UNIVERSITY OF NAIROBI

ASSESSING THE IMPACTS OF CLIMATE VARIABILITY ON THE ACADEMIC PERFOMANCE OF PUPILS IN SIAYA COUNTY, KENYA.

BY

OBONYO MICHAEL OCHIENG

REG. NO: I54/79491/2015

makobonyo80.kenya@gmail.com

School of Physical Sciences

Department of Meteorology

University of Nairobi

P.O.BOX 30197-00100

Nairobi, Kenya.

A Dissertation submitted in partial fulfillment of the requirements for the Degree of Master of Science in Climate Change of the University of Nairobi.

NOVEMBER, 2018.

DECLARATION

DECLARATION BY CANDIDATE

This dissertation is my original work and has not been presented for a degree in this or any other university or institution for academic award. Where other people's work or my own work has been stated, this has been properly acknowledged and referenced in accordance with the University of Nairobi's requirements.

Signature ---------- Date ----------/----------/----------

OBONYO, MICHAEL OCHIENG

I54/79491/2015

DECLARATION BY SUPERVISORS

We the undersigned certify that this M.Sc. Dissertation has been submitted for examination with our approval as the university supervisors.

Signature----------Date ----------/---------/----------

Prof. Joseph M. Ininda

Signature ----------Date ----------/----------/---------

Dr. Gilbert Ouma

Department of Meteorology
University of Nairobi
P.O. BOX 30197 – 00100
Nairobi, Kenya.
www.uonbi.ac.ke

DEDICATION

This work is dedicated to my children Shamim Atieno Ochieng', Trezzy Riana Ochieng' and Bernice Faith Akinyi Ochieng' that they may achieve academically more than I ever did, sooner than I ever did and better than I managed to do.

To my loving spouse Emily Auma Ochieng', father Stephen Obonyo; mother Magdalin Okinyo Obonyo, Sister Lillian Auma and brothers Fredrick, George and Joseph for their prayers, understanding and best wishes during the difficult times of my intellectual discourse.

ACKNOWLEDGEMENT

This dissertation is a culmination of a study that commenced with the enrollment for MSc. (Climate Change) Programme in April 2015. The two years saw the completion of course work, identification of research problem, development of research proposal, presentation of research progress report and submission of final report. This would not have been successful without the backing of various individuals whose efforts I would like to recognize. Foremost, I thank the Almighty God for granting me the necessary wisdom that aided the design, execution and final presentation of this dissertation.

I owe an immense debt of gratitude to my supervisors, Professor Joseph Ininda and Dr. Gilbert Ouma for their scholarly guidance. I am particularly indebted to Professor Ininda. His wise advise, insightful criticism, and patient encouragement aided the writing of this dissertation in innumerable ways right from the formative to the final stage. I am equally grateful to Head teachers in Siaya County, Michael Odhiambo and Fredrick Ododa; my research assistants, Mr. Arodi; Director of Meteorological Services, Siaya County, Mr. Osogo; Kisumu Airport Metrological Services and the County Director of Education, Siaya County for their cooperation and professional assistance that led to the success of data collection during this study.

I would be remiss without mentioning Mrs. Emily Ochieng' and the entire Ochieng's family whose extreme patience, prayers and encouragement will be remembered always. Finally, my friends, classmates and workmates who are too many to be mentioned individually. Kindly accept my sincere gratitude for the role you played towards the successful completion of this dissertation.

While this dissertation is the culmination of my hard work, it would not have been possible without the support of each one of you mentioned above. Together we have a reason to celebrate this success. **May God bless you all!**

ABSTRACT

The occurrence of extreme weather conditions is not uncommon in various parts of Kenya including Siaya County. Adverse weather conditions affect the learning process and this subsequently affects the level of performance in the national examination.

The study assessed the impact of climate variability on academic performance in Siaya County. The data used was rainfall, minimum and maximum temperature and performance at KCPE for Siaya County. The climatic data was obtained from Kenya Meteorological Department while data on performance was obtained from head-teachers in Siaya County. The temporal variations of climatic variables were determined through time series analysis. The time series components analyzed included, the annual cycle, inter annual variability and trends. The trend on academic performance was also examined. The effect of climatic variation on academic performance was examined through correlation and regression analysis. The spatial coherence of performance throughout the county was determined using Principal Component Analysis. In order to evaluate how the residents of this county cope with the impacts of adverse weather, a survey using questionnaire was undertaken.

The results from the study revealed that the Maximum and Minimum temperature is bimodal with the peaks of the minimum temperature occurring in April and November while of the Maximum temperature the peaks occur in February and October. The county has two rainfall seasons namely; March – May and September – December with the peaks occurring in April and November respectively. All the three climatic elements showed inter annual variability; however rainfall variability was higher compared to the other parameters. Both Minimum and Maximum temperatures showed significant positive trend. The rainfall on the other hand has negative trend though not statistically significant. However, the variance in the rainfall has been increasing in the recent years which are consistent with the observed increased frequency in extreme rainfall events.

There is an inverse relationship between minimum temperature and KCPE performance with August having the highest correlation. Cold night temperatures enhance concentration doring studies at night by pupils. Even though KCPE is done in November, the month of August is significant because most of the syllabi ought to be covered by this time to allow for revision and

the accumulative effect of climate variations of the month affects performance in November. The correlation with maximum temperature was generally positive during the cold month and negative during the hot month. The correlation with rainfall was positive though not statistically significant. The regression model developed to predict performance using the three climate parameters explained more than 60% of the variance in each of the sub counties. Clustering of the sub county performance reflected the level of intervention against the impact of extreme weather events.

Results from the survey done revealed that a part from the three weather variables under study; other factors like windstorm, thunderstorm, lightning and biting cold affect learning which in turn affect performance. Most of the respondents also noted that maximum temperatures have become much hotter than before. On set of rains have shifted. Food scarcity, drought, poor health affect academic performance. The number of cases of absenteesim in wet and dry season increases and the level of concentration reduces in high maximum temperatures. Some school roof tops have been blown away by windstorms and some pupils have died due to lightning and thunderstorms. Children have been affected by floods as they move to and from school and this have affected curriculum delivery. The major causes of absenteesim in schools are malaria/cholera followed by famine.

Some of the strategies put in place to cope with the effect of climate variability are having feeding programs at school, water harvesting, learning under trees, adjusting learning time, carrying water from home.

In conclusion, the extreme weather condition was found to negatively impact on academic performance.

The research recommended up scaling of adaptation strategies to cope with the climate variability. The results are also useful in planning and managing risks and disasters associated with climate variability in schools.

TABLE OF CONTENTS

Contents **page**

DECLARATION ..... **ii**

DEDICATION ..... **iii**

ACKNOWLEDGEMENT ..... **iv**

ABSTRACT ..... **v**

TABLE OF CONTENTS vii

LIST OF FIGURES ..... **xii**

LIST OF TABLES ..... **xv**

LIST OF ACRONYMS AND ABBREVIATIONS ..... **xvi**

CHAPTER ONE: INTRODUCTION **1**

1.0 Introduction to Chapter One. 1

1.1 Back ground of the study: 1

1.2 Problem statement: 4

1.3 Research questions 5

1.4 Objectives of the study 5

1.4.1 The Main Objective of the study 5

1.4.2 Specific objectives 5

1.5 Hypothesis 6

1.6 Justification of the study 6

1.7 Area of study 7

1.7.1 The Location of area of study 7

1.7.2 Description of the Physical Features of the Study Area 9

1.7.3 Socio-economic activities: 10

CHAPTER TWO: LITERATURE REVIEW 11

2.0 Introduction to Chapter Two 11

2.1 Internal factors affecting academic performance 11

2.1.1 Genetic factors 11

2.1.2 Motivation to Work 13

2.1.3 Leadership, Administration and Management 14

2.1.4 Reinforcement 16

2.1.5 Individual Differences 17

2.2 Physical factors affecting academic Performance 19

2.3 Cognitive factors affecting performance 19

2.4 The external factors affecting Learning 20

2.4.1 State of the learner 20

2.4.2 Physical environment 20

2.5 Conceptual frame work 22

CHAPTER THREE: DATA AND METHODOLOGY 23

3.0 Introduction to Chapter Three 23

3.1 Data types and sources 23

3.1.1 Primary Data 23

3.1.2 Validity of the questionnaire 24

3.1.3 Reliability of the Questionnaire 24

3.1.4 Secondary sources of data 24

3.2 Data Collection Techniques 25

3.2.1 Research Design 25

3.2.2 Research Procedure 26

3.2.3 Sampling Methodology 27
3.2.4 Simple systematic random sampling. 30
3.3 Data Analysis 30
3.3.1 Data Quality Control 30
3.3.2 Determination of Trends 32
3.3.3 Determination of Relationships 33
3.3.4 Principal component Analysis (PCA) 34
3.3.5 Variability of Climatic Parameters 37
3.3.6 Multiple Linear Regressions 38
3.3.7 Photography 39
CHAPTER FOUR: RESULTS AND DISCUSSION 40
4.1 Results from Data Quality Control 40
4.2 Results from temporal climatic Variability 41
4.2.1 The Annual cycle of climatic variables 41
4.3 Results of Analysis of Academic performance in Siaya County 47
4.3.1 Inter Annual Variability and trend in the academic performance in the sub-counties in Siaya County 47
4.3.2 Results of inter sub-county correlation in Performance 49
4.3.3 Results from Principal Component Analysis of Performance (PCA) 50
4.4 Results of Relationship between climatic variables and academic performance 53
4.4.1 The results from Correlation Analysis of Performance and Climatic variables. 53
4.4.2 Regression Model for Predicting Performance using climatic parameters. 56
4.5 Results and Discussions from the Analysis of Questionnaires. 63
4.5.1 Questionnaire return rate 63

4.5.2 Demographic information 63
4.5.3 Responses on Factors affecting performance 68
4.5.4 Responses on rate of Absenteeism in wet and dry seasons. 73
4.5.5 Responses on Class concentration in high minimum temperature and high maximum temperatures. 74
4.5.6 Responses on Lightning, thunderstorm and windstorm. 76
4.5.7 Responses on Socio – economic information. 82
4.5.8 Responses on Strategies to improve academic performance during climate variability. 84
4.5.9 Responses of learners on how weather elements affect their performance 91
CHAPTER FIVE: CONCLUSIONS AND RECOMMENDATIONS 99
5.0: Introduction to Chapter Five 99
5.1 Conclusions 99
5.2 Recommendations 100
5.2.1 Recommendations to Parents 100
5.2.2 Recommendations to School Administration (Teachers) 101
5.2.3 Recommendation to Government and Non- Governmental Organizations: 101
5.2.4 Recommendation to scientific community and the Academia 102
ANNEXES 113
Annex I: Research Permit requesting data from schools. 113
Annex II: Research permit requesting data from Siaya Meteorological Department. 114
Annex III: Informed Consent. 115
Annex IV: Field Questionnaire for teachers: 116
Annex V: Field Questionnaire for Learners: 124

Annex VI: Schools sampled for the study. 126

Annex VII: KCPE Performance Trends. 131

Annex VIII: Siaya Monthly Rainfall (mm) 132

Annex IX : Maximum and Minimum Temperature of Siaya (^{0}c). 133

Annex X : Sub county Performance. 134

Annex XI: Similarity Index ……..…….....135

LIST OF FIGURES

Figure 1.1: Location of Siaya County in Kenya (source-Google maps). 8

Figure 2.1: Abraham Maslow Hierarchy of Needs (Source- author) 14

Figure 2.2: Conceptual frame work (source, Author, 2017) 22

Figure 4.1: Single mass curve for Ugenya Sub – county KCPE Performance 40

Figure 4.2: Shows Rainfall Variations for Siaya (KMD, 2016) 42

Figure 4.3(b): The mean monthly Minimum temperature over Siaya County 44

Figure 4.4: Annual Rainfall trend over Siaya (KMD, 2016) 45

Figure 4.5 (b): Mean annual Minimum Temperature trends over Siaya County. 46

Figure 4.6: Annual variation in Performance of sub counties within Siaya County over the years (author) 48

Figure 4.7: Performance Trend over Siaya County (author, 2017) 49

Figure 4.8: Grouping of Sub counties based on Factor loading. 52

Figure 4.9: Siaya County Observed and Predicted Performance 59

Figure 4.10: Gem Sub County observed and predicted performance 59

Figure 4.11: Rarieda Sub County observed and predicted performance. 60

Figure 4.12: Ugenya Sub County observed and predicted performance. 60

Figure 4.13: Bondo Sub County observed and predicted performance. 61

Figure 4.14: Siaya Sub County observed and predicted performance. 61

Figure 4.15: Ugunja Sub County observed and predicted performance. 62

Figure 4.16: Demographic information (a) Number of years lived in Siaya County (b) Place of birth (c) age distribution of the respondents. 65

Figure 4.17: Responses on Maximum temperatures of Siaya. 65

Figure 4.18: Responses on Maximum Temperatures of the months of MJJ. 66

Figure 4.19: (c) Opinion on flood occurrence. 68
Figure 4.20: Mean distance from home to the nearest health facility. 69
Figure 4.21: The effect of Poor health of learners on academic performance. 70
Figure 4.22: The effect of Food scarcity on academic performance. 70
Figure 4.23: The effect of Drought on academic performance. 71
Figure 4.24: The effect of Poor Transport network on academic performance. 71
Figure 4.25: How Variation of hot, wet and chilly weather affect academic performance. 72
Figure 4.26. The number of those who fall sick during wet season. 72
Figure 4.27: The Number of pupils that fall sick during drought 74
Figure 4.28. (c) Opinion of Teachers on concentration of pupils at high minimum temperatures. 75
Figure 4.29: (b) Opinion on windstorm occurrences 76
Figure 4.30: Impacts of (a) thunderstorms (b) windstorms in schools. 77
Figure 4.31: (c) Classroom roof of Umer Primary school (Ugenya) destroyed by windstorm (Source, author, 2/6/2017, 4.00 p.m.) 78
Figure 4.32: Schools affected and not affected by floods. 78
Figure 4.33: Pupils and teachers of Ukela Primary school (Ugenya) wading in the floods as they go to school (Source, author, 12/4/2017 ,8.15 a.m.) 80
Figure 4.34: (d) Opinion on the Impacts of thunderstorms on curriculum delivery 81
Figure 4.35: (c) Crops that have Planting periods between March and August. 83
Figure 4.36: Opinion on the growing periods of the crops. 83
Figure 4.37: Opinion on food insecurity. 84
Figure 4.38: (b) Pupils of Mudaho Primary school – Ugunja sub-county feeding at school *(Source, author, 6/3/2017, 11.10 a.m.)* 86

Figure 4.39: (b) (iii) Pupils of Mauna Primary School (Ugunja) using borehole at school (Source, author, 22/2/2016, 10.15 a.m.) 87

Figure 4.40: (c) Strategies to improve performance during windstorms. 88

Figure 4.41: (c) Opinion of pupils on performance of 2017 class compared to the previous class - 2016, the previous class…. 90

Figure 4.42: Opinion on the degree of effect of climate variability on performance. 90

Figure 4.43: Opinion on the major reasons for absenteeism in Siaya County 91

Figure 4.44: Means of transport used by pupils to school in Siaya 91

Figure 4.45: (b) Number of meals taken in a day during famine. 92

Figure 4.46: (b) Number of times pupils take bath during drought 93

Figure 4.47: (c) Residents and school pupils of Kometho in Rarieda Sub county queue for water during drought (Source, author, 17/9/2016, 11.55 a.m.) 94

Figure 4.48: (g) School attendance by pupils during biting cold 96

Figure 4.49: (f) Effects of wind storms on performance. 98

LIST OF TABLES

Table 2.1: Intelligent Quotient Ranges 18

Table 3.1: Sample frame for the schools 29

Table 3.2: The pupils who fall sick in wet seasons 26

Table 4.1: Co-efficient of Variability of climate Parameters 47

Table 4.2: Mean and Variance in Performance of the sub counties 48

Table 4.3: Inter Sub County correlation. 50

Table 4.4: Un-rotated Principal Component Analysis (PCA) 51

Table 4.5: Rotated Principal Component Analysis (PCA) 51

Table 4.6: The Loading on the Rotated Principal Component Analysis (PCA) 52

Table 4.7: Correlation between Minimum Temperature and Performance 53

Table 4.8: Correlation between Maximum Temperature and Performance 54

Table 4.9: Correlation between Rainfall and Performance 55

Table 4.10: Regression Models for Predicting Performance in each sub county. 56

Table 4.11. The skill of forecasting of performance. 62

Table 4.12. Respondents return rate 63

LIST OF ACRONYMS AND ABBREVIATIONS

AR4 - 4th Assessment Report

AR5 - 5th Assessment Report

8-4-4 - Education system in Kenya

ANOVA - Analysis of Variance.

C.A – Chronological Age

C.D.F – Constituency Development Fund

CIDP – County Integrated Development Plan

COP – Conference of Parties

DNA- Deoxyribonucleic Acid

FGM – Female Genital Mutilation

GCC – Global Climate Change

GDP – Gross Domestic Product

GHG – Green House Gases

GoK – Government of Kenya

I.Q – Intelligence Quotient

IPCC – Intergovernmental Panel on Climate Change

ITCZ – Inter Tropical Convergence Zone

JFM – January, February and March

K.C.P.E – Kenya Certificate of Primary Education

Km/hr. – Kilometres per hour

KMD – Kenya Meteorological Department

KNBS – Kenya National Bureau of Statistics

KNEC–Kenya National Examinations Council

KNUT – Kenya National Union of Teachers

M.A – Mental Age

MJJ – May, June and July

MOEST – Ministry of Education Science and Technology

MVP – Millennium Village Project

NE – North East trade winds

PCA – Principal Component Analysis

SE – South East trade winds

SON – September, October and November

UNDP- United Nation Development Program

UNFCCC- United Nations Framework Convention on Climate Change

USA – United States of America

CHAPTER ONE: INTRODUCTION

1.0 Introduction to Chapter One.

This chapter provides a brief description on the study background, the objectives of the study, the problem statement, hypothesis and justification of the study.

1.1 Back ground of the study:

Climate change has been associated with increased variation of weather elements. These increased variability negatively impact on social-economic and political welfare of communities. Education sector as one of the social welfare is negatively affected. Climatic variations affect learning environment which in turn leads to poor academic performance at school. The variations in climatic elements disrupt pupil's attendance at school.

Very high maximum temperature leads to thermal discomfort that effect learning and subsequently academic performance in final examination (Hillier *et* (H. W. , 2012). *al.*, 2012). Extreme heat affects health (McMichael *et al.,* 2000).Affected schools close down when classrooms are destroyed by strong winds and floods. Schools are also used as camps when homes are submerged in floods forcing children to stay away from school.

Weather events such as floods and droughts affect the water quality and hence the health status of learners. Floods may also cut off bridges causing pupil s to be absent from school. Floods and droughts affect food production, transportation, processing and storage (Codjoe and Owusu, 2011). The floods and droughts affect food availability and affordability leading to food insecurity. Unavailability of food leads to nutritional problems that affect the mental and physical development of children and which affect their academic performance.

The Kenya's school education calendar is divided into three terms (cycles) in a year. Term one runs from January to March, Second term is from May to July while third term is from September to November. April, August and December are vacations. Pupils in primary schools sit for the National Examination (K.C.P.E) at the end of October.

Within a year rainfall pattern in Siaya county is characterized by 4 seasons: January to March – Warm and Dry Season, April to June – Long wet season, July to September – Cool Dry Season, October to December – Short wet Season.

Many parts of the earth have experienced increased variation of weather events in the recent years which have been attributed to climate change(McMichael *et.al.,* 2006).The variations in weather events have impacts on the society and its economic assets .These weather events lead to losses of lives and damage of vital infrastructure, discomfort and vector borne diseases (Hillier, 2012; Hirabayashi, 2013; Singh and Micah, 2014; Hirsch and Archfield, 2015).Some of the infrastructure being school physical facilities like classrooms. This has indirect negative effect on academic performance of pupils. Some pupils are struck by lightning and thunderstorm causing death, fear and discomfort among pupils. Research has shown that over the past decades there have been incidences of heat waves, droughts and floods as a result of weather events affecting people (Mahoney, 2012; Hoedjes *et. al.,* 2014;. These affect pupils' academic performance directly or indirectly.

Climate variability looks at short term changes in climate that take place over months, seasons, decades and years. Climate change occurs over longer period of time i.e. from decades to centuries (UNFCCC).

Globally for many years, Climate change is emerging to be the first priority although it remains a challenging environmental concern (Radulescu, 2015). This is evidenced by the series of conferences, advocacies, summits and researches being carried out right from the Rio Earth Summit in 1992 to the COP 21 of 2015. Those charged with making policies are advancing their actions and developing frameworks geared towards an economy that emits low carbon.

Change in Climate is "unequivocal" and -activities practiced by man play a major role In order to avoid climate change it will require large and sustainable decrease in greenhouse gas emissions by mid-century and that net emissions reduce to zero before the year 2100 (IPCC 2014) .The Intergovernmental Panel on Climate Change (IPCC, 2007) indicates that present emission levels have already led to alterations in the earth's systems that will require individuals and communities to develop some response strategies to the negative impacts as mitigation alone will not be enough particularly in relation to public health and societal development. Warmer climates

offer favourable breeding grounds for malaria parasites. These cause malaria to pupils leading to absenteesim at school which finally affect academic performance.

Even though there are natural drivers of climate variability and climate change, the current disturbing trend has been to a greater extent blamed on anthropogenic factors like the burning of fossil fuels, emission from our industries, deforestation, and land use changes (IPCC, 2007; Canadel e*t al.*, 2010). Such human activities do either accelerate the concentration of greenhouse gases in the atmosphere (Canadel *et al.,* 2010), as is the case of burning of fossil fuel emission from industries, or affect the terrestrial carbon sinks (IPCC, 2007), as in the case of deforestation and land use changes.

Greenhouse gas (GHG) emissions, which are major cause of global climate change (GCC), have reached extra ordinary levels since the pre-industrial era (IPCC, 2007).

Empirical data show that the earth's climate has experienced significant warming over time in the recent years (IPCC, 2007). Results from further studies reveal that anthropogenic causes, such as increase in carbon emissions are the key drivers of the change being experienced.

Some human behaviors have mainly focused less on controlling or reducing carbon emissions and more on trying to adapt to the current conditions as a way of reducing vulnerability (IPCC, 2007) while others put focus on mitigation. Both approaches – mitigation and adaptation – have been cited by the IPCC as important human responses to climate change and are vital understandings for a climate knowledgeable citizen.

The economies that are highly responsible for climate change will not suffer much from it, even gaining from it in certain ways; in contrast, nations that contribute less carbon emissions in the atmosphere will be highly and disproportionally affected, due to their environmental and climate characteristics coupled with insufficient technology to cope with the phenomenon (Welzer,2012). In areas where living conditions are already difficult like that of Siaya County, Kenya, variations in temperature, precipitation and resource availability may lead to adverse impacts on people's lives. Moreover, climate variation adds some burdens on vulnerable groups (women and children) (Levi, 2015). In brief, this shows that the impact of climate variability will differ across communities and ecosystems.

The IPCC AR5, 2014 on Climate Change, which was advancement on the AR4 of 2007, showed that the last three decades have experienced greater successive warming of the Earth's surface than any decade since 1850. The variations in the weather elements associated with anthropogenic warming are changing atmospheric, terrestrial and hydrological systems, and more warming could have severe, wide spread and permanent impacts on humanity except if there is an unrelenting global response to stabilize greenhouse gas emissions. Such a response would integrate mitigation (action to reduce greenhouse gas emissions) and adaptation (adjustment in natural or human systems in response to real or likely climatic stimuli and their impacts) (IPCC, 2007, 2014).

Globally, in the United States, educational achievement has been associated with appropriate response to climate variations (Mc Cright, 2010). Climate variability present significant educational challenges: it is essential to know about the causes of climatic variations, its consequences in order to build a more realistic perception of climate risks and better understand our susceptibilities (Hernández, 2015).

1.2 Problem statement:

Literature has it that there has been a fluctuating trend in academic performance in national examinations in Siaya (Sika *et al.,* 2013). Certain regions in Siaya County post impressive academic performance in K.C.P.E while others perform dismally.

Being one of the counties that has produced prominent people like the late Odera Akang'o and the national and international leaders such as, the former American president (Barrack Obama), the recent drop in performance over the years has attracted the attention of stakeholders; hence the need for investigation into the issues surrounding the drop.

A number of theories have been put across to explain the factors that affect academic performance such as pupils' effort (Sieg, 2011 and Fels, 2009), Parents level of education (Anderson, 2016 and Benjamin, 1996), family income (Mayer, 2002), self -motivation, learning preference and class attendance. However, very little studies have been done to link the drop of performance with the climate variability. This study was conducted to investigate the effect of climate change on academic performance.

Siaya County has been experiencing temporal climatic variations. Floods have caused the greatest losses. They seasonally affect parts of Siaya and western regions in Kenya, especially around the Lake Victoria basin (Opere, 2013). Siaya County also suffers impacts of high temperatures, wind and thunderstorms which affect pupils and the learning facilities.

1.3 Research questions

(i) What is the nature of variability of climate elements in Siaya County?

(ii) What is the trend of academic performance in Kenya Certificate of Primary Education in Siaya County?

(iii) How does climate variability affect academic performance of pupils in the Kenya Certificate of Primary Education in Siaya County?

(iv) What Strategies are put in place to adapt to the effect of climate variability on performance?

1.4 Objectives of the study

1.4.1 The Main Objective of the study

The main objective of this study is to assess the impact of climate variability on academic performance in primary schools in Siaya County.

1.4.2 Specific objectives

In order to achieve the overall objective, the following specific objectives were pursued:

(i) To determine the nature of temporal variations of climatic variables in Siaya County.

(ii) To determine the trend in academic performance in the Kenya Certificate of Primary Examinations in Siaya County.

(iii) To examine the effect of climatic variation on academic performance in the Kenya Certificate of Primary Education in Siaya County.

(iv) To investigate Adaptation Strategies put in place to cope with effect of climate variability on performance.

1.5 Hypothesis

Whereas academic performance is influenced by many factors both internal and external factors. The influence of weather is still a dominant factor. Therefore the study was guided by the following hypothesis:

"If climatic conditions are unfavourable, the academic performance of pupils will significantly drop''

1.6 Justification of the study

Climate variability has direct and indirect impact on learning, for instance it may impact on children and teachers physical and psychological environment (Muurlink *et al.*, 2010) or lead to extreme events such as storms that may destroy the learning facilities. That withstanding, there is limited link between climatic elements and performance in this part of the country. Unveiling the information will help in coming up with appropriate adaptation & mitigation strategies.

The impacts of climate change cuts across all social and economic sectors. The manifestation of climate change is through the shift in the mean pattern of climatic parameters and change in the frequency and intensity of climatic extremes.

Climate variations affect academic performance through several ways either directly or indirectly. It affects the nation's economy when crops fail due to drought, food becomes scarce animals which is a source of livelihood to some communities also die; pupils' health is affected by diseases like malaria, chilly weather in the morning making learners not regular in school since they fall sick, some will be travelling far to look for water and food during drought.

Most past studies have been qualitative based mainly on factors affecting learning and climate change awareness in education sector. A study by Abagi (Ghadegbe & Mawuli, 2013) and Odipo (1997) indicate that curriculum implementers and learners' attitudes towards their school work, how classroom is managed, how learners and teachers interact, the overloaded 8-4-4 curriculum, high pupil-teacher ratio, child labour, harmful cultural practices, for example female genital mutilation (FGM) and peer pressure are other reasons that contribute to poor academic performance. Provocative or indecent dressing distracts pupils' and teachers' attention

(Ghadegbe, 2013). In cultures where traditional circumcision is still conducted, the leaners miss school to take part in those ceremonies. Once initiated, the pupils develop negative attitudes towards going to school and at times drops out of school especially boys (Chang'ach, 2012). It becomes difficult for the teachers to discipline them since they regard women as children, their aspirations for education is reduced. During the initiation ceremony the boys are taught to regard themselves superior (Chang'ach, 2012).All these affect learning environment, consequently their academic performance deteriorates.

Quantitative research on climate variability on academic performance may be indirect. For example wet and dry spells have influence on day today agricultural practices like cultivation time, planting, weeding, and harvesting which finally determines production (Bamanya, 2007) .Food insecurity in homes leads to malnourishment of leaners which affect their concentration span. There is significant influence of floods, stormy winds on school infrastructure, vector and water borne diseases like malaria and cholera.

Due to the limited link between climatic elements and academic performance, this study was undertaken to fill this gap. The field of Education was chosen because it is the ultimate bed-rock of development of any nation; hence the call by governments for "education for all."

1.7 Area of study

1.7.1 The Location of area of study

Siaya County is one of the six counties in the former Nyanza province. It covers a total area of 2,530.5 Km². The following are its neighbouring counties: Busia is to the North West, Kakamega and Vihiga to the North East, Kisumu to the South East and Homa bay to the south with Lake Victoria to the South and West (Figure 1.1).The study area lies on the northern shores of Lake Victoria within latitudes 0° 18′ N and 0° 26′ S and Longitudes 33° 58′ E and 34° 33′ E. It has six sub-counties; Bondo, Ugenya, Ugunja, Siaya, Gem and Rarieda. It has a population of 108, 934 (KNBS, 2010).

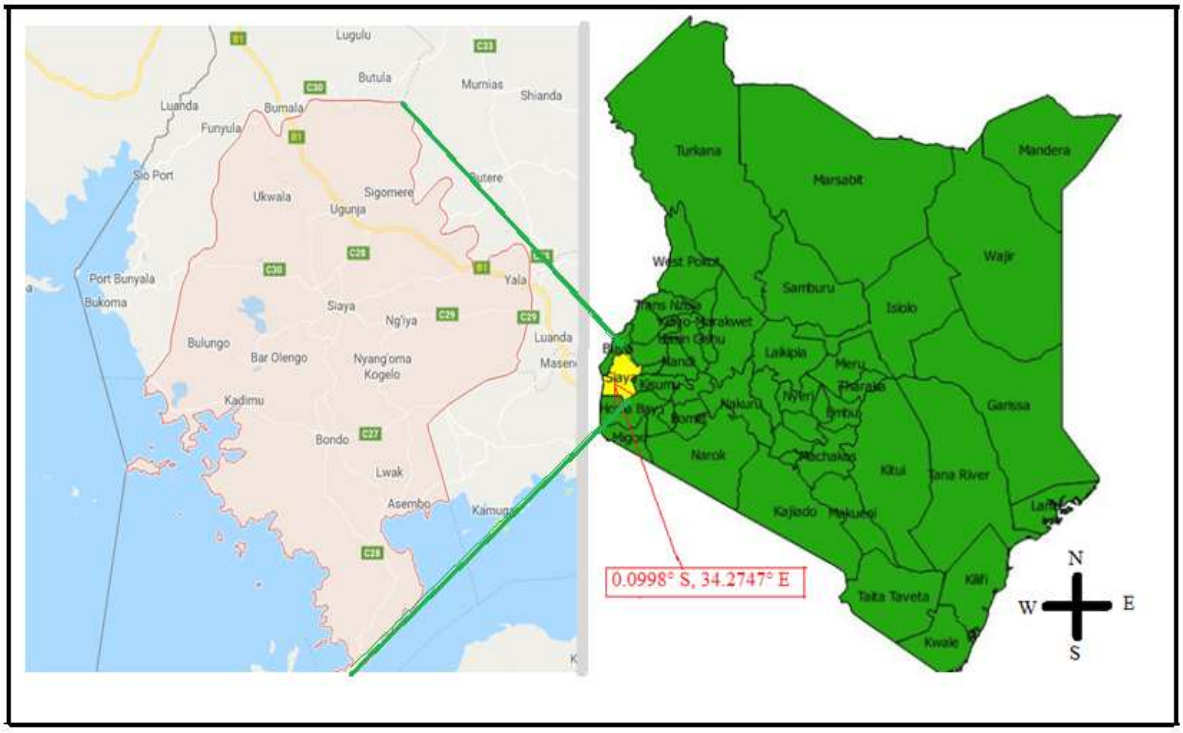


Figure 1.1: Location of Siaya County in Kenya (source-Google maps).

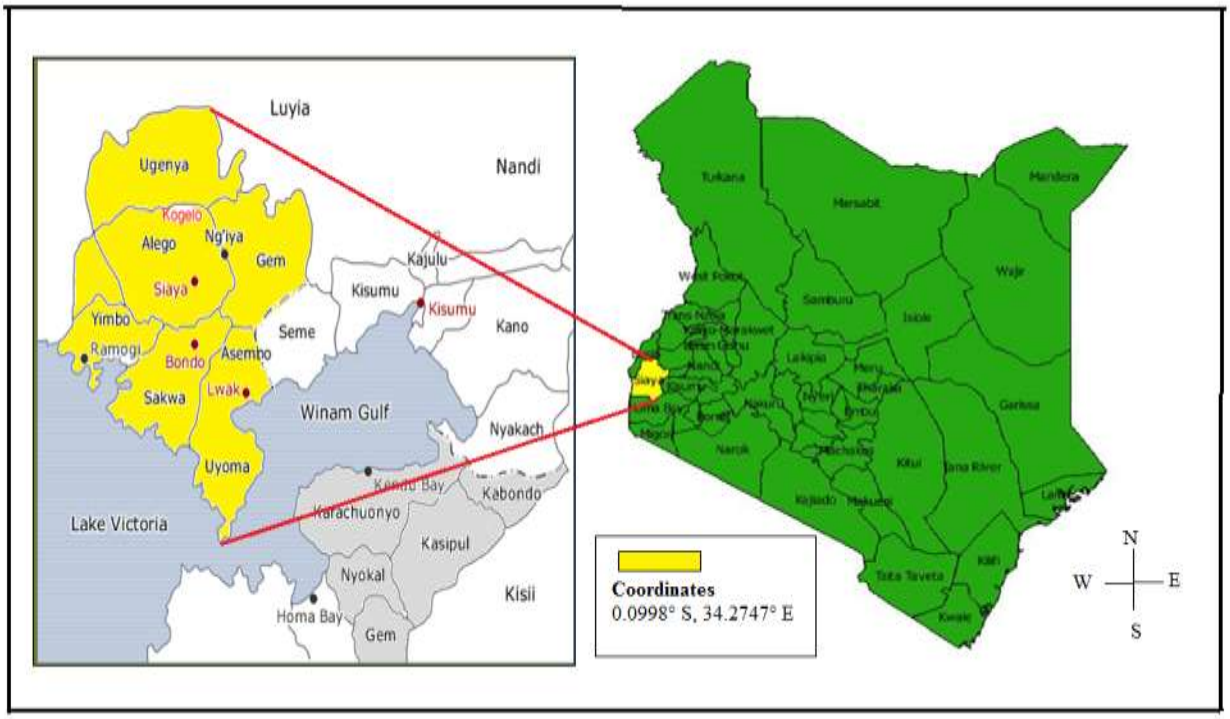


Figure 1.2: Sub counties in siaya and their Neighbours (Source- Google maps).

1.7.2 Description of the Physical Features of the Study Area

The general altitude of the county is between 1,140m on the shore of Lake Victoria and 1,400m above sea level. The Eastern parts such as Ugenya, Ugunja and Gem are on higher altitude and receive high rainfall, therefore they are wetter. The annual rainfall ranges between 800mm-2000mm. The western parts like Rarieda and Bondo are on low altitudes therefore they receive low rainfall therefore they are drier. Rainfall ranges from 800mm – 1600mm.

It also has several hills such as Odiado, Mbaga, Regea, Ramogi, Naya, Akala and Usenge. The relief and altitude influence the amount of rainfall and distribution.

Siaya County consists of several permanent and temporary streams. The water surface area is 1,005 km² (Abura *et al.,* 2017). It has two permanent rivers, River Nzoia and Yala which drain into Lake Victoria. The county also has an ox bow lake (Kanyaboli) on north eastern part of Lake Victoria.

The main water body that passes through it is River Nzoia with several streams. River Yala has its entire basin within Siaya and it drains into Lake Victoria. The county experiences hot and wet climatic conditions. It predominantly experiences convectional rainfall. The county slopes gently from an altitude of about 1350 m high to 1100 m North and East of Lake Victoria.

The rainfall is bimodal distribution with peaks in March - May and November – December (Conway, 1993). Dry seasons are between the months of December to February which is the first term of the school calendar, where the pupils have reported to school and there is a bigger part of syllabus to be covered coupled with sports and other curriculum activities. Besides the main rainfall seasons, substantial rainfall occurs in July and September. These are crucial months in the learning calendar. Most of the syllabi ought to be cleared and the pupils are to embark on serious revision in readiness for the national examinations. Areas around Lake Victoria – Siaya being one of them - have a relatively high mean annual rainfall of 1200 – 1600mm (Nicholson, 1998) with a mean annual temperature of 21.75 ^{o}C.

The rainfall distribution is highly influenced by the south-westerly winds from Lake Victoria, and there are some variations in the spatial distribution of annual rainfall from about 2000 mm in the northern parts to just about 700 mm at the lake. Most of the rainfall occur in the afternoons and generally associated with strong thunderstorms (Yin and Nicholson 1998, Yin et. al., 2000). As

expected there is a small rise in the mean annual temperature and the mean rate of evaporation in Lake Victoria and other rivers due to increased temperatures in the recent past.(Yin and Nicholson, 1998).

1.7.3 Socio-economic activities:

The main economic activity of the people is peasant farming and some are small scale traders. The main crops grown are subsistence crops like maize, sorghum, groundnuts and beans. Sugar cane is widely grown as a cash crop.

Educationally, Siaya County has a total of 850 learning institutions. The Primary schools are 680. The public primary schools are 621 while private schools are 59. The Secondary schools are 160 while tertiary institutions are 10.

CHAPTER TWO: LITERATURE REVIEW

2.0 Introduction to Chapter Two

Several studies have been done by several researchers on factors that affect academic performance. The factors identified may be classified into two main categories, namely internal and environmental. Some of the internal factors include genetic composition, motivation to work, gender, physical state and psychological state while the external factors include socio- economic status of the parents – some pupils absent themselves to go fishing, mining and work in people's farms due to poverty. The other external factors include political environment, the relationship between parents and teachers, nature of discipline altered by the bill of Rights which guarantees a lot freedoms to the pupils, the nature of supervision by the Ministry of Education, physical facilities, weather conditions and inadequate job opportunities after school. As much as we are looking at factors affecting academic performance, the ultimate driving force of learners going to school is to get a job. The shrinking of job opportunities also makes some learners to drop out of school.

2.1 Internal factors affecting academic performance

The internal factors are factors inherent within individual learner which include; genetic, motivation to work, gender, physical state, and psychological state.

2.1.1 Genetic factors

One may feel he or she is just not capable of doing well in mathematics, or that you have a special gift for languages, but scientists have shown that the genes influencing numerical skills are the same ones that determine abilities in reading, arts and humanities (Guardian and Delvin, 2016). The study revealed an indication that academic performance in learners is linked to inheritance, with about 60% of the disparities in learners' results is due to genetic factors.

Children from the same home, going to the same school and even learning in the same classroom differ in academic performance, indicating that other factors besides shared environmental factors must be present (Rimfeld *et al.*, 2016). Previous research has shown that educational achievement

is substantially heritable from the early school years until the end of compulsory education, which means that, to a large extent, differences in children's educational achievement can be explained by inherited differences in children's DNA sequence. It is reasonable to assume that this high heritability of educational achievement is explained by children's aptitude, or intelligence, but we have shown that educational achievement in the early school years is even more heritable than intelligence. Furthermore, recent studies have shown that the high heritability of educational achievement at the end of compulsory education is not explained by intelligence alone, but rather is influenced by a constellation of genetically related traits, such as self-efficacy, behavioral problems, and personality(Rimfeld *et. al.,* 2016).

Research demonstrates that genetic differences between children not only influence how well they perform at school, but also how easy or enjoyable they find learning in general. It is also worthy to note that children may find certain subjects more enjoyable than others even when their achievement is good across subjects.

The fact that genetic factors influence academic performance suggests that there is difference in the ability to perform. It is however assumed that the population sample is normally distributed to take care of this variability.

