International Journal of Development and Sustainability
ISSN: 2186-8662 – www.isdsnet.com/ijds
Volume 3 Number 6 (2014): Pages 1340-1353
ISDS Article ID: IJDS14111002

Edging towards a tipping point? An appraisal of the evolution of livelihoods under climate change in semi-arid Matobo, Zimbabwe

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Abstract

This paper contributes to emerging research on the impacts of climate change on communities in the Global South by mapping and analyzing its impacts on rural livelihoods in semi-arid Matobo District in Zimbabwe. It investigates the possibilities and scope for climate change adaptation in this region as communal households adjust and diversify their livelihood portfolios. In so doing, it finds that climate change has had remarkable consequences on the livelihoods of people in this semi-arid area. It has altered the ecosystem leading to the disappearance of certain plant and insect species that were an essential part of the local natural habitat and livelihoods of local people. Rainfall patterns have also become unpredictable leading to erratic, mostly, poor farming seasons with direct implications on the local food system and rural economy. In response to these climate change induced impacts, a variety of new livelihood strategies are emerging as households seek to cushion themselves against this threat to their sustainability. However, a pertinent question is: how far can these adaptation strategies evolve under the increasing pressure of climate change impacts? In other words, are these communal households urging towards tipping points?

Keywords: Climate change; temperature; precipitation; livelihoods; impacts; adaptation.

Cite this article as: Moyo, P. and Dube, T. (2014), "Edging towards a tipping point? An appraisal of the evolution of livelihoods under climate change in semi-arid Matobo, Zimbabwe", *International Journal of Development and Sustainability*, Vol. 3 No. 6, pp. 1340-1353.

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1. Introduction

In its 2007/08 Human Development Report, the United Nations Development Programme (UNDP) notes that "climate change is the defining human development issue of our generation". The UNDP adds that,

> *Climate change threatens to erode human freedoms and limit choice. It calls into question the enlightenment principle that human progress will make the future look better than the past.... The early warning signs are already visible. Today, we are witnessing at first-hand what could be the onset ofa major human development reversal in our lifetime.* (UNDP, 2007:1).

This UNDP conclusion is reinforced by many others including Brooks et al., (2009:741) who argue that 'climate change is increasingly recognised as a threat to the achievement of the Millennium Development Goals (MDGs), and to human development and well-being globally'. Other multilateral bodies such as the Intergovernmental Panel on Climate Change (IPCC) (2014) share similar observations about the negative threat climate change poses to human development, especially in many poor countries in the Global South. Thus the clear message from current climate change research is that it will reverse many human development gains, deepen poverty, worsen food insecurity and disrupt local livelihoods etc. This scientific narrative is now established and accepted in policy and academic discourse. However, although there is now general consensus that climate change is a reality with severe environmental, economic, health and political implications, there is limited local level empirical evidence showing how climate change is affecting livelihoods in different but specific parts of the Global South and how those livelihoods are evolving under climate change (Brooks et al, 2009; Ayers & Huq, 2009). This is a clear research gap that must be addressed because such local level studies are important for deepening our scientific understanding of climate change impacts in identifiable localities. Furthermore, specific case study nuance is vital in informing and influencing context specific policy formulation in response to the impacts of climate change.

Those who argue that climate change is projected to have telling but largely unknown effects on the livelihoods of local communities especially in the Global South have a strong foundation for their arguments. This is because countries in this geo-political category, especially those in sub-Saharan Africa, are characterised by high poverty levels, vulnerability, precarious livelihoods and already high temperatures thus making them acutely vulnerable. Garcia (2008:3) adds that there are three key factors which partly explain sub-Saharan Africa's vulnerability to climate change. Firstly, the geographical positioning of the African continent gives it one of the warmest climates by its proximity to the equator. Secondly, most African countries depend on the agricultural sector which is sensitive to climate change. Thirdly, gaps (or limitations) in governance, government financing, high rates of poverty and growing populations all expose sub-Saharan Africa to climate change hazards.

