RESEARCH PROJECT

ASSESSING THE TREND IN THE SKILL OF SEASONAL RAINFALL FORECAST IN KENYA.

By

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I45/7746/2017

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A research project submitted in partial fulfillment of the requirement for the award of post-graduate diploma in Meteorology, University of Nairobi.

November, 2018.

DECLARATION

This research project work is my own original work and this has not been presented for a degree in any other University.

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This research project has been submitted for examination with our approval as University supervisors.

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Signature ……………………... Date ……………………………

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DEDICATION

I dedicate this research project to my beloved parents: Stephen and Ruth; my wife, Mary**,** my children; Nimrod and Nadia for their love, support and encouragement during my research.

ACKNOWLEDGEMENTS

Thanks to the **Almighty Lord** for seeing me through my university education this far and successive completion of this Post Graduate Diploma research project. May His Holy Name be glorified forever.

Special thanks to my supervisors and Prof J. M. Ininda andDr. F. J. Opijahof the Department of Meteorology at the University of Nairobi for their support, encouragement, constructive criticisms and continuous guidance that enabled me to complete this project in time.

My sincere gratitude goes to the Kenya Meteorological Department (KMD) for providing the rainfall data and seasonal forecasts for the study .

Special thanks to the academic staff of the Department of Meteorology, University of Nairobi for training me .

Contents

ABBREVIATIONS

The following abbreviations have the following meanings throughout this study unless stated otherwise

KMD ……Kenya Meteorological Department.
MAM……March , April , May
OND…….October November December season
A/AN……Above normal category
N/NN……Near normal category
B/BN……Below normal category

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ABSTRACT

Many socio-economic activities in Kenya are weather and climate dependent. Therefore information on the expected weather is of paramount importance. This information is acquired through use of weather forecasts. The forecasts therefore need to be as accurate and as reliable as possible. How good these seasonal forecasts are can only be determined by assessing the skill of the forecasts.

This study assessed the trend in the skill of seasonal rainfall forecast in Kenya for the years from 2008 to 2017 and consequently sought to determine whether there had been an improvement in the forecast skill over the ten year period. Themonthly rainfall data for twenty years and seasonal rainfall forecasts used in the study were obtained from the Kenya Meteorological Department (KMD). Both graphical and statistical methods were applied in the analyses. The area of study (Kenya) was divided into 12 rainfall homogeneous zones and one meteorological station selected purposively to represent each zone. Long Term Means for each station were determined from which categories were determined as below normal (<75%of LTM) near normal (>75%LTM<125%) And above normal (>125%LTM).The observed rainfall data and seasonal forecasts obtained were used to create 3 by 3 contingency tables for each homogeneous rainfall region which were then used to compute the following statistics; the Probability Of Detection (hit rate) , Heidke Skill Scores, Probability of Detection , False Alarm Ratio and Bias which were then used to assess the forecast skill.

The study showed that for MAM season,the seasonal forecasts were found to be at least 40 % correct which is a modest score. The HSS ranged from a negative value (regions one, six and twelve) to a score of 0.25. This indicates that for the in some regions the standard forecast (chance) is more accurate than the seasonal forecast ,In some regions the score was zero indicating lack of skill while other regions had e very low score regions indicating a low forecast skill. This was also the same for the OND season.

There also was a bias towards forecasting the BN category for the MAM season while the AN category is overforecast in the OND season

In general, the forecast skill was found to be low for both seasons throughout the study period. It also fluctuated from year to year and when an improvement from the previous year was registered, it was modest.

CHAPTER ONE

1.0: Introduction.

Many socio-economic activities in Kenya are weather and climate dependent. There are two main rainfall seasons in Kenya; the long rainfall season (MAM) and the short rainfall season (OND). Topography of Kenya is highly diverse and it contributes towards high spatial variance in distribution of seasonal rainfall. In Kenya, agriculture is one of the main economic pillars.It relies on availability of rainfall thus frequent droughts and floods have potential to intensify socio-economic stressors. This makes seasonal weather forecasts very important for advance planning and preparedness. The information contained in the seasonal rainfall forecasts include; the onset and cessation times, geographical distribution and rainfall distribution.

Verification of forecasts is a process aimed at determining the quality of forecasts. It basically involves measuring the relationship between a forecast value and its corresponding observation of the weather parameter being considered. It's done for; administrative, scientific and economic reasons.

The Kenya Meteorological Department (KMD) - the body mandated to offer meteorological services in Kenya has gone through continuous improvement over the years. This has been done so as to improve the quality of the forecasts it develops. There is access to more complete data, more understanding of tropical meteorology, access to more advanced technology like radar and satellite imagery, incorporation of ensemble forecasting and enhancement of the staff capacity. Hence, there is need to assess how this improvement has impacted on the quality of the seasonal rainfall forecast.

1.1 Statement of the Problem

Variability of rainfall – both spatial and temporal has a huge impact on both social and economic sectors that are climate and weather sensitive. The use of seasonal climate forecasts when making decisions in the more climate-sensitive sectors of the economy cannot be understated. Well-informed decisions are only possible if the forecasts are of good quality., KMD has invested heavily over the years in terms of technology, instrumentation and capacity building of the staff with the aim of improving the quality of its forecasts. Hence the need to assess the impact this investment has had on the quality of the seasonal rainfall forecast.

This study sought to do this by assessing the trend in the seasonal rainfall forecasts skill in Kenya during the period; 2008 -2017.