An assessment is a score about students learning outcome, based on evidence of achievement in examination or test." (Baird *et al.,* 2014). Performance is as a result of learning.

Learning is an internal positive change of behaviour in an organism as a result of experience and this change can be manifested in performance (Thorndike, 1913).

The change in behaviour doesn't mean a change in physical characteristics but change in intellectual (cognitive) and emotional, attitudes and feelings about the knowledge (affective) functioning. Cognitive or development of the mind, mental processes are reorganized in a progressive manner as a result of body maturity and experience from environment one interacts with (Piaget, 1958). Piaget's theory deals with how people with time come to acquire, develop and eventually use knowledge. He looked at the impact a person's childhood had on their development, and the ways in which maturation affect a child's increasing capacity to understand their world. Piaget asserted that children cannot undertake certain tasks until they are psychologically mature enough to do so. He points out four stages of cognitive development:

sensory motor (0-2 years), language development and conceptual thought (2-7 years), concrete operations (7-11 years) and formal operations (11 years and above). This has been taken to mean that before these ages children are not capable (no matter how bright) of understanding things in certain ways. Therefore there is need for rich, supportive environment for their child's natural propensity to grow and learn.

2.1.2 Motivation to Work

According to theory of Hierarchy of Needs by Maslow (1954), there are people's needs that motivate them to work for better performance. These needs are considered most important by people and have to be met in a certain order. He classified the needs into 5 with physiological needs at the base of pyramid being the most important. This is followed by safety needs, social and esteems needs and finally self- actualization (figure 2.1).

- Physiological Needs- these are basic needs for survival that have to be met e.g. food, air, shelter, sleep, water. A pupil needs them to perform well.
- Safety (security needs) – once the survival needs are fulfilled, one needs assurance for protection from physical danger and job security e.g. a school pupil can only be motivated to perform best if their environmental safety and security is guaranteed.
- Social (Affiliation) Needs- human beings need social company. They need other people to interact and relate their problems to. A pupil needs friendship that is why they join clubs like debate.

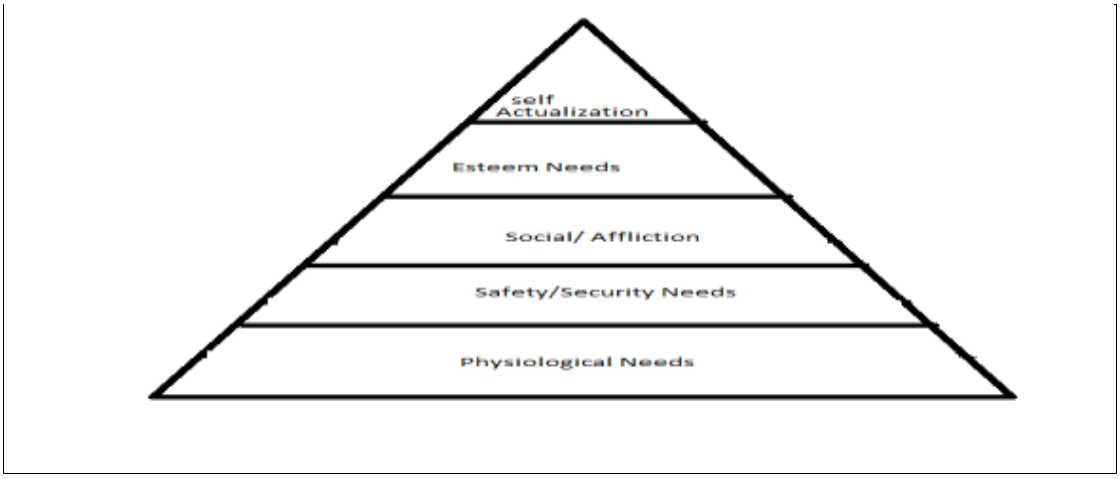


Figure 2.1: Abraham Maslow Hierarchy of Needs (Source- author, 2017)

- Esteem Needs- once the third group of need is fulfilled, desire for work well done sets in. They seek love, respect from others and once this is done the pupil acquires self-confidence, influences others, good reputation (prestige).
- Self-Actualization – this is the final group of need. After self-esteem is met the pupil feels he has satisfied other needs and now feels important. He has maximized his potential.

2.1.3 Leadership, Administration and Management

2.1.3.1 Leadership styles

Leadership is the accomplishment of individual and organizational goals with and through people.

The type of leadership also helps to motivate pupils and teachers to perform well. Some of the examples of leadership styles are (Bass, 2008):

- **Nomothetic style** which only emphasizes work and the attainment of organizational goals only. It is task oriented and ignores the workers who are teachers and the pupils. This kills morale.
- **Idiographic Style** – this considers needs and personalities of both teachers and pupils. Tasks are delegated according to capabilities.

- **Autocratic**–centralizes power and authority. The purpose is to achieve high productivity at the expense of workers.
- **Transactional style** – combines Nomothetic and idiographic. It balances the needs of the organization and the pupils.
- **Laissez-Faire Style** – everyone may do what he wants. There is no real leader and direction.
- **Charismatic Style** – it's based on leader's magnetic personality and influence on others. Having warm personality encourages teachers and pupils to work hard towards better performance.

2.1.3.2 Management

This is working with individuals and group of people to achieve organizational goal e.g. personnel management, recruitment and selection of right caliber of pupils and staff. Some examples of management in school are:

- Finance management – proper financial management through budgeting, accounting and record keeping helps pupils get the best resources and instructional materials for better performance.
- School plant Management – the art of planning of school site, construction of building, maintenance, heating, safety, lighting and repair.
- Policy management – this deals with established policies that guide decision making in establishing laws and regulations.

2.1.3.3 Administration

This is directing and controlling people in social system e.g. school to achieve organizational goals. It deals with the influence of the laws and regulations e.g. KNEC Act (2012) on Examination management, Basic Education Act (2013).

2.1.4 Reinforcement

Tolman and Honzik (1930) Learning theorists noted that performance require reinforcement which is an external drive. Reinforcement is what strengthens somebody in motivating a positive behaviour.

A study was carried out by Blodgett (1929). He designed an experiment involving two groups of hungry rats. One group was allowed to explore a maze that did not have food in the goal box while the second group explored the maze with food in the goal box. The finding was that the second group learned the maze as expected but the first group did not show much improvement. After 7 days Blodgett introduced food in the goal box for the first group and thereafter their performance immediately equaled the second group. This justifies that for learning be translated into performance, appropriate motivation (reinforcement) must be provided.

Hull (1952) came up with a theory of performance.

$$P = D \times L \text{.....(1)}$$

Where **D**. is Drive (Motivation) is a motive that energizes or gives impetus to our behaviour.

L is the Learning process.

P is Performance.

The theory shows that performance is determined by both degree of learning attained and level of motivation.

According to Hull, learning is just one of the variables that determine performance. He argues that teachers tend to assume that the level of performance reflects the strength of what is learned, yet this assumption is erroneous because it often doesn't take into account the contribution made by drive and other factors.

When the drive/reinforcement/ motivation, strength of administration, management and leadership and other factors are held constant, the drop in performance can be correlated with climatic extremes.

However, to assess how much learning has occurred, an examination is administered to determine whether some changes have occurred in behaviour (performance).

2.1.5 Individual Differences

This refers to differences in various individual characteristics e.g. intelligence, attitudes, age, gender, interests, physical appearance.

There exist individual differences that exist among pupils. These differences could be physical, social, emotional or psychological. These differences cause them to perform differently.

Individual differences determined by inheritance and environment. Some human differences are traced to the influence of environment while others are due to inheritance.

The human differences entirely controlled by inheritance or genetic action are skin colour, hair texture, sickle-cell, gender, anemia, colour vision. These differences are fixed genetically and are almost impossible to modify through manipulation of environment. Changes in the structure and activity of the genes called mutation may be brought about by high energy radiation, x-ray or chemicals.

Human differences due to environmental factors such as climate affect behaviour and reactions.

The influence by chemicals or drugs can bring about temporary changes in behaviour. Environmental factors can easily be controlled.

Individual differences can also be due to special children in school. Special children are those who slightly deviate from the average. A Psychologist and Educator; Thorndike (1913) supported the fact that humans perform according to patterns unique to the individual- their intelligence, emotions, memory and attention span.

Attempts have been made to classify pupils on the basis of their intelligence Quotient (I.Q). I.Q is a mathematical formula to measure a person's intelligence. Intelligence is the ability to understand and learn and make judgment or have opinions that are based on reason.

Terman and Merill (1960) came up with classification of learners in different Intelligence Quotient (I.Q) ranges.

Table 2.1: Intelligent Quotient Ranges (Source, Terman, 1960)

I.Q. Range	%in Population	Classification
140-169	1.3	Geniuses/exceptionally gifted
120-139	11.3	Gifted/superior
110-119	18.1	fast learner/high average.
100-109	23.5	Normal
90-99	23.0	Average
80-89	14.5	Retarded/ low average
70-79	5.6	Borderline defective
Below 70	2.63	mentally defective

$$IQ = \frac{(MA)}{(CA)} \times 100 \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (2) \ldots\ldots (Source, Terman, 1960)$$

Where IQ is Intelligent Quotient.

MA is the Mental Age.

CA is the Chronological Age.

IQ is the ratio of mental age (MA) to chronological age (CA) multiplied by 100. For example if a 20 year old answers the questions like a "typical" or "average" 20 year old would, the person would have I.Q of 100.

Gifted pupils are learners with high level of general intelligence. They have active imagination, creative thinking and can be rebellious because of frustrations of being different. They also lose patience of having to wait for the rest of the class to catch up as a result this leads to lose of motivation. The exceptional pupils can also refer to the deaf, blind, speech and hearing problem.

The retarded children are those that are educationally handicapped. American Psychological Association refers to mental retardation as sub-average general intellectual functioning which

originates during the developmental period. This can be due to infant maternal interaction (insufficiency, distortion, cognitive capacities).

Socio-cultural due to child rearing practices, economic level, housing, urban-rural locale.

2.2 Physical factors affecting academic Performance

A study by Eshiwan, (1993) revealed that there are school based factors that contribute to learning outcome of pupils. For example availability of instructional materials, school and class sizes, time management, syllabus coverage and the effectiveness of the school administration. Ngaroga (2007) also found out those school physical facilities such as classroom, libraries, desks and books have a direct bearing on good performance among learners in developing countries. A further study by Wakori (2014) revealed that insufficient instructional material, understaffing, inadequate cooperation among parents and teachers also affect learning in public schools.

According to Wang, *et. al.*, (2015) variables related to learning, include cognitive and affective outcomes, classroom management, quantity of instruction, classroom interactions and climate, and the peer group.

2.3 Cognitive factors affecting performance

This study is based on cognitive- gestalt theory of learning. According to a paper by Burns (1995), people require different things, environments and conditions. That also means that when learners are subjected to the conditions of climate extremes, the need for learning is affected.

Climate extremes interfere with all aspects of life including schooling (Amanchukwu – *et. al.*, 2015). According to the article by Mazon (2014) factors that affect learning are classified into two: external and internal. The internal factors include: Goals set to each learner, motivation of learners, interest in learning, attention given to the learner, drill or practice, aptitude (skills, competencies) and attitude.

2.4 The external factors affecting Learning

2.4.1 State of the learner

Body and home environment also play a role: Various conditions such as malnutrition which is inadequate supply of nutrients to the body, fatigue which makes body weak and poor health are physical obstacles of learning.

Homestead is a where a family members live. If the home environment is not conducive, the learner is not comfortable and this affects his or her learning at school. Certain situations at home are not favourable; poor aeration, dirty and unhygienic environments, poor lighting in the rooms. Such conditions interfere with the learner's rate of learning(Mazon, 2014).

2.4.2 Physical environment

A school's or classroom's design, quality and setting are important in providing a conducive learner friendly atmosphere. The specifications, arrangement, security - proper air circulation, the room temperature – are able to influence learning outcome.

Internal factors held constant, the study is to assess the impact of climate extremes on the external factors.

Many learners are irregular in their school attendance during very heavy precipitation and storms, particularly when there is flooding, roads become muddy and impassable and bridges are swept away. Such absenteeism obviously affects children's learning out- come. Childhood disease is a major cause to school absenteeism. This affects teacher-pupil contact time and incomplete syllabus coverage which in turn leads to low educational performance (Bundy and Guyatt,1996). Whenever there is dry spell, majorly women and girls are tasked with drawing water—a problem which may stop them from going to school as much time is spent on travelling longer distances in search of water. Drought results into food insecurity. This in turn leads to starvation. Starving children have low concentration span. During this time also due to water and pasture shortage boys move with the cattle looking for grass and to water the livestock.

In case of flooding, school going children usually move with their families to safer places to avoid being swept by overflows. This disrupts their normal school studies as this increases their

travelling distance to their schools .High rainfall frequencies also damage their houses, school buildings forcing the children to migrate. Some schools are shut down for some days to allow for the building of new classrooms to replace the damaged ones. This affects the learning outcome and performance in examinations (Ekhtheknaul, 2014) because they waste some days without attending school. It also makes all weather roads muddy and impassable making schools inaccessible for teachers. Cholera, which is associated with drought due to insufficiency of water, also interferes with education of children because they fall sick and spend their school time in hospital.

Climate change causes livelihood imbalance, which is further responsible for drop out from schools (Ekhtheknaul, 2014) during drought, crops that are not irrigated fail in the farms and leading to food shortage; this forces some learners to look for jobs to fend for themselves. Malaria prevalence is increased when it floods (Amekudzi, 2014).Flooded pools of water are potential breeding grounds for mosquito which spreads malaria. Strong winds blow off roof tops of classrooms forcing schools to be temporarily shut down or learners learn under trees.

Globally, according to climate change adaptation plan U.S.A Department of Education (2014), the Climate variability affects the Department's overall mission of enhancing learning outcome and preparation for the competition of the global chances. It can also impact on the Department's capability to guarantee equal access to educational opportunity for every learner. The changing climate is creating additional challenges in maintaining a healthy school environment in the United States (U.S.) (Sheffield et. al, 2017).

In Kenya, the National Climate Change Action Plan 2013-2017 (GoK, 2013) acknowledged that climate change awareness and its impacts is limited in the education curriculum and therefore this study was ideal to critically establish its impacts on academic performance.

2.5 Conceptual frame work

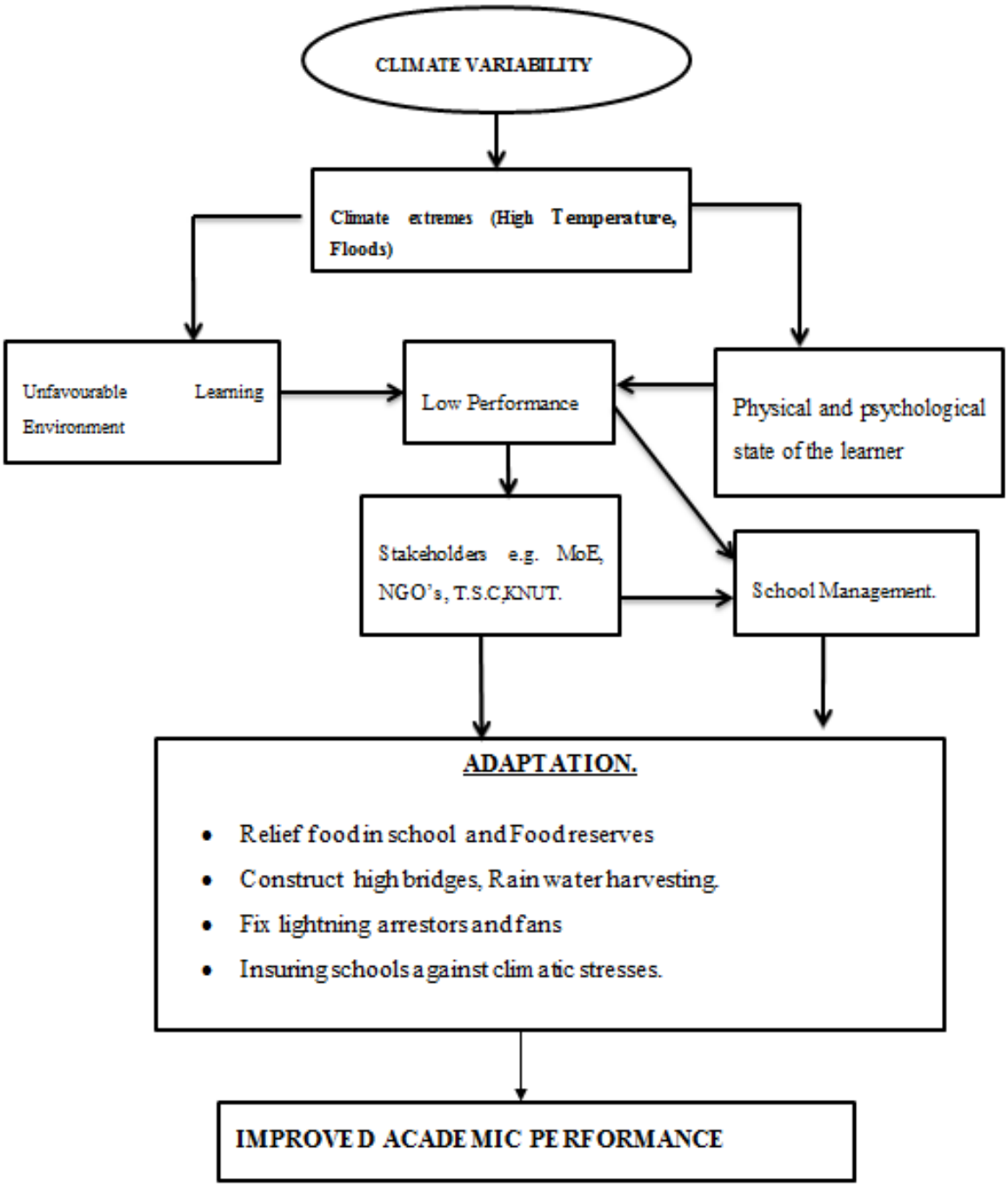


Figure 2.2: Conceptual frame work (source, Author, 2017)

CHAPTER THREE: DATA AND METHODOLOGY

3.0 Introduction to Chapter Three

This section outlines the data and methods used in the research. It includes data types, sources, research design, targeted population, sampling of respondents, data collection process, the data quality control and data analysis. The data that was collected captured both the perception of the respondents and statistical data from Kenya Meteorological Department. The data used includes monthly temperature and rainfall records from Siaya County Meteorological office and K.C.P.E performance from schools.

3.1 Data types and sources

Both primary and secondary data were used in this study.

3.1.1 Primary Data

Primary data was mainly sourced from specific schools within the target community.

The schools were clustered into six sub- counties and then into 34 zones.

From the zones, Simple systematic random sampling technique was used. The schools were selected systematically at an interval from the list. The technique was used because Siaya is a diverse geographical area with many public primary schools. This method provides an opportunity for each school to be selected entirely by coincidence and each member of the target population has equal chance of being included in the sample size.

The raw data was obtained through structured questionnaires and photographs. Every sampled school had 4 questionnaires administered. One for the head teacher and 3 for pupils.

Ground photographs were taken to show the effects of the climate variations on the school physical structures.

3.1.2 Validity of the questionnaire

Validity is the extent to which the instruments used during the study measure what it was intended to. The validity of the questionnaire was based on how it was constructed and its contents.

The study established the validity of the structured questionnaires by pretesting based on a sample in Nyaharwa Zone (Ugenya Sub County) before proceeding to the field to collect data. Four schools were randomly selected. Each school was given a questionnaire for the head teacher and three for the pupils. The questionnaires were the ones to be used for the study. The responses were collected and analyzed.

Both Positive and negative comments were incorporated to make the questionnaire capture appropriate, useful and dependable data whose findings and inferences can be a true reflection of the study population (Mugenda and Mugenda, 2003).

3.1.3 Reliability of the Questionnaire

Reliability is the consistency in the results when the same tool (questionnaire) is used by a different person at a different time when all the other factors are constant. To ascertain reliability, the study tool was done by pre-testing in one identified school (Kogere Primary school) by different research assistants. The responses and analysis by the different research assistants were used to review the data capture tool. Pre –testing enables one to focus on questions to help in clarity and reduce ambiguity.

3.1.4 Secondary sources of data

Secondary data is the work that is already in existence in relation to the research topic which is available in the public domain. A comprehensive literature review was carried out to get information on the research problem relevant to the existing knowledge and research gaps on impact of climate variation on academic performance. The information was obtained from published books, magazines, journals as well as on-line resources within the World Wide Web.

A desk top research was extensively undertaken to establish and review available information and data in relation to the topic and area of study.

Secondary data provided essential qualitative information that further enriched this study.

Siaya County education office provided data on number and nature of schools in the region i.e. Public and Private schools, Primary Boarding and Day schools.

Archived climate data sets on Rainfall and temperature were collected from Kenya Meteorological Department to provide an independent view of climate variability trends over the years. The data used consisted of observed rainfall and temperature data from the year 1990 to 2016. A period of over 2 decades was selected because climate is experienced after a long period of time.

Data on academic performance of sampled schools from 1995 to 2016 was given by head teachers.

The study couldn't go beyond this time since data on school performance beyond this time was missing in most schools. The head teachers provided information on performance in K.C.P.E examinations of their schools and their opinions on the impact of climate variation on academic performance. K.C.P.E results were used because it is the standard measure of achievement for all pupils after undertaking learning an 8 year course. The pupils also gave their opinions on the climate variation on their performance as discussed on the results.

3.2 Data Collection Techniques

The methods that were used to collect and analyze data in this study were: surveys, interviews and from publications. Student t – test was used to test for significance of trends and level of correlation between performance and weather elements.

3.2.1 Research Design

The study was based on a cross-sectional survey design. This is a descriptive research design which involves a representative sub-set of a population. The advantage of this design is that it is relatively quicker and cheaper to undertake and the results can be easily inferred to a larger

population. It allows for qualitative and quantitative data. Quantitative method involves filling of questionnaires by the individual interviewees. A qualitative field survey involves capturing information using Focused Group Discussion. The study used Quantitative methods.

3.2.2 Research Procedure

Before administering the questionnaire, the purpose of the study was explained to the research assistants and the respondents. Those who agreed to be interviewed gave a verbal consent. This study considered gender balance and it ensured that half of the respondents were of either gender.

The data was then entered in excel sheets. The analysis tools were the excel spread sheet and the SYSTAT.

On analysis the data collected from the questionnaires was organized, prepared classified and summarized according to variables and objectives for study in tabular form as in table 3.1.

Table 3.1: The pupils who fall sick in wet seasons

THOSE WHO FALL SICK	**No. of Respondents**	**% of Respondents**
Increases	87	75.65
Decreases	0	0
Remains same	2	1.74
slightly increase	26	22.61
TOTAL RESPONDENTS INTERVIEWED	115	

The totals and percentages of the responses were calculated. The percentage of respondents was obtained by:

$$\frac{Numberofrespondents}{Total...respondents...\text{int}erviewed} \times 100 \quad \text{.....(3)}$$

The percentages of the respondents were presented using histograms and pie charts

3.2.3 Sampling Methodology

The Sampling targeted day primary schools in Siaya County. The choice of public primary day schools was guided by the researcher's assumption that impact of climate variation on academic performance is mainly prominent on public day primary schools as opposed to their counterparts in boarding schools and secondary schools that might be operating under controlled environment. The consideration of climate variability was limited to temperature and rainfall covering a period from 1995 to 2016.

Both cluster and Simple random sampling techniques were used in selecting the sample population.

Cluster (area) random sampling is used when population is spread across a wide geographical area which is the case of Siaya schools. Using this method the population was divided into clusters (groups). The schools were clustered into six sub- counties and then into 34 zones.

The research design cut across different public day primary schools involving a sample of 186 schools from Siaya County. According to the Kenya's Ministry of Education statistics, by the year 2016 the area had 621 public day primary schools.

Many researchers have proposed various methods of determining sample size. Some of the most common methods are discussed below.

The Yamane method (1967) in equation 5 below is used with an assumption of confidence level of 95% and precision level or sample error (e) of 5% (0.05).

$$n = N \big/ (1 + N(e)^2 \quad \text{.....(4)}$$

Where; **n** is the sample size

N is the population size.

e is the sample error.

$$n = 621 \big/ 1 + 621(0.05)^2 \qquad = 243$$

From this method, therefore being that the total population of public day primary schools in Siaya county total up to 621(MOEST, 2016) the sample size of 243 schools was got. This was to be distributed in the whole county.

According to Mugenda and Mugenda (2003) a sample size of 30% of the population is appropriate in social science study; therefore 30% of 621= 186 schools, the study adopted Mugenda (2003) method because the sample size got is easy to work with.

The schools were then grouped into zones and a sample selected depended on the number of schools in each zone. The study used Orodho's (2009) proportionate approach, which begins to determine the probability of selecting any individual from the sampling unit.

This is indicated in equation 6:

$P = n / N$.....(5)

Where:

P is the probability

n is the desired sample size;

N is the total population for all the strata

The probability for inclusion of any school within Siaya County in the sample was thus (**186/621) =0.2995**.The number of schools from each zone to be included in the sample was then arrived at by multiplying the number of schools in each zone by **0.2995** as illustrated in table 3.2.

Table 3.2: Sample frame for the schools

SUB COUNTY	ZONE	NUMBER OF SCHOOLS	SAMPLED SCHOOLS
UGENYA	Sega	14	4
	Bar-Ndege	17	5
	Nyaharwa	17	5
	Gaula	15	5
	Jera	19	6
BONDO	Maranda	16	5
	Aila	17	5
	Bar Kowino	17	5
	Amoyo	20	6
	Nango	20	6
	Nyamonye	17	5
	Usenge	18	5
GEM	Kambare	22	7
	Komuok	15	5
	Sirembe	13	4
	Bar-Kalare	15	5
	Manga	18	5
	Nyawara	23	7
RARIEDA	Manyuanda	18	5
	Ndigwa	19	6
	Uwimbi	21	6
	Mahanya	23	7
	Nyayiera	17	5
	Nyilima	17	5
SIAYA	Kowet	13	4
	Ulongi	23	7
	Awelo	15	4
	Bar-ogongo	21	6
	Kirindo	19	6
	Dibuoro	17	5
	Mwer	18	5
	Ambira	23	7
UGUNJA	Sigomre	25	7
	Sikalame	19	6
TOTAL		621	186

Siaya County Schools: Source (author, 2016)

The schools were then selected from the list of schools per zone provided by County Director of Education, Siaya. The list was based on year of registration of the schools. The individual schools were selected using Simple systematic random sampling.

3.2.4 Simple systematic random sampling.

This is where selection of samples from the sample frame is made at regular intervals. The technique was used because Siaya is a diverse geographical area with many public primary schools. This method provides an opportunity for each school to be selected entirely by coincidence and each member of the target population has equal chance of being included in the sample size. To determine the sample interval (i.e. the interval at which a sampling unit is selected) equation 7 by Orcher (2005) was used.

$K = N / n$.....(6)

Where **K** = sampling interval

N = Population (sampling frame)

n = sample size.

Thus 621/186 = 3.338. Hence, the researcher randomly selected the third school in the population of the zone.

3.3 Data Analysis

In this section methods used in analysis are described.

3.3.1 Data Quality Control

Data quality control is the process of data profiling to discover inconsistencies and other anomalies in the data, as well as performing data cleansing activities (e.g. removing outliers, missing data interpolation) to improve the data quality. It is an (Harman, 1967)attempt by data user to minimize errors and remove mistakes from data set. The inconsistencies may occur from natural influence in observation schedules and methods, instrumental changes or human processes (WMO; 1986).

The most commonly used methods are; mass curves, correlation and regression, relative homogeneity test among others.

3.3.1.1 Estimation of Missing Data

For the missing data, the research employed arithmetic mean ratio which is the simplest and most objective method of estimating data. In this method, the long term averages of two correlated locations such as performance of 2 schools in one zone are used to estimate the missing record using the equation below;

$$X_m = \left(\frac{\overline{X}}{\overline{Y}} \right) y_m \quad \text{.....(7)}$$

Where X_m is the missing data in a station.

$\overline{X}$ Is the long term Mean of the station with missing data in a certain year or month.

$\overline{Y}$ Is the long term Mean of the station with complete data.

y_m Is the corresponding data of a station with the complete data.

This method has an advantage because the significance of the estimated data can be tested using statistical tests. However, its disadvantage is that it doesn't take into account the individual variations of stations like, location, topography, resource allocation.

Since rainfall and temperature data were for a single station, the missing data was filled by interpolation by getting the average of two adjacent data sets.

3.3.1.2 Consistency/ Homogeneity test of the Data

The method commonly used to detect heterogeneity in data sets is single and double mass curves.

In this study a single mass curve was used. In this method cumulative mean rainfall, temperature and performance data (the deviations from the mean) were plotted against time. The graph obtained is a single mass curve. From the shape of the graphs, the data was homogenous by the

straight or approximately straight line obtained. In case data is heterogeneous data show deviations from straight line.

If the data is heterogeneous, then cumulative mean plot of rainfall/temperature/performance data against corresponding cumulative mean rainfall/temperature/performance data from two or more neighbouring stations with homogeneous data are plotted. The graph obtained is a double mass curve and would be used to adjust heterogeneous data sets.

On performance, the initial data organization was to get the annual mean scores per Sub County then the mean score for the whole county. The means were then plotted against the years on histograms and graph to show the trend in academic performance.

3.3.2 Determination of Trends

The trends for performance and climatic elements were determined by plotting annual mean parameters and years using excel.

3.3.2.1 Test for Significance of Trends

It is also called independent t test. It is used to compare means of two unrelated group of samples. It tests whether the average of the variables are significantly different. Once t-test statistic value is determined, you read in t-test table the critical value of Student's t distribution corresponding to the significance level alpha of your choice (5%). The degrees of freedom (df.) used in this test is total of sample: $n_1 + n_2 - 2$

The significance of the observed trends for monthly and annual rainfall and temperature trends were tested using the student t test method. The equation for student t test is;

$$t = \frac{\overline{x_1} - \overline{x_2}}{\sqrt{\frac{s_1^2}{n_1} + \frac{s^2{}_2}{n_2}}}. \quad \text{.....(8)}$$

Where $\bar{X}_1$ = Mean of the first set of values.

$\bar{X}_2$ = Mean of the second set of values.

S_1 = Standard Deviation of first set of values

S_2 =Standard Deviation of Second set of values

n_1 = Total number of values in first set of values.

n_2 =Total number of values in second set of values

3.3.3 Determination of Relationships

The relationship of performance and climatic elements was determined using SYSTAT software.

3.3.3.1 Correlation Method

Correlation Analysis is used to quantify the relationship between two or more variables. The Pearson correlation coefficient (r) has the limits +1 and -1. Zero (0.0) values imply no relationship while + 1.0 and – 1.0 implies perfect positive (direct) and negative (inverse) relationship or high level of linear association between the pair of variables (x, y). The equation is given below;

Where r is the correlation coefficient between x and y where by the variables represent x as rainfall and temperature and y as the performance.

Correlation was used to establish the relationships or association between climate variability and academic performance of learners in the county. It was used to achieve the third specific objective.

3.3.3.2 Testing the significance level of correlation between performance and the weather parameters.

Upon computing the correlations, the significance was assessed using the student t test which involves computing the t test value and comparing it with critical t value from the t tables at 5% significance level. Satisfactory results are interpreted as 95% assurance that the variables being considered are not correlated by chance. The mathematical formula for computing the *t* is given below;

$$r_c = \sqrt{\frac{t^2}{t^2 + n - 2}} \quad \text{.....(9)}$$

Where *r* is the critical value at a significant level of 0.05 = (5%)

t is the value from the student *t* table which is 1.734.

n-2 is the degree of freedom *(df)* number of cases in consideration (20years-2) = 18.

$$\sqrt{\frac{1.734^2}{1.734^2 + (20-2)}}$$

The critical value (r) generated from the student *t-test* table was 0.378329.

Student *t* test was used to compare the averages of Monthly minimum temperature, maximum temperature and Rainfall in order to test which months are significant in determining the performance in each sub-county and the county as a whole.

This was done by testing the level of significance between performance and weather elements.

3.3.4 Principal component Analysis (PCA)

Homogeneity in performance among the sub-counties in the county was also determined using Principal Component Analysis to compare the spatial coherence in performance in the county.

This is a tool used to group or classify features that behave the same or that have similar characteristics. The regions that are affected by the same factors are grouped together.

It was used to compare the spatial coherence within the county by comparing performance in the sub-counties.

Principal Component Analysis is a statistical method which can be used to objectively quantify complex **v**ariability both in time and space**.** Principal component Analysis (PCA) has been widely used to delineate complex space-time correlations between several variables. In this study Spatial-PCA modes were used to study the space characteristics of the academic performance in Siaya County.

The major advantage of PCA is that it enables fields of highly correlated data to be presented adequately by a small number of orthogonal patterns (eigenvectors) and corresponding orthogonal time coefficients. The first principal component or eigenvector is that pattern which explains the greatest fraction of the total variance. Subsequent eigenvectors account for the

largest parts of the remaining variance. This property of extracting principal components in a descending order of the magnitude is very important in cases where only a few components are required to summarize the observed data.

The basic principles of PCA are derived from the concept of variance. The first step usually involves the computation of some measures of association between the set of variables used. This is followed by the construction of a linear set of orthogonal vectors (eigenvectors) that is finally used to represent the various variables. Essentially, the method of principal components consist of a transformation of a greater number of un-orthogonal (manifest) variables into a smaller number of orthogonal variables, which present common causes of manifest variable changes.

If the parameter under study (KPCE performance) is fixed, then it is possible to generate the correlation data matrix between various locations (Spatial-Mode) over a set of periods, or between periods (Temporal -Mode) over a set of locations. The S-Mode can yield groupings of periods with similar spatial patterns. In an S-mode analysis the variables are stations and the observations are the values at each time. The principal component loading matrix contains the correlation of each station with each component. These can be plotted on a map to depict the spatial pattern of each component.

In T-mode analysis, the standardized data matrix is transposed so that each of the individual time periods is changed to a variable while the station names become observations. This analysis produces components with loadings on the individual times (forming a "time series"), and amplitudes or scores on the observations (stations), give the spatial pattern. The factor loadings in T-mode analysis are also time coefficients, which can be used as weights in areal averaging. While S-mode can be used to classify locations with similar temporal anomalies, T-mode can be used to classify years which the specific sub-regions experienced similar spatial anomalies.

The principal component analysis, the orthogonal functions are defined as mathematical linear transformation of the original data. Mathematically, a variable Z may be transformed in terms of m components as shown below:

$$Z_i = \sum_{i=1}^{m} a_i F_i \quad \text{..... (10)}$$

Where Z_i is variable *i* in the standardized form

F_i Represents the orthogonal vector (Eigen vector)

a_i Is the standardized multiple regression coefficient of the variable *i* on factor *i*

In this study, we have used PCA S-mode to demarcate homogenous sub counties with respect to KCPE performance. This method has widely been used in determining regional homogeneous rainfall zones over Kenya and East Africa by Ogallo (1989), Oludhe, (1987), Basalirwa (1991) and Okoola (1996) among many others. Detailed discussions on this method are presented by Catell, (1966) and Herman, (1967).

3.3.4.1 Significance of factor coefficients

In testing the statistical significance of the factor coefficients, the formula developed by Burt and Banks (Burt, 1952) was applied. It noted that factor loading were, correlation coefficients and for the purposes of specifying an acceptable level of significance they could be treated in a similar manner to correlation coefficients. However Burt and Banks showed that as one progressed from the first to subsequent factors in the extraction process the standard error (SE) of subsequent loadings increased. They, therefore, produced a formula for computing the standard error of a loading which includes the necessary correction for the factor number. This formula is of the following form.

Standard error of a loading =standard error of a correlation $\sqrt{\frac{n}{n+1-m}}$ **..... ...(11)**

Where **n** is the number of variables and **m** the number of components.

The standard errors of correlations may be estimated from the table given by Child (1990).

Significant component have coefficients greater than twice the standard error of the loading. This criterion was used in this study to determine the statistical significance of the loadings.

3.3.4.2 Number of Significant Principal Components (Eigenvectors)

Both principal component and factor analyses deal with fallible data. Individual measurements and correlation among variables are subject to the vicissitudes of sampling. As a consequence, there is sampling variation present in the results of the analyses. The judgment concerning the statistical significance of the number of common factors, m, to be extracted during the factoring should be based on their contribution to the reproduced correlations as related to the actual sampling variations of these correlations. Many researchers, therefore, have proposed various methods of determining the numbers of significant principal components (factors). Some of the most common methods of determining the number of component/factors to be retained in any factor solutions are discussed below.

One of the simplest methods of determining the significant principal components was developed by Kaiser (1959). The method assumes that all principal components with eigenvalues greater or equal to one are significant.

Cattell (1966) has suggested that the Kaiser's criterion may be more reliable only when the number of variables is between 20 and 50. However, the Kaiser criterion has the advantage of each of application, to compute factoring and has been incorporated in many computer subroutines (Nie, *et. al.,* 1970)

Other methods of determining the significant principal components are The Scree Method, The Logarithm of the Eigenvalues (LEV) Method, and the details of the methods can be found in Okoola (1996). In this study Scree method was used to determine the significant principal component. In order to obtain distinct pattern, the PCA were rotated using Varimax.

3.3.5 Variability of Climatic Parameters

The study involved determining the temporal variability of climatic elements, namely, minimum temperature, maximum temperature and rainfall. The first step involved data organization into mean annual maximum and minimum temperature and mean annual rainfall. The means were plotted against the years to determine the trends.

3.3.5.1 Co-efficiency of variability:

To determine the variations of the climatic parameters, co-efficiency of variability was used; it normalizes the data so that we can compare the various parameters of different magnitudes.

$$\textit{Coefficient of variability} = \frac{(SD)}{\bar{X}} \times 100 \quad \text{.....(12)}$$

Where SD is the Standard Deviation,

$\overline{X}$ Is the mean of weather elements

3.3.6 Multiple Linear Regressions

Using the observed performance, a multiple linear regression model was used to generate the predicted performance for the last 5 years from 2011 to 2016 for every sub county and then the county. The following linear regression model was used;

$$y = a + b_1 x_1 + b_2 x_2 + \text{.....} + b_n x_n \text{.....(12)}$$

Where ***y*** is the dependent (predicant) variable in this case performance. $\boldsymbol{X_n}$ is the predictor (dependent) variable in this case the climatic parameter, ***a*** is the intercept and ***b*** is the coefficient.

3.3.6.1 Determination of Predictors

The predictors were then determined using stepwise method. This was done using backward and forward steps which are in built in the SYSTAT software.

3.3.6.2 Goodness of fit

Both Chi square and Coefficient determination (R Squared) were used to test the skill of each model (the goodness of fit). Whether the model can forecast into the future or not.

Chi square was used to test the forecasting skill of the models, whether the models used have the ability to predict into the future so that we can continue using them. Goodness of the model was tested by getting the total of the chi square (χ^2) of the predicted and observed performance of the last 5 years. The total chi square becomes the computed value. The computed value was then compared with tabulated or critical value with df = K-1, where k is the number of categories in

this case k= 5-1, 5 is the predicted years of Performance df = *4* at level of probability of 0.05. When there is no discrepancy or much difference between observed and predicted values, the error becomes small. The smaller the error the better the model. Therefore the model is said to have skill for predicting the future.

3.3.7 Photography

Photographs were used for ground visual interpretation. They were used to capture the impacts of the climate extremes on the physical structures of the schools and some of the coping strategies in use in the schools. In addition to that, photography was used to capture environmental impacts of drought on water resources which cause the children to spend considerable time in search of water.

CHAPTER FOUR: RESULTS AND DISCUSSION

4.0 Introduction to Chapter Four

This chapter presents the results obtained using the methods described in chapter three.

The results obtained from examining the quality of the data used in the study is presented in section 4.1.

In section 4.2, the results obtained from analysis of temporal variation of climatic variables. Siaya County is presented in section 4.3, while the relationship between climatic variables and performance is presented and discussed in section 4.4.

4.1 Results from Data Quality Control

Both climatic data and the academic performance data were subjected to quality control. The quality examined in the present study was consistence. This was accomplished through the homogeneity test of single mass curve. All the data used in the study was homogeneous and hence suitable further analysis. An example of the result obtained is shown in figure 7.

