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Climate Change Impacts, Adaptation and Coping Strategies at Malindza, a Rural Semi-Arid Area in Swaziland

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Abstract: The objective of the study was to assess the impacts of climate change faced by rural households in the lowveld of Swaziland, using Malindza as a case study area, and further identify adaptation and coping strategies employed by households. A questionnaire was developed and used to conduct interviews from 160 households randomly selected in four rural communities of the study area. Data were analysed with SPSS software, and reported in forms of tables and figures. More or less all the respondents (99%) were aware of climate change and climate change variability, Sources of information included radios (92.5%), television (5.6%) and agricultural extension officers (2%). The information was however considered inadequate and of short term remedy as it was in the form of daily weather forecast. The perceived effects of climate change included crop failure (99%), loss of livestock (99%) and drying of surface water (99%). Only 9% of the households harvested enough maize to last for a year, and the rest (91%) had to rely on buying maize, exchanging it for labour or receiving food aid. The climate change adaptation strategies practiced included contour ploughing (49%), use of organic fertilisers (29%) and crop rotation (20%). Thirty two percent of the households planted hybrid maize seeds and 15% planted open pollinated maize seeds. Another 26% planted both hybrid maize and open pollinated maize seeds. On the other hand, coping strategies practiced included selling or consuming small livestock and chicken (97%), consuming maize left for seeds (93%) and reducing food intake (23%). It was clear that the effects of climate change in rural areas were severe and needed to be addressed before critical damages like loss of human life manifest. The government should ensure that farmer's knowledge on climate change and variability is increased through education to improve their adaptive capacity.

Keywords: Adaptation, Climate Change, Climate Variability, Coping, Adaptive Capacity

1. Introduction

Swaziland is a landlocked country located on the southern part of the African continent along the geographic coordinates 31°30'E and 26°30'S and has an area of 17,363 km^2,with a population of about 1.2 million inhabitants (Government of Swaziland, 2007a). It shares its boundaries with South Africa and Mozambique (Figure 1). The general climatic characterization of Swaziland is sub-tropical with wet hot summers and cold dry winters. About75% of the annual rain falls in the period from October to March. The cold dry winters are during the months of April to September (Government of Swaziland, 2010).

The CSIRO and the MIROC models predicts a temperature increase of about 1–1.5 ^{0}C and 1.5 ^{0}C respectively and the average daily temperatures of an area may further increase to about 2–2.5 ^{0}C by 2050 for the country (Manyatsi et al., 2013). The models further estimated a 200 mm reduction in rainfall in most parts of the country. Climate change as a phenomenon has some implications for the developing countries, most of which are negative (Kandji et al., 2006).

Climate variability can be defined as the short-term variations in mean state of the climate and variations in other statistics (such as the occurrence of extremes) on all temporal and spatial scales beyond that of individual weather events. This differs from climate change which refers to a change in the state of the climate that can be identified by changes in the means and/or changes in the variability of its properties, and that persist for an extended period (IPCC, 2007). The effects of climate change includes among other things the rise in sea level, changes in the intensity, timing and spatial distribution of precipitation, changes in temperature and the frequency, intensity and duration of extreme climate events such as drought, floods and tropical storms (IPCC, 2007). The changes in temperature and precipitation have resulted in changes in land and water managements that have subsequently affected agricultural productivity in all developing countries (Kandji et al., 2006).

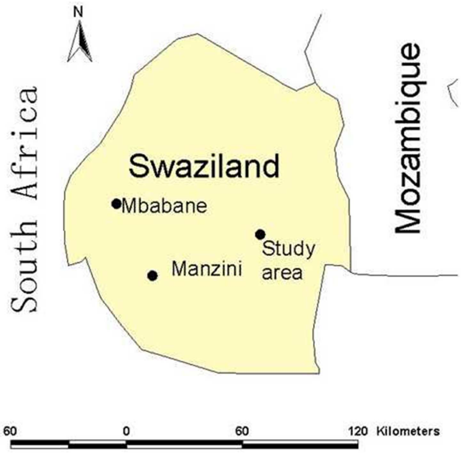

Figure 1. *Map of Swaziland showing location of major towns and study area.*

Evidence from different climate change prediction models suggests that climate change and variability are likely to significantly increase the risk of crop and livestock failures, unless significant adaptation and coping strategies are employed (Chambwera and Stage, 2010). However, rural communities lack the sufficient knowledge, financial capacity and resources to implement the best mitigation practices for sustainable agricultural production. Climate variability and change have brought changes in the timing and length of the growing season and these have affected crop growth in different parts of the country (Manyatsi et al., 2010).

