Physics and Chemistry of the Earth 67–69 (2014) 164–172

Contents lists available at ScienceDirect

Physics and Chemistry of the Earth

journal homepage: www.elsevier.com/locate/pce

Assessing indigenous knowledge systems and climate change adaptation strategies in agriculture: A case study of Chagaka Village, Chikhwawa, Southern Malawi

Emmanuel Charles Nkomwa [a], Miriam Kalanda Joshua [a], Cosmo Ngongondo [a,*], Maurice Monjerezi [a], Felistus Chipungu [b]

[a] *University of Malawi, Chancellor College, Faculty of Science, P.O. Box 280, Zomba, Malawi*
[b] *Ministry of Agriculture and Food Security, Bvumbwe Agricultural Research Station, Bvumbwe, Malawi*

ARTICLE INFO

Article history:
Available online 16 October 2013

Keywords:
Climate variability
Indigenous knowledge systems
Adaptation
Agriculture

ABSTRACT

In Malawi, production from subsistence rain fed agriculture is highly vulnerable to climate change and variability. In response to the adverse effects of climate change and variability, a National Adaptation Programme of Action is used as framework for implementing adaptation programmes. However, this framework puts limited significance on indigenous knowledge systems (IKS). In many parts of the world, IKS have shown potential in the development of locally relevant and therefore sustainable adaptation strategies. This study was aimed at assessing the role of IKS in adaptation to climate change and variability in the agricultural sector in a rural district of Chikhwawa, southern Malawi. The study used both qualitative data from focus group and key informant interviews and quantitative data from household interviews and secondary data to address the research objectives. The study established that the local communities are able to recognise the changes in their climate and local environment. Commonly mentioned indicators of changing climatic patterns included delayed and unpredictable onset of rainfall, declining rainfall trends, warming temperatures and increased frequency of prolonged dry spells. An analysis of empirical data corroborates the people's perception. In addition, the community is able to use their IKS to adapt their agricultural systems to partially offset the effects of climate change. Like vulnerability to climate change, IKS varies over a short spatial scale, providing locally relevant adaptation to impacts of climate change. This paper therefore advocates for the integration of IKS in programmes addressing adaptation to climate change and vulnerability. This will serve to ensure sustainable and relevant adaptation strategies.

1. Introduction

Agricultural production remains key to the national economies and people's livelihoods in Sub Saharan Africa. In Malawi, agriculture is the single most important sector, contributing about 33% to the Gross Domestic Product and 80% to national employment, with 90% of the labour force located in rural areas (NSO, 2009). However, the sector is highly vulnerable to the effects of climate change due to heavy reliance on rain fed agriculture. Climate change is defined as a change in the state of the climate that can be identified (e.g. using statistical tests) by changes in the mean and/or the variability of its properties and that persists for an extended period, typically decades or longer (Trenberth et al., 2007). For Malawi, vulnerability and adaptation assessment reports for the years 2001, 2002 and 2010 (GoM, 2010) clearly indicate that the country is experiencing a variety of climatic hazards, which include intense rainfall, floods, seasonal droughts, multi-year droughts, dry spells, cold spells, strong winds, thunderstorms, landslides, hailstorms, mudslides and heat waves, among others. Recent climate trends assessments in Malawi show that the mean annual temperature increased by 0.9 °C between 1960 and 2006, with an average rate of 0.21 °C per decade. The frequency of cold days and nights has decreased significantly since 1960 in all seasons (McSweeney et al., 2008). These changes in climate are expected to continue to negatively affect on agriculture production across the continent, with small scale farmers being more vulnerable (Easterling et al., 2007), resulting in widespread poverty and food insecurity.

The Malawi Growth and Development Strategy II (MGDS II) recognises the risks of climate change to achieving sustainable economic growth in the country and adaptation programmes and projects are implemented under a framework outlined in a National Adaptation Plan of Action (NAPA). The IPCC defines

* Corresponding author. Tel.: +265 1 524 222, mobile: +265 882 223 083; fax: +265 1 524 685.
E-mail address: cngongondo@cc.ac.mw (C. Ngongondo).

1474-7065/$ - see front matter © 2013 Elsevier Ltd. All rights reserved.
http://dx.doi.org/10.1016/j.pce.2013.10.002

adaptation as the, "adjustment in natural or human systems to a new or changing environment", in response to actual or expected climatic stimuli or their effects, which moderates harm or exploits beneficial opportunities. Rural farming communities have over the years relied on indigenous knowledge systems (IKS) as a means of adapting to constantly varying and changing climate (Nyong et al., 2007). Indigenous or traditional knowledge refers to the knowledge and know-how accumulated across generations (Agrawal, 2003; IPCC, 2007). IKS have shown potential in development of locally relevant and sustainable adaptation strategies for adaptation to a variable climate in the agricultural sector (Watts, 1983; Richard, 1986; Chang'a et al., 2010; Adger et al., 2003; Guthiga and Newsham, 2011; Kalanda-Joshua et al., 2011; Joshua et al., 2012), mainly in the understanding of weather patterns through the use of natural indicators such as changes in the behaviour of local flora and fauna (DMCN, 2004; Kalanda-Joshua et al., 2011; LEAD-SEA, 2011).

This study was therefore based on the notion that incorporating indigenous knowledge into climate change policies and interventions can lead to the development of effective adaptation strategies that are cost effective, participatory, locally relevant and sustainable (Hunn 1993; Robinson and Herbert 2001). Nakashima et al. (2012) report that collaboration between indigenous knowledge holders and mainstream scientific research is generating new co-produced knowledge relevant for effective adaptation action at local level. This is because the knowledge is learned, identified and applied within farmer's cultural setting (Kalanda-Joshua et al., 2011). Since IK is site specific, it is essential to assess IK specific to a community in order to develop localised policies and intervention. Therefore, this study explored the role of IKS in agricultural adaptation to the impacts of climate change and variability. Specifically, the study (i) established climate change risks based on people's perception and empirical evidence, (ii) determined the impacts of climate change and variability on agriculture, and (iii) analyzed the significance of indigenous knowledge in climate change adaptation in agriculture.