1.2. Objectives of the Study.

The main objective was to assess the skill of the seasonal rainfall forecasts issued by the Kenya Meteorological Department for the 2008 – 2017 period.

The specific objectives were to determine;

i). The forecast skill for the MAM seasonal rainfall forecast.

ii). The forecast skill for the OND seasonal rainfall forecast.

iii).The trend in the skill of the MAM and OND seasonal rainfall forecasts.

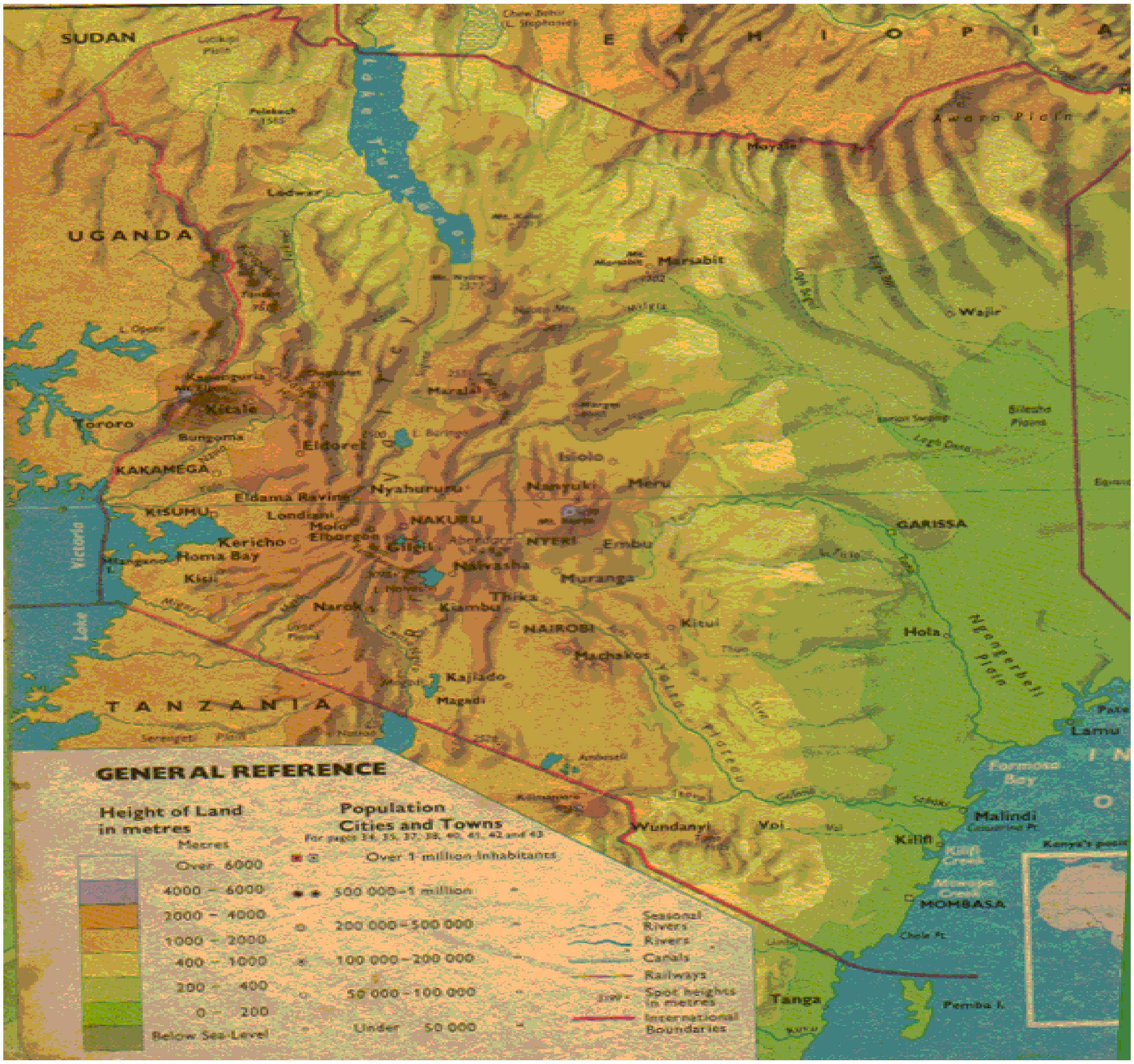
1.3. Justification

The use of seasonal climate forecasts when making decisions in the more climate-sensitive sectors of the economy cannot be under stated . Well-informed decisions are only possible if the quality of the forecasts is good.

The Kenya Meteorological Department has over the years been investing in terms of; technology, instrumentation and capacity building of its staff. Also, there is access to more complete data, more understanding of tropical meteorology and incorporation of ensemble forecasting .All this has been done with the aim of improving the quality of the forecasts that KMD issues. This study will provide information on whether there has been an improvement in the quality of forecasts produced by the KMD. The results from the study will provide information to the the stakeholders on the state of seasonal rainfall forecasting in Kenya..

1.4. Area of Study

Figure 1.Area of the study region showing the main physical features.



Kenya is found in East Africa and lies between 5°N-5°S and 34°E-42°E). Its area coverage is approximately 580,000 km². There are two main rainfall seasons in Kenya; the long-rain season (MAM) and the short-rains season (OND). Between the two seasons, the region usually experiences a dry spell. Some of the weather systems that influence the rainfall received over Kenya are: the Inter-Tropical Convergence Zone (ITCZ), the Subtropical Anticyclones, the Congo Air mass and Monsoons.

