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VULNERABILITY OF COMMUNITIES TO CLIMATE CHANGE INDUCED DISASTER RISKS AND POTENTIAL MENTAL HEALTH OUTCOMES IN ISIOLO COUNTY, KENYA

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Abstract

Purpose: The study was conducted to identify and evaluate disaster risks and mental health outcomes caused by extreme climate events.

Methodology: Quantitative data was obtained from existing climate and mental health (1984-2019) records, while qualitative data was obtained from literature review of case studies and content analysis, Focus Group Discussion and household survey in four major zones for two consecutive years. ArcGIS software method explored various properties of the climate systems to infer the distribution of climate parameters, select extremes value and calculate linear trend of time series. The quantitative data was analyzed using statistical tools in Excel, IBM SPSS version 20 while climate data analysis was done using R software (version 3.21).

Results: The exceedance threshold of $\mu = 340\ mm$ was chosen. On the other hand, mean exceedance threshold of $\mu = 36.5^0C$ and $\mu = 11.38^0C$ for minimum and maximum temperatures respectively. The rainfall band was very high or very low, deemed to create disaster risks. The results revealed that the most common disaster risks include: drought and heatwaves, strong sand storms, flash floods and floods. The duration of time, frequency and unpredictable weather variability events were above critical threshold, hence categorized as high risk, rated 1, hence fatal.

Unique Contribution to Theory and Practice: The study provides historical empirical data on hazard mapping and mental health outcomes to enable policy and programmes formulation by state and nonstate actors. The study recommends development of robust environmental health procedures to diagnose mental disorders, mapping of disasters; mental disorder epidemiology and make it user friendly to advice policy, scale up solutions and accelerate evidence informed advocacy on adaptation and resilience mental health programme strategies

Key words: *Climate Change, Extreme Events, Hazards, Disaster Risks, Mental Health Outcomes*.

1.0 INTRODUCTION

Extreme climate hazards are becoming more and more alarming due to the scale of destruction and devastation which is on rise. Global demographic trends depict a gloomy picture of vulnerability to sudden-onset (floods) and slow-onset (drought) hazards and disasters (Banholzer *et al*., 2014). Scientists have predicted that the disasters occurrence rate, magnitude and ferocity are more grievous due to the consequences of climate change (Elizabeth et al., 2013).

Flood and drought disasters killed 700,000 people worldwide and economic devastation was approximated at US$ 1.3 trillion (UNISDR et al., 2018; UNISDR, 2012) from the year 2005 to 2015. The same duration also saw disasters affect over 1.5 billion people with women, children and people in vulnerable situations excessively impacted worldwide (UNISDR et al., 2018; UNISDR, 2012). The results of extreme climate disasters globally are documented and well-articulated.

The Climate Risk Index (Kreft et al., 2014) rates developing countries especially in Sub-Saharan Africa as more prone to disasters, largely due natural hazards related to climate change (UNISDR & CIMA, 2018) than developed countries. This increases physical and psychological challenges. The weather-related impacts have affected most countries particularly in Haiti, the Philippines and Pakistan (Jamal, 2016). The Asian Pacific region is most prone to extreme climate events (Jamal et al., 2016).

Extreme climate events may lead to despair, suicidal tendencies and, if prolonged, scatter hopes and expectation of recovery (Bourque and Cunsolo, 2014). Evidence shows that the exposure to hurricane Katrina stressors was sharply linked to commonness of mental disorders amidst the population (Galae et al., 2007). Climate change-related disasters may prompt mental disturbances which are caused by crisis situations (Clayton et al., 2014).

Physical and mental health of the individuals and communities are affected directly due to exposure of heat waves, drought and flood disasters. These present a situation where the immediate impacts tend to overwhelm the capabilities of the affected population (Francois et al., 2014). The disasters of high magnitude leave many people traumatized and deprived of everything including loss of dignity (Obradovich et al., 2018). The level of exposure to disaster related stressors: serious injuries, fear of death or death, family separation by prolonged displacement may lead to acute or chronic mental disorders (Freedy et al., 2007).

The horn of Africa's Arid and Semi-Arid (ASAL) lowlands of Djibouti, Ethiopia, Somalia and Kenya are acutely vulnerable to food security crises (World Bank, 2011). The impacts of extreme climate events are being felt equally in Kenya; an example is Isiolo County, which is located in eastern part of ASAL in Kenya that cover about 80% of the country's land area, experiences persistent drought and flood (Isiolo CIDP, 2013). High disaster impacts are rapidly growing particularly in middle-income countries posing a major risk (Imelda et al., 2014). The identification and assessment of the disaster's risks in relation to mental health have not been quantified not only in Isiolo County, but nationally in Kenya.

The research study addresses climate change extreme events related to disaster risks and mental health in a pastoralist context. This paper outlines climate change-related disasters caused by extreme events (floods and drought) in Isiolo County and the impacts on mental health. Thus, this study provides a preliminary framework in Table 1 below outlining the research design

Research design summary				
Source population	Climate data	Mental health data	Policies & Programs data	Exposure outcome
KMD, MOH, MEWNR, and relevant state departments and agencies, Civil Society Organization Opinion leaders and policy makers MH patient and affected grassroots communities	**Historical data:** Temperatures Rainfall Vulnerability	**Historical data:** Mental disorder: **Mood disorder;** (depression, mania, psychotic, suicidal ideations) **Anxiety disorders;** (GAD, Panic, phobia, OCD, PTSD) Substance Use Disorder (SUD), **Personality disorders:** conduct, ADD/ AHD & Psychopaths	**Historical data:** Actors The policies & programs interventions	**Model types:** Flood, drought Hazard and mental disorder maps Time series. Linkages of Policies and programmatic interventions Document actors

Figure 1: Theoretical Framework (©Peninah, 2017)

2.0 METHODS

2.1.1 Methods

Data on climate change hydro-meteorological disasters was obtained from case studies and content analysis. The current maximum and minimum monthly temperature and rainfall data was derived from Isiolo Meteorological Satellite Station records from the Kenya Meteorological Department (KMD), Ministry of Environment and Natural Resources (MENR) headquarters, Nairobi. The data obtained covered the period 1984-2013 and was used to analyze trends and extreme climate variability. The Generalized Pareto Distribution (GPD) was fitted on the maximum precipitation for various exceedance thresholds. Thereafter, a Mean Excess (ME) plot was generated to identify the possible threshold of the maximum precipitation with 95% confidence intervals, based on recommendations by Coles (2001).

The digital elevation model, the slope, flow accumulation and land cover maps were derived from the United States Geological Survey website (https://www.usgs.gov) for the year 2016 and ArcGIS software. This was utilized to derive hazard zones in the region. The detailed examination of magnitude of the risk, hazards and (or) disasters already documented from the secondary sources was collated to estimate how much the streams and adjacent areas could be prone to floods events and the vulnerability to ecosystems.

The purposively selected household respondents sample size of 288 with a 95% confidence level was surveyed using probability and non-probability sampling design. Probability sampling design deployed stratified sampling where entities were select from various distinct gender, social class and education.

