have recorded 0mm of rainfall from June to October and rains from November to May, a situation that makes possible for local people to predict rainfall trend by counting months. This is not always the case in the area since there are some years that recorded 10 months of rainfall for example in 2007.

There is a lot of similarities between the findings of this study and a study in 2008 by Mwaura in Western Kenya who noted that indicators of, among other things, birds, white aunts and lightening are used by local people to forecast rainfall. Also Kihupi et al (2002) in northern zones of Tanzania, Dodoma, Singida and Arusha noted that the presence of higher than normal flowering intensity of trees is good sign for well distributed rainfall in the area. These practices help farmers to judge on the proper time to start farming and when to harvest in order to increase crop productivity which could have been affected due to climate variability.

Conclusion

The aim of this study was to examine the role of indigenous knowledge systems related to agriculture in adaptation to effects of climate variability. Specifically the study focused on identifying the factors contributing to socio-economic and environmental vulnerability to the effects of climate variability in Kondoa district; to find out the effects of climate variability on agriculture in Kondoa district; and to understand indigenous knowledge systems related to agriculture and their effectiveness in adaptation to the effects of climate variability in Kondoa district. Lastly, it intended to recommend on strategies in which IKS related to agriculture can be incorporated in environmental policy and legislation in Tanzania. Basing on the findings of this study it is concluded that:

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The communities in the study area are vulnerable to the effects of climate variability due to: first, nature dependents on rain-fed agriculture which is the main economic activity that supports livelihoods in the area and second, variability in climate of the area; the area has arid climate which receives rainfall between 300-500mm a year, the semi arid climate which receives average rainfall between 500-700mm and humid climate which receives average rainfall between 700-1000mm. This rainfall variation in the area is unreliable and thus it affects agricultural activities.

This has brought effects such as reduction of crop yields and animal productivity due to shortage of pasture, water and eruption of crops and animal diseases. However, these communities have developed IKS that help them in reducing the magnitude of these effects. The IKS developed includes knowledge in weather forecasting, knowledge in soil fertility management, crop management and knowledge in water resources management.

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