Climate change adaptation and coping strategies distinguishes between farmers' short-term and long-term responses to climate variability, climate change and food insecurity (Mudzonga, 2011). Although farmer's adaptive and coping strategies may not succeed completely, they form the basis of solutions to natural disaster preparedness. Addressing the threat of increased animal and crop failure posed by climate change will require better quantification of climate change effects, greater attention to prioritizing which forms of production systems are more vulnerable, and redoubling farmers efforts in the management of land and water resources, especially in drought stricken areas (Kandji et al., 2006).

There has been a sharp decline in crop production levels and crop diversity in Swaziland, which is affecting the country's economy as it is highly dependent on agriculture (Shongwe et al., 2013). The loss in crop yield in the country was noticeably higher in the lowveld as compared to the other ecological zones. The yield reduction was due to some arable land left uncultivated due to delayed rainfall and the high risk of making loss from agriculture. About 40% of arable land in the lowveld has not been cultivated for over 10 years and rural communities were solely dependent on social interventions for food aids (Manyatsi et al., 2010).

The objective of the study was to determine the climate change impacts, and adaptation strategies in Swaziland, using Malindza, a rural community as a case study.

2. Methodology

2.1. Description of Study Area

The study was conducted at Malindza area, under the Lubombo administrative region of Swaziland (Figure 1). Annual rainfall has varied from 200 mm in 1990 and 2005 to a high of 800 mm in 2000. Since 2011, there has been a continuous decline in the annual rainfall in the area. Since the year 2000, average temperatures increased form 28^0C to a high of 31^0C in 2011 (Government of Swaziland, 2014). The area is also prone to drought and climate variability. Households rely on growing crops such as maize, sweet potatoes, beans, pumpkin, and jugo beans for livelihood. However, due to high temperatures and low summer rainfall, yield, in particular maize are poor in most years. Households in the area also rear livestock such as cattle, goat and poultry.

2.2. Data Collection

The study was conducted at Malindza chiefdom, which has four communities (Lawini, Malindza, Njobo and Sikhuphe). The total number of households in the four communities is 363 with a population of 2,548 inhabitants (Government of Swaziland, 2007a). The list of households was used as sampling frame, and they were allocated identification numbers. A sample size calculator (Creative Research Systems, 2014) was used to determine the representative households for data collection at 95% confidence level and 5% confidence interval. The representative number of households was found to be 160. The households to be sampled were randomly selected. The number of households that were randomly selected from each community is shown in Table 1.

Table 1. *Number of households that were selected for interviews from each community.*

Community	Number of households selected
Lawini	34
Malindza	50
Njobo	57
Sikhuphe	19
Total	160

A questionnaire that was developed by FANRPAN (2013) was modified for use to collect both qualitative and quantitative data. The questionnaire solicited information on household profile, agricultural productivity, understanding of climate change, climate change adaptation and coping strategies. Prior to administering the questionnaire, it was pretested by administering it to 20 households within an adjacent community for face and content validity. The questionnaire was further modified based on the feedback from the pre-test. The questionnaire was administered through interviews in each of the selected households, and the respondent was the head of each household, or any adult person who was available at the time of conducting the interviews.

2.3. Data Analysis

The collected data were coded and entered into a Statistical Package for the Social Sciences (SPSS) computer software for analysis (SPSS, 2008). Descriptive statistics that were used to analyse the data included percentages and frequencies. The primary data collected from the sampled households was used to establish respondents' perception on the impacts of climate variability and change in the area. Moreover, the data was used to determine different adaptation and coping strategies employed by households in the area. The results were presented in the forms of tables and graphs.