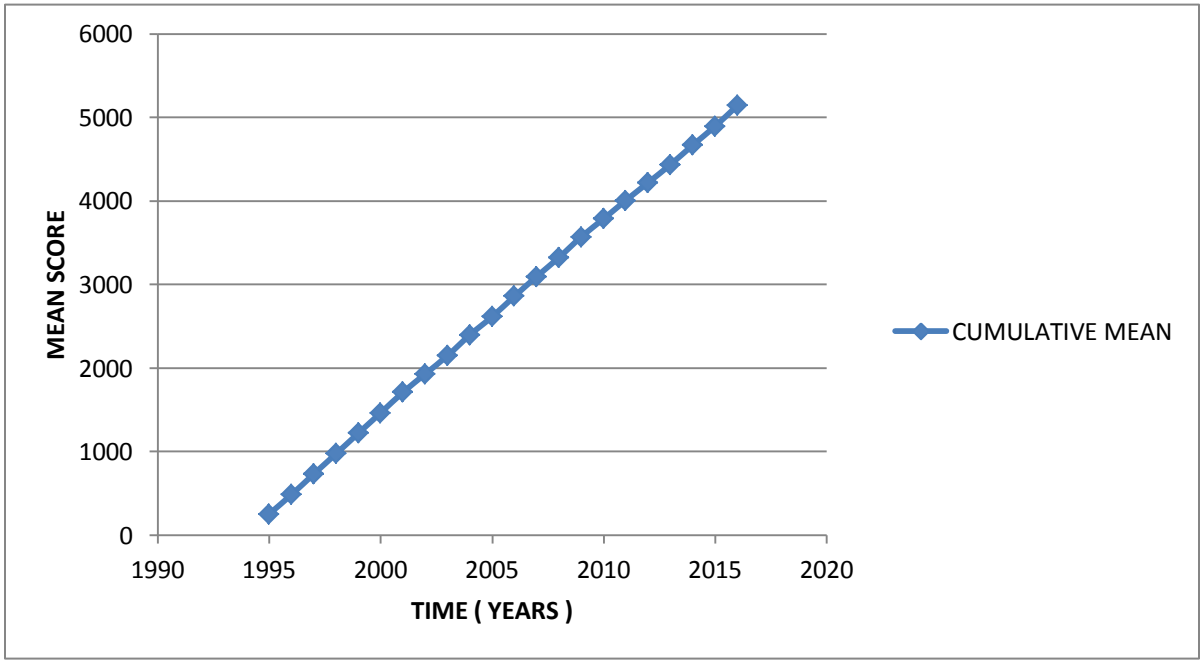


Figure 4.1: Single mass curve for Ugenya Sub – county KCPE Performance

4.2 Results from temporal climatic Variability

The temporal characteristics of climatic variables examined in the present study included; the annual cycle, inter annual variability and trend.

4.2.1 The Annual cycle of climatic variables

4.2.1.1 Monthly Mean Rainfall

Figure 4.2 shows the monthly mean rainfall over Siaya County. The rainfall is bimodal. The peaks occur around March to May (MAM) and September to November (SON). However, the peak observed around MAM is higher than that around SON. December to February (DJF) and June to August (JJA) depicts the two minima observed although the JJA has a higher minimum rainfall.

Over the study period, the wettest and the driest monthly rainfall averages were 223.63mm and 41.96mm in April and February respectively.

The rainfall pattern in Siaya is bimodal and this is linked with oscillation of the Inter Tropical Convergence Zone (ITCZ). This is a narrow zone where low level moving air masses from both hemispheres converge. The up and down movement is brought about trade winds. It crosses the equator in April as it migrates to Southern Hemisphere (SH). North East (NE) and South East (SE) trade winds converge at the ITCZ. The SE trade winds bring long rains between March and May. NE brings short rain in October to December hence season of short rain (Mutai *et. al.*, 1998).

Between January and February the amount of rainfall is low with February having lowest of 41.96mm. April and May portrays rainfall highest rainfall of 223.63mm. This leads to floods making the roads muddy and impassable, pupils' books get drenched, sweeping away of bridges. This makes the pupils to arrive at school late.

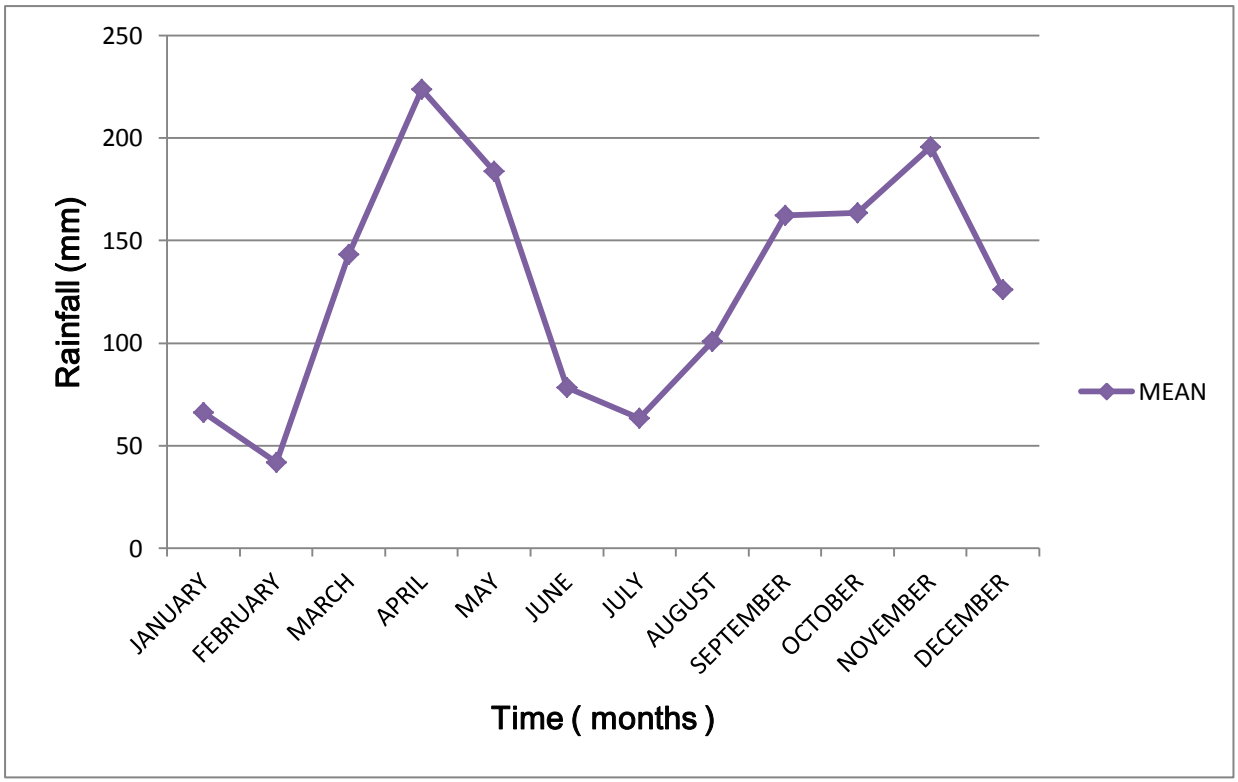


Figure 4.2: Shows Rainfall Variations for Siaya (KMD, 2016)

4.2.1.2 Maximum Temperature Variations

The analysis of maximum temperature variations in figure 4.3 (a) shows that the average (normal) maximum temperature ranges from 28.94 °C to 30.86 °C. The maximum temperatures of the months of February to March and May to July are deviating from the average**.** February and June are the peaks of maximum temperature. February is the highest maximum temperature while June is the lowest minimum temperature. These months are critical in school calendar.

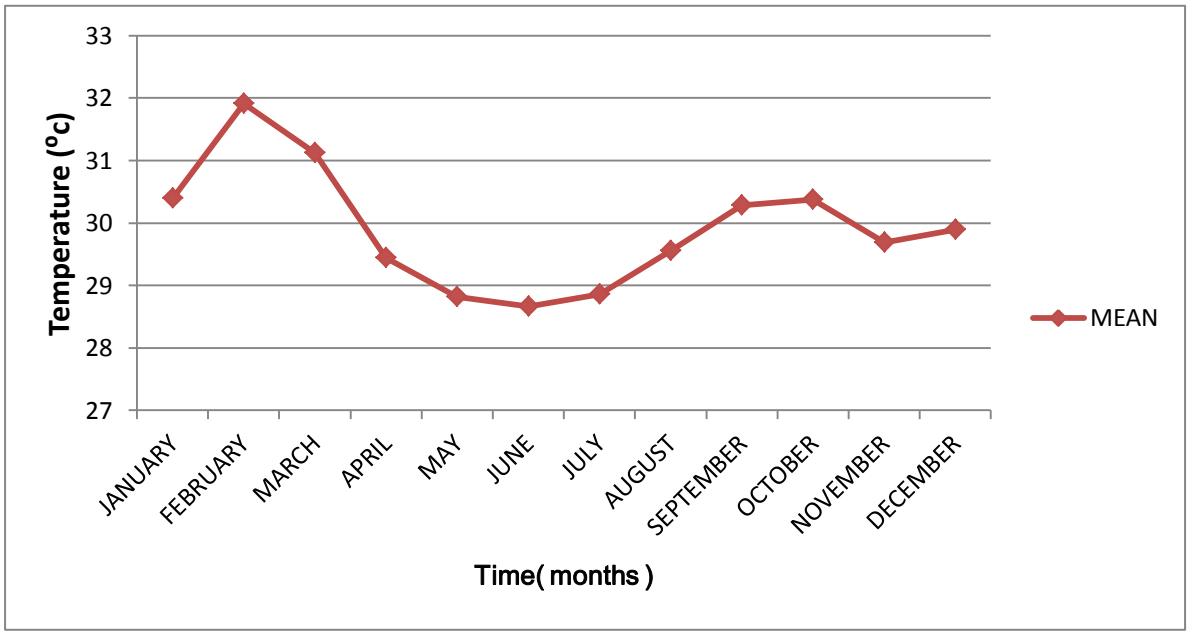
What drives the seasonal pattern of maximum temperature is the solar radiation. The annual cycle of radiation is linked with position of the sun. This may be due to the north – south shift of the position of the overhead sun. During this time (March and September) the sun is directly overhead the equatorial region, therefore maximum insolation is realized. The maximum solar radiation is received at the equator and the length of day and night is nearly equal .This is referred to as *equinox*. The word is derived from two Latin words '*aequus'* meaning equal and '*nox'* meaning night. Though in reality, equinoxes don't have 12 hour daylight. There are two

equinoxes every year – in March and September. The March equinox happens between 19th and 21st March.

The sun passes equator in March and September. This is due to the tilting of the Earth at 23.4° in relation to the ecliptic orbit hence leading to high temperatures and because since Siaya is near the equator with latitude 0° 18′ N and 0° 64′ S and Longitudes 33° 58′ E and 34° 33′ E, it experiences the same temperature.

The sun passes equator in March and September but from figure 4.3(a) Siaya experiences maximum temperatures much earlier in February and later in October before the sun crosses the equator. Whereas solar radiation drives the temperature change, this could be due to advection of hot air masses from the desert leading to the change in temperature. October is expected to be colder but because of cloud cover, there is high temperature.

In maximum temperature, February and March are hot months. In November, there is a drop in temperature; this might be due to high cloud cover which reflects much of the solar radiation back to space. The hottest month observed was February with a temperature of 31.91 °C.



4.3. (a) The mean monthly Maximum temperature over Siaya County

Figure 4.3 (b) shows that Minimum temperature is bimodal i.e. two peaks within a year in the moths of April and November while maximum temperatures are in the months of February and October.

Minimum temperature is high in MAM and SON with the highest peaks in April and November. The month with the warmest night temperature is April with a temperature record of 18.28 °C. This could be attributed to a blanket of shielding effect by clouds making the nights warm. July was observed as the month with the coldest morning at 16.98 °C. In July advection of cold air during day and night and decreased day time heating due to stratus clouds in the sky during this season leads to cold nights.

It is warmer in April and November at night due to high cloud cover which act as blanket trapping the long wave radiations.

However the peak observed around January to March in maximum temperature and MAM in minimum temperature is more defined than that in SON. The reason could be the faster northward and slow southward shift of the overhead sun as it apparently passes through the equator.

The normal minimum temperature of the county lies between 16.88 °C and 17.37 °C .Siaya County experiences the highest minimum temperatures in the month of April. During this time the morning temperature is colder than other months.

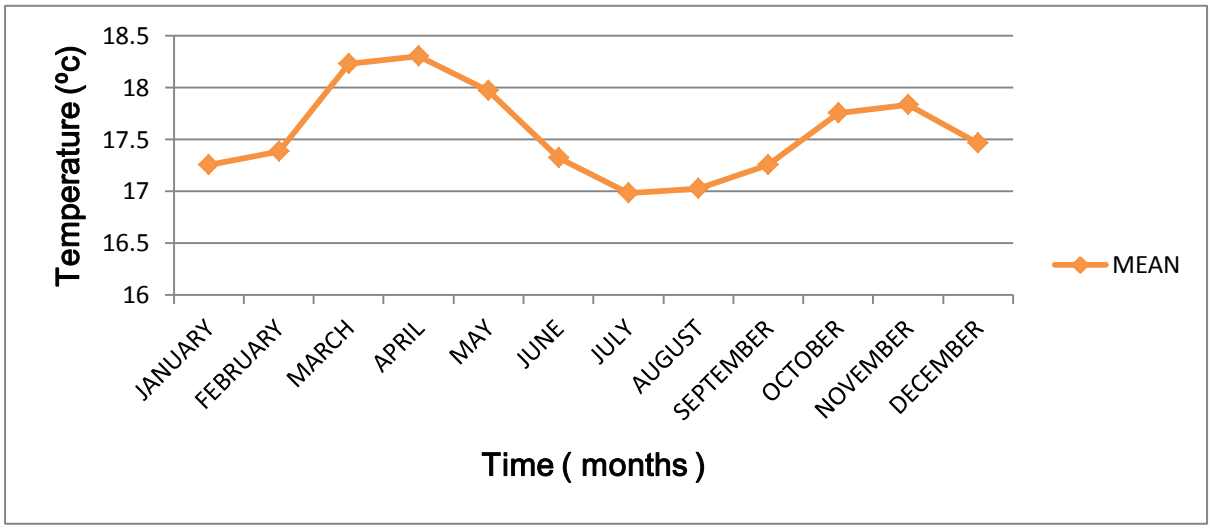


Figure 4.3(b): The mean monthly Minimum temperature over Siaya County

Figure 4.4 shows the time series of rainfall over Siaya County. Generally the annual mean rainfall trend has been on the decline over the years with the year 2011 being the driest with rainfall amount of 67.71mm and the year 2002 being the wettest with annual rainfall of 188.51mm. Other studies for example (Abura *et.al.* 2017) have reported that on average the area receives annual rainfall of between 800mm -2000mm. This shows a decline in the annual rainfall over the area.

In the first decade from 1995 to 2005 there was a slight increase in rainfall with the year 2002 being the peak . In the second decade from 2006 to 2016, the area experienced a decline in the rainfall amount. The slope of the decline was steeper than the increase, so that over the whole period there is a negative trend.

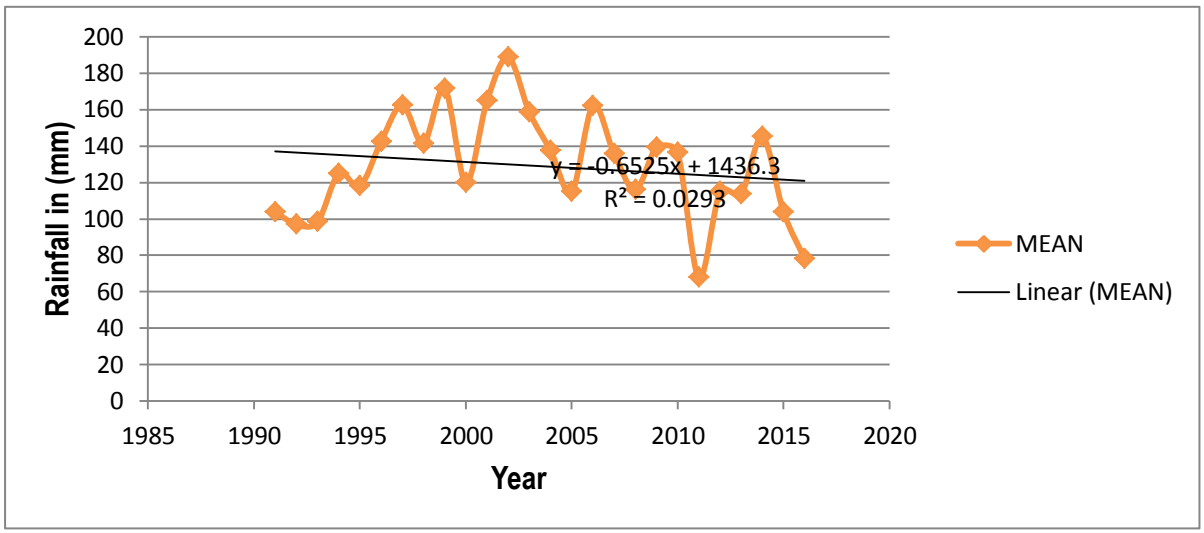


Figure 4.4: Annual Rainfall trend over Siaya (KMD, 2016)

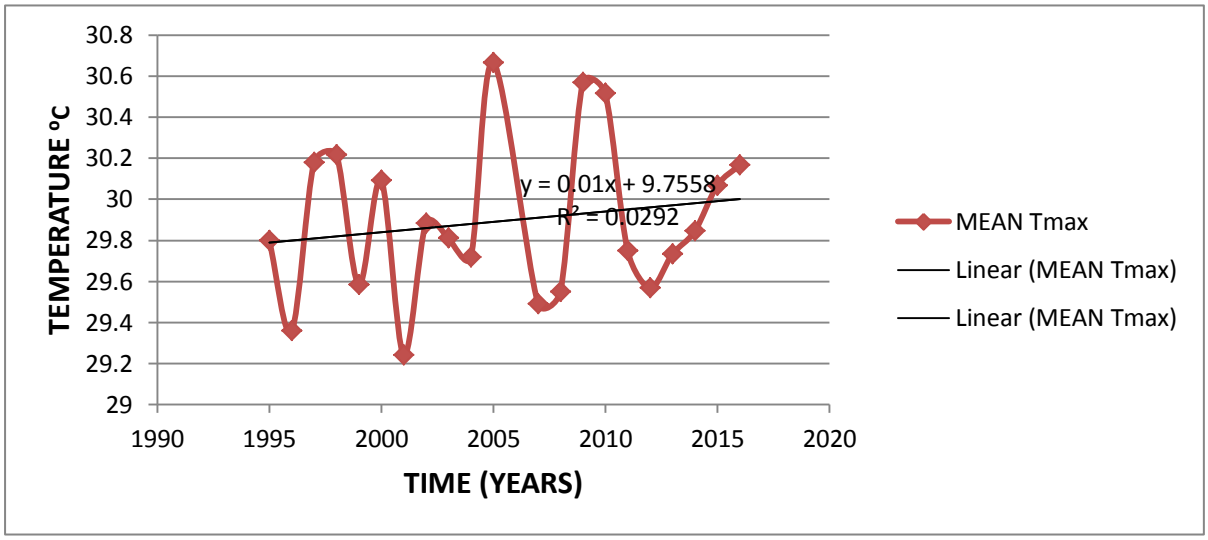
The time series of maximum and minimum temperature over Siaya County is shown in figure 4.5(a) and figure 4.5(b) respectively.

Over the study period, the year with the highest maximum temperature was 2005 with a record of 30.66 ºC and the year with the highest minimum temperature was 2015 with a record of 18.52 ºC. The slope of the minimum temperature is steeper than that of maximum temperature. Since the minimum temperature occurs at night it implies that the nights are becoming warmer. Warm night temperature due to cloud cover and water vapour which forms a layer that allows shortwave energy to penetrate but absorbs and retains long wave (terrestrial) radiations from the ground. This keeps the night warm.

The lowest maximum and minimum temperature records of 29.24 °C and 17 °C were observed in 2001 and 1999 respectively.

The study noted that maximum and minimum temperature has been increasing. Thus the day and night temperatures have been getting hotter.

(a)



(a) **Mean annual, maximum temperature trends over Siaya County**

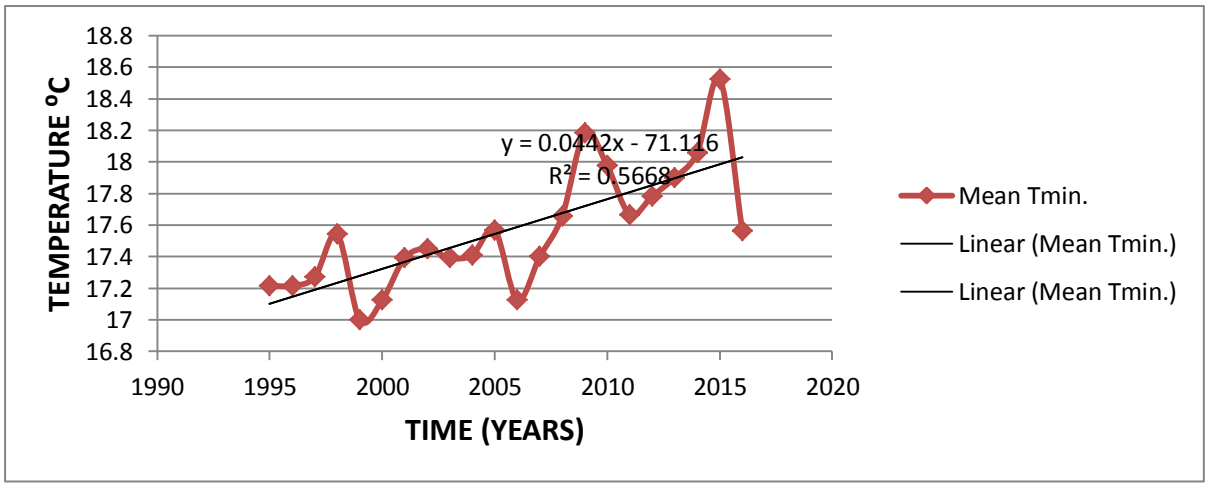


Figure 4.5 (b): Mean annual Minimum Temperature trends over Siaya County

Table 4.1 shows the co efficient of variability of climate parameters. From the three climatic variables, the one with the highest variability is rainfall with a variation of 22.09 followed by minimum temperature with 2.18. Maximum temperature has the lowest variability of 1.32.

Table 4.1: Co-efficient of Variability of climate Parameters

Climatic variable	**1995 - 2005**	**2006 - 2015**	**1995 - 2015**
Rainfall	**16.32 %**	**23.9 %**	**22.09 %**
Minimum Temperature	**0.92 %**	**1.88 %**	**2.18 %**
Maximum Temperature	**1.44 %**	**1.25 %**	**4.3 %**

4.3 Results of Analysis of Academic performance in Siaya County

In this section, the results from the analysis of academic performance within the sub counties and the county are presented and discussed.

4.3.1 Inter Annual Variability and trend in the academic performance in the sub-counties in Siaya County

Figure 4.6 shows the inter- annual variation of K.C.P.E performance of Ugenya, Siaya, Ugunja, Rarieda, Bondo and Gem sub counties. The mean and variance of each sub county are shown in table 4.2. As can be seen from the figure and the table, the sub counties depict varying performance. In all the sub counties, a decline in performance is evident.

It is evident from figure 4.6, during the study period Siaya sub-county performed better than the rest of the sub counties. In particular its highest performance was recorded in the year 2000 when it had a mean of 262.18. On the other hand, Ugenya performed generally poorer than the other sub counties, with the worst performance being recorded in 2012 when it had a mean of 211.78. It can also be noted that Ugenya had the highest variability in performance compared to other sub counties.

Table 4.2: Mean and Variance in Performance of the sub counties

Sub County	Mean	Variance
Ugenya	233.8015	180.1543
Bondo	239.8336	32.89597
Gem	239.5979	38.01826
Rarieda	239.0255	33.59397
Siaya	243.9973	39.86203
Ugunja	240.4086	26.43537

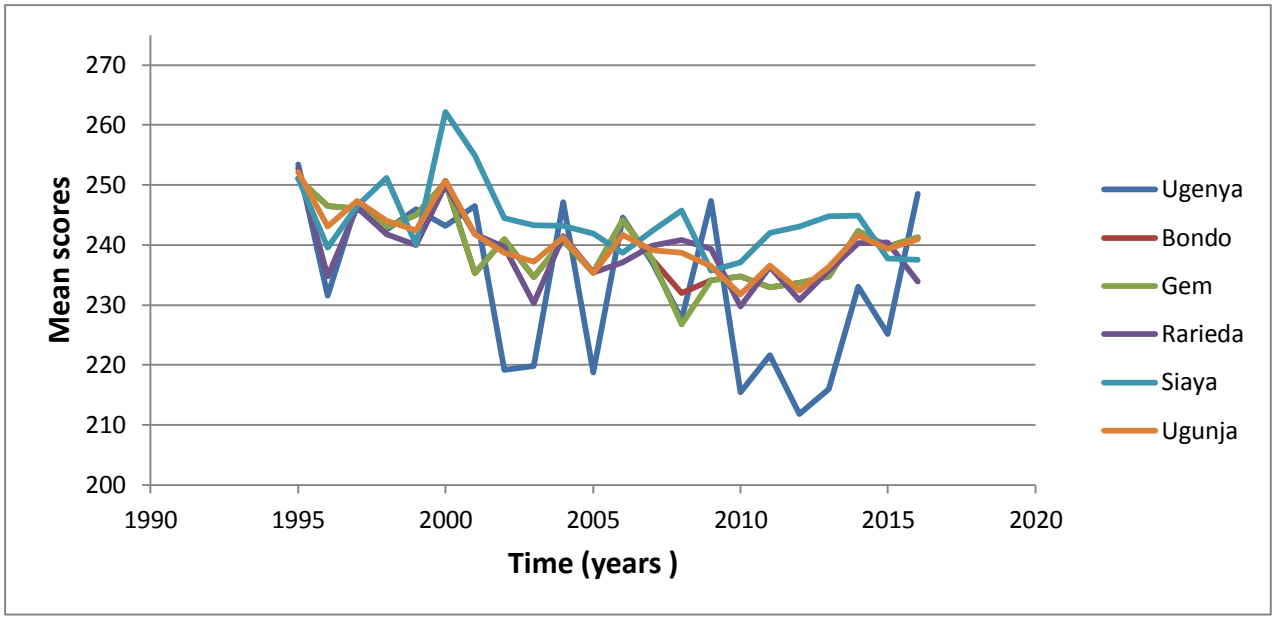


Figure 4.6: Annual variation in Performance of sub counties within Siaya County over the years (Source. Author, 2016)

Figure 4.7 shows the time series of the performance for Siaya County. Generally Siaya County performance in the national examination has been decreasing since 1995. Over the study period the highest score over the county was 252.74 which were recorded in 1995. The year 2010 recorded the lowest the lowest performance of 231.98. Based on the number of subjects examined at school which are 5, the threshold for average performance is a mean score of 250. For the period examined in the present study, the county exceeded this mark in only two years.

From the analysis of the results, there was a drop in performance between the years 2000 to 2003 (250.742 to 236.125) by 14.617. This observation may be connected to the impact of increased maximum temperature which was there from 2001 to 2005 (29.33 °C – 31.3 °C) as shown in figure 4.5 (a). An increase of 1.9 °C. From the year 2012 to 2014, the county registered an improvement in performance of 9.185 (from 232.6035 to 241.789) and it was this time increase in amount of rainfall was observed (from 67.708mm in 2011 to 145.058mm in 2014). An increase of 77.35mm. The improved performance was attributed to increased food production due to increased precipitation as shown in figure 4.4.

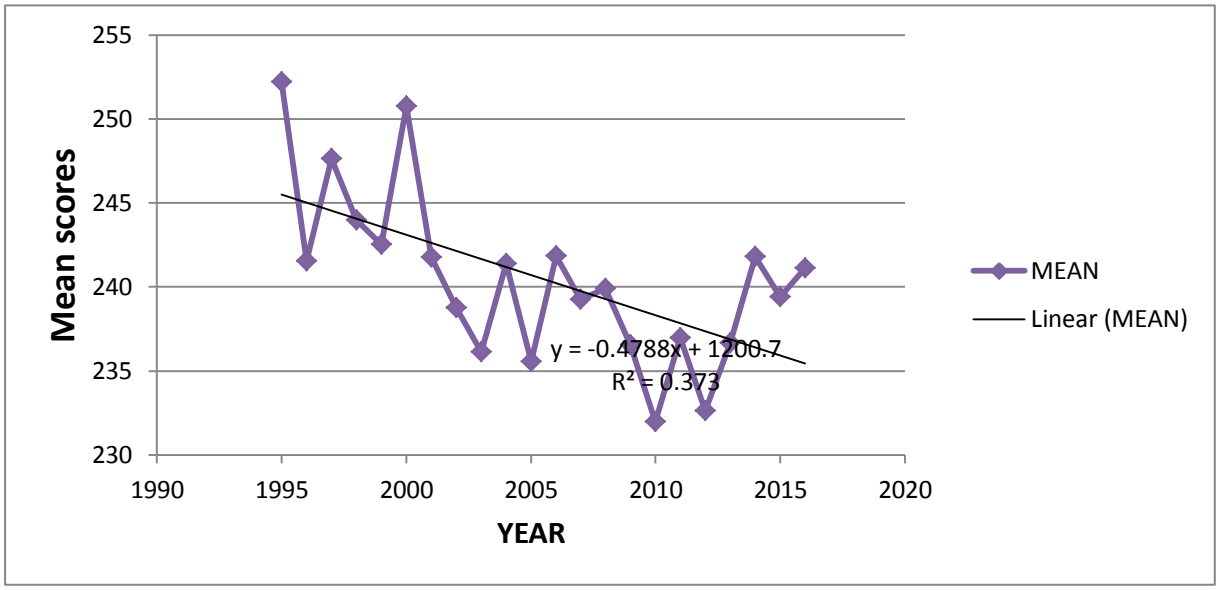


Figure 4.7: Performance Trend over Siaya County (author, 2017)

4.3.2 Results of inter sub-county correlation in Performance

Table 4.3 shows the inter sub county correlation. It can be seen that most of the sub counties are positively correlated, an indication that during most years there will be either be improved or drop in performance across the county. However, Siaya Sub County was significantly correlated with two sub counties, namely Rarieda and Ugunja. The significant values are bolded.

Table 4.3: Inter Sub County correlation

SUB - COUNTY	UGENYA	BONDO	GEM	RARIEDA	SIAYA	UGUNJA
UGENYA	**1.000**					
BONDO	**0.612**	**1.000**				
GEM	**0.588**	**0.985**	**1.000**			
RARIEDA	**0.662**	**0.655**	**0.597**	**1.000**		
SIAYA	0.259	0.372	0.335	**0.655**	**1.000**	
UGUNJA	**0.747**	**0.881**	**0.833**	**0.86**	**0.62**	**1.000**

4.3.3 Results from Principal Component Analysis of Performance (PCA)

Table 4.4 shows the Eigen values and the variance explained by the first three PCA while table 4.5 shows variance explained by the rotated PCA. The accumulative variance explained by the first three PCA is 95%. Table 4.6 shows the loading of the sub-counties in the rotated PCA. The PCA was rotated in order to obtain clear and distinct results. Ugenya had higher loading on factor 3, while Bondo and Gem on factor 1. Rarieda had higher loading on factor and 3 while Siaya on factor 2. Ugunja had higher loading on all the three factors.

Figure 4.8 shows the grouping of the sub-counties based on the rotated PCA. From the figure it can be seen that Bondo and Gem Sub-counties were clustered together that means the performance in the two sub-counties are influenced by similar factors. One of these factors was due to the feeding program in the two sub counties. In Gem, UND in partnership with Millennium Promise Alliance and Earth Institute of Columbia university introduced Sauri Millennium Village Project (MVP) in 2005 which introduced a daily meal during school year for over 21,000 school going children, every school was provided with a dairy cattle, improved water supplies by providing water tanks in schools. This improved school retention. In Bondo, the CDF has funded feeding program in all public schools in the area.

Ugenya - Ugunja and Rarieda were grouped together as shown in the plot (Figure 4.8). This was due to similar socio-economic and political factors which is similar in the three sub counties.

Siaya Sub-county is standing alone and is generally far from the rest. From figure 4.6 the performance of Siaya has been better compared to the other sub-counties, this is due to the high

spirit of competition among schools and urbanization; this could also be due to good will from the leaders. Most schools are within the reach of town, hence access to better facilities which can impact positively on performance. The lines spreading in figure 4.8 are vector points indicating the loadings.

Table 4.4: Un-rotated Principal Component Analysis (PCA)

Eigen Number	**1**	**2**	**3**
Eigen value	4.297	0.905	0.556
Variance explained	4.297	0.905	0.556
%variance explained	71.610	15.089	9.263

Table 4.5: Rotated Principal Component Analysis (PCA)

Eigen Number	**1**	**2**	**3**
Variance explained	2.450	1.678	1.629
%variance explained	40.837	27.970	27.155

Table 4.6. (a) Component loadings on the Un Rotated Principal Component Analysis

SUB COUNTY	**Eigen Un rotated PCA**		
	1	**2**	**3**
UGENYA	0.772	0.205	0.571
BONDO	0.911	0.307	-0.267
GEM	0.878	0.354	-0.302
RARIEDA	0.873	-0.294	0.193
SIAYA	0.611	-0.746	-0.173
UGUNJA	0.983	-0.037	0.007

Table 4.6: (b) The Loading on the Rotated Principal Component Analysis (PCA)

SUB-COUNTY	Eigen Rotated PCA		
	1	**2**	**3**
UGENYA	0.334	0.103	0.917
BONDO	0.925	0.215	0.307
GEM	0.943	0.165	0.268
RARIEDA	0.363	0.642	0.584
SIAYA	0.155	0.964	0.075
UGUNJA	0.662	0.503	0.525

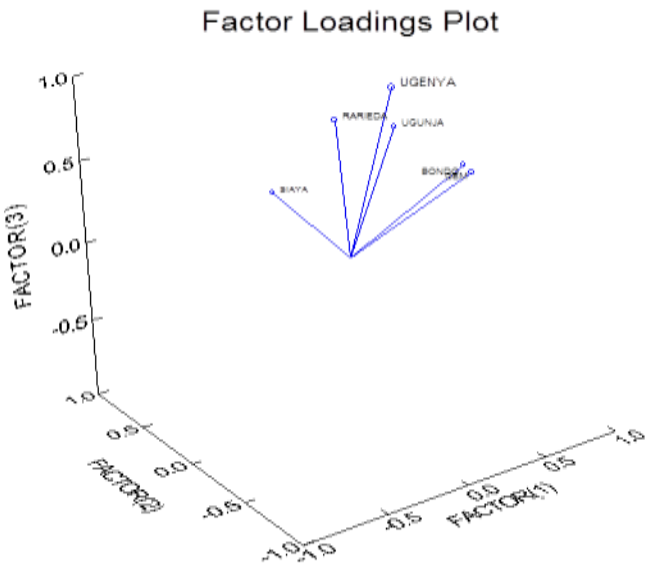


Figure 4.8: Grouping of Sub counties based on Factor loading

4.4 Results of Relationship between climatic variables and academic performance

This section presents the results of correlation between the academic performance and climatic variables and predicted performance. The predictive potential of performance using climatic variables is also presented.

4.4.1 The results from Correlation Analysis of Performance and Climatic variables.

Tables 4.7, 4.8 and 4.9 show the correlation between the performance and the monthly climatic parameters. Based on the student t – test, a correlation with absolute value greater than 0.378 is significant.

Table 4.7. Shows the correlation between monthly minimum temperature and performance of each sub county. From the table it can be seen that generally, the minimum temperature is negatively correlated with performance; thus when the minimum temperature goes down, the performance goes up. This means that lower temperatures leads to conducive environment for the pupils to concentrate on their studies.

Table 4.7: Correlation between Minimum Temperature and Performance

	SUB - COUNTY/ COUNTY						
MONTH	**UGENYA**	**BONDO**	**GEM**	**RARIEDA**	**SIAYA**	**UGUNJA**	**COUNTY**
JAN	0.25	0.043	0.053	-0.036	-0.11	-0.006	-0.36
FEB	-0.29	-0.329	-0.312	-0.433	-0.363	**-0.466**	**-0.484**
MAR	-0.02	-0.052	-0.029	-0.284	-0.408	-0.213	**-0.462**
APR	-0.075	-0.059	0.014	-0.268	-0.254	-0.208	**-0.426**
MAY	-0.313	-0.242	-0.179	**-0.429**	-0.109	**-0.389**	**-0.525**
JUN	**-0.474**	-0.209	-0.174	-0.318	-0.239	-0.277	**-0.418**
JUL	-0.156	-0.063	-0.053	-0.301	-0.329	-0.173	**-0.502**
AUG	-0.228	**-0.528**	**-0.459**	**-0.428**	**-0.41**	**-0.562**	**-0.681**
SEP	0.038	-0.239	-0.246	-0.061	-0.296	-0.19	**-0.558**
OCT	0.07	-0.001	-0.019	-0.026	-0.107	0.004	-0.346
NOV	-0.082	-0.264	-0.237	-0.239	-0.277	-0.21	-0.323
DEC	-0.137	-0.392	**-0.42**	-0.135	-0.038	-0.271	**-0.624**

In table 4.8, the earlier part of the year shows that the maximum temperature is negatively correlated with performance, while in the later part of the year it is positively correlated. In the Earlier months when the maximum temperature is low, the performance goes up and in the later

months as the maximum temperature decreases the performance goes down. This could possibly be due to low concentration among pupils. During hotter season, due to the high temperatures most parts of Siaya experience water stress leading to water shortage. This makes the pupils travel for longer distances to collect water forcing them to miss school or report late. The high day temperature also leads to thermal discomfort.

Table 4.8: Correlation between Maximum Temperature and Performance

	SUB - COUNTY/ COUNTY						
MONTH	**UGENYA**	**BONDO**	**GEM**	**RARIEDA**	**SIAYA**	**UGUNJA**	**COUNTY**
JAN	-0.315	-0.327	-0.337	-0.368	**-0.662**	**-0.477**	-0.172
FEB	0.009	-0.028	-0.014	-0.073	**-0.5**	-0.183	-0.24
MAR	0.202	0.02	0.04	0.177	-0.097	0.099	-0.314
APR	-0.15	-0.164	-0.142	-0.057	-0.033	-0.128	0.142
MAY	-0.06	-0.213	-0.213	-0.17	-0.079	-0.128	-0.176
JUN	-0.01	-0.166	-0.124	-0.13	-0.295	-0.243	-0.318
JUL	-0.212	-0.217	-0.157	-0.258	-0.368	-0.326	**-0.503**
AUG	0.219	0.218	0.231	0.07	-0.26	0.133	-0.036
SEP	**0.435**	**0.476**	**0.46**	**0.427**	0.139	**0.471**	0.189
OCT	0.026	0.002	-0.05	0.046	-0.226	-0.064	-0.086
NOV	-0.22	-0.207	-0.277	-0.117	-0.01	-0.181	0.162
DEC	0.047	-0.134	-0.193	-0.137	-0.081	-0.096	0.108

Rainfall is generally positively correlated as observed from table 4.9. An increase in rainfall contributes to high performance and this is linked to food production. Good rainfall allows for crop production increasing the food availability. Although it can be noted that there is low correlation which indicates that the relationship is not linear.

Increased intensity of rainfall will interfere with the transport and school physical facilities. Floods sweep bridges, classrooms and destroy books. Roads become muddy and at times impassable. This disrupts attendance and arrival time since children waste time wading in the floods; schools are also temporarily closed, there is power outage. In Kenya a good number of children still find themselves out of school due to several reasons one of them being floods (Achoka & Maiyo, 2008). During floods many roads are destroyed or washed away making schools inaccessible therefore the attendance rate becomes low. Usable toilets are limited and health facilities unreachable causing learners to suffer illnesses hence unable to attend school

(Okuom et. al., 2012). In the month of April and December, the pupils may not be in school but the weather conditions in those months may determine agricultural productivity and the conditions of the months extends into school terms since they are transition months. Cumulatively this affects environment of the learners and hence affecting academic performance.

