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INFLUENCE OF SEASONAL VARIATIONS BETWEEN FLOODING AND DROUGHT EPISODES ON THE INCIDENCES OF GASTROINTESTINAL INFECTIONS ALONG THE LOWER RIVER SIO WATERSHED, WESTERN KENYA

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Abstract

Global climate change and variability is expected to cause warming temperatures, sea-level rise, and a change in frequency of extremes of the hydrologic cycle (more floods and droughts). This study focuses on the implications of heavy precipitation on with an in-depth look at related health risks along river Sio watershed. Such heavy precipitation events often result in substantial societal impacts, including an increased risk of disease outbreaks. The general objective of this study was to evaluate the influence of seasonal variations between flooding and drought episodes on the incidences of gastrointestinal infections along the lower river sio watershed, western Kenya. Anthropogenic Global Warming Theories guided this study. The study adopted cross-sectional research design with a target population of 5959 persons. The study adopted a stratified random sampling technique and sample size of 357 determined using Krejcie & Morgan table (1970). The study used structured questionnaires and interview guides as the main tools of data collection. Quantitative data was analyzed using descriptive statistics and presented in tables, while qualitative data was analyzed according to the themes based on research questions and the objectives and thereafter, inferences and conclusions drawn. The study concluded that seasonal variations between flooding and drought episodes influence incidences of gastrointestinal infections along the lower river Sio Watershed. It was recommended that the policy makers, planners, local authorities and community should consider climate variability such as seasonal variations between flooding and drought episodes when working towards improving incidences of gastrointestinal infections along the lower river Sio Watershed.

Keywords: *Seasonal Variations, Flooding and Drought Episodes, Gastrointestinal Infections, River Sio Watershed*

INTRODUCTION

Today, climate change has become a worldwide concern as it affects the physical and biological systems across all continents due to recent shifts in weather patterns (Asante & Amuakwa-Mensah, 2014). The impact of climate change and variability on human health is significant and can occur through direct or indirect means (Costello et al., 2009; IPCC, 2014, 2007). The consequences of climate change on human well-being encompass various aspects, including the increased transmission of diseases carried by vectors like insects, ticks, and rodents, as well as food- and water-related illnesses. Additionally, climate change can lead to changes in the occurrence of diseases associated with air pollution and airborne allergens. It is possible for climate change to disturb or alter natural systems, thereby enabling diseases to spread or emerge in areas where they were previously limited or non-existent. Conversely, some diseases may decline due to climate change making certain areas less hospitable for disease-carrying vectors or pathogens (National Research Council, 2001). While immediate effects such as deaths caused by heatwaves and floods prompt immediate policy responses, the long-term effects primarily occur through modifications in natural ecosystems, affecting disease vectors, waterborne pathogens, and contaminants (National Research Council, 2001).

The connection between temperature variability and its impact on gastrointestinal (GI) infections has raised concerns, as reported by Xu et al., (2012). Climate change presents various challenges to human health, both directly and indirectly. These challenges include alterations in vector distribution, food availability, the occurrence of epidemics, and disasters. The direct effects of global temperature increase, whether observed as long-term trends or heatwaves, have significant implications for human health (Manser et al., 2013). Recent studies have highlighted the potential influence of changes in ambient temperature, considered a factor of climate change, on the transmission of infectious diarrhea (Checkley et al., 2000). Akil et al., (2014) argue that there is a strong positive relationship between the prevalence of salmonellosis and temperature rise. Similarly, Xu et al. (2012) identified a positive correlation between ambient temperature and pediatric GI infections. However, the impact of climate variables, particularly temperature, on different age groups in various geographical areas and climate zones lacks comprehensive documentation.

According to the IPCC (2001), African nations face the highest susceptibility to the consequences of climate change. These adverse effects are exacerbated by several factors, including widespread poverty, disease outbreaks, and a high population density. These factors are projected to increase the demand for food, water, and livestock forage in the next 30 years (Davidson et al., 2003). Droughts and floods predominantly characterize the climate in Africa. Based on observed and projected impacts of climate change, it is likely that Africa will experience more severe effects compared to other regions (Davidson et al., 2003). This is primarily due to the greater vulnerability of Africa's economy, including crop production, livestock farming, and tourism, to climate variability, geographical exposure, and low incomes (Collier et al., 2008; Yanda & Mubaya, 2011). Despite Africa bearing the heaviest burden of climate change impacts, it is actually the least responsible for global carbon emissions (Collier et al., 2008; Deressa and Hassan, 2009).

