Climate change trends and environmental impacts in the Makonde Communal Lands, Zimbabwe

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DATES:
Received: 04 Aug. 2014
Revised: 30 Sep. 2014
Accepted: 22 Oct. 2014

KEYWORDS:
climate change; biophysical impacts; ecosystem services; Makonde Communal Lands; Zimbabwe

HOW TO CITE:
Sango I, Godwell N. Climate change trends and environmental impacts in the Makonde Communal Lands, Zimbabwe. S Afr J Sci. 2015;111(7/8), Art. #2014-0266, 6 pages. http://dx.doi.org/10.17159/sajs.2015/20140266

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During the last century, climate has increasingly become variable and changeable, with significant deviations from the observed normal averages, which often leads to disruptive consequences to ecosystems and livelihoods. Climate change induced environmental challenges are viewed to be particularly severe to economically challenged tropical societies including the Zimbabwean rural communities. We sought to determine local level climate change trends and associated biophysical implications in the Makonde Communal Lands of Zimbabwe. Our findings suggest that there has been significant climate change in the Makonde Communal Lands since 1962. The climate change observed has induced the deterioration of ecosystem productivity, diversity and services, to the detriment of human livelihoods. We provide insights into how to better understand local level dynamics between climate change and local ecosystem goods and services as the basis of livelihood in marginalised rural communities. Among the key reasons for concern about impacts of anthropogenic activities on climate is the fact that changing climate has direct impacts on the biophysical world, which in turn is a vital asset for human livelihoods, economies and general well-being.

Introduction

Climate implies the long-term average of the individual weather conditions that communities experience every day.[1] It is amongst the most important determinants of survival and human livelihoods.[2] Climate is a particularly strong factor for low-income rural communities whose livelihoods heavily depend on rain-fed subsistence agriculture, such as the Makonde Communal Lands of Zimbabwe – the study area and focus of this paper.

During the course of human civilisation, communities in all parts of the world have developed ways of earning livelihoods and supplying their needs for food, water, shelter and other goods and services that are adapted to benefit from the climates in which they live.[3] However, during the last century, climate has increasingly become variable and changeable, with deviations that are too far from the observed normal averages, often leading to disruptive consequences to ecosystems, livelihoods and human well-being.[4] Such major climatic deviations have become a major cause for concern in the modern world environment. In particular, impacts of anthropogenic activities on climate have become one of the most striking environmental challenges affecting current civilisations.[5]

Concerns about climate change and its associated environmental degradation are receiving increasing attention, particularly in tropical Africa, because of the large proportion of the rural population living in already ecologically vulnerable zones.[6] Evidence from the Intergovernmental Panel on Climate Change[2] suggests that sub-Saharan Africa is likely to emerge among the most vulnerable regions to climate change, with likely agricultural losses of up to 7% of the affected countries' gross domestic product.[7] Since 1900, much of southern Africa has progressively experienced warmer temperatures, rising on average 0.7 °C, and an overall decline in precipitation of 5%. If global mitigatory actions remain as weak as they currently are, many communities of the world, particularly in tropical rural Africa, are likely to experience some of the worst impacts of climate change in the current century.[8] The notable increase in the frequency and severity of drought and other weather extremes is proving to be among the biggest threats to the livelihoods of rural communities which rely heavily on climate-sensitive livelihoods. The level of vulnerability is particularly widespread given that the rural population in Zimbabwe, as in other sub-Saharan countries, comprises about 70% of the national population.

Given the growing evidence of climate change and its potential negative impacts on livelihoods, particularly those of the poor and vulnerable rural farming households and communities of Zimbabwe, our key concern in this study was to provide insights leading to the enhanced understanding and/or management of climate change related risks, thereby introducing opportunities for addressing overall livelihood vulnerability. The study is intended to highlight the adversity of the downstream externalities of global climate change. While the body of knowledge on climate change, its negative impacts, vulnerability and adaptation has grown significantly over the recent years, every local community has its own challenges associated with climate change. There is a need for more research on micro-level climate change impacts on livelihoods.