2. Study area and methods

The study was conducted in Chagaka Village located in Mbewe Extension Planning Area, Chikhwawa district in Southern Malawi (Fig. 1). Chikhwawa district is located in lower Shire River flood plain. The area is prone to both drought and flood events. Annual rainfall ranges from 170 to 967 mm with a mean annual temperature of 37.6 °C (Joshua et al., 2011).

The study employed a combination of data collection methods for triangulation and validation. Qualitative data included documentation of traditional indicators used to predict weather patterns, people's perception of climate change, its impacts and adaptation strategies in the agricultural sector. The qualitative data were collected using key informant interviews and Focus Group Discussions (FGDs), held separately. A total of 10 key informants were selected taking into consideration the age of the individuals and the nature of their work in the village. The key informants comprised Agricultural Extension and Development Officers, Agricultural Extension and Development Coordinator, village headmen and selected elderly people with standing peerage.

The FGDs involved 15 and 20 purposely selected female and male participants, respectively, comprising of different groups of people such as boys and girls, men and women, the elderly and recent immigrants to the village. Three FGDs were conducted: Firstly, the male and female participants were separated into two gender distinct groups, while ensuring fair representation of the different groups of people, to get their observations on strategies, challenges and opportunities; Secondly, the male and female participants were mixed to get their observations on the same aspects. The gender based separation of the respondents into different groups was also meant to address cultural norms whereby the women may find it hard to express themselves in the presence of their husbands or village elders. At the time of the study, Chagaka Village had a total of 65 households. Out of the total households, 19 household respondents, comprising 12 and 7 male and female headed households, respectively, were randomly selected to participate in a household survey, representing 30% of the study population (Edriss, 2006). The interviews and FGDs were held around the three specific study objectives of (i) analysing farmers' perceptions of climate change and variability, (ii) significance of indigenous knowledge in climate change adaptation in agriculture and (iii) impact of climate change and variability on their agricultural production.

To validate the people's perception on climate change and variability, quantitative data were used. These were comprised of empirical rainfall and temperature data for the period 1971–2007 and were sourced from the Malawi Department of Meteorological Services and Climate Change and Illovo Sugar Company for Nchalo Weather Station (Fig. 1).

All collected qualitative data was thematically analysed, i.e. the data was categorised into major emerging themes. Quantitative data was analysed in excel and SPSS to produce summaries in graphs and frequencies/percentages. Rainfall and temperature data were standardised to get anomalies in order to establish annual variability and the trend in climatic variables, respectively. Linear regression was used quantify the slopes and direction of trends.

3. Results and discussions

3.1. Local communities perception of weather, climate change and climate variability

3.1.1. Traditional indicators for climate and weather prediction

People in Chagaka Village described the climate of their area as characterised by very high temperatures (slightly decreasing in May–July) and generally low rainfall with an erratic pattern. Rainfall is seasonal and is experienced during November–April. The farmers have historically utilised a variety of traditional indicators in making farm level decisions regarding farming systems such as crop choice and planting time. These indicators are based on cultural and traditional beliefs related to their perceived behaviour of the environment, animals such as birds and insects and tree species. Examples of tree species used in weather prediction include *Adonsonia digitata* (baobab/*mlambe*), *Cordyla africana* (*mtondo*), *Faidherbia albida* (*nsangu*) and *Mangifera indica* (mango). The shedding of leaves and the later production of flowers by these tree species than their usual time indicates drought. Table 1 provides a summary of the traditional indicators that the community uses to predict weather and climate and inform decision on farming activities. The main challenge in using these IKS indicators for weather prediction is the climatic change and environmental degradation since most of the natural prediction entities such as forest and wildlife which were abundant in the past are no longer available (LEAD SEA, 2011).

Furthermore, the respondents reported that a high occurrence of ants (locally called *Nyerere*) and termites (locally known as *Ngumbi*) indicates good amount of rains for planting crops. However, the occurrence of non-flying termites in a maize field indicates a prolonged dry spell. Consequently, farmers are unable to weed to avoid crop destruction by the termites. It was also reported that initially, the high temperatures between September and October indicated good rains. However, currently, a drought is expected. Similarly, a drought is expected when a bird locally