In February the pupils have just been enrolled in a new class in first term where the larger part of the syllabus is to be covered which requires favourable temperatures. While in June the pupils are in the middle of the year and most of the syllabus ought to have been covered. It is characterized by intense revision in preparation for the forthcoming final examinations. Heat exposure may affect educational performance in both the short and long run. Taking an examination on a 90^0 F day relative to a 72^0 F day leads to a decrease in exam performance (Park, 2017). When the temperatures are too cold or too hot the brain is constantly reminding the body to do something about that condition. Because of this constant interruption the pupil doesn't concentrate (Dunn and Dunn, 1993).Being critical months of school calendar, this cause discomfort to learners hence affecting their academic performance. SON season is where the pupils are preparing to sit for their final examinations and favourable environment in terms of physical facilities, books, weather are required for good academic performance. The warm temperature in SON and DJF offer suitable climate for the breeding of mosquitoes leading to malaria outbreaks. This leads to absenteeism from school.

Table 4.9: Correlation between Rainfall and Performance

	SUB - COUNTY / COUNTY						
MONTH	**UGENYA**	**BONDO**	**GEM**	**RARIEDA**	**SIAYA**	**UGUNJA**	**COUNTY**
JAN	0.268	0.04	0.062	0.12	0.264	0.108	0.328
FEB	0.204	-0.015	0.012	-0.065	-0.128	-0.038	0.202
MAR	-0.067	0.141	0.117	-0.151	-0.343	-0.021	0.235
APR	0.173	0.088	0.124	0.117	0.048	0.116	0.291
MAY	-0.226	-0.081	-0.038	-0.295	-0.278	-0.31	0.06
JUN	**0.396**	0.232	0.26	0.216	**0.388**	0.331	**0.353**
JUL	-0.095	0.201	0.163	-0.074	0.056	0.127	0.322
AUG	-0.075	-0.191	-0.248	-0.077	0.107	-0.143	0.125
SEP	-0.137	-0.161	-0.201	-0.026	0.357	-0.075	-0.217
OCT	0.21	0.248	0.202	0.427	0.241	0.313	0.194
NOV	0.063	0.313	0.329	0.151	0.099	0.221	0.286
DEC	0.241	0.35	**0.378**	0.19	-0.071	0.202	0.096

4.4.2 Regression Model for Predicting Performance using climatic parameters.

The study investigated the predictability potential of the performance using the climatic variables. Multiple linear regression models developed for each sub county is shown in table 4.10. From the table it can be seen that the R^2 for all the sub counties and the county is over 50%, which is an indication of goodness of fit. The analysis of variance for the models is given in table 4.11, this confirms the goodness of fit. A large f value (one that is bigger than the F critical value (tabulated f) means something is significant, while a small p value means all results are significant. A higher F-ratio means that the model explains goodness of fit. This shows that the models have high predictability.

Table 4.10: Regression Models for Predicting Performance in each sub county.

MODEL	R -Squared
$County = 324.248 - 8.985 * AUGMinTemp. + 2.293 * AUGMaxTemp . + 0.060 * FEBRain$	0.827
$GEM = 735.886 - 8.973 * NOV.Min.Temp - 1.548 * FEB.Max.Temp. - 10.003 * MAYMax.Temp + 0.035 * MAR.Rain - 0.046 * AUG.Rain.$	0.714
$RARIEDA = 529.670 - 6.880 * MAYMax.Temp. - 2.989 * JULMax.Temp - 0.035 * MAR.Rain$	0.613
$UGENYA = 305.874 + 10.546 * APR.Min.Temp + 25.232 * SEP.Min.Temp. - 14.464 * MAYMax.Temp. - 10.098 * JUL.Max.Temp. + 0.168 * JUNRain.$	0.870
$BONDO = 491.382 - 8.487 * NOV.Min.Temp. - 5.263 * MAYMax.Temp. + 1.702 * SEP.Max.Temp.$	0.5777
$SIAYA = 395 - 3.738 * JAN.Max.Temp. - 1.019 * FEB.Max.Temp. - 0.030 * MAYRain.$	0.751
$UGUNJA = 343.576 - 8.488 * AUG.Min.Temp. + 1.512 * SEP.Max.Temp. + 0.042 * FEB.Rain - 0.031 * MAYRain.$	0.789

Table 4.11 (a): Analysis of Variance for Siaya County.

Source	Sum of Squares	df.	Mean Square	F-ratio	P
Regression	267.955	3	89.318	20.774	0.000
Residual	55.894	13	4.300		

(b) Analysis of Variance for Gem.

Source	Sum of Squares	df.	Mean Square	F-ratio	P
Regression	519.502	5	103.900	5.502	0.009
Residual	207.713	11	18.883		

(c) Analysis of Variance for Rarieda.

Source	Sum of Squares	df.	Mean Square	F-ratio	P
Regression	358.626	3	119.542	6.857	0.005
Residual	226.634	13	17.433		

(d) Analysis of Variance for Ugenya.

Source	Sum of Squares	df.	Mean Square	F-ratio	P
Regression	2278.185	5	455.637	14.673	0.000
Residual	341.575	11	31.052		

(e) Analysis of Variance for Bondo.

Source	Sum of Squares	df.	Mean Square	F-ratio	P
Regression	355.031	3	118.344	5.907	0.009
Residual	260.427	13	20.033		

(f) Analysis of Variance for Siaya Sub county.

Source	Sum of Squares	df.	Mean Square	F-ratio	P
Regression	560.067	3	186.689	13.089	0.000
Residual	185.421	13	14.263		

(g) Analysis of Variance for Ugunja.

Source	Sum of Squares	df.	Mean Square	F-ratio	P
Regression	365.998	4	91.500	11.218	0.001
Residual	97.881	12	8.157		

Figure 4.9 to 4.15 show the observed and the model simulated performance for the county and each sub county. Figure 4.15 indicates declining trend in performance therefore adaptation strategies needs to be put in place. The years 1995 to 2011 were the training period periods while the last 5 years were used to test the models. The test of the skill for the predictability of each sub county as shown in table 4.12. In figure 4.9, predicted county performance from 2014 to 2016 is not reliable an indication that apart from increased Maximum and Maximum temperature in August and February rain, there are other factors affecting performance.

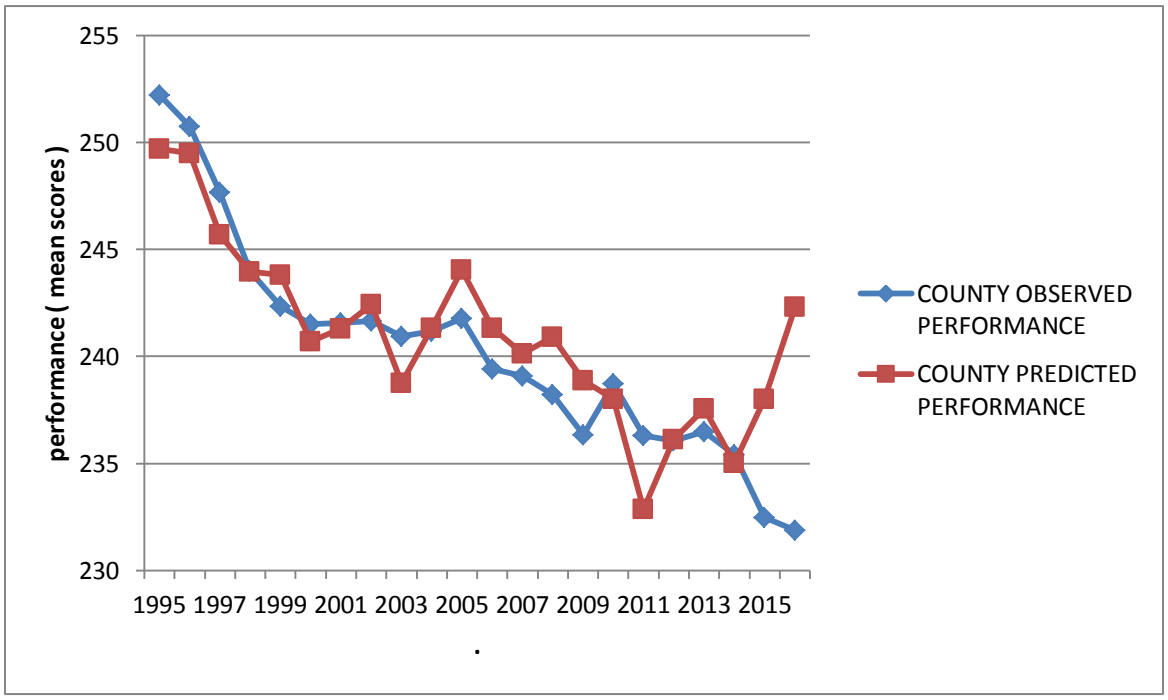


Figure 4.9: Siaya County Observed and Predicted Performance

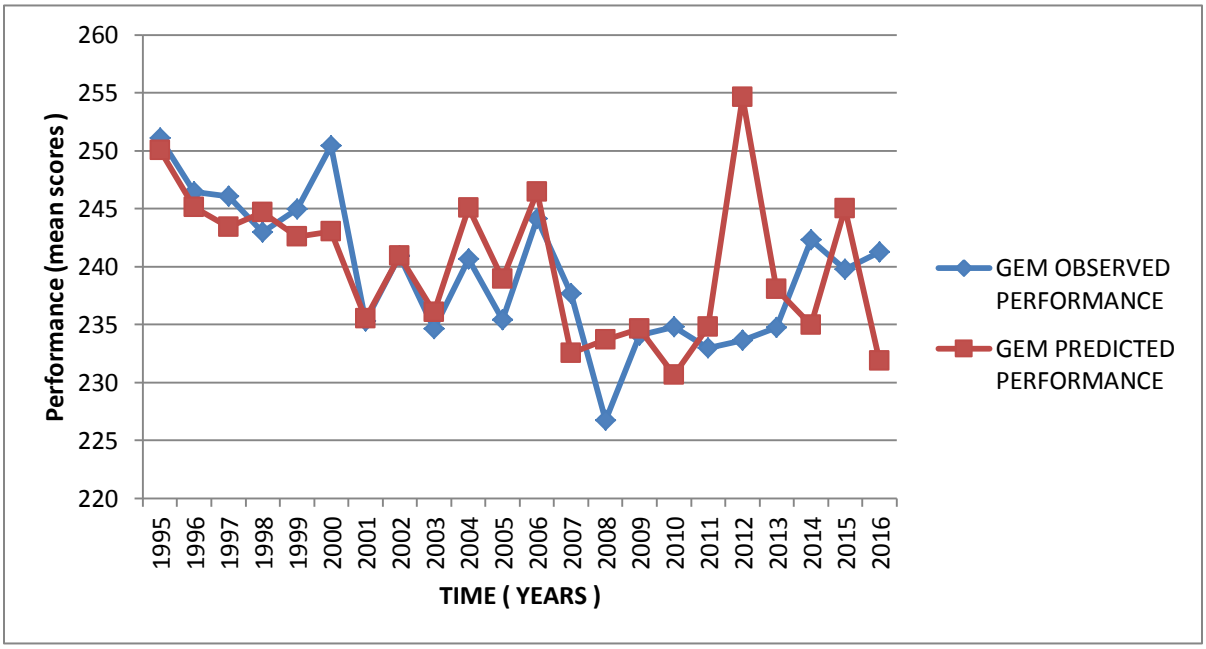


Figure 4.10: Gem Sub County observed and predicted performance

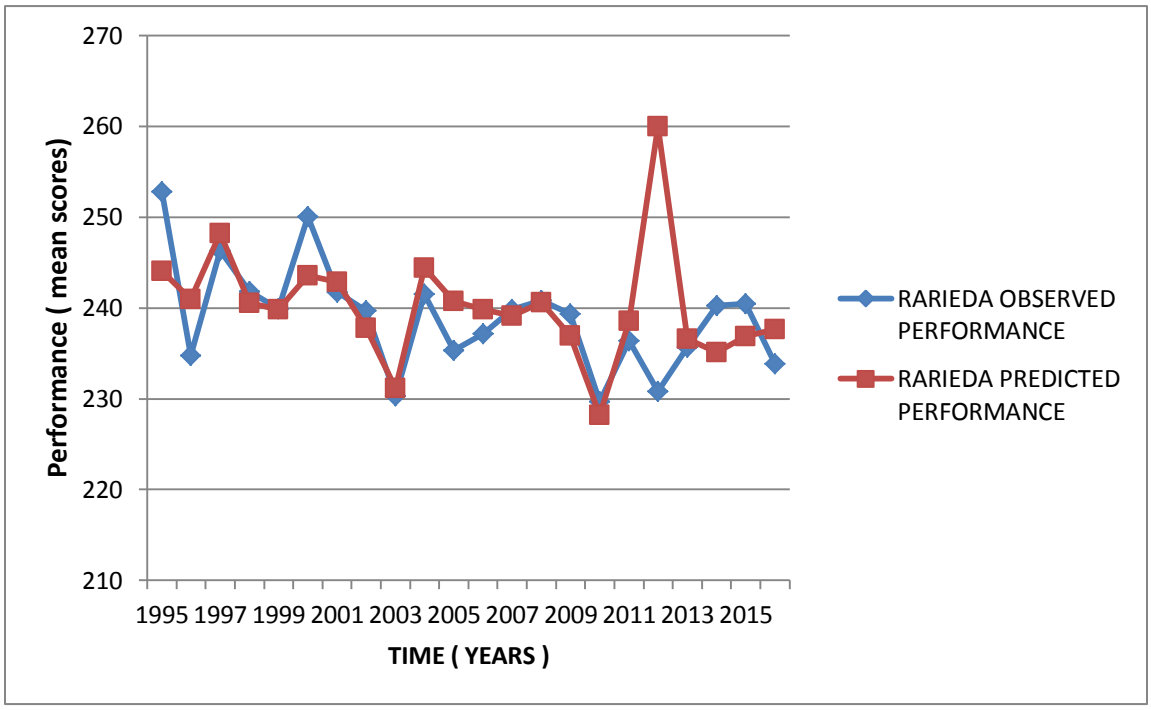


Figure 4.11: Rarieda Sub County observed and predicted performance.

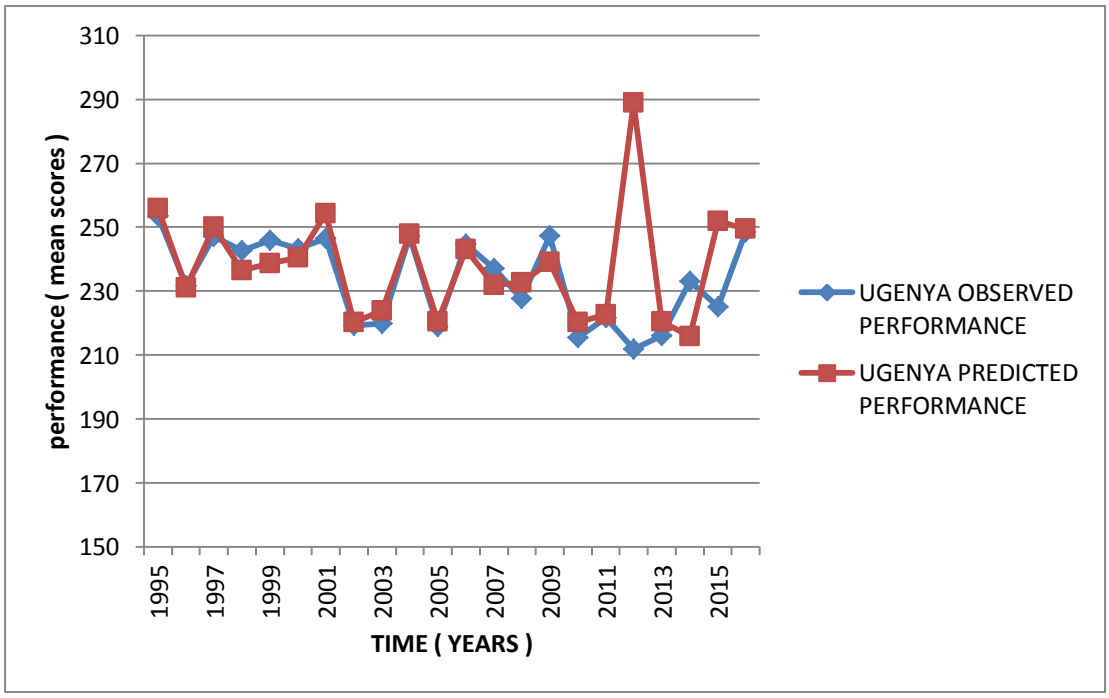


Figure 4.12: Ugenya Sub County observed and predicted performance.

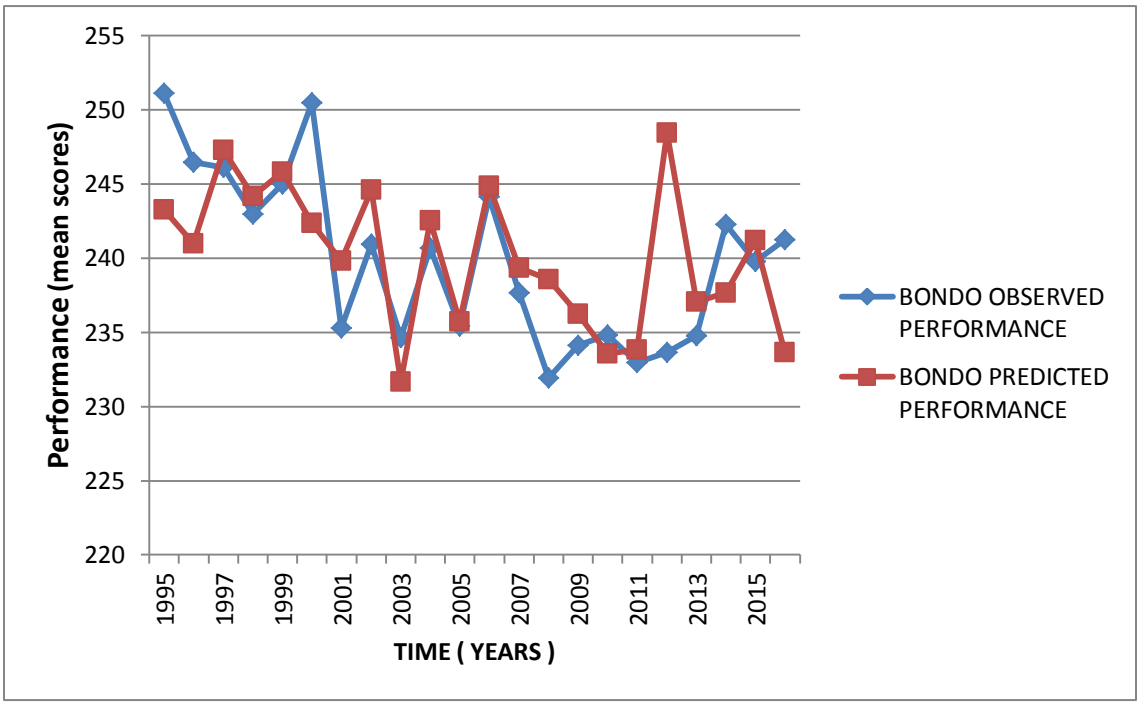


Figure 4.13: Bondo Sub County observed and predicted performance.

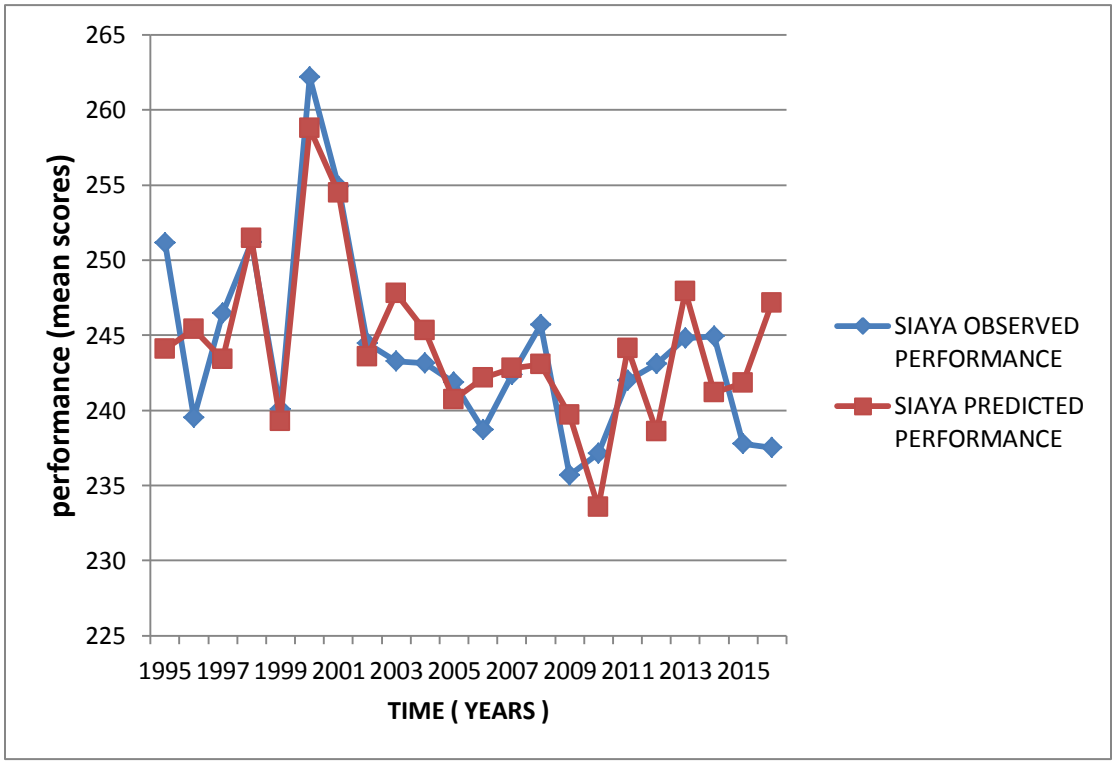


Figure 4.14: Siaya Sub County observed and predicted performance.

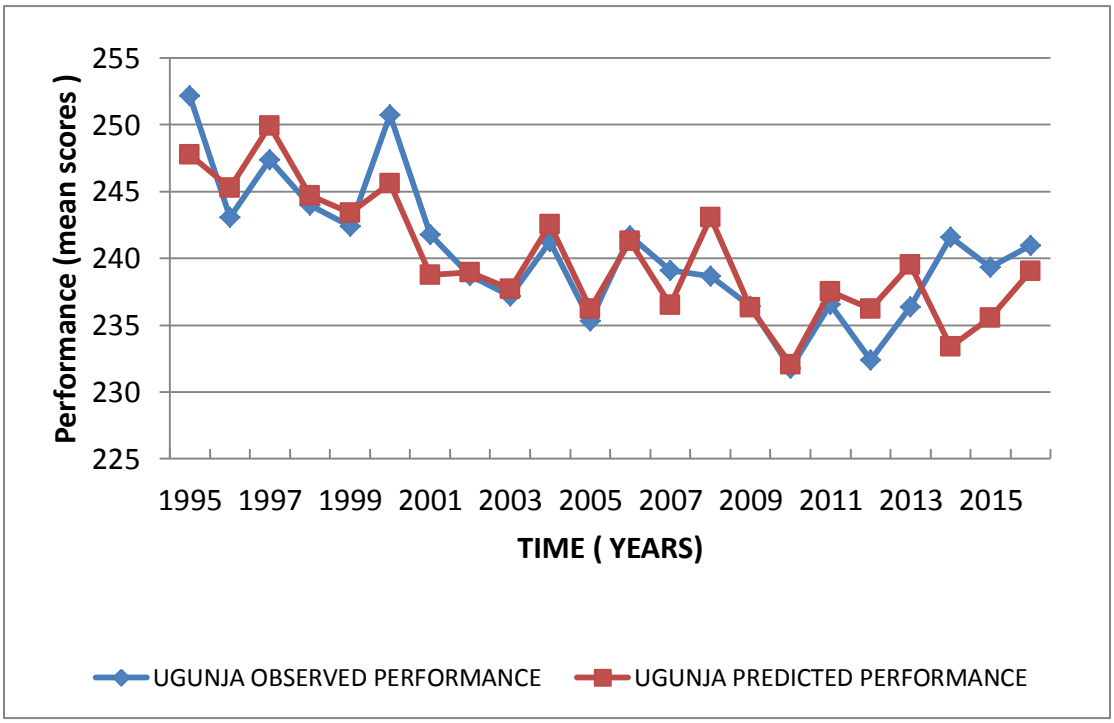


Figure 4.15: Ugunja Sub County observed and predicted performance.

Table 4.12. The skill of forecasting of performance.

SUB COUNTY	***Df (k-1)***	**Tabulated chi square (χ^2) /critical value**	**Computed chi-square (χ^2)**	**Model skill**
UGUNJA	4	9.488	0.465047	High forecast skill
UGENYA	4	9.488	32.65193	Low forecast skill
BONDO	4	9.488	1.294485	High forecast skill
SIAYA	4	9.488	0.641442	High forecast skill
GEM	4	9.488	2.630907	High forecast skill
RARIEDA	4	9.488	3.910024	High forecast skill
COUNTY	4	9.488	0.608346	High forecast skill

4.5 Results and Discussions from the Analysis of Questionnaires.

The analysis of the responses given by head teachers and learners on their opinions on how climate variations affect performance are presented in this section.

4.5.1 Questionnaire return rate

It is the proportion of the questionnaires that are returned to the researcher from the sample that participated in the survey. 180 head teachers returned their questionnaires making a return rate of 96.77%. Out of 528 pupils, 520 returned the questionnaires constituting 98.48%. The average return rate was 97.63% as shown in table 4.12.

A questionnaire return rate of 80% and above is absolutely satisfactory, while 60% - 80% return rate is quite satisfactory and a rate below 60% is barely acceptable (Edwards *et al.,* 2002)

This implies that the questionnaire return rate for this study was good for all the targeted respondents.

Table 4.13. Respondents return rate

Respondents	**Sample size**	**Response**	**Return Rate (%)**
Head Teachers	186	180	96.77
Pupils	528	520	98.48
Total	**714**	**700**	**97.63**

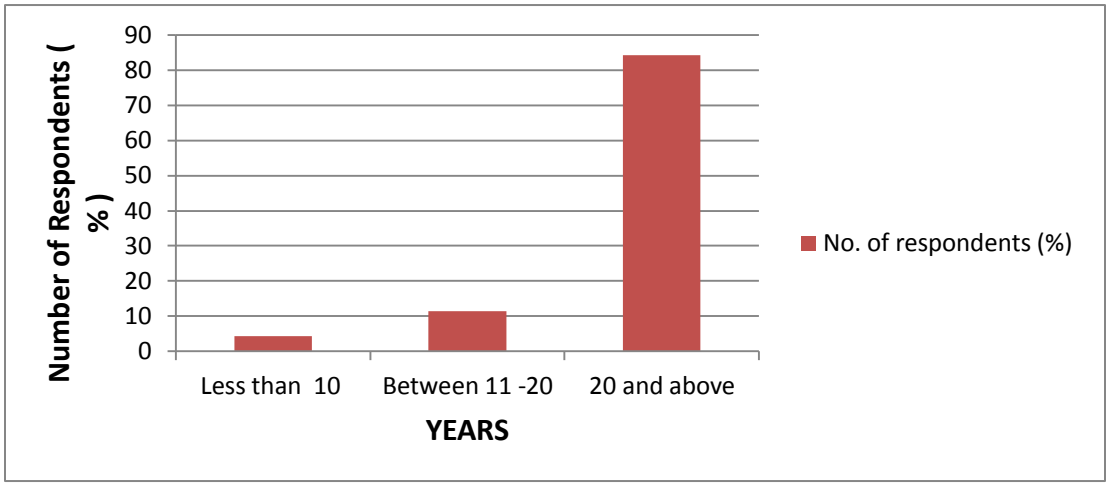
4.5.2 Demographic information

This was based on years lived in the county, place of birth and age distribution and this is represented in figure 4.16 (a) (b) and (c). This was important because it provided indigenous knowledge of climatic patterns over Siaya County.

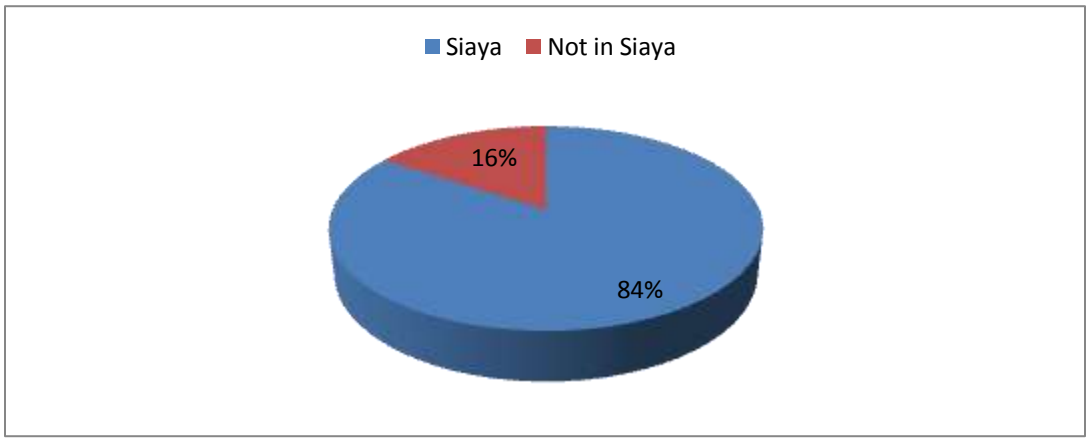
Out of the 114 respondents interviewed, figure 4.16 (a) shows that the majority of the respondents (84.2%) had lived in Siaya County. Therefore they have experienced different climatic patterns in the county hence knowledgeable on the climate of the county over time.

In figure 4.16 (b), most of the respondents (80%) were born and lives in Siaya County. Therefore most information given was as a result of own experience by the respondents.

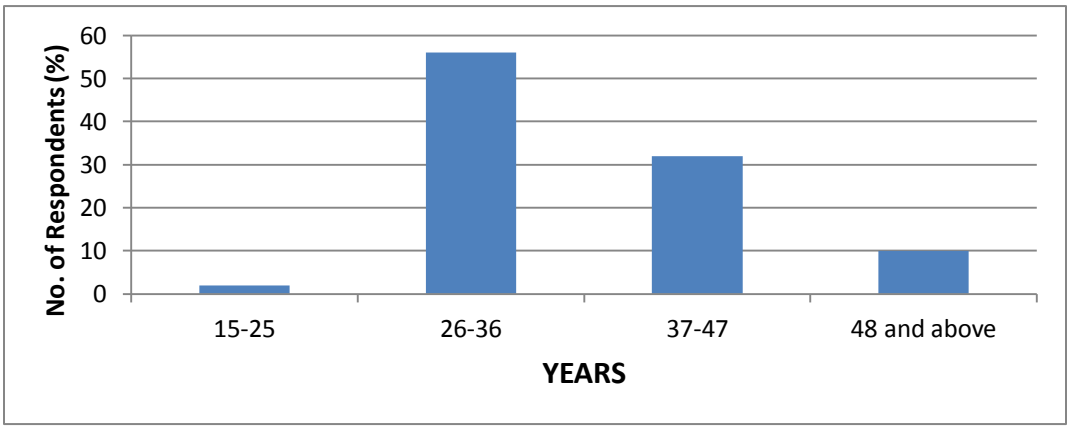
More than half of the total respondents were aged 26-36 as shown in figure 4.16 (c). This helped to provide much and more reliable information on climatic patterns in the county since the interviewees were mature enough.



(a) Number of years lived in Siaya County



(b) Place of birth



(c) Age Distribution

Figure 4.16: Demographic information (a) Number of years lived in Siaya County (b) Place of birth (c) age distribution of the respondents.

Based on the respondents interviewed, the study noted that 60% of these people had a feeling that maximum temperatures of Siaya County has been increasing every year and it has become hotter compared to the past and none believed it is getting cooler. This is shown in figure 4.17.

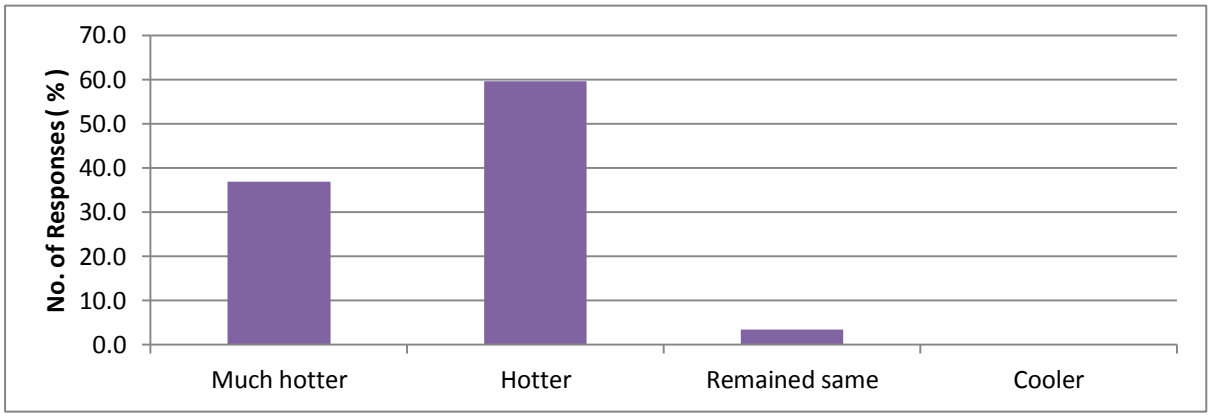
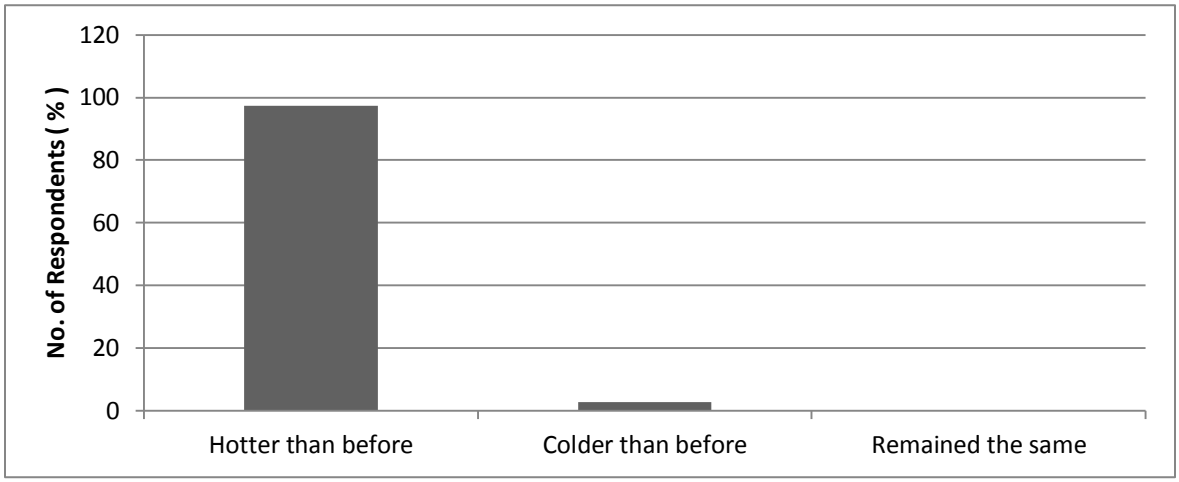


Figure 4.17: Responses on Maximum temperatures of Siaya.

From figure 4.18 (a), 97% of the respondents noted that the maximum temperatures of the months of January, February and March have become hotter than before while none indicated that the maximum temperatures have remained the same. Only 2% indicated that it has become colder than before.

Asked on opinion on the maximum temperatures of months of May, June and July. There was no clear cut on the perceptions whether it has become colder or warmer than before. 36% of the respondents noted that it has become colder than before while 38% noted it has become warmer than before. Besides, they also noted that temperatures experienced during June-July cold seasons were warmer than they had been in the past.

(a)



Responses on Maximum Temperatures of the months of JFM

(b)

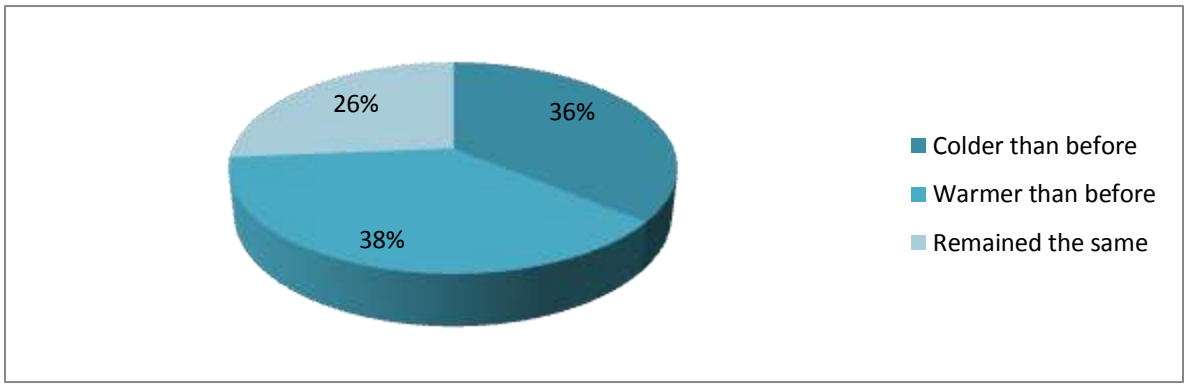
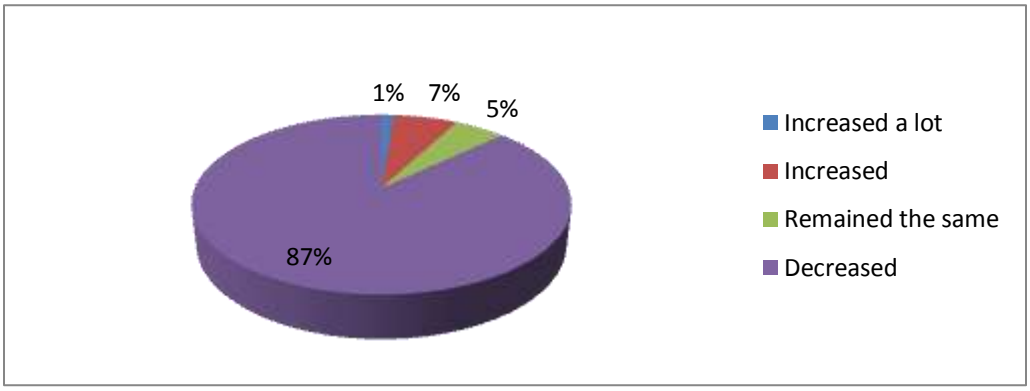


Figure 4.18: Responses on Maximum Temperatures of the months of MJJ

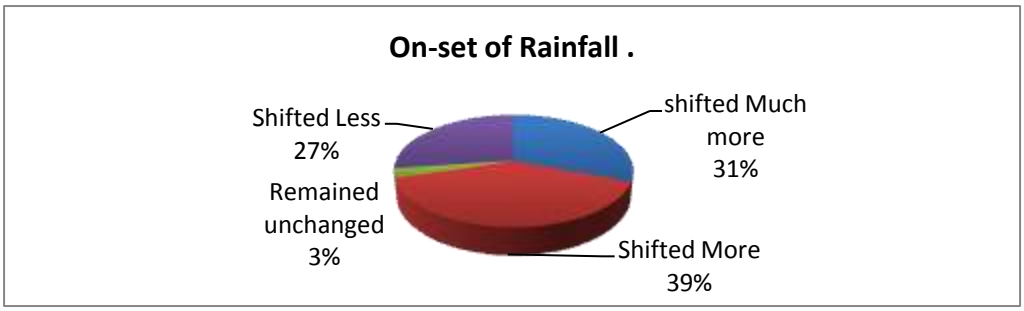
Majority of the respondents noted that the amount of rainfall has decreased over time as shown in figure 4.19 (a). Only 1% noted there has been an increase in the amount of rainfall.