Topography of Kenya is highly diverse and this gives rise to mesoscale systems that modify the rainfall regimes. This in turn causes high spatial variance in the distribution of the seasonal rainfall.

1.5. Limitations of the study

This study encountered the following limitation; KMD issues forecasts in five categories: Above Normal to Normal, Normal to Above Normal, Normal, Normal to Below Normal and Below Normal to Normal. However, the categories used in this study were limited to three; Below Normal, Near Normal and Above Normal. This had an impact on the computation of skill scores.

CHAPTER TWO

LITERATURE REVIEW

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2.0. Seasonal Rainfall Forecasting in Kenya

Seasonal climate forecasting is one of the most promising developments for the early warning of climate hazards (Murphy et al., 2001).

When preparing Long-range forecasts of seasonal rainfall in East Africa, statistical methods and dynamical models are used. A combination of the two is also used. Before the start of each rainfall season, the National Meteorological Agencies of the countries use statistical methods to come up with their seasonal forecasts. Reference is also made to output from Coupled General Circulation Models (CGCMs), which produce global monthly rainfall forecast.

In Kenya, the Kenya Meteorological Department issues seasonal rainfall forecasts before the start of both rainfall seasons. Forecasts for the long-rains season are based on weak correlations between regional rainfall indices and SSTs and the QBO.

The Kenya Meteorological Department (KMD) develops statistical seasonal rainfall forecasts for each region of the country are using a program called SYSTAT. Global SSTs of up to 6 months prior to the rainfall season are correlated with historical rainfall data from synoptic weather stations. A single rain gauge station with good quality rainfall data is used to represent each homogeneous rainfall region. A seasonal rainfall forecast model is developed using SYSTAT.

Comparison of these forecasts with the statistical forecasts from neighboring countries, as well as against the forecasts from several global dynamical models, issued by Meteorological agencies in Europe and the USA is then made. A consensus forecast- which gives the probability of rainfall forecast being in a particular category (below-normal, near-normal or above-normal rainfall), across the whole of the Greater Horn of Africa is then made..This forecast is then re-adjusted by each country's Meteorological office.

2.1. Forecast Verification

Forecast verification entails assessing and quantifying the relationship between forecasts and their corresponding observations. It is done so as to either to determine the utility of the forecast or to determine the skill of the forecaster. Some of the attributes associated with different verification measures include: Accuracy, skill, sharpness and reliability. Accuracy refers to how agreeable the forecasted value is to the true observed value. The difference between the two values is the referred to as the error. A small error is an indication of great accuracy and vice-versa. Skill refers how accurate a forecast is compared to the accuracy of forecasts produced by other standard procedures.

CHAPTER THREE

3.0 DATA AND METHODOLOGY

This chapter is devoted to the data used in the study and various methods which were used to achieve various objectives of the study.

3.1 DATA

In this study, monthly rainfall totals for twelve representative stations and seasonal rainfall forecasts (both MAM and OND seasons) were used. These were acquired from the Kenya Meteorological Department. The monthly rainfall data used was for the period from 1998 – 2017. The seasonal rainfall forecasts were for the period from 2008 – 2017.Table 1 below shows the names of the stations used in the study and the regions they represent while Figure 2 shows the distribution of these stations in Kenya.

MAM season			OND season		
No.	**Station**	**Region**	**No.**	**Station**	**Region.**
1	Lodwar	**R1**	1	Lodwar	**R1**
2	Moyale	**R2**	2	Marsabit	**R2**
3	Wajir	**R3**	3	Garissa	**R3**
4	Voi	**R4**	4	Voi	**R4**
5	Lamu	**R5**	5	Lamu	**R5**
6	Mombasa	**R6**	6	Mombasa	**R6**
7	Makindu	**R7**	7	Makindu	**R7**
8	Dagoretti	**R8**	8	Dagoretti	**R8**
9	Maralal	**R9**	9	Nyahururu	**R9**
10	Timboroa	**R10**	10	Timboroa	**R10**
11	Narok	**R11**	11	Narok	**R11**
12	Kakamega	**R12**	12	Kisumu	**R12**