3. Results and Discussions

3.1. Profile of Households

The age of household heads ranged from 17 to 80 years, with 54 years being the mean for the 160 households in the study area. The results further shows that males were the most dominant heads of households as 63% were male headed while 37% were female headed (Table 2). This indicates that in the households, the final decision makers were predominant males and this has an implication on decision making regarding the adoption of climate variation and change adaptation and coping strategies. Some studies reported that female headed households were more likely to take up climate change adaptation measures as opposed to males (Shongwe et al., 2013).

Table 2. *Gender of household heads (N=160).*

Community	Household gender		Total
	Male	Female	
Lawini	21	13	34
Malindza	31	19	50
Njobo	35	22	57
Sikhuphe	14	5	19
Total N	101	59	160
Total %	63	37	100

The majority (53.8%) of household heads were married with another 31.3% being divorced (Table 3). Married households possess better chances of adapting to climate variability and change as they share ideas and workloads than single, widowed and divorced households (FAO, 2007). Thirteen percent of the household heads were single and 3% of these households were child headed. Many African countries were greatly affected by the HIV/AIDS pandemic and it caused serious damage to the agriculture sector, especially in areas highly dependent on labour for production (UNAIDS, 2002). In Swaziland for example, about 25% of the population was infected with the HIV/AIDS virus (WFP, 2005).

Table 3. *Marital status of household heads (N=160).*

Community	Marital Status of household head				Total
	Married	Single	Widow	Divorced	
Lawini	23	1	9	1	34
Malindza	19	10	18	3	50
Njobo	33	5	19	0	57
Sikhuphe	11	4	4	0	19
Total N	86	20	50	4	160
Total %	53.8	12.5	31.3	2.5	100

The level of education of households has an impact on the adoption of adaptation and coping strategies, as households with educated household heads were likely to adopt climate change adaptation strategies (Deressa et al., 2011). Farmers' education, access to extension and credits, climate information, social capital and agro-ecological settings have great influence in farmers' choice of adaptation methods to climate variability and change (Manyatsi et al., 2010). About 34% of the household heads had not attended any formal education. Sixteen percent of the of household heads attended primary school but could not complete primary education, while 13% completed their primary education, but could not go any further than that. Twenty percent attended secondary school without completion while only 2% completed secondary school. Only 11% of the population completed high school education, 3% obtained college certificates, while only 1% had attended and completed university education (Figure 2). The fact that the majority of household heads (63%) had not gone beyond primary school (Grade 7) was likely to compromise the understanding of climate change issue, and the adoption of climate change adaptation strategies.

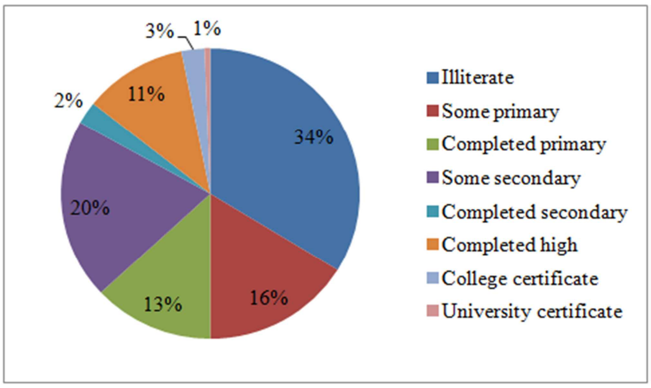

Figure 2. *Education level of household heads.*

The study area had a very high unemployment rate of 54%. Some adaptation and coping strategies are dependent on the availability of capital to buy farming inputs and implements (UNFCCC, 2007). Seven percent of the respondents relied on subsistence agriculture and could sell excess produce once in a while to buy farming inputs. Child headed households were more vulnerable to the effects of climate change and other shocks (Government of Swaziland, 2007b). Poverty is a key driver of vulnerability to climate change as it directly affects food security and increases community's reliance on natural resources. Child headed and female headed households have less access to credit and are less able to respond to financial constrains in cases of loss of crop due to drought and other hydrological disasters (Young, 2008).