The opinions and views were sought among different parties either in three (3) small groups of 3-5 above and (two) 2 large groups of 11 to 20 participants from 2015 to 2016. The two (2) large groups of FGD, workshops and shared agenda were held on August 19th 2015 and April 28th 2016 during dry and wet months, respectively, to be able to get varied responses on drought, floods and mental health.

2.2.2 Data Analysis

Qualitative data were analyzed through content analysis technique by clustering into themes drawn from the data collected. GIS methods were used to explore various properties of the climate system in Isiolo: infer the distribution of climate variables, select extremes value and calculate the linear trend of the time series. Flood hazard Index sensitivity (FHIS index), Palmer Drought Severity Index (PDSI) and Flooding, Geology Land Use, Elevation and Hydrology using the drainage network sensitivity analysis (FIGUSED-S) statistical methods were used to estimate flood and drought disaster risks. Flood hazard assessment was done by processing quantitative hydro meteorological and geospatial data from space borne sensors, a hydrologic modelling application.

The quantitative data were analyzed using statistical tools in Excel, SPSS version 20 while rainfall and temperature analysis was done using R software (version 3.21), ArcGIS and mental health data were ranked using criteria for Diagnostic and Statistical Manual of Mental Disorders plus International Classification of Diseases (ICD 11) diagnostic tools.

The interviews and discussions, notes that were taken during the sessions were later filled in against the guides to facilitate analysis. The hazards and disasters were ranked according to the impacts and the probability of a hazardous event placed on scale 0-1; where 0 indicates no fatality and 1 fatality. In addition, fatalities and socio-economic damages were gauged using IPCC risk assessment on the severity of uncertainties of climate change-related disasters. Collation and triangulation from both qualitative and quantitative datasets were employed to make a better interpretation of the objectives and questions of this mapping.

3.0 RESULTS

3.3.1 The Sample Population Characteristics

The respondents interviewed during the study were evenly distributed in the following Primary sampling wards Bullapesa, Burat, Cherab, Garbatulla, Ngaremara, Wabera, Sericho and Oldonyiro of Isiolo County. The age range of the respondents was from 16 to 70 years with the highest percentage being (29.2%) between 31-40 years followed by 28.8% who were 21-30 years while 21.5% were aged 41-50 years. Most of the respondents studied revealed that they had primary education (35.3%), followed by those who had no education at all (32. 8%). Only 3.8% of the respondents had a university education.

The study established that the main economic activities carried out in Isiolo County is agropastoralist and pastoralist as indicated by 58.4% respondents. It was found that the majority of the interviewees were pastoralist (30.2%), followed by agro-pastoralists (27.7%), then house wives. Among the 288 respondents interviewed in Isiolo County, 80% reside in rural areas and 19.4% reside in urban areas). The study findings show that in Isiolo County, 35.8% of residents live in clustered settlements, while 39.2% live in scattered settlements. Less than 24.3% of the respondents live in linear settlements. The results show that 16.3% of the respondents live in permanent homes, 60% live in semi-permanent homes while 23.6% live in temporary homes.

3.3.2 Climate Change Scenarios

The three decades' records of rainfall and temperature from 1984 to 2013 for all stations in Isiolo County were used to track variability and trends of extreme events related to climate change. The nature, occurrence and strength of the disaster events determines susceptibility to physical and human environment. The disaster risks were assessed in reference to floods, flash floods, extreme heat and drought occurrence depicted in Table 1 below.

Table 1: Flood and Drought Incidents in Kenya from 1992 to 2017, (UNISDR AF and CIMA, 2018)

Event	Types of drought/floods	Years	Area of coverage
Floods	Moderate	1982	Arid and semi-arid regions
	Severe	1985	Widespread
	El Niño –Most severe	1997/1998	Widespread
	Severe	2002	Widespread
	El Niño	2006	Widespread
	Severe	2008/2009	Widespread
	El Niño –very severe	2015/2016	Widespread
		2018	Widespread
Drought	Moderate Moderate	1983/1884 1991/1992	Arid and semi-arid regions ASAL regions
	Severe	1995/1996	Widespread
	Severe	1997	Widespread
	Severe	1999/2000	Widespread
	Severe	2004	Widespread
	Severe	2005	Widespread
	Severe	2008/2009	Widespread
V	Very Severe	2010/2011	Widespread
	Severe	2016/2017	Widespread

This is summarized in the divergent graph below to show down crossing and up crossing of the annual maximum and minimum rainfall extent of annual exceedances (1984-2013). The annual rainfall deviation from the mean analyses the extreme events projections of wet and dry years (Figure 1). This pattern of very high and deficit rainfall has negatively impacted food, water, health, social systems, peace and security of the County.

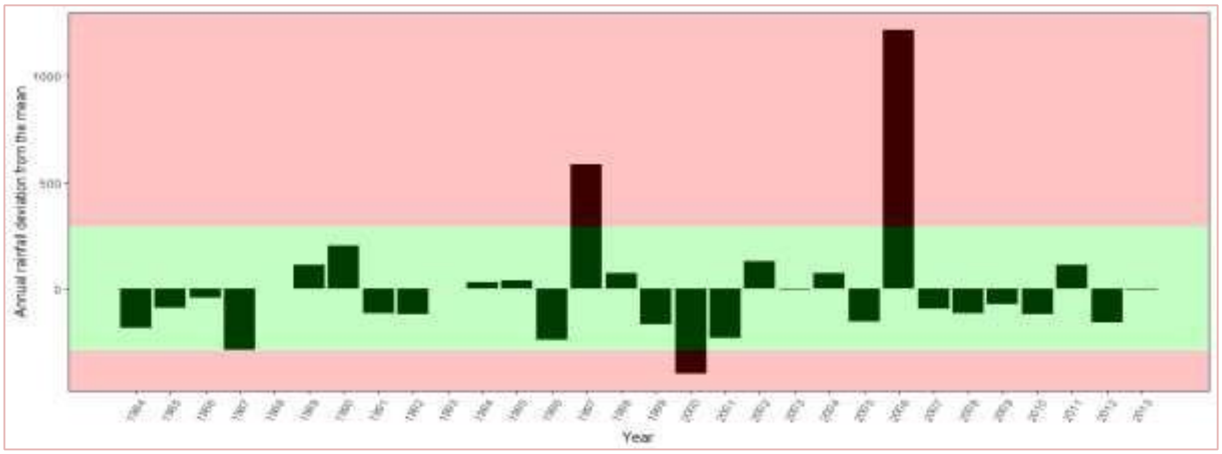

Figure 2: Standardized minimum and maximum annual rainfall Exceeded averaged for sixteen satellite stations in the study area (©Peninah, 2017)

3.3.2.1 Rainfall trend analysis

The trend of the mean annual precipitation from 1984-2013, was tested using a non-parametric Spearman test for trend. The highest mean annual rainfall is 2100.7 mm in the year 2006 and the lowest is 186 mm in the year 2000 for all selected sites in Isiolo County. The wet years were 1990, 1994, 1996, 2002, 2006 and 2011 with the wettest years being 1997 and 2006. The driest year was 2000, while other dry years occurred in 1987, 1991, 1996, 2000, 2005 and 2007. The graphs below have utilized threshold method to determine whether an observation is extreme i.e., all observations have greater than some high value (threshold).

