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Assessing Climate Variability Adaptation and Coping Strategies Among Rural Households in Kenya.

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The aim of this study is to assess the adopted water scarcity adaptation and coping strategies of rural households to climate variability. It also identifies suitable strategies that minimize the impact of climate variability on water sources in arid and semi-arid (ASALs) in Kenya. The study was carried out in Makindu Sub-county, Makueni County, Kenya. Data collection techniques such as questionnaires and in-depth interview with 370 households, key informants interviews were used to assess the adaptation and coping strategies of rural households and identify the most suitable strategies for the study area. Rainfall data was collected from Makindu Meteorological station and used for meteorological drought characteristics analysis. Standardized Precipitation Index (SPI) was used to analyze drought severity in the study area between 1980 and 2011. SPI was used to quantify precipitation deficit for various time scales. Drought Intensity (DI) was used to determine decadal drought intensities. SPI results showed that 18 years out of 31 with negative SPI values an indication of drought severity occurrence. The year 2005 was the driest in the area with an SPI of -1.76. The study also showed increasing drought intensities from 1990s to 2000s. The study showed that the rural households had adopted varied adaptation and coping strategies to cope with impact of drought extremes on water sources. However, increase in drought characteristics occurrences minimized their resilience and adaptive capacities. The study observed that the strategies employed are unlikely to enable them cope with recent climate change and variability regimes, therefore need for most suitable and viable ones. The study identified viable strategies such as rainwater harvesting and sinking boreholes as long term measures that can enhance rural households' resilience to climate change extremes in ASALs of Kenya.

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Introduction

Climate change adaptation is no longer an auxiliary but long term reaction option only to be considered if all else fails. It is now prevalent for those communities disadvantaged by the impacts of present day climatic hazard [1]. People therefore, should adapt to precipitation variability and the spatio-temporal timeframes beyond that of specific precipitation events [2]. This is because water may be available but its use is constrained in terms of availability, quantity and quality [3]. For instance, Pastoralist dig shallow wells on dry water pans to access the water for their livestock and other basic uses. RUTTEN (2005) argues that Maasai pastoralist in Kajiado County, Kenya made use of dry river beds during dry spells by scooping sand in search of water. In order to adjust to water shortages, some changes are urgently required that will maintain and improve the potential of water supply systems to keep serving its function [4]. For instance, rain water harvesting constitutes a reliable source of drinking water and if properly managed, could reduce water and food crisis in several developing countries [5]. Adaptation is adjustment of social and environmental systems to changes and shocks [6]. For example, in Samburu county pastoralist dig shallow wells in the river beds where water accumulates during rainy season and is of help during drought spells [7]. Further, in Egypt rainwater harvesting is an alternative to more expensive desalination of blackish ground water [8]. Therefore due to stresses posed by drought and water scarcity there is need for households to adjust to the shocks for better livelihood. Studies by Sewell, Kates and Phillips (1968) show adaptation as a strategy that requires more time. It involve changes in lifestyles, livelihood systems and agricultural practices. All these changes requires water availability which remains a pressure on regions under threat of climate change (IPCC Technical "climate change and water", 2008). Kenya being a water scarce country therefore, should conserve water sources and start new ways of harvesting rain and underground water [9] .There is need for informative mechanisms that can address drought related water scarcity. Therefore, it is important to assess adaptation strategy of drought related water scarcity in Makindu Sub-County of Makueni County. WARMA (2015) argue that measures like building dams, pans and harvesting rainwater should be put in place to ensure water availability for all in ASALs.

The current trends indicates that water shortage challenges will continue to become increasingly complex. This will conflict all other sectors of developmental such as energy, agriculture, mining, education and environment transportation and communication [3]. Geographical distribution of water resources does not correspond to water demand. For example, in South Africa water resources are scarce and limited in extent (RSA, 2002). Practical solutions to water challenges depend not only on availability of water but also on factors such as water management process and capacities of the institutions [3-4]

According to (UNDP, 2006) approximately 1.2 billion people and almost one fifth of the world population occupy areas of physical water scarcity. Further, 500 million people are approaching the situation and another 1.6 billion people confront economic water scarcity where regions lack necessary infrastructures to draw water from rivers and aquifers. This calls for right political decisions and relevance of studies that are being conducted on the national, regional and local to address water problems [3].