In terms of knowledge gap, until fairly recently, work investigating the impacts of and responses to climate change tended to be more prolific in the northern hemisphere. It is therefore pertinent that the long history of neglect of research on climate change and its impacts in the southern hemisphere be addressed. In this paper, we therefore seek to provide a broader view on the complex set of risks of climate change and its biophysical implications for rural, farming community livelihoods. A systems approach is applied to cover the mulitidimensional nature of climate change and its associated microscale implications. This particular focus of study is considered important for prioritising the places and people for whom adaptation intervention is required. The findings of the study are anticipated to contribute to a body of knowledge to furnish academia, global leaders, policymakers, local authorities and planners with a comprehensive understanding of the local level dynamics of climate change and its impacts.

Context of the study

Makonde Rural District lies in the Mashonaland West Region in the northwestern part of Zimbabwe. The rural district is divided into two main areas: the large-scale commercial farming area in the north and the Makonde Communal Lands which cover the southern section of the district. It is the Makonde Communal Lands in particular which constitute the area of interest in this study. Figure 1 shows the geographical location of the Makonde Communal Lands in the Makonde Rural District.

In terms of historical background, the Makonde Communal Lands as a geographical and socio-economic unit are a product of the colonial legacy which created a dual subdivision of the country into two agrarian structures. One was the commercial farming zone (Regions I to III) of the settler community in the more accessible and agro-ecologically productive regions, while the other constituted more remote reserves for the natives, on poorer soils and in hot and dry lowland regions (Regions IV and V).[9,10]

Factors such as the naturally stressed ecosystems, growing population pressure and the communal tenure system of access to and use of land resources has had a heavy toll on the state of the environment in Zimbabwe's communal lands such as the Makonde Communal Lands. According to Murombedzi[9] and Doré[11], the colonial legacy of this dual agrarian structure has prevailed through the Zimbabwean independence and continues to exist today, as evidenced by the drought-prone Makonde Communal Lands which are juxtaposed with the well-served agro-ecologically advantaged Makonde large-scale commercial farming area.

In terms of scope, therefore, the study is confined to the Makonde Communal Lands of Zimbabwe. The communal lands cover a narrow belt along the southern end of the Makonde Rural District, sharing a northern border with the Makonde commercial farming area (Figure 1). The study area is divided into six wards which are altogether divided into 10 villages, upon which the study's framework for stratified sampling is based. The subjects of the study are mostly the smallholder farmers across the 10 villages.

Theoretical background

Among the most striking environmental challenges affecting the earth is anthropogenic climate change.[4] Climate change is defined by a number of factors, including: temperature, humidity, rainfall, air pressure and wind and severe weather events.[12,13]

The Intergovernmental Panel on Climate Change[2] has reported that the average temperature of the earth's surface has risen by 0.74 °C since the late 1800s. Of the 12 warmest years in the instrumental record of global surface temperature since 1850, 11 occurred between 1995 and 2006.[3,14] The linear warming trend over the 50 years from 1956 to 2005 (0.13 [0.10 to 0.16] °C per decade) is nearly twice that for the 100 years from 1906 to 2005.[15,16]

Global warming is causing adverse impacts on the biophysical environment ranging from the melting of major glaciers and sea level rise to increased weather hazards and biodiversity loss.[17] With reference to climate change trends experienced in sub-Saharan Africa, Chishakwe[17] points out that the region has experienced a warming trend and increased climate variability over the past few decades. Smith et al.[18] suggest that temperatures in the sub-region have risen by over 0.5 °C during the last 100 years. During this period, the sub-region has also experienced a downward trend in rainfall[19]; rainfall in the region in the early 1990s was 20% lower than that in the 1970s, with significant droughts in the 1980s, early 1990s, and in 2002.[20]

