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Study of Soil Erosion

Geographic Information System

Highlights

Mudumalai Tiger Reserve

Occurrence of Corundum Crystals

Discovering Thoughts, Inventing Future

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Study of Soil Erosion Risk in the Basin of Northern Al-Kabeer River in Lattakia using Remote Sensing and Geographic Information System (GIS) Techniques

By Dr. Mona Barakat, Dr. Ilene Mahfoud & Aymen A. Kwyes
Tishreen University, Syria

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Strictly as per the compliance and regulations of :

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To achieve this objective, the first phase of the study evaluates the soil erosion viability by estimating soil texture, Soil depth and stoniness percent. Consequently, soil erosion viabilities were classified according to its influencing degree in soil erosion. The potential risk erosion map was depending on cross all information which obtained from soil erodibility, erosivity index and the degree of slope on study area was formed by using GIS technologies.

Land cover map of study area was produced and classified to two classes depending on soil protection degree. Then, an actual risk map of soil erosion was prepared after crossing land cover and potential risk erosion classes of study sites.

The results showed that 2.47% of the study area facing high risk of soil erosion, while the soil risk was moderate in 22.18% and low in 75.35% of the study area. The high risk erosion spots mainly located in the center and northern parts of the study area. Moreover, the study confirm that the land cover is the most influential factor in soil water erosion, which reduced about 60.93% of the high risk of potential soil erosion.

Keywords: risk water erosion, geographic information system, Al-Kabeer northeren river, CORINE methodology.

I. Introduction

Water erosion is the result of overlap between the factor of soil and the worker rainfall (Kertesz and Gergely, 2011), which is one of the most important environmental problems and agricultural, because it causes the loss of the elements of fertility in the soil (N, P, K and grained soft), which leads to lower the productive capacity of the soil, and thus exit from the process of agricultural production (Tingtinget al., 2008), also works on the pollution of water bodies as the outputs of soil erosion up to aquariums closed and caused the phenomenon of eutrophication (Eutrophication) deprives so its vital importance and economic (Schiettecatte, 2007), as a result, leading to the loss of the most important exporters are essential for the continuation of human and two water and soil, especially soil erosion processes that are fast, unlike soil formation processes that are very slowly.

The factors affecting the water erosion of the soil in Syria in general and the Syrian coast in particular are many and varied, and has been highlighted in a study carried out by the (UNEP, 2004), and most notably the rain, the decline of soil and vegetation, so locating dangerous drift and evaluation is important and necessary. in order to develop appropriate strategies for soil and water conservation.

The identification of areas of the seriousness of water erosion ways through traditional estimating quantities of soil lost is difficult and is not possible in areas with large spaces and differentiated terrain , and he needs to make a lot of efforts and exchange huge amounts (Zhang *et al*., 2010;Ren, 2011), which requires finding alternative methods and fast help identify threatened areas drift in order to accelerate the adoption of appropriate measures to reduce degradation processes, such as the use of some experimental models that rely on measuring factors drift locally as an erosion rain, worker susceptibility of soil to erosion, factor terrain factor vegetation, which gave good results faster and less expensive when used with remote sensing techniques and geographic information systems (Prasann *et al*., 0.2013), which is one of the tools actors in the process of studying the vegetation and monitor the changes that defects during different periods of time (Ahmad and Verma, 2013), and help access to spatial database and wide to identify areas at risk of water erosion, and was able to determine the rate of deterioration and the development of strategies and plans necessary for the maintenance of those areas soils (Sakthivel *et al*.,.2011)

Used a lot of models in determining the seriousness of the drift depending on the techniques of

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remote sensing and geographic information systems, it has been to predict the risk of soil erosion and determine the spatial distribution has (Aydin and colleagues, 2010), so we will adopt in our study on one of these models, a model coordinate information environment (CORINE: Coo Rdination of Information Environment.

II. The Importance of Research and its Objectives

Leading factors causing erosion in the river basin Great Northern (human activity, and precipitation, high terrain corrugated and steep) to the loss of agricultural soils and the degradation characteristics Al_khasobeh, low production capacity, and that the arrival of the outputs of the drift to the river leads to the contamination of water basin and low value bio and agricultural.

The difficulty of identifying areas of dangerous drift by estimating the amount of soil lost in this area because of the large area of the hand, and Oaourtha hand, requires the use of modern technologies Kniz geographic information (GIS) to identify and assess the seriousness of the drift so that the foundation stone at the development of the necessary procedures for soil conservation and the reduction of erosion, where the aim of this study was to:

Determine the risk of soil erosion and spatially distributed in the pelvic area and the Near East to the Grand River in the north of Latakia, depending on the model Corinne COREIN.

III. Materials and Methods of Work

a) Study area

The study was conducted in the basin Near and Middle River Great Northern in the province of Latakia (Syria) , which is one of the largest coastal rivers , as it stems from the northern end of the western mountains of Latakia , specifically from high located at the Turkish border and is known mountains Ansari northern province of Latakia , the study covers an area of 430.43 km 2 , as a rise in some areas about 1530 m , where is the vegetation with the following components (agriculture field - forests - groves of citrus and olive trees and other fruit) , shown in Figure (1) study site on the map of administrative divisions of Syria and in the province of Latakia .

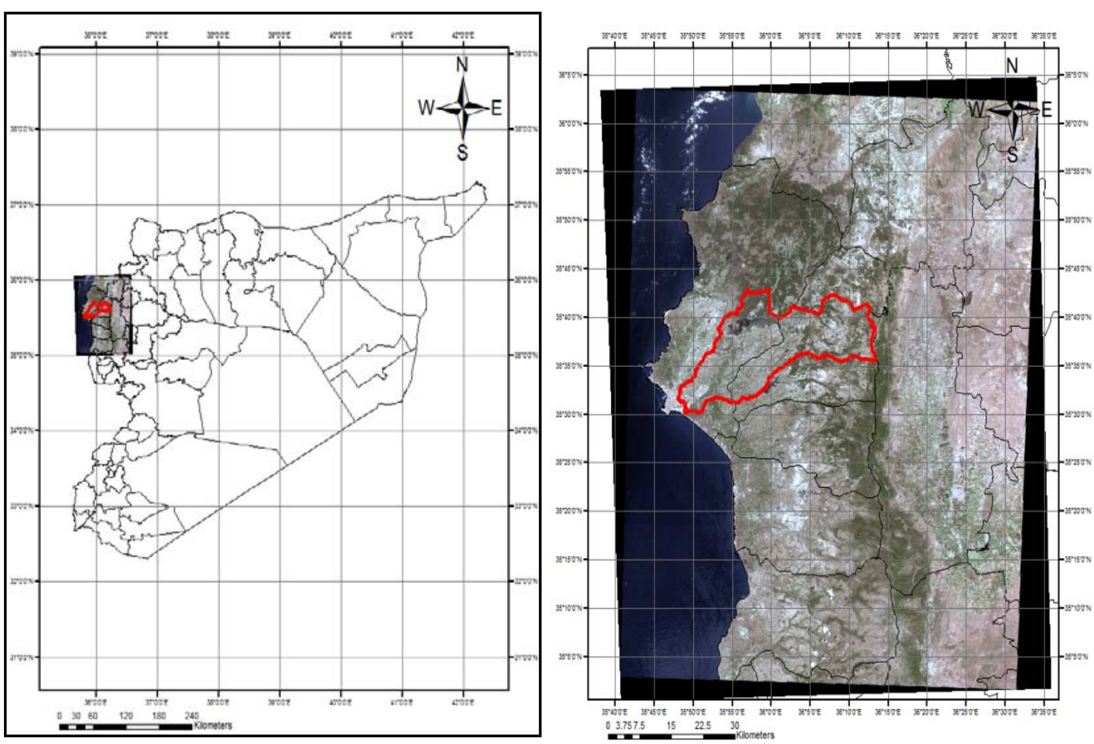


Figure 1 : Location of the study area on the map of Syria (a), and in the province of Latakia (b)

b) Collect Soil Samples

Collected 100 soil samples from sites randomly distributed in the study area form (2), as it took samples at each of the 5 points form with each other an envelope mailed equilateral along the diameter of 22:00 from a depth of 0-10 cm, formed including soil sample vehicle, transported to the laboratory, and removed the roots and plant residues and dried anaerobically and Sieving diameter of 2 mm sieve to get the soft soil and then conducted some tests of physical and chemical laboratories in the College of Agriculture at the University of October.

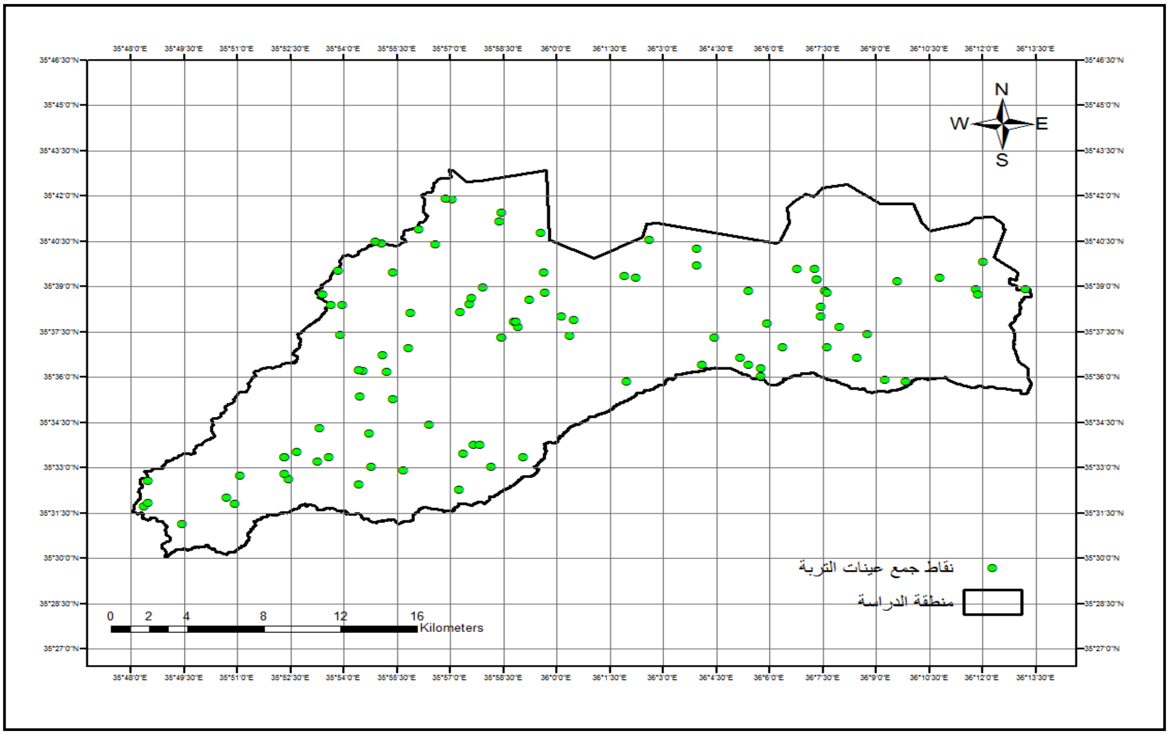


Figure 2 : map showing points of collection of soil samples in the study area

Was performed mechanical analysis of the soil using a method hydrometers, and determine the strength of the soil using the triangle textures by American classification (USDA), were identified as the percentage of coverage of the surface with gravel by taking an area of 13:00 2 from the sample and then measuring the coverage ratio with gravel, and measured the depth of the soil through using a metal rod runway was planted in the soil at the center of the sample, the sampling sites were identified using a global Positioning system (GPS: Global Position System).

Has been collecting climate data (monthly amounts of precipitation and temperature) of the meteorological station at (mouthpiece) for ten years (2011-2001), where values ranged between average annual rainfall (550-1006) mm, while the values ranged between monthly average temperatures (12 -28) degrees Celsius.

c) Corinne model (CORINE: COoRdination of information on the Environment)

Based methodology to assess the risk of water erosion of the soil using a model Corinne, at the expense of some of the factors affecting the drift : the portability factor of soil erosion, rainfall erosion factor, factor inclination and vegetation factor, where both were calculated from previous indicators as follows :

i. *Soil Erodibility Index*

Affected index susceptibility of soil to erosion each of the (soil texture, depth and percentage of coverage of the surface with gravel), as classified by the strength of the soil to four rows deep in three rows, while the percentage of coverage of the surface with gravel are classified in two rows (Table 1), and calculates the index susceptibility soil erosion, according to the following equation:

Index susceptibility to soil erosion,= Soil Texture X Soil Depth X Percentage of Stones Covered.

Table 1 : the ranks of each type of textures, depth and vulnerability index for soil erosion by CORINE

Class	soil texture	Stoness Class	Soil Depth)cm(	Erodibility
0	Rock Land	-	-	0
1	Low Erodibility Soil (Clay–Sandy Clay–Silty Clay)	<10%	75>	0-3
2	ModeratlyErodibility Soil(Sandy Clay Lome–Clay Lom–Silty Clay Lome–Lome Sand–Sandy)	>10%	25-75	3-6
3	High Erodibility Soil (Lome-SiltyLome-Silty-Sandy Lome)	-	25<	>6

ii. *Rainfall erosion index(Erosivity Index)*

Index was calculated based on the rainfall erosion of all Station Fournier Index(FI) and (BGI: Bagnouls-Gaussen Index) is calculated as rainfall erosion index using the following relationship:

Rainfall erosion index = index Fournier row X row index Bagnold - Gawsn

The index is calculated Fournier (FI) according to the following equation:

$$FI = \sum_{i=1}^{12} \frac{P_i^2}{P}$$

Where

pi: the amount of monthly precipitation in mm.

P: Total annual rainfall in mm.

The index of Bagnold - Gawsn (BGI) is calculated according to the following equation.

$$BGI = \sum_{i=1}^{12} (2t_i - P_i)K_i$$

Where

ti: Average monthly temperature b (degrees Celsius).

Ki: calculated value when 2ti-pi> 0.

Where Ki factor was calculated by the relationship (Ki = 2ti-pi), which is calculated when 2ti-pi> 0 and neglect If this ratio is less zero.

Index has been divided into five rows FI index and BGI to four rows, while the erosion index was divided into three rows rainfall as in the following table.

Table 2 : Values and the ranks of both index and index Fournier Bagnold - Gawsn, and rainfall erosion index by model CORINE

Class	FI	Classification	BGI	Classification	Erosivity	Classification
1	< 60	Very low	0	Humid	<4	Low
2	60-90	Low	0- 50	Moist	4 -8	Moderate
3	90-120	Moderate	50 - 130	Dry	>8	High
4	120-160	High	>130	Very Dry		
5	>160	Very High				

iii. *Slop Index*

Was to determine the degree inclination using digital elevation model (DEM):has been obtained from the Public Authority for Remote Sensing (GORS) in the patient, has been manufacturing DEM in 2011 from the image accurately ester 30 m,. Were divided depending on the degree of inclination model CORINE to four rows in the table as (5).

Table 3 : Values and the Classesof Slopedegree by CORINE model

Class	(%)Slope Angle	Classification
1	5 >	Gentle to flat
2	5-15	Gentle
3	15-30	Step
4	>30	Very steep

iv. *Potential Soil Erosion Risk*

Was calculated potential danger (underlying) to soil erosion using the following equation.

The potential Soil Erosion Risk index = soil Erodibility map X Erosivity index X Slope Map

Was divided potential risk of erosion into four rows , there is no danger (0), low (0-5), average (5-11) and high (> 11).

v. *Land Cover*

Was obtained on the map represent the different types of ground cover in the study area and using a satellite image of the type (Landsat TM) taken on 08/28/2011, was rated among the coverage of ground in this map represented by the degree of protection of the soil and in accordance with the model Corinne to two rows: (1) full protection (Fully Protected) It includes forests, bodies of water, construction, roads and rocky Land. (2) Protection of incomplete (Not Fully Protected) which includes land crops and fruit trees in addition to the land of olive and citrus.

vi. *Actual Soil Erosion Risk*

Actual risk was calculated for each point of the soil samples by selecting a row the potential danger to her, and then determine the type of ground cover and the actual risk is calculated for each point of law the following :

Actual Soil erosion Risk = Potential SoilErosion Risk map xVegetation map

The class of the actual risk of erosion into three ranks of low, medium and high.

d) Mapping

ArcGIS10 program was used to get the maps required for each of the indicators except for the previous rainfall erosion index. Where to get maps of soil properties (soil texture, soil depth, the percentage of gravel cover) by applying the logarithm of Kriging on samples collected Haklaa. Expresses this logarithm process statistical geography allows estimating a surface depending on the values of a set of points distributed (samples) on this surface and actress for a particular phenomenon, and supports its core principle on the theory of variable -site The Regionalized Variable Theory which assumes that the change phenomenon represented by a set of samples raster Distributed on a surface according to the place shall be homogeneous from a statistical standpoint across the surface, as was the distribution of traits of the soil of the strength and depth of the coverage in areas with gravel samples over the entire study area. In a later step, has been used three maps representing characteristics of the soil to get on the map of soil susceptibility to erosion, as this map that represents the product of the maps of the three above-mentioned among them.

Was then prepare a map of the tendency that has been obtained using a digital elevation model (DEM) 30 m pixel accuracy. We subsequently prepare a map of the inherent risk of erosion by multiplying the process to my map susceptibility to soil erosion and tilt with the value of the index factor rainfall according to the equation mentioned in paragraph (3.3.4).

At a later stage, have been prepared Coverage Map Land cover for ground study site based on the satellite image of the moon Landsat TM taken on August 28, 2011, through the application of technology Category observer Supervised Classification mentioned on image using the program ERDASImagine8.4. Been dropping 75 sample field on the satellite image in order to identify areas of training (Training Zones) , which was used to collect spectral information representing various types of ground cover in the study area, and after the completion of the configuration file spectroscopy was performed classification process observer using the logarithm of the probability -Azam (Maximum Likelihood). Coverage was ground in the resulting image classification process through the ranks 5: (1) Forests, (2) Bodies of Water, (3) Construction - Methods - Tkchwet rocky, (4) crops - fruit trees, (5) Citrus - Olive. Was then testing the accuracy of the classification process by using a matrix error (Error Matrix). We eventually reclassified coverage map land resulting from the classification process according to the model Corinne into two rows:(1) full protection (Fully Protected) It includes forests and water bodies, construction, roads, Altkchwet rock, and (2) the protection of non- full (Not Fully Protected), which includes land crops and fruit trees (Kaltvahiat and almonds ... etc.) in addition to the land of olive and citrus .

In the final stage, have been prepared map of the actual risk of water erosion of the soil in the study area in accordance with the model Corinne through the process of multiplying the map to the inherent risk of erosion with map coverage of land reclassified into two rows by the degree of protection of the soil.

IV. Results and Discussion

a) Soil Erodibility Index

i. *Soil Texture*

The soils Celtic textures and fine sandy loam and more resistant to erosion of sandy soils and sandy Allomah and Allomah (Corbaneet al.,.2008). It has been observed that 37.52% of the soils studied with the strength of (C, SC, SiC), which is characterized resistant severe erosion, while 35.81% of the soils strength (SCL, CL, SiCL, LS), a soil medium resistance to erosion, and 26.67% of the strength of soils (L, SiL, SL), a weak soils resistance to erosion. Figure (3) varieties strength of soils and their distribution within the study area.

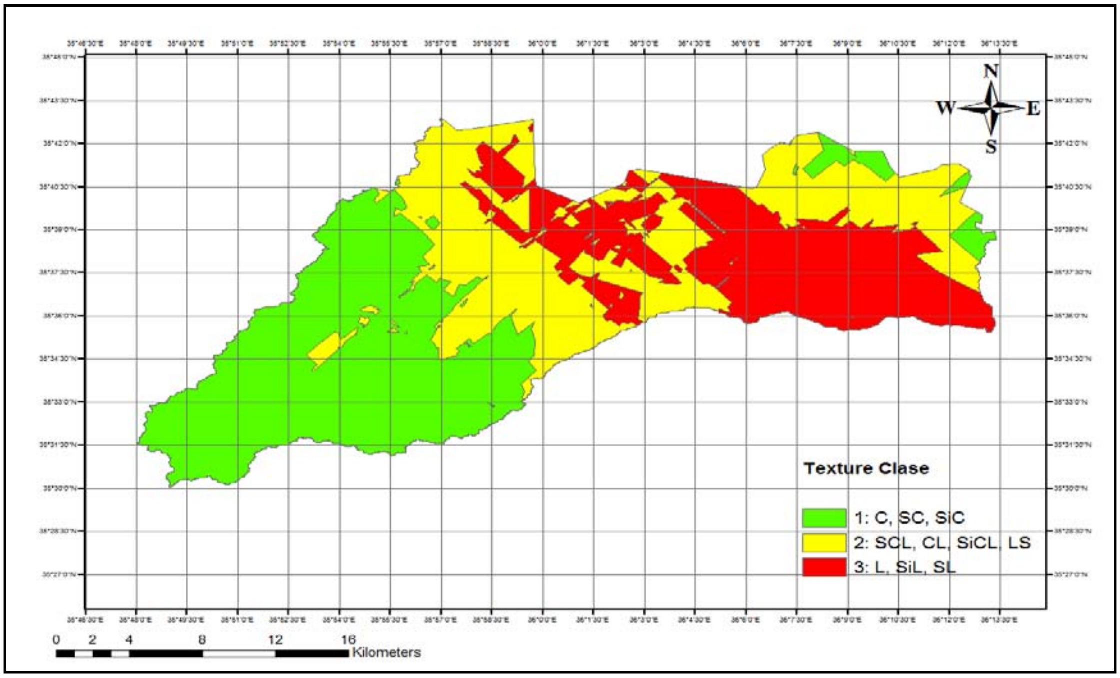


Figure 3 : among the soil texture map of the study area

ii. *Soil Depth*

the greater the depth of the soil increased ability to absorb rain water and said the amount of water runoff and therefore less drift (Marina et al., 2008) Study showed that 44.40% of the soil with a depth of more than 75 cm low susceptibility to erosion , and 39% of the soils studied with a depth of between 25-70 cm were classified as medium susceptibility to erosion, while the percentage of severe soil erosion susceptibility to 16.16% with a depth of less than 25 cm (Figure 4).