In order to achieve this goal, while most attempts to mitigate the impacts of climate change and variability in developed nations focus on reducing carbon emissions, developing countries, especially African nations, are primarily concerned with adapting to a changing climate. Consequently, developed countries have yet to experience the detrimental effects of global warming. However, in Africa, many of these adverse consequences are already being witnessed (Collier et al., 2008). Among the sectors that will face the greatest challenges, the healthcare system stands out due to its vulnerability to extreme weather events. In East Africa, these changes will have significant implications for water resources, food security, disease spread, natural resource productivity, sea-level rise, and desertification (Collier et al., 2008). According to Holmgren and Oberg (2006), the individuals most at risk during climate change are those residing in floodplains, coastal regions, mountains, and those lacking the means to adapt. This group includes the largest, most populous, and poorest country in East Africa.

The frequent and intensity of heavy rainfall are expected to increase, leading to floods. These floods will contribute to higher concentrations of pathogens in natural bodies of water, resulting in poorer quality of drinking and bathing water, crops, and shellfish. Additionally, heavy rainfall and floods can lead to the overflow of sewage treatment plants, the runoff of animal waste and manure, and the redistribution of contaminated sediments. The Government of Kenya (2002) has projected that climate change will cause rising temperatures and decreased precipitation in semi-arid areas by 2030, along with a doubling of CO_2 levels compared to baseline scenarios. This will negatively impact maize yields and livestock, leading to a shortage of forage and increased issues with marketing infrastructure unless appropriate measures are implemented to address the effects of climate change. Overall, Kenya is expected to experience increased rainfall. Despite the variable nature of climate and its potential adverse effects on development, only a small number of African countries effectively utilize climate information (IRI, 2005).

Waterborne and vector-borne illnesses, caused by a variety of bacteria, viruses, and protozoa, have been responsible for numerous disease outbreaks (Craun et al., 2006). In developing nations, such as those in Africa, millions of people are affected by these waterborne and vector-borne diseases (Fenwick, 2006). The World Health Organization (WHO) states that each year, approximately 3.4 million people, primarily children, succumb to diseases related to water (WHO, 2014). Furthermore, the United Nations Children's Fund (UNICEF) assessment reveals that contaminated water leads to the death of 4,000 children every day (UNICEF, 2014). According to WHO, more than 2.6 billion individuals lack access to clean water, resulting in approximately 2.2 million deaths annually, with 1.4 million of those being children. By improving water quality, the global burden of disease could be reduced by approximately 4% (WHO, 2010). In developing countries, conditions like cholera and diarrhea are the primary causes of illness (Nelson et al., 2009). Diarrhea caused by drinking contaminated water accounts for 2 to 2.5 million deaths each year (Fenwick, 2006). In lakes and reservoirs, the presence of elevated pathogens is often associated with storm events, and stream inflow is identified as the main source of pathogens during these events. Increased river flows likely disturb sediment, resulting in higher pathogen levels in the water (Jameison et al., 2005). El-Gilany and Hammad argue that persistent mobility caused by childhood diarrhea can have long-term consequences on growth and cognitive function due to the depletion of essential bodily fluids and vital nutrients, leading to dehydration, malnutrition, growth failure, and mortality.

Statement of the Problem

Diarrheal disease poses a significant global health challenge, responsible for the majority of childhood deaths worldwide. It is anticipated that climate change will have a particularly detrimental effect on this disease (Rosenthal, 2009). The global burden of diarrheal disease is expected to increase due to climate change, with limited knowledge about the specific climate drivers in Africa. Sub-Saharan Africa is especially vulnerable as it carries the highest burden of infectious diseases and is projected to be severely impacted by climate change (Murray et al., 2010). Recognizing the role of climate variability in influencing infectious diseases is crucial for climate change preparedness, particularly in Africa, where it is an urgent area of focus.