Mary and Majule[21] carried out a study on the impacts of climate change and variability in Tanzania. Findings show that the local people perceived the changes in temperature and rainfall pattern and that the changes have affected crop and livestock productivity and have had a significant impact on rural livelihoods and food security. Mary and Majule's[21] study revealed that agriculture, forestry, water, coastal resources, livestock and human health were adversely affected by climate change. The specific stressors of climate change in the study manifested in the form of increasing frequency of floods, drought, erratic rains and other extreme events. The community perceptions of the most important factors undermining peasant livelihoods were, in decreasing order: increasingly unpredictable and declining amounts of rainfall, with unclear onset and ending; rising mean temperatures and pest prevalence; and increasing frequency, severity and duration of droughts.[21] Mary and Majule's[21] conclusion was that all livelihoods (including off-farm livelihoods) in the district were climate change sensitive, which implies that adaptation options to climate change in the district were not sustainable. With reference to the general climate response scenario in sub-Saharan Africa, Yohe[22] reiterates that most rural households in the region are hardly coping with the climate change impacts and as such, the current response options are not sustainable both in socio-economic and ecological terms.

Methodological approach

The objective of our study was to determine climate change trends and associated environmental implications in the Makonde Communal Lands of Zimbabwe. Based on this objective, we sought to answer the following questions:

- Is climate change occurring in the Makonde Communal Lands?
- What climate change trends are experienced in the Makonde Communal Lands?
- What climate change induced biophysical changes are occurring in the Makonde Communal Lands?

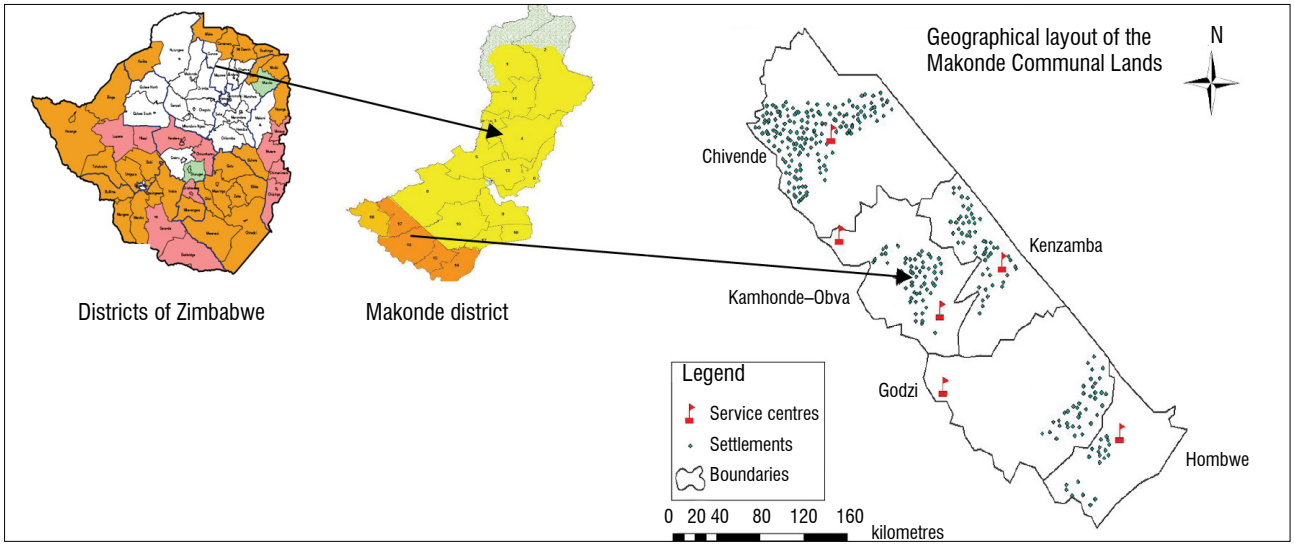


Figure 1: Geographical location of the Makonde Communal Lands within the Makonde Rural District of Zimbabwe.

Accordingly, the design for this research and the accompanying instruments were essentially determined by the research objective and corresponding research questions.[23-25]

Among the critical steps in our endeavour was the need to seek written consent and authority from the local authority for the study area (Makonde Rural District Council) and key informants in the study. The written consent in this regard was accordingly granted. With regard to the consent of the households, the Makonde Rural District Administrator, as the gatekeeper for the rural district, assured the necessary support and cooperation. Issues of confidentiality and anonymity were given serious consideration during the entire research process. The study was approved by the University of South Africa's College of Agriculture and Environmental Sciences Ethics Committee.