On rainfall pattern, 70% of the respondents interviewed noted that the rainfall pattern has changed and it is unpredictable by the farmers**.** The onset of rains keeps shifting. This has affected agricultural productivity leading to food shortage.

More than half of the respondents noted that the flood occurrence in the county has reduced. 24% stated it has remained the same, 18% believed it has increased and 6% believed it has increased a lot.



(a) Opinion on total annual rainfall



(b) Opinion on on-set of rainfall

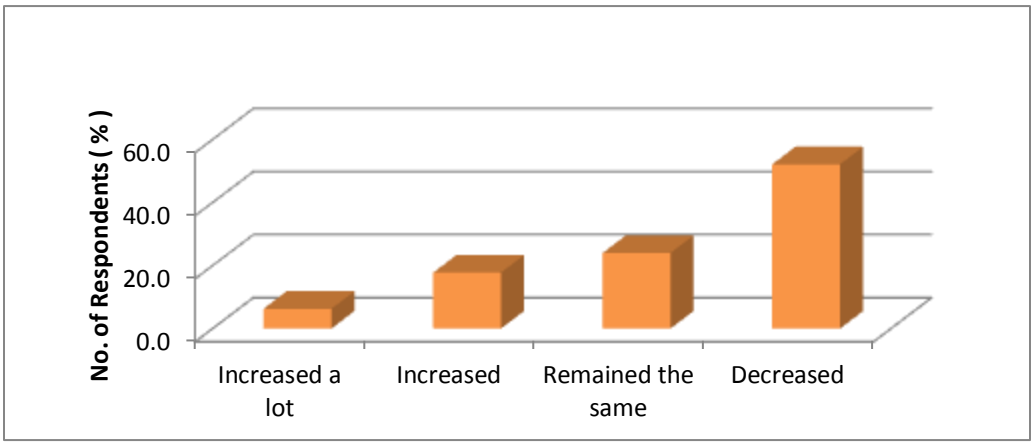


Figure 4.19: (c) Opinion on flood occurrence

4.5.3 Responses on Factors affecting performance

There are several aspects that influence performance at school, distance from nearest health facility and urban centre. When there is a nearby health facility and urban centre, most of the social services are available e.g. good road network, medical services, water which helps in coping with the effects of varying climatic conditions. Other factors include number of learners per class, teachers strike and inadequate resources, lack cooperation between parents and teachers and overloaded curriculum. This study focused on state of health, food scarcity, drought, poor transport network, which are climate related.

Analysis of distance from the nearest health facility in figure 4.20 it is noted that more that 79 % of the homes are 5 km or less to the nearest health facility followed by a distance of between 6 – 10 km. This is an indication that they are able to get medical services with ease in case they fall ill as a result of extreme climatic events.

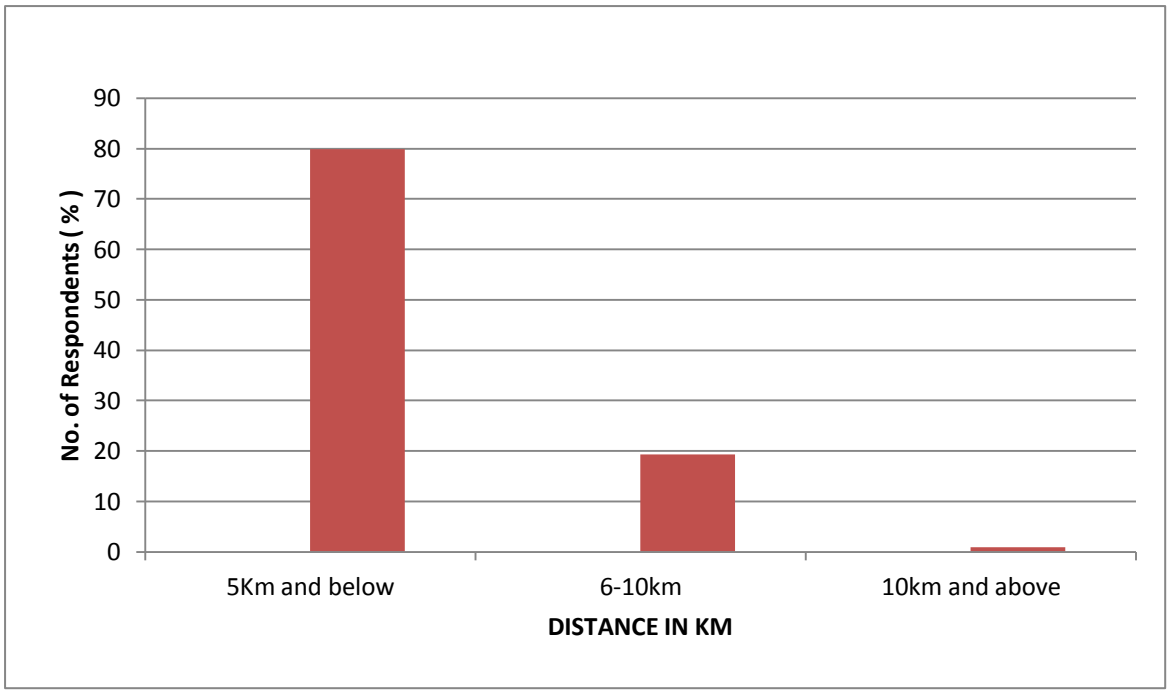


Figure 4.20: Mean distance from home to the nearest health facility.

More than half (88%) of the respondents acknowledged that poor health due to climatic conditions impact negatively on academic performance to either some or high extent as shown in figure 4.21. It was noted that effect of climate variability leads to ailments like malaria, typhoid, cholera, pneumonia.

Over 50% of the respondents indicated that famine affects performance to a higher extent while 37% indicated that it affects to some extent (Figure 4.22). Food shortage is witnessed as a result of failed crop production which can be attributed to reduced rainfall, crop pests. This leads to malnutrition. Malnutrition is a chronic condition as a result of under or over consumption of essential micro or macro nutrients relative to the physiological and pathological requirement (Ecker and Nene, 2012). It develops when the body doesn't get enough nutrients to function properly. It is caused by lack of food or unbalanced diet(Chinyoka and Naidu, 2013). Children who don't take sufficient nutrients like calcium, potassium, vitamin C may not work to their full potential at school due to poor brain development hence affecting academic performance (Nabarro *et.al*, 2012).

Drought is as a result of hot temperatures with long period of inadequate or no rainfall. Majority of the respondents indicated that drought affects performance to some extent (Figure 4.23). There was no clear cut in those who believed that it affects academic performance to a little or high extent. This could be because; the impact is not equally felt in the whole county.

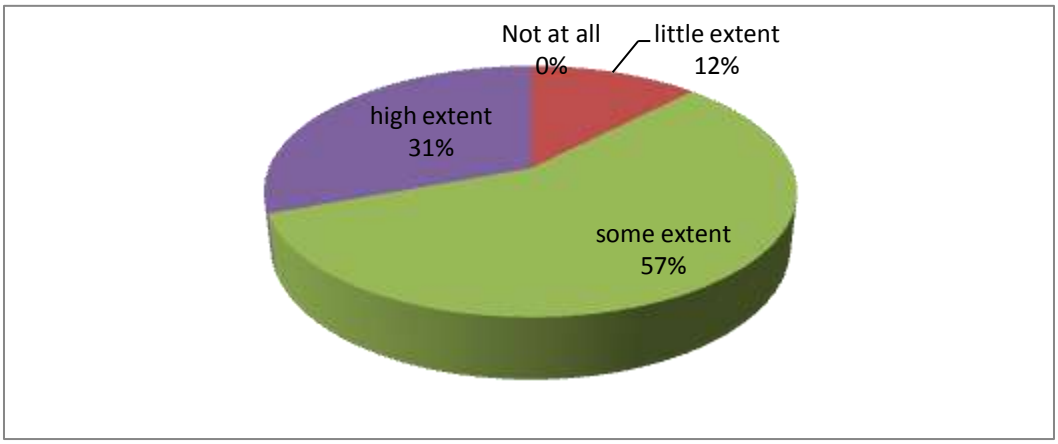


Figure 4.21: The effect of Poor health of learners on academic performance.

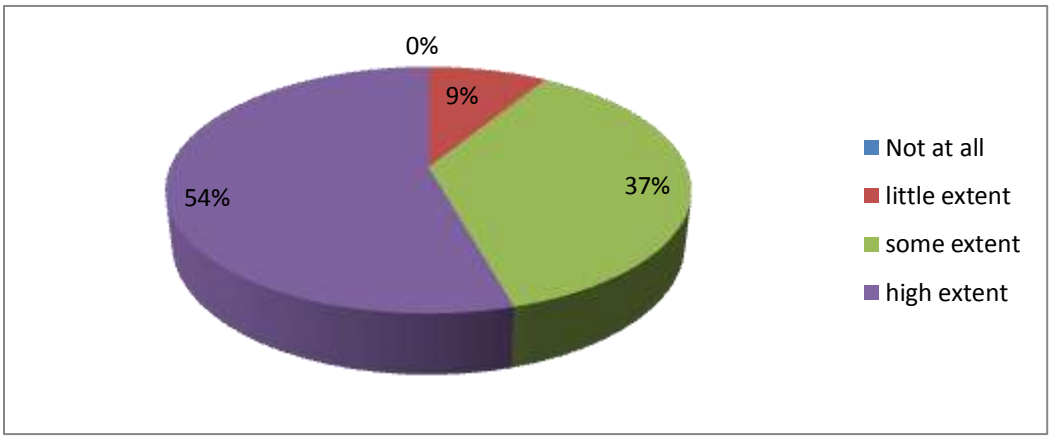


Figure 4.22: The effect of Food scarcity on academic performance.

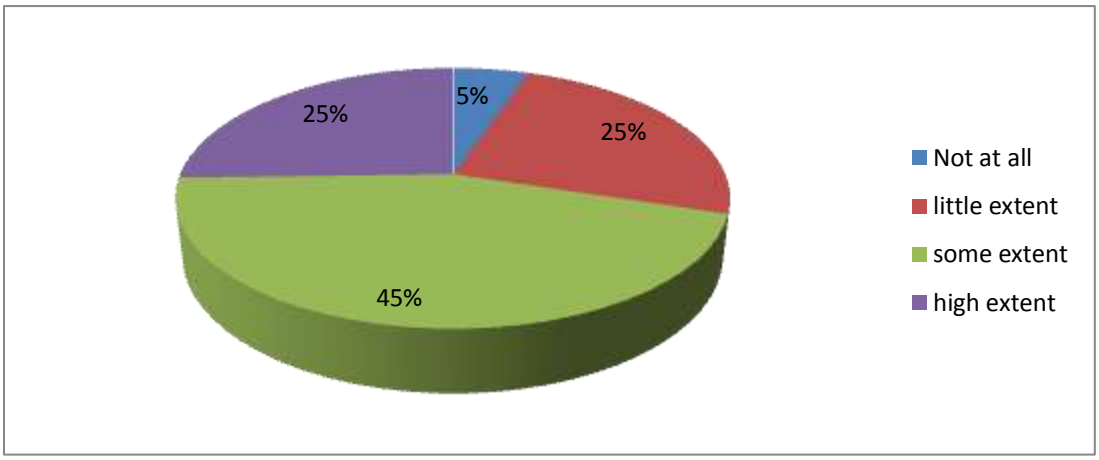


Figure 4.23: The effect of Drought on academic performance.

Poor transport network is as a result of damaged bridges, roads and paths due to floods which sweep them away. Based on the total respondents, 89% of them noted that poor transport influences performance and only 11% noted it has no effect. Poor transport affects movement to and from school making the teachers and pupils arrive late. This affects lesson attendance (Figure 4.24).

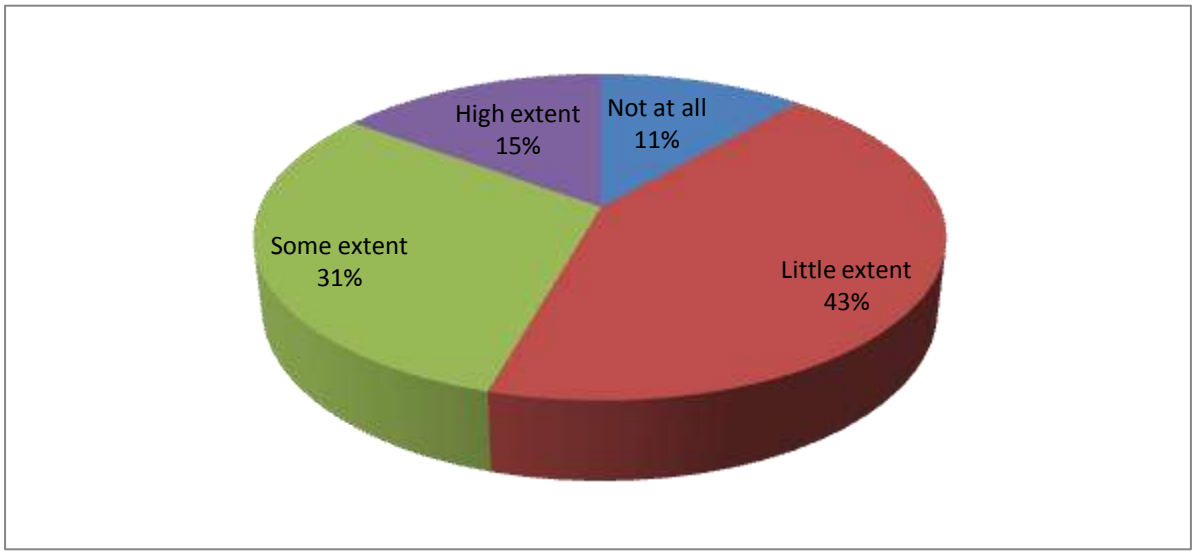


Figure 4.24: The effect of Poor Transport network on academic performance.

Adverse weather conditions like hot afternoon, chilly morning, heavy rains were some of the factors cited by the respondents to affect academic performance in schools to some extent as shown in figure 4.25. Very Chilly morning affects children with respiratory infections; heavy rains interfere with arrival time, damage of classrooms and also lead to waterborne diseases.

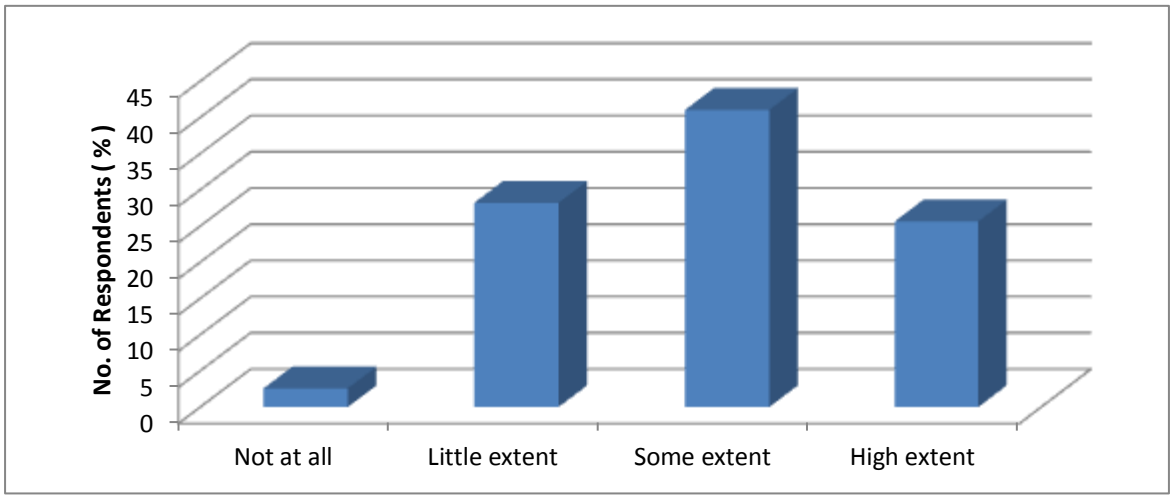


Figure 4.25: How Variation of hot, wet and chilly weather affect academic performance.

The distribution of the respondents in figur**e** 4.26 showed that the number of the pupils who fall sick increases in wet seasons. This is because of increased cases of malaria and water borne diseases like cholera.

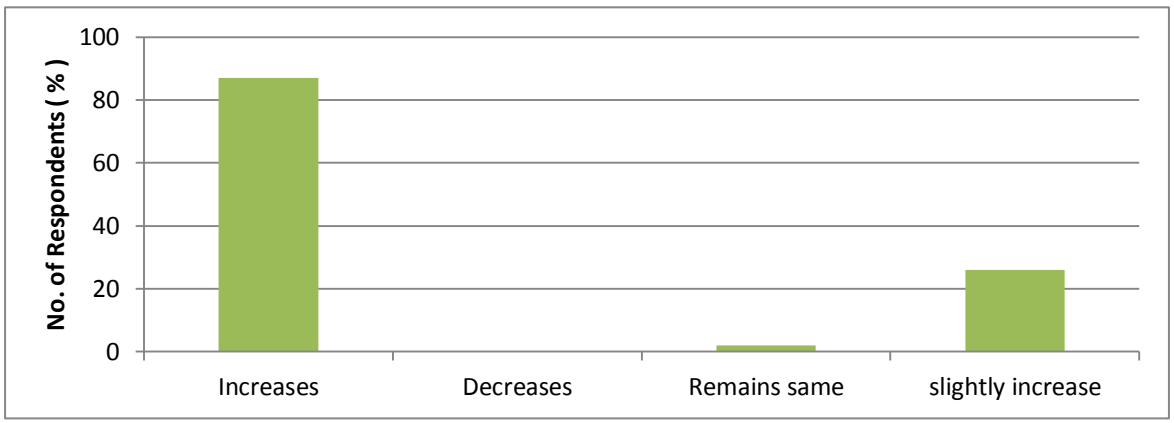


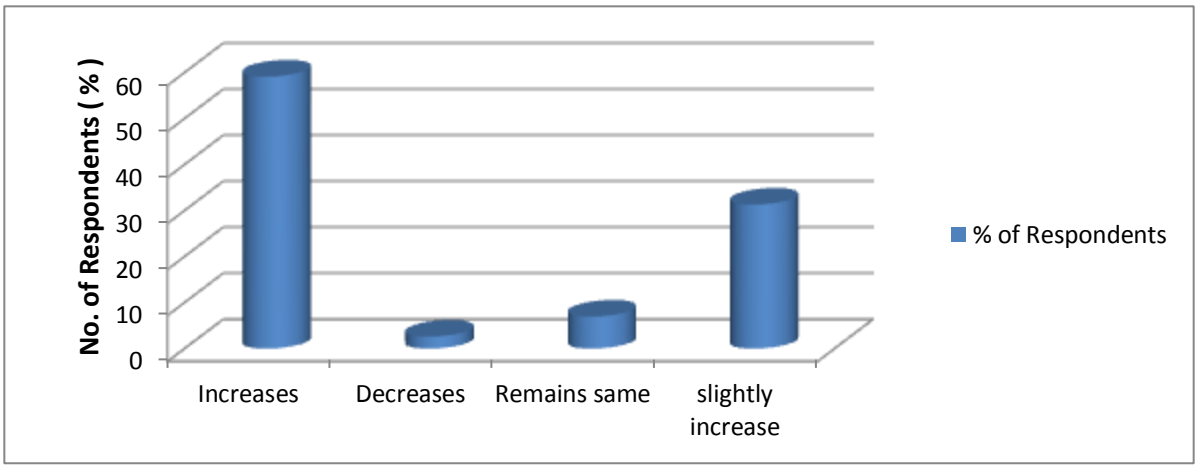
Figure 4.26. The number of those who fall sick during wet season.

4.5.4 Responses on rate of Absenteeism in wet and dry seasons.

In the figure 4.27 (a), 59% of the respondents noted that the number of pupils who absent themselves from school increases while 31% indicated it slightly increases in wet seasons. This is because during this period there is an increase in prevalence of cold, fever, pneumonia, asthma and water borne diseases like cholera. This makes them lag behind in syllabus coverage hence poor academic performance.

During drought, over 28% of the respondents noted that number of pupils who fall sick increases and 39% slightly increases (figure 4.27 b). This is due to poor hygiene which leads to diseases like typhoid, flue. Most families lack food and water leading to malnutrition.

(a)



The Number of pupils that fall sick during wet season

(b)

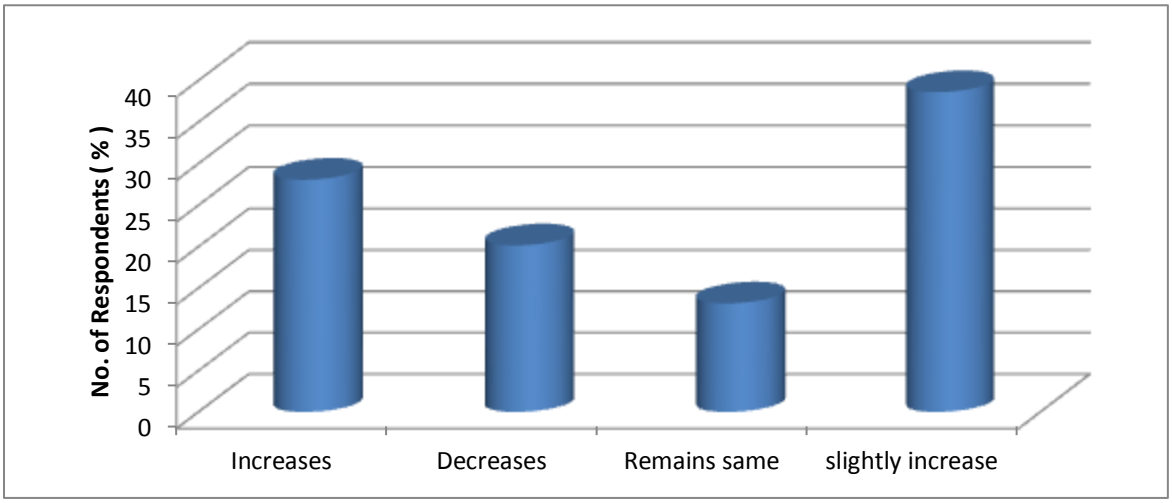


Figure 4.27: The Number of pupils that fall sick during drought

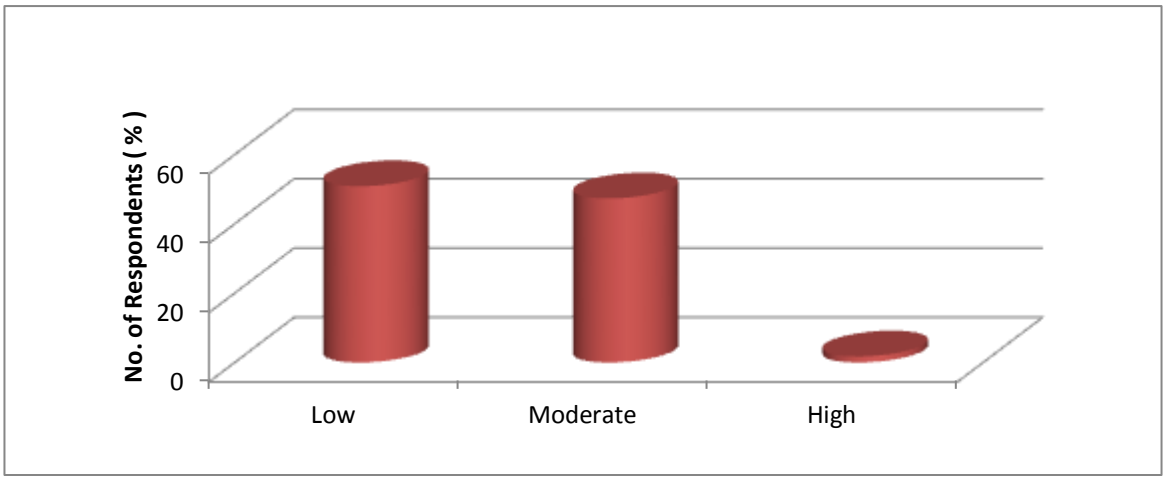
4.5.5 Responses on Class concentration in high minimum temperature and high maximum temperatures.

As per the level of class concentration. The teachers were able to observe leaners' class participation during low and high temperatures and gave the following observations.

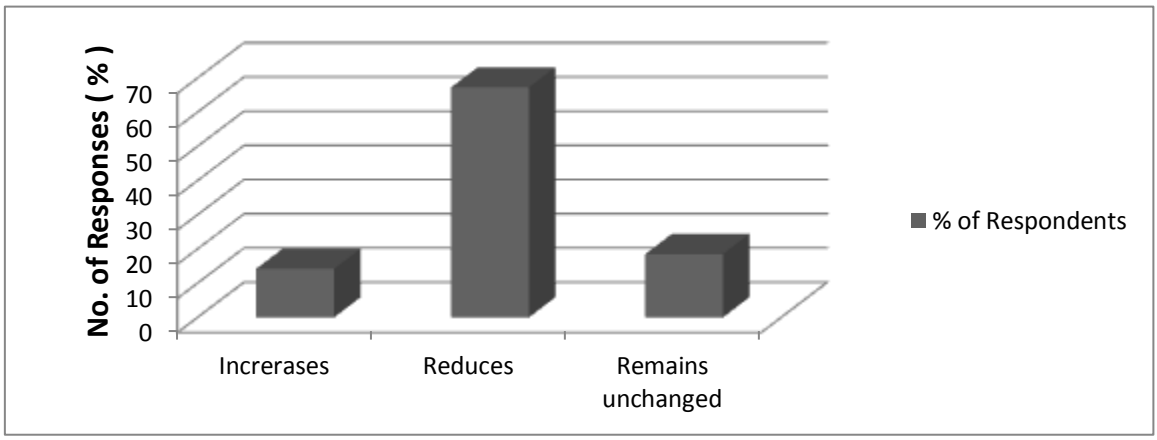
When minimum temperature increases (Fig. 4.28 a), 51% of the teachers noted that the level of concentration becomes low, 47% noted that it becomes moderate while only 1% believed it increases the concentration.

When maximum temperature increases; majority of the teachers and the pupils cited that it becomes low. The teachers noted that during high temperatures half of the class feel sleepy and don't participate fully in the lesson. (Fig.4.28 b)

There was no clear cut whether low minimum temperature can lead to low or high concentration among the pupils. Reason could be the teachers have not taken keen interest on their concentration level during this time.



(a) Opinion of Pupils on Level of concentration at high minimum temperature



(b) Opinion of Teachers on Level of concentration at high maximum temperature

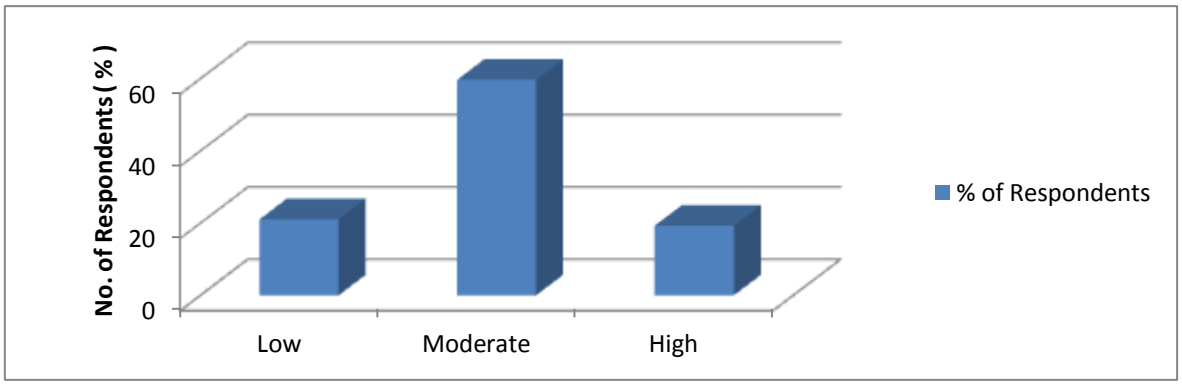
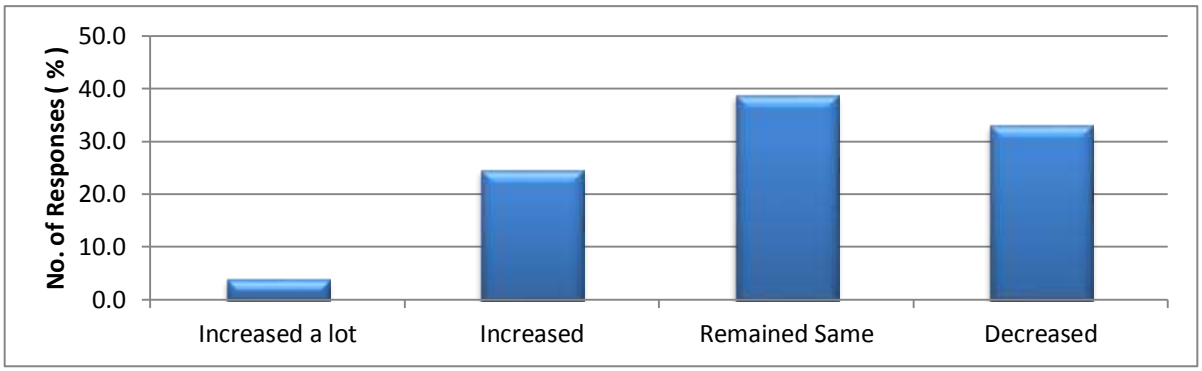


Figure 4.28. (c) Opinion of Teachers on concentration of pupils at high minimum temperatures.

4.5.6 Responses on Lightning, thunderstorm and windstorm.

Over 38% of the respondents interviewed noted that occurrences of lightning and thunderstorms has neither increased nor reduced. 39 % noted It has remained the same while 33% felt it has reduced (figure 4.29 a). This phenomenon creates fear in pupils, destroys school facilities and at times can strike pupils causing death. Most lightning casualties occur in open areas like fields and under trees (Curran, *et. al.*, 1997). It also inflicts severe injuries (Cooper, 1995).

On wind storms, the majority of the respondents of about 40% noted that it has increased over time in the area. This has a destructive effect on school facilities like classrooms, library and books making learners to be displaced (figure 4.29 b).



(a) Opinion on lightning and thunderstorms

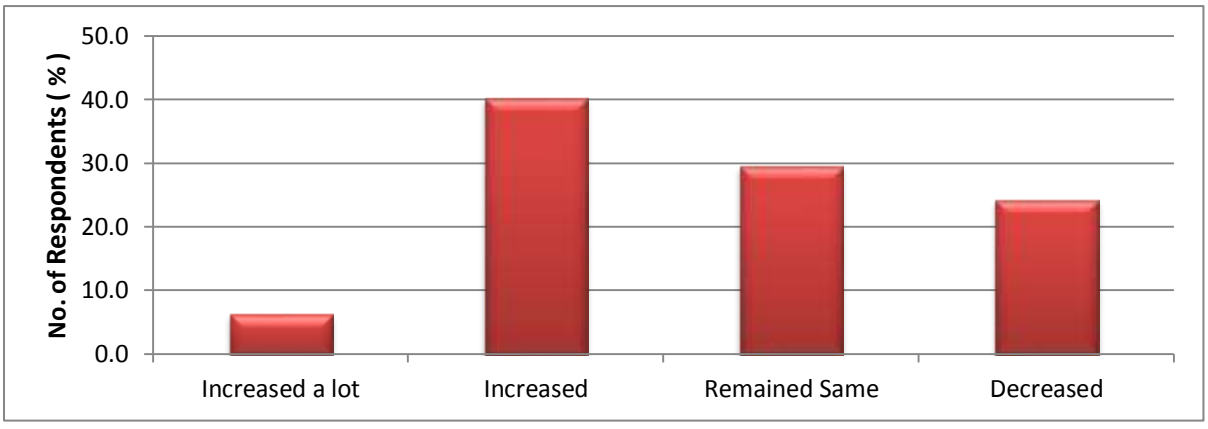


Figure 4.29: (b) Opinion on windstorm occurrences

In figure 4.30 (a) 63% of the respondents noted that the main impact of thunderstorm is destruction of classrooms; library and administration block. This is followed by falling trees and shock to the learners as noted by 26%. 11% indicated that it leads to death of learners and teachers.

The schools that have been affected by the windstorms, 73% indicated it has led to destruction of classrooms and office followed by 24% who said it has led to the falling of school trees and the rumbling shocking the learners. It has also led to the deaths as indicate by 2.7% of respondents.

(a) (b)

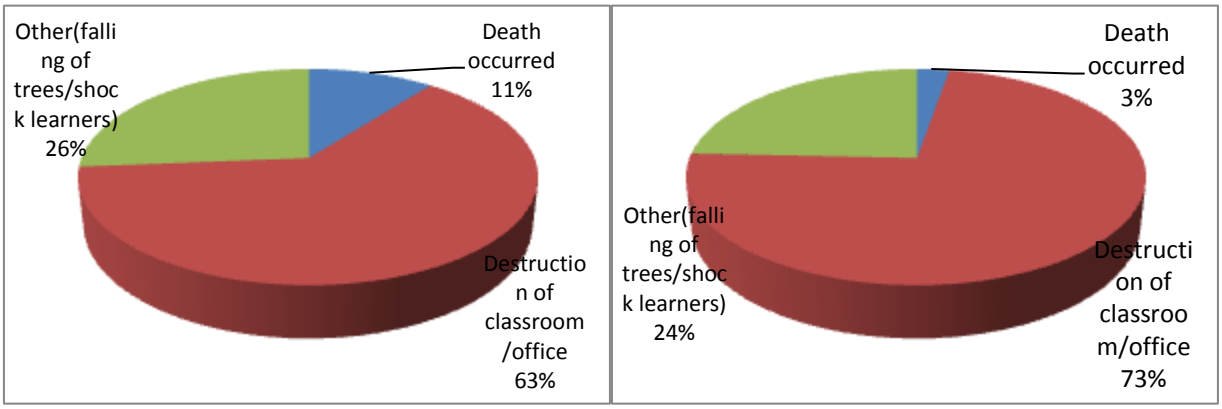


Figure 4.30: Impacts of (a) thunderstorms (b) windstorms in schools.

(a) Classroom roof of Sikalame primary school (Ugunja) (b) Ulwani Primary school (Ugunja) destroyed by windstorm (source, author, 7/12/2017, 3.34 p.m.)

Figure 4.31: (c) Classroom roof of Umer Primary school (Ugenya) destroyed by windstorm (Source, author, 2/6/2017, 4.00 p.m.)

In figure 4.32, 17% of the schools sampled indicated that they have either been affected directly or indirectly by the floods resulting from heavy rains.

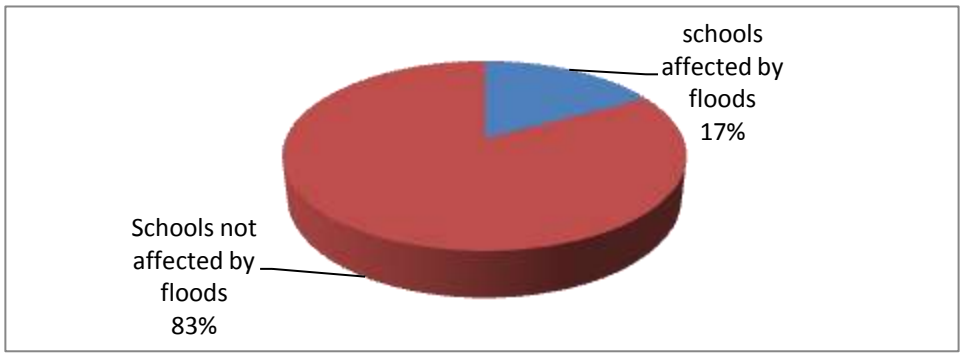
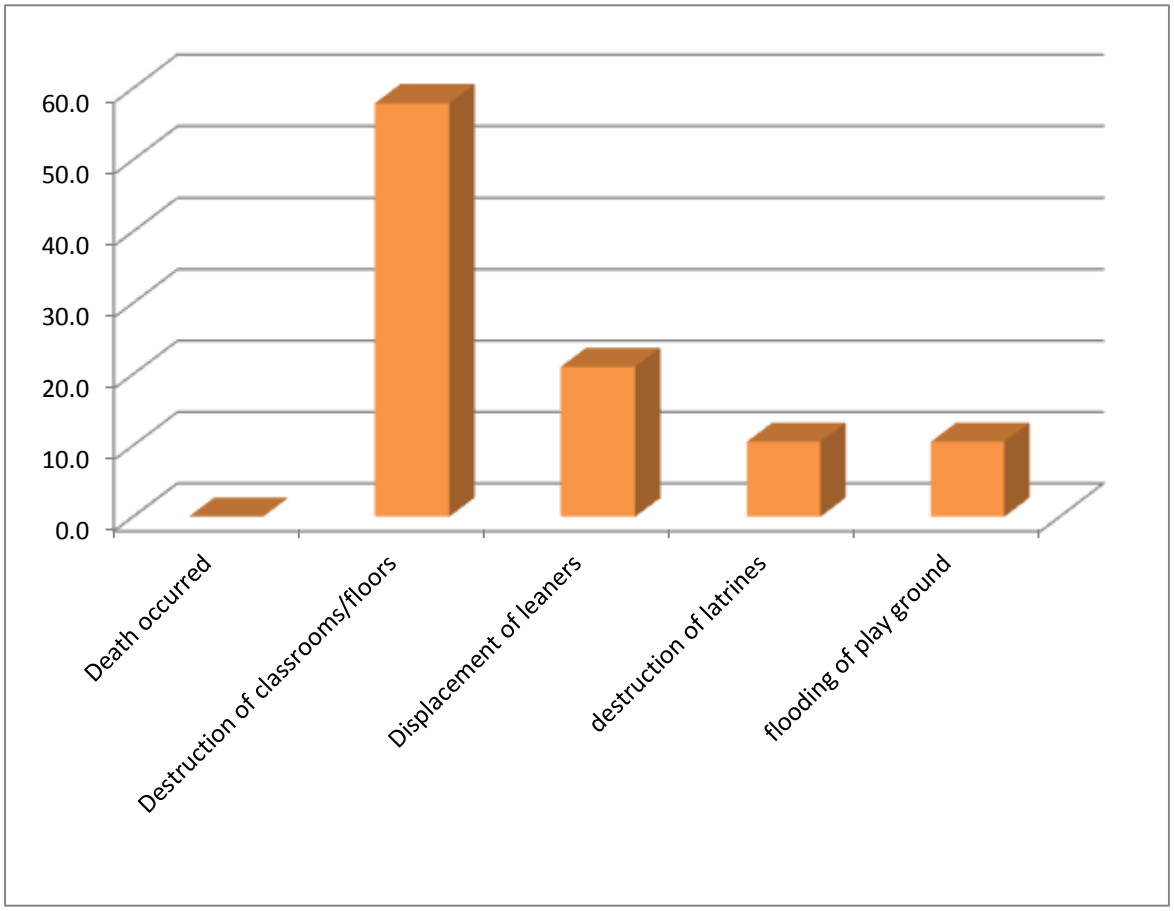


Figure 4.32: Schools affected and not affected by floods.

During rainy season, pupils and teachers find it difficult to commute to and from school. Streams break their banks and the bridges get swept away. Flood occurrences have mainly destroyed classrooms with 58% of the respondents noting that in figure 4.33(a). This has been followed by the displacement of the learners as noted by 21% of the respondents. 11% also noted that it leads to destruction of latrines.

Heavy rains in the evening make them reach home late and have limited time for night studies. After heavy rains, play grounds become flooded, roads become impassable, their books and uniforms get soaked in the water as shown in figure 4.33 (b).