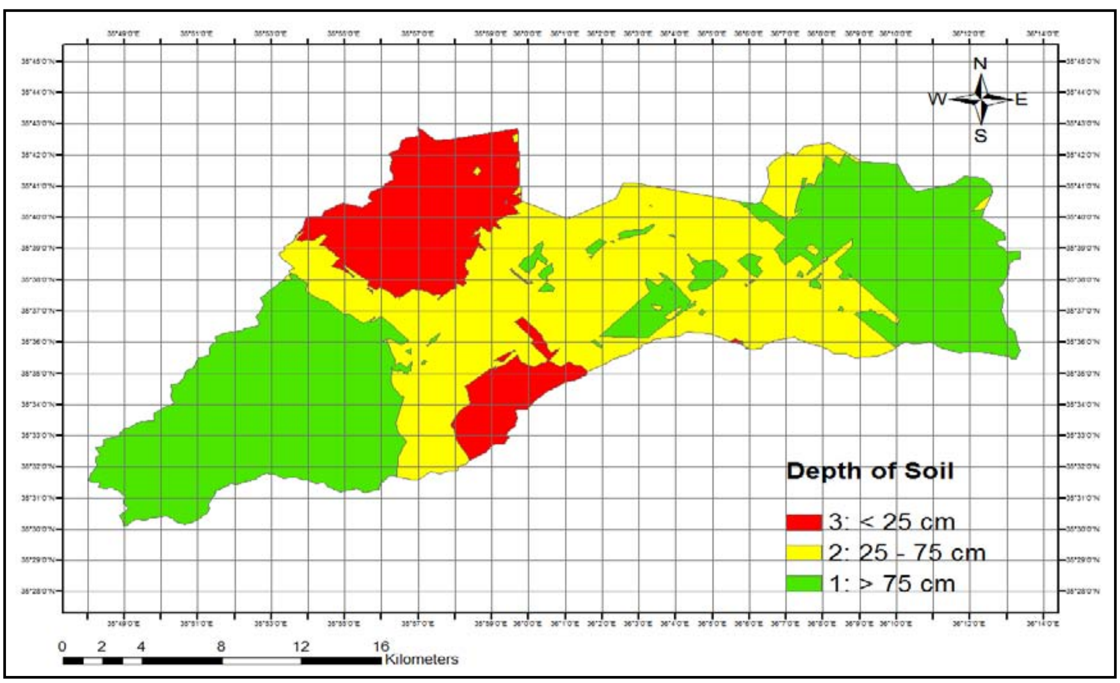


Figure 4 : map the ranks of the depth of the soil in the study area

iii. *Surface Coverage of the Soil with Stoness*

The presence of gravel over the surface of the soil can be a factor to protect the soil from rain drops act (Yukselet al.,.2008). It was found that 41.31% of the soils studied with superficial coverage of more than 10%, providing full protection of the soil while the percentage of soil surface coverage of less than 10%, which provides full protection is 58.69% of the study area (Figure 5).

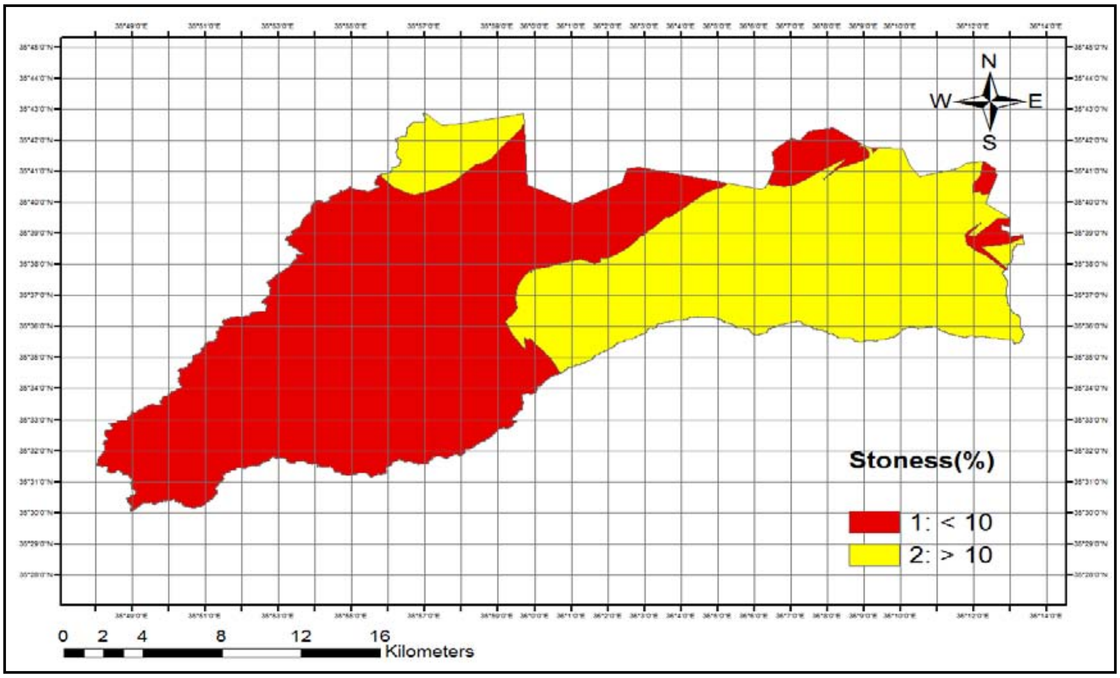


Figure 5 : Map ranks the coverage of the surface of the soil with gravel in the study area

iv. *Soil Erodibility*

Have been prepared map susceptibility of soils to erosion of multiplying the ranks of both the soil texture, depth and percentage of coverage of the surface with Stoness which as previously stated in the way of working, and is shown in Figure (6) index susceptibility of soil erosion in the study area .

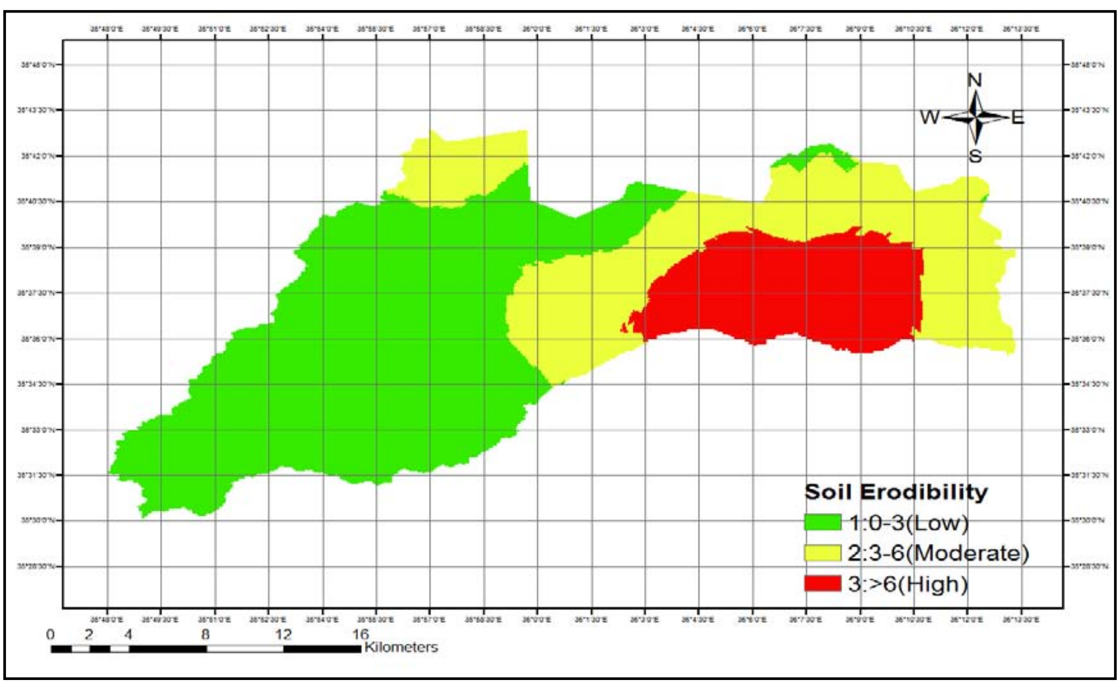


Figure 6 : Erodibility map of the study area

Seen from the previous figure that 53.41 % of the land area studied was the index usability of erosion is located within the first row, where the value of the index susceptibility of soil to erosion ranged between (0-3) any high scalability little drift, while the value of the index ranged between (3-6) at about 30.45 % of the area studied and therefore fall within the second row, a high susceptibility medium to drift, while the remaining percentage of the area of the study area 16.14% fall within the third grade and were of a high affinity for the drift where the Erodibilityindex is<6.

b) Degrees of Slope

The tendency of the most important factors causing soil erosion, due to its effect on the rate of runoff and the amount of water on the window to the soil (Dragut and Eisank, 2012). Has been getting on the map tendency using digital model of the rise has been classified into four classes according to CORINE, as the percentage of degree inclination low in the first grade 46.17 and occupied an area of 198.79 km 2, while the degree of inclination average in the second row ratio of 38.9 % and occupied an area of 167.47 2 km from the area of the study area, while the extreme degree inclination and 12.44 % occupied an area of 53.57 km 2 of the study area, either very severe regression rate reached 2.49% and filled an area of 10.7 km 2, as shown in Figure 7.

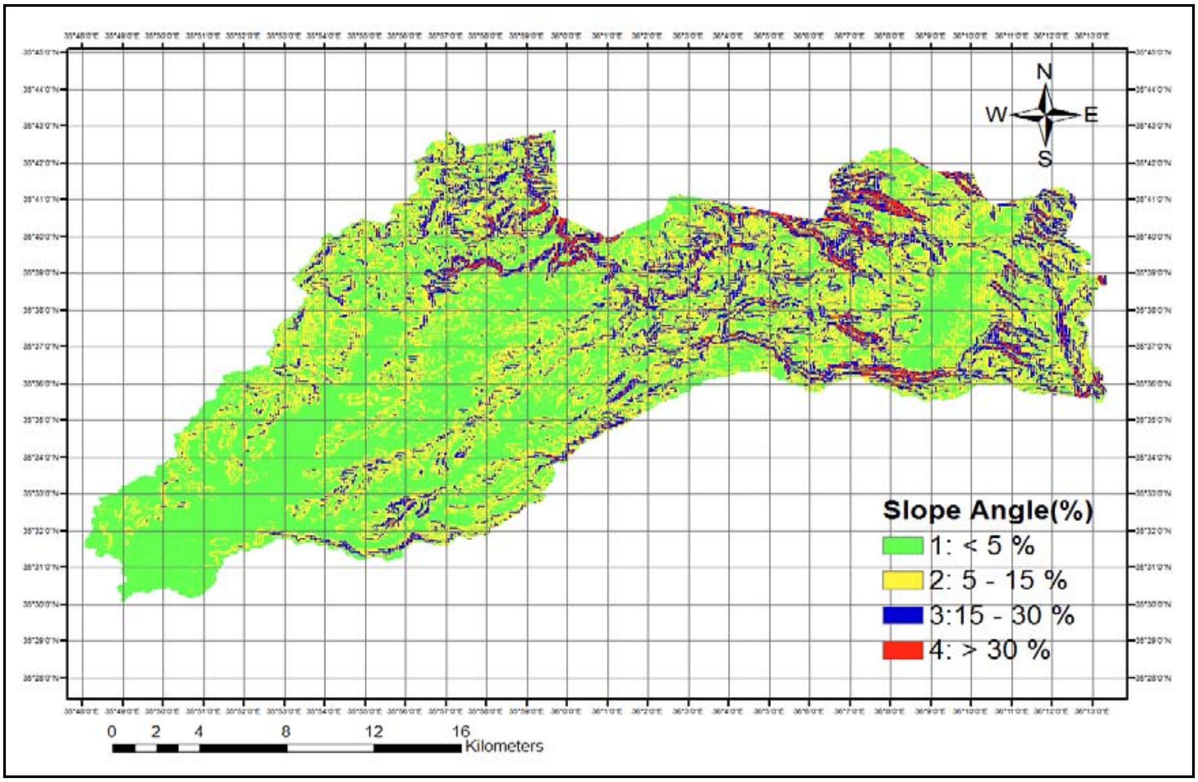


Figure 7 : Slopedegrees Mapof the study area by CORINEmethodology

c) Erosivity Index

Index values were calculated rainfall and erosion in the table (5), depending on climatic data and of both temperature and rainfall. Where is noted that the value of the index Fournier calculated from data terminal climate of the study area is equal to 135.456, located in the fourth grade, according to Corinne, while the value of the index Bagnold - Gawsn 244.77, located within the fourth grade according to Corinne, and therefore the value of the index erosion rainfall equals 16, which is within the grade 3 which indicates high rainfall erosion index.

Table 5 : Fornerindex Bagnold –Gawsn index for the years 2000-2010

Mean	Years											Index
	2010	2009	2008	2007	2006	2005	2004	2003	2002	2001	2000	
135.46	116.35	156.15	137.47	122.9	85.07	75.17	187.28	151.42	111.34	236.38	110.47	MFI
244.77	351.54	1183.24	235.18	250.8	201.3	198.1	302.7	229.6	255.40	213.78	270.83	BGI
16												EI

d) Potential Soil Erosion Risk

The figure shows (8) to 6.40% of the area studied was the potential danger of soil erosion by severe, concentrated in the eastern regions where the gradient where very severe, while the potential danger was average in% 28.85 of the area of the study area is focused in central and eastern regions, while focusing little danger in the central and southern regions where, and hit rate of 64.74% of the area studied.

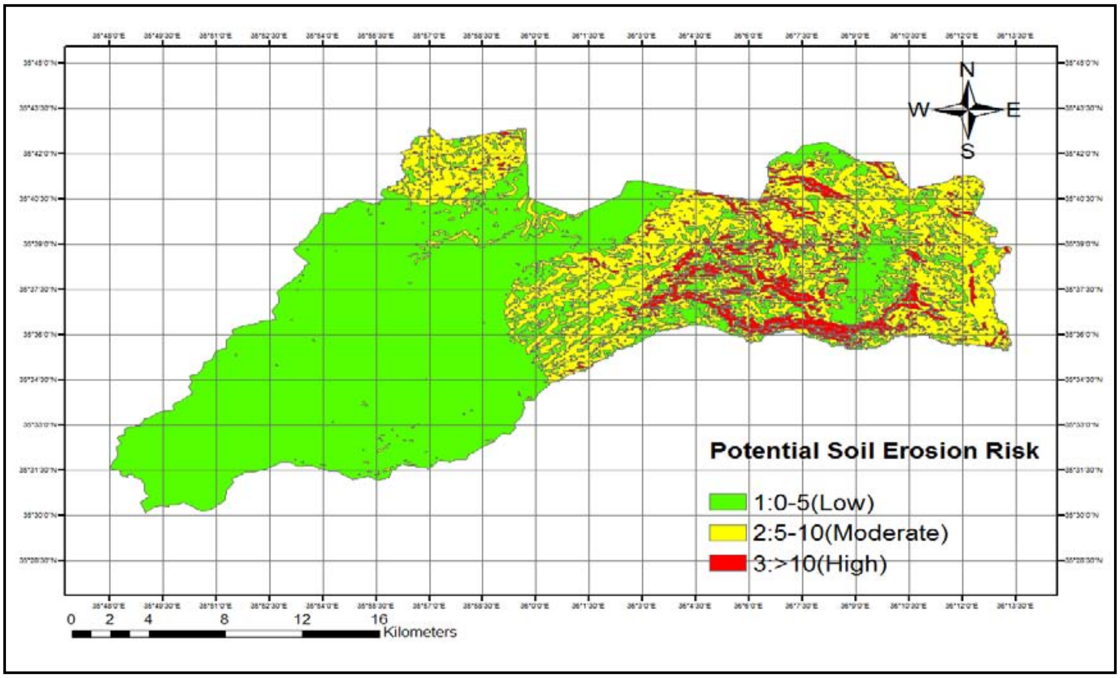


Figure 8 : Map of the potential danger of soil erosion

e) Land Cover Index

Plays Cover Ground role in alleviating the collision between the raindrops and the soil surface, and reduce the rate of runoff over the soil, and reduce the severity and seriousness of soil erosion (Estoquea and Murayam, 2011), and therefore it has been relying on the lid Ground mainly to estimate the actual risk of erosion soil.

The figure shows (9) Ground cover map resulting from the classification process observer accuracy rating of (87.44), as shown in Table (6) which expresses the error matrix. Map shows the cover ground that the biggest part of the study area is used in the cultivation of citrus and olive trees, especially the west and center of the study area, while the forests spread over small areas in the northern part near the dam , October 16, as well as in the eastern part where there are with areas planted with fruit and applestrees, in addition to agricultural crops.

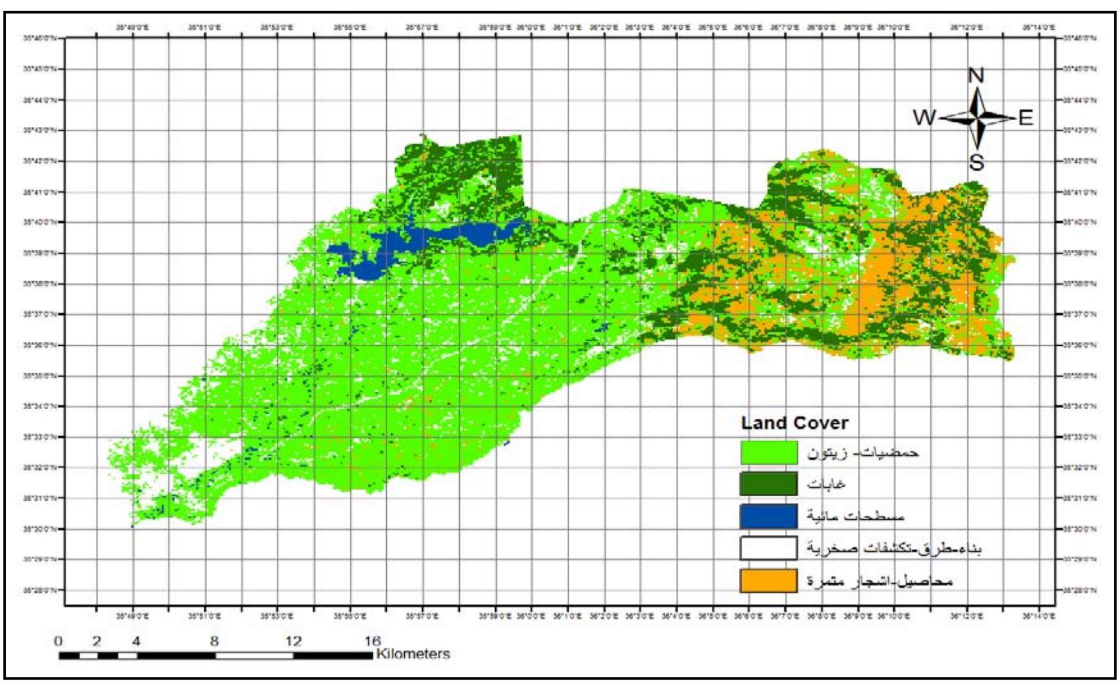


Figure 9 : Land cover map of the study area and represent different types of ground cover in the study area

Table 6 : Matrix Error for the classification process observer

Class Names	Reference Data						User's Accuracy %
	Forest	Water Bodies	Bulding-Rods-Rock Land	Field Crop -Fruit trees	Citrus trees-Olive	Total	
Forest	610	1	0	1	225	837	72.88
Water Bodies	0	1181	0	0	18	1199	98.49
Bulding-Rods-Rock Land	3	2	1033	10	232	1280	80.70
Field Crop-Fruit trees	0	0	2	827	123	952	86.87
Citrus trees-Olive	9	37	10	26	4636	4718	98.26
Total	622	1221	1045	864	5234	8986	87.44
Producer's Accuracy	72.88	98.49	80.70	86.87	98.26		

Represents (Figure 10) Land Cover Map after the re-classified according to the model Corinne into two rows (full protection and the protection of non-full), where the study indicates that 27.10% of the study area with full protection (forests - Bodies of Water - constructors and Buildings - Methods - Tkchwet rocky (and that 72.9% of the area studied with incomplete protection which includes land planted with citrus, olive and fruit trees and crops.