1. Study area: Makindu Sub-County

The study was conducted in Makindu Sub-county of Makueni County in South Eastern part of Kenya. The region falls under ASALs of Kenya. The dominant economic activities are subsistence agriculture and agro-pastoralism. The livelihood systems are exposed to drought occurrences. The dominant ethnic community is the Akamba with few Maasai who practice pastoralism

2. Geographical Setting

Makindu Sub-County (Fig. 1) has an average elevation of about 1064 meters above sea level. It is located in south eastern Kenya with a size 2075.6 km$^{2.}$ It lies on latitude 2^0 10^1 and 2^0 South and longitude 37^0 40^1 and 37^0 55^1 East [10]. It is typically arid and semi-arid land (ASAL) and often experiences prolonged drought. According to 2009 census report, the population of the Sub-county stands at 42,042 with 9,907 households [11].

The area normally experiences a bimodal rainfall distribution patterns with long rains falling in March, April and May (MAM) and short rains experienced in October, November and December (OND) [10]. However, this has kept on changing since rainfall onset may start earlier than the said month or start later than the expected time. The area lies in lower side of Makueni County and receives annual rainfall ranging from 300mm-400mm (Makueni CIDP, 2013). Drought is a recurrent phenomenon in the climatic history of the region. Rainfall has been characterized by spatio-temporal distribution and variability which leads to water scarcity. Over the last couple of years extreme temperatures have been reported. For instance the area often experiences a minimum temperature of 240C to a maximum temperature of 35.80C [10].The predominant vegetation in this area is mainly a cover of shrubs and thicket, grass and herbaceous plants. The dominant wood tree species include baobab trees (Adansonia digitata), Umbrella thorn tree (Acacia tortilis), Terminalia brownie, Sanseveria, Acacia melliferra and Acacia etbaica [13].The soils in this area are well drained, shallow to deep, yellowish red to dark brown colored, friable high rich in calcisols, cambisols, luvisols dominated by calcium carbonate [12]

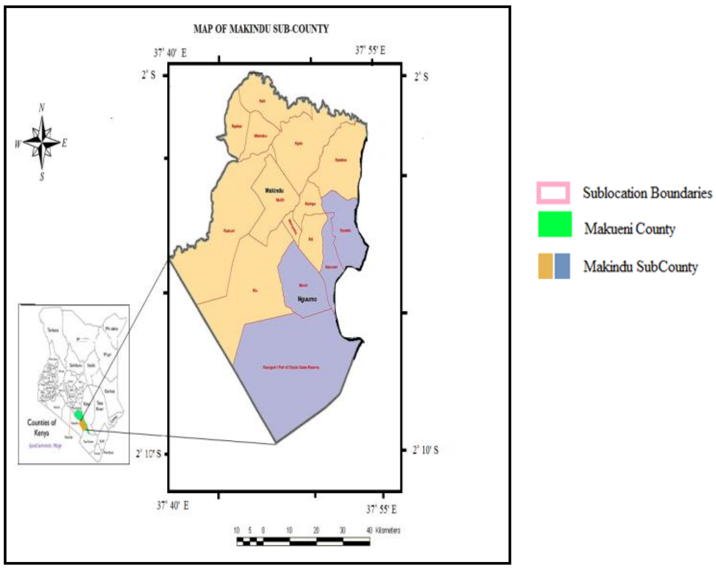

Fig. 1: Location of Study Area in Makueni County
Source**: www.Patrickmusimba.co.ke**

Methodology

1. Research Design

The study research design used was a mixed research approach. A combination of qualitative and quantitative research methods were adopted. Quantitative data was obtained from Makindu Meteorological Station and was used to analyze drought severity and drought intensity. Qualitative method was adopted to examine the perceived impact of drought on water resources and identify the households' adaptation and coping strategies to water scarcity. Interview schedules and questionnaires were used to gather data from rural households. The study also employed key informants interviews to supplement data got from rural households.