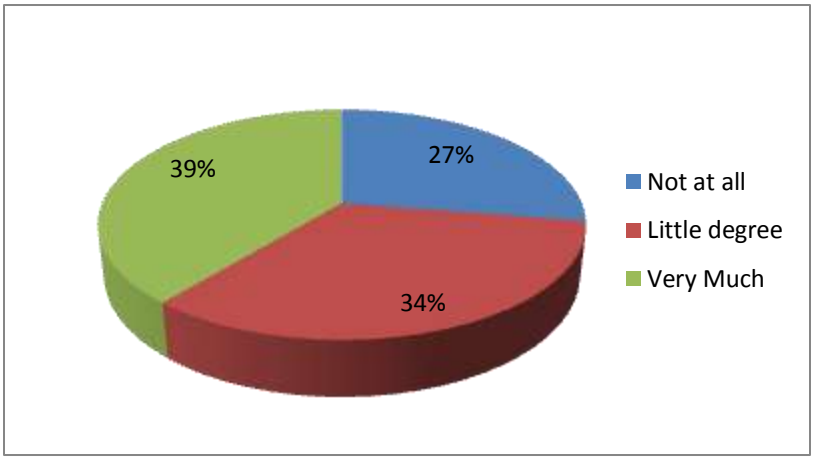
(a)



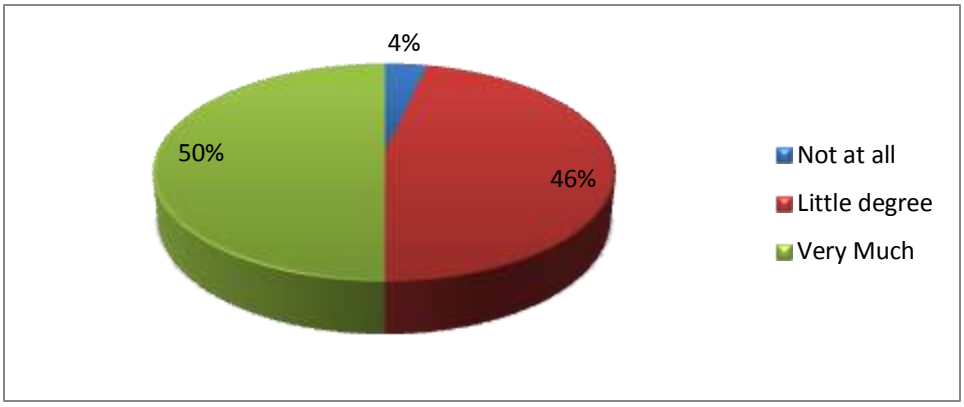
(a) Impacts of floods in schools

Figure 4.33: Pupils and teachers of Ukela Primary school (Ugenya) wading in the floods as they go to school (Source, author, 12/4/2017 ,8.15 a.m.)

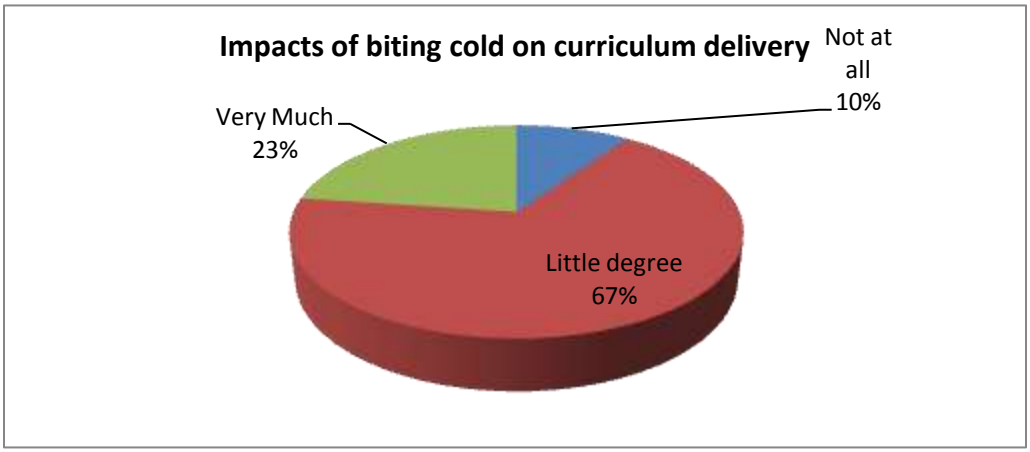
From figure 4.34, the respondents noted that floods and high temperature affects curriculum delivery very much which in turn affects academic performance while biting cold and thunderstorm to a little extent affect curriculum delivery.



(a) Opinion on the Impacts of floods on curriculum delivery



(b) Opinion on the Impacts of high temperature on curriculum delivery



(c) Opinion on the Impacts of biting cold on curriculum delivery

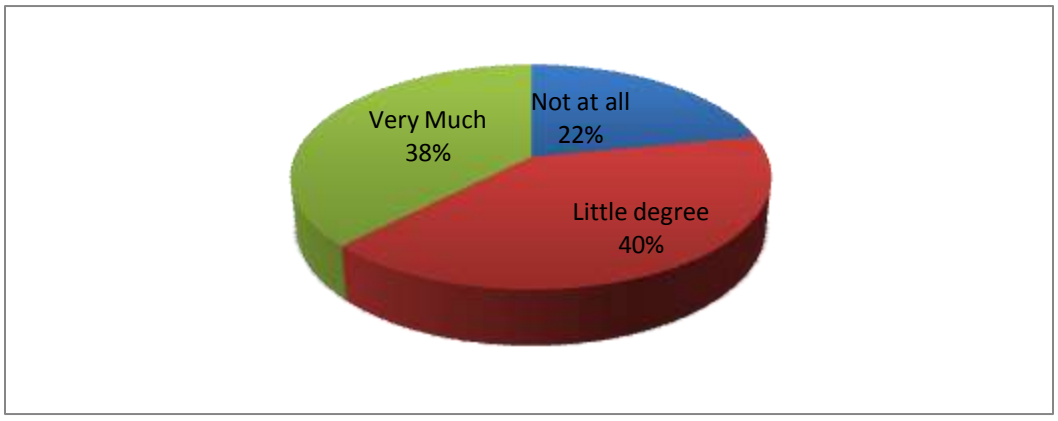


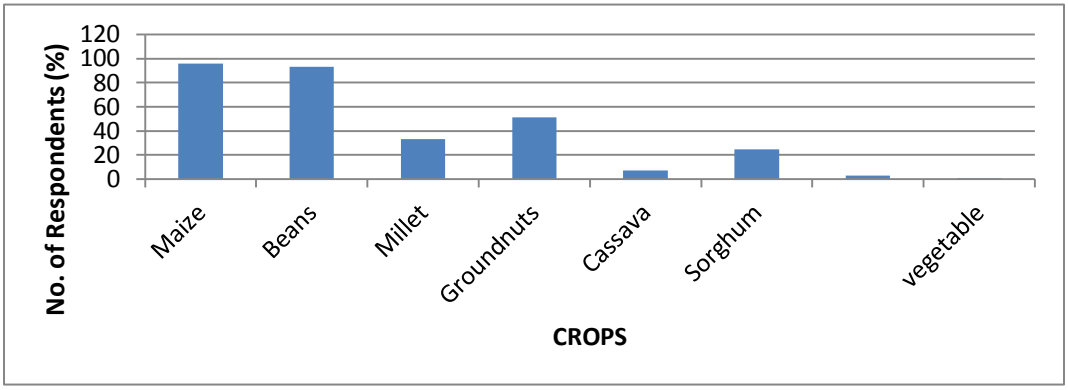
Figure 4.34: (d) Opinion on the Impacts of thunderstorms on curriculum delivery

4.5.7 Responses on Socio – economic information.

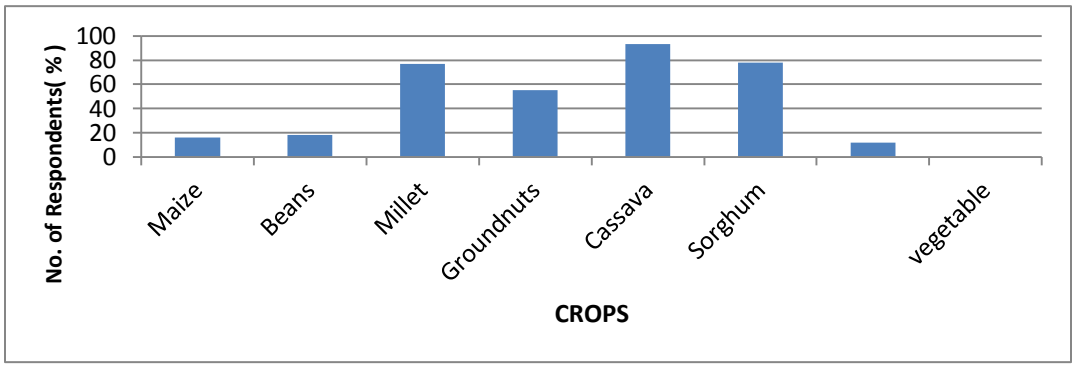
Climate variability has also affected crop production. Crops mainly grown in Siaya are maize, beans, millet, groundnuts, cassava, arrow roots and sorghum. Maize, beans, groundnuts were some of the crop mentioned to be grown twice in a year as indicated in figure 4.35 (a) and . 4.35 (b). Millet, cassava, groundnuts and sorghum have one growing season in a year. The planting periods of most of these crops are either March or August.

The opinion on growing seasons of the staple foods was represented by figure 4.35 c.

Majority of the respondents noted with concern that the growing seasons of most crops have shifted due to the shift in weather patterns. The respondents reported that delays in the onset of long rainy season had the resultant impact on cropping season. Consequently, this resulted in the extension of growing season for most crops.



Crops that are grown twice in a year



Crops that are grown once in a year

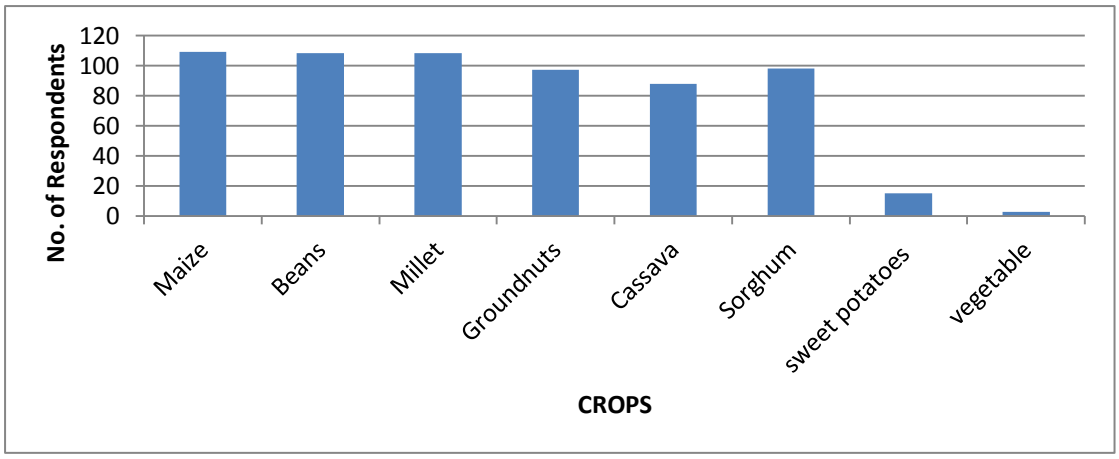


Figure 4.35: (c) Crops that have Planting periods between March and August.

Most of the respondents noted that the growing seasons for most crops have changed (Figure 4.36).

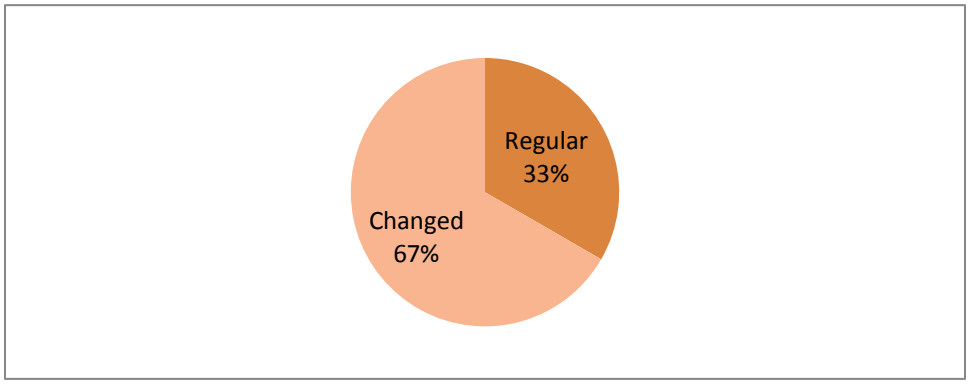


Figure 4.36: Opinion on the growing periods of the crops.

On food security in the county, 83% of the respondents noted that the county has become food insecure and most families survive on a meal or none in a day (Figure 4.37). Most children report to school without taking anything having gone without food the previous day. Food insecurity in the county is as a result of variability in climatic patterns of the region. Prolonged drought leads to crop failure. Shortage of food force children to do odd jobs to get money to buy food. The pupils miss school as they take part in child labour. Children report to school hungry making them not concentrate in class. They become physically weak and are unable to participate in co curriculum activities.

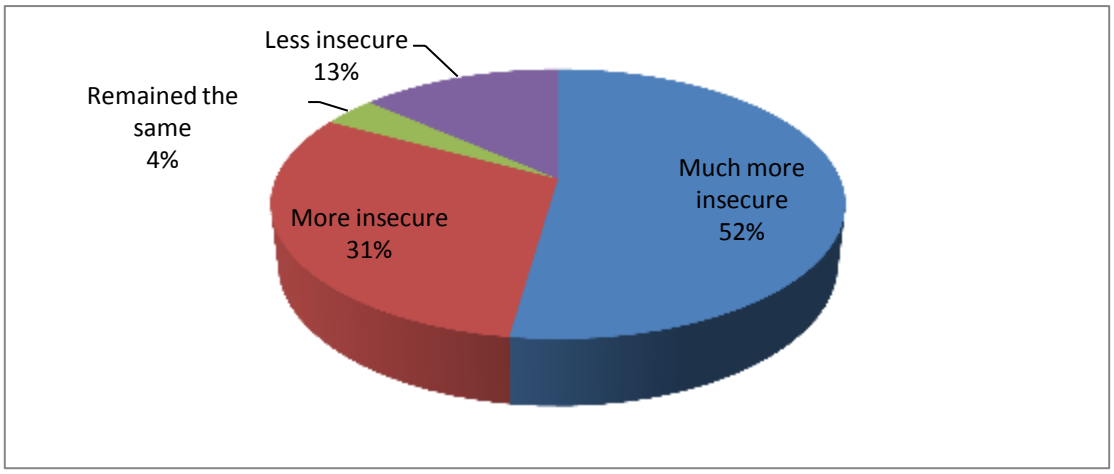


Figure 4.37: Opinion on food insecurity.

4.5.8 Responses on Strategies to improve academic performance during climate variability.

When interviewed, the respondents indicated that there are some strategies put in place to counter the impacts of climate extremes on performance in schools.

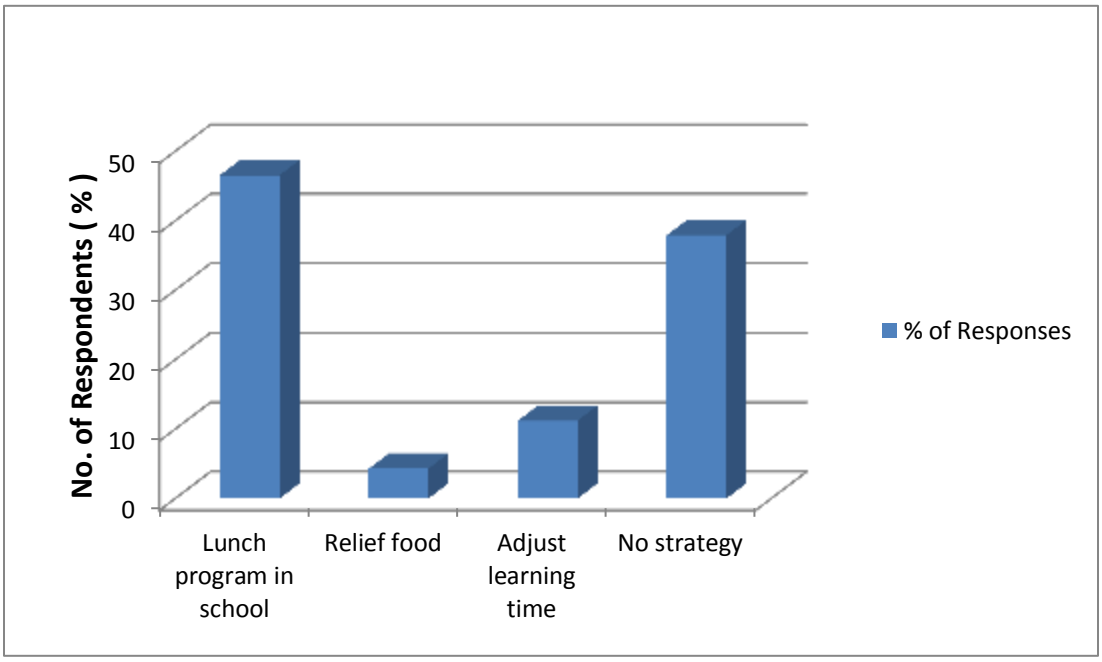
In the case of famine, 47% of the sampled schools had lunch programmes in school supported by the school parents or other stakeholders (figure 4.38 a). Schools such as Ulumbi primary School in Gem Sub-County-all pupils were feeding in school; an initiative supported by parents and Millennium Village Project**.** 38% of them had no strategy while 11% adjusted learning time whereby lessons start very early and end early to allow those who fend for themselves and their families to get time to go home and look for food. A small percentage of schools obtain relief food from either donors or government i.e. schools in Bondo Sub county had lunch program supported by C.D.F (Constituency Development Fund).

From figure 4.39 (a), majority of the respondents had no strategy put in place during very high temperatures. The pupils have no option but to stay inside the hot classrooms. 28% conduct their lessons under the tree when temperatures are high. 21% adjust their learning time tables so that the Lessons begin early when the weather is still cold and end early at noon. No school had installed cooling gadgets in the classrooms as a way of cooling down the temperature.

In case of water shortage, most of the children carry water from their homes (Figure 4.40 (a)). A few schools buy the water while a small number have no strategy at all since they have boreholes and water tanks at school.

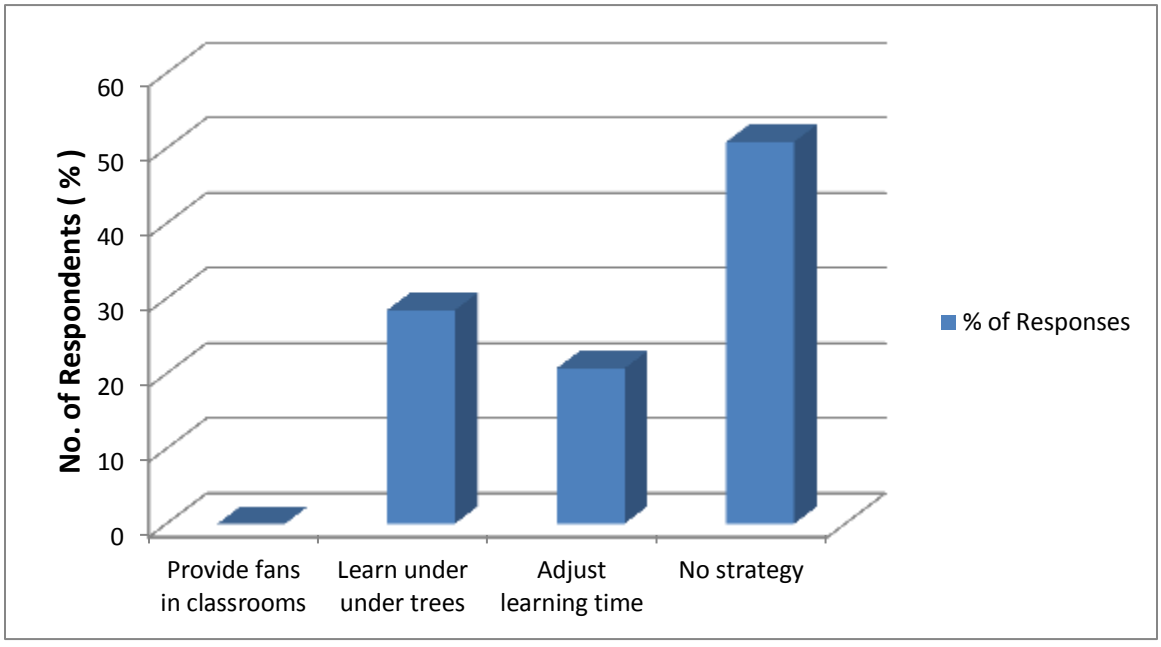
Half of the respondents indicated that they take no action when floods occur, 46% adjust the learning time to allow the floods to subside. Nearly 1% provides an alternative means of transport to enable children reach school (Figure 4.40(b)).

When windstorms destroy facilities in the school most of the respondents (68%) in figure 4.40 (c) indicated they organize for remedial lessons to recover the lost time. 22% take no action while 10% close down the schools to allow for renovations.



(a) Strategies to improve performance during famine

Figure 4.38: (b) Pupils of Mudaho Primary school – Ugunja sub-county feeding at school ***(Source, author, 6/3/2017, 11.10 a.m.)***



(a) Strategies to improve performance during high temperatures

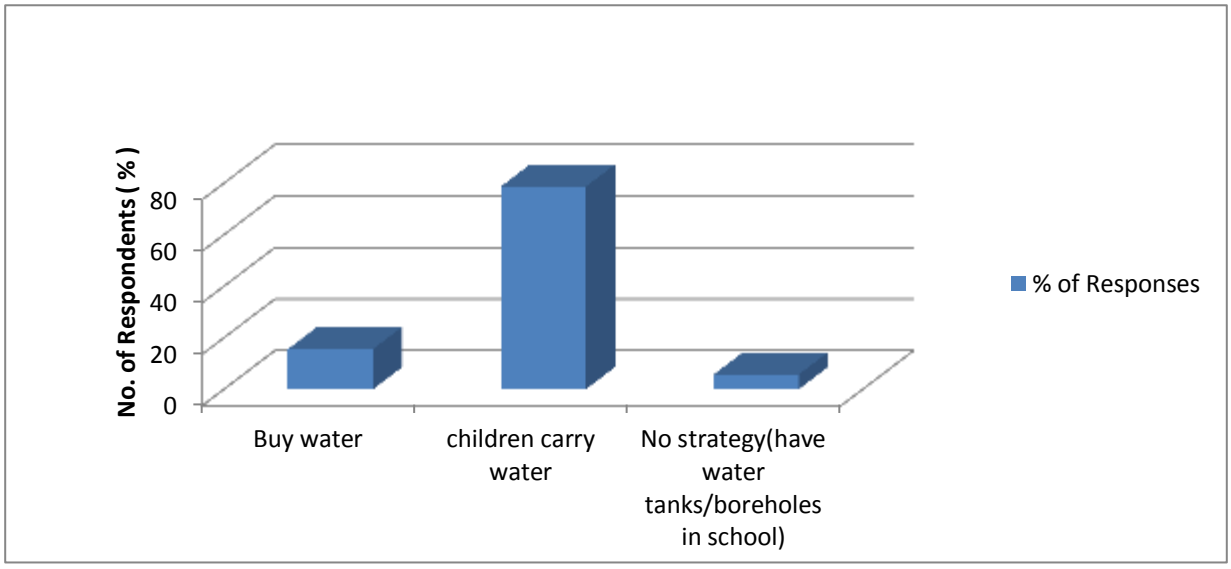
(i) **(ii)**

(b) (i) Nyaharwa Primary school (Ugenya) learning under trees during hot afternoon (ii) water harvesting tank in Ulwani Primary (Ugunja)- Source, author, 20/8/ 2017, 3.34 p.m.)

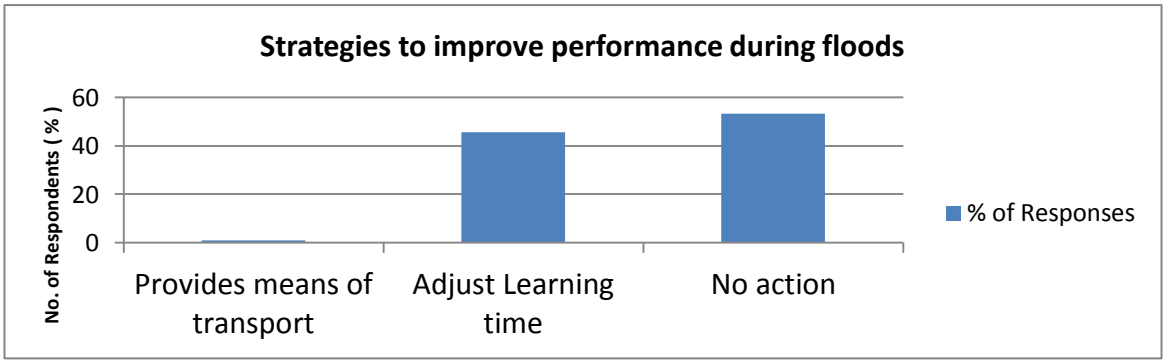
(iii)

Figure 4.39: (b) (iii) Pupils of Mauna Primary School (Ugunja) using borehole at school (Source, author, 22/2/2016, 10.15 a.m.)

(a)



(a) Strategies to improve performance during water shortage



(b) Strategies to improve performance during floods

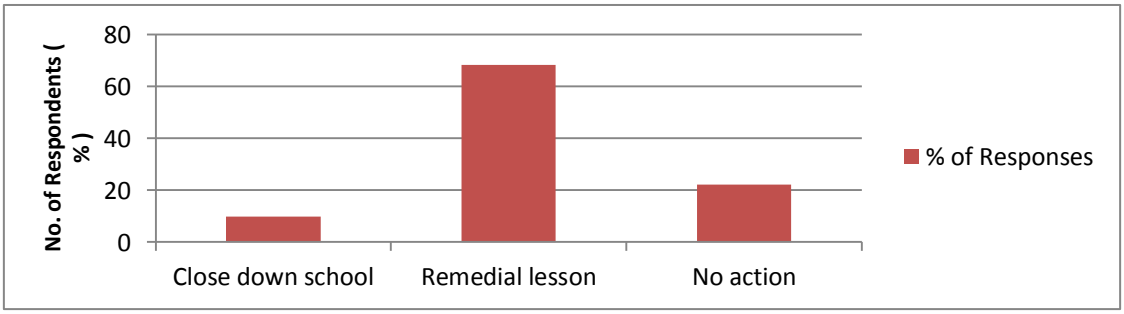
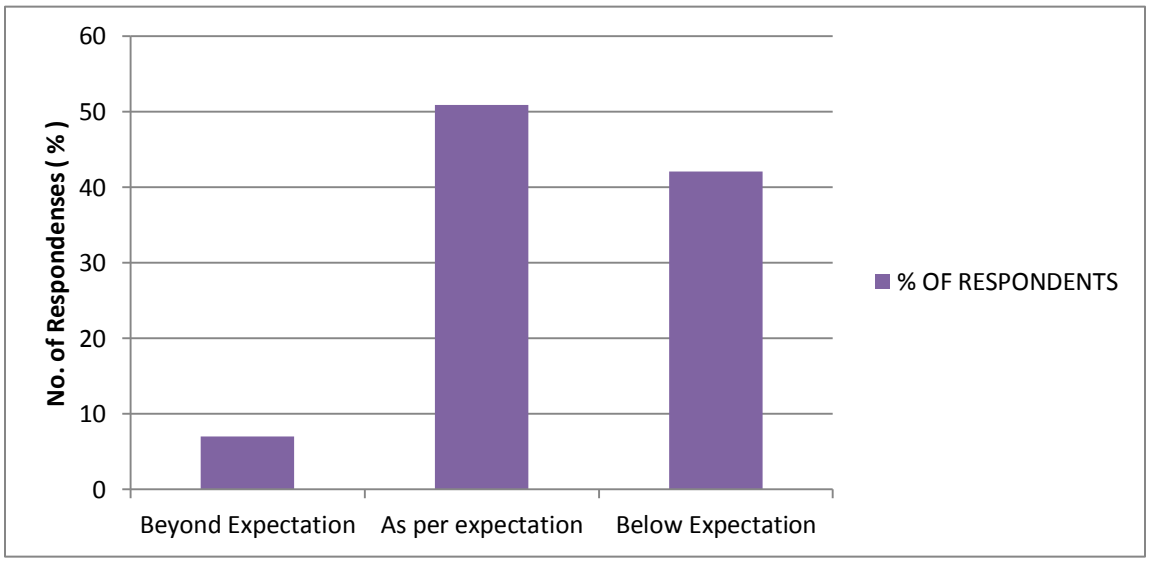


Figure 4.40: (c) Strategies to improve performance during windstorms.

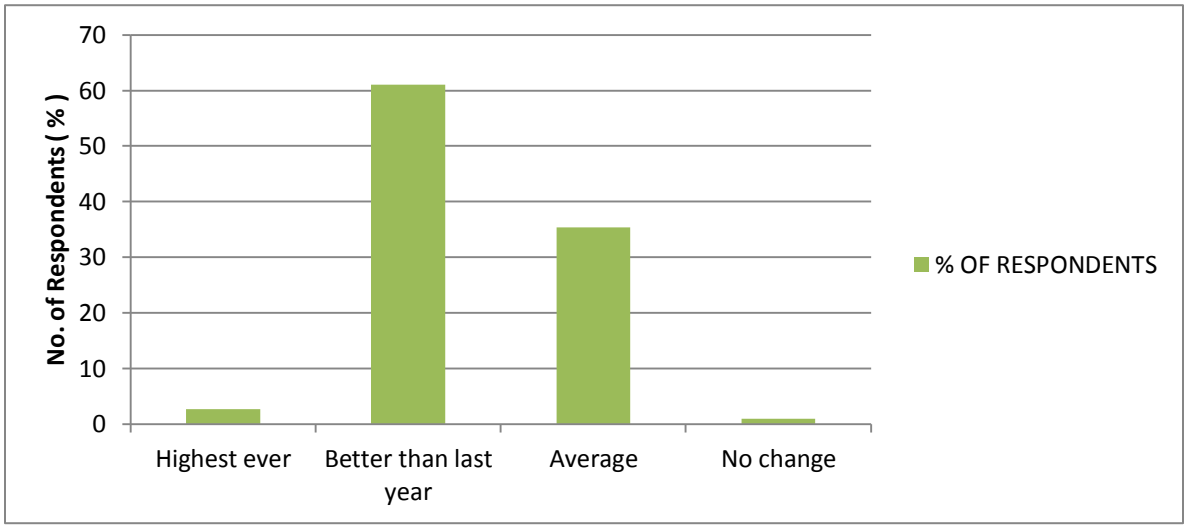
More than 50% of the respondents (teachers) in figure 4.41 (a) noted that the previous year's performance was as per their expectation due to myriad of challenges; climate variations being

part of them. 42% indicated it was below their expectation with 7% noting it was beyond their expectations**.**

Most of the respondents in figure 4.41 (b); both the teachers and the pupils were optimistic with the performance in the year ahead of them with 61% expecting the performance to better while 1% of teachers had a feeling that there would be no much change since there had been adverse food insecurity coupled with introduction of new educational policies and reforms that they were yet to adjust to. 91% of the pupils expecting to perform better than the previous year in figure 4.41 (c).



(a) Opinion of teachers on performance in K.C.P.E 2016



(b) Opinion of teachers on performance

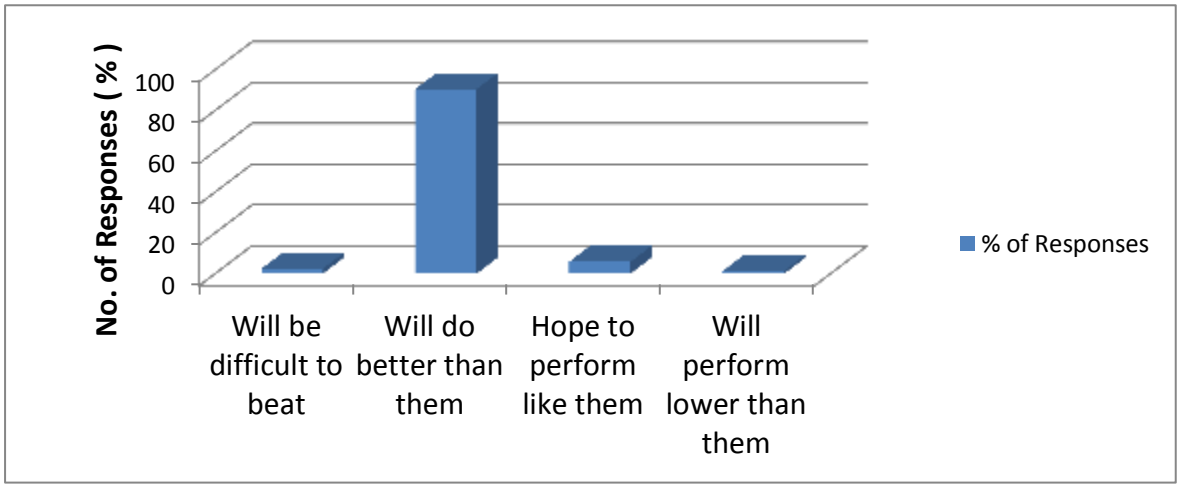


Figure 4.41: (c) Opinion of pupils on performance of 2017 class compared to the previous class - 2016, the previous class…..

Generally more than a half of the respondents indicated in figure 4.42 that variability in climatic elements to some extent affect performance even though not in totality.

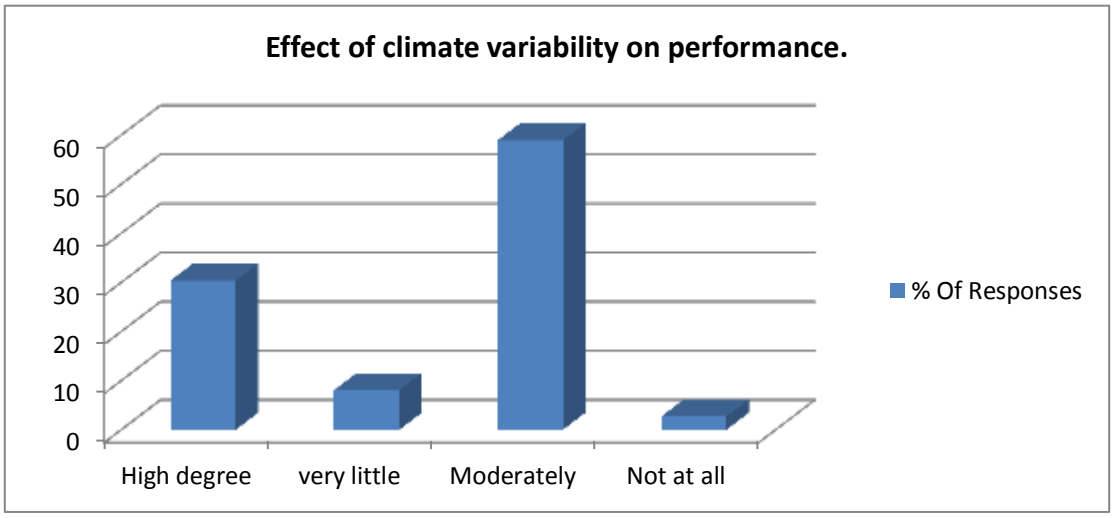


Figure 4.42: Opinion on the degree of effect of climate variability on performance.

Based on the responses in figure 4.43, the main cause of absenteesim in schools as noted by the majority of the respondents is sickness due to malarial/ cholera related infections. This is followed by famine and water scarcity being the third contributor; all being climate related.

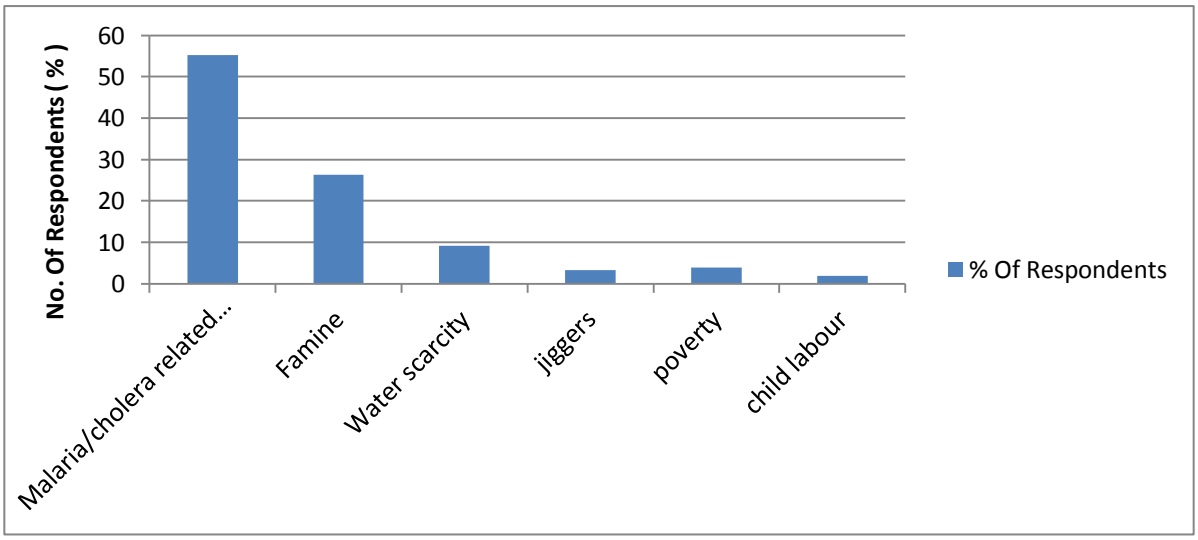


Figure 4.43: Opinion on the major reasons for absenteeism in Siaya County

4.5.9 Responses of learners on how weather elements affect their performance

Majority of learners indicated that they walk from home to school and back, while 5% use bicycle (figure 4.44). The majority is affected by muddy roads and broken bridges when they move to and from school.

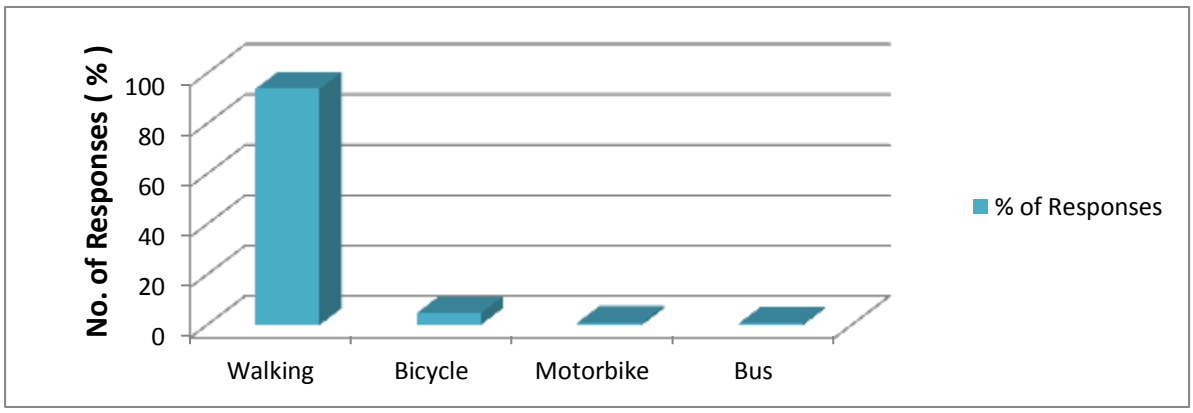
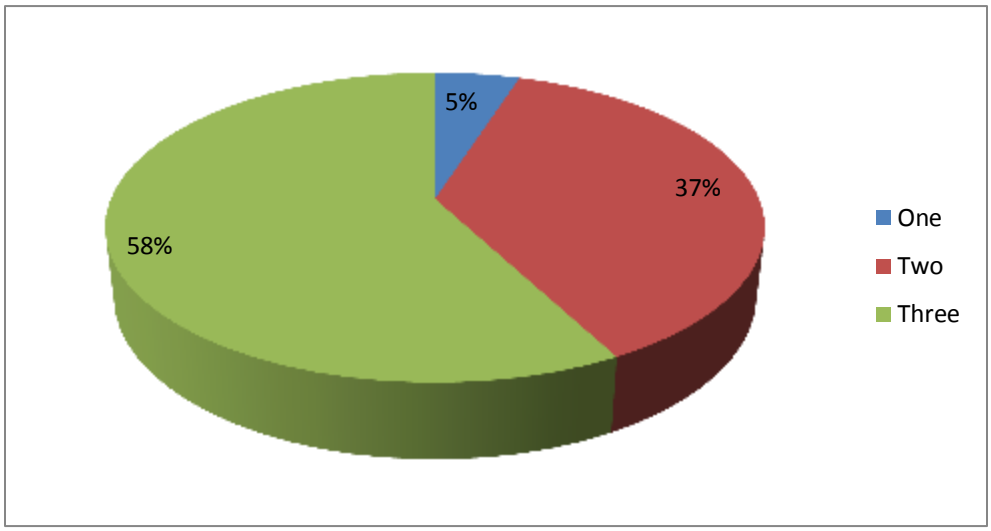


Figure 4.44: Means of transport used by pupils to school in Siaya

Under normal circumstances without adverse food shortage, most of the pupils take three meals in a day i.e. break-fast, lunch and supper while 37% take lunch and supper alone (Figure 4.45 a).