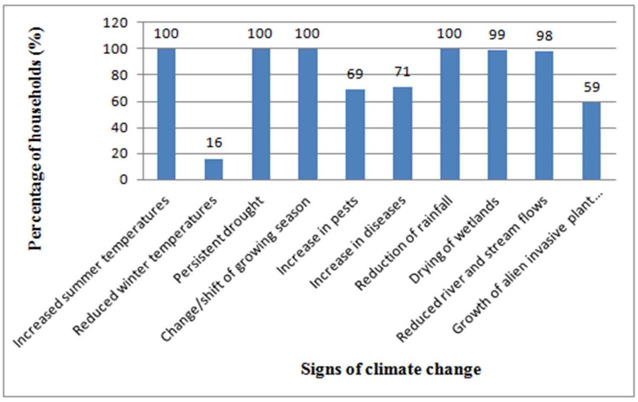

Figure 3. *Perceived signs of climate change.*

3.2. Knowledge and Understanding of Climate Change

More or less all the households' heads (99%) had heard about climate variability and change but the information was inadequate and of short term remedy as they only receive climatic information in the form of daily weather forecast. Sources of information included radio (92.5% of respondents), television (5.6% of respondents) and extension officers (2% of respondents). Another challenge for the communities was that weather prediction information was provided for major towns and was not relevant to rural areas. Weather forecast should provide medium to long term information to increase the warning times for climatic hazards and minimise climatic risks (Manyatsi, 2010). Proper delivery of information on climate change is important for communities to plan better adaptation and coping strategies. Moreover, the feeling of some respondents was that information relevant to improving agriculture production could be sent through the rapid increasing mobile telephone to reach the otherwise remote and unreachable areas. Encouraging farmers' field days among rural communities could also be effective for the rapid spread of new technologies (Manyatsi et al., 2010).

The perceived signs of climate change are shown in Figure 3. They included increased summer temperatures, persistent drought, shifting of growing season and drying of wetland. The results also concur with findings by other researchers who stated that there have been frequent drought occurrences in Swaziland since 1983. The most severe drought occurred in 1983, 1992, 2001, 2007 and 2008 (Manyatsi et al., 2010). The perceived climate change effects included crop failure, increased soil erosion, loss of livestock and increased risks of fires (Figure 4).

3.3. Crop Production and Productivity

Twenty four percent of the households cultivated the same area that they did some ten years ago. Another 25% cultivated just more than 50% of their arable land. About 28% did not grow any crop (Table 4).The reasons for reduction in area under crop production or not growing any crops included shortage of farming inputs, family disputes over land, perceived lack and unreliability of rainfall and persistent drought (Figure 5). The largest land under crop production for a household was 4 ha with the highest yield for maize for one household being 1,500 kg (30 bags). The majority of households did not get enough harvest for maize to last them the whole year, as only 9% of the households harvested enough maize to last them for the whole year. About 65% of the households reported that their land productivity was poor due to loss of soil fertility and soil erosion. They attributed that to shortage of farm (kraal) manure, which used to be applied in their fields. The lack of farm manure was attributed to the reduction in the number of livestock in the study area due to drought and shortage of drinking water.

Forty four percent of households used hybrid seeds for maize. The hybrid maize seeds were purchased from input dealers. The agricultural extension officers from the Ministry of Agriculture recommended the varieties to grow. The suppliers of hybrid maize varieties in the country include Pannar and Seed-Co (Government of Swaziland, 2013). Twenty one percent of households planted open pollinated variety and about 35% planted a combination of both open pollinated and hybrid seeds (Table 5). The open pollinated variety was either recycled from previous harvest or obtained from relatives and neighbours. The hybrid seed were more tolerant to drought, as compared to the open pollinated variety. They were however expensive to purchase and needed more inputs in terms of fertiliser. The Ministry of Agriculture has realised the potential of open pollinated maize varieties (OPVs). Three OPV maize varieties; namely ZM521, ZM309 and ZM611, have been developed in an effort to improve maize production in the country (Government of Swaziland, 2011). Households in the area further intercrop maize with pumpkins, and legumes such as beans, groundnuts, and bambara nuts (jugo beans). The wide variety of crops in the field minimises risk of loss due to poor rains, and it adds variety to household's diets. Including leguminous crops also improves soil fertility and improves crop yields with minimal application of inorganic fertilizers.