The time series plot shows the wet, very wet, dry and very dry years shown by dashed lines. Also, the highest and the lowest amount of rainfall are shown in Figure 2.

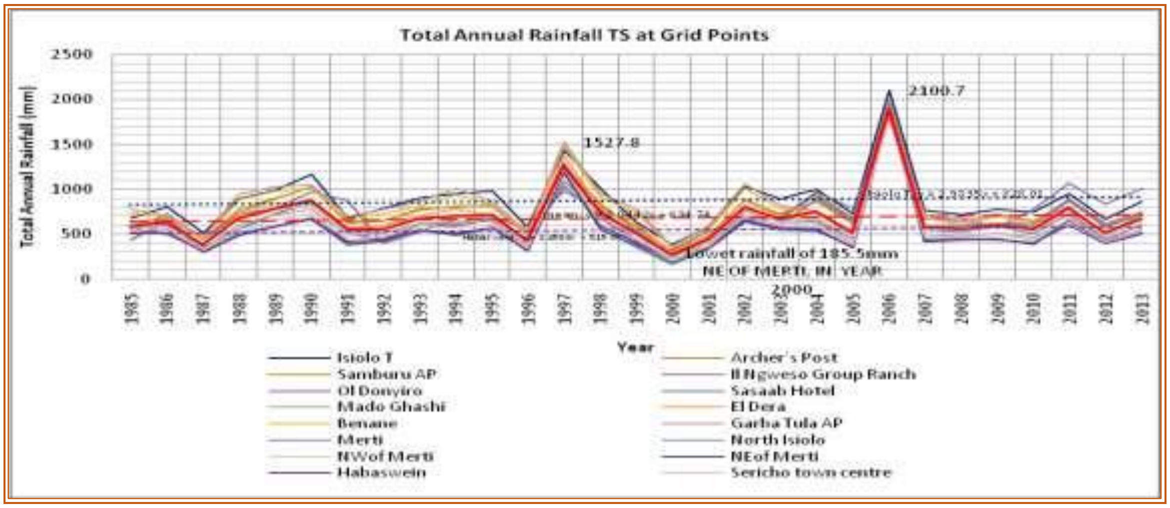

Figure 3: *Total annual rainfall (mm) trends for the sixteen satellite locations in the study area from 1984 to* **2013 (©Peninah, 2017)**

The distributions of threshold excesses have been graphically presented in Figure 3 PeaksOver-Threshold (POT) of the exceedance threshold of $\mu = 340\ mm$ was chosen.

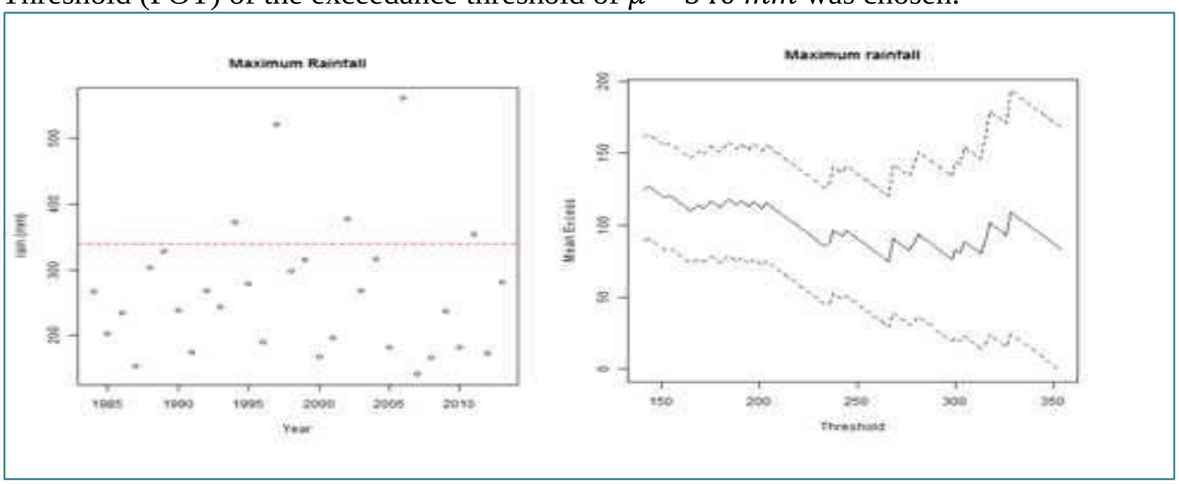

Figure 4: Mean Excess (ME) plot and General Pareto Distribution (GPD) showing Peak-Over-Threshold (POT) for extreme rainfall data (©Peninah, 2017)

The mean Excess of 340 mm is lower than the Semi-arid region which is usually above 500 mm per annum. This depicts climate change in variability and extreme events records. The threshold Mean Excess (ME) plot and General Pareto Distribution (GPD) were used to show the points above, the overall significant increases (Davison et al., 1990). According to rainfall data analysis, ME plot was heavy-tailed and shown extreme-valued data exceedances over a sufficiently high threshold. Using the GPD distribution of peaks-over-threshold (POT)

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method analysis of extreme values (Ghosh et al., 2013) approximation of the tail of distribution was derived.

31.3.2.2 Temperature trend analysis

The findings show that the temperatures are high throughout the year, with the highest mean annual temperatures experienced during the driest spell in the year 2000. A threshold for temperatures extreme events analysis for annual maximum and minimum temperatures series result is represented in Figure 4. The variability of the temperatures for each year estimate extreme spread is very large - approximately 25°C. Hence, the mean exceedance threshold is $\mu = 36.5^0C$ and $\mu = 11.38^0C$ for minimum and maximum temperatures, respectively.