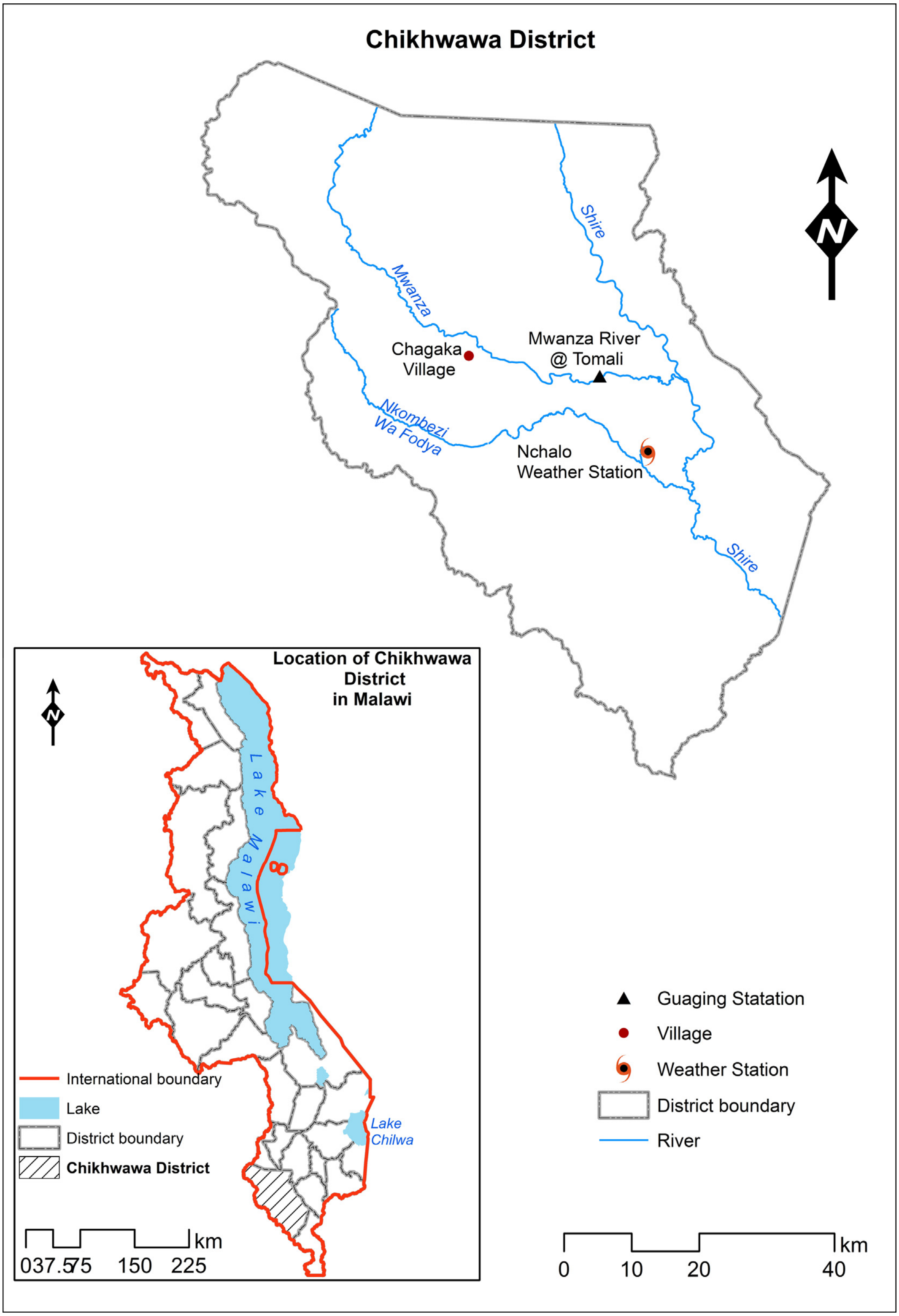

Fig. 1. Map of Malawi showing Chikhwawa district and study area.

known as *Chikhaka* is spotted close to the households and there is a high occurrence of grasshoppers (locally known as *dziwala*). Furthermore, strong winds with rain crowds were historically an indication of drought but they are now associated with rains.

In addition to indicators presented in Table 1, Joshua et al. (2011) established that all years associated with drought or low rainfall are preceded by poor fruiting or low production of fruits such as *Nyenza* and *Cordyla african* (mtondo), in addition to having cooler temperatures from October to early December. Other indicators of a good rainfall season include: outbreak of army worms, early production of flowers by *Nkunkuru* trees and early onset of rains. Chirwa et al. (2011) reported that over the past decades, a dark cloud to the west of the area could be used to predict floods. Chiefs would therefore use this indicator to warn their

Table 1
Traditional indicators used to predict weather events and plan farm activities in Chagaka Village, Chikhwawa District.

Indicator	Event	Decision on farming activities
Shedding of leaves by tree species. E.g. *Adonsonia digitata* (baobab/ mlambe), *Cordyla african* (mtondo), *Faidherbia albida* (nsangu)	Onset of rains and indication of a well distributed rainfall season	Choice of crop variety. Time to prepare land and plant crops
Flowering of plant species and high production of fruits. E.g. *Ziziphua Mauritania* (Masau) and *Mangifera indica* (Mango)	Onset of rains and good rainfall season with well distributed rainfall	Time to prepare land and plant crops
Peculiar sound produced by male goat	On set of rains	
Occurrence of ants locally called *Nyerere* and *Ngumbi* (flying/white ants)	Good amount of rains	Time to plant crops
Occurrence of termites in maize field when they have already planted crops	Prolonged dry spell	No weeding. Otherwise they will destroy crops
Occurrence of grasshoppers and a bird called *Chinkhaka* seen flying in household vicinity	Drought	
Very high temperatures by mid November	Drought	
Strong winds before an impending rain event	Previously (decade ago) meant no rains but now they are associated with stormy rains	

communities to move upland. However, the current study noted that in recent years, communities find it difficult to predict floods using this traditional indicator probably because the flooding events are experienced in the absence of local rains. They largely result from flooding of the nearby Mwanza and Mkombedzi wa Fodya Rivers which bring water from upland areas, hence rendering communities and their livelihood activities very vulnerable as shown by Kalinga-Chirwa et al. (2011).

3.1.2. People's perception of climate change risks

In recent years (since the 1990s, according to the respondents), the local community, largely from their own observations, perceive some changes in their climate and local environment. The changes reported were largely related to rainfall, temperature and winds. The key indicator for rainfall change reported was high variability in the rainfall pattern. It has been noted that rainfall onset has shifted from November to December/January. Other indicators of change included unpredictable onset of rainfall, declining rainfall trends, warming temperatures, increased frequency of and prolonged dry spells and relatively lower temperatures from October to early December. In addition, there is high occurrence of floods from the Mwanza River (Fig. 1), as a result of high rainfall in the surrounding highlands, and strong winds. The occurrence of this type of floods is difficult to predict as they are not linked directly to rainfall events in their area, leaving the households very vulnerable. Table 2 documents major climatic events that have occurred in the past decade based on the people's recollection. Although there is a possibility that the community got some information on the events from extension services, the study established that mostly these events were predicted using the traditional indicators discussed in Section 3.1.1 and recorded from their own experience.

To establish the cause of climate change in the study area, it was observed that individuals had difficulties in giving reasons for their perceived changes in climate. However, there was a clear mention by 48.1% of the respondents that there has been massive deforestation in the villages over the last 15 years associated with house construction materials such as curing of bricks and building poles or timber harvesting. Some respondents indicated an increase in fire activities in recent years. However, the villagers had challenges to directly link these activities to climate change. From the people's perception, it can be said that what was seen as climate change by the people in Chagaka Village is simply variability and not climate change as the case of Nessa Village (Kalanda-Joshua et al., 2011).