Design and instruments

A mixed research strategy was adopted in which both qualitative and quantitative approaches were included. Given the multidimensional nature of climate change indictors, a pluralistic approach in the survey was found to be the most appropriate. A mix of meteorological, biophysical, and sociocultural dimensions, altogether constituting a rural livelihood system, was covered. In order to have a scientific perspective of climate change trends in the case study, quantitative meteorological data recorded between 1962 and 2009 were taken as the principal form of data in this study. The data source for this critical raw data was the Zimbabwe's Department of Meteorological Services. Data on forest cover and related ecosystem goods and services were also obtained. A qualitative methodology of inquiry was adopted to allow for the interpretation of events and phenomena such as those identified in determining climate change trends and associated environmental implications in the Makonde Rural District of Zimbabwe.[25] This method included a focus on qualitative interpretation of people's perceptions and meanings attached to social phenomena, attitudes, beliefs and value systems.[25]

As expected of a case study, a mix of data collection instruments was employed in the study: key informant interviews; household questionnaires; documentation and archives' review; and structured field observations. Key informant interviews are among the critical instruments employed in the case study. By means of purposive sampling, a number of institutions were identified based on their special involvement or engagement in the issues of climate change and related biophysical and cultural changes.

The institutions purposively selected in the survey were the Ministries of Environment and Natural Resources (the Department of Meteorological Services and Environmental Management Authority); Local Government; Agriculture and Land Resettlement (Agricultural Research and Extension Services) and Labor and Social Welfare. The key informants provided vital information about the climate change patterns and their biophysical impacts and local level responses to the problem as applicable to the scope of their responsibilities. For the historical profiling of local climate change knowledge and experiences, 10 elders were selected by means of a snowball sampling method and unstructured interviews were conducted with one elder from each of the 10 villages.[26]

The questionnaire survey as a tool was adopted in this particular study because it is the most appropriate and cost-effective method of surveying a large sample population as in this particular case in which 500 households were surveyed. Given the data collection costs and other constraints, a sample of 500 households was viewed as significantly representative of the population under study. A stratified random sampling framework was employed to ensure proportionate representation of all the 10 villages under study, while at the same time giving each village-level household an equal opportunity to be included. From the household survey, we sought to elicit socio-economic characteristics of households and their knowledge and experience concerning local climate change and variability trends together with associated environmental implications.

Field observations were also conducted in and across the 10 villages in the study area to examine selected biophysical indicators and livelihood impacts in the area. Aspects for observation in the case study included: biophysical conditions, land use and artifacts and other indicators of climate and associated environmental change.

A comprehensive literature survey was conducted to review climate change scenarios and associated biophysical implications at various geographical scales ranging from global to local level. Also derived from the theoretical framework was the methodological aspect of the Millennium Ecosystem Assessment (MEA).[27]

The analysis of data in the study involved both quantitative and qualitative techniques. For the quantitative data, Statistical Packages for Social Sciences (SPSS), complimented by Microsoft Excel, was used to determine correlations and cross-cutting issues. In order to understand the biophysical and socio-economic dynamics of the study area, some maps on human settlements and food security situation were generated. A basic geographical information system (GIS) was employed as a means to integrate different components of the prevailing environmental conditions and community well-being. The analysis also involved an evaluation of the natural ecosystem services connected to local livelihood sectors with great emphasis on how climate change impacts on forests and other land resources and in turn how these influence the identified livelihood sectors.

For the qualitative data, detailed descriptions and classifications were constructed to provide insight into the research questions. Typologies were created to analyse qualitative data.[28] The typological technique aided in highlighting the Makonde community's vulnerability setting. The creation of taxonomies highlighted the hierarchical and other relationships among categories and sub-categories of research themes. Visual representations such as conceptual maps, tables and charts were also employed to analyse and organise the data in order to gain insight into the setting.[25]

Finally, the study included the gathering, analysis and interpretation of climatic and other biophysical data with emphasis on the past and current scenarios, with little reference to climate modelling for potential future impacts. This position was taken because of the inherent weaknesses associated with climate modelling for the future 'scenarios'. Smit and Pilifosova[28] argue that assumptions put forward in climate modelling fail to match with behaviours, both natural and human.