Previous research has identified various climatic factors associated with diarrheal disease, such as temperature, rainfall, relative humidity, and air pressure, which may vary across different regions. However, the lack of empirical data has led to significant uncertainty regarding the exact nature of these potential climatic impacts. This knowledge gap requires immediate attention

(Kolstad et al., 2011), especially in vulnerable regions with low adaptive capacity due to underlying issues like poor governance, poverty, and inadequate resource management.

Examining historical data presents an excellent opportunity to evaluate the interactions between climate and health. Unfortunately, long-term time series data is often unavailable, and confounding factors over a similar study period are rarely identified at the same spatial and temporal scale (McMichael, 2016). This is particularly true in Kenya, where long-term health data is frequently lost or inconsistently collected due to weak health infrastructure and inadequate recording and archiving practices.

To develop effective mitigation and adaptive strategies that safeguard the most vulnerable populations expected to withstand the worst of climate change impacts, it is crucial to understand the potential health consequences along the River Sio Watershed. These populations are likely to face the greatest challenges and have the least capacity to adapt.

Hypothesis of the Study

H_{01}: There is no significant association between seasonal variations between flooding and drought episodes and incidences of gastrointestinal infections along the lower river Sio Watershed, Western, Kenya

LITERATURE REVIEW

Theoretical Framework

According to the first theory of climate change, it is argued that the release of greenhouse gases into the atmosphere by human activities, primarily carbon dioxide (CO2), methane, and nitrous oxide, is leading to a severe increase in worldwide temperatures. This process is referred to as the enhanced greenhouse effect. The term used to describe this theory in short is "anthropogenic global warming" or AGW (IPCC, 2007). The sun's energy moves across space and arrives at Earth. The Earth's atmosphere mostly lets the sunlight pass through, allowing it to reach the surface. At the surface, some of the sunlight is absorbed while the rest is reflected back as heat into the atmosphere. In the atmosphere, specific gases known as "greenhouse gases" absorb the reflected or internal heat radiation, causing the atmosphere to become warmer than it would be without them.

Water vapor is the primary contributor to the greenhouse effect, accounting for approximately 36 to 90 percent of its impact. Following water vapor, other greenhouse gases such as carbon dioxide (CO2), methane, and ozone contribute smaller percentages, ranging from less than 1 to 26 percent, 4 to 9 percent, and 3 to 7 percent, respectively. It should be noted that these estimates vary significantly due to ongoing debates and uncertainties. Over the past century, human activities like burning wood, fossil fuels, and deforestation have been attributed to roughly a 50 percent increase in atmospheric CO2 concentrations. If the burning of fossil fuels and deforestation continue at the current rate, it is projected that the amount of CO2 in the atmosphere could double over the next century. This projection assumes that natural "sinks," which absorb CO2, do not keep up with the emissions. These findings were reported by the IPCC in 2007.

According to supporters of the theory of anthropogenic global warming (AGW), Earth's climate is influenced by various external factors, such as changes in solar radiation and the planet's orbit. However, they argue that these factors alone cannot explain the observed increase in Earth's temperature over the last thirty years. While the direct impact of fabricated greenhouse gases is relatively small, the AGW theory suggests that positive feedback mechanisms amplify their effects by two to four times. Even a slight temperature increase leads to increased evaporation, resulting in higher water vapor levels in the atmosphere, which in turn contributes to further warming. Additionally, global warming can cause a reduction in ice and snow cover, exposing more ground and open water surfaces that are less reflective than snow and ice. Consequently, these surfaces absorb more solar radiation, leading to additional warming. Furthermore, warming temperatures may trigger the release of methane from frozen peat bogs and CO2 from the oceans (IPCC, 2007).