3.1.3. Climate variability and trends from empirical evidence

To compare the people's perceptions on climate change, rainfall and temperature data for Nchalo weather station (Fig. 1) during the 1971/1972–2007/2008 agricultural seasons were analysed for trends and variability. The results show that the scientific data generally agrees with the people's perception of climate change risks as highlighted in Section 3.1.1. Fig. 2a shows annual rainfall variation for Nchalo from 1970 to 2007 which had mean annual rainfall of 717.2 mm/year. Standardised annual rainfall anomalies, i.e. departures from the mean divided by the standard deviation are shown in Fig. 2b. Although the people could only recollect climatic events only from early 1990s, the variation for Nchalo weather station is quite evident from 1970s (Fig. 2). The variation is notable in total annual rainfall, seasonal trends as well as rainy

Table 2
Summary of major climatic events and their impacts.

Year	Key events	Impacts
1986/1987	Drought	Famine due to crop failure
1988/1989	Floods	Famine due to crop destruction Livestock and Crops washed away resulting in food shortage Loss of properties
1990/1991–1993	Drought/prolonged dry spell	Famine due to crop failure
1994	Drought/prolonged dry spell	Famine due to crop failure
1997/1998	Floods	Famine due to crop destruction
2000	Flash floods	Crops were destroyed for those people have their land near the rivers Famine due to crop destruction
2003	Drought/prolonged dry spell	Famine due to crop destruction
2005/2006	Too much rainfall and strong winds	The excessive rains and strong winds destroyed crops especially maize and fruits resulting in hunger Increase incidences of malaria, diarrhea and HIV cases
2006/2007	Floods along the river banks. There were no rains locally, but rains from upland	Washed away people and livestock, as there was no warning of oncoming floods
2007/2008–2011/2012	Prolonged dry spells and mid season drought; and floods along the river banks	Low or no harvest

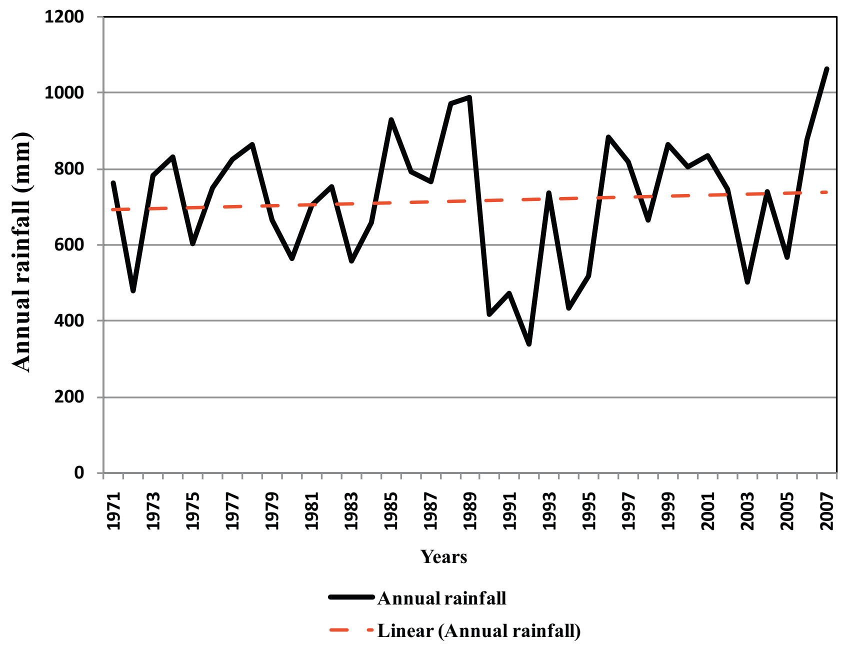

Fig. 2a. Annual rainfall series and linear trend for Nchalo station from 1971/1972 to 2007/2008.

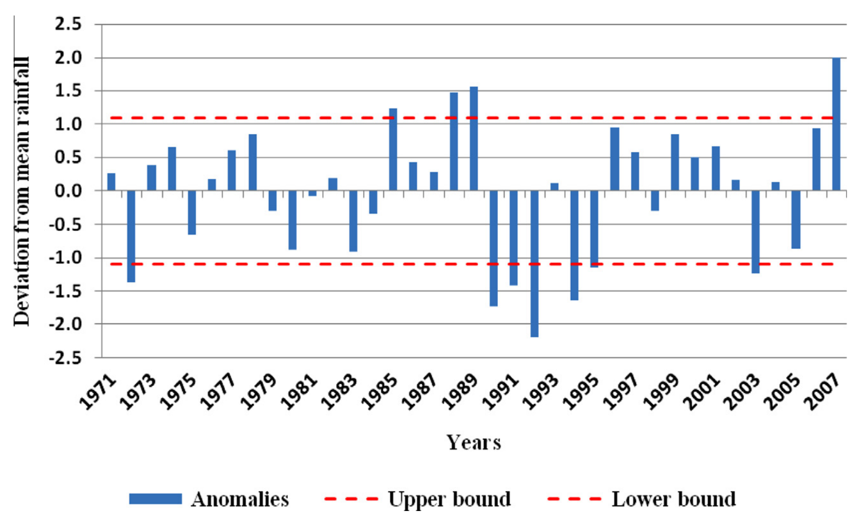

Fig. 2b. Annual rainfall anomalies for Nchalo weather station from 1971/1972 to 2007/2008.

days. A positive trend in the rainfall which was not statistically significant at 95% confidence level was found. The linear regression trend test shows slight positive slope of 0.01 mm/year.