2. Rainfall Data

The data used in the study includes rainfall data for three decades (1981-2011) from Makindu Meteorological Station in Makueni County, Kenya. The data includes records and observations for 31 years which is conventional for climatic studies analysis [14]. The rainfall data was analyzed using Standardized Precipitation Index (SPI) to quantify and analyze drought severity. Drought Intensity was used to compute the three decadal drought intensities. The SPI has been used in previous studies in arid and semi-arid areas (ASALs) of Kenya for instance Turkana County [15] and Laikipia County [16]. Drought intensity was obtained by subtracting the annual rainfall totals for a given year from the mean annual rainfall for 31 years (1981-2011

Meteorological drought in the study area were classified as mild or near normal when SPI values ranged from 0 to -0.99, moderate when the range was between -1.00 to -1.49. Severe droughts occurred when the SPI values ranged between -1.50 to -1.99 and extreme droughts occurred when the SPI value was between -2.00 and below. The normal mean precipitation is when SPI was zero (0.00). Each drought episode was characterized by lead-time which is the number of months within drought event before SPI ≤ -1 is reached; duration, defined by time between its beginning to its end; magnitude was calculated by the sum of SPI for every month from the initiation to the end of each drought event and the intensity: ratio between magnitude and duration of the drought episode. The standardized precipitation index (SPI) was used to monitor moisture supply conditions and identified emerging drought months which were used and computed on various time scales (1981-2011.

Sampling and Data Analysis Procedures

The study used proportionate and purposive sampling to select sub-locations from Makindu Sub-County locations and Key informants respectively. The locations included Ngakaa, Twaandu, Kiboko and Makindu. In the sampled sub-locations, rural households were randomly interviewed using questionnaire. A total of 370 rural households were interviewed. Data from key informants which included Ministry of water and irrigation County officers, Kwa-vombo Spring managers, and Kibwezi Makindu, Water and Sanitation Company (KIMAWASCO) managers was also gathered. Semi-structured questionnaires were used to collect data. The instrument collected data on general household characteristics which included gender, age, family size, educational background, perceived impact of drought on water sources and adopted adaptation and coping strategies to water scarcity in the area. The collected data was coded and analyzed using SPSS (Version 20) (SPSS Statistics, 2011). The software was fundamental in analyzing general households' characteristics, Perceived impacts of drought on water sources and the employed adaptation and coping strategies of rural households in the study area.

Results and Discussion

This section examines and presents drought characterization; drought severity and drought intensity for the three decades from 1981-2011. The perceived impact of drought on water sources and adaptation and coping strategies are also discussed. Further, the paper examines the challenges faced by rural households as they address water scarcity

1. Drought Characterization

Drought is a recurrent phenomenon in arid and semi-arid areas (ASALs) of Kenya. However previous studies are showing that the areas are getting drier due to increased drought frequency [15-16]. The study in context used SPI to analyze and quantify drought severity in Makindu Sub-county. Analysis shows that mild/near normal, moderately dry and severe droughts were experiences in Makindu Sub-county in the year between 1981and 2011 in the study area. . Mild/ Near normal droughts occurred in the year 1985, 1986, 1991, 1993, 1995, 1996, 2000, 2002, 2004, 2007, 2008, 2010, 2011 and had drought severity ranging from -0.03 in the year 1986 and -0.87 in the year 2008. Moderate droughts were experienced in the year 1987, 2003, and 2009 with drought severity index of between -1.06 in 2009 and -1.43 in the year 1987. Severe droughts occurred in 1983 and 2005 with drought severity of -1.60 and -1.76 respectively (Tab. I).These widespread droughts in the study area had posed a major threat to water sources.). Drought severity was expressed as follows:

$SPI = (x - \bar{x}) / \delta$ ....Equation 1

Where;

X = Annual rainfall amount for a given year; $\bar{X}$ = Mean annual rainfall for the period of 31 years (1981 - 2011).

Tab. 1: Drought Severity in Makindu Sub-County between 1981and 2011

Drought years	Annual rainfall (mm) (x)	SPI (Drought standardized precipitation index)	Drought Quantification
1983	257.4	-1.60	Severe dry
1985	501.9	-0.40	Near Normal
1986	577.8	-0.03	Near normal
1987	293.4	-1.43	Moderately dry
1991	488.9	-0.46	Near Normal
1993	443.2	-0.69	Near Normal
1995	465.9	-0.58	Near Normal
1996	454.4	-0.63	Near Normal
2000	521	-0.31	Near Normal
2002	491.4	-0.45	Near Normal
2003	362.2	-1.09	Moderately dry
2004	501	-0.40	Near Normal
2005	225.8	-1.76	Severely dry
2007	467.8	-0.57	Near Normal
2008	405.6	-0.87	Near Normal
2009	368.7	-1.06	Moderately dry
2010	537.6	-0.22	Near Normal
2011	450.8	-0.65	Near Normal