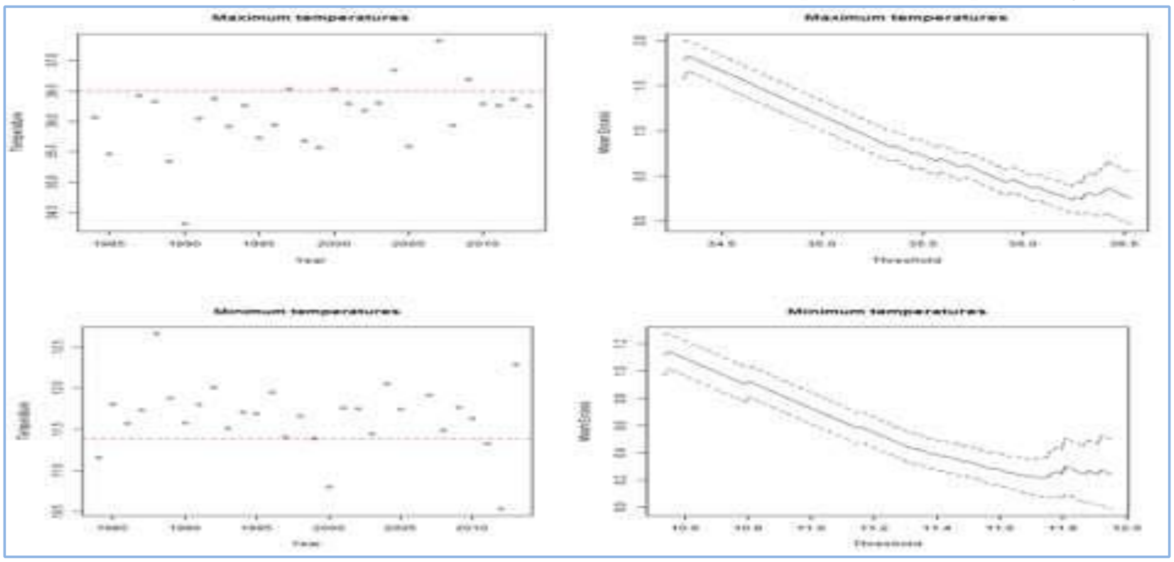

Figure 5: Mean Excess (ME) plot and General Pareto Distribution (GPD) showing Peak-Over-Threshold (POT) for extreme maximum and minimum temperature data. (©Peninah, 2017)

3.3.2.3 Community perception of changing climate

According to the study finding, the majority of respondents (63.9%) had lived in the area for over 30 years while 14% have lived in the area between 10 and 30 years. Those who had lived there for less than 10 years were 21%. The study showed that 58% of natives confirmed to have witnessed changes in the weather and climate patterns within the 30 years they have lived in Isiolo County.

3.3.3 Floods and Drought Disaster Risks Assessment

3.3.3.1 Flood and flash flood disaster risk assessment

From the study findings, Isiolo sub-catchment has been identified as one key flood-prone area. Flash and river floods are quite common along Merille River and Isiolo town. The river floods are gradual in occurrence and mostly predictable because they build up slowly till the river channel is full and

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overflowing, yet still, it is seasonal. The flash floods occur without warning as a result of accelerated surface run off due to short heavy rainfall. The county chronological information on natural events is limited and the impacts of disaster risks are scanty. The maps shown in Figure 1.4 represent the slope (DEM) which is a major factor in flooding.

The slope determines the direction and the amount of surface runoff and the infiltration rate. The steep slopes are more susceptible to surface runoff, hence slow to flooding. The undulating slopes are susceptible to waterlogging where water usually accumulates in depressions depending on soil type and land cover. The even slopes are highly susceptible to floods in Isiolo and occupy large geographical areas. The excess water from river Merille always gathers in areas where the slope has a low gradient. Low elevation and gentle slopes are a combination of factors that have been used to predict floods and subsequently used in emergency preparedness and management. Isiolo County has a saucepan type of topography which leads to accumulation of water in low areas.

The DEM and slope raster are represented in Figure 5. Although most of Ewaso Nyiro North Catchment area is defined as arid sub-counties, severe flood damages have been reported in the various parts of the catchment area. Drainage density is a vital factor controlling the flood hazard. Where the density is high the rate of soil erosion is high and the alluvial deposits occur at downstream zones.

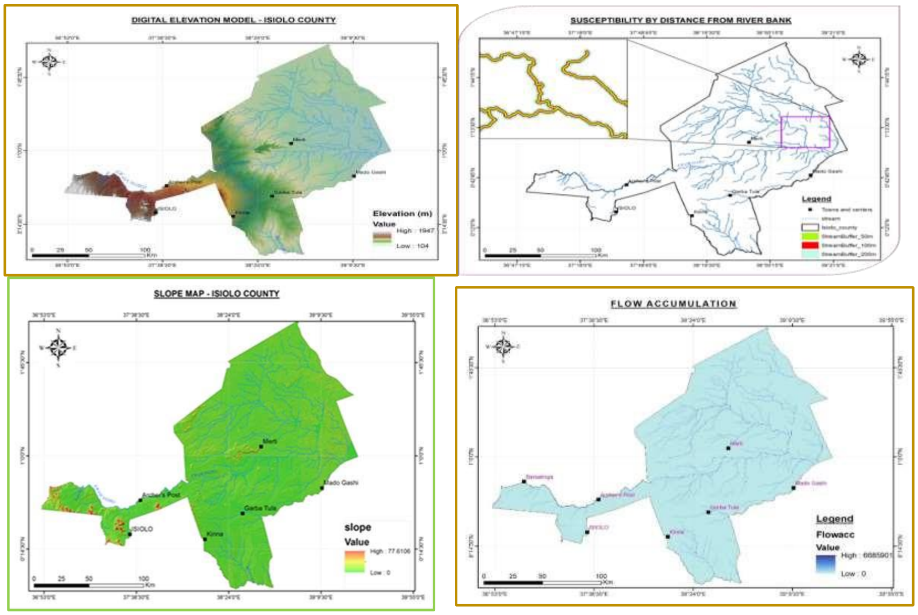

Figure: Digital elevation, slope, susceptibility by distance from River bank and flow (©Peninah 201

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The flow accumulation map shows that the flood water depth increases immensely due to sporadic intense rainfall with medium to very high flood hazard. Besides flash floods of river Merille are also very common. The land cover and geology of the area provide information on how past hazardous events exposes the human and physical environment to disaster risks (Figure 5). The study established that the degree of damage to elements at risk depends on the speed of flood water mostly in the areas affected by riverbank erosion. The uncertainties of flood exposure and vulnerability are mainly confined to the Isiolo Township and the riverbanks which is attributed to heavy erratic rainfall (Figure 6).