Fig. 2b depicts a highly variable temporal rainfall pattern during the period 1971–2007. This is shown in the rainfall anomalies. Although, with minor differences, the scientific analysis (Fig 2b) largely supports respondents' observations recorded in Table 2. Fig 2b shows that 1985/1986, 1988/1989, 1989/1990 and 2007/2008 seasons had significantly high rainfall which resulted into floods. This is indicated in Fig 2b by a positive rainfall anomaly which exceeded the 95% limits or outer bounds (dotted horizontal lines in Fig 2b) for significant mean deviation. However, the station registered very low rainfall during 1990/1991, 1991/1992, 1992/1993, 1994/1995 and 2003/2004 rainfall seasons. These resulted into droughts that were also reported by the respondents in Table 2. The drought years are marked by a negative anomaly in Fig 2b which shows significant deviation from the mean annual rainfall at 95% confidence level. From people's perception, the 1991/1992 drought was the worst ever experienced in the area. This observation is concordant with EM-DAT: The OFDA/CRED International Disaster Database records, which show total number of affected people exceeding all the other disaster years from 1900 to 2012. Similarly, Tirivarombo and Hughes (2011) reported that 1992 drought year is deemed the worst in recent years for the whole SADC region resulting in 50% reduction of cereal production and increased cereal imports from an annual average of 1.6 to over 6 million tonnes.

Fig. 2c shows a general decline of rainy days especially for the month of October. This probably explains the reported increased occurrence of prolonged dry spells in the study area. The number of rainy days is crucial to types of crops grown and soil moisture availability. Soil moisture availability especially during the sensitive stages of a crop's life cycle affects crop yield. Thus good yield is determined by the availability of adequate soil moisture at critical stages of plant growth. Deprivation of the required soil moisture during the critical growth periods often lead to stressed crop

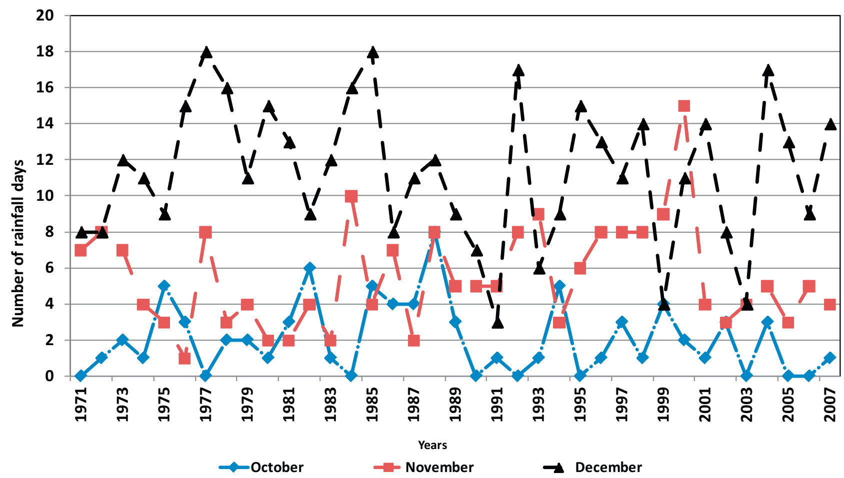

Fig. 2c. Number of rainy days in Nchalo from October to December (1971–2007).

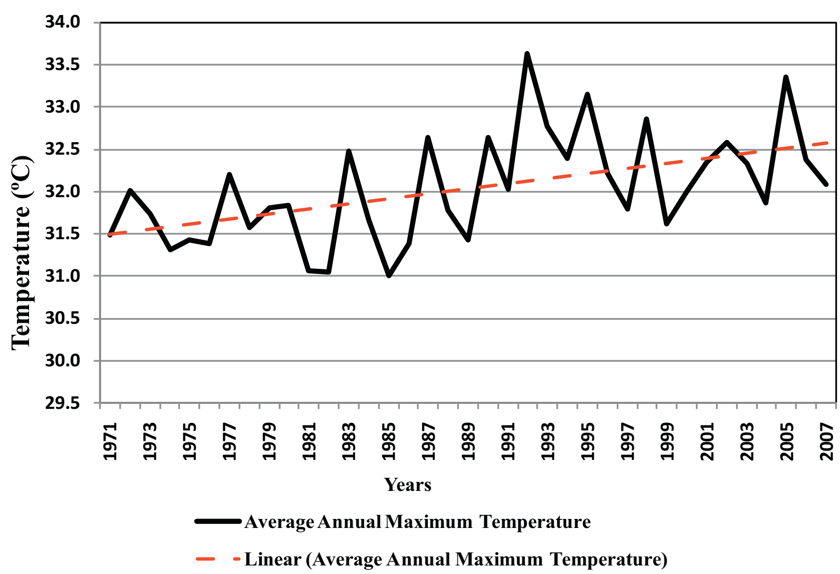

Fig. 3a. Annual maximum temperature series and linear trend for Nchalo Station 1971–2007.

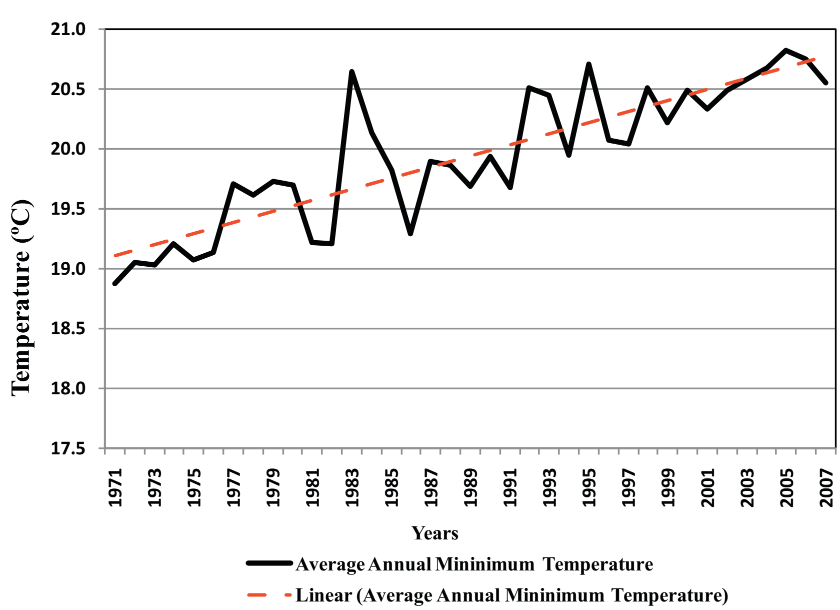

Fig. 3b. Annual minimum temperature series and linear trend for Nchalo Station 1971–2007.