Results and discussion

Climate change trends in the Makonde Communal Lands

We examined whether climate change had been experienced in the area and what trends had been observed. Our key findings suggest that climate change in the Makonde Rural District has been significant during the past 30 years. The mean annual temperatures recorded since 1962 show an increasing warming trend. In terms of rainfall pattern, the mean rainfall amounts recorded during the same period illustrate increasing annual rainfall variability, with a falling trend over the recent decades.

Our findings concur with those of Weart[5] – among the most striking environmental challenges affecting the earth is anthropogenic climate change. The climate change trends observed in the Makonde Communal Lands suggest a progressive warming of the temperature conditions, falling of rainfall amounts and increasing variability of rainfall received between and within rainfall seasons. The analysed rainfall and temperature data that were obtained from the Department of Meteorological Services generated a pattern that clearly confirms the changing climate in the district. Figures 2 and 3, respectively, show the temperature and rainfall patterns experienced over a period of 36 years (since 1962) in the Makonde Rural District.

Whilist there is significant interannual variability in mean temperature beween 1962 and 2008 (Figure 2), the trends displayed show a departure (or anomalies) from the general average and the anomalies are mostly positive. The anomalies shown in Figure 2 are larger in more recent years (beginning in the 1980s), suggesting that the rate of increase of mean temperature is increasing over time. This finding is consistent with detected increases in global and regional annual surface temperatures discussed earlier. A trend analysis of temperature in the study area revealed an increase in both annual maximum and minimum temperatures between 1962 and 2008. Further analysis showed that the period of most rapid warming occurred since the early 1980s to date.

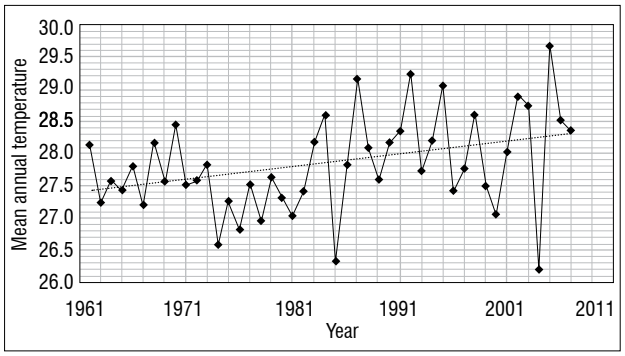


Figure 2: Mean annual temperature (°C) changes in the Makonde Rural District from 1962 to 2008.

In terms of rainfall, the patterns of annual rainfall between 1962 and 2008 shown in Figure 3 are in agreement with already gathered evidence of rainfall trends, which suggest a progressive decrease in annual rainfall over southern Africa. The extreme dips notable in Figure 3 symbolise the increasing interannual rainfall variability associated with increasingly frequent and severe drought spells over the past 20 years. The alternating patterns of below-normal (most frequent) to above-normal rainfall periods reveal the trends of both climate variability and climate change in the Makonde Communal Lands.

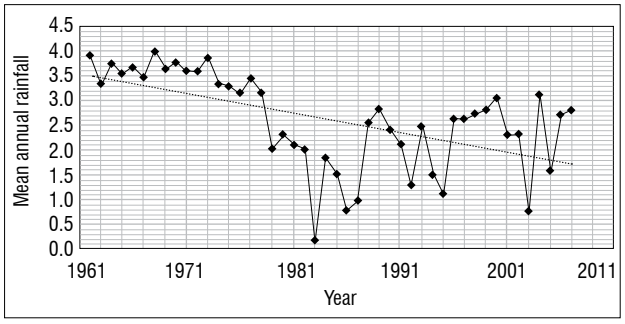
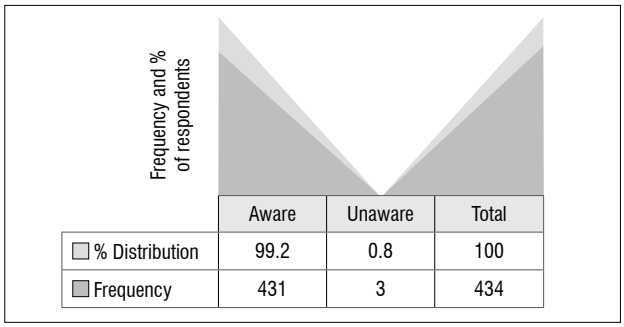


Figure 3: Mean annual rainfall (mm) changes in the Makonde Rural District from 1962 to 2008.