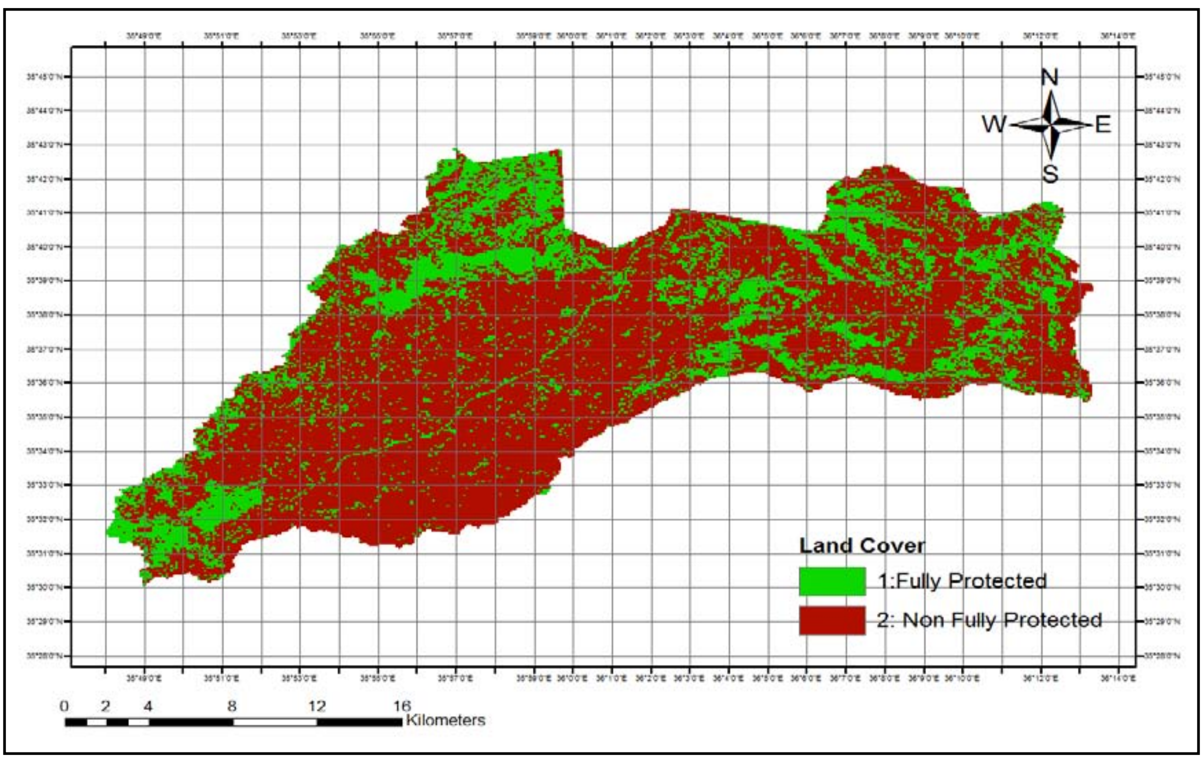


Figure 10 : land Cover map classes in the study area

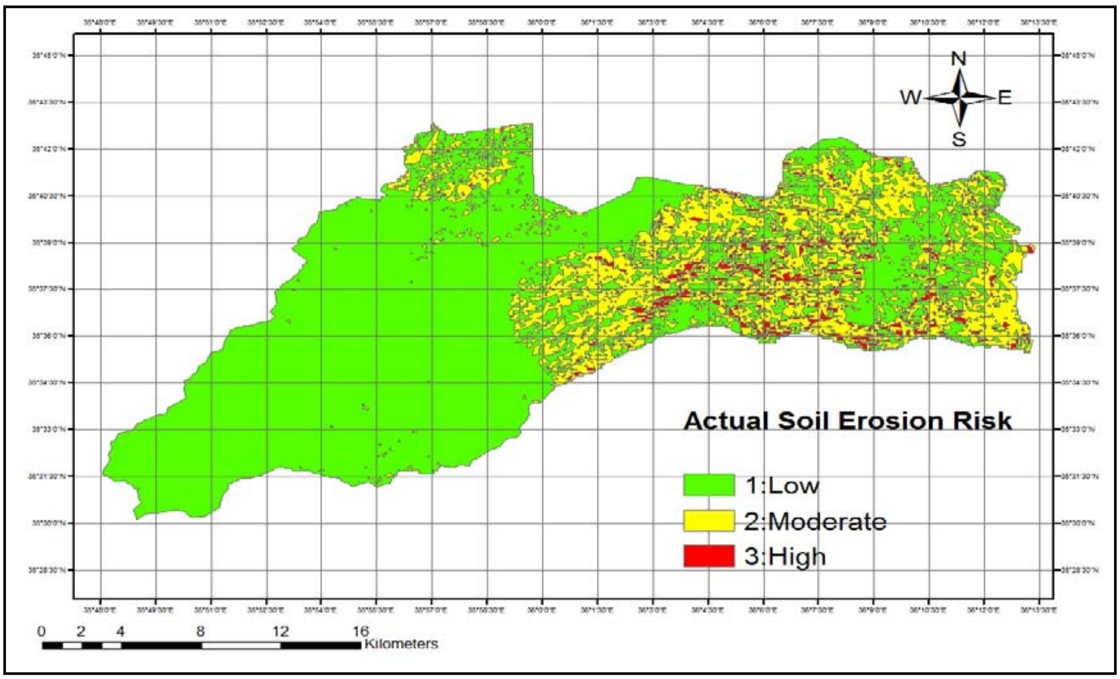
f) Actual Soil Erosion Risk

The table (7) shows the difference between the areas of potential risk and areas of actual risk of soil erosion , and this is due to the role of Cover Ground in reducing the risk of soil erosion, as the proportion of areas that were classified as having the degree of high risk in the map of the potential danger of erosion from 6.40 % to 2.47 % in the map of the actual risk, after taking the factor of land cover into account the rate of 60.93 %, this corresponds to what referred to (Ekpenyong, 2013) to confirm the role of vegetation in minimizing the potential risk of erosion due to the protection and coverage provided by the soil. On the other hand, the percentage of areas that were classified as falling under little threat in the map of the potential danger increased from 64.74 % to 75.35 %. And fell in the average risk of 28.85 % to 22.18 %, respectively, in the map of the actual risk of erosion.

The concentrated areas of the actual risk the very soil erosion in the central and eastern parts of the study area, as well as was the case for the risk the actual average has also focused in the central parts of Eastern and Central North, while focusing the actual risk low in the central and western parts of them (Figure 11).

Table 7 : The Values of the Potential and Actual Erosion Risk

Classes	Potential Erosion Risk		Actual Erosion Risk		Classes
	Area(Km^2)	%	Area(Km^2)	%	
1:(Low)	278.73	64.74	324.41	75.35	(Low):1
2:(Moderate)	124.21	28.85	95.53	22.18	(Moderate):2
3:(High)	27.59	6.40	10.59	2.47	(High) :3
Total	430.53	100	430.53	100	Total



Form 11 : Actual Soil Erosion Risk of map in the study area

V. Conclusions and Recommendations

1-Study pointed to the positive role played by the ground cover to protect the soil from erosion , falling values of the actual risk of soil erosion compared to the potential threat of erosion after the introduction of worker land cover , which led to the devaluation of the real danger by 60.93 % of the value of the potential risk grade soils severe dangerous drift .

2-The use of GIS techniques to map the risk of drift depending on the model CORINE is quick and effective way to assess the risk of soil erosion and the low cost and large area . This technique has proved effective in showing the impact of each indicator used in the model Corinne on the actual risk of erosion , and helped in determining the spatial distribution of the areas of risk , which leads to facilitate and accelerate the development of strategies and take actions necessary to protect those soils .

3-Recommend follow-up study to other regions differentiated in terms of soil and vegetation and climatic conditions and using the model Corinne.

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Monitoring Changes in Forest Fire Pattern in Mudumalai Tiger Reserve, Western Ghats India, using Remote Sensing and GIS

By Satyam Verma, Kuimi Tampeimi Vashum, Sathya Mani & Shanmuganathan Jayakumar
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Abstract- This study was aimed to evaluate the spatial and temporal patterns of forest fire between 1999 and 2014 using remote sensing and GIS in Mudumalai Tiger Reserve, Western Ghats. Remote Sensing and GIS are very effective tools in detecting active fire, mapping burned area, analyzing fire risk and preparing improved management plans. We used Landsat TM, ETM+, OLI-TIRS and Fire location data for this study. In our study, we found that the annual rate of fire was 3141.46 hectare year^{-1} (9.78%) with an average number of 22 fire incidences per annum. Maximum area was burned in 2004 (10451 hectares) whereas in 2013, we did not record any fire incidence through Lands at images. Fire occurred between January and May and utmost incidences in February and March (93.64%). However, 58.86 % of detected fire incidences were in February alone.

Keywords: *forest fire; spatial pattern; temporal pattern; remote sensing; GIS..*

GJSFR-H Classification : FOR Code: 070503

MONITORINGCHANGESINFORESTFIREPATTERNINMUDUMALAITIGERRESERVEWESTERNGHATSINDIAUSINGREMOTESENSINGANDGIS

Strictly as per the compliance and regulations of :

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Keywords: forest fire, spatial pattern, temporal pattern, remote sensing, GIS.

I. Introduction

Forest fire is an important constituent in many forest ecosystems in spite of its diverse effects. Increasing fire frequency is a matter of serious concerns in tropical forests (Kellman et al. 1996). In the tropics, large parts of the forest are burning as an unintended consequence of current land-use practices (Cochrane 2003). Its immediate effect depends on the intensity of fire, but long-term effects depend also on fire frequency and seasonality (Gill 1975). Fire has a wide range of impact on flora, fauna and soil dynamics. (Verma and Jayakumar, 2012; Certini, 2005) Recurrent fires can significantly alter the structure, composition and biomass of forests, which are not adapted to fire (Xaud et al. 2013). According to the FSI report on forest fire (2012) 8,645 forest fire incidences were reported in 2004-2005 and 13, 898 in 2010-2011 in the India.

Most of these fires were reported in dry deciduous forests. In India, accidental fires occur in the dry season accredited to human use of forests (Saha 2002). The northeastern part of the India suffers from fire, mainly because of age-old practice of shifting cultivation (Puri et al. 2011). Forest fires are also very frequent across the Western Ghats (Kodandapani et al. 2004) and played a significant role in the vegetation history of Western Ghats (Chandran 1997). Western Ghats is the biodiversity hotspot with highest human population density (Cincotta et al. 2000). The mean fire-return interval in Western Ghats shortened from 10 years in 1910-1921 to 3.3 years in 1990-2002 (Kodandapani et al. 2004; Renard et al. 2012).

Remote sensing and GIS played a foremost role in the study of factors influencing the occurrence of fire and understanding the dynamic behavior of fire (Jaiswal et al. 2002; Lentile et al. 2006). Remote sensing is used for a variety of aspects of fire studies, as fire risk prediction, spread modelling, active fire detection, burned area mapping and to check the regeneration status of forests. Burned area mapping has been carried out using a wide range of satellite sensors that exploits the differences observed in the spectral signatures between healthy forest canopy and forests destroyed or damaged by fire (Gerard et al. 2003). Burned area can be estimated by various methods that include visual interpretation, supervised classification and through normalized burn ratio (NBR) index. Images from MODIS and Landsat TM/ETM+ satellites are a common source of data and have potential to monitor forest fires (Benito and Torralbo, 2012).

Few researchers have attempted to study forest fire in the Mudumalai. For example, Kodandapani et al. (2004, 2008 and 2009) studied fire history, the fire return interval, ecological impact of fire and conservation threats of forest fire in the Western Ghats from 1989 to 2005 and Mudumalai Tiger reserve (MTR) was a part of their study area. Srivastava et al. (2014) mapped fire risk areas in MTR and Mondal and Sukumar (2014) studied characteristic weather pattern associated with fire. Verma and Jayakumar (2015) studied impact of fire on stand structure and regeneration of trees in MTR. This study was designed to assess the fire pattern in MTR between 1999 and 2014.

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II. Material and Methods

a) Study Area

This study was carried out in Mudumalai Tiger reserve. MTR is located between 11^0 32' & 11^0 43' N and 76^0 22' & 76^0 45' E at the tri-junction of Kerala, Karnataka and Tamil Nadu states, in the state of Tamil Nadu and is a part of the Nilgiri Biosphere Reserve that covers 5500 Km^2. MTR stretch over an area of 321 Km^2 with an average altitude of 1000 m (Fig. 1). Based on the climate of the area, there are three distinct seasons recognized. January-May is a dry summer season. Annual rainfall ranges from about 800 to 2600 mm and represents a strong east-west gradient. The temperature ranges from 13^0C in December to 34^0 C in April. Mean temperature varies 21^0 to 25^0 C in different parts of the reserve. Forest fires are very common in MTR, which occur typically between January and April.

b) Data Collection

Toposheets (58 A6 and 58A10) were collected from the Survey of India in 1:50,000 scales. Burned area maps were collected from the forest department, Tamil Nadu that were accessible from 2001 to 2012. Burned area maps for 1999, 2000, 2013 and 2014 were prepared using Landsat images downloaded from USGS web site (Table 1). Fire location data was downloaded from NASA Fire Information for Resource Management System (FIRMS) from January 2001 to June 2014 and used to compute the number of fires and their proximity to the road, footpath, and settlements (Table 1). All the images were geometrically corrected based on Survey of India topographic maps using ERDAS Imagine 11.0 software.

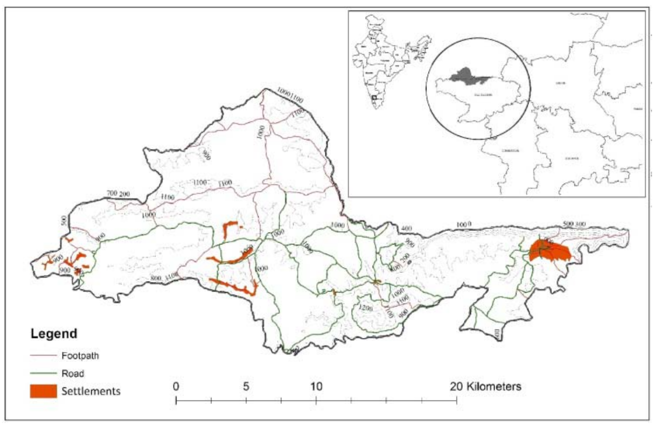

Figure 1 : Location map of the study area

c) Data Analysis

Fire locations were identified using NASA Fire Information for Resource Management System (FIRMS) data, from January 2001 to June 2014. Supervised Classification was performed, based on the shortwave infrared composite image (band combination 7-4-3 in Landsat ETM+) to delineate the burned area. SWIR bands are especially suited for camouflage detection, change detection, disturbed soils, soil type, and vegetation stress. Newly burned land reflects shortwave infrared light and appears red in this combination. Maximum likelihood classification technique was used for the supervised classification. Before the classification, representative training sites were extracted by visually selecting pixels representing burned and unburned surfaces. Fire maps for all years were transformed into raster data and combined using map algebra to prepare fire frequency maps. Vegetation map of MTR was prepared from recent satellite images LANDSAT 8, OLI-TIRS, p144 & r52 March 31, 2014) by supervised classification using Maximum likelihood classifier.

Data used	Data types	Data sources	Temporal availability
Topography and burned area data	Toposheet 58 A6 & A10	Survey of India	
	Burned Area Maps	Tamil Nadu Forest Department	2001-2012
	Fire Location data (MOD14/MYD14)	NASA Fire Information for Resource Management System (FIRMS)	January 2001– June 2014
Remotely sensed data	LANDSAT 5, TM, p144 &r52	USGS, EarthExplorer	Feb 02, 1999 & Apr 07, 1999
	LANDSAT 7, ETM+, p144 &r52	USGS, EarthExplorer	Jan 28, 2000, Apr 17, 2000, May 03, 2000 & Mar 2001
	LANDSAT 8, OLI-TIRS, p144 &r52	USGS, EarthExplorer	Apr 13, 2013, March 31, 2014,May 02, 2014

(Mean burned area, number of fire incidences and fire return interval (FRI) for each forest type were calculated.

Proximity analysis was carried out for roads, footpaths and settlements inside MTR to recognize their influence on forest fires. Roads, footpaths, settlements layers were prepared using the Survey of India toposheets (58A6 & 58A10). Regression analysis was done to see the relationship between total numbers of fires with increasing distance. All statistical analyses were done using IBM SPSS Statistics 20.

III. Results

a) Temporal Pattern of Fire

Fire incidences in MTR ranged from 0 to 82 with an average of 22 incidences per year and maximum incidences of fire occurred in 2009. The forest was burning with an annual rate of 9.78% (3141.46 hectare) for 16 years. The total 29.91% area did not receive fire at all in past 16 years (1999-2014) (Table 2).

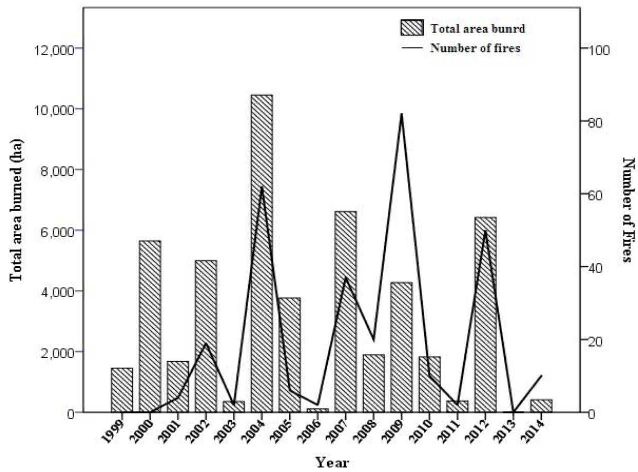

Figure 2 : Total area burned each year from 1999 to 2014 and the number of fires each year from 2001 to 2014

Whereas 26.49% area burned once, 18.62% twice, 14.00% thrice, 8.30% received four times, 2.40% five times and only 0.25% received six time fire. Maximum of 32.56% of the total forest area was burned in 2004. Fire occurrences were not detected in 2013.

Table 2 : Area burned in different fire frequency from 1999-2014

Burn Frequency	Area (Ha)	Area (%)
0	9601.11	29.91
1	8503.29	26.49
2	5977.02	18.62
3	4494.00	14.00
4	2664.30	8.30
5	770.40	2.40
6	80.25	0.25
Total		100

During 2000, 2002, 2004, 2007, 2009 and 2012, the burned forest area ranged between 4000 and 8000 hectares, while in 2003, 2006, 2011 and 2014 fire burned less than 500 hectares (Fig. 2). Fire pattern in MTR was generally uniform for the period of analysis, where the higher occurrences of fire with more forest area burned in a year was followed by a few occurrences of fire with less area burned.

In our study, we recorded a maximum of six fire frequencies. Only 80.25 hectares of MTR received six-time fire in the 16 years of the study period between 1999 and 2014. Burned area decreased with increasing fire frequency. It is evident from the fire frequency map (Fig. 3) that majority of fires occurred in dry deciduous forest patches, which is in the middle and North Western side of the MTR. The moist deciduous forest on the southern side experienced least number of fires. Similarly, the scrub forest on the eastern side experienced a small number of fires during the analysis period.

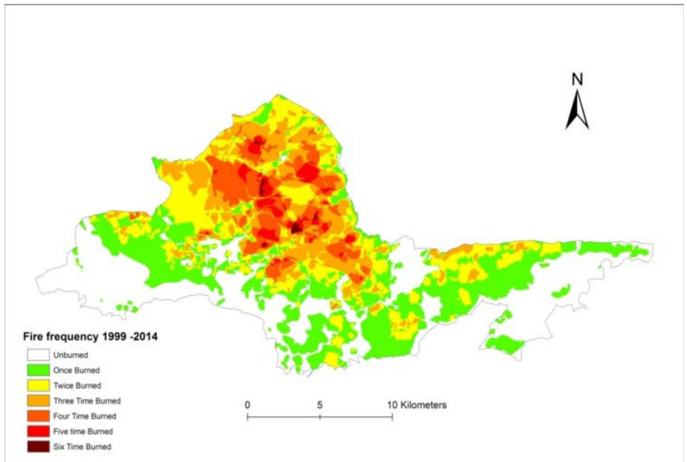

Figure 3 : Forest fire frequency map of Mudumalai Tiger Reserve (1999-2014)

Table 3 : Mean area burned, number of fires and fire return interval in different forest types in MTR from 1999-2014

Vegetation type	Area burned (1999-2014) (%)	Mean annual area burned (Ha)	Number of fires	Fire return interval (Year)
Dry Deciduous	88.23	2730.09 ± 2828.43	266	8.71
Moist Deciduous	23.15	86.78 ± 305.81	11	15.64
Dry Thorn	54.76	322.11 ± 825.93	22	13.25

Dry deciduous forest showed least fire return interval (FRI) of 8.71 year and was more prone to fires (Table 3), the moist deciduous forest was less prone to fire with a FRI of 15.64 year. FRI for the dry thorn forest was 13.25 years. Mean area burned between 1999 and 2014 was highest in dry deciduous forest (2730.09 ± 2828.43 hectares) followed by dry thorn forest (322.11 ± 825.93 hectares) and moist deciduous forest (86.78 ± 305.81 hectares). Most of the fires in MTR were recorded in February and March (Fig. 4). In our analysis, 4.68% of the fires were recorded in January, 58.86 % of fires in February, 34.78 % in March, 1% in April and fire occurrence was rare (0.66%) in May. Overall, 93.64% of fires were recorded in the months of February and March from 2001 to 2014.