Table 1. *The stations used in the study and the region they represent.*

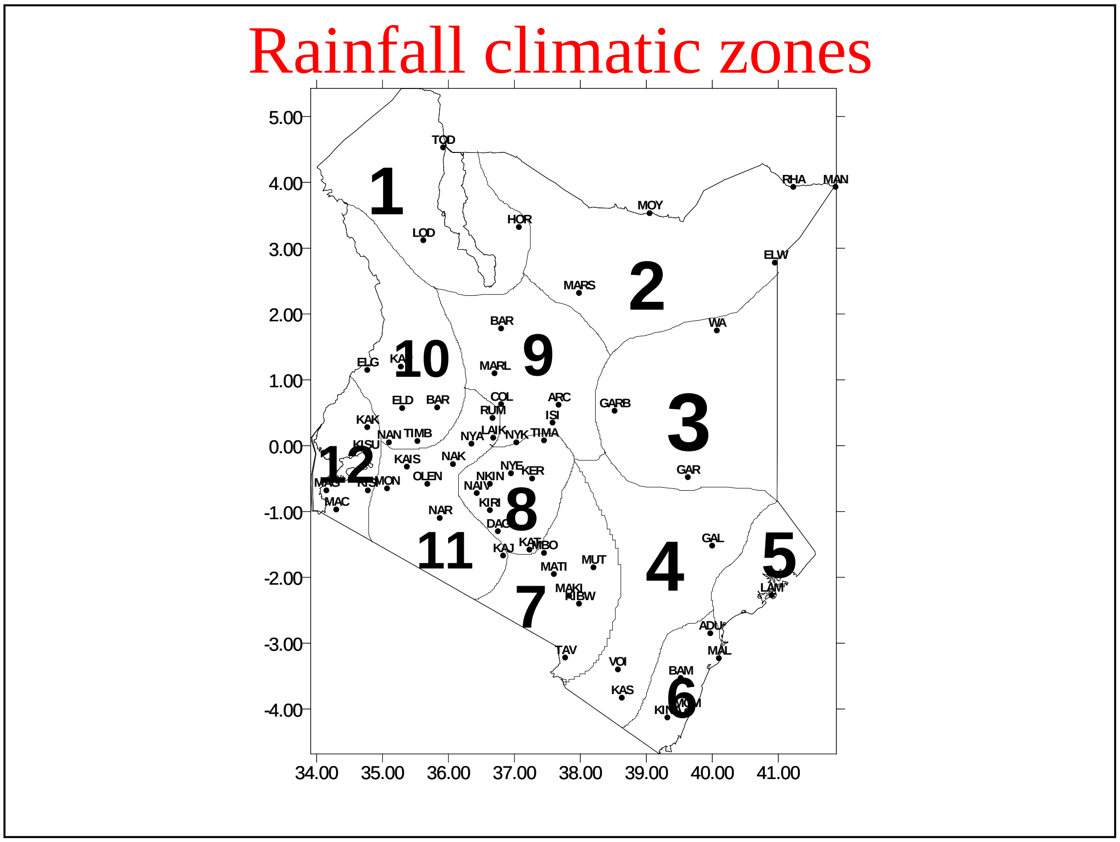

Figure 2: Homogeneous climate zones over Kenya showing the rainfall stations (*Source: Drought Monitoring Centre, (DMC), Nairobi 2000)*

3.1.1. Estimation of Missing Monthly Rainfall Data

Simple arithmetic mean was used to fill in the missing rainfall data. This involved obtaining long-term mean for the station and using it to fill the missing gaps. This was computed using the equation 1 below.

$$\overline{A} = \frac{1}{n} * \sum_{i=1}^{n} x_i$$

……………………………..Equation 1.

Where $\overline{A}$ is the arithmetic mean, n represents the number of monthly rainfall values being averaged and x_1 represents the value of each individual monthly rainfall.

3.1.2. Data Quality Control.

The single mass curve method was used to test for homogeneity of the rainfall data for each station. In this method, the cumulative totals are plotted against the years. A straight line was obtained for homogeneous records with data points closer to the line. If a data point was found to be far from the line of best-fit then the data set was considered not to be homogeneous. This test was done for the MAM and OND seasons using the MAM totals and OND totals respectively.

3.2 :METHODOLOGY.

3.2.1 RAINFALL DATA

Monthly rainfall data (1998-2017) for 12 Meteorological stations, each representing each zone within the study area was used to:

i).compute the long-term mean (LTM) for each station,

ii).compute the (MAM) and the (OND) seasonal rainfall performance for the period under study(2008 – 2017).

3.2.2. Categorizing the observed seasonal rainfall

The following categories of the observed seasonal rainfall were used ; Below Normal(BN) for received rainfall amount that was less than 75% of the long term mean for the rain gauge station representing that region, Near Normal(N/NN) if the amount received fell between 75% and 125% of the long term mean and Above Normal(A/AN) if the amount received exceeded 125% of the long term mean.

3.2.3. Forecast Verification

Table 2 shows a 3 by 3 contingency table was used to verify the forecasts.

Table 2.A 3 by 3 contingency table used to compute the seasonal forecast skill scores.

		FORECAST			
		Below Normal	Near Normal	Above Normal	Total
O B S E R V E D	Below Normal	A_{11}	A_{12}	A_{13}	J
	Near Normal	A_{21}	A_{22}	A_{23}	K
	Above Normal	A_{31}	A_{32}	A_{33}	L
	Total	M	N	P	T

3.2.3. Computation of the Skill scores

Values tabulated from table 2were used to compute the associated scores as shown on table 3.

Table 3: Skill scores and their computation.

STATISTIC.	**COMPUTATION**
Percent correct	$100*(A_{11}+A_{22}+A_{33})/T$
Heidke Skill Score	$(A_{11}+A_{22}+A_{33}-(JM+KN+LO)/T)/ (T-(DM+HN+LP)/T)$
POD of a below normal FORECAST	A_{11}/J
POD of a normal forecast	A_{22}/K
POD of an above normal forecast	A_{33}/L
FAR of below normal forecasts	$(A_{21}+A_{31})/M$
FAR of near normal forecasts	$(A_{12}+A_{32})/N$
FAR of above normal forecasts	$(A_{13}+A_{23})/P$
bias – below normal (BN)	M/J
bias – near normal (NN)	N/K
bias – above normal (AN)	P/L

This approach enables one to compute a number of statistics that can be used verification of forecasts were. The percent correct indicates the worthiness of the forecasts.

The HSS values range from negative infinity to positive infinity; a negative indicates that the forecast is worse than that of climatology 1, 0 indicates no skill and a positive number indicates skill, the greater the number, the greater the skill.

The probability of detection (P.O.D.) or the Hit Rate is the ratio of the number correct to that observed in each category. It evaluates the ability to forecast a particular category correctly.

CHAPTER FOUR

RESULTS AND DISCUSSIONS

4.0 HOMOGENEITY TESTS

The results of the homogeneity tests conducted on the data are shown in the figures that follow.