Source: Authors compilation Makindu Meteorological Station data (2015)

Drought intensities in the study area varied from one decade to the other. For the period between 1983-1987 drought intensity was 30.10 percent below the mean, 20.58 percent below the mean for the period between 1991 and 1996 and 28.3 percent below the mean for period from 2000-2009.(Fig. 2,3 and 4) The results indicated that there were decreasing decadal drought intensities from 1980s to 1990s. Conversely, there was increasing decadal drought intensities from 1990s to 2000s.). Drought intensity was expressed in the following formulae;

$$DI = \frac{x - \bar{x}}{\bar{x}}$$ ....Equation 2

DI = Drought intensity

$\bar{X}$ = Mean annual rainfall for the study period (1981 - 2011)

X = annual rainfall for a given year

Decadal drought intensity = Average of drought years/Mean annual rainfall*100

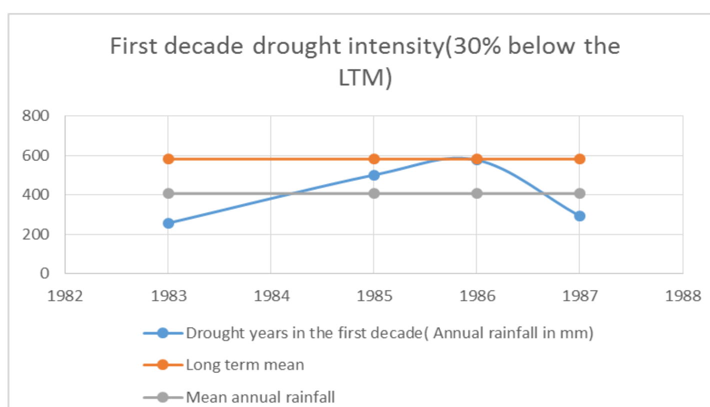

Fig. 2: First decade drought intensity

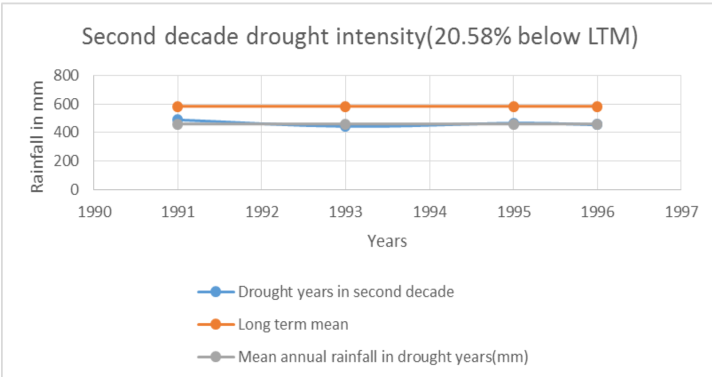

Fig. 3: second decade drought intensity

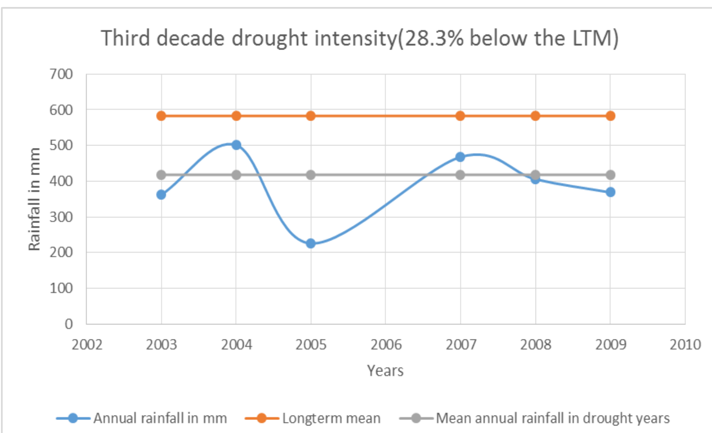

Fig. 4: third decade drought intensity

Source: Authors compilation Makindu Meteorological Station data (2015)

The unpredictable decadal drought intensities is likely to have been influenced by an active ENSO cycle which had five EL- Nino episodes (1982/1983, 1986/1987, 1991/1993, 1994/1995 and 1997/1998 and three La-Nina episodes of 1984/1985, 1988/1989, 1995/1996 [17].