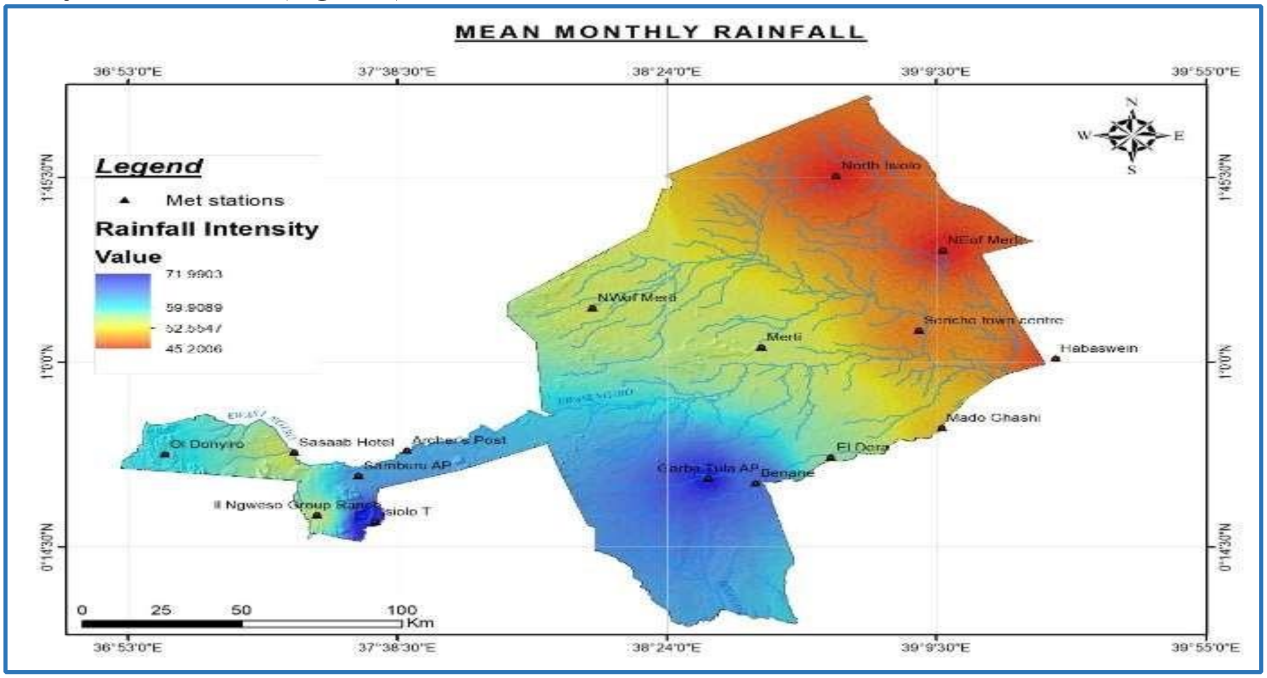

Figure 7: Mean monthly rainfall (mm) in Isiolo County for the 1884-2013 period (©Peninah, 2017)

1.3.3.2 Heatwaves and drought disaster risk assessment

As reported by respondents' heatwaves and drought are and have been a major hazard in Isiolo County for many years. It was rated a recurrent phenomenon, with the latest occurrences happening in 2005, 2006, 2008, 2011 and 2017 as indicated in Table 1.1 due to the high level of environmental degradation activities, deforestation, soil erosion and charcoal burning among others. The problem associated with drought was reported by 165 (57.3%) respondents who observed that drought has been seasonal, 30.2% of the respondents noted that drought is experienced yearly, and the rest observed that the drought phenomenon was monthly or rare. These results are summarised in Table 2.

Table 1: Heatwaves and drought occurrences per ward based on household survey for the Jan 2014-Dec 2015 period

Ward	Monthly	Seasonal	Yearly	Rarely	Total
Bullapesa	6	8	8	1	23
Burat	2	18	9	1	30
Cherab	1	27	0	0	28
Garbatulla	3	16	34	3	56
Ngaremara	6	15	6	0	27
Oldonyiro	6	56	9	0	71
Wabera	4	25	21	1	51
Total	**28**	**165**	**87**	**6**	**286**

Most respondents stated that the heat waves and drought occurrence per ward varied temporally (seasonally and annually) and spatially. A stakeholder noted that drought which is precipitation deficiency over an extended period is prevalent and leads to failure of crops and livestock production. These events and uncertainty spread over all areas in the arid region. The drought was reported to be the most common natural hazard affecting severely two major study locations of Oldonyiro and Yamicha where it recurs after every 6 to 7 years. A major drought event in 2008/2009 was reported to have had a severe impact in Isiolo County. Analysis of the weather in 7 (seven) specific study points show that there were severe rainfall deficits for the years.

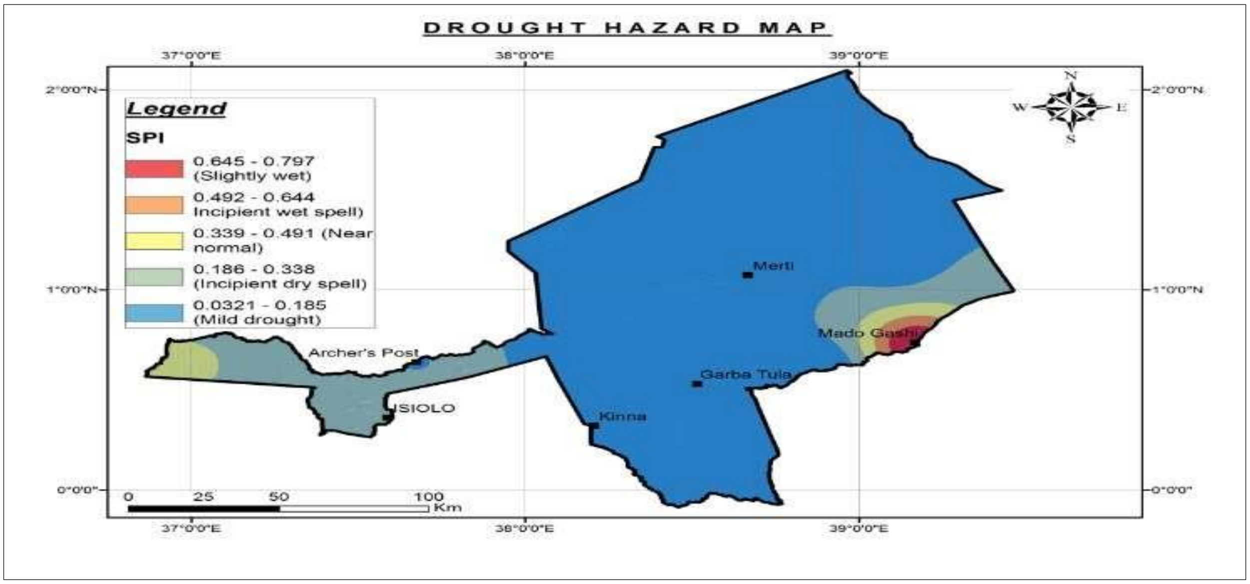

Figure 8: Drought Hazard map of Isiolo County (©Peninah, 2017)

This was established by the 123 (43.9%) respondents who agreed that floods occur seasonally and 86 (30.7%) of the respondents agreed that floods are witnessed yearly with Garbatulla ranking highest with 27 (31.4%) of respondents. Oldonyiro settlement recorded the highest number of respondents who asserted that floods occur rarely because it's located on the higher grounds near Mount Kenya.

The degree of damage to elements at risk depends on the speed of floodwater and the areas affected by riverbank erosion. The flood vulnerability and risks are mainly confined to the Isiolo Township and the riverbanks. The disaster-prone areas as per household data analysis categories are potential risk (45%), high risk (33%), low risk (16%), and no risk (4%).