From the perspective of indigenous knowledge systems, community experiences, knowledge and perceptions on climate change in the area were examined in the field. All key informants – from the Environmental Management Authority, Agriculture Research and Extension Services and Makonde Rural District Council to the local leaders and the non-governmental organisations operational in the study area – concurred that there was significant climate change occurring, with progressively warming temperatures and falling rainfall amounts. The most outstanding indicator of climate change among the key informants was the increasing frequency and severity of drought spells occurring in the Makonde Communal Lands. The household questionnaire survey revealed a similar result – awareness of varying and changing climate was almost 100% among households. Community climate change awareness was also investigated (Figure 4). Figure 4 shows that only 0.8% of community members are not aware of the changing climate in the district.

The majority (66.4%) of the study population has experienced significant climate change, with 28.6% suggesting that the climate change is intensifying. Specifically, about 63% of the sampled population suggested that there has been a significant change in the climate. About 80% indicated that they had experienced a progressive fall in mean annual rainfall amounts in the past 30 years. In terms of the prevalence and severity of drought spells over the past years, a total of 49.3% and 44.2% of the community indicated that they either often or very often experienced drought spells over the past 30 years, respectively. As shown in Figure 5, an estimated 76.2% of the sample suggested an increasing severity of the drought spells in the case study.



	Aware	Unaware	Total
% Distribution	99.2	0.8	100
Frequency	431	3	434

Figure 4: Community awareness of local climate change in the Makonde Rural District ($n=434$).

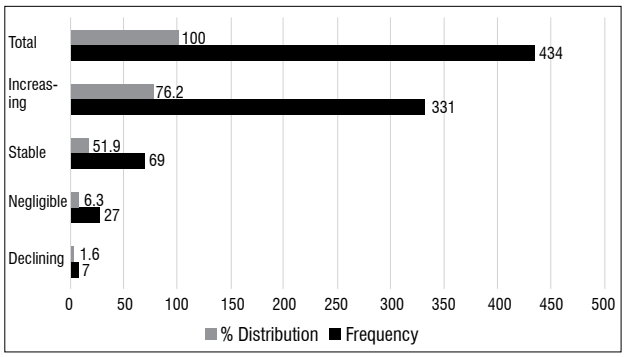


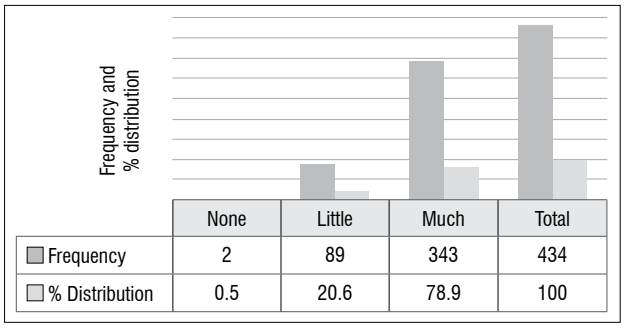
Figure 5: Community perceptions of the severity of drought spells over the years ($n=434$).

Given the observational record of the scientifically availed temperature and rainfall changes for the Makonde Rural District over a period of at least 30 years, examined in parallel with the community experiences and indigenous knowledge systems on climate change, we conclude that there has been significant climate change in the Makonde Communal Lands. In spatial terms, climate change in the study area is more severe in the northeastern part of the study area, covering Villages 17 and 18 in the Kenzamba area (see Figure 1). This part of the study area experienced more severe drought spells because of its extreme northerly position towards the drier agro-ecological Region IV. The soils in this region are more sodic and water resources are generally much scarcer than in the southern and central parts of the study area.