2. Perceived Impact of Drought on Water Sources

ASALs in Kenya are characterized by high evapotranspiration and exceeding annual precipitation. [18]. Drought has had a lot of impact on water sources. Previous studies show that pastoralists in Mandera County [19] migrate in search of water due to dried water pans resulting from drought. OPIYO (2014) observed that 18 % of households in Turkana County perceived that drought led to drying up of water sources of the already water stressed County. In the study area drought was the major cause of the drying up of rivers and streams as perceived by 71.4 percent of the households. Drying up due to abstraction was mentioned by 11.6 percent of the household. While 17.0 percent of the households argued that both drought and water abstraction led to drying up of rivers and streams. (Fig. 5)

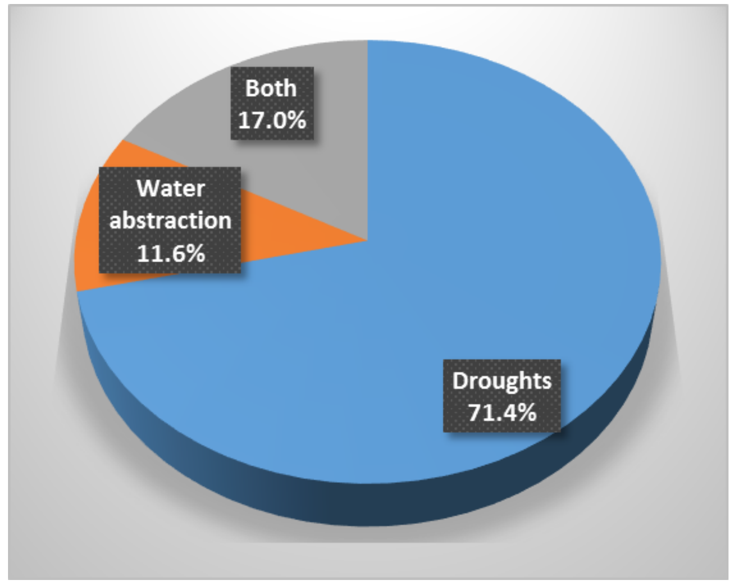

Fig. 5: perceived impact of drought on rivers and streams

Shallow wells were common in Rivers Makindu, Kiumbi, Muooni, Kikuu and Wayona. The study established that there were communal shallow wells which included Mathayoni, Kalakalya, Mumbuni and Soto that served residents of Kaunguni Sub Location. Analysis shows that 64.1 percent of the households perceived that drought led to reduced amount of water in shallow wells while 35.9 percent indicated that drought led drying up of water in shallow. For instance, the study established that prolonged droughts of 2002-2005 and 2007 -2011 led to drying up of all shallow wells, rivers and streams with exception of River Kiboko. This prompted community in partnership with NGOs to sink boreholes.

Earth dams and water pans were also affected by prolonged and severe droughts. Results showed that 42.2 percent of the households perceived that drought led to drying up of earth dams and water pans. 26.2 percent of the households perceived that drought led to reduction of water levels in earth dams and water pans. About 31.6 percent of the households perceived that levels of water in the earth dams and water pans went down because of siltation, leaching and high rate of evaporation and over use by households. This statement corroborates with [20] that due to failed short term rains and subsequent failing of long rains there has been reduced flow and drying up of water resources such as earth dams and water pans.

As established by the study, Earth dams in the area were used to ease overuse of boreholes by rural households and livestock in different sub locations. They included Sekeleni, Kwa-Mweu/Munyalo, Miangeni, Kwa-Kasina and Kwa-Luma. Households from Mitendeu and Ndovoini Sub-Location perceived that siltation and overuse by residents led to reduced water holding capacity of water in Sekeleni and Kwa-Luma earth dams. This statement agrees with [21] who observed that earth dams in Laikipia County were faced by the problems of siltation, high evaporation rates, seepage, ownership and community management. 85.7 percent of the households perceived that drought led to reduced flow of water in Kwavombo spring while 14.3 percent of households stated that encroachment of people who practiced irrigation farming around the spring contributed to reduction levels of water leading to rationing of amount of water supplied to households'.