During famine, a half of the respondents indicated that they struggle to get two meals; breakfast and supper while 30% take only supper with 2% going without food.

(a)



(a) Number of meals taken in a day under normal circumstances

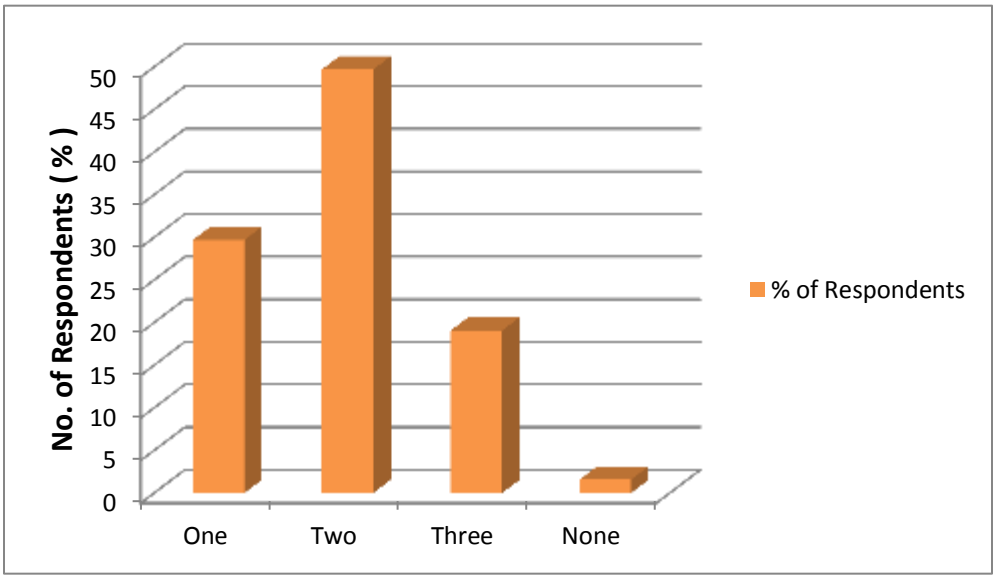
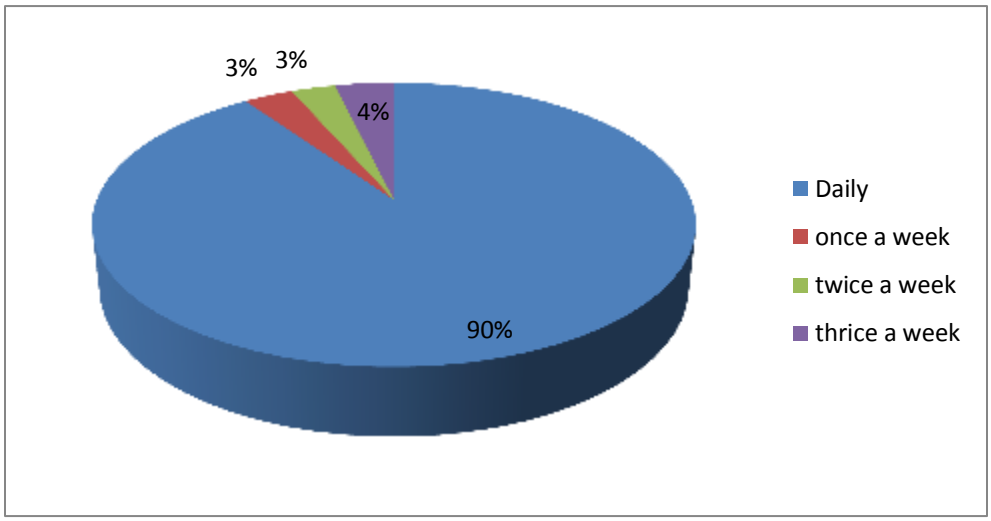


Figure 4.45: (b) Number of meals taken in a day during famine.

Majority of the respondents (90%) take bath on a daily basis but during drought only 53% take bath daily followed by 31% taking it thrice a week skipping some days (Figure 4.46). This is done to minimize on water wastage. Reducing the days of bathing is appropriate coping strategy to help strengthen resilience.



(a) Number of times pupils take bath under normal circumstances

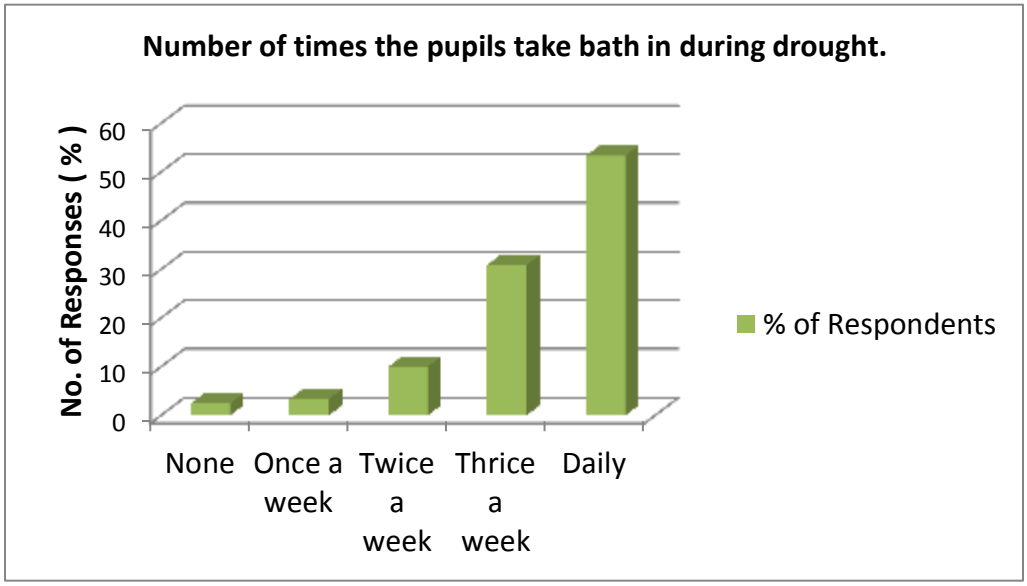
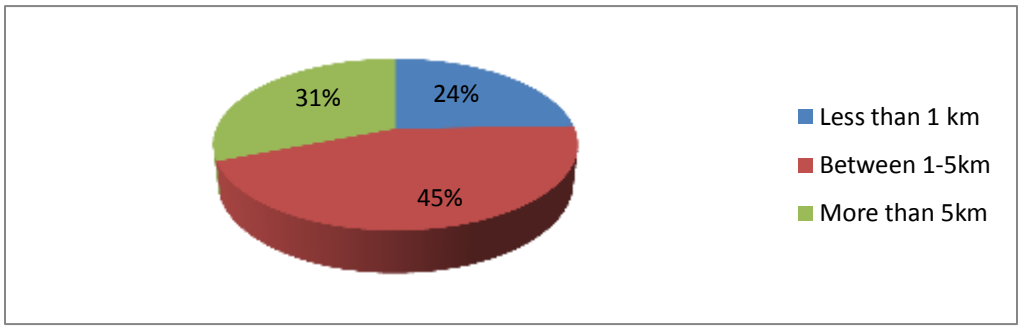
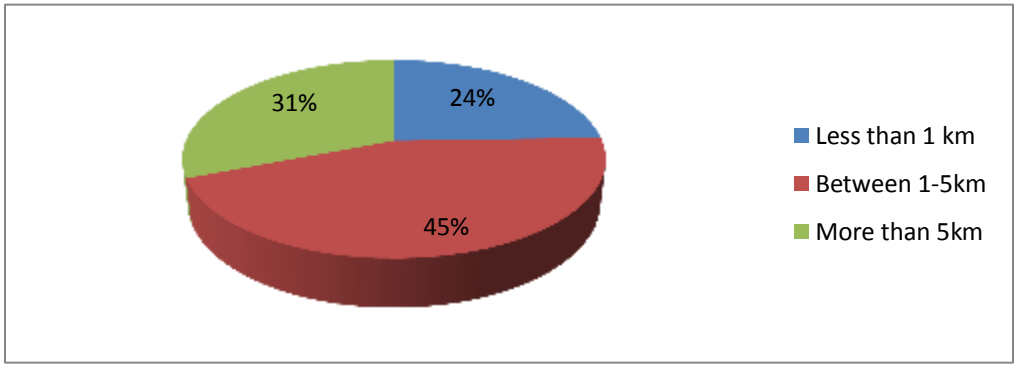


Figure 4.46: (b) Number of times pupils take bath during drought

For the learners without water at home and school; most of them cover an approximate distance between1-5km to collect the water walking on foot (Figure 4.47 a). 31% of the pupils cover more than 5km. During drought the distance travelled is maintained as shown in figure 4.47 (b).This is as result of most water sources in the county are permanent. Despite this a lot of study time is wasted as the pupils make travel longer distances to look for water during drought since the water table reduce (Figure 4.47 c).



(a) Distance travelled to collect water on normal days

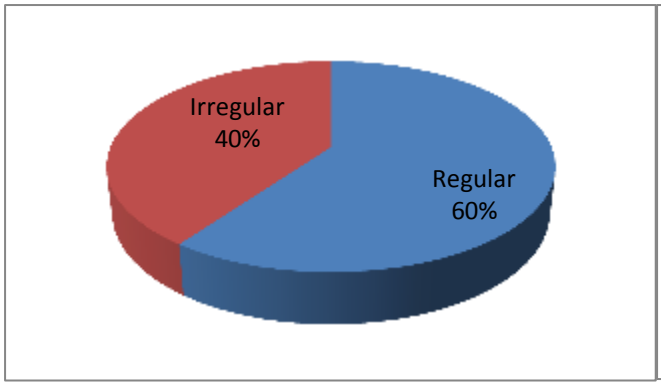


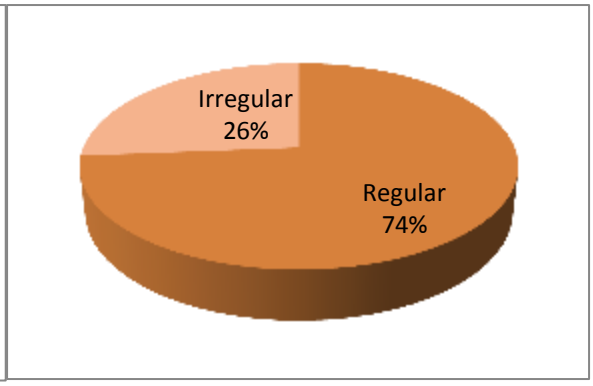
(b) Distance travelled to collect water when there is drought

Figure 4.47: (c) Residents and school pupils of Kometho in Rarieda Sub county queue for water during drought (Source, author, 17/9/2016, 11.55 a.m.)

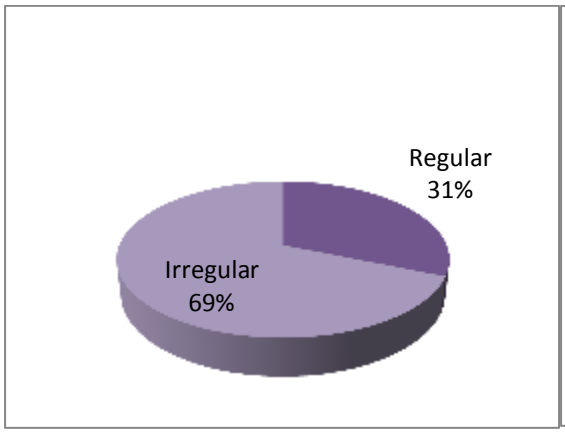
4.5.9.1 School attendance during various weather events

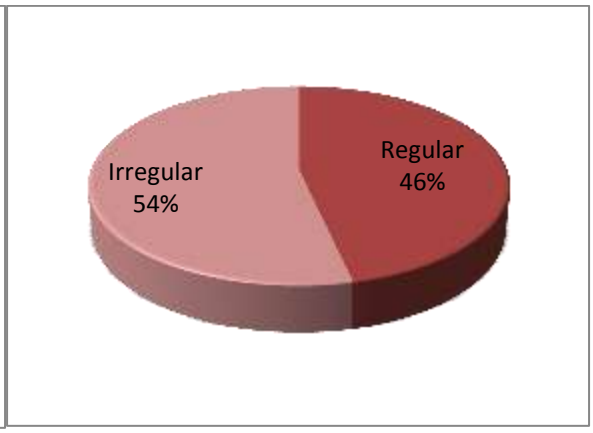
Despite drought, high temperature and biting cold in the morning, the study noted that children are regular in their school attendance (Figure 4.48 a, b, d, e, f, g) except during floods (Figure 4.48 c). During very heavy rains which cause floods, famine, thunderstorm and stormy weather many pupils are irregular in their school attendance.



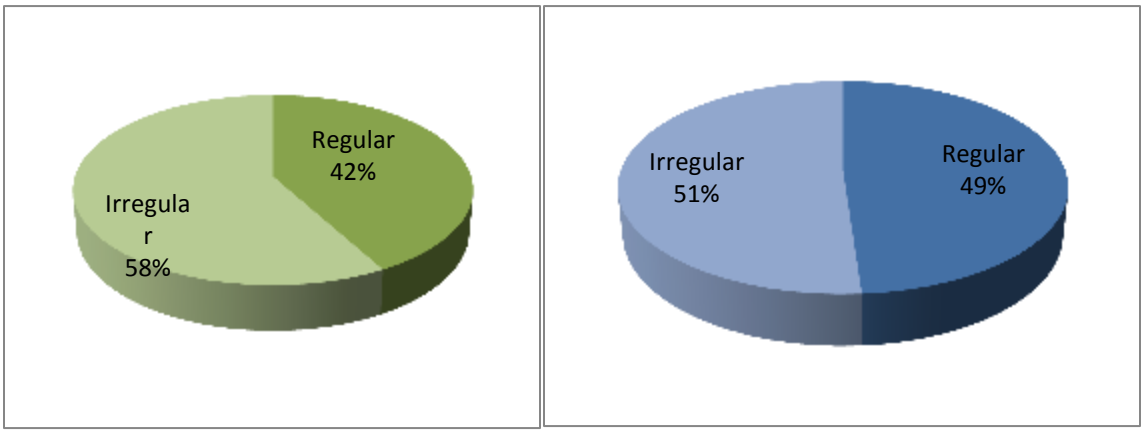


(a) School attendance by pupils during drought (b) School attendance by pupils during high maximum temperatures





(c) School attendance by pupils during floods (d) School attendance by pupils during famine



(e) School attendance by pupils during thunderstorm (f) School attendance by pupils during stormy weather

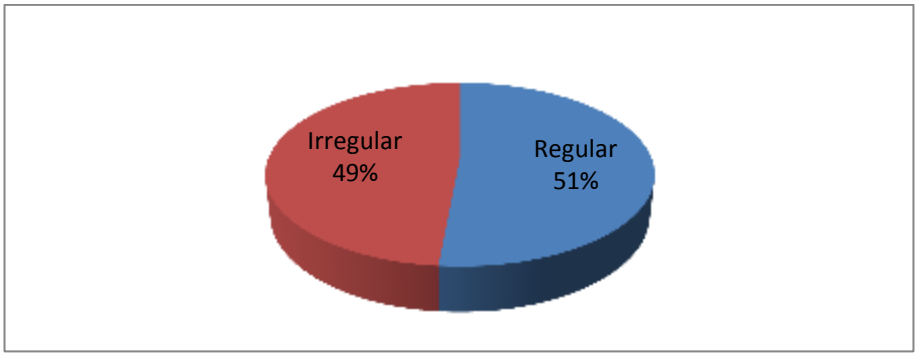


Figure 4.48: (g) School attendance by pupils during biting cold

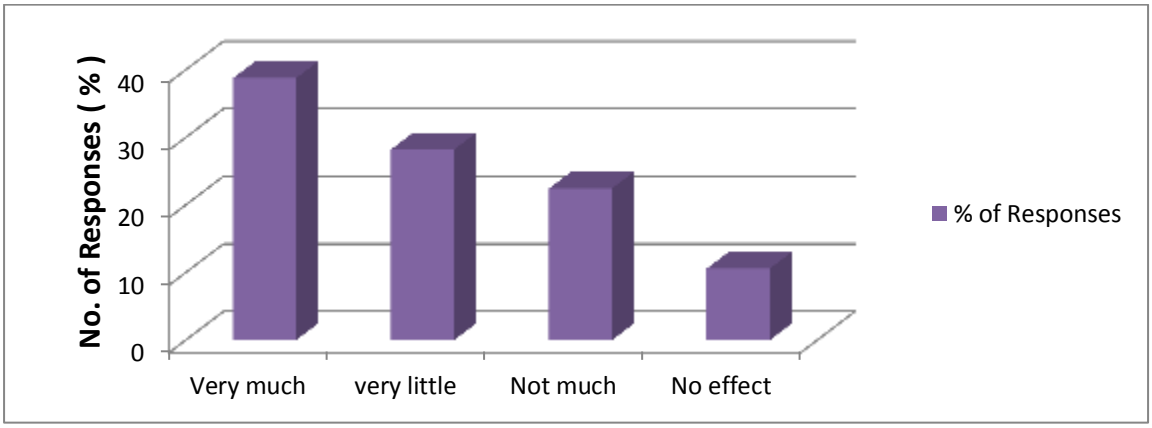
4.5.9.2 How various weather events affect academic performance

Asked for their opinion on the impacts of variation of weather elements in their academic performance at school, 39% of the respondents noted that very high maximum temperatures affect them very much followed by 28% who indicated a little (Figure 4.49 a).

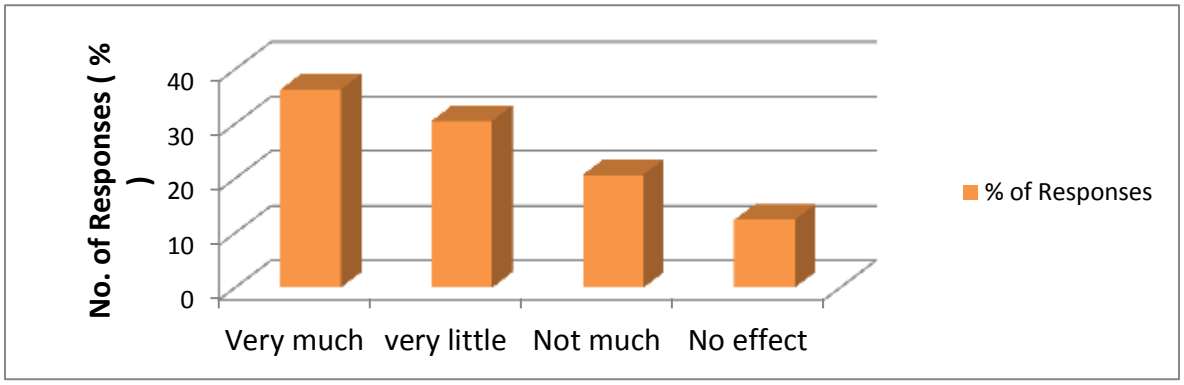
Floods, drought and famine were indicated to affect performance very much with 36%, 41% and 48% of the respondents respectively followed by 31%, 28%, 26% indicating its impacts to very little extent (Figure 4.49 b).

A slight majority of the respondents 28.9% and 30% indicated that lightning and windstorms to a very little extent affect performance (Figure 4.49 c).

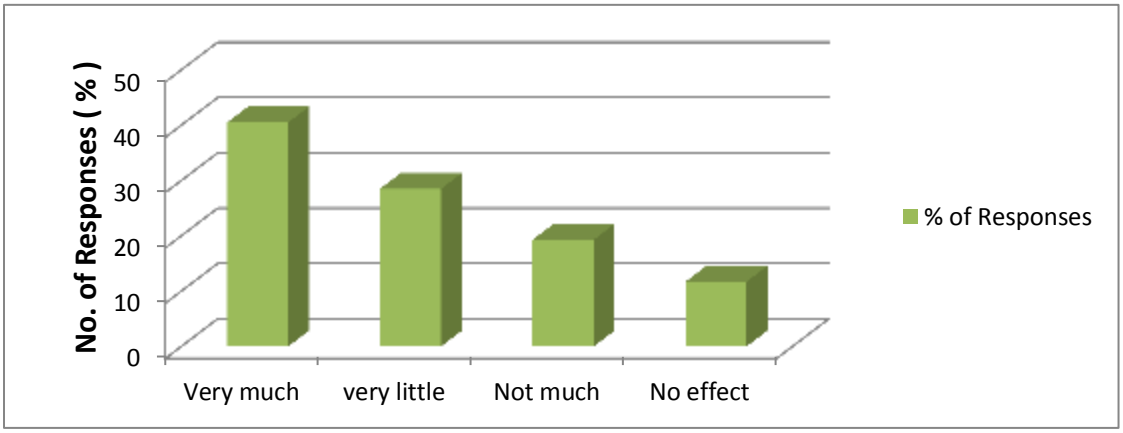
Generally, the respondents indicated food scarcity as the major impediment to performance Figure 4.49(d). This suggests that regardless of the type of prevailing weather, performance will be enhanced by ensuring food security.



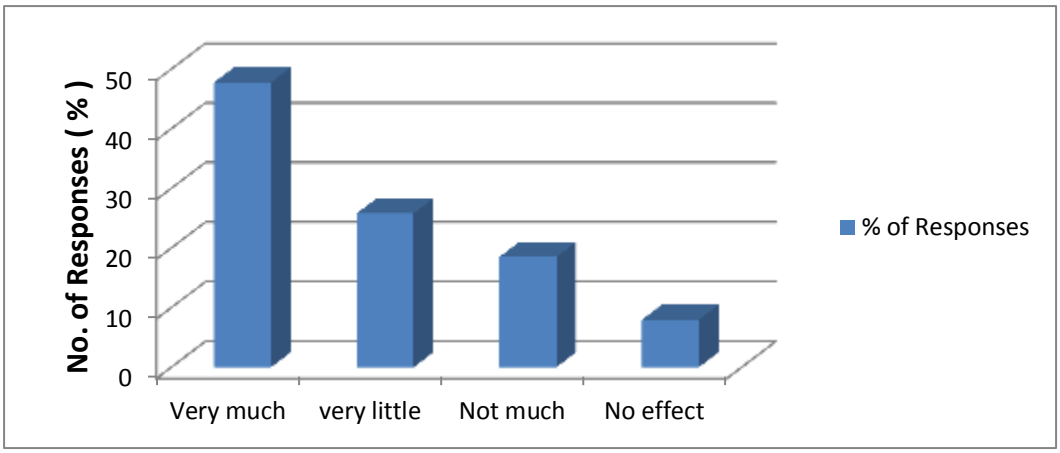
(a) Effects of very High Temperatures on performance



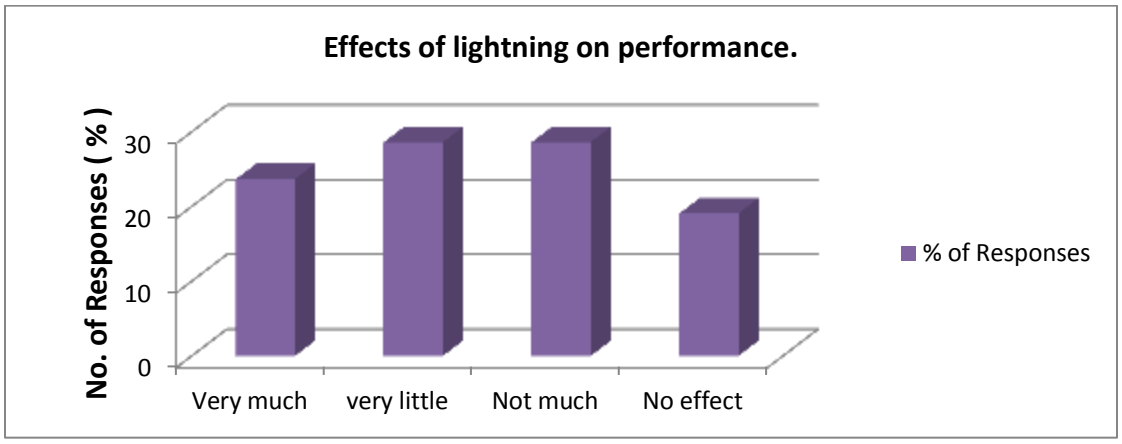
(b) Effects of Floods on performance



(c) Effects of drought on Performance



(d) Effects of famine on Performance



(e) Effects of lightning on Performance

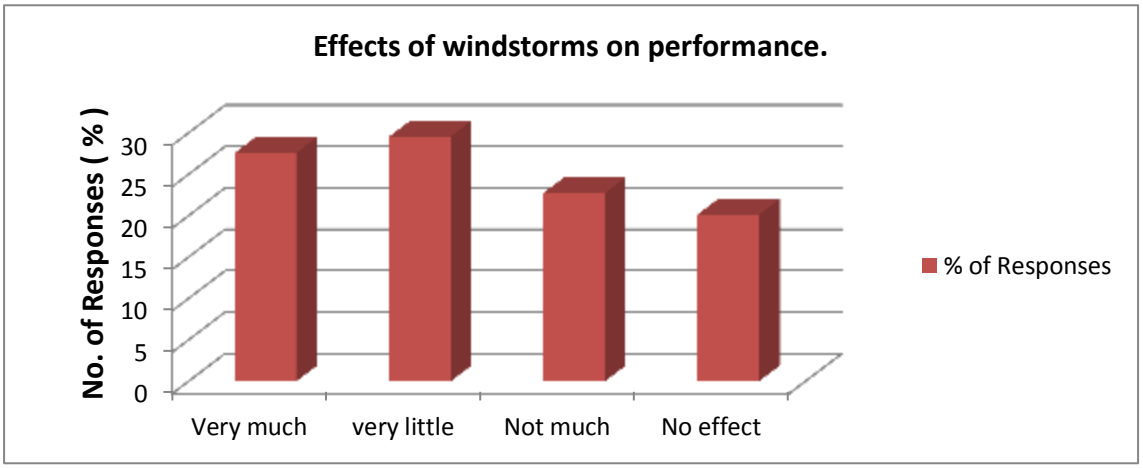


Figure 4.49: (f) Effects of wind storms on performance.

CHAPTER FIVE: CONCLUSIONS AND RECOMMENDATIONS

5.0: Introduction to Chapter Five

The conclusions derived from the study are presented in this chapter. The recommendations and suggestions for further studies are also provided.

5.1 Conclusions

Results obtained from the study indicate that there has been variability of climatic elements in Siaya County. The three climatic variables studied namely; rainfall, minimum and maximum temperature displayed a strong seasonality. Inter annual variability was also evident depicting years with extreme events. Both Minimum and Maximum temperatures have been increasing over the years. The trend in the rainfall has been decreasing though not statistically significant. However, the variance in the rainfall is observed to have increased in the recent past implying increased extreme events.

The analysis of the Kenya Certificate of Primary Education performance in Siaya County indicated a general decline in all the sub counties. There is an inverse relationship between minimum temperature and KCPE performance with August having the highest correlation. The nature of relationship between maximum temperature and performance depended on the month. Cold months were positively correlated with performance and warm months were negatively correlated. However, the values were not statistically significant except for September that indicated significant positive correlation.

The relationship between rainfall and performance is generally weak an indication of non-linear relationship. This is consistent with the fact that both below normal and excessive rainfall impact negatively on performance. Low rainfall leads to drought and hence unavailability of food which negatively affect learning process. Excess rainfall interferes with transport system and damage learning facilities. The regression model developed to predict performance using weather parameter show that at least 60% of the variance may be explained by weather.

The sub counties were clustered into three groups, which is an indication that besides weather there are other factors that influence performance which were captured using the questionnaires.

The majority of the respondents concurred that weather conditions does have significant impact on performance in spite of other factors like overloaded curriculum, teachers' strikes, in adequate teaching and learning resources . The strategies put in place such as the feeding program were able to adapt against the impact of adverse weather. Provision of water harvesting tanks and boreholes reduces time wastage to look for water hence accorded enough time for learning.

Adjustment on school daily learning schedule in line with the change in the weather ensures optimum learning.

5.2 Recommendations

Based on the findings from the present study, in order to ensure sustainable improvement in performance, the following recommendations are made to various stakeholders;

5.2.1 Recommendations to Parents

They need to be sensitized on the impact of climate on learning so as to take the appropriate action that will enable their children learn comfortably such as dressing the children appropriately depending on prevailing weather.

In order to enable their children to have ample time to do their studies, they should put in place adaptation measures such as installing tanks to store water, sinking boreholes, proper diet for proper physical and mental development.

On transport, the parents should ensure safety from long exposure to extreme weather effects by providing a convenient means of transport in places where the school is far from homes.

Whenever there is an outbreak related to weather, the parents should take appropriate action to ensure the children receive proper medical attention.

5.2.2 Recommendations to School Administration (Teachers)

The head of the institution should maintain conducive learning environment during all seasons for example

Learning time tables should be adjusted during adverse weather elements to allow timely and adequate syllabus coverage to help better academic performance; Plan for outdoor lessons by providing open places and tents to be used as classrooms during hot afternoon temperatures.

Teachers should identify the major reasons for absenteeism and collaborating with parents to minimize rate of absenteeism associated with adverse weather.

5.2.3 Recommendation to Government and Non- Governmental Organizations:

When designing the school facilities like classrooms, there should be proper ventilation for free circulation of air to cushion against high afternoon temperatures. Construct high bridges leading to schools, repair of roads and supply of water tanks to harvest rain water to help during drought.

Fans should be installed in study rooms to keep the pupils alert when studying and doing homework. This can easily be achieved since the government is determined to provide electricity to every home and school.

It is recommended that schools be insured against environmental stresses to cushion the learners and the teachers from the risks related to climate variability. Areas where lightning and thunderstorm is common an intergraded lightning safety plan is needed (Orville, 2000)by installing Lightning arrestors.

The pupils should be given medical insurance scheme, good water treatment plan for schools and supplied with mosquito nets to reduce absenteeism cases as a result of malaria and water borne diseases.

Relief foods and feeding program should be rolled out in day schools .The County Governments in the County Integrated Development plan and in the National Government budget, some funds should be set aside to initiate feeding program in schools to help retain children in school during adverse climatic conditions. They should also ensure children are provided with balanced diet Nutritional insufficiency can hamper traits inherited for academic performance.

The examining criteria should incorporate the climatic conditions of the various learners.

Drug abuse in schools and teenage pregnancy is also common in schools. Government should stamp out the selling of illegal drugs in the school neighborhood and also ban night discos where most school going children are lured to. More campaigns and creation of awareness on dangers of drug abuse and early pregnancies should be done by the government.

5.2.4 Recommendation to scientific community and the Academia

There is need to carry out an analysis of thermal discomfort index since it has a direct bearing on the alertness of learners; to establish what degree of hotness or coldness is suitable for learning.

I recommend that a study be done on the impact of the climate variability on other components of learning particularly the co curriculum activities and develop guide line for optimum conditions for specific games and sports.

REFERENCES

(KICD), T. K. (2017). *Basic Education Curriculum Framework.*

(UNFCCC), U. N. (n.d.). Article 1. *World Meteorological Organization*.

Abagi, O., & Odipo, G. (1997). *Efficiency of primary education in Kenya : situational analysis and implications for educational reform.* Nairobi: Institute of Policy Analysis and Research.

Abura, B., Hayombe, P., & WArkach, K. (2017). Rainfall and Temperature Variations Overtime (1986-2015) In Siaya County, Kenya. *International Journal of Education and Research, 5*(10).

Achoka, J., & Maiyo J. (2008). Horrifying Disasters in Western Kenya. *Impact on Education and National Development*.

Allen, M. R., Vincente R., B., John, B., Wolfgang, C., Renate, C., John A., C., et al. (2014). IPCC fifth assessment synthesis report - Climate Change 2014 synthesis report. *The Physical Science Basis. Contribution of Working Group 5 to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change*.

Amanchukwu, R. N., Nwachukwu, P. O., & Ajuru, I. (2015). Climate Change Education in Nigeria: The Role of Curriculum Review. *Education*.

Amekudzi, Codjoe, S., & Appiah, N. S. (2014). The impact of climate change on malaria in coastal Ghana.

Anderson, A., Anderson, J., Hare, J., & Marriane, M. (2016). *Language Learning and Culture in Early Childhood; Home,School and Community contexts.* New York and London: Routledge.

Anyanwu, R., Lesley Le Grange , & Beets, P. (2015, August). Climate change science: The literacy of Geography teachers in the Western Cape Province, South Africa. *South African Journal of Education,, 35*(3).

Baird, J.-A., Therese N. Hopfenbeck, Paul Newton, Gordon Stobart, & Anna T. Steen-Utheim. (2014). *Assessment and Learning.* London: Oxford University Centre for Educational Assessment.

Bamanya. (2007). Intraseasonal characteristics of daily rainfall over Uganda during the wet seasons. MSc.

Bamanya. (2007). Intraseasonal characteristics of daily rainfall over Uganda during the wet seasons. MScthesis (unpublished), University of Nairobi, Kenya.

Bartels M, Rietveld, M., GC, V. B., & DI, B. (2012, 12 5). Heritability of educational achievement in 12-year-olds and the overlap with cognitive ability. *PubMed*, pp. 544-553.

Basalirwa, C., J.O. Odiyo, R.J. Mngodo, & E.J. Mpeta. (1991). The Climatological Regions of Tanzania based on the Rainfall Characteristics. *International Kournal of Climatology, Vol. 19*.

Bass, B. B. (2008). *The Bass Handbook of Leadership: Theory,Research, and Managerial Applications.* New York: The Free Press.

Benjamin. (1996). *Family Literacy:Directions in Research and Implications for Practice.* Santa Babra: University of Carlifonia.

Blodgett, H. (1929). *The effects of the Introduction of Reward upon the maze Performance in rats.* University of California Publications in Psychology.

Bofferding, L., & Kloser, M. (2015). Middle and high school students' conceptions of climate change mitigation and adaptation strategies. *Environmental Education Research, 21*(2).

Buggy, Conor J, McGlynn, & Gale. (2014). Climate change awareness in a developing nations' second level. *United Nations Sustainable Development Network 2nd Annual.*

Bundy, D., & H.L. Guyatt. (1996, August 1). Schools for health: Focus on health, education and the school-age child. *Trends in Parasitology, 12*(8), pp. 1-14.

Burns, S. (1995). 'Rapid changes require enhancement of adult learning'. *HRMonthly June*, pp 16-17.

Burt, C. (1952, June). Tests of significance in factor analysis. (M. V. Davier, Ed.) *British Journal of Statistical Psychology*.

Canadel, J., Ciais, P., Dhakal, S., Dolman, H., Friedlingstein, P., Gurney, K., et al. (2010). Interactions of the carbon cycle, human activity, and the climate system. *Current Opinion in Environmental Sustainability*, pp. 301-311.

Catell, R. (1966). The scree test for the number of factors. *Multivar. Beha. Res., vol. 1*, pp. 245–276.

Chang'ach, J. K. (2012, April). An Unfinished Agenda: Why is the Boy Child Endangered? *International Journal of Academic Research in Business and Social Sciences, 2*(4).

Child, D. (1990). The essentials of factor analysis. *2nd ed.*

Chinyoka, K., & Naidu N. (2013). Uncaging the Caged: Exploring the Impact of Poverty on the Academic Performance of Form Three Learners in Zimbabwe. *International Journal of Educational Sciences, 6*, 203- 213.

Conway, D., & Hulme, M. (1993). Recent fluctuations in precipitation and runoff over the Nile sub-basins and their impact on Main Nile discharge. Climatic Change 25127-151Economist, 2009: East Africa‟s Drought A Catastrophe is Brewing.

CrightMc, Riley E. Dunlap, & Robert J. Brule. (2010). *Climate Change and Society: Sociological Perspectives.* Oxford University Press.

Daniel O. Olago. (2009). *Kenya: Climate Change Impacts, Vulnerability, Mitigation and Adaptation Strategies.*

Dunn R., & Dunn K. (1993). Teaching secondary students through their individual learning styles.

Dutta, P., & Varsha Chorsiya. (2013, August). Scenario Of Climate Change And Human Health In India. *International JournalL of Innovative Research & Development, 2*(8).

Ecker, O., & Nene M. (2012). Nutrition policies in developing countries: Challenges and highlights. Policy Note 1.

Edwards, P., Ian Roberts, Mike Clarke, Carolyn DiGuiseppi, Sarah Pratap, Reinhard Weintz, et al. (2002, May). Increasing response rates to postal questionnaires: systematic review. *BMJ*.

Ekhtheknaul. (2014). Climate Change and School Going Children in Bangladesh: Understanding the Relationship.

Eshiwani, G. S. (1993). *Education in Kenya since independence.* Government Printers, Nairobi.

Fankhauser, S. (2016). *Adaptation to climate change.* University of Leeds , Grantham Research Institute on Climate. London: The Centre for Climate Change Economics and Policy (CCCEP) .

Fels. (2009). *Publications - Fels Research Institute for the Study of Human Development.* the University of Michigan.

Ghadegbe, R. S., & Mawuli, Q. (2013). The Impact of Indecent Dressing on the Academic Performance of Students in Tertiary Institutions, a Case Study of Ho Polytechnic in Ghana. *Journal of Education and Practice, Vol.4*(No.18).

GoK. (2013). National Climate Change 2013-2017.

Google Maps. (2018.Siaya County.Retrieved and edited from https://www.google.com/maps/search/SIAYA+COUNTY+LONGITUDE+AND+LATITUDE/@-0.0580238, 3. (n.d.).

Guardian, & Delvin, H. (2016). Genes influence academic ability across all subjects. *Genetic Literacy Project*.

Hales. (n.d.). Impacts on health of climate extremes. *Climate Change and Human Health*.

Hanley, J. A., Abdissa Negassa, Edwardes, M., & Janet E. Forrester. (2003, February 15). Statistical Analysis of Correlated Data Using Generalized Estimating Equations: An Orientation. *American journal of Epidemilogy, 157*(4).

Harman, H. (1967). Modern Factor Analysis.

Haverinen-Shaughnessy, U., & Shaughnessy, R. (2015, August 28). Effects of Classroom Ventilation Rate and Temperature on Students' Test Scores. *PLOS One*.

Hernandez, F. H. (2015). Education in Times of Climate Change: Facilitating Learning to build to build a culture of Climate Protection. *Monograph: Living with Climate Change* .

Hiller. (2012). Prevalence and Impact of Chronic Musculoskeletal Ankle Disorders in the Community.

Hirabayashi Yukiko, M. R. (2013). Global flood risk under climate change. *Nature Climate Change*.

Hirsch, R., & S.A. Archfield. (2015.). Floods trends: Not higher but more often. *Nature Climate Change*, 5:198-199.

Hoedjes, J., A. Kooiman, B.H. Maathuis, M.Y. Said, R. Becht, A. Limo, et al. (2014). A conceptual flash flood early warning system for Africa, based on terrestrial microwave links and flash flood guidance. *ISPRS International J. Geo-Information.*, 584-598. .