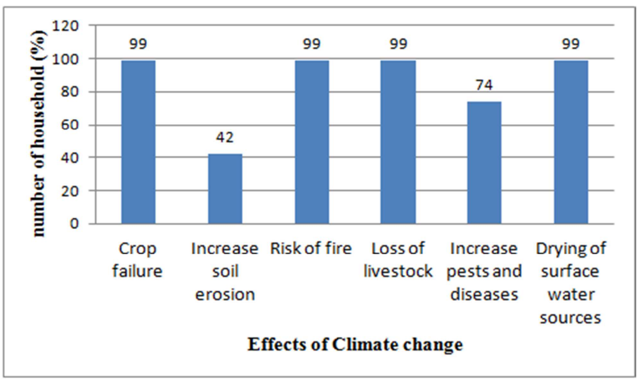

Figure 4. *Perceived effects of climate change.*

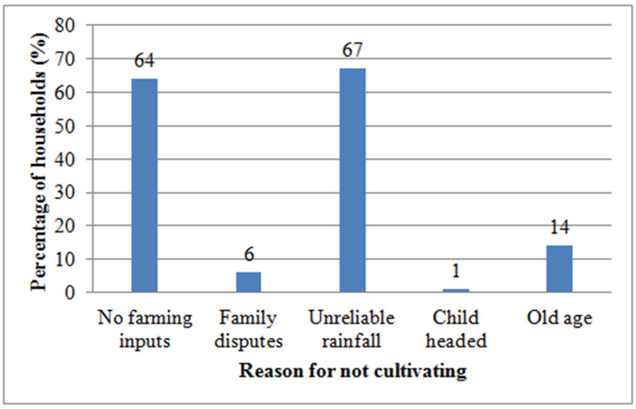

Figure 5. *Reasons for not cultivating some part of the land.*

Table 4. *Proportion of land being cultivated (N=160).*

Community	Cultivated land					Total
	Whole area	More than half	Half	Less than half	None	
Lawini	5	8	6	6	9	34
Malindza	11	15	9	3	12	50
Njobo	13	13	2	8	21	57
Sikhuphe	10	4	1	2	2	19
Total N	39	40	18	19	44	160
Total %	24.3	25.0	11.3	11.9	27.5	100

Table 5. *Variety of maize seeds grown.*

Community	Planted seed variety				Total
	No crop	Hybrid	Open pollinated	Both	
Lawini	8	11	3	12	34
Malindza	12	5	17	16	50
Njobo	21	24	3	9	57
Sikhuphe	3	11	1	4	19
Total	44	51	24	41	160
Total %	27	32	15	26	100

3.4. Climate Change Adaptation and Coping Strategies

Climate change adaptation practices include all the proactive measures or responses to the effects of climates change and variability that rural households use to reduce vulnerability (World Bank, 2003). Adoption of such measures is considered to be very important in poverty reduction especially in highly affected areas like the lowveld of Swaziland. The results indicate that about 50% of the households ploughed their fields along the contours which reduce the risks of soil erosion in cases of extreme rainfall (Table 6). The cultivation along the contours is in line with the Kings Order of 1953 (Manyatsi, 1998). Contour ploughing ensures that most water infiltrates the soil other than being lost as runoff (Manyatsi et al., 2010). Drought tolerant varieties also play a major role in improving crop yield but most farmers lacked sufficient capital to buy the seeds.