3.3.3.3 Community perception on flood and drought disaster risks

The study found that greater proportions of the population in Isiolo County are being impacted by climate change-related disasters. The results show that 60% of the respondents asserted that floods disasters affected them while 33% mentioned that drought was a challenge to their livelihood and health. During the FGDs and household interviews, respondents considered the likelihood and associated impacts of disaster risks scenarios

The events outlined were analysed and uncertainties gauged on potential outcomes: which are large or severe as depicted by above descriptions. Knowledge-based probabilities (with the above interpretation) and judgments of the strength of knowledge supporting probabilities of occurrences were used to analyse the risks (IPCC, 2014; Aven, 2014). The precise probability confidence level is expressed by a probability interval of 60-90% which is closely linked to livelihood dimensions

3.3.4 Vulnerability of Isiolo Residents to Disaster risks

The characteristics of the vulnerability/risks to floods and drought disasters are presented in terms of settlement patterns and disease prevalence in this section. The disaster-prone areas as per household data analysis categories are potential risk (45%), high risk (33%), low risk (16%), and no risk (4%). The findings show that majority of settlements are temporary and semi-permanent. It was found that in Odha 100% of the settlements are temporary, in Merti North 33% are temporary and 77% semi-permanent, in Kiwanjani 85% are semi-permanent, in Ngaremara where 85% are semi-permanent and in Garbatulla where 63% are semi-permanent. The findings also revealed that 100% of Central Isiolo has permanent homes which are equally susceptible to floods.

3.3.5 Isiolo Residents Bio Psychological Functioning

The respondents reported that physical diseases such as respiratory, pneumonia, malaria, diarrhoea and typhoid fever have increased since 2006 and were now more prevalent during the study period (2014-2016). The results indicate that 105 (43.6%) respondents said the epidemics occur seasonally while 51(21.2%) said that they occur monthly. 28 (11.6%) respondents noted that the diseases occur yearly while 57(23.7%) respondents said the epidemics occur rarely.

The respondents cited that the strong winds were common at Merti, Cherab, and Duma Yamicha. Also, they noted that in Merti, the winds were stronger in 2016 leading to sand dunes and subsequent human respiratory diseases and kalaazar for animals. The psychological functioning of the residents who lived in Isiolo was investigated given climate change over time and adaptation rated from low to very high.

Table 3: HH survey of respondents ranking of the prevalence of mental health living in Isiolo County

Native of the area	No. of respondents	Percent	Cumulative Percent
Low	167	58.0	58.0
Moderate	72	25.0	83.0
High	15	5.2	88.2
Very high	19	6.6	94.8
None	5	1.7	96.5
Don't know	6	2.1	98.6
No answer	4	1.4	100.0
Total	**288**	**100.0**	

During floods waterborne diseases are common while during drought periods airborne illness is prevalent, FGD stakeholders asserted. The most frequent physical illness and mental disorders reported by psychiatric nurse's key informants during client profiling and summaries are shown in Table 1.4.

Table 4: Common physical and mental illness among the 121 clients sample population in Isiolo County

Physical	Mental
Respiratory infections especially Pneumonia	Mixed anxiety and depression
Diarrhoeal and typhoid fever	Panic disorders
Skin diseases	Manic depressive psychosis
UTI	Depressive episodes
Dental disorders	Drug-induced psychosis
Ear and eye infections	
Road traffic accidents	

4.4 DISCUSSION

4.4.1 Predisposition to Hazards and Human Vulnerability

4.4.1.1 Human fragility to disaster risks

The major erratic heavy rainfall, flash floods and floods occurrence are hard to foresee but residents of Isiolo County are tremendously affected for they are left homeless and destitute. This is an indication that floods and flash floods can impact these settlements adversely. Most of temporary and semi-temporary settlements are near the riparian areas of River Merille whose drainage basin is characterised by numerous gullies. These housing types are located either in plains and rugged terrain physical landscape, ranging from small rural to urban types of settlement, but are not climate-resilient.

Possible impacts were recorded to quantify the probability of loss and damage. Several factors analysed to evaluate vulnerability to extreme climate events. The effects or outcomes of disasters was one of the considerations. The vulnerability indicators analyzed were the age of the participants, the education level, occupation, types and patterns of settlements. The likelihood of several people left dead and injured and destruction from the disaster risks was rated 1.

The adverse climate events pose psychological susceptibility to the human and physical environment because the disaster risks involved were greater than those with which the systems coped and adapted. For instance, crops were not able to withstand some drought situation, and below 250mm certainly, all failed. The farming societies cope with different degrees of drought situations, but severe and repeated drought overwhelmed them due to famine. Flood events, on the other hand, are seasonal, but come with roaring ravages of the human and physical environment.

The results show the vulnerability of pastoral communities to disaster risks due to repeated exposures to drought and floods. It was found that human beings, livestock and assets suffer adverse effects when impacted by prolonged natural hazardous events. This implies that most of the residents in pastoral communities were in constant movement to search for water and pasture for their livestock. It was established that movement from one place is an adaptation strategy to withstand extreme climate events impacts.

4.4.1.2 Physical predisposition to hazards

The two years' risk assessment was conducted to identify hazards, exposure and susceptibility to floods and drought events damages, on the social-economic and physical environment. The findings show that the overall trend of the rainfall data is increasing per decade, with interludes of driest months observed during the whole period. The analysis depicts increases in the level of extreme precipitation in observational and modified generated data. The flood and drought hazard data retrieved from secondary sources indicated that they are frequent and widespread in Kenya.

The participatory community risk assessment ranking of the disaster risks, in terms of severity and duration, was high. The stakeholders who participated in the study noted that although floods are viewed as a low-risk hazard, their impacts are of high importance while drought is a high-risk hazard and the impacts are of high importance. The participants noted that Isiolo County is a high -risk area for drought and floods.

Retrospectively the data analysed from HH survey indicate that the probability of hazards reoccurrence is high. The floods were of high intensity, though the frequency was low. The combined secondary and primary historical data show the trends of wet and dry years. Also, the frequency was high but was of low intensity. Isiolo County is relatively low-lying and prone to flooding with an adverse effect on the quantity and quality of vegetation of the county. Thus, analysing extreme rainfall data in terms of river flood defence systems has been used to identify the high threshold for modelling extremes. The severity of floods is influenced by the conditions of the catchments, the infrastructure and the vulnerability of people. The disaster risk assessment systematically indicated that risks occurrence due to the potential hazard and the vulnerability of the pastoral communities in Isiolo County.

Human sensitivity to floods and drought was assessed in terms of the physical predisposition of communities and systems to potentially damaging extreme climate events and resilience to such events. The severity of the impact threats ranged from low risk, high security to high risk, low security. The acceptable tolerance levels of natural processes such as rainfall and temperatures are beneficial resources. The critical threshold beyond 'normal' band of tolerance, the weather elements become a hazard (upper and lower damage threshold). Very high or very low rainfall band is deemed to create floods and drought disasters.

The hazard magnitude is evaluated depending on losses (expected risk); the probability of occurrence of potential damage (hazard); serious disruption of normal societal functioning (disaster). Over the duration of time, frequent/intense but unpredictable weather variability and events around critical threshold may have much significance. The data analysed shows the prevalence of the extreme event in Isiolo County by use of the sensitivity to environmental hazards and society tolerance thresholds.