Given sub-Saharan Africa's susceptibility to climate change, it is thus pertinent for research energies to be directed towards understanding its impacts on this continent hence our focus on Zimbabwe. Our main aim is to examine the impacts of climate change on local livelihoods in South Western Zimbawe (specifically in Matopo district) and how locals are adapting and evolving their livelihoods under climate change circumstances. Such specific focus is important as it allows for area specific understanding of the effects of

climate change on different ecological regions in Zimbabwe and in different localities. This rationale speaks to Saarinen et al's (2012) argument that the diversity of ecological climatic regions means that the impact of climate change cannot be fully understood by studying a limited number of dissimilar case studies. More cases studies such as this one and more literature is required to understand the phenomenon across different regions and localities in sub-Saharan Africa. In line with this argument, Scoones (2009:2) notes that 'diversity is the watchword, and livelihoods approaches have challenged fundamentally single-sector approaches to solving complex rural development problems. The appeal is simple: look at the real world, and try to understand things from local perspectives'. This means that understanding the effects of climate change in one community cannot be used to adequately explain the same in a different community. Livelihoods are highly localized in their outlook and their resilience to external shocks differs. This local specificity is important in analysis not as an academic endeavour but for policy makers as well who need precise information that is up-to-date about the current and potential future impacts of climate change. Such unambiguous climate change information is important for policy responses and development programming at the local level.

2. Climate change and human development: A synopsis

Climate is a critical controlling variable in the human development process. Pittock (2005) notes that climate is a critical dimension to human development since natural ecosystems are dependent upon climatic conditions. In the past few decades, the global community has come to realize and accept that climate change will negatively affect the ecosystem which human beings depend on for food, medicine, energy, water and shelter etc (Sokona and Denton, 2001:119). While ecosystems have long been under threat from poor and unsustainable natural resource use, a combination of natural and man-made climate change factors will accelerate their devastation. According to Stern (2007:65) 'ecosystems will be particularly vulnerable to climate change with one study estimating that 15 - 40% of species face extinction with 2◦C of warming.' A more elaborate explanation is advanced by Shaw et al. (2011:466) who notes that

> *Climate change is likely to affect the abundance, production, distribution, and quality of terrestrial ecosystems. Therefore, ecosystem services such as climate stabilization through carbon sequestration, the provision of non-irrigated forage for livestock and wildlife species, the delivery of water which supports fish for commercial and recreational sport fishing, the provision of critical habitat for biodiversity, and many other types of ecosystem services are likely to be impacted by a changing climate.*

Biodiversity will not be spared by climate change either. Changing climate patterns would cause particular species of plants and living organisms to either adapt or die because they thrive under particular ecological and climatic conditions. This is in line with Gosling's et al (2011:448) contention that loss of biodiversity would be between 20% and 30% if global temperature increases by about 2%.Those living

organisms that fail to adapt would eventually be drastically reduced or extinct (in extreme cases). This biodiversity imbalance will lead to further ecological destabilization and an alteration of community livelihoods in affected areas.

In addition to ecosystem and biodiversity destruction, climate change also has negative effects on water security, agricultural production and food security. Furthermore, it increases exposure to natural hazards such as floods and droughts (Stern, 2007; UNDP, 2007; Shaw et. al, 2011 & Gosling, 2011). The Stern Review of 2007 concluded that one of the ways in which climate change would be felt was through remarkable changes in the distribution patterns of water across the world. This would not only affect the aggregate amount of water in specific geographical areas but also the seasonality and variability of the amount of water available. The UNDP adds that 'changed run-off patterns and glacial melt will add to ecological stress, compromising flows of waterin a water scarce environment by 2080' (UNDP, 2007:9). Some countries in Southern Africa, the Mediterranean Basin and South America are bound to have reduced water availability as a result of the dynamics of climate change (Stern, 2007). Kummsa and Jones (2010) add that since 95% of Africa's agriculture is rain fed, it is thus highly vulnerable to reduced water availability due to climate change. In Southern Africa, there is already scientific evidence which shows that the region will become generally hotter and drier as the next decades unfold. Furthermore, studies already show that rainfall patterns have become unpredictable and volatile with some rainfall seasons now shorter thereby affecting cropping seasons (Mubaya, et. al, 2012).