Supporters of the theory of anthropogenic global warming (AGW) argue that the approximately 0.7°C increase in temperature over the past 150 years, as well as the roughly 0.5°C rise in the last three decades, can be primarily attributed to human-induced greenhouse gas emissions. They dispute or disregard assertions that suggest the entire temperature increase could be attributed to the Earth's natural recovery from the Little Ice Age (1400-1800). Instead, they rely on computer models that are built upon scientific principles, theories, and assumptions to forecast that a doubling of atmospheric CO2 levels would result in an additional 3.0°C (5.4°F) increase in global temperatures by the year 2100 (Al Gore, 2006).

According to supporters of the theory, when climate models are used in reverse, they tend to forecast greater warming compared to the actual warming that has taken place. However, this disparity, they argue, can be attributed to the cooling effects caused by aerosols and soot, which are produced by the burning of fossil fuels. Additionally, the models anticipate a higher degree of warming in the tropics' atmospheric layer known as the troposphere than what has been observed through satellite and radiosonde measurements. Nonetheless, those who believe in anthropogenic global warming challenge the data indicating this discrepancy (Al Gore, 2006).

Supporters of the theory of anthropogenic global warming (AGW) argue that human-generated carbon dioxide (CO2) is accountable for various calamities such as floods, droughts, extreme weather conditions, crop failures, species extinctions, the proliferation of diseases, coral bleaching in oceans, famines, and numerous other catastrophes. According to them, these disasters will increase in frequency and intensity as temperatures continue to rise. They contend that substantial and swift reductions in human emissions are necessary to protect the planet from these disastrous occurrences, as emphasized by Al Gore in 2006.

Empirical Review

In recent decades, there has been widespread acknowledgment that natural fluctuations occurring in specific areas of the Pacific Ocean have a substantial influence on global weather and climate patterns (Amarasekera et al., 2017; Eltahir, 2016; Zaroug et al., 2014). The most prominent of these fluctuations is known as the El Niño–Southern Oscillation (ENSO), which occurs approximately every 4 years but can range from 2 to 7 years in duration. Despite its geographical distance from Africa, ENSO exhibits a significant association with changes in rainfall across the eastern part of the African continent. However, the nature of these correlations and their alignment with the seasonal cycle vary across different regions (Camberlin et al., 2001).

Eltahir (1996) discovered that approximately 25% of the natural variations in the annual flow of the Nile could be attributed to ENSO (El Niño-Southern Oscillation). In light of this correlation, Eltahir proposed utilizing this observed relationship to enhance the predictability of Nile floods. Wang and Eltahir (1999) suggested an empirical approach for forecasting medium- and long-term Nile floods (around six months in advance) by incorporating ENSO information. Additionally, Amarasekera et al. (1997) demonstrated that ENSO episodes exhibit a negative correlation with the floods of the Blue Nile and Atbara rivers, which have their source in Ethiopia.

Putter et al., (1998) conducted a study on the Nile River's historical discharge using the Roda Nilometer in Cairo, Egypt, and found evidence of decadal periodicities. They proposed a potential link between high-frequency peaks in the discharge and ENSO. Abtew et al., (2009) analyzed monthly rainfall data from a network of 32 rain gauges in the upper Blue Nile Basin. Their findings indicated that La Niña year tend to experience high rainfall, while El Niño years tend to have low rainfall. Furthermore, they discovered that extremely dry years are more likely to occur during El Niño years, while extremely wet years are highly probable during La Niña years.

In their study, Seleshi and Zanke (2004) concluded that the rainfall in the Ethiopian Highlands during the period of June to September is linked to the Southern Oscillation Index (SOI) in a positive manner, while it has a negative correlation with the sea surface temperature (SST) in the equatorial eastern Pacific. Understanding the timing of El Niño and La Niña events is advantageous because previous research by Barnett et al. (1988) and Latif et al. (1998) has demonstrated their predictability up to 6-12 months in advance.