4.4.1.3 Progression of hazards to disaster risks

The flood, flash floods, heatwaves and drought events were a threat to Isiolo residents due to the observed harm to humans. Majority of the respondents had lived in Isiolo County for over 30 years (63.9%), hence experienced the changes in weather patterns. Several attested to staying in potentially risky, high risk and low-risk areas. The household survey respondents observed that their occupations are directly impacted by water-related hazards contributed to by changing climate and variability. They noted changes in precipitation patterns leading to either increased floods in some seasons or prolonged drought in others which precipitated adverse effects of the disaster risks.

Keith, (2013) asserts that the progression of risks, hazards to disasters gauge uses two parameters: fatalities and socio-economic damage. Floods and drought disaster risks cause adverse effects to the community's physical and human health either in small to catastrophic scale (Steffen et al., 2013). Most of the sample population in different wards experienced floods and drought hazards. This is clearly illustrated in Table 1 where Oldonyiro ward rates the highest in disaster risks prevalence.

The fatalities and socio-economic damage are used in this study for scaling hazard impacts into disasters. Most extreme climate events, such as severe floods and drought were monitored and recorded in Isiolo County from 1984-2013 and have a known probability of occurrence. The level of disaster risk was high from the climate-related extreme events; floods, flash floods, extreme heat and drought.

4.4.2 Floods and flash floods Disaster Risks

Floods experienced in Isiolo County are as a result of heavy rainfall or flash floods. Heavy rainfall causes flooding when watercourses cannot retain the water in the channel, hence overflows above the banks as runoff. The deluge is also caused by high rainfall on the upstream catchment areas around Mount Kenya and the Aberdare ranges. The main floods zones delineated in the workshop included Merti, Malkadaka, Garfasa, Isiolo Township, Modagashi, and Merille River. These areas have been reported as the most affected areas by floods in the county according to Water Resource Authority flood monitoring over the year (Water Resource Users Association) who prepared the map during the JICA project, 2014). The flood problem was mentioned several times by communities during FGD with WRA monitoring team. The floods alert in Isiolo County of 20142015 shows that the incidences increased in 2015 to 4.5m on the gauge which means the disaster level was high.

Coupled with the absence of vegetation cover (bare soil and open bush) in most of Isiolo County, implies that the area is prone to flooding, and subsequent degraded land. The slope stability is determined by type of rocks and land cover. The hills on either side of the undulating ground make the area susceptible to flood. The hilly catchments lead to flash flood downstream River Merille, hazard increases with decreased percolation, which causes an increase in overland and river floods as reported by an earlier study (Ouma et al., 2014).

Flash floods are mainly experienced Isiolo Central and Merti areas and also happen along the Ewaso Nyiro drainage though this is a blessing in disguise because they carry alluvial soils to the lower parts of Sericho. Colins, (2016) asserts that the absence of flow control structures in the basin has rendered the basin vulnerable to floods. The flash flood is a disaster risk which harms human environment especially temporary structures where there are channel paths of water passage or inundation. Natural and artificial vegetation is overwhelmed by the risk of inundation. Gully erosion is common exposing risks of landslides phenomenon threatening agriculture land, settlement and environment.

4.4.3 Drought Disaster Risks

The droughts have been recorded significantly in the County. The risk description covered the following dimensions: the assigned probability of the event, consequences which were marked to be high and measure of the strength of knowledge that the probability was based on. The outcomes and scenarios were analysed depending on strength of the knowledge gathered from interviewees focused group discussions and content analysis.

Drought and unpredictable rainfall were recorded as some of the key vulnerabilities related to extreme climate events. Merti and Sericho are the county's most ASAL areas impacted by severe famine. The temperature recorded is high throughout the year, but varies in higher altitude area in the county. The mean annual temperature in the county is 30°C. As a result, devastating drought and famine were declared a national disaster by H.E. President Uhuru Kenyatta on 11th February 2017. The County is one of the most affected in Kenya, where drought experienced usually vary from moderate to extreme intensity. The consecutive low rains experienced for three years sequentially resulted in high moisture deficits and degraded soils.

The local communities have little they can do to avert meteorological drought (Dai, 2011; Zhao et al., 2014; Nicholls et al., 2005). The drought events are escalated by drying up of surface and underground water mainly the shallow wells, boreholes, sub-surface dams and water pans due to the increased frequency of drought patterns in Isiolo County. Increased drought pattern has significantly contributed to the decline in the quality of life in the study area.

4.4.4 Disasters due to Climate Change Extreme Events in Isiolo County

The analyses outcomes were either 0 or 1 where 0 indicated no fatality and 1 fatality. The analyses are subjective to measure of unpredictability conditions of some background knowledge K (the Bayesian perspective). The tropical cyclones have increased disaster risks, which carries extreme impact on communities' socio-economic at large. Using qualitative confidence system IPCC expressed risk analysis using "five qualifiers: very low, low, medium, high and very high". These concepts are utilized to interpret climate change scenarios and disaster risk. There was a high level of uncertainty in socio-economic settings and fatality and qualified the extreme climate events as high to very high extremes. The IPCC guidance confidence level of usage of the five qualifiers was used by stakeholders to evaluate the disaster risks based on evidence and agreement among experts. The policymakers and other relevant stakeholders agreed in unison that disaster risk range from high to very high.

4.4.5 Extreme Climate Events and Disaster Risks

A permanent change in variability and mean weather conditions have a possibility triggering different types, frequency and severity of extreme weather events Climate change brings with it (O'Brien, 2006). Increasing temperatures of about 1ºC will occur by the 2020s, and 4ºC by 2100 globally. The warming will continue increasing tropical cyclones which are projected to alter Kenya's mean weather conditions, including the climate extreme events pattern, (AEA Group, 2008a). Kenya projections show that a general decrease in mean annual precipitation will occur during long rains of March to May causing drying out (Herrero et al., 2010). On the other hand, wetter conditions are likely during the short rains of October to December bringing inland heavy rainfall increased flooding. The alternate drying and wetting in the country will increase in intensity floods, drought and severe high temperatures. Kenya is significantly vulnerable to extreme climatic events which have posed a significant risk and most disaster-prone countries in the world. Floods and droughts during wet and dry extremes respectively are a major concern with major droughts occurring about every 10 years, and moderate droughts or floods every three to four years (AEA Group, 2008a).

The research has shown that Isiolo County is impacted by rainfall extremes and variability. The losses arising from alternate floods and drought over many decades are enormous, amounting to colossal sums of money. There is compelling evidence that climate-induced shocks have affected the pastoral communities, and droughts (sometimes severe) are the most frequent of climate

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incidents in most parts of the county. Other hydro-meteorological events are occasional heavy rainfall, floods and flash floods which pose significant risks to humans and the physical environment. These results are consistent with observed trends in the world (US Global Change Research Programme, 2014).

The pastoral households in Isiolo County are vulnerable in several ways as seen in the results chapters of this paper since the natural resources relied upon by the poor are severely impacted. The natural disasters consequences include crop failure, reduced yields, low food intake and decline in level of nutrition. The livestock livelihood also suffers from low milk and meat production, depressing the purchasing power of pastoralists and increasing vulnerability to food insecurity.