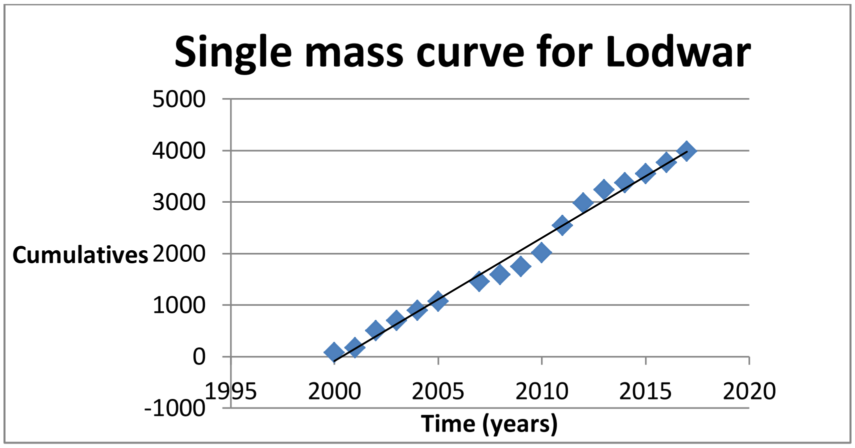

Fig 3: Single mass curve for Lodwar

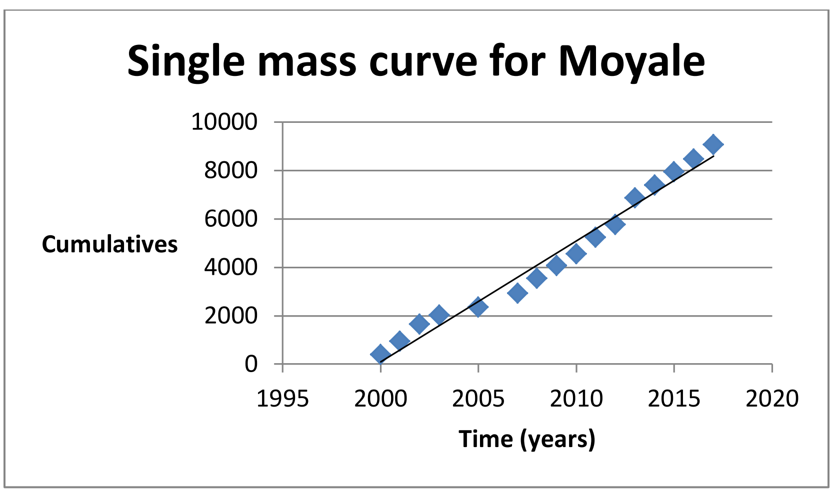

Fig 4: Single mass curve for Moyale

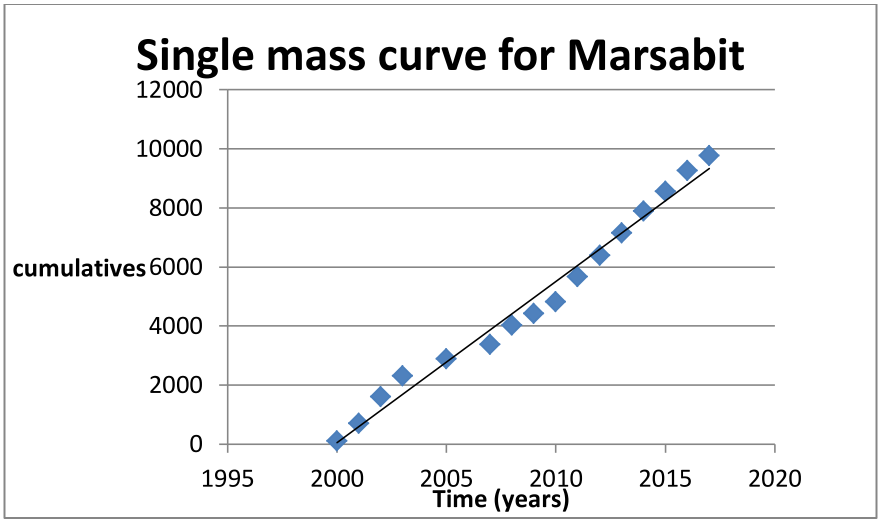

Fig 5: Single mass curve for Marsabit

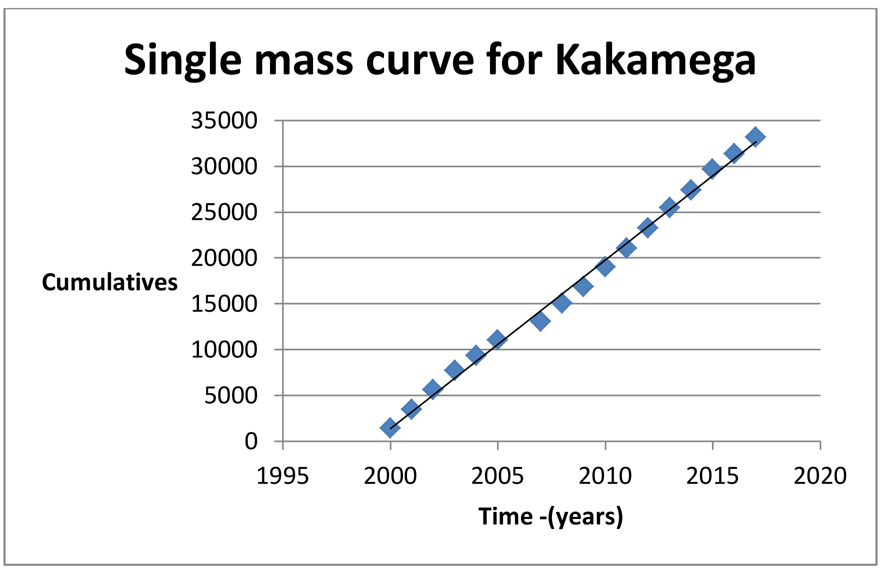

Fig 6: Single mass curve for Kakamega

From the figures above it is seen that most of the data points selected lie on or near the straight line. This is a proof that the data is reliable hence can be used for analysis.