Some climatology simulations point to increased incidences of localized flooding due to climate change induced unusual high rainfall amounts over short periods of time. Emerging evidence from Mozambique seems to validate this simulation. In the year 2000, large parts of southern Mozambique experienced abnormal rainfall resulting in flooding which led to an estimated 800 deaths, the destruction of infrastructure and the outbreak of water borne diseases (Patt and Schroter, 2008). More climate change induced flooding in southern Mozambique followed in the year 2013 resulting in the death of at least 36 people and the displacement of over 70 000 other people (BBC, 2013). For the foreseeable future, it appears southern Mozambique will continue to experience recurrent flooding. This flooding is clearly impacting local livelihoods confirming the UNDP's (2007:1) observation that climate change is indeed 'holding back the efforts of the world's poor to build a better life for themselves and their children', especially in many Global South countries such as Mozambique.

Any change in water availability (unreasonably more or less), access and security has a direct bearing on agricultural production and food security, especially in many countries in the Global South with large populations that depend on rain-fed subsistence agriculture. These water insecurity impacts on agricultural production (and by extension on food security) are further compounded by climate change related increasing temperatures. Current general climate trends show that global temperatures have been increasing at a rate of about 0.85^0C per century and this rate is expected to increase due to intensified industrialization (IPCC, 2013).Consequently, the UNDP (2007) estimates that high temperature induced drought affected areas could expand by between 60 and 90 million hectares by the year 2060. If indeed drought affected hectares increase by that much globally, this would deepen the poverty, vulnerability and food insecurity situation of so many

in the Global South, especially in drought prone agro-based African countries such as Zimbabwe, Malawi, Mozambique etc.

3. Study Area

Zimbabwe is divided into five agro-ecological regions on the basis of average precipitation, temperature, and soil quality and vegetation characteristics among other factors. Matobo District is in the South Western part of Zimbabwe, about 100 kilometres from the second largest city of Bulawayo. Some parts of the District are in agro-ecological zone IV while others are in zone V. Agro-ecological zone IV is characterized by rainfall amounts ranging between 450mm and 650mm per year. This agro-ecological region is also characterized by frequent and long dry spells during the rainy season. Agro-ecological region V is characterized by rainfall amounts below 450 mm per year. The two regions are also characterized by high temperatures averaging 26^{o}C.

4. Research methodology

This study used a qualitative approach and research methods. Purposive sampling was used to select three wards in Matobo district. A ward is a third tier unit of public administration in Zimbabwe preceded by a province and district respectively. The three purposively selected wards were Gwezha, Makhasa and Zamanyoni. Within these three wards, 81 households (27 per ward) were selected using simple random sampling. Given this sample size, it follows that the analytical generalizations herein are more indicative than representative.

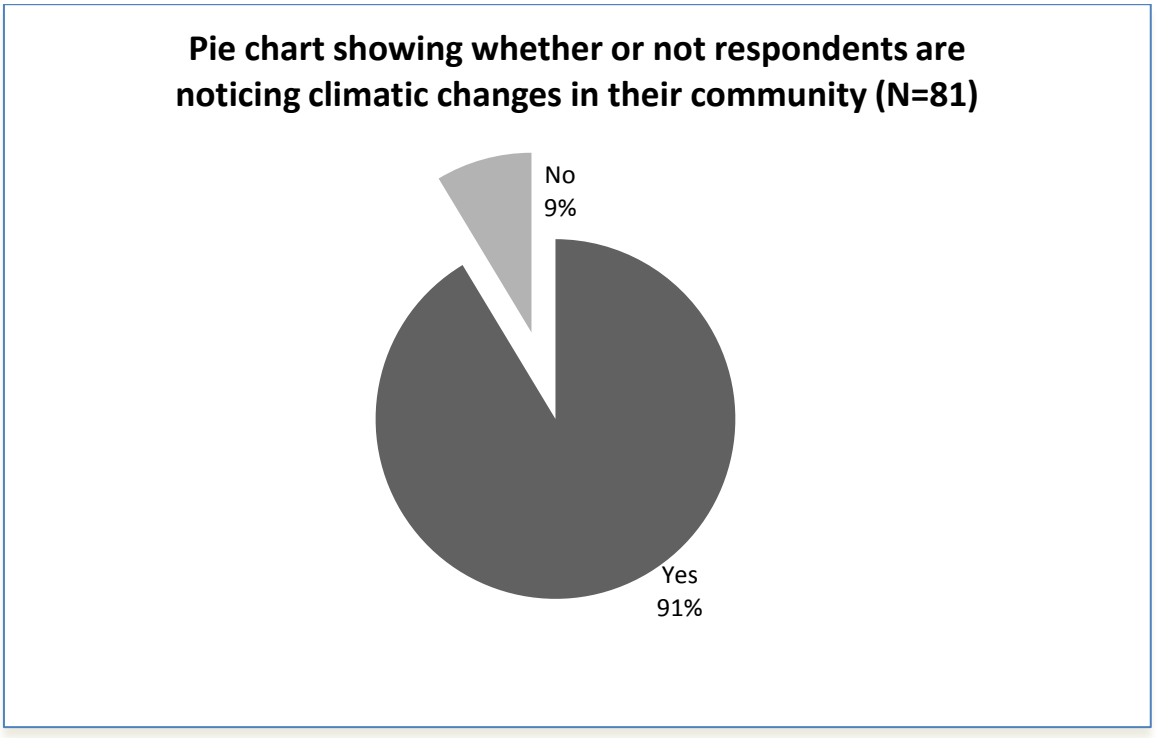
Household heads were the majority questionnaire respondents among the 81 sample households. Where the household head was not available, the next person responsible for socio-economic decision making became the respondent. The household questionnaire sought to capture the views and experiences of respondents in relation to the adaptation of their livelihoods in response to climate change induced temperature and precipitation changes, water availability, access and utilization (water security), crop and livestock productivity, quality of grazing pastures, ecosystem services and biodiversity.