3. Households Adaptation and Coping Strategies to Water Scarcity

Analysis shows that households' used various water scarcity adaptation and coping strategies. 33.5 percent using rain water harvesting techniques, 22.4 percent using boreholes, 14.6 percent using piped water, 8.6 percent used shallow wells, 8.9 percent trekking for long distances, 6.0 percent adopted water tankering while 6.0 percent used earth-dams, sand dams and pans as short term measures to address water scarcity. (Tab. 2).

Tab. 2: Adaptation Strategies to Water Scarcity

Adaptation strategies	**No. of rural households**	**Percentages (%)**
Boreholes	83	22.4
Rainwater harvesting	124	33.5
Piped water connections	54	14.6
Coping strategies	**No. of rural households**	**Percentages (%)**
Water tankering	22	6.0
Earth dams, Sand dams and pans	22	6.0
Shallow wells	32	8.6
Trekking for long distances,	33	8.9
Total	370	100

Source: Authors compilation from field data, 2015

From the study, rain water harvesting was the most preferred water scarcity adaptation strategy. This was because the households used storage structures such as storage tanks and techniques like roof catchment to harvest water which go to waste during rainy season in the months of March ,April and May(MAM) and October, November December(OND. These results are consistent with [21] who observed that most households' adapt to erratic water supply by buying water containers for storage purposes once the water is harvested.

Households with tanks of large storage capacity practiced roof water harvesting during rainy season. This provided water unto them during the dry spells. MINISTRY OF WATER AND IRRIGATION-MWI (2015) argue that rain water harvesting presents opportunities to address water scarcity in ASALs during periodic dry spells. Further, Studies by [22] shows that if water was affordably cheap, there would be resources for rural households to develop. This is because water scarcity denies households means to develop. In addition, [23] found that rainwater harvesting is very effective and inexpensive and can be effectively used in ASALs which are highly affected by water scarcity. Households stated that rainwater could take about 2-3 months once it was harvested. This ensured availability of water during dry months from June to July. Rainwater water harvesting and storage is vital in ensuring water availability especially during prolonged dry season and droughts. It has high degree of reliability especially to rural households who have invested in high capacity rainwater storage tanks [24-25]

The study established that water from the boreholes was available all times. This implies that boreholes are reliable sources of water in Makindu Sub-County during water scarcity regimes. This statement corroborates with US-GEOLOGICAL SURVEY (1993) assertion that in arid or dry regions people rely on ground water (Boreholes) to meet their needs. For instance, in Isiolo County, boreholes were the most reliable sources of water during dry spells [26].

Findings indicated that piped water was also a reliable because its source. Its source was Kwa-Vombo spring which was permanent. However, there was rationing because 2596 households in the locations used it. The rationing made taps to run dry four times a week in Kalii, Kai, Kaunguni Sub-Locations which were the farthest from Kwa-Vombo spring. Households from Kiu and Manyatta Sub Location stated that piped water was reliable to them because of their proximity to the spring. In case of damaged pipes, the study established that there were delays in repairing them. This was because of poverty and inability of rural households to pay bills. This finding corroborates with [23] who stated that households' inability to pay electricity bills and delays in fixing damaged pipes made piped water unreliable. This implies that existing piped water should be improved through increasing the community drawing points for instance water kiosks and subsidizing of water bills. This finding corroborates with [27] who stated that in Marsabit County people were able to access water from piped water supply from built kiosks.

The study also established that Germany Agro-Action (GAA) was involved greatly in disilting earth dams. The purpose was to maintain them and ensure maximum harvesting of surface run-off during rainy season. This suggests that well-constructed and maintained earth-dams can serve households and their livestock for long time during drought years. However, three of the earth dams which included Kwa-Kasina, Miangeni, Kwa Munyalo/Mweu earth-dams did not survive the period of prolonged drought. According to [23] most of the earth dams do not survive entire period of drought due to extremely high evaporation rate, leaching and sedimentation. In addition, earth dams did not sustainably keep water for long duration due to high rate of evaporation and siltation. This assertion concurs with [28] who stated that water from earth-dams have short life span due to high rates of evaporation and sedimentation. Further, according to [29] in the ASALS, evaporation of open water sources can have a decrease in water levels amounting to 0.9-1.4m within a period of about six month. Shallow wells and earth dams were at threat due to their openness and high rate of evaporation in the area as established by the study.