Table 3
Monthly Mann–Kendall trend test statistic for Nchalo station 1971–2007.

Variable	Month	Mann–Kendall trend		
		a[a]	*z*	*b*
Maximum temperature	January	−1.96	0.52	1.96
	February	−1.96	0.42	1.96
	March	−1.96	0.29	1.96
	April	−1.96	−0.2	1.96
	May	−1.96	−0.85	1.96
	June	−1.96	−1.62	1.96
	July	−1.96	−1.62	1.96
	August	−1.96	−0.69	1.96
	September	−1.96	0.48	1.96
	October	−1.96	1.13	1.96
	November	−1.96	1.36	1.96
	December	−1.96	0.8	1.96
Minimum temperature	January	−1.96	1.01	1.96
	February	−1.96	0.94	1.96
	March	−1.96	0.78	1.96
	April	−1.96	0.2	1.96
	May	−1.96	−0.77	1.96
	June	−1.96	−1.48	1.96
	July	−1.96	−1.51	1.96
	August	−1.96	−1.17	1.96
	September	−1.96	−0.29	1.96
	October	−1.96	0.41	1.96
	November	−1.96	0.87	1.96
	December	−1.96	1.01	1.96

a[a] and b are the critical values at $\alpha = 0.05$ significant level.

development which may result in reduced crop yield and consequently increased vulnerability of the most vulnerable community members (Tirivarombo and Hughes, 2011).

Similarly, temperature data between 1971 and 2007 also support villagers' observations that the area is now warmer than the past years (Figs. 3a and 3b). Figs 3a and 3b show increasing trend for both minimum and maximum temperatures, with marked warming for minimum temperature. Similarly, both the Mann–Kendall trend test and linear regression trend tests confirmed the change in temperature reported by the respondents as depicted by the observed minimum and maximum temperature with significant trends at 95% confidence level (Table 3) and the temperature anomalies (Fig. 3c and 3d).

The temperature anomalies in Figs. 3c and 3d also show that from 1971 to 1990 there is predominantly negative anomaly in both maximum and minimum temperatures reflecting cooler temperatures. The negative temperature deviations were statistically significant between 1981 and 1985, as shown by anomalies exceeding the 95% outer bounds. Fig. 3d shows that minimum temperature anomalies were significantly below the mean temperature during 1971–1976, 1981 and 1982. Higher temperatures are also notable from 1990. Both the maximum and minimum temperature anomalies show statistically significant positive anomalies from around 1992, 1995 and 2007 which exceeded the 95% outer bounds. These results are in line with the global trends and regional trends that on average the Earth temperature has increased (Joshua et al., 2011) suggesting that people's observations were valid.

The study however observed that it is not easy for the people to recall from memory the key events that occurred over a decade ago unless it had very significant impacts on their livelihoods. This could also be an indication of IKS weakness whereby information is not being passed on between generations. This role is normally played by the elderly in a community who are above 40 years old (Chang'a et al., 2010).

3.2. Impact on agriculture (crop and livestock production)

The study established that climate change is impacting crop yields, types grown and farming practices. Generally, there has been a decrease in yield per unit hectare for most of the food crops (Table 4), with maize as the mostly affected due to prolonged droughts and inadequate rainfall.

About 78% of the household respondents indicated that crop pests also reduce crop yield. Frequent occurrence of the crop pests is being associated with climate change. The prevalent crop pests in the village include:

1. American ball worm in cotton which reduces cotton yields- as the balls just drop
2. Army worms locally known as *Mbozi* before onset of rainfall- new occurrence
3. Stalkborer locally called *Mtchembere zandonda* are a new problem in the village and affect sorghum and maize
4. Locusts or giant grasshoppers locally called *Abobo/nukhadala*, maggots locally known as *dzongolo and nthusi/mphutsi zoyera* affect cotton. Prevalence is higher than the past ten 10 years.

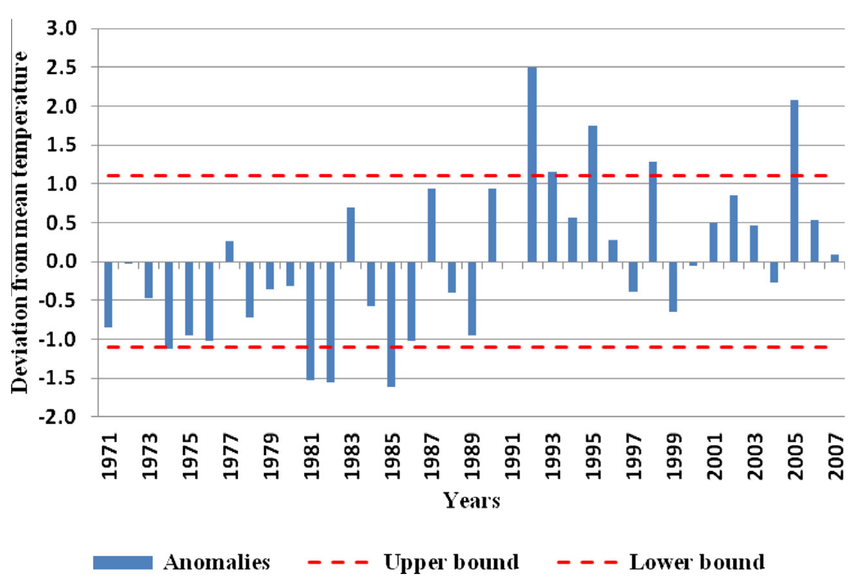

Fig. 3c. Annual maximum temperature anomalies for Nchalo weather station from 1971–2007.