Huho, J. M., & Mugalavai, E. (2010). The effects of droughts on food security in Kenya. *International Journal of Climate Change: Impacts and Responses* , 61-72.

Hulls. (1952). *Hull's Reinforcement Theory.*

IPCC. (2007). Climate Change 2007. *Synthesis Report. Contribution of Working Groups I, II and III to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change (IPCC)*.

IPCC Climate change 2014 synthesis report Contribution of Working Groups I, I. a. (2014). IPCC, Geneva, Switzerland.

Kabir, M. I., Rahman,, M. B., Smith,, W., Lusha, M. F., & Milton, A. H. (2016, April 4). Climate change and health in Bangladesh: a baseline cross-sectional survey. *Global Health Action, 9*.

Kaili Rimfeld, Ayorech, Z., Dale, P. S., Kovas, Y., & Plomin, R. (2016, June 16). Genetics affects choice of academic subjects as well as achievement. *Scientific Reports*(6).

Kaiser, H. (1959). ‘Computer program for varimax rotation in factor analysis'. *Educ. Psych. Meas.*, pp. 413-420.

KNBS. (2010). The 2009 Kenya population and housing census . *Kenya Ministry of State for Planning, Na-tional Development and Vision 2030*, 297 pp.

Knight, K. W. (2016). Public awareness and perception of climate change: a quantitative cross-national study. *Environmental Sociology, 2*(1).

Krapohl, E., Rimfeld K, Shakeshaft,, N., Trzaskowski,, M., McMillan, A., Pingault, J. B., et al. (2014, October 21). The high heritability of educational achievement reflects many genetically influenced traits, not just intelligence. *Proceedings of the National Academy of Sciences of the United States of America, iii (42)*.

Levy, B. S., & Jonathan A. Patz. (2015). Climate Change, Human Rights, and Social Justice. *Annals of Global Health*.

Luo YL, Kovas Y, Haworth CM, & Plomin R. (2012). The etiology of mathematical self-evaluation and mathematics achievement: understanding the relationship using a cross-lagged twin study from age 9 to 12. *Author Manuscript*.

Mahoney, K. A. (2012). Changes in hail and flood risk in high-resolution simulations over Colorado's mountains. . *Nature Climate Change.*, 125-131 .

Mallakpour, I., & Villarini, G. (2015, February 9). The changing nature of flooding across the central United States. *Nature Climate Change*, 250-254.

Maslow, A. H. (1954). *Motivation and personality.* New York:Harper and Row.

Mayer, S. E. (2002). *The Influence of Parental Income on Children's Outcomes.* New Zealand: Knowledge Management Group, Ministry of Social Development.

Mazon, J. (2014). The influence of thermal discomfort on the attention index of teenagers: an experimental evaluation. *International journal of biometeorology*.

McCright. (2010). *Climate Change and Society: Sociological Perspectives.* Oxford University Press.

McLeod, S. A. (2013). *Tolman - latent learning.* Retrieved from https://www.simplypsychology.org/tolman.html.

McMichael. (2000). The urban environment and health in a world of increasing globalization: issues for developing countries. *Bull World Health Organ*.

McMichael, A. J., Woodruff, R., & Hales, S. (2006, March 11-17). Climate change and human health: present and future risks. *Science Direct, 367*(9513), 859-869.

Mugenda, & Mugenda. (2013). Research Methods; Quantitative and qualitative Approaches. ((2nd Ed). Nairobi).

Mutai, C., M.N Ward, & A.W Colman. (1998). Towards the prediction of the East Africa short rains based on sea-surface temperature–atmosphere coupling. *International Journal of Climatology*.

Muurlink, O., & Matas, C. F. (2010). *Climate Change and Classroom: The Power of Weather to Interfere with Global Education (2010)*. Griffith University.

Nabarro, D., Menon, P., Ruel, M., & Yosef, S. (2012). Scaling Up Nutrition: A global movement to accelerate progress in reducing maternal and child under-nutrition Brief 9. In: J. Linn. (ed.). .

Naoufal, N. (2014). Peace and environmental education for climate change: challenges and practices in Lebanon. *Journal of Peace Education, 11*(3).

Nchungo, J. (2013). *FACTORS AFFECTING STUDENTS' ACADEMIC PERFORMANCE*.

Newman, T. P. (2016, February 11). Tracking the release of IPCC AR5 on Twitter: Users, comments, and sources following the release of the Working Group I Summary for Policymakers. *Public Understanding of Science, 26*(7).

Ngaroga, M. (2007). Education for Primary Teacher education.

Nicholson, S. (1998). Historical fluctuations of Lake Victoria and other Lakes in the Northern Rift valley of East Africa. *Environmental Change and Response in East African Lakes*, pp 7 - 35.

Nie, N. H., Bent, D. H., & Hull, C. H. (1970). SPSS: statistical package for the social sciences.

Ogallo, L. J. (1989). The Spatial and Temporal Patterns of the East African Seasonal Rainfall derived from Principal Component Analysis (PCA). *International Journal of Climatology, Vol.9*.

Ojoyi, M. M., & Kahinda, J.-M. (2015). An analysis of climatic impacts and adaptation strategies in Tanzania. *Emarald Insight, 7*(1).

Okongo, R. B., Ngao, G., Rop, N., & Nyongesa, J. W. (2015). Effect of Availability of Teaching and Learning Resources on the. *Journal of Education and Practice, 6*(35).

Okoola, R. (1996). Space-time characteristics of the ITCZ over equatorial Eastern Africa during anomalous rainfall years. *International Journal of Climatology*.

Okuom, H., Simatwa E., Olel M., & Wichenje K. (2012, February). Assessment of Factors that Contribute to Repetition and Dropout of Pupils in Primary Schools in Flood Prone Areas of Nyando District, Kenya. *An Analytical Study. Education Research, Volume 3 (2)*, pp 190 - 201.

Oludhe, C. (1987). Statistical Characteristics of Wind Power in Kenya. 17.

Omari, K. (2010). *Gender and Climate change:Botswana Case Study*. capetown: Heinrich Böll Foundation Southern Africa.

Ongoma, V., T Guirong, B A Ogwang, & J P Ngarukiyimana. (2015). Diagnosis of Seasonal Rainfall Variability over East Africa: A Case Study of 2010-2011 Drought over Kenya. *Pakistan Journal of Meteorology, 11*(22).

Opere, A. (2013). Floods in Kenya. 315-325.

Orodho, J. (2009). Elements of education and social science research. ((2nd Ed.)).

Orville, R. (2000). Personal Communication, figure of average cloud-to-ground lightning flash density for the contiguous U.S. from the National Lightning Detection Network (1989-1998).

Owusu, C. a. (2011). Climate change, food security, and livelihoods in sub-Saharan.

Park, J. (2017, February 26). Temperature, Test Scores, and Human Capital Production.

Piaget, J. (1958). The growth of logical thinking from childhood to adolescence. AMC, 10, 12.

Puteha, M., Hairy Ibrahim, M. H., Adnana, M., Ahmada, C., & Noh, N. M. (2012). Thermal comfort in classroom: constraints and issues. *Scieverse science Direct*.

Radulescu, & Ioan, I. (2015). New Challenges for Agriculture within the Context of Climate Change. 253-262.

Rimfeld, Ayorech, Z., Dale, P. S., Kovas, Y., & Plomin, R. (2016). Genetics affects choice of academic subjects as well as achievement. *Scientific Reports*.

Salvia, J., Ysseldyke, J., & Witmer, S. (1995). Assessment: In Special and Inclusive Education 11th Edition. *Amazon*.

Selase, G. R., & Quashie Mawuli. (2013). The Impact of Indecent Dressing on the Academic Performance of. *Journal of Education and Practice, 4*(18).

Sheffield, Uijttewaal, S. A., Stewart, J., & Galvez, M. P. (2017). Climate Change and Schools: Environmental Hazards and Resiliency. *International Journal of Environmental Research and Public Health, Vol. 14(11)*.

Sieg. (2001). *Better Education for Students and Teachers Act: report of the Committee on Health, Education, Labor, and Pensions, United States Senate* (Vol. 107). United States: U.S. G.P.O.

Sika, J. O., F.Q., G., & Andrew , R. (2013). Rate and Trends of Academic Performance Index and Level of Subject Satisfactory Outcomes. *Journal of Economics and Sustainable Development, 4*(8).

Singh, A. S., & Micah B , M. (2014). Sampling Techniques & Determination of sample size in applied Statistics Research. *International Journal of Economics, Commerce and Management, 2*(11).

Terman, L., & Merill Maude A. (1960). *Stanford-Binet Intelligence Scale: Manual for the Third Revision Form L-M with Revised IQ Tables by Samuel R. Pinneau.* Boston (MA): Houghton Mifflin.

Thorndike, E. (1913). *Educational Psychology: The Psychology of Learning.* New York: Teachers College Press.

Tolman E.C, & Honzik C.H. (1930). *Introduction and Removal of Reward, and Maze Performance in Rats.* California: University of California Publications in Psychology.

Tong, S., Confalonieri U, Ebi K, & Olsen J. (2016). Managing and Mitigating the Health Risks of Climate Change: Calling for Evidence-Informed Policy and Action. *Environmental Health Perspective, 124*(10).

Wadsworth, B. J. (1996). *Piaget's theory of cognitive and affective development : foundations of constructivism.* White Plains, N.Y. : Longman Publishers USA, ©1996.

Wakori, K. S. (2014). Factors Affecting Performance in the Kenya Certificate of Primary Education a Case of Kirinyaga West District Kenya. *Mediterranean Journal of Social Sciences , vol.5*(No.5).

Wang, M. C., Geneva D. Haertel, & Herbert J. Walberg. (2015). What Influences Learning? A Content Analysis of Review Literature. *Journal pof Educational Research*, pp 30-43.

Wang, M. C., Haertel, G., & Walberg, H. (1990). What Influences Learning? A Content Analysis of Review Literature. *The Journal of Educational Research, 4*(1).

Welzer. (2012). *Climate Wars: What People will be Killed for in the 21st Century.*

Wilson, B. G., Myers, K. M., & Madsen, K. (2000). Situated Cognition in Theoretical and Practical Context. *American Psycological Association*.

WMO. (1986, May). Guidelines on the Quality Control of Surface Climatological Data. *World Climate Data Programme*.

Yamane. (1967). Statistics: An Introductory Analysis. (2nd Edition).

Yang, W., Seager, R., Cane, M., & Lyon, B. (2014, October 30). The Annual Cycle of East African Precipitation. *Journal of Climate*.

Yin, X. S., Nicholson, & M. B. Ba. (2000). On the diurnal cycle of cloudiness over Lake Victoria andits influence on evaporation from the lake. *Hydrol. Sci. J, 45*, 407–424.

Yin, X., & Nicholson, S.E. (1998). The water balance of Lake Victoria. *Journal of Hydrological Sciences, Vol. 43*(Issue 5), pp. 789-811.

ANNEXES

Annex I: Research Permit requesting data from schools.

Research permit was obtained from the University of Nairobi, Department of Meteorology.

UNIVERSITY OF NAIROBI
DEPARTMENT OF METEOROLOGY

Telegrams: Varsity, Nairobi
Telephone: 254-020-4442014/4449004
Ext. 2070

P O Box 30197,00100
NAIROBI, KENYA

REF: UON/CBPS/MET/6/9

August 25, 2016

Ministry of Education
Siaya County Education Office
P. O. Box 803
SIAYA

Dear Sir,

REF: REQUEST FOR DATA FOR MR. MICHAEL O. OBONYO

The above named person is a Master of Science (Climate Change) student at the Department of Meteorology, University of Nairobi, admission number I54/79491/2015.

As part of his course, his research project is entitled, "***Impacts of climate extremes on Performance in Siaya County, Kenya***". He would like to obtain data on; School mean scores in the National Examinations from the year 1995-2015

Yours faithfully

CHAIRMAN
DEPARTMENT OF METEOROLOGY
UNIVERSITY OF NAIROBI
dept-meteo@uonbi.ac.ke

DR. ALFRED O. OPERE
CHAIRMAN
DEPARTMENT OF METEOROLOGY

Annex II: Research permit requesting data from Siaya Meteorological Department.

UNIVERSITY OF NAIROBI

DEPARTMENT OF METEOROLOGY

Telegrams: Varsity, Nairobi
Telephone: 254-020-4442014/4449004
Ext. 2070

P.O. Box 30197, 00100
NAIROBI, KENYA

August 25, 2016

Director
Kenya Meteorological Services
P. O. Box 30259-00100
NAIROBI

Dear Sir,

REF: REQUEST FOR DATA FOR MR. MICHAEL O. OBONYO

The above named person is a Master of Science (Climate Change) student at the Department of Meteorology, University of Nairobi, admission number I54/79491/2015.

As part of his course, his research project is entitled, "***Impacts of climate Extremes on Performance in Siaya County, Kenya***".

He would like to obtain data on; Annual Rainfall data and Annual Temperature data from 1995 to 2015 from the following stations, Siaya Raingauge station, Uholo Automatic weather station, Kakamega & Kisumu Meteorological Stations.

CHAIRMAN
DEPARTMENT OF METEOROLOGY
UNIVERSITY OF NAIROBI

DR. ALFRED O. OPERE
CHAIRMAN
DEPARTMENT OF METEOROLOGY

Annex III: Informed Consent.

An informed consent to collect data from schools was obtained from County Director of Education, Siaya County.

REPUBLIC OF KENYA

MINISTRY OF EDUCATION, SCIENCE & TECHNOLOGY

State Department of Education

Telephone:
Fax:

COUNTY DIRECTOR OF EDUCATION
SIAYA COUNTY
P.O. BOX 564
SIAYA

When replying please quote

Ref. SCA/10/VOL I

Friday, September 30, 2016

TO WHOM IT MAY CONCERN

RE: RESEARCH AUTHORIZATION: MICHAEL O. OBONYO

The above mentioned has been mandated to carry out research in Siaya County vide an authorization letter from University of Nairobi Department of Meteorology
Ref. No. UON/CBPS/MET/6/9

The research title is "***Impacts of climate extremes on Performance in Siaya County, Kenya***".

Kindly accord him the necessary assistance.

COUNTY DIRECTOR OF EDUCATION
SIAYA COUNTY
30 SEP 2016
P.O. Box 109-40603 SIAYA

SAMUEL C. ONDIEKI
FOR: COUNTY DIRECTOR OF EDUCATION
SIAYA COUNTY

Our Vision: To have a globally competitive quality education, training and research for Kenya's sustainable development

Annex IV: Field Questionnaire for teachers:

Questionnaire's serial no.————————

INTERVIEW SCHEDULE

TOPIC OF STUDY: ASSESSING THE IMPACT OF CLIMATE VARIABILITY ON LEARNING ACADEMIC PERFORMANCE IN SIAYA COUNTY, KENYA.

PART 1: INFORMED CONSENT:

Dear respondent, Mr. Michael Ochieng Obonyo Reg. No.I54/79491/2015, is a master student of Climate Change in the Department of Meteorology (University of Nairobi, Kenya). I am conducting a research based on the topic above. The information is being collected for academic purposes only and therefore no personal benefits or risks to your participation. The information received will be handled with utmost confidentiality; and therefore the only identification on the questionnaire will be the questionnaire code. The interview will be approximately 35minutes and I will appreciate if you answer all the questions. For more information or query on the study, kindly contact the researcher on the following cellphone number (0725550134) or e-mail (obonyo80@students.uonbi.ke)

N/B: Please answer each of the following questions as honestly as you can.

Sub county _____ Zone _____ School _____

Date _____ Time _____

PART 2: DEMOGRAPHIC INFORMATION.(Tick inside (√) the appropriate box)

1. Age of Respondent: 20- 29 years. ☐ 30-39 years ☐ 40 years + ☐

2. Gender: Male ☐ Female ☐

3. Place of Birth: _____ county.

4. Highest Level of education of the respondent.

P1 certificate ☐ Diploma ☐ Bachelor's Degree ☐

Master's Degree ☐ other (Specify) _____

5. I have lived in Siaya county since (put year): _____

6. Our school is: Public ☐ Private ☐

PART 3: INFORMATION ON FACTORS AFFECTING LEARNING ENVIRONMENT.

(Tick inside **(√)** the appropriate box)

7. How far is the school from the nearest health facility?

Less than 5km ☐ 6-10 km ☐ More than 10 km ☐

8. How far is the school from the nearest urban Centre?

Less than 5km ☐ 6-10 km ☐ More than 10 km ☐

9. What is the average number of pupils per class?

Less than 20 ☐ 21-40 ☐ 41-60 ☐ More than 60 ☐

10. To what extent do the following affect learning?

Factors affecting learning	**Not at all**	**Little extent**	**Some extent**	**High extent**
Poor Health				
Food scarcity				
Water scarcity				
Poor transport				
Teacher's strike				
Bad weather				
Lack of cooperation among teachers & parents				
Inadequate resources				
Overloaded curriculum				

11. During wet seasons the number of children who fall sick.

Increases ☐ Decreases ☐ Remains same ☐ slightly increase ☐

12. During wet seasons the number of children who are absent from school.

Increases ☐ Decreases ☐ Remains same ☐ slightly increase ☐

13. During dry seasons the number of children who fall sick.

Increases ☐ Decreases ☐ Remains same ☐ slightly increase ☐

14. What is the level of class concentration during Very high temperatures?

Low ☐ Moderate ☐ High ☐

15. What is the level of class concentration during Very low temperatures?

Low ☐ Moderate ☐ High ☐

PART 4: CLIMATE VARIABILITY INFORMATION :(tick appropriate box)

16. How often does the area experience very high temperatures?

Not at all ☐ every year ☐ Every 5 years ☐

17. Have the months of January to March.

Become hotter than before ☐ colder than before ☐ remained the same ☐

18. Are the colder months of July – August.

Colder than before ☐ Warmer than before ☐ remained the same ☐

19. How do you feel the following climate related factors have changed in the recent years compared to the past?

a) The total amount of rainfall per year

Increased a lot	Increased	Remained same	Decreased	Decreased a lot

b) Temperatures

Much hotter	Hotter	Remained same	Cooler	Much cooler

c) Length of growing period for food crops.

Much longer	longer	Remain the same	Shorter	Much shorter

d) Incidence of food insecurity

Much more insecure	More in secure	Remained the same	Less insecure	Much less insecure

e) Rainfall occurrences.

Much more variable	More variable	Remained the same	Less variable	Much less variable

f) Floods occurrences.

Increased a lot	Increased	Remained same	Decreased	Decreased a lot

g) Lightning and Thunderstorms occurrence.

Increased a lot	Increased	Remained same	Decreased	Decreased a lot

h) Wind storms occurrences.

Increased a lot	Increased	Remained same	Decreased	Decreased a lot

20. Has the school had thunderstorms in the recent past? Yes ☐ No ☐

21. If yes, in no. 15 above what happened?

Death occurred	Destruction of classrooms	Other (specify)

22. Has your school experienced windstorms in the recent past? Yes ☐ No ☐

23. If yes, in no. 16 above what happened?

Death occurred	Destruction of classrooms	Other (specify)

i. The frequency of the Windstorms has: increased ☐ Decreased ☐

ii. When was the last windstorm? (Year) _____

24. Has your school been affected by floods in the recent past either directly or indirectly?

Yes ☐ No ☐

25. If yes in no. 24 above, what were the effects?

Death occurred	Destruction of classrooms	Other (specify)

26. To what degree is curriculum delivery affected when the following climate variations occur?

Climate variation	Degree		
	Not at all	Little	Very Much
Floods			
High Temperatures			
Biting cold			
Wind storms			
Thunderstorms			

27. How frequent is your school affected by the following factors affecting learning:

Factors affecting learning	**Not at all**	**Occasionally**	**Frequently**
Floods			
High Temperatures			
Biting cold			
Wind storms			
Thunderstorms			
Drought			
Water scarcity			
Famine			

PART 5: SOCIO – ECONOMIC INFORMATION. (Tick inside (√**)** the appropriate box)

28. How many crops growing seasons do you have in a year for each of the crop type named below? **Answer as 1, 2, 3 or more.**

Crop type	Season /year	Specific months in a year
Maize		
Beans		
Millet		
Ground nuts		
Cassava		
Sorghum		
Other (specify)		

29. Are the above named crops growing seasons regular annually or they have changed over the years:

Regular ☐ Changed ☐

30. During the time of famine what strategies are laid by school to improve academic performance?

Lunch program in school ☐ Adjust learning time ☐

Depend on relief food ☐ No strategy ☐

31. During the time of very high temperatures, what strategies are laid by school to improve academic performance?

Provide fans ☐ learn under trees ☐ Adjust learning time ☐ No strategy ☐

32. During the time of water scarcity, what strategies are laid by school to improve academic performance?

Buy water ☐ Children carry water from home ☐ No strategy ☐

33. During the time of heavy rains, what strategies are laid by school to improve academic performance?

Provide means of transport ☐ Adjust learning time ☐ No action ☐

34. During the time of storms, what strategies are laid by school to improve academic performance?

Close down school ☐ Remedial lessons ☐ No action ☐

35. Which years have the area faced acute food insecurity?

_____

36. Which specific years have your school performed well since 1995?

_____

37. What is your feeling in the last year's KCPE Results?

Beyond My expectation ☐ as per my expectation ☐ below my Expectation ☐

38. In your opinion this year the performance of your school will be?

Highest ever ☐ Better than previous year ☐ Average ☐ No Change ☐

39. In your opinion, to what degree has climate variation affected your school academic performance?

High degree ☐ Very little ☐ Moderately ☐ Not at all ☐

40. What are the major reasons for absenteesim in your school?

☐ Sickness, name of disease (s) _____

☐ Famine

☐ Water scarcity

☐ Other (specify) _____

THANK YOU FOR YOUR TIME!

Annex V: Field Questionnaire for Learners:

Questionnaire's serial No. _____

TOPIC OF STUDY: ASSESSING THE IMPACT OF CLIMATE VARIABILITY ON ACADEMIC PERFORMANCE IN SIAYA COUNTY, KENYA.

N/B: Please answer each of the following questions as honestly as you can.

Sub county _____ Zone _____ School _____

Date _____ Time _____

1. Which means of transport do you use when going to school? Walking ☐ Bicycle ☐ Motor bike ☐ Bus ☐

2. How many meals do you take per day? One ☐ two ☐ Three ☐

3. How many meals do you take per day during famine? One ☐ two ☐ Three ☐ None ☐

4. How frequent do you take bath? Daily ☐ once per week ☐ twice per Week ☐ thrice per week ☐

5. How frequent do you take bath when water is scarce? None ☐ once a week ☐ twice a week ☐ thrice a week ☐ daily ☐

6. How long do you travel to collect water? Less than 1 km ☐ between 1-5km ☐ more than10km ☐

7. When it is dry, how long do you travel to collect water? Less than ☐ 1 kmBetween1-5km ☐ more than 5km ☐

8. When temperatures are high, your class concentration. Increases ☐ Reduces ☐ remains unchanged ☐

9. How is your school attendance during variation in the following events?

Variation of climatic events	Regular	Irregular
Water scarcity		

Famine		
Flooding		
Thunderstorms		
High Temperatures		
Stormy weather		
Biting cold		

10. How do the following climatic events affect your studies? (Tick appropriate column)

climatic events	**Degree of Effect**			
	Very much	**Very little**	**Not much**	**No effect**
a)Very High temperatures				
b)Very High rainfall				
c) Water scarcity				
d) Food scarcity				
e)Lightning				
f) wind storms				

11. What is your opinion in your performance this year? Do you think the previous class?

Will be difficult to beat ☐ you will do better than them

Hope to perform like them ☐ will perform lower than them ☐

THANK YOU FOR YOUR TIME!

Annex VI: Schools sampled for the study.

SUB-COUNTY	ZONE	NO	SCHOOL
UGENYA	Sega	1	Kogere
		2	Waliera
		3	Nyalenya
		4	Kagonya
	Nyaharwa	5	Lunga
		6	Milambo
		7	Ndenga
		8	Nyaharwa
		9	Humwend
	Bar- Ndege	10	Nyalenda
		11	Ukela
		12	Umer
		13	Urenga
		14	Murumba
	Gaula	15	Lwero
		16	Got omalo
		17	Nzoia
		18	Diraho
		19	Simur
	Jera	20	Ligala
		21	Mauna
		22	Uchola
		23	Nyamsenda
		24	Ohando
		25	Nyangungu
BONDO	Aila	26	Bar opuk
		27	Kamnara
		28	Lwala
		29	Mawere
		30	Nyabenge
	Bar kowino	31	Bar Kowino
		32	Dier Aora

		33	Kibuye
		34	Nyawita
		35	Sinapanga
	Maranda	36	Agwara
		37	Gunda sigomre
		38	Maranda
		39	Milenga
		40	Nyadusi
	Amoyo	41	Bur - Lowo
		42	Got abiero
		43	Magak
		44	Migono
		45	Nyaguda
		46	Otuoma
	Nango	47	Lenya
		48	Miyandhe
		49	Odao
		50	Onyinore
		51	Serawango
		52	Uyawi
	Nyamonye	53	Bur – Yiro
		54	Kasau
		55	Muguna
		56	Odhuro
		57	Pap
	Usenge	58	Jusa
		59	Mahanga
		60	Nyabondo
		61	Rapogi
		62	Sika
GEM	Kambare	63	Dhene
		64	Uthanya
		65	Ndiru
		66	Odendo
		67	Ojwach
		68	Rachare

		69	Wangbith
	Komuok	70	Dienya
		71	Kotoo
		72	Nyasidhi
		73	Ulamba
		74	Wangoji
	Sirembe	75	Bar Komeno
		76	Ndegwe
		77	Nyapiedho
		78	Ujimbe
	Bar Kalare	79	Kanyarut
		80	Mindhine
		81	Omindo
		82	Ramula
		83	Uranga
	Manga	84	Ligoma
		85	Maliera
		86	Mulare
		87	Musembe
		88	Nyabeda
	Nyawara	89	Bar Turo
		90	Kagilo
		91	Luri
		92	Muhanda
		93	Olengo
		94	Rawalo
		95	Ulumbi
RARIEDA	Manyuanda	96	Got Kojwang
		97	Kawuondi
		98	Misori
		99	Nyakongo
		100	Tanga
	Ndigwa	101	Kadundo
		102	Lwala Rahogo
		103	Migowa
		104	Naya

		105	Nyagoye
		106	Ranyala
	Uwimbi	107	Gagra
		108	Dagamoyo
		109	Kunya
		110	Madiany
		111	Ochienga
		112	Pala Kobong
	Mahaya	113	Kometho
		114	Kiswaro
		115	Ndwara
		116	Nyamor
		117	Rakombe
		118	Rarieda
		119	Tiga
	Nyayiera	120	Gundarut
		121	Kusa
		122	Lwak Mixed
		123	Oboch
		124	Saradidi
	Nyilima	125	Boi
		126	Kandaria
		127	Kadhere
		128	Okiro
		129	Raliew
SIAYA	Kowet	130	Hono
		131	Nina
		132	Nyamila
		133	Uyoma
	Ulongi	134	Boro
		135	Kanayboli
		136	Liganwa
		137	Nyadhi
		138	Obambo
		139	Pap Boro
		140	Urim

	Awelo	141	Agoro Lieye
		142	Bar Agulu
		143	Madede
		144	Achage
	Bar Ogongo	145	Magungu
		146	Mugane
		147	Nyanginja
		148	Ochiewa
		149	Pap Gori
		150	Rapogi
	Kirindo	151	Aluny
		152	Umala
		153	Nduru
		154	Pap Nyadiel
		155	Sigana
		156	Usula
	Dibuoro	157	Goro
		158	Kabura Ulwan
		159	Ndiwo
		160	Sidundo
		161	Uhuyi
	Mwer	162	Kalkada
		163	Malomba
		164	Nyalwanga
		165	Rasungu
		166	Ulawe Apate
UGUNJA	Ambira	167	Daho
		168	Mauna
		169	Nyamasare
		170	Raduodi
		171	Sango
		172	Ogeda
		173	Umina
	Sigomre	174	Ginga
		175	Bar Atheng
		176	Lukongo Luduha

		177	Luru
		178	Ngop Misengni
		179	Tihinga
		180	Ugana
	Sikalame	181	Lolwe
		182	Markuny
		183	Murumba Yiro
		184	Ulhowe
		185	Ruwe
		186	Ulanda
TOTAL	34	186	

Annex VII: KCPE Performance Trends.

PERFORMANCE IN K. C. P. E FROM 1995 -2016.

NAME OF SCHOOL: _____

YEAR	**1995**	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**
MEAN													
2008	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**					

Annex VIII: Siaya Monthly Rainfall (mm)

YEAR	JANR	FEBR	MARR	APRR	MAYR	JUNR	JULR	AUGR	SEPR	OCTR	NOVR	DECR
1989	18.3	89	245.4	153.9	257.7	33.9	24.7	0	0	0	0	0
1990	0	217.4	154.5	185.3	206.7	16.2	48.6	106.8	138	157.8	69.5	74
1991	101	12.8	103.7	176.6	236.3	42.3	57	24.1	91.9	169.5	54.3	176
1992	0	60.9	54.8	145.3	185	95.8	86.1	54	86	105	152	139
1993	172	35.4	50.4	126.7	154.8	66.8	7	119.5	117	115.3	127	87.6
1994	16.6	18.5	145	186.1	188.1	62.8	75.2	111.1	165	138.3	335	58.5
1995	19.6	44.1	211.2	240.2	138.3	68.5	74	60.8	118	225.5	136	78.1
1996	95.4	116.2	184.8	210.9	221.2	85.3	130	105.2	177	89.2	258	36.3
1997	44.8	0	108.8	392.9	152.4	129.8	25.7	69.3	20.2	158.2	449	399
1998	223	38.6	96.3	418	140.3	95.3	21.6	3.6	217	217.2	188	38
1999	110	0	290.5	167	224.6	54.1	126	269.8	185	250.4	165	217
2000	7	0	91.2	160.3	85.2	123.6	84.2	93.4	258	200.2	181	154
2001	235	77.5	111.1	248.3	228.1	161	29.5	272	221	136.4	192	64.8
2002	152	5.5	184.3	390	313.8	45.4	70.5	162.8	155	166.2	423	194
2003	35.7	31.5	250	316.5	174.6	138.4	130	107.8	192	223.9	213	87.9
2004	117	220.9	98.7	209.4	128.5	94.5	84.4	48.1	121	196.9	200	131
2005	41.2	18.2	170	164.3	249.3	99.8	76.8	118.1	157	148.9	86.7	46.6
2006	41.7	54.9	230.6	243.9	165.5	133.1	67.3	87.9	150	206.1	255	309
2007	66.8	95.8	120.2	212.6	280.2	127.2	81.3	86.6	206	106.4	133	113
2008	24.3	11.3	175.1	141	119.3	32.1	88.8	241.7	239	205.7	107	6.5
2009	69.9	47	121.1	365	174.1	87.2	15.6	77.6	181	189.8	183	159
2010	50.4	74.2	243.3	169.9	286.8	24.14	24.1	185.9	149	146.6	158	122
2011	1	19.7	77.4	152.8	38.7	0	0	0	130	142	190	61.9
2012	0	21.3	49.7	234.1	169.4	89.6	46.1	102.4	185	118.7	197	165
2013	50.5	34	137.3	223.2	155.5	29.1	123	82.9	174	135.6	117	102
2014	35.1	21.7	106.7	89.4	252.8	64.9	58.1	89.3	250	215	382	175
2015	3.5	17.4	198.53	226.2	161.31	45.6	21.3	20.7	151	197.2	104.6	97.8
2016	7.23	13.61	112.9	203.7	154.7	42.5	43.4	28.6	120	47.9	100.3	60.3

Annex IX : Maximum and Minimum Temperature of Siaya (^{0}c).

YEAR		JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	AV
1995	Tmax.	30.9	30.7	30.6	29.9	28.4	28.5	27.7	30.6	30.3	29.9	29.7	30.4	**29.8**
	Tmin.	17.0	16.8	17.4	18.5	17.3	17.7	16.7	16.4	17.2	17.5	17.7	16.4	**17.2**
1996	Tmax.	30.1	29.9	29.8	29.4	28.9	27.3	27.9	29.4	29.5	30.0	30.0	30.1	**29.4**
	Tmin.	16.6	17.6	18.0	17.7	17.7	17.4	16.6	16.6	16.8	17.0	17.5	17.1	**17.2**
1997	Tmax.	17.4	32.8	33.9	28.4	27.8	29.0	28.9	30.4	33.8	31.2	28.4	28.0	**29.2**
	Tmin.	22.1	16.2	18.2	18.0	16.7	16.4	17.2	16.5	16.9	17.9	18.3	17.7	**17.7**
1998	Tmax.	29.0	30.4	31.8	30.3	29.2	28.6	28.4	30.2	31.3	29.3	30.8	32.3	**30.1**
	Tmin.	17.9	17.8	18.3	18.7	18.5	16.5	16.6	16.9	16.9	17.9	17.3	17.3	**17.6**
1999	Tmax.	30.6	34.0	28.8	28.7	28.4	28.7	28.2	28.4	29.3	29.7	30.5	29.7	**29.6**
	Tmin.	17.4	16.7	18.2	17.8	17.2	16.4	16.2	16.2	17.1	17.3	17.2	16.4	**17.0**
2000	Tmax.	27.7	29.6	30.5	28.8	28.7	28.2	28.6	29.0	30.7	30.1	29.4	28.6	**29.2**
	Tmin.	17.4	17.0	17.5	17.9	18.3	16.8	16.5	16.7	17.0	17.7	17.7	17.8	**17.4**
2001	Tmax.	27.7	29.6	30.5	28.8	28.7	28.2	28.6	28.8	29.2	29.6	28.3	29.9	**29.0**
	Tmin.	17.4	17.0	17.5	17.9	18.3	16.8	16.5	17.1	17.3	17.4	17.7	18.2	**17.4**
2002	Tmax.	29.2	32.3	29.8	29.1	28.5	28.7	29.9	30.0	31.4	31.3	29.1	29.0	**29.9**
	Tmin.	17.8	17.7	17.9	18.2	18.0	16.7	16.2	16.8	17.0	17.7	17.7	17.6	**17.4**
2003	Tmax.	29.9	29.7	29.8	29.4	29.6	28.5	28.8	28.9	28.7	29.5	30.9	30.2	**29.5**
	Tmin.	16.7	16.7	16.9	18.0	18.0	17.4	16.7	17.1	16.8	17.5	18.0	16.6	**17.2**
2004	Tmax.	30.6	30.9	31.3	28.9	28.8	27.9	28.0	27.8	29.6	30.4	29.3	29.8	**29.4**
	Tmin.	17.6	17.0	18.5	18.4	17.6	16.3	16.0	17.8	17.1	17.5	17.4	17.7	**17.4**
2005	Tmax.	30.2	33.3	29.9	31.3	28.7	28.8	28.6	29.6	26.8	28.6	31.4	33.8	**30.1**
	Tmin.	17.5	17.7	18.0	18.3	18.2	17.0	16.3	16.6	16.2	14.6	17.7	17.6	**17.1**
2006	Tmax.	30.3	34.0	30.1	27.4	28.1	28.7	29.6	29.8	30.8	31.9	28.3	32.8	**30.2**
	Tmin.	18.2	18.3	18.5	17.9	17.8	16.9	17.3	17.2	17.1	18.1	17.8	17.7	**17.7**
2007	Tmax.	29.1	34.4	30.3	30.3	29.5	28.0	27.9	28.6	29.4	31.1	30.6	30.1	**29.9**
	Tmin.	17.4	19.6	16.5	17.7	17.8	17.5	16.6	17.3	16.9	16.9	17.3	17.1	**17.4**
2008	Tmax.	31.2	31.2	30.3	29.0	29.0	28.1	27.9	28.8	29.4	31.3	32.0	32.7	**30.1**
	Tmin.	17.2	17.8	17.8	17.4	17.3	16.9	16.8	16.7	17.4	18.0	17.7	18.4	**17.5**
2009	Tmax.	31.6	31.4	32.3	29.3	28.9	30.0	30.0	30.9	30.7	30.7	30.1	29.8	**30.5**
	Tmin.	17.2	17.7	18.3	18.3	18.0	16.4	16.4	17.7	17.7	17.9	18.3	17.7	**17.6**
2010	Tmax.	32.5	30.8	30.3	30.5	29.5	30.1	30.1	30.2	30.0	30.9	30.1	30.0	**30.4**
	Tmin.	17.7	18.9	18.5	18.9	19.5	17.8	17.9	17.8	17.5	18.5	18.1	17.7	**18.2**
2011	Tmax.	31.2	32.5	31.3	30.6	29.1	28.6	29.5	28.6	28.9	29.6	27.8	29.1	**29.7**
	Tmin.	17.7	17.3	18.7	18.4	17.7	18.4	17.1	17.6	17.5	17.7	18.1	17.9	**17.8**
2012	Tmax.	31.8	31.9	31.4	27.5	27.0	27.8	27.5	28.8	29.0	30.7	29.4	28.8	**29.3**
	Tmin.	16.3	17.7	18.4	18.7	18.0	17.7	17.2	17.3	17.4	18.0	17.7	17.6	**17.7**
2013	Tmax.	29.8	30.5	30.9	28.6	29.0	29.0	29.7	28.7	30.0	30.0	29.8	29.1	**29.6**
	Tmin.	17.3	18.9	18.7	18.5	18.2	17.8	16.8	17.2	17.2	18.2	18.0	18.1	**17.9**
2014	Tmax.	30.6	31.3	31.7	29.5	29.5	29.7	29.4	28.7	29.4	29.6	29.9	30.1	**30.0**
	Tmin.	17.5	18.3	18.8	18.6	18.8	18.3	17.9	17.4	16.9	17.0	17.5	17.6	**17.9**
2015	Tmax.	30.7	33.0	33.5	28.6	28.6	28.3	29.8	30.9	30.2	30.5	28.6	28.1	**30.1**
	Tmin.	17.1	17.4	18.4	18.6	18.5	18.4	17.8	17.6	18.1	18.8	17.8	18.2	**18.1**
2016	Tmax.	29.6	32.0	32.7	29.2	29.1	29.0	29.4	31.7	30.8	29.8	28.4	30.3	**30.2**
	Tmin.	18.6	18.7	19.7	19.7	18.9	17.8	18.2	17.3	17.7	18.6	18.5	18.6	**18.5**

Annex X : Sub county Performance.

YEAR	Ugenya	Bondo	Gem	Rarieda	Siaya	Ugunja
1995	253.4388	251.0946	251.0946	252.8125	251.1265	252.1926
1996	231.6004	246.4562	246.4562	234.7437	239.5393	243.0951
1997	247.1664	246.0959	246.0959	246.3144	246.4828	247.3833
1998	242.5936	242.967	242.967	241.807	251.2014	243.9996
1999	245.9872	244.99	244.99	239.9343	240.0542	242.415
2000	243.2232	250.4435	250.4435	250.0389	262.1818	250.7565
2001	246.5252	235.2772	235.2772	241.7597	254.9084	241.784
2002	219.1816	240.953	240.953	239.7047	244.4399	238.7048
2003	219.7976	234.6427	234.6427	230.3013	243.2722	237.2115
2004	247.102	240.6811	240.6811	241.5123	243.1532	241.2627
2005	218.7888	235.4204	235.4204	235.3545	241.8796	235.3148
2006	244.598	244.1303	244.1303	237.1204	238.726	241.6863
2007	237.1136	237.6564	237.6564	239.8473	242.3807	239.1018
2008	227.5812	231.9351	226.7502	240.7899	245.7099	238.6692
2009	247.346	234.1079	234.1079	239.3698	235.6726	236.4227
2010	215.5056	234.8005	234.8005	229.6955	237.128	231.7929
2011	221.6388	232.9772	232.9772	236.3539	241.9926	236.5801
2012	211.7796	233.642	233.642	230.8214	243.1036	232.3791
2013	215.9856	234.7632	234.7632	235.7023	244.7857	236.3707
2014	233.0472	242.2897	242.2897	240.2603	244.9331	241.5771
2015	225.152	239.7666	239.7666	240.46	237.7704	239.3388
2016	248.48	241.2486	241.2486	233.8577	237.4992	240.9508