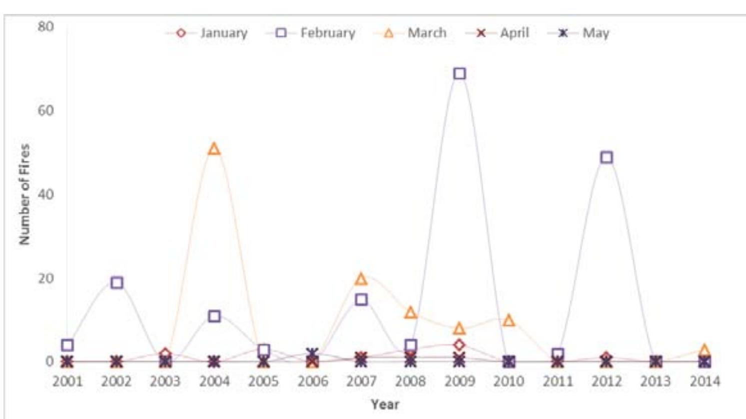

Figure 4 : Analysis of fire season in MTR from 2001 to 2014

b) Spatial Pattern analysis

We analyzed the spatial pattern of fire to determine proximity of forest fire to roads, footpaths and settlements. The roads (R2= 0.849, p= 0.000) and footpaths (R2= 0.729, p= 0.001) showed a strong association with fires (Fig. 5a & 5b).

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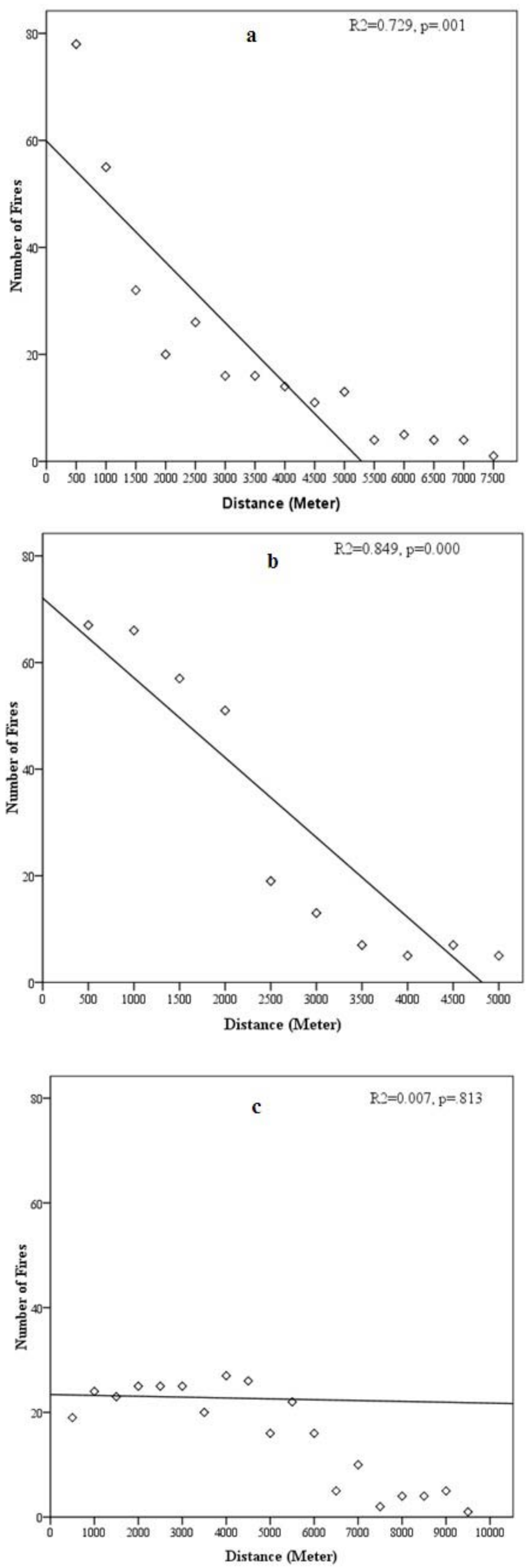

Figure 5 : Analysis of number of fire incidence from 2001 – 2014 with increasing distance from; a. Footpaths; b. Roads and C. Settlements

Fire incidences decreased with increasing distance from the roads and footpaths. Settlements (R2= 0.007, p= 0.813) did not show any noteworthy association with fire incidences (Fig. 5c). Numbers of fire occurrences within one km of footpaths and roads were 133 each and 43 around settlements in 16 years.

IV. Discussion

Fire is a significant recurrent disturbance with potentially severe consequences in MTR. Forest fires have been a part of these ecosystems for many thousands of years (Chandran 1997; Gadgil and Chandran 1988) but fire frequency have been changed noticeably in the past 100 years, first increased due to growing human use of forest (Kodandapani et al. 2004) and later decreased in preceding decade owing to effective management practices and research conducted in past 25 Years in MTR. The causes of these fires are poaching, antler collection, grazing, tourism, estates and settlements in and around the reserve (Srivastava et al. 2014). The tribal's in these forest light fire to facilitate their hunt for shed antlers of 'Chital' (Axis axis) and Sambar (Cervus unicolor) (Johnsingh 1986). The poachers light fire for visibility. Fire incidences were recorded very high with a break of 1- 3 years. The same pattern is observed in the total burned area. Explanation for this could be the less availability of fuel for burning in the consecutive years. This reduction in flammability, however, may be short-lived if delayed tree mortality or tree fall increases surface fuels in future years (Balch et al. 2008).

In MTR, fire return interval was considerably declined (9.83 years) in past 16 years (1999- 2014) compared to previous decade. Kodandapani et al. (2004) reported 3.3 years mean fire return interval for MTR in 14 years of the study period (1989-2002). In a different study which included 7 years of data between 1996 and 2005, Kodandapani et al. (2009) recorded 7 years of mean fire return interval for Nilgiri landscape which includes MTR. The drastic reduction in the fire frequency could be ascribed to the anti-causative factors, particularly stationing of the anti-poaching-cum-fire camps in the year 2000, and ban on the operation of private vehicles as a consequence of restricted tourism (Srivastava et al. 2014). Other management practices include clearing of fire lines, removing lantana near the roads and prohibiting tourism in fire season. Annual rate of area burned was significantly reduced (9.78%) compared to earlier study of Kodandapani et al. (2004), who reported three time higher rate (30%) of burning between 1989 and 2002. Annual rate of burning in MTR was also less than Similipal Biosphere Reserve Odisha, India in the same decade, where 20.7% of burning rate was reported by Saranya et al. (2014).

The spatial pattern of forest fire locations is of interest for fire occurrence prediction and for understanding the role of fire in landscape processes. Fire occurrence could be affected by vegetation type, climate, topography and anthropogenic variables. There is variability in the susceptibility of fires across different vegetation types (Cochrane 2003; Cumming 2001). Dry deciduous forests are more vulnerable to the fire due to high fuel load, presence of grasses and low rainfall. Forest fires in the tropical dry deciduous forests have significantly changed the species diversity, structure and regeneration in MTR (Kodandapani et al. 2004). Almost whole central part of the reserve received more than five fire incidences in the past 16 years, which was principally covered by dry deciduous forest. Forest fires were rare in moist deciduous forest and very less in dry thorn forest.

Proximity of fire to roads, footpaths and settlements (Fig. 5a, b and c) was analyzed by assuming that most of these fires were deliberate or unintended, caused by the spark of the vehicle, poaching, antler collection or from settlements. Roads and footpaths provide quick and easy access to areas. Roads showed more noteworthy association with fires, and the number of fires was decreasing with increasing distance from roads. The study area is a tiger reserve, but few roads are used for tourism and local transport. One highway also passes all the way through the study area. Fire on both sides of the road could be unintentional by tourists or by the spark of the vehicles. We recorded the high number of fires around footpaths also, which considerably decreased with increasing distance. In MTR, the footpaths were used by tribes and burning along the footpaths suggests that most of these fires might be intended. Our results were supported by the study of Narayanaraj and Wimberly (2012), they studied influences of forest roads on the spatial patterns of human-and lightning-caused wildfire ignitions and found that fire incidences are declining with increasing distance from roads and footpath. The fire showed relatively less proximity to settlements, which may be owed to the presence of watch towers, forest guards and forest offices near the settlements. It suggests that area around roads and footpaths need special attention for fire fighting.

V. Conclusion

In this study, we analyzed the pattern of forest fires in MTR in the past 16 years from 1999 to 2014. Analysis of spatial and temporal pattern of fire in the past will be vital to recognize and predict trends in fire pattern in the future. Compared to the previous studies conducted in and around the MTR, the fire frequency decreased evidently, but still forest is burning with an annual rate of 9.78%, which is the matter of vast apprehension. Results also showed that fires were more associated with footpaths and roads rather than settlements. This study can help the forest managers to improve management strategies to combat forest fires. Detrimental and beneficial impact of fire on flora, fauna and soil ecology needs to be thoroughly studied in shifting fire regime.

VI. Acknowledgments

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Characterization of Historical Seasonal and Annual Rainfall and Temperature Trends in Selected Climatological Homogenous Rainfall Zones of Uganda

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Abstract- There is general lack of scientific consensus on the trend and distribution of annual and seasonal rainfall and temperature in Uganda. This study used both observational and AgMerra rainfall and temperature data for the period 1980-2010 to characterize the trend and variability in seasonal and annual rainfall, maximum and minimum temperatures across 12 different rainfall homogenous zones (K, H, ME, L, J, F, MW, D, E, A1, A2, and I) of Uganda. Trends analysis was done using regression method, while coefficient of variation and ANOVA techniques were used to analyze variability. The results show statistically significant increasing trends ($P \leq 0.05$) in annual rainfall amount in zone A1 and a declining trend for zone K ($P<0.05$).

Keywords: rainfall variability, rainfall trends, farmers' perceptions, eastern uganda.

GJSFR-H Classification : *FOR Code: 300899*

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Keywords: rainfall variability, rainfall trends, farmers' perceptions, eastern uganda.

I. Introduction

The weather is an important part of the natural environment (Gomez-Martin, 2005), which affects in various ways many of human activities (Trenberth *et al.*, 2000; Tuckera and Gilliland, 2007). Agriculture is one of the most climate sensitive sectors globally (IPCC, 2001; United Nations, 2009). In many parts of the world including Uganda, agriculture is mainly rain-fed; hence failure of rains can lead to crop failures, food insecurity, famine, mass migration, and negative national economic growth (Stampone *et al.*, 2011). In Uganda, agricultural still remains one of the major economic sectors contributing more than 20% of Uganda' GDP and employing over 80% of the population and is the main means of subsistence of most small holder farmers (Mukiibi, 2001; AGRA, 2010; MAAIF, 2011).

Uganda is endowed by a variety of climatic conditions despite lying within a relatively humid equatorial climate zone due to geographic features such as topography, prevailing winds, lakes, and rivers cause local variations in annual precipitation and temperature, leading to large differences and a relatively complex pattern of annual rainfall (Byakola 2007). Rain falls during two seasons in the south and one season in the north and eastward Chetri *et al.* 2004). This is linked to the seasonal migration of primary humid air masses and convergence zones over Africa that shift towards a northerly location in August and to the south in January. The country is divided into 16 climatologically homogenous zones (Basalirwa, 1995). This information has been usefully applied for planning purposes, and particularly in the agricultural sector. Recent analyses have demonstrated that certain climatic parameters in selected zones have significantly changed with time (Nimusiima *et al.*, 2013). These changes have seriously affected planning and management of subsistence and cash crops in those zones (Phillips and McIntyre, 2000; Fischer *et al.*, 2005). Limited studies have tried to analyze at a fine-scale climatic trends in East African sub-regions and Uganda in particular (Phillips and McIntyre, 2000; Thornton *et al.*, 2009). This is due to lack of complete long-term datasets covering all the regions, existence of complex environmental conditions induced by the topography, proximity to large inland water bodies, and the existence of large tracts of forest

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(Myers, 1991; Indeje *et al.*, 2000). This study evaluates trends in rainfall and temperature (Tmax and Tmin respectively) for all climatologically homogenous zones of Uganda to assist small holder farmers and land use managers in developing effective adaptive management.

II. Materials and Methods

a) Description of major homogeneous climatic zones

Uganda lies in East Africa, astride the equator with its area lying between latitude 4012'N and 1029'S and longitude 29034'W and 3500'E (Ojakol, 2001). The country occupies 241,551 square kilometres of largely fertile arable land. It is bordered to the east by Kenya, to the north by South Sudan, to the west by the Democratic Republic of Congo, and to the south by Rwanda and Tanzania. The country is located on a plateau, averaging about 1100 meters above sea level sloping down to the Sudanese Plain to the north. Large parts of the country have fertile soil with regular rainfall and agriculture is the mainstay of both the national economy and the main source of livelihood for most Ugandans. Subsistence farming is the main source of household income for the majority of Ugandans. The country is divided into 16 Homogenous climatological zones (Figure 1) (Basalirwa, 1995) which are described in Table 1.

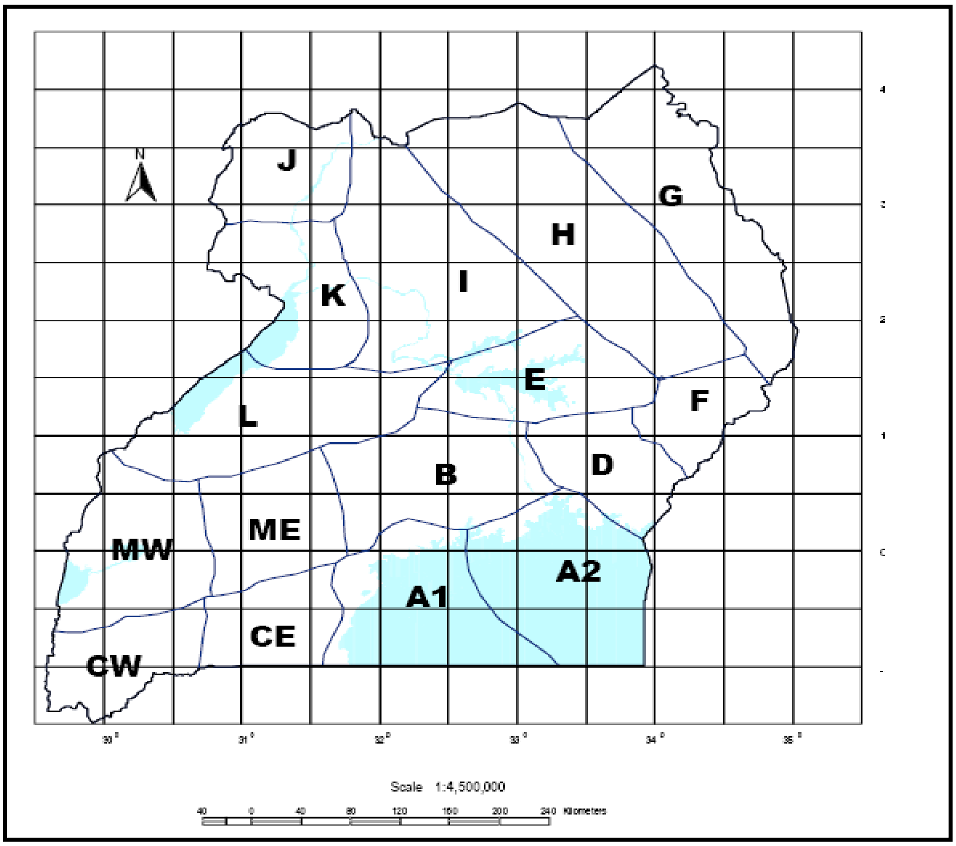


Figure 1 : Climatologically Homogenous rainfall zones of Uganda (Basalirwa, 1995)

Table 1 : Description of the climatologically homogenous rainfall zones of Uganda

Climatologically homogenous rainfall zones	Representative station	Annual Rainfall and its zonal variability
A1	Entebbe	Western Shores of L. Victoria and Western Masaka. Two rainy seasons, main season March to May with peak in April and secondary season October to December with a peak in November
A2	Jinja	Average rainfall range of 1215 mm - 1328 mm, two rainy seasons in the southern part with the main season from March to May with peak in April and secondary season from August to November with a peak in October/November.
D	Tororo	Average rainfall range of 1215 mm - 1328 mm, two rainy seasons in the southern part with the main season from March to May with peak

		in April and secondary season from August to November with a peak in October/November.
ME	Mbarara	Average of 1223 mm. High variability, lowest-800 mm.
L	*Masindi*	Average of 1270 mm, STD 135mm. High variability, from-800 over Eastern Lake Albert parts to-1400mm over the western parts.
E	Soroti	Annual rainfall average of 1250 mm, with two rainy seasons. The main season occurring in March to May with the peak in April, November with a moderate peak in October/November.
F	Mbale	Average rainfall range of 1215 mm - 1328 mm, two rainy seasons in the southern part with the main season from March to May with peak in April and secondary season from August to November with a peak in October/November.
H	Kitgum	Average of 1197 mm, STD 169 mm, Moderate variability, 1000 over-due north and northeastern parts to -1300mm over the southern parts. One rainy season of about 7 months, April to late October with a main peak in July/August and secondary peak in May.
I	Gulu	Average of 1340 mm, STD 155 mm, moderate variability from- 1200 over northwestern and western parts to- 1500 mm over the southern parts
J	Arua	Average of 1371 mm, STD = 185mm. Moderate variability, from 1200 over the eastern parts and higher-1500 mm over the western parts
K	Nebbi	Average 1259 mm, STD= 195 mm. High variability from-800 within the Lake Albert-1500mm over the western part. Mainly one rainy season of about 8 months, late March to late November with the main peak. August to October and a secondary peak in April/May.
MW	Kasese	Kasese rift valley, highest overslopes of Rwenzori Mountains, over 1500 mm.