Biophysical impacts of climate change in the Makonde Communal Lands

In light of the MEA's[26] assertion that there is an intricate association between climate and environmental resources on one hand and livelihoods on the other, climate change variables in the Makonde Rural District were also observed to influence local biophysical factors, such as plant and animal growth, water cycles, biodiversity and nutrient cycling. The MEA was adopted in the study to examine the environment through the framework of ecosystem goods and services.

Among the major environmental components affected by the changing climate in the case study is water resources. As much as 78.9% of the study population experienced significant impacts of local climate on local wetlands, springs, rivers and streams (Figure 6). With regard to domestic water supply, 64.3% experienced a decline in availability, 30.6% experienced seasonal availability, and 5.1% suggested that their local water sources had completely dried up. In terms of the state of drinking water, as much as 41% of the community perceived it as poor, 20.7% as deteriorating, and 10.6% apiece perceived it as very poor and critically poor. Focusing on water supply for livestock and irrigation purposes, 40.1% of households sampled suggested that it had become poor and mostly seasonal, whilst 11.3% and 11.1% perceived it as very poor and critically scarce, respectively.

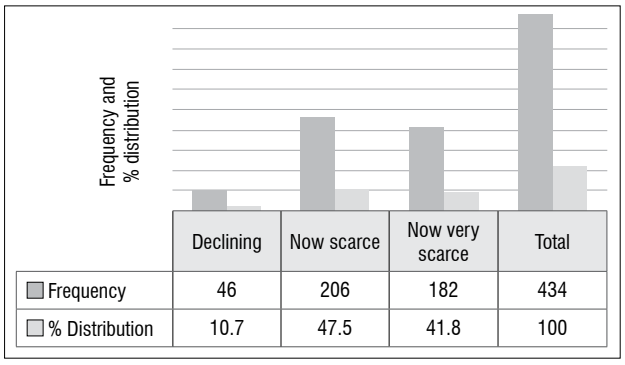


	None	Little	Much	Total
Frequency	2	89	343	434
% Distribution	0.5	20.6	78.9	100

Figure 6: Community perceptions of the climate impacts on local wetlands (n=434).

It is interesting to note that 17.1% of the local households in the case study found the water supply to be good and reliable for livestock and irrigation purposes. These households were generally from a section of the study area that is agro-ecologically endowed. This community of households is largely situated in the area to the southern tip of the communal area (Hombwe–Mukohwe), bordering the agro-ecological zone II (see Figure 1). Incidentally, in terms of water infrastructure, this community enjoys the privilege of accessing the small earth dam that was built for the St Rupert's Mission Hospital.

The other biophysical resource that is critical in sustaining rural livelihoods is forest resources for food, wood, medicinal and other domestic purposes. Figure 7 illustrates community perceptions of the climate change impacts on wild food and other forest resources. Almost half (47.5%) of the Makonde community has experienced a growing scarcity of forest resources for various domestic purposes. A further 41.8% suggested that the resources were now very scarce because of persistent drought spells undermining ecosystem recovery and productivity. The traditional wild fruits which used to be in abundance were now very scarce and many species that provide fruits, wood and traditional medicines had disappeared from the local agro systems.



	Declining	Now scarce	Now very scarce	Total
Frequency	46	206	182	434
% Distribution	10.7	47.5	41.8	100

Figure 7: Local community perceptions of the state of forest food resources (n=434).

In terms of wild animals, elders recalled times when there used to be an abundance of small antelopes, bushbucks and other small mammals, birds and fish contributing to a rich food reserve for the community. According to the elders, all that remains is the baboons and monkeys which, because of the growing scarcity of wild food sources, are increasingly encroaching onto crop fields and homesteads, thus further threatening the declining crop yields and domestic small livestock such as goats, chicken and rabbits.