.Table 4 : The forecast and corresponding observed MAM seasonal categories for each region.

YEAR	**Forecast (F) and Observed (O) for MAM .**																							
	R1		R2		R3		R4		R5		R6		R7		R8		R9		R10		R11		R12	
	F	**O**	**F**	**O**	**F**	**O**	**F**	**O**	**F**	**O**	**F**	**O**	**F**	**O**	**F**	**O**	**F**	**O**	**F**	**O**	**F**	**O**	**F**	**O**
2008	B	B	B	N	B	B	B	A	B	A	B	N	B	A	B	B	B	N	A	N	B	N	A	N
2009	A	B	B	N	B	B	B	N	B	B	B	B	B	B	B	B	B	B	A	N	B	N	A	N
2010	A	A	A	A	A	A	B	N	B	A	B	A	A	A	A	A	A	A	A	A	A	N	A	N
2011	B	N	B	B	B	B	B	A	B	B	A	B	B	B	N	B	B	B	A	N	N	B	A	N
2012	N	A	B	B	B	A	B	N	B	B	B	B	B	N	N	A	B	B	N	N	N	N	N	N
2013	B	A	B	A	B	A	B	A	A	A	A	A	B	N	A	N	B	N	A	N	A	A	A	A
2014	A	B	B	N	B	B	B	N	B	N	B	N	B	A	A	B	B	N	A	B	A	B	A	N
2015	A	N	B	N	B	B	B	N	B	N	B	A	B	N	N	A	B	A	A	N	N	N	A	A
2016	B	A	B	A	B	B	B	B	A	N	A	N	B	N	N	A	B	B	N	N	N	N	N	A
2017	N	N	B	N	B	B	B	B	B	N	B	A	B	N	B	B	B	B	N	N	B	B	N	N

Table 4 shows the forecast and the corresponding observed MAM seasonal categories for each region. From the table, it can be seen that the below normal category was the most forecast while the near normal was the most observed over the study period. The BN category was most forecast in all the regions except regions; VII ,X and XII

Table 5: Skill scores for Seasonal forecasts for each region for the MAM season in Kenya.

	HOMOGENOUS RAINFALL REGION											
STATISTIC	**R1**	**R2**	**R3**	**R4**	**R5**	**R6**	**R7**	**R8**	**R9**	**R10**	**R11**	**R12**
% Correct	30	30	70	20	40	30	30	40	60	40	50	30
HSS	-0.061	0.114	1.62	0	0.032	-0.045	0.11	0.131	0.25	0.13	0.23	-0.30
POD(BN)	0.333	1	1	1	0.75	0.667	1	0.6	1	0	0.33	0
P.OD(NN)	0.333	0	0	0	0	0	0	0	0	0.38	0.5	0.29
POD(AN)	0.25	0.333	0.33	0	0.333	0.25	0.33	0.25	0.5	1	1	0.33
FAR(BN)	0.75	0.78	0.33	0.8	0.625	0.714	0.78	0	0.44	0	0.67	0
FAR(NN)	0.5	0	0	0	0	0	0	1	0	0	0.25	0.5
FAR(AN)	0.75	0	0	0	0.5	0.667	0	0.667	0	0.86	0.67	0.83
BIAS(BN)	1.33	4.5	1.5	5	2	2.33	4.5	0.6	1.8	0	1	0
BIAS(NN)	0.67	0	0	0	0	0	0	4	0	0.38	0.67	0.57
BIAS(AN)	1	0.333	0.33	0	0.667	0.75	0.33	0.75	0.5	7	3	2

Table 5 shows the skill scores for each region. From the table, it is evident that the seasonal forecasts were found to be at least 40 % correct for the MAM season with larger percentages correct for region three (70%) and region 9 (60%), respectively. The percentage correct were however below 40% for the rest of the regions.

The HSS ranged from a negative value (regions one, six and twelve) to a score of 0.25. This indicates that for the regions one, six and twelve the standard forecast (chance) is more accurate than the forecast. The HSS score for region four is zero indicating lack of skill while the score are very low for the rest of the regions indicating a low forecast skill.

POD scores are higher for BN and AN categories as compared to the NN category .The FAR for BN category is higher for all the regions except regions eight, ten and twelve as compared to the other categories .This is .

The BIAS category indicates a tendency to over forecast BN category in most of the regions except regions eight, ten and twelve where NN and AN categories are over forecast respectively**.**

Table 6 : The forecast and corresponding observed OND seasonal categories for each region.