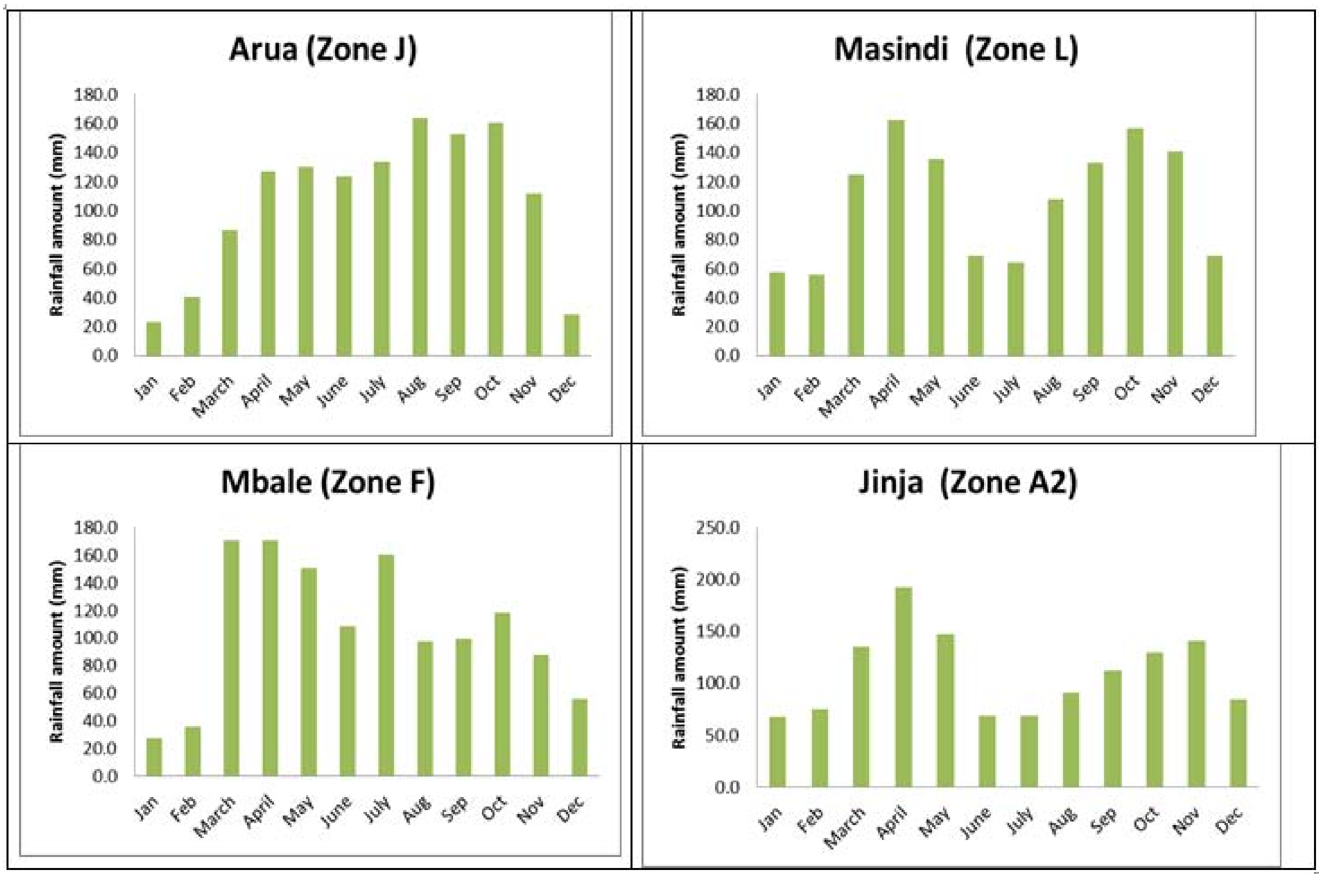
b) Characterization of the historical climatic trends

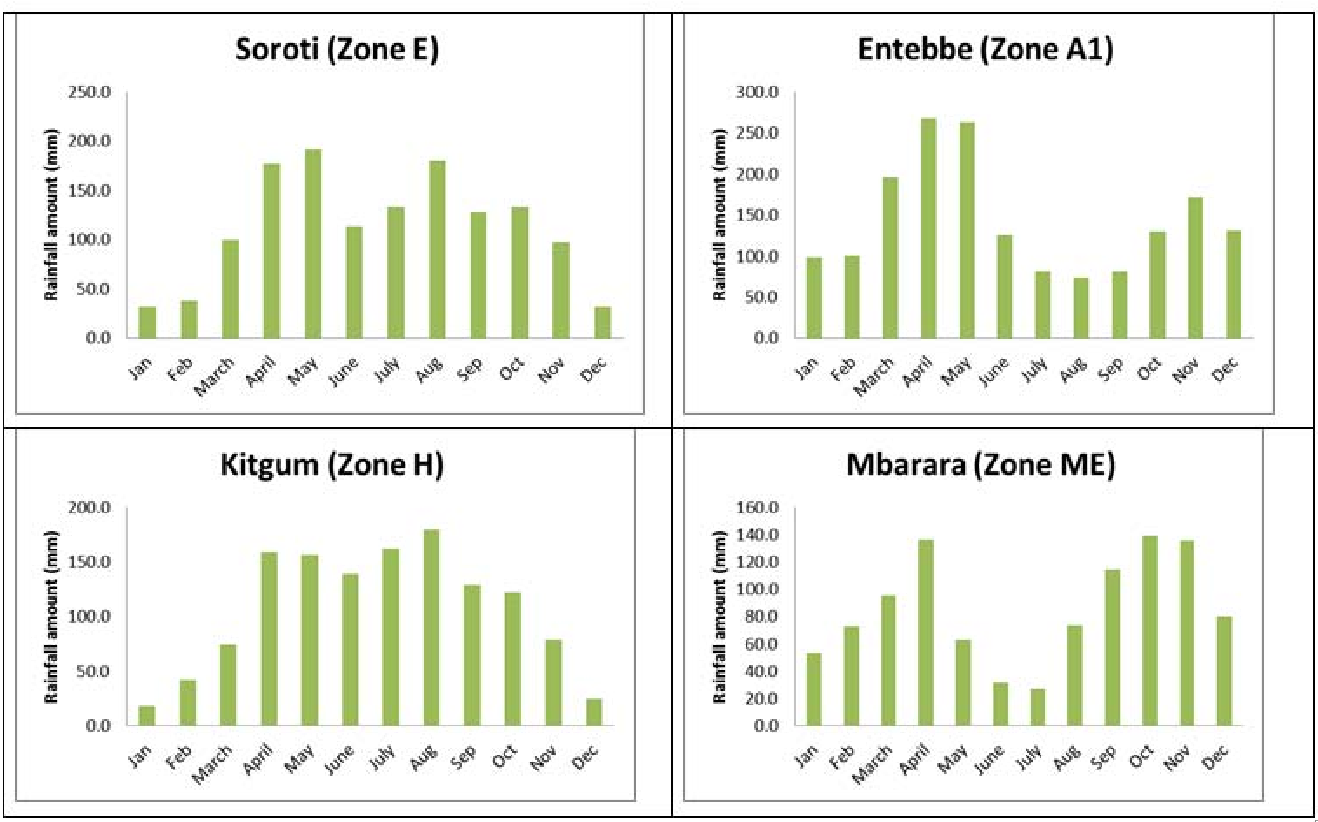
To characterize the historical climatic trends, a representative station was identified in each of the 16 climatologically homogenous zones based on availability of data for rainfall and temperature (maximum and minimum) at Uganda Meteorological Department. Stations with a maximum 15% data gap for the studied period were considered adequate for the study. Most of the stations had monthly data for a period of 1970 to 2005, but the analysis conducted in this study only covered the 1970 to 2000 period. In addition, Long-term climate data (1980-2010) was obtained from the NASA's climate data repository Modern Era-Retrospective Analysis for Research and Applications (AgMERRA) (Rienecker *et al.*, 2011; Ruane *et al.*, 2014) for the stations considered in the study. MERRA data are produce using their 4-Dimensional Variational (4D-Var) assimilation system and were provided in AgMIP extension (Ruane and Goldberg, in preparation). AgMERRA data were used to fill temperature gaps for the stations presenting gaps and were adjusted to fill gaps in rainfall for stations without rainfall data for the period 1980 to 2000 (Ruane et al., 2015). The percentage of gap filled varied from one station to another, but it ranged from 2 to 14% for the studied stations. Station records were evaluated for discontinuities by inspection of each time series and station then tested for homogeneity using the Student's t-test and the Mann-Whitney test (von Storch and Zwiers, 1999; Stampone *et al.*, 2010) before subjecting the dataset to trend and variability analysis using regression techniques, autocorrelation and coefficient of variation for monthly, seasonal and annual values; respectively using Genstat version 13th Edition.

III. Results and Discussion

a) Monthly rainfall patterns

The monthly rainfall patterns of the selected rainfall climatological zones are shown in Figure 2. Rainfall showed a bimodal pattern for all the rainfall zones with clear seasons for L, A2, ME, MW and D; while the zones K, H, F, I, and E had rainfall amount above 50 mm for at least nine months in a year. All these zones had their first peak in April. The second peak was observed in October for L and ME. The rainfall zone A1 had peak rainfall amount for the month of April and May. A2 and A1 zones had their second peak in November and of relatively lower rainfall amount than first peak. The second peak of the rainfall zones ME and D was in October-November. The rainfall zones J, H, F, I and E tended to have a peak in August, except zone F which had a prolonged peak in the months of March to July. Months with minimum rainfall amount varied from one rainfall zone to another. The zones L and A1 had lowest rainfall values in the months of January, February, June, July and December. The rainfall zone A1 had its monthly lowest values in January, February, July, August and September. The rainfall zone D had January, July and December as month with lowest rainfall amount; while ME had June and July as months with lowest rainfall amount. Apart from the rainfall zone E and F which had lowest rainfall amount in December to February and January to February; respectively, all the remaining rainfall zones had their minimum rainfall amount in December to January.





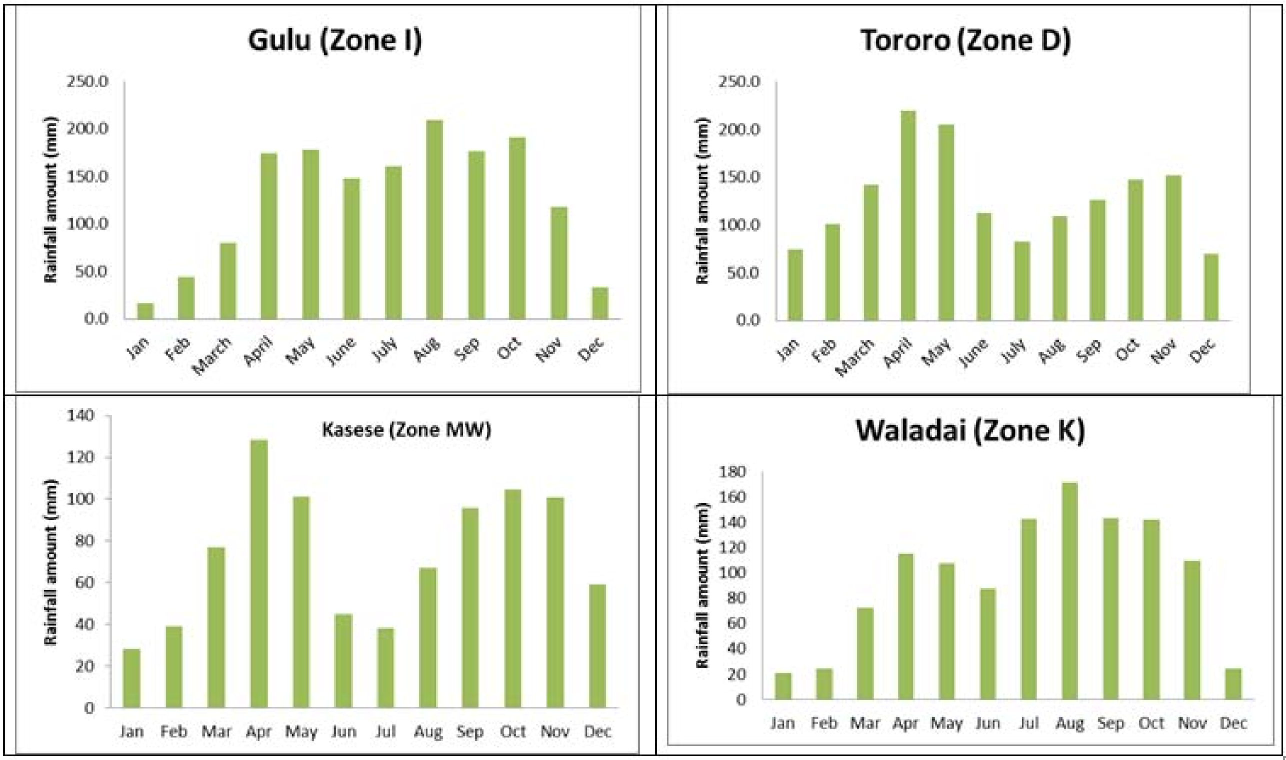


Figure 2 : Monthly rainfall distribution in selected climatological rainfall zones of Uganda (Average of 30 years: 1970-2000)

b) Seasonal rainfall

Seasonal MAM and SON average rainfall amount, maximum and minimum, standard deviation and coefficient of variation are shown in Table 2 for all the studied zones. The average rainfall amount varied between 237 mm (MW) and 536.8mm (F) for MAM and 426.9 mm (MW) and 837.5 mm (L) for SON. A relatively lowest MAM maximum rainfall amount (428 mm) was recorded in Zone ME and the highest (864.2 mm) in zone F. Zone MW recorded the relatively lowest minimum (88.4 mm) and zone A2 the relatively highest rainfall amount (349 mm) for MAM. The relatively lowest SON maximum rainfall amount (837.5 mm) was recorded in zone L and the lowest (426.9) in zone MW. The minimum amount of rainfall under SON was observed under zone D (83.1 mm) and the highest (346 mm) under L. The standard deviation varied between 66.1 mm (J) and 148.4 mm (F) for MAM and 71.7 mm (F) and 155.9 mm (D) for SON. The coefficient of variation (CV) varied between 15.6 % (A2) and 34.7% (D) for MAM and 17.8 % (J) and 42.8% (D).

Table 2 : Summary statistics of MAM and SON rainfall amount in the selected zones

Zones	MAM				SON			
	Mean (30 years)	Max (Min)	σ	CV	Mean (30 years)	Max (Min)	σ	CV
E	472.8	753 (317.6)	121.9	25.8	358.0	463.8 (216.3)	76.8	21.5
A2	491.8	632 (349)	77.1	15.6	408.3	527.6 (227)	79.8	19.5
D	372.8	636.6 (137.9)	129.4	34.7	364.2	780.3 (83.1)	155.9	42.8
F	536.8	864.2 (233)	148.4	27.6	316.3	481.2 (209.9)	71.7	22.6
L	464.8	731 (313)	94.8	20.4	560.5	837.5 (346)	136.8	24.4
J	260.7	400 (140.5)	66.1	25.4	459.8	626.3 (225)	81.9	17.8
MW	237.0	460.5 (88.4)	81.7	34.4	274.4	426.9 (141.8)	80.7	29.4
ME	292.9	428 (146)	69.8	23.8	384.1	596.2 (207)	92.8	24.2
H	402.4	705.4 (286)	88.8	22.07	334.9	531 (167.6)	95.0	28.4
I	433.0	708.8 (242.3)	93.7	21.6	483.8	803.3 (275.5)	139.0	28.7
K	295.4	516 (137.9)	85.1	28.8	394.9	552(216)	83.5	21.1
A1	679.6	1123.6 (322)	200.5	29.5	359.9	605.3 (182.5)	110.0	30.6

Seasonal rainfall trends varied from one climatological homogenous rainfall zone to another and season. Three categories of trends were observed on the selected and studied zones. These included zones without any significant seasonal trend, zones with only one season showing a significant trend, and zones for which both seasons varied significantly with time. Zone ME and H (Figure 3) are in the first category; seasonal rainfall amount were undulating without significant pattern ($P>0.05$). The Pearson correlation between year and rainfall was also very low and not significant for both season in the two zones and were of 0.09 for SON and -0.16 for MAM in Zone H; and of -0.028 for SON and -0.148 for MAM in zone ME. For zones K, F, and J only one season showed a clear temporal trend in rainfall amount ($P>0.05$).

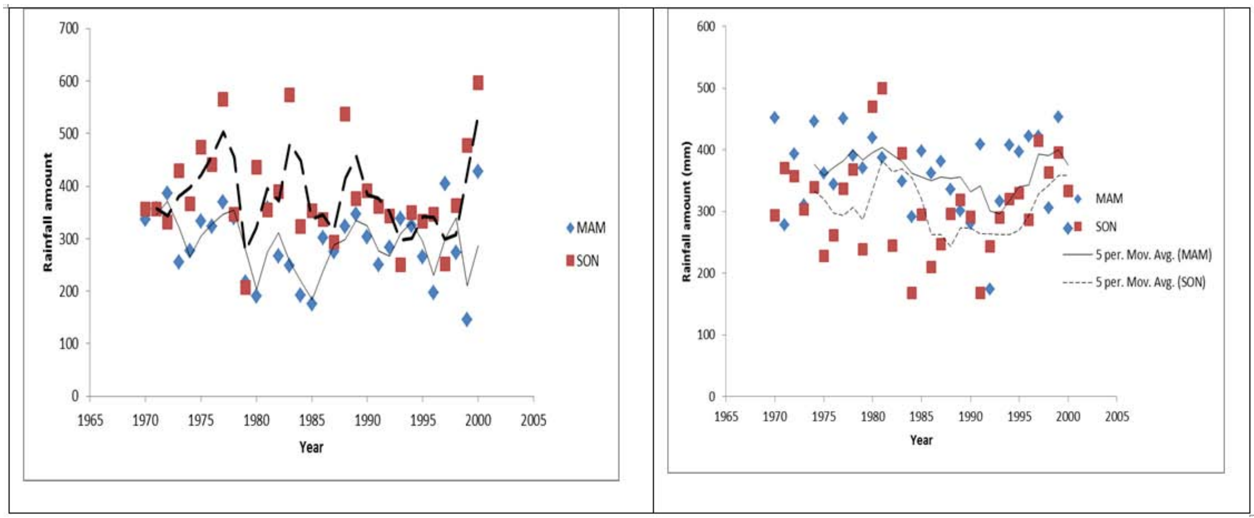


Figure 3 : Moving average trend in seasonal rainfall amount in climatologically homogenous rainfall zone ME (left) and zone H (right)

In zone A1, F, J and K, only MAM rainfall amount linearly changed overtime ($P< 0.05$) (Figure 4). For Zone F ($Y=10.22t-19743$; $R^2=0.39$, $p<0.001$) and A1 ($Y=12.09t-23332$; $R^2=0.31$; $p=0.003$) MAM rainfall amount increased significantly over the years; while in zone J ($Y= -4.04t+ 8279.2$; $R^2=0.39$, $p<0.001$) and K ($Y=-6.33t+13263$; $R^2=0.49$; $P<0.001$) it declined over the years. MAM rainfall tended to have a relatively high value of rainfall zone F and A1 than SON; an opposite trend was observed in zone K and J. The rainfall difference between MAM and SON in the three rainfall zones tended to increase gradually with time.

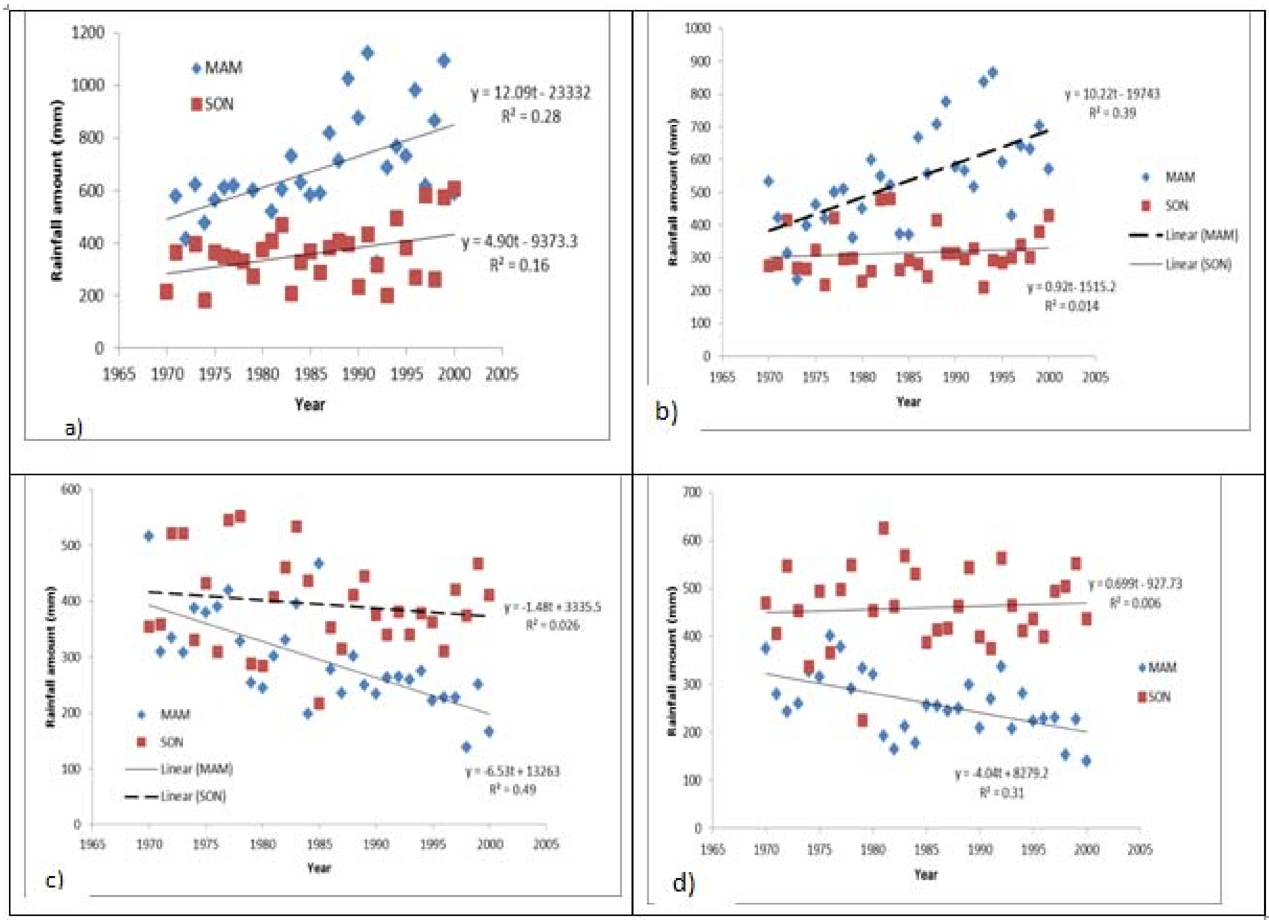


Figure 4 : Temporal trend in seasonal rainfall amount in climatologically homogenous rainfall, A1 (a) zone F (b); and K (c), zone J (d)

For D and L rainfall amount significantly varied for both MAM and SON ($P < 0.05$). For D both seasons showed a significant polynomial trend of power 3 in rainfall amount with a determination coefficient $R^2=0.47$ and 0.44 for SON and MAM; respectively. The first 15 years, MAM rainfall tended to have a relatively higher value than SON, and a relatively lower value for the next 15 years. In Zone L, both MAM and SON increased significantly over the years ($Y=10.68t+20637$, $R^2=0.50$, $p<0.001$ for MAM, and $Y=5.5t-10449$, $R^2=0.28$, $p=0.002$ for SON).