Recent studies on the impacts of climate change on rivers have mostly emphasized nutrient loads and sediment transport (Wilby, 2006; Chen *et al.,* 2007; Kaushal *et al.,* 2008; Tong *et al.,*2007; Hanet *al.,*2009; Tu, 2009; Hamilton, 2010; Desortová and Punčochář, 2011; Lee *et al.,* 2010; Wilson and Weng, (2011) in a recent study performed by Zhang *et al.,* (2012) simulated the impacts of climate change on the stream flow and non-point source pollutant loads in the Shitoukou reservoir catchment, China. The results indicated that the annual NH_4^+-N load into the Shitoukoumen reservoir would exhibit a significant downward trend with a decreasing rate of 40.6t per decade under the A2 scenario. Nõges *et al.,* (2011) reported that an increase in the winter precipitation in the Ticino river basin of southern Europe was likely to increase the nutrient loadings in the lakes and contribute to eutrophication.

Moreover, considering both point sources and agricultural diffuse sources, Martínková *et al.,* (2011) used SWIM (Soil & Water Integrated Model) to simulate changes in the nitrate load from the Jizera catchment (Czech Republic) under theA1Bscenario.Although the results varied in the different simulated periods, the nitrate loads of most periods were positively correlated with the water discharge and precipitation. Similarly, Arheimer *et al.,* (2005) simulated changes in the nutrient loads and algae growth in the Leonard River system in Southern Sweden using water quality and ecological models under the A2 and B2 scenarios and concluded that an increase in the temperature, would result in a50% increase in the total phosphorus, a 20% the total nitrogen, and 80% increase in cyanobacteria.

METHODOLOGY

A cross sectional design was used since it allows collection of data in more than one case at a single point in time and detection of patterns of association among variables (Bryman, 2004). The research covers Sio River Watershed which has an area of approximately 1450 sq.km and is located between latitudes N 00 23.005 North of Equator and longitudes E 34 08.745 East of Greenwich Meridian. The population being studied in this particular research includes individuals aged 18 years and above residing in villages within the chosen wards, County Government officials involved in the Natural Resources and Environment department, as well as local leaders such as Ward Administrators and Village Administrators. The study employed two sampling techniques, purposive and random sampling. A multi-stage random sampling method was employed to select the location, sub-location, and villages within the four sub-Counties of Busia County. Within each of these areas, random sampling was utilized to choose specific locations, sub-locations, villages, and households for the study. The sampling frame was constructed based on the administrative boundaries of Busia County. The formula previously used by fisher *et al.,* (1998) was adopted to determine the sample size of this study.

Sample size n = $\frac{Z^2pq}{e^2}$

Z- Standard normal deviate set at 2.17 (97% confidence interval)
q = (1-0.42) =0.58
P- Households with water pipes coverage in Busia County, 42% (DWINR, 2010)
e- Precision set at 0.03 to improve precision and accuracy

$\frac{2.17^2 \times 0.42 \times 0.58}{0.03^2}$

= 359

The study examined both primary and secondary information to achieve its objectives. Interviews were conducted with a group of thirty-six (36) important individuals to gather comprehensive information. Both closed and open-ended questionnaires was used to gather data from various community members engaged in different economic activities such as livestock keeping, beekeeping, crop cultivation, as well as those involved in resource management. The researcher used non-participatory observation to collect data about regions prone to floods, areas near the Sio River that frequently flood, and areas severely affected by drought. In this study, a researcher-guided group discussion was used to collect information from a specific group of individuals who are elderly members of the community and have firsthand experience of the effects of climate variability over an extended period. The information obtained directly from original sources experienced editing to detect mistakes and ease input. Subsequently, it was encoded, condensed, and examined. Computer programs like Microsoft Excel and Statistical Package for Social Science (SPSS) was employed to analyze the numerical data. Content analysis was utilized to evaluate the data obtained from important sources, employing a systematic approach that condenses lengthy text into a few categories using predefined coding rules (Stemler, 2001). The study data was presented in tables, figures, plates and text to facilitate interpretation and discussion of the findings.

FINDINGS AND DISCUSSIONS

A total of 359 questionnaires were sent out to the respondents to fill. Of these questionnaires, 252 were returned for analysis. The returned 252 questionnaires accounted for 70.2% response rate. A response rate of 70% and above is adequate (Mugenda & Mugenda, 2003), accordingly, a response rate of 93.7% was acceptable for data analysis.