In an effort to broaden and deepen the quality of data collected as well as compensate for weaknesses inherent in questionnaire usage, focus group discussions and in-depth key informant interviews were also employed. One focus group discussion (FGD) was held in each of the three wards. Each FGD had 15 purposively selected participants drawn from local subsistence farmers, traditional leaders and local ward councilors. The aim of the FGDs was to further probe findings emerging from questionnaire responses while also allowing participants to further explain, debate and adds some important data that might not have been captured in the questionnaire survey. Given their expert knowledge about climate change in Zimbabwe in general and in Matobo in particular, key informants from the Department of Agricultural Extension Services, Forestry Commission and Zimbabwe National Water Authority were also a vital source of information for the study.

5. Climate change awareness amongst small scale farmers in Matobo: Scientific and religious interpretations

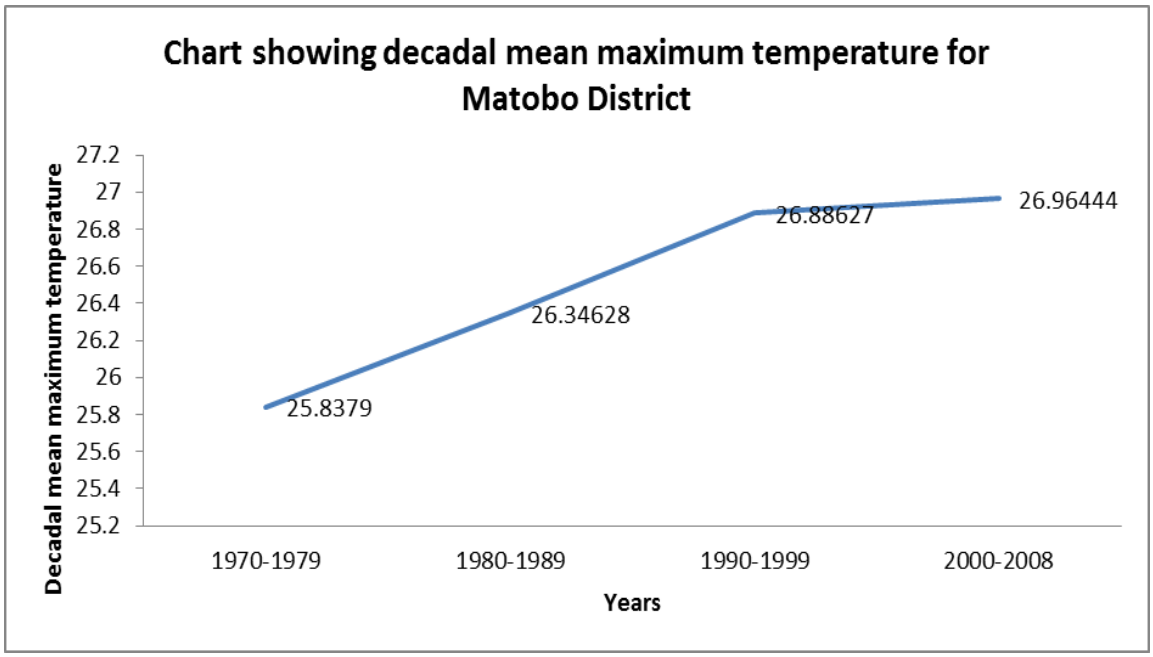
A significant number of small scale farmers (49%) were aware that climate change is a challenge facing the global community while fifty one percent (51%) reported that they had not heard about it. However, while the majority in the sample did not know about climate change as a global human development challenge, the overall majority (90%) in the sample were noticing several significant changes in local weather patterns. They indicated that rainfall patterns and temperature trends had changed over the years as shown in chart 1 below:

Chart 1. Pie chart showing whether or not respondents are noticing climatic changes in their community (N=81)

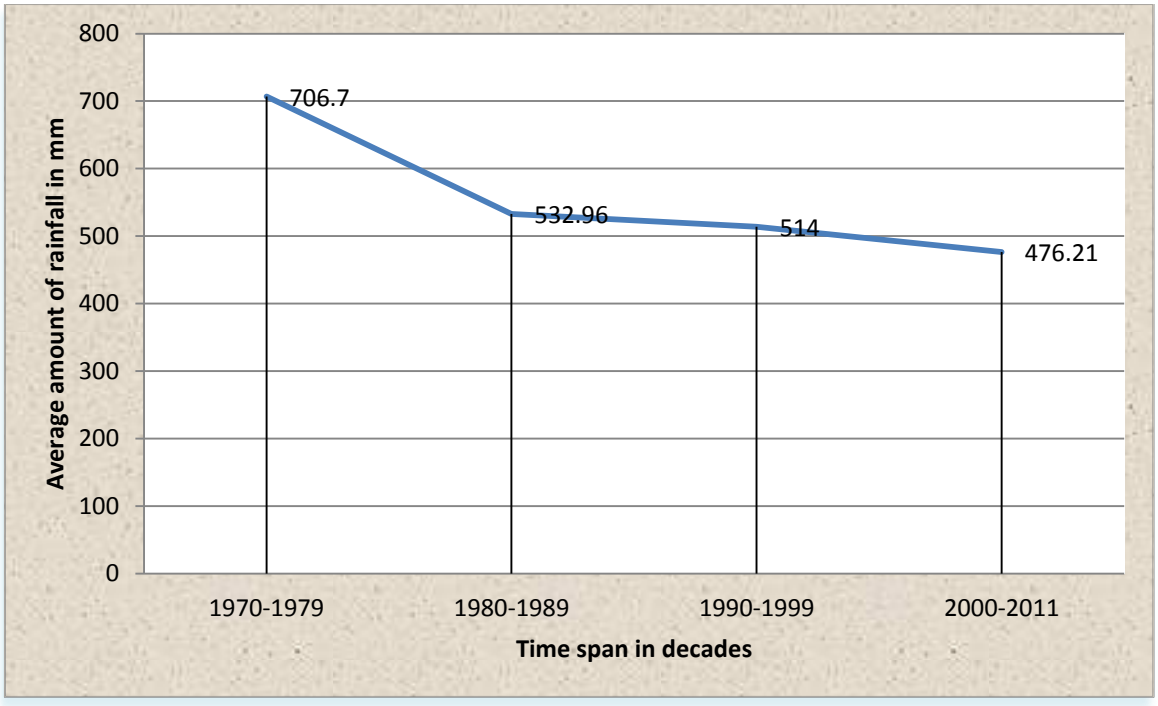


Data gathered through focus group discussions (FGDs) corroborated the dominant household survey position that temperatures had drastically increased over the past decades while the rainfall amount per agricultural season was steadily decreasing. The FGD participants noted that in addition to the reduced amount of precipitation, the wet season had also become much shorter than it was in the past since they now usually receive their first rains in December or January as opposed to October. This has thus drastically reduced the length of the planting season with negative agricultural production consequences as will be discussed later. It was further pointed out by the FGD participants that in some of the years when the first

rains were received in October, they tended to be too erratic with some months going for weeks without any rain. These observations (about rainfall and temperature changes) by the study respondents correspond with meteorological data collected by the Zimbabwe Meteorological Services Department in Matobo District over the last 40 years as shown in graphs 1 and 2 below:



Graph 1. Matobo district decadal mean maximum temperatures
Source: Zimbabwe Meteorological Services Department (calculations and graphs by authors)



Graph 2. Matobo district decadal mean rainfall patterns
Source: Zimbabwe Meteorological Services Department (calculations and graphs by authors)

The above two graphs are in line with Matobo smallholder farmers' perceptions that rainfall amounts have been decreasing over the last four decades while temperatures have been steadily increasing. These rainfall decreases and temperature increases are also in unison with projections made by the UNDP (2007) and Stern (2007). While temperature changes in Matobo may appear somewhat minimal, it should be remembered that it only requires a temperature change threshold of2^{o}C to realize catastrophic changes in the atmosphere according to some projections (see Stern, 2007; Pittock, 2005).

It is important to highlight indigenous knowledge systems and oral traditions based interpretations of the causes of climate change in Matobo locality. Participants in the focus group discussions partly attributed observed climate changes to the fact that local people were no longer observing traditional rituals especially rain making ceremonies at the nearby Njelele shrine. Njelele is one of the oldest and revered religious shrines in Zimbabwe. Nyathi (2014) argues that "in times gone by, the hill [Njelele] was the spiritual centre for people from far and near. Every year in about August pilgrims trekked on foot to perform rain rituals" hoping to religiously "manipulate the environment to induce it to release the rains". However, in the recent past, these traditional rain making ceremonies are hardly conducted. According to study participants, this has made the Njelele 'god' unhappy hence the reduction in rainfall amounts and increased temperatures in the local community. While some climatologists and scientists might be quick to dismiss this traditional and religious interpretation of reduced rainfall in Matobo as a fable, it is worth recording for that is what some in the local community perceive as one of the climate change causes. This indigenous knowledge systems or oral tradition interpretation of the causes of climate change appears to be prevalent in some parts of Zimbabwe as well as confirmed by Mubaya et al (2012) who found that 45% of farmers in Lupane District in Zimbabwe thought that droughts and hot temperatures were being caused by ancestral spirits and God. If such a view about climate change causes is prevalent in many parts of Zimbabwe, it means it has implications in terms of how rural communities will cope and adapt to the human development threats caused by climate change. Perhaps further studies would help to elucidate the effect of spiritual (traditional) beliefs on climate change coping and adaptation in rural communities.

6. Climate change impacts on livelihoods in Matobo District: Emerging evidence

The reduction in rainfall amounts and increasing temperatures in Matobo have a number of livelihood effects. Given that the majority of locals are smallholder farmers who predominantly rely on rain-fed mixed subsistence agriculture; these drastic changes in weather patterns are directly affecting the core of their existence. The production of staple crops (that include maize, wheat, groundnuts, round-nuts) is being done

under unfavourable 'stressed' weather conditions. Consequently, crops are susceptible to wilting during most planting seasons (due to low rainfall and high temperatures) leading to severely reduced food crop harvests and losses of input investments. Secondly, farmers noted that rainfall patterns are now erratic and unpredictable. While rains used to start falling around October in the past, they now start around late November to early December ending in February or early March. This unpredictable delayed onset of rains (and early termination) is disruptive to farm planning. Farmers indicated that they are no longer sure of when to start tilling the land and plant the first seeds. As one respondent noted:

> *Farming is now like gambling because we do not know when to start, if you start early you might lose, and the one who started late might win. We don't know when to plant any more. Sometimes you delay planting and then you never plant at all because the rains may not come at all at the end* (Gwezha FGD participant 1).

This uncertainty among farmers has many implications. Firstly, delayed planting might mean crops do not mature for harvest due to a shorter farming season. Secondly, dry planting is equally risky since rains might be further delayed resulting in seeds failing to germinate. Thirdly, farmers are now tilling and planting on less land due to increasing uncertainty about rainfall thus lowering net harvests. Even when good rain seasons are occasionally received, farmers are unable to maximize production since they would have cultivated less land from the onset. All these uncertainties mean that food crop production (which is central to locals' livelihoods) is now subject to farming 'guesswork'. Such a situation which makes a key element of local livelihoods a question of 'guesswork' means the community now subsists in an environment of underlying perpetual vulnerability.