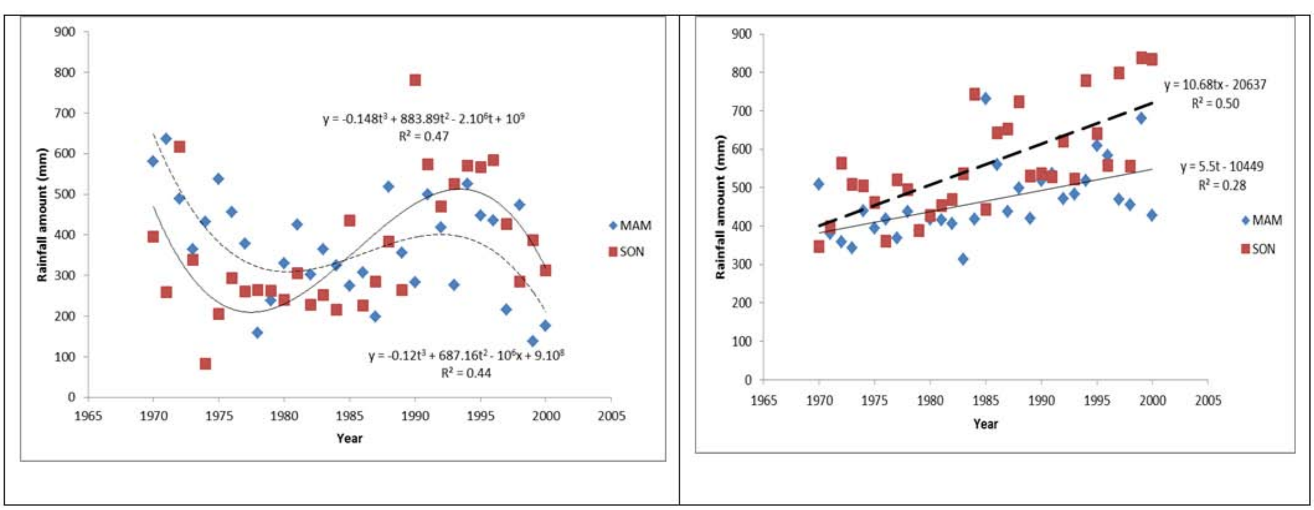


Figure 5 : Temporal trend in seasonal rainfall amount in climatologically homogenous rainfall zone D (left) and zone L (right)

The gradient of SON rainfall amount was relatively higher in zone L, implying an increasing difference between SON and MAM rainfall over the years in this zone. In zone E, though the two seasons showed an opposite linear trend, only the SON rainfall changed significantly over the years. The SON rainfall linearly increased with time (Y=4.09t-7761.7; R^2=0.19; p<0.001).

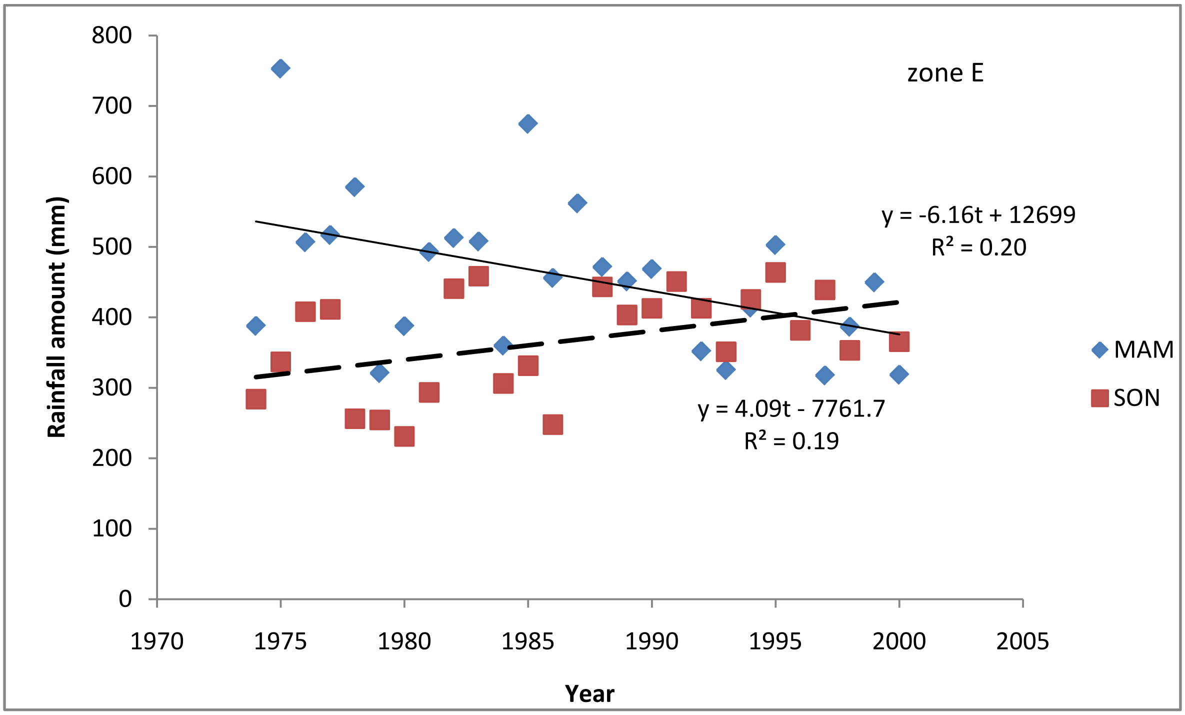


Figure 5 : Temporal trend in seasonal rainfall amount in climatologically homogenous rainfall zone E

For zones I, MW and A2 both seasons varied significantly with time, following different either quadratic shape for one and linear for the other one (Figure 6). For Zone I, the SON rainfall followed a quadratic shape (Y=1.039t^2-4124.5t+ 4.10^6; R^2= 0.30) with a minimum rainfall in 1985 while the MAM rainfall declined gradually over the year (Y=-4.49t+9344.2; R^2=0.19; P=0.04). For the zones MW and A2 the MAM followed a quadratic shape ((Y=0.69t^2-2733.1t+3.10^6; R^2=0.48 for MW; Y=0.44t^2-1725.1t+2.10^6; R^2=0.16 for A2) and the SON varied gradually of the years (Y=-4.41t+9030.2; R^2=0.24) for MW; Y=4.16t-7849.6; R^2=0.25; P=0.02 for A2). The minimum MAM rainfall was observed around the year 1980 and 1982 for MW and A2; respectively.

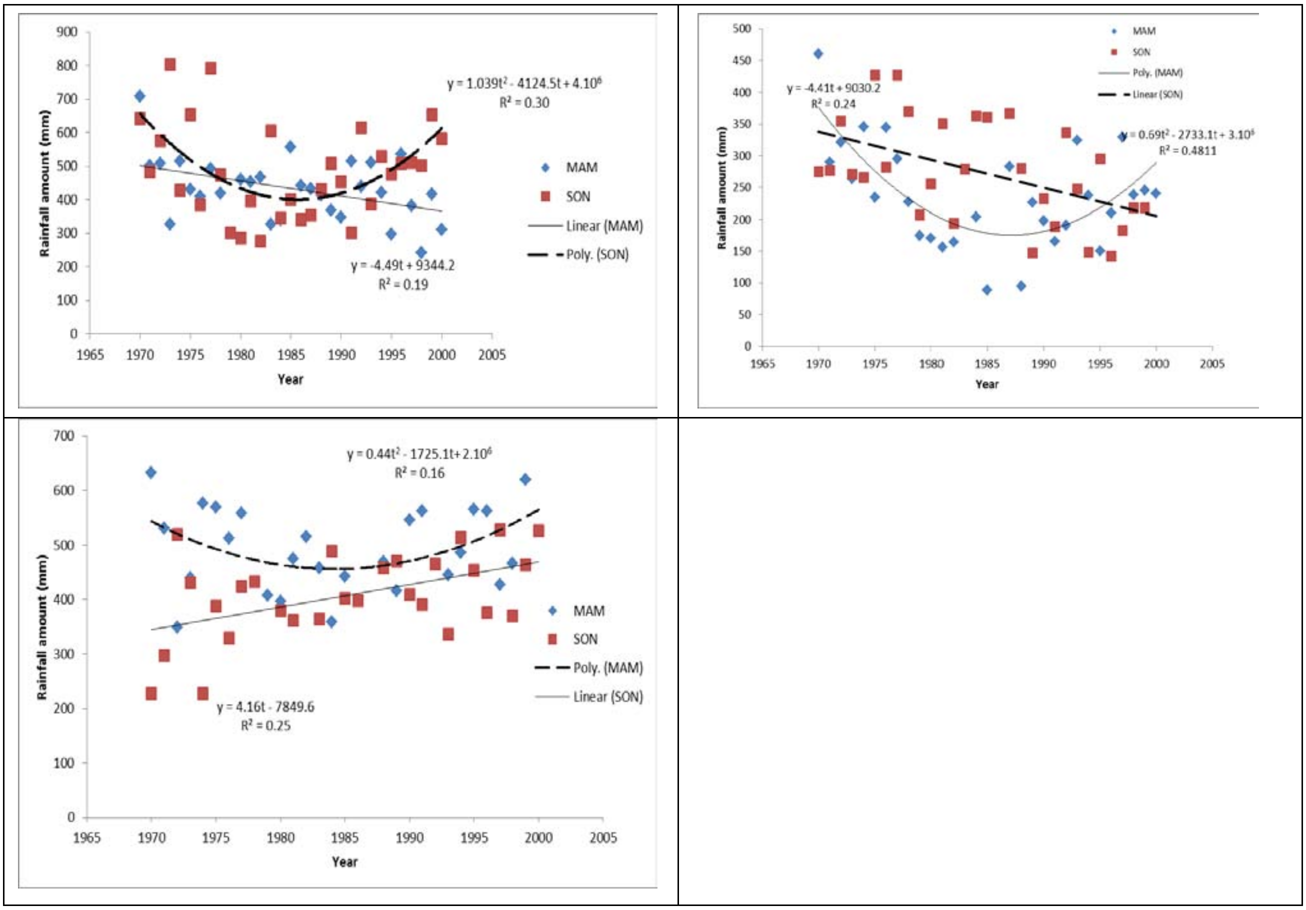


Figure 6 : Temporal trend in seasonal rainfall amount in climatologically homogenous rainfall zone I (a); MW (b) and A2 (c).

c) *Annual trend*

Annual rainfall averages varied across zones and ranged between 864.2 mm for Zone MW and 1618.4 mm for A1 (Table 3). ME and MW had the lowest average annual rainfall compared to the other zones. A1 had a relatively higher average annual rainfall amount compared to other zones, though not significantly different with that of the rainfall zone I. The latter average annual rainfall amount did not significantly differed from that of zone D. These were followed by the rainfall amount of zone A2, which in turn did not differ considerably from that of D and E. Zone E belonged to a group of zones (F, L, H and J) with no significant difference pairewise. The average rainfall amount for zone J did not considerably varied from that of zone K, though significantly higher than that of ME and MW. The CV for the studied period ranged from 12.8% for zone L to 27.2% for zone ME. Zones with CV less than 15% included K and A2, those with CV between 15% and 20% were D, F, H, I and J. Other zones such A1, E, ME had CV above 20%.

Table 3 : Descriptive characteristics of annual rainfall averages in the selected climatologically homogenous zones of Uganda (1970-2000)

Zone	Mean (30 years)	Max (Min)	σ	CV
	(mm)			(%)
A1	1618.4^{a}	2679.2 (1139)	329.8	20.4
A2	1408.2^{bde}	1633.1 (914.2)	182.2	14.1
D	1500.5^{bf}	1904.0 (1072)	235.9	15.7
ME	938.8^{c}	1353 (273.7)	255.1	27.2
MW	864.2^{c}	1150.8 (582.9)	140.1	16.1
L	1275.5^{d}	1826.2 (954.5)	163.8	12.8

E	1312.9^{d}	1844.5 (623.0)	268.0	20.4
F	1256.1^{d}	1713.5 (768.5)	236.5	18.8
H	1285.1^{d}	1908.6 (899.0)	219.3	17.1
I	1529.6^{af}	2103.4 1134.1)	237.8	15.5
K	1162.5^{cg}	1141 (853)	153.4	13.2
J	1240.6^{dg}	1635.3 (616.2)	218.6	17.6
LSD	110.5			

σ: Standard deviation

The annual rainfall amount did not show any significant linear trend ($p>0.05$) for all the studied rainfall zones, except zone A1 and K (Figure 7). For A1 annual rainfall amount increased significantly with time following the equation $y=15.34t-28832$ ($R^2=0.18$ and $p= 0.02$); while in Zone K it decreased significantly following the equation $y = -7.06x + 15170$ ($R^2=0.18$ and $p= 0.019$).

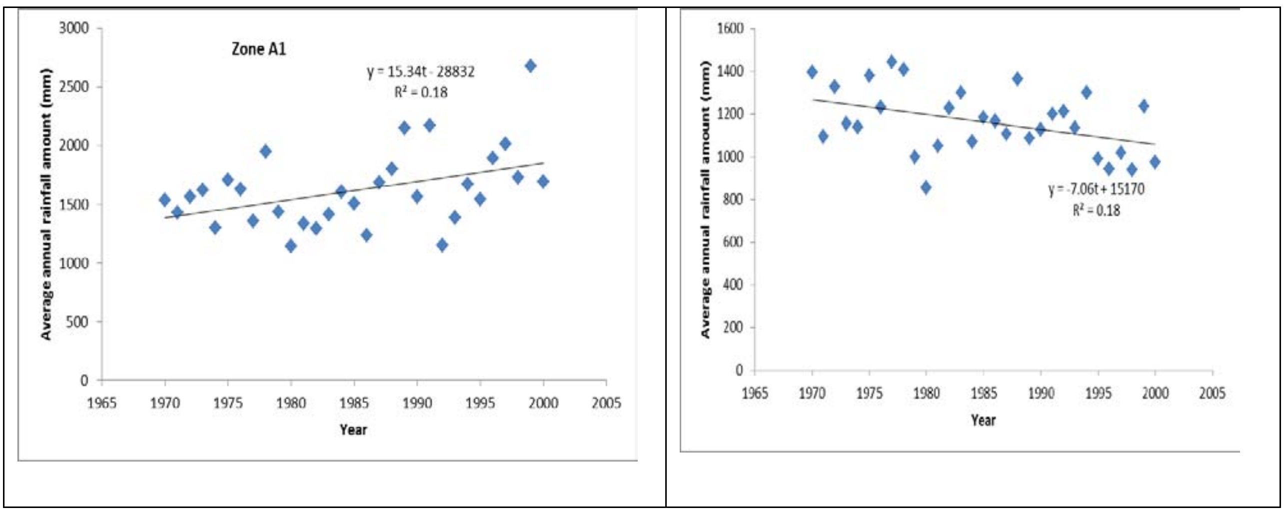


Figure 7 : Temporal trend in seasonal rainfall amount in climatologically homogenous rainfall zone A1 (left) and zone K (right).

The CV of all the studied rainfall zones showed significant trend over the years ($P<0.05$). For most the studied zones the annual rainfall amount variation increased gradually for A1, H, I, E, MW. It is linearly declining with time for zone D; and followed quadratic trend with a maximum between for A2, F, K and ME. All the other zones had a linearly increasing trend over time (Figure 8).

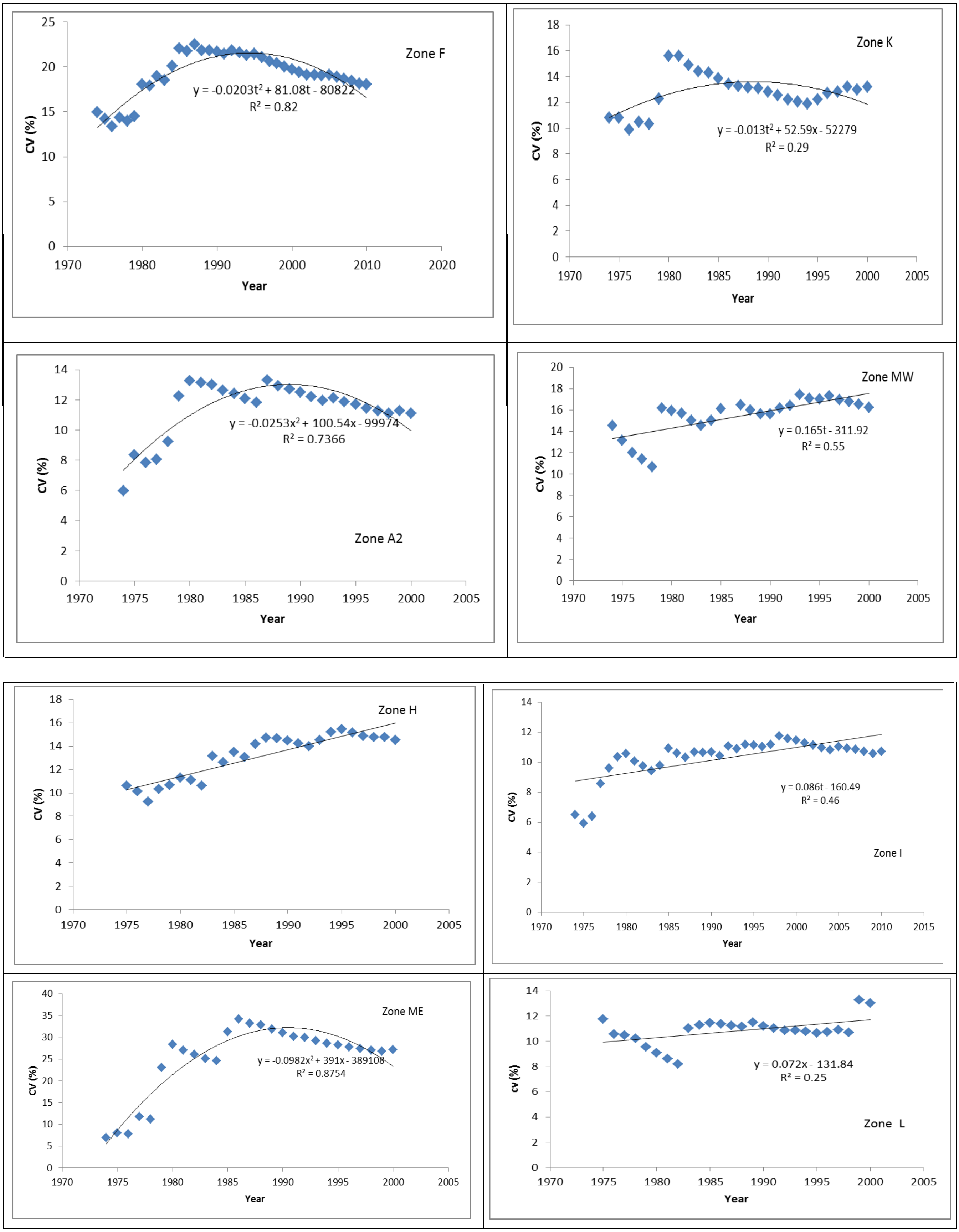


Figure 8 : CV of the annual rainfall amount in the studied homogenous rainfall zones

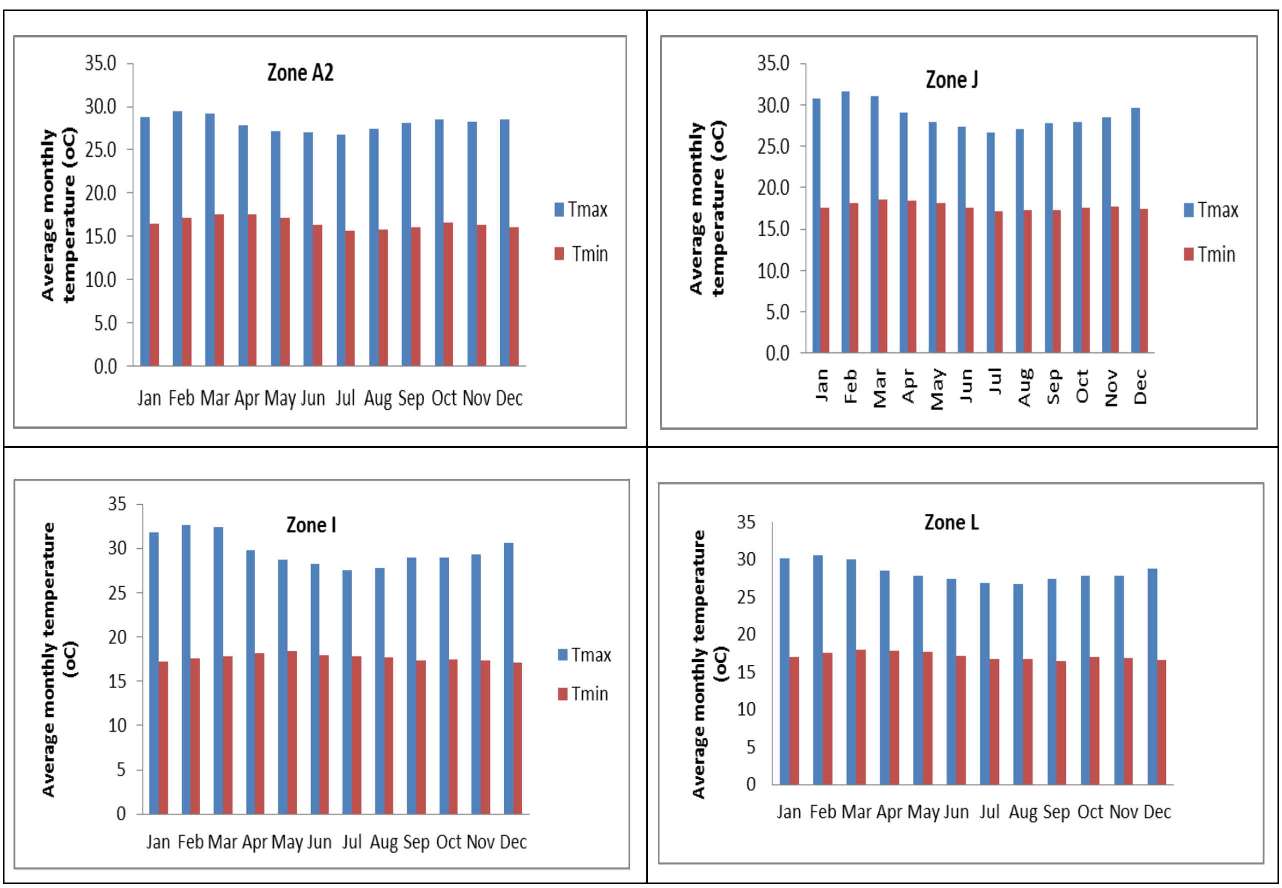
IV. Maximum and Minimum Temperature

a) Monthly temperature distribution

The monthly maximum and minimum temperature distributions are depicted in Figure 9. Monthly maximum and minimum temperature values varied from one rainfall zone to another. Generally, both temperatures tend to be high from January to March for all zones. They decline progressively up to July before start increasing slowly up to December, except for A1, ME and F for which both maximum and minimum temperature presented peaks in February-March and August-September. The relatively lowest average monthly Tmax (26.17°C) was recorded in ME and the highest (36.06°C) in H. The relatively lowest average monthly minimum temperature (13.35°C) was recorded in F; while the relatively highest (20.76°C) in zone E.