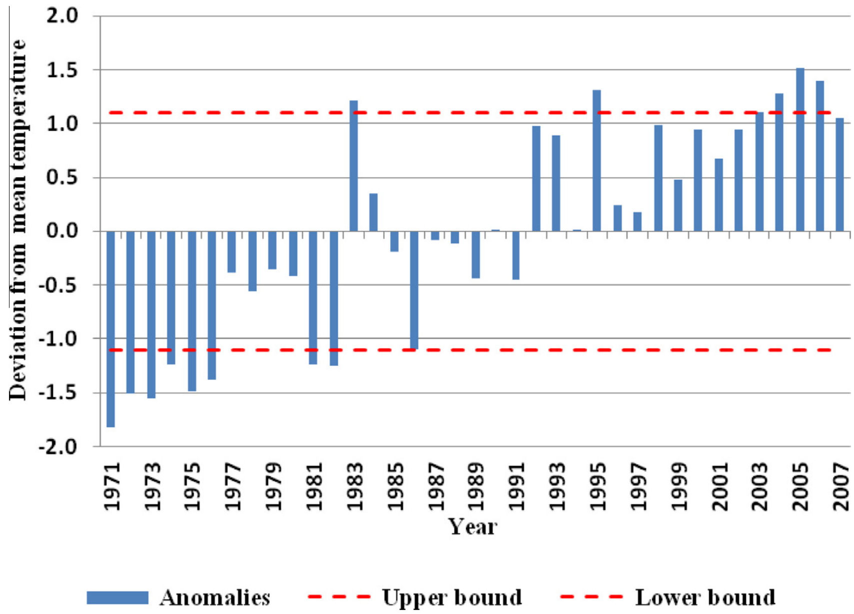

Fig. 3d. Annual minimum temperature anomalies for Nchalo weather station from 1971–2007.

Table 4
Change in yield of the present crops (men's perspective).

Crop	Earlier years' yield per acre	Current yield per acre
Maize	2–3 carts × 6 (50 kg bags)/600–900 kg	2–3 bags/ 100–150 kg
Cotton	8 bags/800 kg s	5 bags/ 500 kg s
Sesame	6 bags/300 kg	1 1/2 bag/ 75 kg
Sorghum (kawala – local variety)	10 bags/500 kg	5–7 bags/ 250–350 kg
Sorghum – improved varieties (chabalala, Napirira research varieties)		12–14 bags/ 600–700 kg s

Cotton pests were so severe during the 2011/2012 growing season that spraying was perceived not effective, although this could also be due to improper use of chemicals. For both maize and cotton, the cropping calendar has slightly changed due to change in rainfall pattern (Table 5). In addition, the farmers' ability to tell the onset of the planting season with reasonable accuracy has diminished. This results in trial and error planting, sometimes up to 5 times. Transplanting to fill gaps (from failed germination) is adversely affected by very high temperatures and prolonged dry spells. Irrigated agriculture is also affected in some years due to delayed drying off of water logged soils along the banks.

Furthermore, the respondents indicated that climate change has also adversely affected livestock production. About 96% of the household respondents as well as the key informants and focus group participants attributed this to frequent outbreaks of diseases such as foot and mouth, Newcastle and African swine fever. These were historically not common in the village. In addition, the respondents have noted decreased pasture quality and quantity and water shortage, which become more severe during the dry season.

3.3. Adaptation to climate change effects in Chagaka Village

In response to the effects of climate change on agricultural production, there has been a change in type of crops and varieties grown in Chagaka Village in the last 10 years. People are now growing more drought tolerant crops and early yielding varieties of the crops they plant including pearl millet, followed by sorghum. Maize is mainly grown under irrigated agriculture. The prevailing climate has forced people to grow pearl millet, although the processing of pearl millet is long and tedious and some people are allergic to it. People are shifting from traditional farming practices such as flat cultivation to planting on plain and tie ridges, use of

Table 5
Cropping calendar (women perspective).

S/N	Activity	Maize		Cotton	
		Original period	New period	Original period	New period
1	Farm preparation	August–October	August–October	July–October	July–October
2	planting	November–December	December–January	November–December	December–January
3	Weeding	November–December	December, January–February	November, December–February	December, January, February
4	Spraying			December–April	January–February
5	Harvesting	April–May	May–June (but may be done in March, if rains were earlier)	April–June	April–June
6	Processing – grading and shelling	June–early August	June–early August	April–June	May–June

manure, planting one seed per station, using sunken beds in irrigation (for water conservation and reducing irrigation frequency), frequent spraying against pests in cotton which is expensive and labour demanding, short duration crop varieties. The aim is to improve yields under the prevailing conditions. Thus these changes are responding to the current drop in the yield/acre (productivity) of the present crops (Table 5). Reduction in yield is mainly attributed to drought or prolonged dry spells. However, improved varieties of drought resistant crops such as sorghum register higher yield than the local varieties.

Additionally, the study established that there is more diversity of livestock reared today compared to the past to risk reduction and income diversification. In the village, there are more goats and poultry than cattle. It was established that due to water shortage and pasture, goats are more resilient and adaptable than cattle. The common types of livestock in order of priority are goats, cattle, pigs and poultry.

4. Conclusion

The study assessed role of IKS in climate change adaptation in agriculture production in Chikhwawa District in southern Malawi. The results have shown that the local communities can recognise some changes in weather patterns that have occurred in their area. Key climatic events that occurred from 1986 were also identified. The people's perceptions about the changes were validated with empirical data from a nearby weather station during 1970–2007. Further, the community is able to notice and make changes in their agriculture systems in relation to climate change and variability effects by devising coping and adaptation strategies. These climate change adaptation strategies include changes in crops from non to traditional crops; cropping patterns and intensification of livestock production especially of goats and local chicken is clear indication of the relevance of adaptation strategies to climate change effects.

The results suggest that integrating local knowledge in developing localised and relevant climate change adaptation strategies is essential in Malawi. This can be achieved by creating a forum for interaction between scientists and indigenous knowledge holders. The forum can be useful in demystifying conventional science and allow the IKS holders contribute to climate or weather forecasting process. A comprehensive framework for facilitating the engagement process was proposed by Dekens (2007). In Bolivia, DeAngelis (2013) recommended the Creation of policies that can improve adaptive capacity and indigenous people's status. This could be achieved by including the indigenous people as joint decision makers in local and national adaptation initiatives. The same authors also suggested the promotion of the use of indigenous knowledge through international initiatives such as the United Nations Framework Convention on Climate Change (UNFCCC). The indigenous groups in Bolivia requested the UNFCCC to host regular international sessions for sharing experiences on the use of IKs in climate change adaptation.