Seasonal Variations between Flooding and Drought Episodes on Incidences of Gastrointestinal Infections

The study adopted descriptive and inferential statistical analysis. This helped to assess the influence of seasonal variations between flooding and drought episodes on the incidences of gastrointestinal infections along the lower river Sio Watershed, Western Kenya, Kenya. For analysis, descriptive statistics (frequency, percentage, and mean distribution) for the level of agreement on a five-point Likert scale of the variable, seasonal variations between flooding and drought episodes was determined and summarized in Table 1.

Table 1: Seasonal Variations between Flooding and Drought Episodes and Incidences of Gastrointestinal Infections

Statements		SD	D	U	A	SA	MEAN
The nature of seasonal cycle vary across different regions and exhibits a significant association with changes in rainfall	F	14	18	16	107	97	**4.01**
	%	**5.6**	**7.1**	**6.3**	**42.5**	**38.5**	

That natural fluctuations occurring in specific areas have a substantial influence on global weather and climate patterns	F **%**	3 **1.2**	32 **12.7**	16 **6.3**	99 **39.3**	102 **40.5**	**4.05**
That an increase in the temperature, would result in an increase in the total phosphorus, nitrogen, and cyanobacteria	F **%**	6 **2.4**	11 **4.4**	34 **13.5**	81 **32.1**	120 **47.6**	**4.18**
Understanding of the timing of rainfall pattern is advantageous because it allows for planning	F **%**	31 **12.3**	4 **1.6**	16 **6.3**	98 **38.9**	103 **40.9**	**3.94**

Source (Researcher, 2023)

Table 1 shows that 107(42.5%) of the respondents agreed with the nature of seasonal cycle vary across different regions and exhibits a significant association with changes in rainfall, 97(38.5%) strongly agreed, 18(7.1%) disagreed, 16(6.3%) were undecided and 14(5.6%) strongly disagreed with the statement. The study findings suggested that the respondents agreed (Mean=4.01) that natural fluctuations occurring in specific areas have a substantial influence on global weather and climate patterns. An interviewee who had the following to say supported this-

"... Despite its geographical distance, ENSO exhibits a significant association with changes in rainfall across the eastern part of the African continent. However, the nature of these correlations and their alignment with the seasonal cycle vary across different regions ...Male Participant, 50 years, key informant.

This implies that key informants, officials, and local leaders closely monitor the climate variability influences incidences of to enhance the gastrointestinal infections. This is in line with the findings of Camberlin et al., (2001) that most prominent of these fluctuations is known as the El Niño–Southern Oscillation (ENSO), which occurs approximately every 4 years but can range from 2 to 7 years in duration. Despite its geographical distance from Africa, ENSO exhibits a significant association with changes in rainfall across the eastern part of the African continent. However, the nature of these correlations and their alignment with the seasonal cycle vary across different regions.

Similarly, 102(40.5%) of the respondents strongly agreed with the statement that an increase in the temperature, would result in an increase in the total phosphorus, nitrogen, and cyanobacteria, 99(39.5%) agreed, 32(12.7%) disagreed, 16(6.3%) were undecided and 3(1.2%) strongly disagreed with the statement. It emerged from the study that the respondents agreed (Mean=4.05) that natural fluctuations occurring in specific areas have a substantial influence on global weather and climate patterns.

On whether climate variability influences incidences of gastrointestinal infections, 120(47.6%) of the respondents strongly agreed with the statement, 81(32.1%) agreed, 34(13.5%) were undecided, 11(4.4%) disagreed and 6(2.4%) strongly disagreed with the statement. The study findings suggested that the respondents agreed (Mean=4.18) that understanding of the timing of rainfall pattern is advantageous because it allows for planning. This was supported by an interviewee who had the following to say;

"... Additionally, climate change can lead to changes in the occurrence of diseases associated with air pollution and airborne allergens. It is possible for climate change to disturb or alter natural systems, thereby enabling diseases to spread or emerge in areas where they were previously limited or non-existent.…Female Participant, 45 years, official member.