Table 4 : Range of Tmax and Tmin for the studied rainfall homogenous zones of Uganda

Zone	Temperature range (°C)	
	Tmax	Tmin
J	28.11-34.05	17.56-19.08
K	28.78-31.63	17.72-18.62
A1	26.13-26.93	17.82-18.46
I	27.51-32.61	17.14-18.39
A2	26.78-29.43	15.69-17.53
L	26.78-30.56	16.53-17.95
F	26.31-28.80	13.35-15.32
ME	26.17-27.65	13.41-14.40
E	28.11-34.27	19.41-20.76
D	27.44-31.13	15.60-17.22
MW		
H	29.18-36.06	17.29-19.60



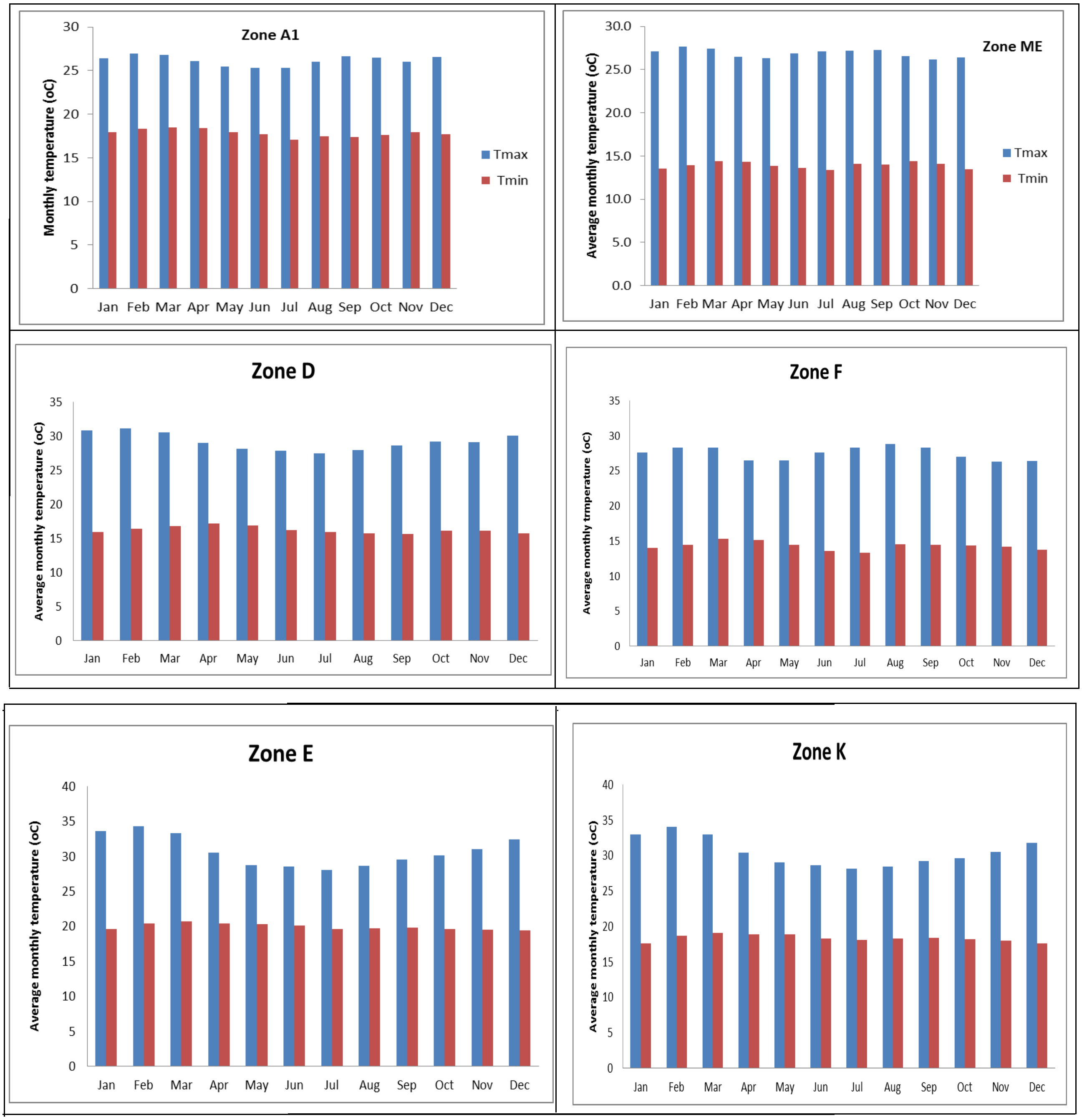


Figure 17 : Temporal trend in monthly temperature in selected climatologically homogenous rainfall of Uganda

b) Seasonal trends

Seasonal temperature variations were observed for the rainfall zones I, A1, L, D and E. In zone I, both Tmax and Tmin increased linearly for both seasons (P<0.001) with R2 ranging between 0.56-0.65 (Figure 9). For A1 and L seasonal temperatures increased linearly for both MAM and SON except for Tmax for SON (P<0.05) (Figure 10). For zone D, Tmax and Tmin increased linearly for both seasons (P<0.05). For zone L, Tmin for both MAM and SON increased with the time (P=0.001) with a similar gradient (0.035°C/yr) since 1970. For zone E, Tmax increased for MAM (R^2=0.16; P=0.077) and SON (R^2=0.15, P=0.08).

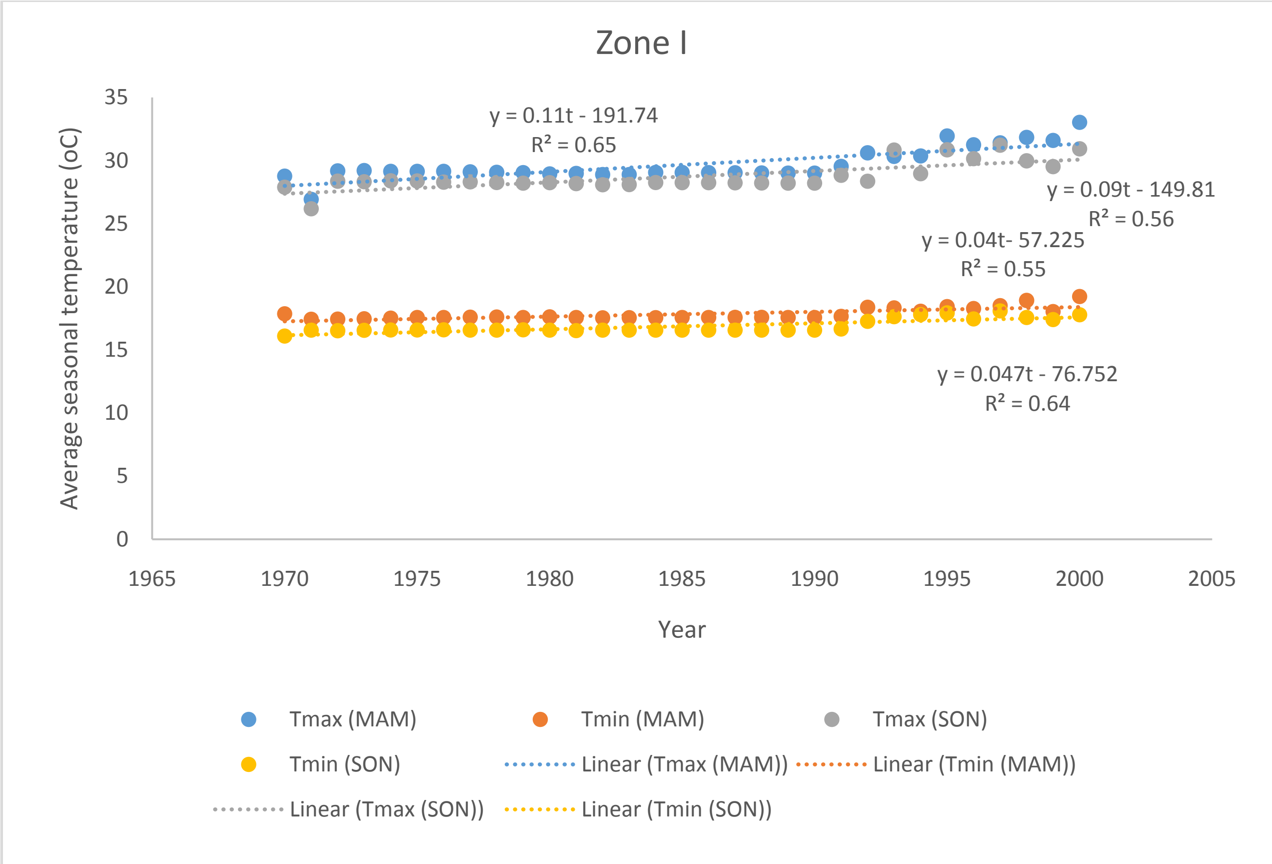


Figure 9 : Temporal trend in seasonal temperature in climatologically homogenous rainfall zone I

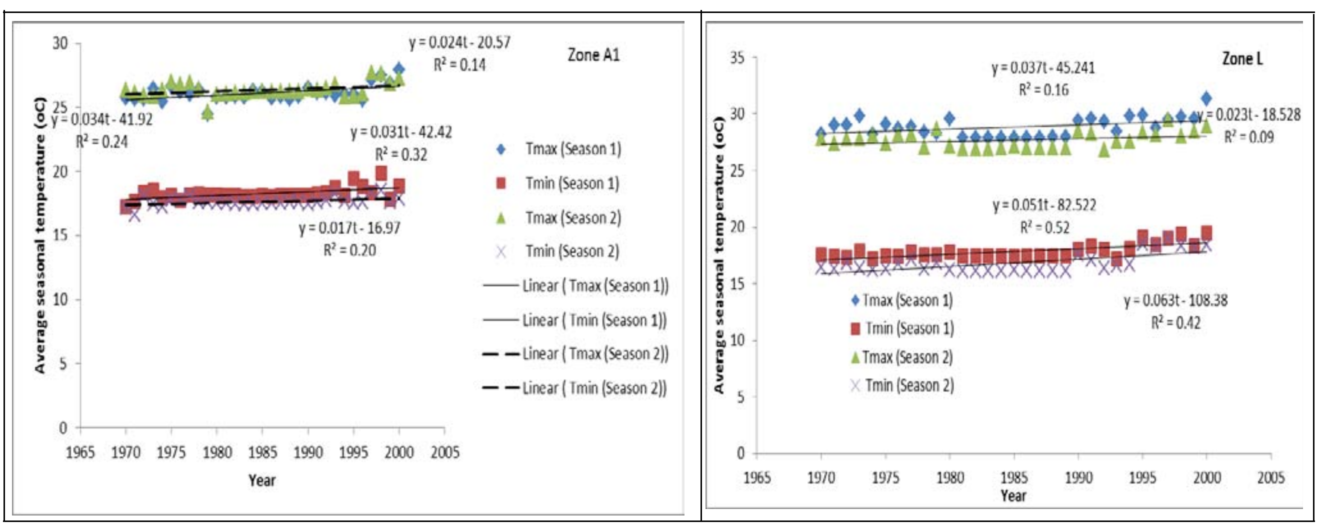


Figure 10 : Temporal trend in seasonal temperature in climatologically homogenous rainfall zone A1 (left) and L (right)

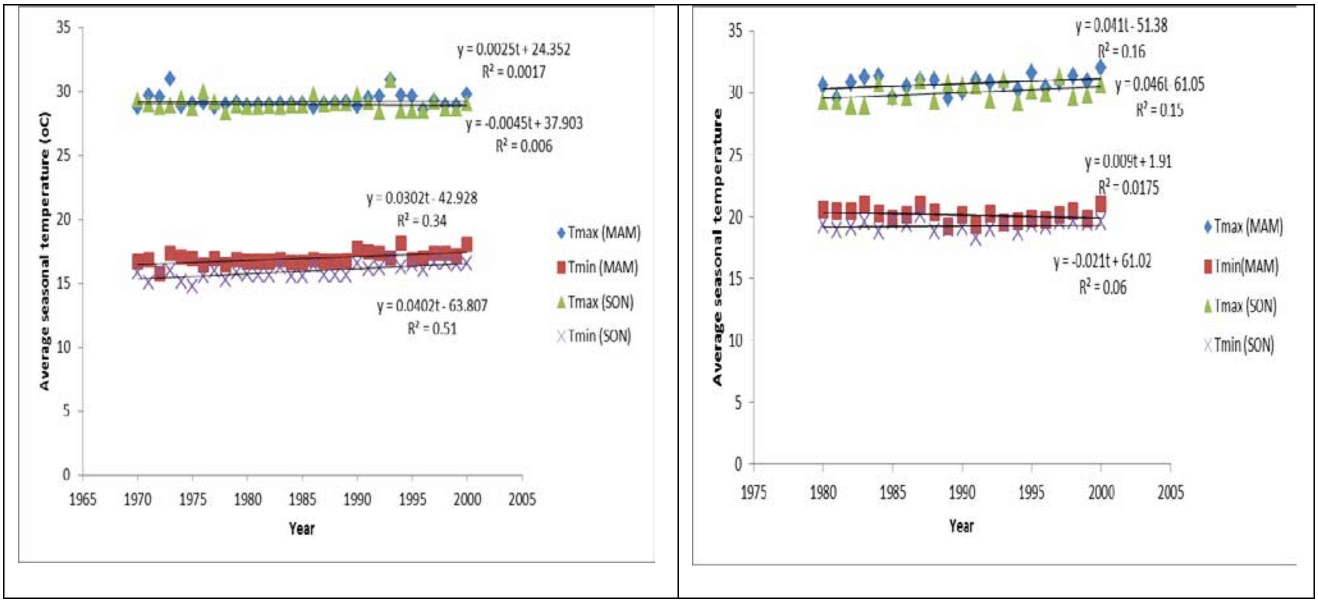


Figure 11 : Temporal trend in seasonal temperature in climatologically homogenous rainfall zone D (left) and E (Right)

Generally, there was very small variation (less than 1 °C) between average Tmax and Tmin in MAM and SON for a given zone; except for zone J and I were it was greater than 1 °C for Tmax, D, L and I for Tmin. In these zones, MAM tended to have a relatively higher temperature than SON. I most cases CV were very similar for both seasons for Tmax and Tmin, and below 5% except for zone ME.

Table 5 : Descriptive statistics of average seasonal maximum temperature

Zones	MAM				SON			
	Mean (30 years)	Max (Min)	σ	CV	Mean (30 years)	Max (Min)	σ	CV
E	30.71	32.00 (29.54)	0.65	2.03	30.01	31.29(28.99)	0.74	2.36
A2	28.1	29.3 (26.7)	0.63	2.23	28.3	29.2 (27.1)	0.43	1.52
D	29.25	30.97 (28.57)	0.55	1.87	29.0	30.87 (28.36)	0.51	3.21
F	27.07	28.17 (26.09)	0.58	2.12	27.21	28.51 (25.86)	0.59	2.99
L	28.81	31.28 (27.88)	0.85	2.95	27.71	29.44 (26.87)	0.70	2.52
J	29.4	30.6 (28.0)	0.64	2.19	28.1	29.0 (27.0)	0.49	1.75
MW								
ME	26.73	27.66(25.83)	0.52	1.95	27.05	29.15 (25.60)	0.83	3.07
H								
I	29.66	33.02 (26.94)	1.26	4.26	28.72	31,21 (26.18)	1.09	3.18
K								
A1	26.11	27.92 (24.45)	0.64	2.46	26.38	27.73 (24.66)	0.58	2.21

Table 6 : Descriptive statistics of the average seasonal minimum temperature

Zones	MAM				SON			
	Mean (30 years)	Max (Min)	σ	CV	Mean (30 years)	Max (Min)	σ	CV
E	20.14	21.00(19.26)	0.51	2.41	19.26	20.13 (18.32)	0.41	2.03
A2	17.4	18.6 (15.8)	0.56	3.19	16.4	17.5 (15.6)	0.54	3.03
D	16.95	18.11 (15.73)	0.47	2.78	15.92	16.87 (14.77)	0.51	3.21

F	14.98	15.66 (14.30)	0.37	2.48	14.35	15.15 (13.58)	0.43	2.99
L	17.85	19.44 (17.17)	0.64	3.57	16.84	18.97 (16.14)	0.89	5.27
J	18.4	19.1 (17.7)	0.36	1.98	17.5	18.0 (17.0)	0.24	1.36
MW								
ME	14.16	15.77 (11.40)	1.13	7.99	13.73	15.80 (10.67)	1.13	8.25
H								
I	17.83	19.23 (17.43)	0.46	2.59	16.88	18.09 (16.10)	0.53	3.18
K								
A1	18.25	19.87 (17.23)	0.49	2.69	17.65	18.5 (16.6)	0.36	2.02

c) Annual trend

Annual variations in maximum and minimum temperatures are depicted in Figure 12 and 14. Three types of trends have been observed in the studied zones. In zone A1, A2, I and L, both annual average Tmax and Tmin have been increasing overtime (P<0.001). For zone K, E, F and D only one of the two average annual temperature showed a significant linear trend. For zone K, E and F, only Tmax showed a linear increase overtime while for zone D only Tmin had significantly increased with time. In other zones such as ME, L and J no significant linear trend was observed in both average annual temperatures.