The hard-hit sectors of the economy are crop farming and livestock keeping among the pastoralist creating a ripple effect to other sectors. The scarcity of, or a lot of water and pasture increases inter-communal conflicts which in turn disrupt social structures and traditional coping mechanisms as a result of displacements. This is compounded by high poverty being experienced in the ASAL region which aggravates vulnerability and subsequently mental-related disorders. The identified climate-related disasters with significant impact on health, drawn from the records in Isiolo County, are summarized in Table 5.

Table 5: Disaster Impacts Matrix and its Implication

Disaster event	**Dryland environment**	**Impacts on community**	**Human Implications**
Drought / Extreme heat	Drying of vegetation, soil erosion accelerating environmental degradation, species extinction, strong winds characterized sand dunes	Affects agriculture, endangering food security, constant movement, human wildlife conflicts-all are life threatening	□ Somatic diseases: Kalaazar, respiratory diseases, malaria, malnutrition, growth stagnation, heat rash, fainting, trachoma, scabies. □ Mental diseases: stressful traumatic
Heavy Destruction of ecosystem, destroyed farmland, □ rainfall / gully erosion, submerged damage of homes and Floods / terrain by excess water in property, displacement Flash gentle undulating slope of people			Somatic diseases: diarrhoea, typhoid, bacteria dispersion, malnutrition. Mental diseases: GAD, depression,
floods areas □ experiences; grief, anxiety, adjustment, mood, dissociative disorders			paranoid feelings, social dysfunction, PSTD, ADA and other bipolar disorders

4.4.5 Climate Change Disaster Adaptation Model to help pastoralist communities' deal with mental health issues and gain resilience

Climate risks directly affects people's health, livability and workability; assets and services. The communities' vulnerability is deemed high due climate related damage for they lack the resources and adaptive capacity to withstand major events such as floods and drought. The goal of great leaders is to continuously better tomorrow than it is today. The Ministry of Interior and Coordination, with close collaboration with relevant ministries will come in handy to deliver vital mental health services to pastoralists communities in Isiolo County.

The local knowledge is necessary to define relevant hazards and disaster risks and feasibility of different actions. The county and national governments can increase resilience systematically by identifying high impact adaptation options: preparedness, incorporate awareness of physical climate risks and optimizing emergency response. Effective and efficient coordinated comprehensive disaster risks management include all cycles: Prevention, preparedness, response and recovery. Multi-sectoral collaboration on national climate health strategy or action plan to alleviate climate sensitive risks such as mental health is very crucial. These augers well with provisions of UNFCCC to reduce vulnerability and build resilience of the society. The framework below is suggested to enhance collaboration between ministries, departments and agencies of the government as depicted in Figure 8.

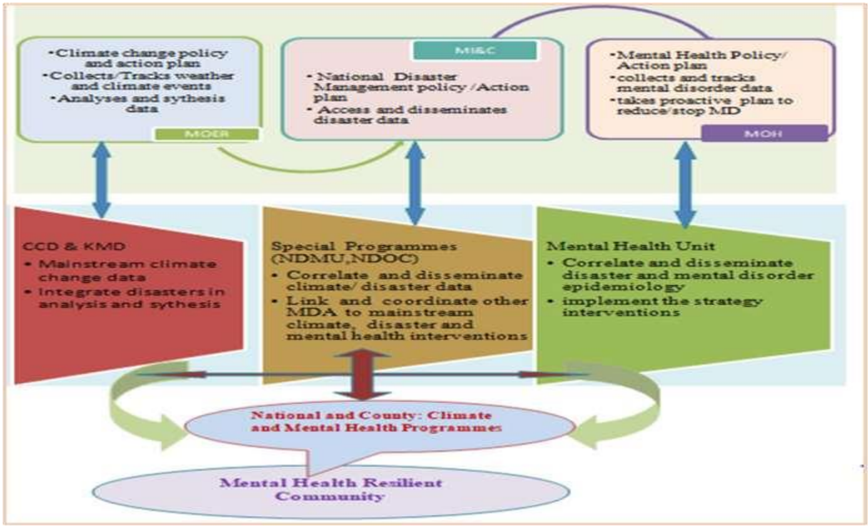

Figure 9: Climate Change Disaster Adaptation Model to help pastoralist communities' deal with mental health issues and gain resilience (©Peninah, 2020)

5.0 CONCLUSION

The tropics low-pressure belt makes air warm and moist, either weakening the cyclone bringing dryness or strengthening it bringing heavy rainfall. The harsh weather conditions render communities vulnerable to natural hazards. The recurrent extreme events have increased hydrometeorological hazards and resultant scenario of disaster risks. There are pronounced natural disasters such as heatwaves, drought, heavy rains, floods, and strong winds through analysis of risk scenarios in Isiolo County. Floods are sudden and drought is slow natural disasters risk prevalent in Isiolo County. Excess rainfall, floods, high temperatures and drought lead to adverse health impacts on the health of human and animal populations.

The disaster risks lead to harm and loss of livelihood due to unpreparedness at the local level. The capacities available such as livelihoods (crops, livestock, jobs, equipment, roads, bridges facilities (schools, hospital, houses- temporally) and people health and lives are ravaged by the disasters. The disruptions due to the displacement of people from homes, deaths, injuries, and destruction properties, homes, and infrastructures take a toll on lifestyles in general. The extreme events lead to deaths and untold suffering due to injuries incurred, loss of property and livelihoods. The emergencies of extreme climate events culminate to cholera epidemic or malnutrition may overwhelm the capacity of the communities due to unpreparedness and inadequate resources to offer ever needed support systems (Wisner at el., 2003). The ecosystems are also adversely affected leading to resource use conflict between different communities. Pollution of water sources is common in the study areas, which was blamed for causing waterborne diseases. More findings show weather changes trigger waterborne and non-communicable disease outbreaks.

The alternate flooding and drought severe events impact on mental health and increase psychological traumatic situations. The ecological sensitivity people are living in and pre-existing vulnerability profoundly impacts mental health wellbeing (Francois, 2014). Disasters risks predispose communities to extreme climate events which they are susceptible too. The sudden or gradual devastating conditions due to vagaries of weather and climate change increase the technical and financial needs of the communities. Climate change-related disaster risks challenges database is necessary to advise policy.

1.6 RECOMMENDATION

Based on the findings of this research the following actions are recommended to build resilience to the impacts of climate change related extreme events/disasters on mental health and improve on the related framework for delivery of mental health services:

i. Extreme climate hazard risk and vulnerability mapping in a GIS environment is necessary to provide users with comprehensive, site-specific assessments to advise policy actions that are user friendly at the community level.

ii. There is need to develop robust environmental health procedures to diagnose mental disorders during natural disasters and quantify prevalence epidemiology through Health

Information Systems. The study recommends mapping of mental disorder epidemiology and make it user friendly to advise policy on adaptation and resilience mental health interventions.

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