In an effort to cope and adapt to erratic unpredictable rainfall patterns, focus group participants suggested that access to irrigation equipment and water was the most viable strategy that would enable them to continue practicing subsistence agriculture. While this might sound like a novel suggestion, in the local Matobo context this suggestion is however fraught with many obstacles. Firstly, there are no boreholes close to the farming fields. This means these will have to be drilled at a cost first. Whether local farmers have the financial resources for this is uncertain. Secondly, even though there is a local dam, it is five kilometres away from the nearest farming fields. It therefore means the farmers will either have to finance the laying of underground water pipes to their fields or use bulk water tankers to transport water from the dam to the fields. These are both expensive propositions for a community of smallholder farmers who have negligible immovable and movable assets.

Diminishing rainfall amounts are also having a negative effect on bulk water availability in local rivers, streams, wetlands and wells. Focus group discussion participants indicated that rivers which used to flow for most of the first half of the year were drying up earlier than usual. This change is not only explained by reduced rainfall but increased evaporation rates due to increased temperatures. This means there is now reduced bulk water for domestic livestock, wild animals and for usage by locals in a variety of agricultural endeavours and domestic chores. Furthermore, wetlands which were previously productive agricultural sites are now scorching dry. The drying and eventual disappearance of these wetlands has adversely affected local

livelihoods. Farmers who used to grow local rice varieties are now unable to do so. This has thus affected local food availability since rice which used to be grown locally for subsistence purposes is no longer part of the local food system. The drying of wetlands has also exposed the local community to water stress. Farmers indicated that they used to fetch water from wells in a local wetland known as Matapeni which has however dried up due to reduced rainfall and increased evaporation rates. The drying up of these wells means water insecurity is now a real threat in the community. Local residents now have to walk distances of up to eight kilometres to the nearest water point. Women, who are predominantly responsible for domestic household chores such as sourcing water in this community, bear the brunt of this water insecurity as they are the ones frequently walking these long distances in search of water.

The decrease in precipitation and the increase in temperatures are also negatively affecting the local ecosystem and biodiversity. The new climate conditions are negatively affecting indigenous plant species and organisms. For example, the local ecosystem in Matobo is known for the abundance of the *mopane* tree which is a breeding platform for the *mopane* emperor moth. Eggs laid by the *mopane* emperor moth hatch on the *mopane* tree producing a local protein delicacy called *'imbrassia belina'* (or *mopane* worms) known in the local isiNdebele language as '*amacimbi*'. During their growth, *'amacimbi'* feed on *mopane l*eaves. However, according to respondents, due to reduced rainfall and rising temperatures, *mopane* trees are no longer blooming enough leaves for *'amacimbi'* hatching and feeding leading to a net reduction in *'amacimbi'* harvests per season. The local farmers noted that this reduction in harvests has negatively affected their livelihoods since they are no longer selling enough to meet domestic expenditure needs such as school fees, health fees, and the purchase of basic food and other household utensils. Focus group participants also indicated that some wards in the district no longer had *'amacimbi'*; a clear indication that the continued availability of this local delicacy is under imminent threat due to climate change induced changes in the local ecosystem and biodiversity. It is however our view that there is need to further investigate whether changing climate is solely responsible for this reduction in quantities of locally available *'amacimbi'*. Such a word of caution arises because it is possible that over-harvesting of '*amacimbi*' in past years is the primary cause of this decline in quantities. As Toms *et al*., (2003), observe; to maintain a sustainable harvest

> *The [mopane] worms that are not harvested leave the trees and pupate underground. The life cycle is completed when the adult moths emerge from the pupae, mate and lay eggs. If the cycle is broken at any point by excessive harvesting, for example, it will not be possible to maintain a sustainable harvest.*

Changing precipitation and temperature patterns are also affecting natural production of seasonal wild fruits especially tubers. Focus group participants noted that wild tubers known in the local isiNdebele language as *izadenda*(wild tuber that looks like a sweet potato) and *izagons*i had previously been in abundance in local forests especially during the rainy season (November to March/April). These tubers constituted an important supplementary vegetable diet for the locals, especially boys and young men who rummaged forests in search of these while herding livestock or hunting wild animals. However, reduced rainfall and increasing temperatures (which have increased evaporation rates thus affecting soil moisture) are disrupting the natural regeneration of these tubers. The obvious consequence of this is the subtraction of

these tubers from the local food system. While it will be a bit of a stretch to suggest that this means the food security of the locals is being affected, it cannot be denied that their diet (especially for boys and young men) has been altered due to climate induced changes in the local ecosystem.