Water tankering was also adopted as a coping strategy. However, it was very expensive and was commonly used during prolonged droughts. Water was supplied by only one company (KIMAWASCO) and therefore accessibility and reliability was a challenge. This finding agrees with [30] who stated that water tankering is unreliable and unsustainable for longer term; it is not a common adopted strategy in Kenyan ASALs and is mostly used in extreme drought events. In addition a study by [30] shows that people in Isiolo County could not access water from water tankering because it is not practiced in large scale and the cost involved was huge.

4. Challenges to Adaptation and Coping Strategies

Analysis showed that 33 percent of the households indicated poverty as the major challenge in the area, 13.8 percent argued that inadequate power supply and 13.2 percent stated political wrangles and resistance from the community. Other challenges included water borne diseases, high cost of storage facilities and influx of people near Kwa-Vombo spring as stated by 10.8 percent, 9.percent and 6.5 percent of the households respectively (Fig. 6)

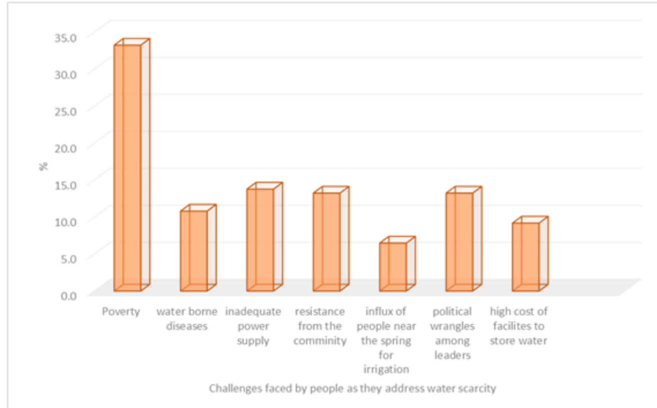

Fig. 6: Challenges to Adaptation and Coping Strategies

Previous studies shows that poverty is a major setback to adoption of water adaptation and coping strategies. For instance, [24] asserts that it is a hindrance to rainwater harvesting technologies in Makueni County. The study established that Poverty negatively affected water harvesting techniques' and boreholes because of high cost of storage tanks and high cost of sinking boreholes. Studies by [31] showed that households with higher income generation are suitably able to manage climate impact on water sources, water scarcity being one.

Households indicated that earth-dams and water pans were the highest affected in terms of water borne diseases. This was attributed to their openness, contamination from animal droppings and washing of clothes by households. This finding is in line with [23] who stated that earth- dams are unhygienic for home use because majority of them are open and livestock drink water directly from them. Inadequate power supply negatively affected Kwa-Vombo spring and boreholes. This was because boreholes using solar power were slow influencing the flow of water and delaying households for many hours while inadequate power supply in the spring led to water rationing.

The study established influx of people near the spring for irrigation highly affected the levels of water in Kwa-Vombo spring. This led to water rationing affecting the amount of water reaching the households. In addition, findings indicated that people were reluctant in conserving water and supporting projects initiated by N.G.O s because of political interference. They also indicated that politicians used water scarcity issue to gain political mileage. This led to poor support of the existing water projects. These findings concurs with[27]) who found that in Marsabit County water was rationed during dry season whereby each village got water one day at a time and this led to a week or two week cycle and each household was allowed a maximum of 6 jerricans.

Conclusions

Climatological statistical analysis showed more years with rainfall below the long-term mean of the 31years analysed leading to long-term drought episodes. The long-term droughts were more frequent in the 2000s decade than in 1990s and 1980s. Further, the area was characterised by alternating decadal drought intensities with 30.10 percent below the mean in 1980s and 28.3 percent in 2000s. The drought frequency increased since there were more drought years from 2000-2011 compared to 1990-1999 and 1981-1989. This information is essential for adaptation to water scarcity and extreme drought events in the future. Result also showed that amount of water in the resources available was decreasing due to drought of varied severities. This decrease in amount of water was in tandem with households' perceptions on the impact of drought on water resources Analysis also showed that rural households embraced rainwater harvesting techniques, sinking boreholes as adaptation strategies to water scarcity. However, they were faced by challenges of varied magnitude which included influx of people near permanent Kwavombo springs and poverty.

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