YEAR	**Forecast (F) and Observed (O) for OND Season**.																							
	R1		R2		R3		R4		R5		R6		R7		R8		R9		R10		R11		R12	
	F	**O**	**F**	**O**	**F**	**O**	**F**	**O**	**F**	**O**	**F**	**O**	**F**	**O**	**F**	**O**	**F**	**O**	**F**	**O**	**F**	**O**	**F**	**O**
2008	A	A	B	N	B	N	A	B	B	B	A	B	A	B	A	N	B	A	A	N	A	B	A	N
2009	N	A	A	N	A	A	A	A	A	A	A	A	N	N	N	N	A	A	A	N	A	N	A	N
2010	B	B	B	B	B	B	B	N	B	B	B	B	B	B	B	N	B	B	N	N	B	N	N	N
2011	N	A	N	A	N	A	A	A	A	A	A	A	A	N	A	A	N	A	N	A	A	A	N	A
2012	A	A	A	N	A	N	A	N	A	A	A	N	A	A	A	A	A	B	A	A	A	A	A	A
2013	B	B	B	N	B	B	N	N	N	B	N	N	N	A	N	N	B	B	A	A	N	B	A	N
2014	B	N	A	A	A	N	A	B	A	N	A	A	B	N	A	N	A	N	A	N	B	N	A	N
2015	A	N	A	A	A	N	A	N	A	N	A	A	A	B	A	N	A	N	A	A	A	A	A	A
2016	N	B	B	B	B	B	B	B	B	B	B	B	B	N	B	B	B	B	N	B	B	B	N	B
2017	N	A	A	N	N	B	A	B	A	B	A	N	A	N	A	A	N	A	N	B	N	B	A	N

Table 6 shows the forecast corresponding observed OND seasonal categories for each region. From the table, it can be seen that the above normal category was the most forecast while the near normal was the most observed over the study period. The BN category was most forecast in all the regions except regions one.

Table 7: Skill scores for the Seasonal forecasts for each region for the OND season in Kenya.

	HOMOGENOUS RAINFALL REGION											
STATISTIC	**R1**	**R2**	**R3**	**R4**	**R5**	**R6**	**R7**	**R8**	**R9**	**R10**	**R11**	**R12**
% Correct	40	40	40	40	60	70	30	60	40	40	40	30
HSS	0.12	0.17	0.12	0.1	0.4	0.5	0.02	0.41	0.06	0	0.11	-0.14
POD(BN)	0.66	1	0.75	0.19	0.6	0.67	0.33	1	0.75	0	0.25	0
P.OD(NN)	0	0	0	0.25	0	0.33	0.2	0.33	0	0.25	0	0.17
POD(AN)	0.4	0.67	0.5	0.25	1	1	0.5	1	0.25	0.8	1	0.67
FAR(BN)	0.33	0.5	0.25	1	0	0	0.66	0.5	0.25	0	0.67	0
FAR(NN)	1	1	1	0.5	1	0	0.5	0	1	0.7	1	0.67
FAR(AN)	0.33	0.6	0.75	0	0.5	0.43	0.8	0.5	0.75	0.5	0.4	0.71
BIAS(BN)	1	2	1	0.71	0.6	0.67	1	2	1	0	0.75	0
BIAS(NN)	2	0.2	0.5	0.5	0.5	0.33	0.4	0.33	1	1	0.67	0.5
BIAS(AN)	0.6	1.67	2	0.25	2	1.75	2.5	2	1	1.5	1.67	2.33

Table 7 shows the Skill scores for the Seasonal forecasts for each region for the OND season in Kenya. From the table, it is evident that seasonal forecasts were found to be at least 45% correct for the OND season with larger percentages correct for region six (70%) and region eight (60%), respectively. The percentages correct were however averaging 40% for the rest of the regions. The HSS scores were very low averaging0.2 indicating a low forecast skill for most of the regions. Region ten scored a zero indicating no skill while region twelve had a negative score implying that the standard forecast (chance) is more accurate than the seasonal forecast.

The POD scores are higher for the BN and AN categories as compared to the NN category .The FAR for the NN category are higher for all the regions except regions; four, six, eight, ten and twelve as compared to the other categories.

The BIAS category indicates a tendency to over forecast AN category in most of the regions except regions one and four where NN and BN categories are over forecast respectively**.**

MAM SEASON.

Table 8: Skill scores for seasonal forecasts for the period from; 2008-1017 for the MAM season in Kenya.

	YEAR									
STATISTIC	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**
% Correct	25	58.3	50	50	58	33.3	46.7	25	41.67	66.7
HSS	0	0.189	0	0.02	0.318	0	-0.29	-0.053	0.125	0.351

Table 8 shows the skill scores for MAM season for the years 2008 - 2017.From the table, it can be seen that the highest percent correct was scored in the year 2012 (58%) and the lowest in the years 2008 and 2015. The average score is approximately 40%. The HSS scores range from negative for years 2014 and 2015 implying that the standard forecast (chance) is more accurate than the seasonal forecast. Years 2008 and 2010 scored a zero indicating no skill while the rest of the years indicate a low forecast skill.