Lastly, 103(40.9%) of the respondents strongly agreed with the statement that understanding of the timing of rainfall pattern is advantageous because it allows for planning. 98(38.9%) agreed, 31(12.3%) strongly disagreed, 16(6.3%) were undecided and 4(1.6%) disagreed with the statement. It emerged from the study that the respondents tended to agree (Mean=3.94).

These findings are in agreement with recent studies performed by Zhang *et al.,* (2012) who simulated the impacts of climate change on the stream flow and non-point source pollutant loads in the Shitoukou reservoir catchment, China. The results indicated that the annual NH_4^+-N load into the Shitoukoumen reservoir would exhibit a significant downward trend with a decreasing rate of 40.6t per decade under the A2 scenario. Nõges *et al.,* (2011) reported that an increase in the winter precipitation in the Ticino river basin of southern Europe was likely to increase the nutrient loadings in the lakes and contribute to eutrophication.

Moreover, considering both point sources and agricultural diffuse sources, Martínková *et al.,* (2011) used SWIM (Soil and Water Integrated Model) to simulate changes in the nitrate load from the Jizera catchment (Czech Republic) under the A1B scenario. Although the results varied in the different simulated periods, the nitrate loads of most periods were positively correlated with the water discharge and precipitation. Similarly, Arheimer *et al.,* (2005) simulated changes in the nutrient loads and algae growth in the Leonard River system in Southern Sweden using water quality and ecological models under the A2 and B2 scenarios and concluded that an increase in the temperature, would result in a 50% increase in the total phosphorus, a 20% the total nitrogen, and an80% increase in cyanobacteria.

These descriptive statistics of objective one was followed by a Chi-square test of association. The Chi-square test at $p \leq 0.05$ significance level illustrating statistically significant association between seasonal variations between flooding and drought episodes and incidences of gastrointestinal infections along the lower river Sio Watershed, Western Kenya. To achieve this, the hypothesis below was tested.

H_{01}: *There is no significant association between seasonal variations between flooding and drought episodes and incidences of gastrointestinal infections along the lower river Sio Watershed, Western, Kenya*

Table 2: Chi-Square Test of Association between Seasonal Variations of Flooding and Drought Episodes and Incidences of Gastrointestinal Infections

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	534.463[a]	132	.000
Likelihood Ratio	276.084	132	.000
Linear-by-Linear Association	93.807	1	.000
N of Valid Cases	252		

a. 152 cells (97.4%) have expected count less than 5. The minimum expected count is .01.

Source (Researcher, 2023)

Table 2 shows that the p value (p=0.000) for criteria used in allocation and disbursement of SECBF was less than 0.05. Therefore, the hypothesis, "there is no significant association between seasonal variations between flooding and drought episodes and incidences of gastrointestinal infections along the lower river Sio Watershed, Western, Kenya" was rejected. This implies that there is statistically significant association between Seasonal variations between flooding and drought episodes and incidences of gastrointestinal infections along the lower river Sio Watershed, Western, Kenya.

Incidences of Gastrointestinal Infections

The study adopted descriptive and inferential statistical analysis. This helped incidences of gastrointestinal infections along the lower river Sio Watershed, Western, Kenya. For analysis, descriptive statistics (frequency, percentage, and mean distribution) for the level of agreement on a five-point Likert scale of the variable, incidences of gastrointestinal infections along were examined and summarized in Table 3.

Table 3: Incidences of Gastrointestinal Infections

Statements		SD	D	U	A	SA	MEAN
The direct effects of global temperature increase have significant implications for human health	F	19	27	10	102	94	**3.89**
	%	**7.5**	**10.7**	**4.0**	**40.5**	**37.3**	
That there is a connection between temperature variability and gastrointestinal infections	F	6	19	23	99	105	**4.10**
	%	**2.4**	**7.5**	**9.1**	**39.3**	**41.7**	
That there is a positive correlation between ambient temperature and pediatric GI infections	F	13	3	19	66	149	**4.34**
	%	**6.0**	**1.2**	**7.5**	**26.2**	**59.1**	
That floods contribute to high concentrations of pathogens in natural bodies of water, resulting in poorer quality of drinking and bathing water	F	7	6	19	91	129	**4.31**
	%	**2.8**	**2.4**	**7.5**	**36.1**	**51.2**	