From the perspective of a rural setting of smallholder farmers, climate change has a direct effect on all food security dimensions which include food availability, food accessibility and food systems stability. It also has an impact on human health, livelihood assets and food production. Forest resources in the study area are under threat from climate change and other climate change induced pressures such as excessive wood harvesting, gold panning and veld fires. The changing rainfall and temperature regimes have had an impact on the availability of many forest resources such as food, wood and other livelihood assets in the area. The depletion of wild food resources has not only exacerbated the insecurity of the community, but has also forced baboons, monkeys, wild pigs and other wildlife to turn to crop fields and domestic livestock for food. This wildlife encroachment has intensified food insecurity among smallholder farmers and the conflicts between the community and wild animals. Productive time is often wasted spent guarding the crop against invasion by wildlife.

Among the major assets that support rural livelihoods and sustain household well-being is livestock ownership. Among the ecosystem services that the community traditionally enjoys is pasture for livestock, which is similarly under threat from the climate change–ecosystem degradation interface. About 32% and 19.4% of the community suggested that the pasture was now scarce and very scarce, respectively. The combined climate change impact of increasing water scarcity, forest depletion and declining pasture availability and quality has seriously undermined livestock productivity, variety, health and numbers in the local villages. As much as 49.8% of the surveyed households incurred significant losses in livestock size, particularly during the series of drought periods mentioned earlier. An estimated 49.5% of the sampled households conceded that the health and quality of the remaining livestock had dropped significantly. The combined effect of climate change induced food shortages and increasing risk of loss of livestock from drought and disease has seen many households forced to sell off their livestock at uneconomically low prices.

As earlier noted, even within the relatively small geographical unit of the Makonde Communal Lands, there is some degree of spatial heterogeneity in terms of climate change trends and related environmental manifestations. Whilst the majority of the households suffer the climate change induced scarcities of water, forest resources and pasture, a certain cluster of households in the study area have experienced little to no negative effects on their livelihoods, food security and general well-being. These households are mostly confined to the southeastern tip of the district, where the conditions are more humid, being geographically linked to the agro-ecological Region II, with higher, more reliable rainfall and richer agro-ecosystems.

Conclusion

Based on the observed meteorological records over the past 30 years and local community knowledge systems, the smallholder farming community of Makonde Communal Lands is experiencing significant climate change. An analysis of meteorological data, questionnaire responses and interview transcripts tapping into local community experiences and indigenous knowledge systems led to the conclusion that there has been significant climate change in the study area since 1962. The climate change trends clearly manifest in the form of progressive warming, falling mean annual rainfall amounts and the increasing frequency and severity of drought spells in the Makonde Communal Lands.

As a consequence of climate change occurring in the Makonde Communal Lands, the study has noted three dimensions of vulnerability to the changing climate among which is the physical–environmental dimension which refers to the emergent local climatic conditions and associated biophysical impacts. The biophysical changes experienced in the area are in the form of the deterioration of ecosystem productivity and diversity. From the perspective of the biophysical dimension of vulnerability, the changing climate in the Makonde Communal Lands has had a significant effect on the state, productivity and diversity of local biophysical resources. The survey revealed that local climate change has induced the progressive degradation of local environmental assets such as forests and associated products, wildlife, water, pasture and soils.

Given the multifaceted nature of the climate change phenomenon and the associated impacts on ecosystems, economies and general human well-being, a mix of measures needs to be explored. These measures include the need to bridge climate change information gaps at national and local level; address institutional capacity constraints in climate change and environmental management; and put in place a multi-stakeholder approach

to institute, implement and monitor a comprehensive community-based natural resources management system and sustainable intensification of land and animal husbandry practices. Specific areas that need capacity building include: weather focusing, climate change monitoring and early warning systems; climate change education; and appropriate weather information dissemination to farmers in order to strengthen climate resilient livelihoods.

Acknowledgements

We thank the Exxaro Chair in Business and Climate Change at the University of South Africa for partial sponsorship of the fieldwork and the Unisa Bursary Section for payment of 2013 tuition fees for I.S.

Authors' contributions

I.S. performed the data collection and data analysis and wrote the manuscript. G.N. supervised the entire research process, provided guidance on the design of the research project, made conceptual contributions and provided overall quality assurance for the manuscript.

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