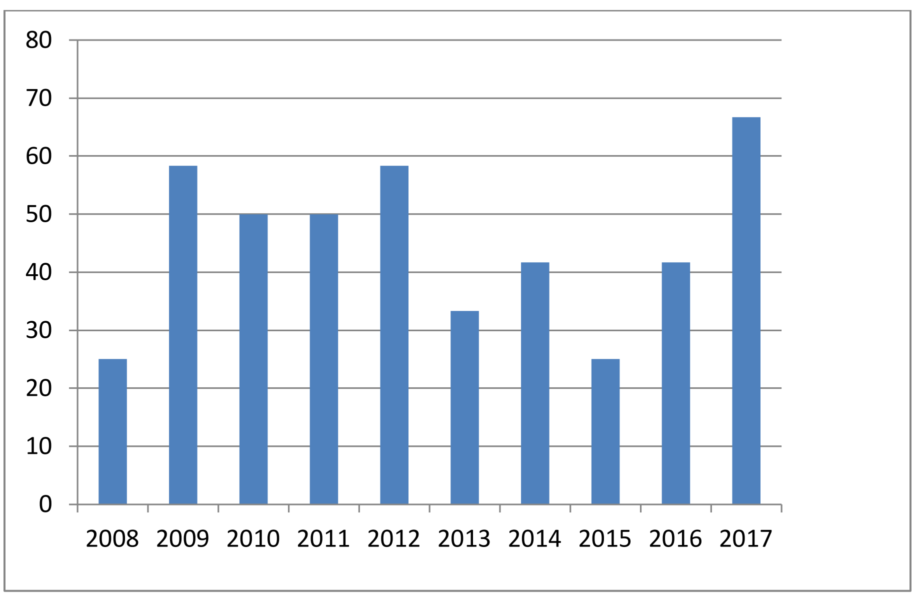

Figure 7 :Percent correct for MAM season.

OND SEASON.

Table 9: Skill scores for Seasonal forecasts for the period from; 2008-2017 for the OND season in Kenya.

	YEAR									
STATISTIC	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**
% Correct	08.3	50	75	41.7	50	50	16.7	41.7	75	08.6
HSS	-0.18	0.18	0.44	0	0	0.22	0.01	0	-0.125	-0.22

Table 9 shows the skill scores for OND season for the years 2008 - 2017.From the table, it can be seen that the highest percent correct was scored in the year 2010 and the lowest in the years 2008 and 2017. The average score is approximately 40%. The HSS scores range from negative for years 2010,2016 and 2017 implying that the standard forecast (chance) is more accurate than the seasonal forecast. Years; 2011,2012 and 2015 scored a zero indicating no skill while the rest of the years indicate a low forecast skill.

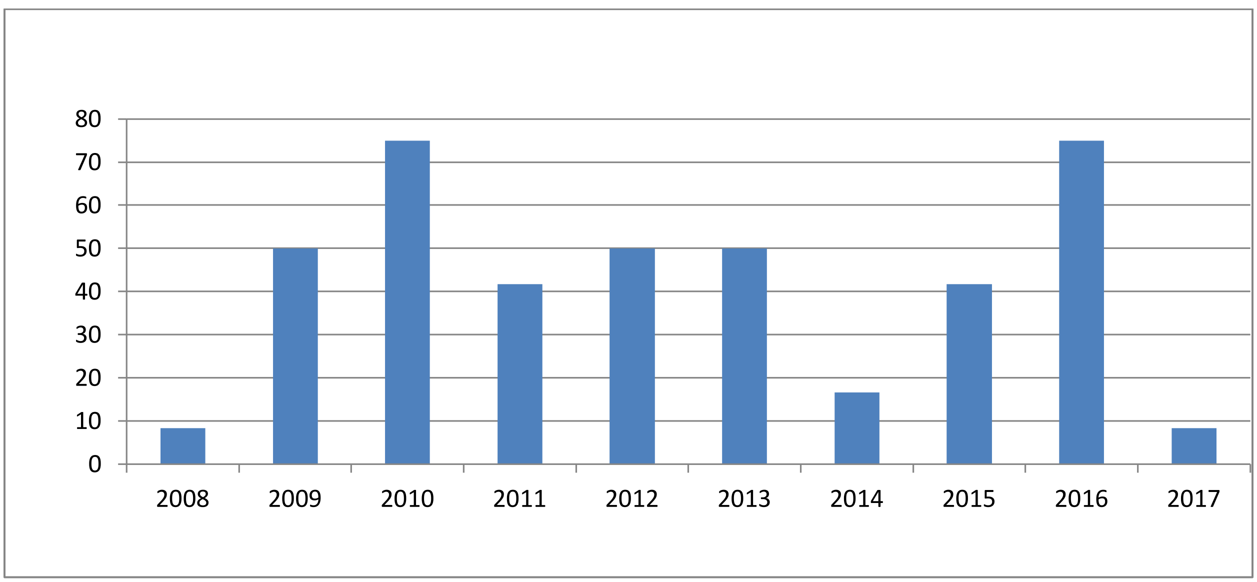

Figure 8: Percentage correct for the OND season.

CHAPTER FIVE

CONCLUSIONS AND RECOMMENDATIONS

5.1 CONCLUSIONS

From the results obtained for MAM season, the seasonal forecasts were found to be at least 40 % correct which is a modest score. The HSS ranged from a negative value (regions one, six and twelve) to a score of 0.25. This indicates that in some regions, the standard forecast (chance) is more accurate than the seasonal forecast ,In some regions, the score was zero indicating lack of skill while other regions had e very low score regions indicating a low forecast skill. This was also the same for the OND season.

There is also a bias towards forecasting BN category for the MAM season while the AN category is over forecast during OND season

In general, the forecast skill was found to be low for both seasons throughout the study period. It also fluctuated from year to year and when an improvement from the previous year was registered, it was modest.

5.2 Recommendations

The following recommendations were made from the study:

More should be done so as to improve the quality of seasonal forecasts. This includes incorporation into the forecasting process of models that can capture the role of local effects like topography, especially when down scaling the seasonal forecasts to regional/county level.

Further study should be conducted in which the sample size of the stations used will be increased. This is because accuracy of skill scores depends on sample size.

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