The results further showed that 29% of the households used organic fertilizer (mostly animal manure) and 20% practise crop rotation. The reduction in number of farmers using organic fertiliser is attributed by the fact that most farmers had lost their livestock due to drought and poor rainfall that affected pasture and rangelands. None of the household in the study area grew their crops using minimum tillage practices. Minimum tillage is one of the important adaptation practices which have yielded positive results to the effects of climate change in different parts of the world (Manyatsi and Mhazo, 2014). Benefits of minimum tillage include providing soil cover which helps reduce water evaporation, reduce soil temperatures and increases water infiltration (Ngigi, 2009). Other benefits include reducing soil erosion and weed infestation in the fields, increase soil fertility, improve soil structure and reduce pest and disease infestation. It is important that farmers at Malindza adopt this practice as it seemed to have increased yield and improved crop quality in different parts of the world.

Table 6. *Climate change adaptation practices by households.*

Climate change Adaptation practices by households	Number of households	Percentage of households
Stop grass burning	153	96
Contour ploughing	79	49
Organic fertilizers	46	29
Crop rotation	32	20
Rotational grazing	4	3
Agroforestry	2	1

Table 7. *Coping strategies adopted by households.*

Climate change coping strategies by households	Number of households	Percentage of households (%)
Sell or consume seeds meant for planting next season	149	93
Borrow food or money for food	135	84
Sell or consume livestock	106	66
Change to cheaper family diets	100	63
Have some days without eating at all	36	23
Work overtime or take another job	88	55
Use money intended for investing in small business	27	17
Children discontinue school	7	4
Sell some household possessions	3	2
Sell agriculture tools or implements	2	1
Access to micro finance loans	2	1

Only 1% of the households used agroforestry which also helps in reducing excessive evapo-transpiration thus increasing water use efficiency in plant. Some of the household with livestock used rotational grazing to ensure that their cattle survive the winter (dry) season.

As one of the coping mechanisms some 73% of the households had reduced the size or the number of their meal intake (Table 7). Moreover, 63% of the households in the area opted for food products that cost less in order to cope with shortage of food. About 55% of the respondents worked overtime or took double jobs in order to provide food for the family. Some households further mentioned that their children had been forced to leave school as there was no money to pay fees. The results also show that most households had sold and/or consumed more of either small or large livestock in order to provide food for their family. About 95% of the respondents failed to reserve maize for recycling as seeds for the following season. In another research that was done for an area that had similar climatic conditions to Malindza, it was found that the dominant coping strategies to effects of drought included receiving food rations and farm inputs from Non-Governmental Organisations, Benefiting from government feeding schemes at schools and benefiting from water that was delivered to households by the National Disaster Management Agency (Vilane et al., 2015).

4. Conclusion

The results demonstrated that climate change and climate variability was affecting the Malindza area. Only 9% of the households harvested enough maize to last for the whole season, and the rest had to rely on purchased maize or food aid (which had also declined). The majority of the household heads (54%) were not employed. Over 70% of the households did not plant all the available cropping area due to problems that included lack of farming inputs and unreliable rainfall.

The climate change adaptation strategies included contour ploughing, use of organic fertilizers and crop rotation. On the other hand, coping strategies included reducing the number of meals eaten per day, selling or consuming of small livestock and selling or consuming of maize that was reserved for seeds. One of the most significant impacts of climate change encountered by the rural households at Malindza area was loss of crop yield, especially maize. Farmers were failing to produce sufficient food that could sustain them throughout the season. Apart from the impacts of crop losses, climate change had caused severe losses in livestock, adding pressure to food security among households. Also of significant impact in livestock production was the drying of surface water sources like dams, streams and rivers. Farmers were faced with challenges of increasing pests and diseases which had become a major issue due to the increasing temperatures and reduced rainfall. The late onset of rain had affected households in the sense that it delayed the availability of wild fruits and animals which households could use as food sources. The lack of proper adaptation in the area is mostly attributed to the lack of knowledge of the adaptation practices while some households' regards adaptation practices as laborious and time consuming. Some adaptation practices that have been adopted included contour ploughing, reducing the size of land planted land, practising crop rotation and use of organic fertilisers.

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