Acknowledgements

This work contributes to the project on Capacity building in the agriculture sector for climate change adaptation Tanzania and Malawi being implemented Natural Resources and Environment Centre of the University of Malawi in collaboration with Institute of Resource Assessment of the University of Dar es Salaam funded by the Rockefeller Foundation. The authors sincerely acknowledge the financial support. We further thank community of Chagaka, all the agricultural and meteorological officers who provided the data used in this paper.

References

Adger, W.N., Saleemul Huq, S., Brown, K., Conway, D., Hulme, M., 2003. Adaptation to climate change in the developing world. Progress in Development Studies 3 (3), 179–195.

Agrawal, A., 2003. Indigenous Knowledge and the Politics of Classification. International Social Science Journal 54, 173.

Chang'a, L.B., Yanda, P.Z., Ngana, J., 2010. Indigenous knowledge in seasonal rainfall prediction in Tanzania: a case of the South-western Highlands of Tanzania. Journal of Geography and Regional Planning 3 (4), 66–72.

DeAngelis, K., 2013. Building Resilience to Climate Change Through Indigenous Knowledge – the Case of Bolivia. <http://cdkn.org/resource/building-resilience-to-climate-change-throughindigenous-knowledge-the-case-of-bolivia/> (accessed 21.07.13).

Dekens, J., 2007. Local Knowledge for Disaster Preparedness: A Literature Review. International Centre for Integrated Mountain Development, Kathmandu.

Drought Monitoring Centre Nairobi (DMCN), 2004. *Traditional indicators used for climate monitoring and prediction by some rural Communities in Kenya*. A contribution to the harmonization of traditional and modern scientific methods of climate prediction in Kenya. Drought Monitoring Center, Nairobi. Pilot Application Project.

Easterling, W. et al., 2007. Food, fibre and forest products. In: Parry, Martin et al. (Eds.), Climate Change 2007: Impacts, Adaptation and Vulnerability. Cambridge University Press, Cambridge and New York, pp. 273–314.

Edriss, A., 2006. Introduction to Statistics. Bunda College of Agriculture, University of Malawi, Lilongwe, Malawi.

Government of Malawi. 2010. Second National Communication of Malawi. Ministry of Natural Resources and Environmental Affairs, Lilongwe, Malawi.

Guthiga, P., Newsham, A., 2011. Meteorologists Meeting Rainmakers: Indigenous Knowledge and Climate Policy Processes in Kenya. IDS Bulletin 42, no. 3.

Hunn, E., 1993. What is traditional ecological knowledge? In: Williams, N., Baines, G. (Eds.), Traditional Ecological Knowledge: Wisdom for Sustainable Development. Centre for Resource and Environmental Studies, ANU, Canberra, pp. 13–15.

IPCC, 2007. Summary for Policy makers, Fourth Assessment Report (AR4). Cambridge University Press, New York.

Joshua, M.D., Ngongondo, C., Monjerezi, M., Chipungu, F., Lyimo, Malidadi, C. 2012. Unpublished. Situation Analysis – Participatory Building of Capacity for Climate Change Adaptation in the Agricultural Sector in Tanzania and Malawi. Natural Resources and Environment Centre, Chancellor College, Zomba, Malawi.

Kalanda-Joshua, M., Ngongondo, C., Chipeta, L., Mpembeka, F., 2011. Integrating indigenous knowledge with conventional science: enhancing localised climate and weather forecasts in Nessa Mulanje, Malawi. Journal of Physics and Chemistry of the Earth 36 (14–15), 996–1003.

Kalinga-Chirwa, R., Ngongondo, C., Kalanda-Joshua, M., Kazembe, L., Pemba, D., Kululanga, E., 2011. Linking rainfall and irrigation to clinically reported malaria cases in some villages in Chikhwawa District Malawi. Journal of Physics and Chemistry of the Earth 36 (14–15), 887–894.

LEAD-SEA., 2011. Scientific validation of traditional early warning signals for floods and drought in Nsanje and Chikwawa Districts Consultancy Report, Chancellor College, Zomba, Malawi.

McSweeney, C., New, M., Lizcano, G., 2008. UNDP Climate Change Country Profiles: Malawi. <http://countryProfiles.geog.ox.ac.uk/index.html?country=Malawi&d1=Report.

National Statistical Office, 2009. 2008 Population and Housing Census, National Statistical Office, Zomba, Malawi.

Nyong, A., Adesina, F., Osman Elasha, B., 2007. The Value of Indigenous Knowledge in climate change mitigation and adaptation strategies in the African Sahel. International Development Research Centre, Nairobi, Kenya.

Nakashima, D.J., Galloway McLean, K., Thulstrup, H.D., Ramos Castillo, A., Rubis, J.T., 2012. Weathering Uncertainty: Traditional Knowledge for Climate Change Assessment and Adaptation. Paris, UNESCO, and Darwin, UNU, 120 pp.

Tirivarombo, S., Hughes, D.A., 2011. Regional droughts and food security relationships in the Zambezi River Basin. Journal of Physics and Chemistry of the Earth 36 (14–15), 977–983.

Trenberth, K.E., Jones, P.D., Ambenje, P., Bojariu, R., Easterling, D., Klein Tank, A., Parker, D., Rahimzadeh, F., Renwick, J.A., Rusticucci, M., Soden, B., Zhai, P., 2007. Observations: surface and atmospheric climate change. In: Solomon, S., Qin, D., Manning, M., Chen, Z., Marquis, M., Averyt, K.B., Tignor, M., Miller, H.L. (Eds.), Climate Change 2007: The Physical Science Basis. Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA.

Richard, P., 1986. Coping with Hunger: Hazards and Experiment in an African Rice Farming System. Allen and Unwin, London.

Robinson, J., Herbert, D., 2001. Integrating climate change and sustainable development. International Journal of Global Environmental Issues 1 (2), 130–148.

Watts, Michael., 1983. Silent Violence: Food, Famine and Peasantry in Northern Nigeria. University of California Press, Berkeley, CA.