The same can be said about another wild fruit known in the local isiNdebele language as *umwawa* (a hard shelled fruit which is yellow inside when ripe). Respondents indicated that this wild fruit used to be in abundance in local forests. In addition to consumption at local household level, entrepreneurial locals would harvest the fruit and resale it to people from other parts of the country or dry it and transport to Bulawayo metropolitan for trade in informal urban markets. Those who engaged in such trade would raise significant amounts of money for use in a variety of household livelihood activities. However, according to respondents, *umwawa* trees are no longer as productive as they used to be. Most of the fruit trees are bearing less due to reduced rainfall and dry soils. Those trees which are still regenerating the fruit are producing it in smaller low quality and low quantities. The local explanation of this decline is changing local climate patterns. The above Matobo rainfall and temperature change patterns (see Graph 1 and Graph 2 above) seem to corroborate this local explanation of reduced *mwawa* production. However, it is also subject to question whether the changing local climate is the only explanatory factor for this reduced productivity by *mwawa* trees. A primary question to be asked by any future research into this issue should interrogate whether levels of soil fertility in these local forests remain 'rich' or fertile enough for the growth and maturity of quality *mwawa* fruits seasonally. Secondly, the 'lifespan' (hence productive lifespan) of the *mwawa* trees should be ascertained. This is crucial because it is possible that the observed reduced productivity might simply be an indication of the depreciation of the trees' productive lifespan rather than a function of local climate changes.

Climate change induced ecological changes are also affecting livestock grazing pasture in Matobo. A new trend of persistent droughts is scorching grazing resources for livestock. Without any access to local relief grazing (for example paddock controlled feeding), the physical condition of local livestock is thus very poor with some succumbing to starvation. This suggests that the local farmers no longer get the full market value of their livestock at auction due to drought depressed prices. According to the farmers, some have actually lost their cattle herds due to these persistent droughts. The situation was dire in 2012 (the year preceding data collection for this study) with many farmers from different wards in the district reporting huge cattle losses. All this suggests that local farmers are being deprived of a livelihood resource which they have all along depended on to raise household income to finance their children's school fees and household members' hospital fees and basic necessities. While some local farmers have attempted to adapt to these drought conditions by practicing a form of transhumance known in the local isiNdebele language as *ukulagis*a (Nyathi 2000 cited in Moyo et al., 2013), it is perhaps more sustainable for the farmers to begin to explore investing in drought resistant small livestock such as goats. However, given the social prestige and status that accompanies cattle ownership in the local community; it will take sustained education and persuasion for the local farmers to see investment in small livestock as worthwhile and economically viable.

7. Conclusion

The foregoing discussion suggests that most rainfall, temperature and ecological systems dependent livelihoods are at risk in Matobo district. While these climate change induced risks are not unique to Matobo, what is clear is that Matobo smallholder farmers have not diversified their livelihood portfolios. Their continued reliance on rain-fed mixed farming activities means their livelihoods portfolios are not resilient enough (if at all). Since they rely on livelihood strategies with similar risk attributes, their livelihood portfolios are thus vulnerable to similar hazards. Even though the farmers are implementing a variety of coping and adaptation strategies such as delayed planting of crops, they should perhaps be conscientised about the advantages of switching to small grain drought resistant crops. Secondly, their desire to switch to irrigation farming in response to limited bulk water access calls for state or development agencies intervention since they don't have the resources to finance this switch. For those farmers who rear livestock, controlled pen (or paddock) feeding and/or switching to small drought resistant livestock such as goats might be the answer to continuously diminishing grazing pasture. However, whether the local farmers have the resources for fencing to create these paddocks and buying stock feed is the question. If indeed they don't have these resources, external intervention either through state or development agencies might be their only realistic option. Without necessarily suggesting that external interventions (be they state driven or development agency driven) might be a 'panacea' to some of the coping and adaptation challenges being faced by smallholder farmers in Matobo, it however appears that they will have a crucial role to play in order to achieve climate change resilience in the foreseeable future. All the above also suggests that climate change programming in Matobo should focus on educating and ensuring that local farmers diversify their livelihood portfolios to include off-farm income generating activities. Such diversification is crucial since too much reliance on on-farm activities is clearly exposing them to perpetual vulnerability to climate change.

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