Source (Researcher, 2023)

Table 3 shows that 102(40.5%) of the respondents agreed with the statement that direct effects of global temperature increase have significant implications for human health, 94(37.3%) strongly agreed, 27(10.7%) disagreed, 19(7.5%) strongly disagreed and 10(4.0%) were undecided on the statement. The study findings suggested that the respondents tended to agree (Mean=3.89) that direct effects of global temperature increase have significant implications for human health. This was supported by an interviewee who had the following to say;

> *"…The impact of climate variables, particularly temperature, on different age groups in various geographical areas and climate zones lacks comprehensive documentation...." Female Participant, 52 years, Key Informant.*

Additionally, 105(41.7%) of the respondents strongly agreed with the statement that there is a connection between temperature variability and gastrointestinal infections, 99(39.3%) agreed, 23(9.1%) were undecided, 19(7.5%) disagreed and 6 (2.4%) strongly disagreed with the statement. It emerged from the study that the respondents agreed (Mean=4.10) that there is a connection between temperature variability and gastrointestinal infections.

On whether there is a positive correlation between ambient temperature and pediatric GI infections, 149(59.1%) of the respondents strongly agreed with the statement, 66(26.2%) agreed, 19(7.5%) were undecided, 13(6.0%) strongly disagreed and 3 (1.2%) disagreed with the statement. The study findings suggested that the respondents agreed (Mean=4.34) that there is a positive correlation between ambient temperature and pediatric GI infections.

Lastly, 129(51.2%) of the respondents strongly agreed with the statement that floods contribute to high concentrations of pathogens in natural bodies of water, resulting in poorer quality of drinking and bathing water, 91(36.1%) agreed, 19(7.5%) were undecided, 7(2.8%) strongly disagreed and 6(2.4%) disagreed with the statement. It emerged from the study that the respondents agreed (Mean=4.31) that floods contribute to high concentrations of pathogens in natural bodies of water, resulting in poorer quality of drinking and bathing water.

These findings agree with Xu et al., (2012) that there is connection between temperature variability and its impact on gastrointestinal (GI) infections has raised concerns, as reported by climate change presents various challenges to human health, both directly and indirectly. These challenges include alterations in vector distribution, food availability, the occurrence of epidemics, and disasters. The direct effects of global temperature increase, whether observed as long-term trends or heatwaves, have significant implications for human health (Manser et al., 2013). Recent studies have highlighted the potential influence of changes in ambient temperature, considered a factor of climate change, on the transmission of infectious diarrhea (Checkley et al., 2000). Akil et al., (2014) argue that there is a strong positive relationship between the prevalence of salmonellosis and temperature rise. Similarly, Xu et al. (2012) identified a positive correlation between ambient temperature and pediatric GI infections. However, the impact of climate variables, particularly temperature, on different age groups in various geographical areas and climate zones lacks comprehensive documentation.

Conclusion

From the findings, the study concludes that seasonal variations between flooding and drought episodes influence incidences of gastrointestinal infections along the lower river Sio Watershed, Western Kenya. It is concluded that there is a statistically significant association between seasonal variations between flooding and drought episodes, disease outbreaks, and government policies and incidences of gastrointestinal infections along the lower river Sio Watershed, Western Kenya. Henceforward, when the county government officials and the local members involved closely monitor the natural fluctuations occurring in specific areas, when they discover that an increase in the temperature, would result in an increase in the total phosphorus, nitrogen, and cyanobacteria or understand the timing of rainfall pattern, it is advantageous because it allows for planning then they will address the issue of incidences of gastrointestinal infections along the lower river Sio Watershed.

Recommendations

The study recommends that the national and county government should develop a policy framework that commits the government to train local members on climate variability and incidences of gastrointestinal infections. Additionally, the study recommends that the government should develop a policy framework that would guide local members to undergo mandatory and comprehensive training on disaster management. Lastly, the policy makers and community should consider Climate variability such as seasonal variations between flooding and drought episodes when working towards improving incidences of gastrointestinal infections along the lower river Sio Watershed, Western Kenya.

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