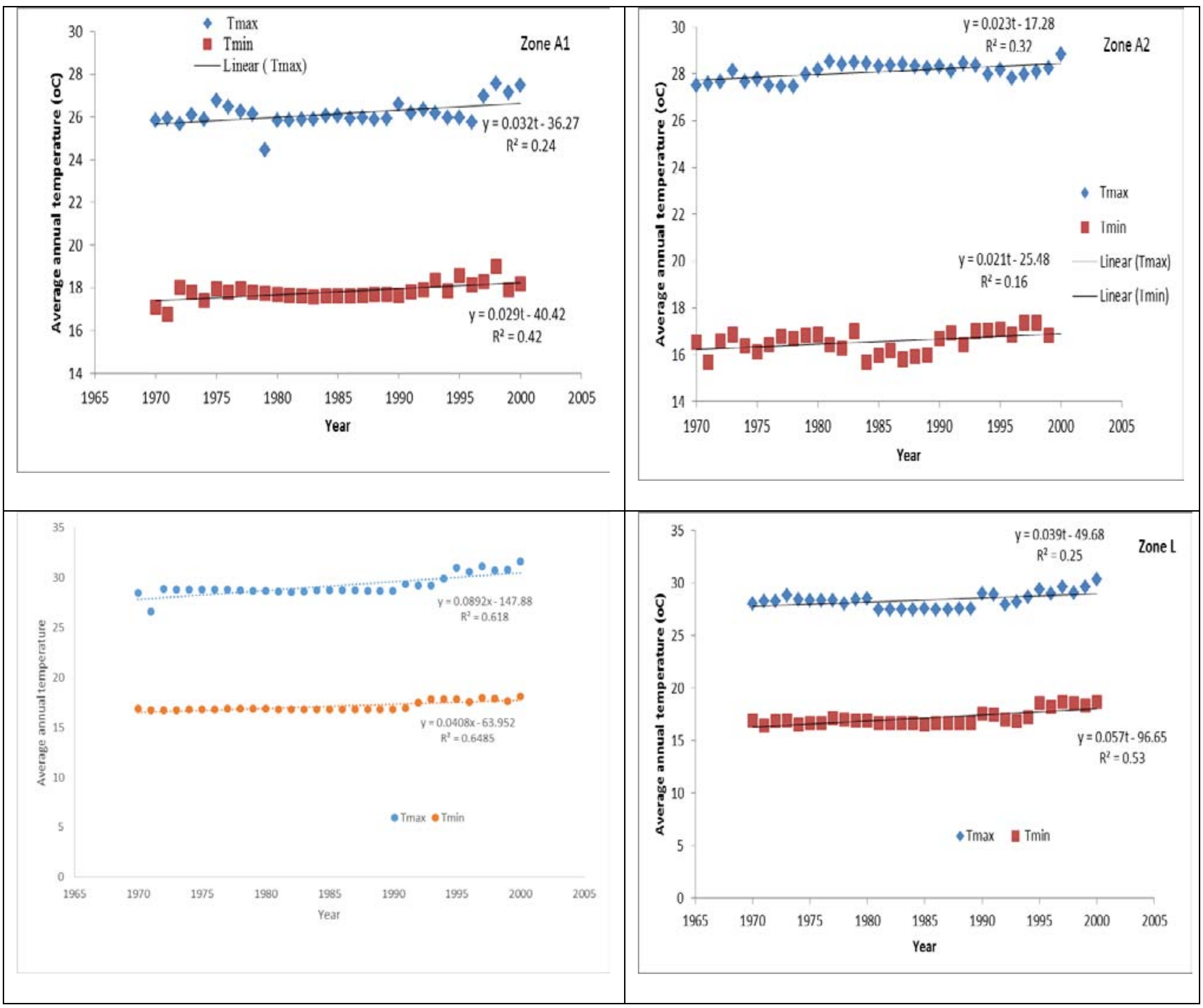


Figure 12 : Temporal trend in annual temperature in climatologically homogenous rainfall zone A1, A2, I and L

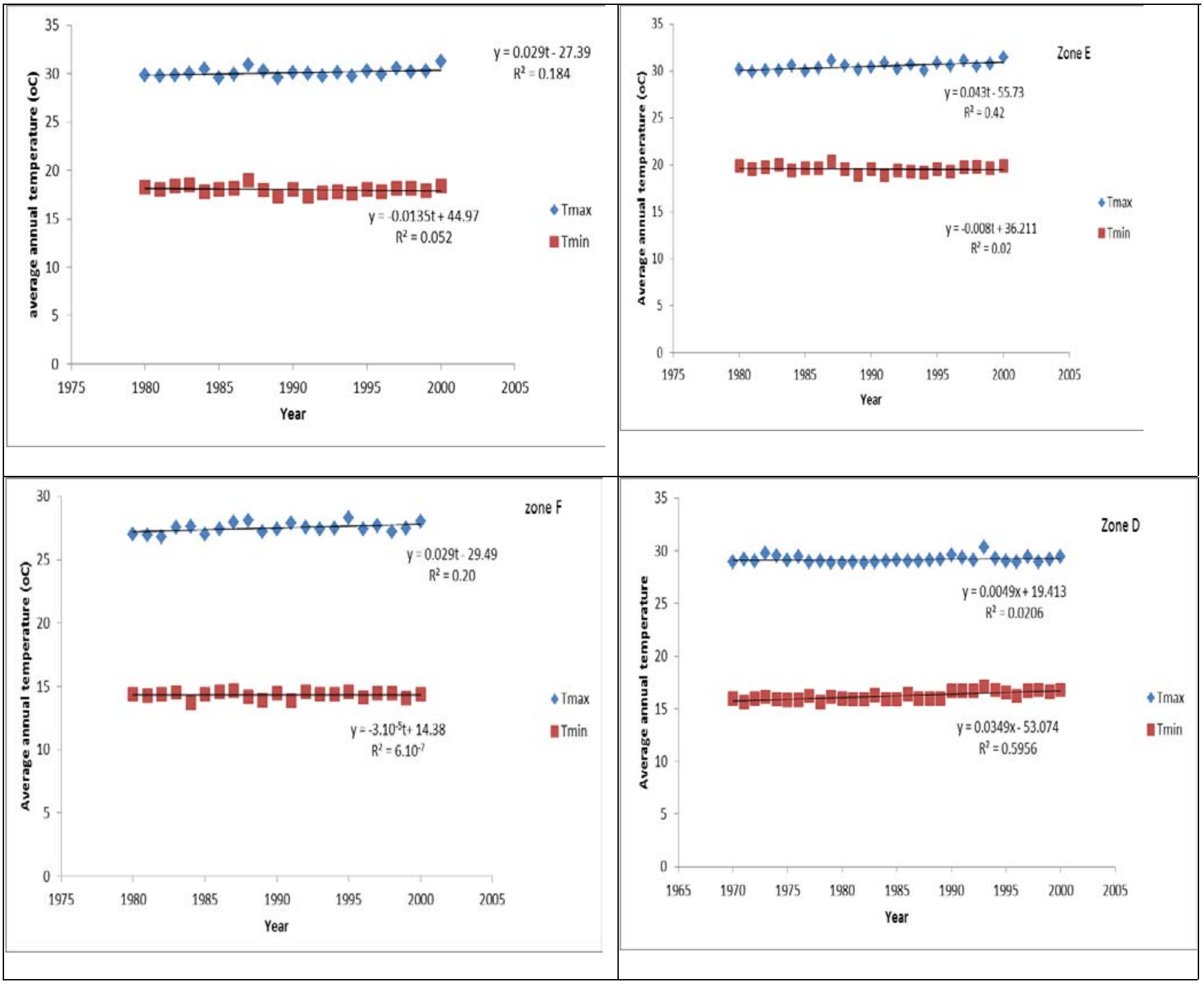


Figure 13 : Temporal trend in annual temperature in climatologically homogenous rainfall Zone K, E, F and D

V. Discussion of Results

Apart from zones G, H and F, which exhibit a unimodal pattern with monthly maxima around JJA, all the other rainfall zones tend to behave bimodally, with a rainfall peak during MAM and a second during SON. This is in line with Kigobe *et al.* (2013) who observed that G, H and F tended to have unimodal pattern in the Kyoga basin. This bimodality is strong around the Equator, becoming less strong in the northern and southern regions of the country. The Inter Tropical Convergence Zone (ITCZ) driving southeasterly and northeasterly moist air currents from the Indian Ocean is the major seasonality factor (Nieuwolt, 1979; Mutai *et al*., 1998; Phillips & McIntyre, 2000). In Uganda, it has induced two seasons in the southern part of the country, and unimodal patterns towards the north, with the central part of the country as a transitional zone for the patterns observed in the north and south.

Seasonal and annual trend in rainfall varied from one zone to another, in term of magnitude and direction. Only Zones ME and H did not show any significant seasonal trend for the studied period. MAM increased for Zones A1 and F, and declined for J and K. For A1 and F, MAM rainfall tended to have a relatively high value of rainfall amount than SON; an opposite trend was observed in zone K and J. In zone E, the SON rainfall linearly increased with time. Our observations only corroborates Kansiime *et al.* (2013) findings that ASON rainfall amount increased in the Lake Kyoga basin, and MAM increase in zone F. We did not observed SON significant variation for A1 representing the Lake Victoria crescent nor a declining trend in MAM; perhaps because their definition of the long-rain season (MAMJ) which included the month of june. Our observations are also in line with Kigobe *et al.* (2013) observations in zone D were no significant seasonal trends was not observed.

The seasonal rainfall amount change was only significantly reflected for zone A1 and K. The annual rainfall amount increased significantly for A1 and declined for Zone K; respectively. Stampone et al. (2011) also observed that seasonal variations were not reflected in annual trends in their study of rainfall zones around Kibale national Park. This is attributed to several environmental factors (Horton, 1995) including topography, disparate and discontinuous land cover types, and seasonally distinct forcings on weather patterns, and proximity to large bodies of water (Ogallo, 1989; Meher-Homji, 1991; Basalirwa, 1995; Nicholson and Kim, 1997; Mutai *et al*.;1998; Indeje *et al*., 2000; Phillips & McIntyre, 2000). Other influences on rainfall variability include tropical storms, continental low-level troughs, extra-tropical weather systems and local meso-scale systems (Indeje *et al*., 2000). The role of land cover, most particularly vegetation cover and the effects of anthropogenic activities like deforestation cannot be overemphasised (Pielke, 2007; Webb, 2005; Meher-Homji, 1991). Deforestation affects rainfall through changing rates of physical evaporation, transpiration, surface albedo, and aerodynamic roughness (Pielke, 2001; Ray et al., 2006; Pielke et al., 2007). Vertical atmospheric motion forcing induced by topography in generation and modification of precipitation has been well studied (Roe, 2005; Smith, 2006).

The CV of all the studied rainfall zones showed significant trend over the years (P<0.05). It increased for all studied zones, declined for zone D and followed a quadratic trend with a maximum for F, K and ME. The magnitude of CV is in line with observations of Kansiime et al. (2013) in eastern Uganda. CV in this region was less than 30% for all locations they studied in eastern Uganda, and within the range of CV reported in the region. Seleshi and Zanke [10] obtained annual and seasonal rainfall (Kiremt and Belg seasons) CV values ranging between 10 and 50% in Ethiopia; were highly variable with CV values ranging between 0.10 and 0.50. Relatively high values (41%, 39% and 47%; respectively) have been recorded in for Machang'a, Kiritiri, and Kindaruma in Kenya (Kisaki et al., in press). This high variability have been connected to sea-surface temperature (SST) gradient fluctuations, especially the El Niño Southern Oscillation (ENSO) (; Shisanya, 1990; Mutai *et al*., 1998; Indeje *et al*., 2000; Mutai & Ward, 2000; Anyamba et al., 2001; Ntale & Gan, 2004). ENSO teleconnections affect the northern and southern regions of Uganda differently. In the south, El Niño leads to higher rainfall amounts and emphasizes the bimodal pattern, while La Niña leads to lower rainfall (Phillips & McIntyre, 2000). In the north of the basin, El Niño is associated with depressed July–September rainfall amounts and an increase in October–December rainfall, while La Niña has exactly the opposite effect. Some studies also link the annual variability of East African rainfall amount to Indian Ocean SST and corresponding wind anomalies (the Indian Ocean Dipole Mode) (Saji *et al*., 1999; Iizuka *et al*., 2000; Black *et al*., 2003).

Temperature trends also varied from one rainfall zone to another. Average Tmax and Tmin increased linearly for both seasons for I and D. For A1 and L only Tmax for SON did not show significant variation (P<0.05). For zone L, the MAM Tmin significantly increased gradually for both seasons; while for zone E, Tmax increased only for MAM. The annual Tmax and Tmin increased linearly with time for zone A1, A2, and L. For zone K, E and F, only Tmax increased linearly with time; while for zone D only Tmin had significantly increased with time. As for rainfall, the change in temperature in the studied rainfall zones is linked to the ~1°C warming in the Indian Ocean and overturning circulations bringing dry hot stable air masses down across parts of the Horn of Africa (Funk and others, 2008; Williams and Funk, 2011; Williams et al., 2011). It has been consistent and persistent over the 1950-present era, and is uniformly reproduced by all the IPCC climate models and several different precipitation time series (Williams and Funk, 2011; Adler et al., 2003; Kanamitsu *et al.* 2002; Xie and Arkin 1997; Chen et al. 2003; Smith et al. 2010). Funk *et al.* (2008) suggested that the warming in the Indian Ocean is likely to be at least partially caused by anthropogenic greenhouse gas emissions.

VI. Conclusions and Recommendations

In light of the above results and discussions we conclude that rainfall and temperature trends have varied from one rainfall zone to another in Uganda. Seasonal variations in rainfall have been observed in A1, F, K and J inter annual variations have been detected in most of the studied rainfall zone. While temperature variations have been observed in rainfall zone A1, A2, K, E and F. The variability in rainfall places increased climatic pressures on the agricultural sector in Uganda, the backborne of Uganda's economy. Effort should be made to take advantage of the increasing trend in rainfall amounts in certain zones and promote best management practices to cope up with the negative impacts related with the variation in climatic parameters.

VII. Acknowledgements

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Occurrence of Corundum Crystals in Conglomerate Beds of Bharweli Manganese Ore Belt (Madhya Pradesh), India

By F. N. Siddiquie & Kh. Burhamuddin
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Abstract- Bharweli mine is situated at $21^{0}50'$N latitude and $81^{\circ}14'$E longitude. It lies within the Manganese belt of Madhya Pradesh and adjoining parts of Maharashtra andforms an East-West trending arcuate belt of 150 Kms long. It is enclosed within the metasedimentary sequence of Sausar Group of rocks belonging to Precambrian age. Regionally, it is situated in Mansar Formation and rocks comprise of quartzite, sericite schist, phyllite and conglomerate. It also has some carbonate associations, containing stratiform manganese ore comprising Braunite, Bixbyte, Hollandite, Hausmannite, Pyrolusite and Psilomelane which form the largest manganese reserves in India.

Keywords: bharweli mine, sausar group, precambrian age, mansar formation, conglomerate, corundum, malegaonmagjin, balaghat district.

GJSFR-H Classification : FOR Code: 059999p

OCCURRENCEOFCORUNDUMCRYSTALSINCONGLOMERATEBEDSOFBHARWELIMANGANESEOREBELTMADHYAPRADESHINDIA

Strictly as per the compliance and regulations of :

Occurrence of Corundum Crystals in Conglomerate Beds of Bharweli Manganese Ore Belt (Madhya Pradesh), India

F. N. Siddiquie [α] & Kh. Burhamuddin [σ]

Abstract- Bharweli mine is situated at 21^{0}50′N latitude and 81°14′E longitude. It lies within the Manganese belt of Madhya Pradesh and adjoining parts of Maharashtra andforms an East-West trending arcuate belt of 150 Kms long. It is enclosed within the metasedimentary sequence of Sausar Group of rocks belonging to Precambrian age. Regionally, it is situated in Mansar Formation and rocks comprise of quartzite, sericite schist, phyllite and conglomerate. It also has some carbonate associations, containing stratiform manganese ore comprising Braunite, Bixbyte, Hollandite, Hausmannite, Pyrolusite and Psilomelane which form the largest manganese reserves in India. Conglomerates comprising the beautiful fairly coarse crystals of corundum (precious variety) mostly of almond size and deep violet in colour, concentrated at one place are encountered on the NNE flank of canal in Malegaon Magjinarea.

Keywords: bharweli mine, sausar group, precambrian age, mansar formation, conglomerate, corundum, malegaonmagjin, balaghat district.

I. Introduction

The Madhya Pradesh manganese belt with adjoining parts of Maharashtra make an arcuate belt of about 150 kms long and 25 to 30 meters wide and extend in the East West direction from Chindwara district in the West through Nagpur and Northern Bhandara District in the middle of the Balaghat. The entire Belt is an integral part of the once thought oldest formations of central India, with gneissic intrusions. Balaghat mine is in Balaghat district of Madhya Pradesh and is about 210 Kms from Nagpur. It is situated at 21^{0}50′N latitude and 81°14′E longitude. The strike length of ore body is 2.8 kms having a NE–SW general strike direction and dip varies from 25^0 to 85^0 W. The width of the ore body is 1.0 meter at both ends where as it increases to 30 m in the central portion and hasan average thickness of 10 metres. The manganese Ore deposit occurs in lenses of varying sizes and in persistent beds of the lower part of the sequence of meta sedimentary rocks (metamorphosed sedimentary) of the Sausar Group of Pre-Cambrian age. These manganiferrous rocks are underlain by intensely metamorphosed ore and the Para gneisses which may or may not be a part of the lower Sausar Group. Granites, gneisses and pegmatites of Precambrian ages are allemplaced in the Sausar Group of rocks.

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II. Geology of the Sausar Group

The manganese deposit of the Balaghat district, M.P., occurs as NNE–SSW to ENE-WSW trending conformable bands, enclosed within the metase dimentary sequence of Sausar Group of rocks of Precambrian age (Banerjee, D.C. et. al., 2007). On regional scale, the geology is represented by the Sausar Group of rocks of central India and has been dated by Rb–Sr methods on the Tirodi Gneiss as 1525 m.y. (Sarkar, et. al., 1986). In addition, U-Th-Pb methods on pegmatites (Holmes, 1955) and K-Ar methods on micas (Sarkar, et. al., 1981) yield close ages in the range of 1000 to 850 m.y. The Sausar Group comprising of quartzite, pellite and carbonate associations contain stratiform manganese deposits which isthe largest manganese resource in India (Dasgupta, et. al., 1984; Bhowmik, et. al., 1997). Structural studies on the Sausar Group have been carried out in detail by several workers (Straczek, et. al., 1956; Narayanaswamy, et. al., 1963; Basu and Sarkar, 1966).

The Sausar Group witnesses three phases of deformation and four phases of metamorphism, where metamorphism of this group of rocks was roughly synchronous with the various stages of deformation. The first phase of deformation produced isoclinal folds, axial plane schistosity and mineral lineation. The second phase of deformation generated super folds and crenulation cleavage while the third deformational phase formed open folds with steeply dipping axial planes (Sarkar, et. al., 1977). Different workers have given the stratigraphic sequence of Sausar Belt such as West (1936), Strackzec, et. al., (1956), Shukla and Anandalwar (1959), Narayanaswamy, et. al., (1963), Rao (1979) and Bandopadhyay, et. al., (1995). Because of lateral facies changes in the area, the sequence and the names of the formations differ slightly from place to place (Roy, 1973). Stratigraphic succession of the Sausar Group of Bastar Craton (Bandopadhyay, et. al., 1995), modified from Narayanaswamy et. al., (1963) is given in the table 1.

III. Regional Geology

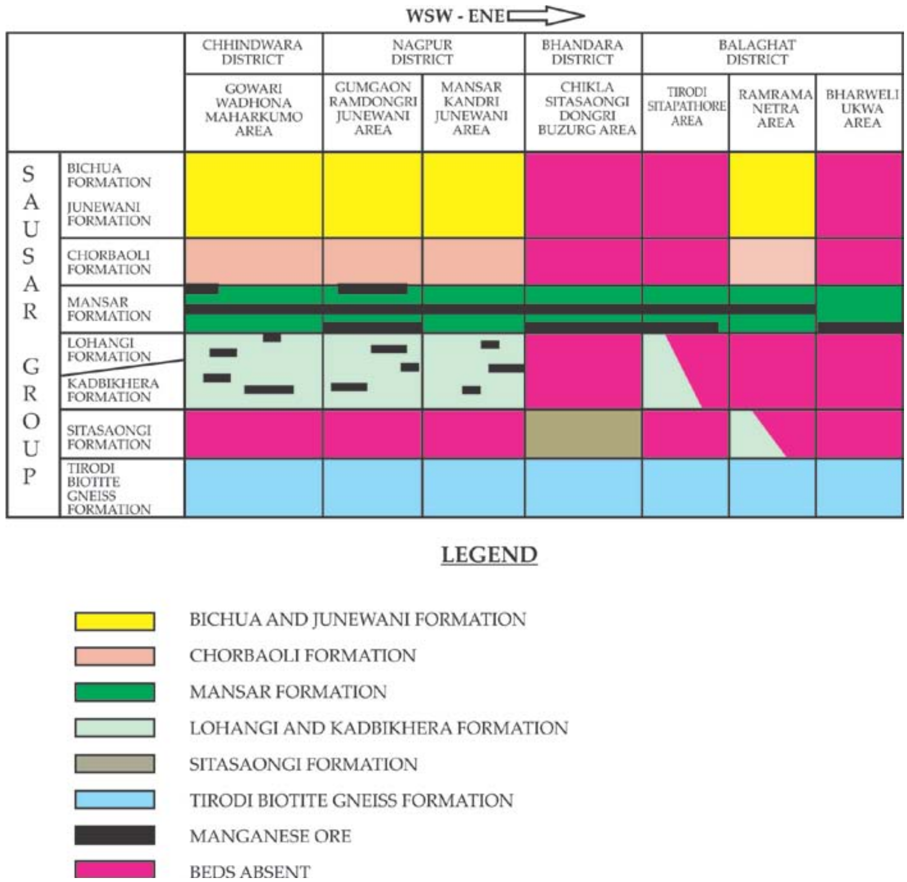
The Bharweli manganese mine is situated in the Mansar Formationwhichis a thin sequence of muscovite schist, muscovite biotite schist, sericite schist and phyllites, commonly garnetiferous. These rocks contain much sillimanite in the rich grade zone of metamorphism, staurolite in the middle grade zone and sericite schist occurs in the low to high grade zone (16 to 20%) indicating that the source rocks were highly argillaceous. Conglomerates along with pebbly grits and quartzites with minor amounts of quartzite-sericite muscovite schist often feldspathoids are together grouped tentatively in the Mansar Formation. The conglomerates and the pebbly grits are the most prominent outcrops forming the bottommost members of the Sausar Group as seen in the area and are in contact with the granitic gneisses to the south and manganese horizon to the north and have varying thickness.

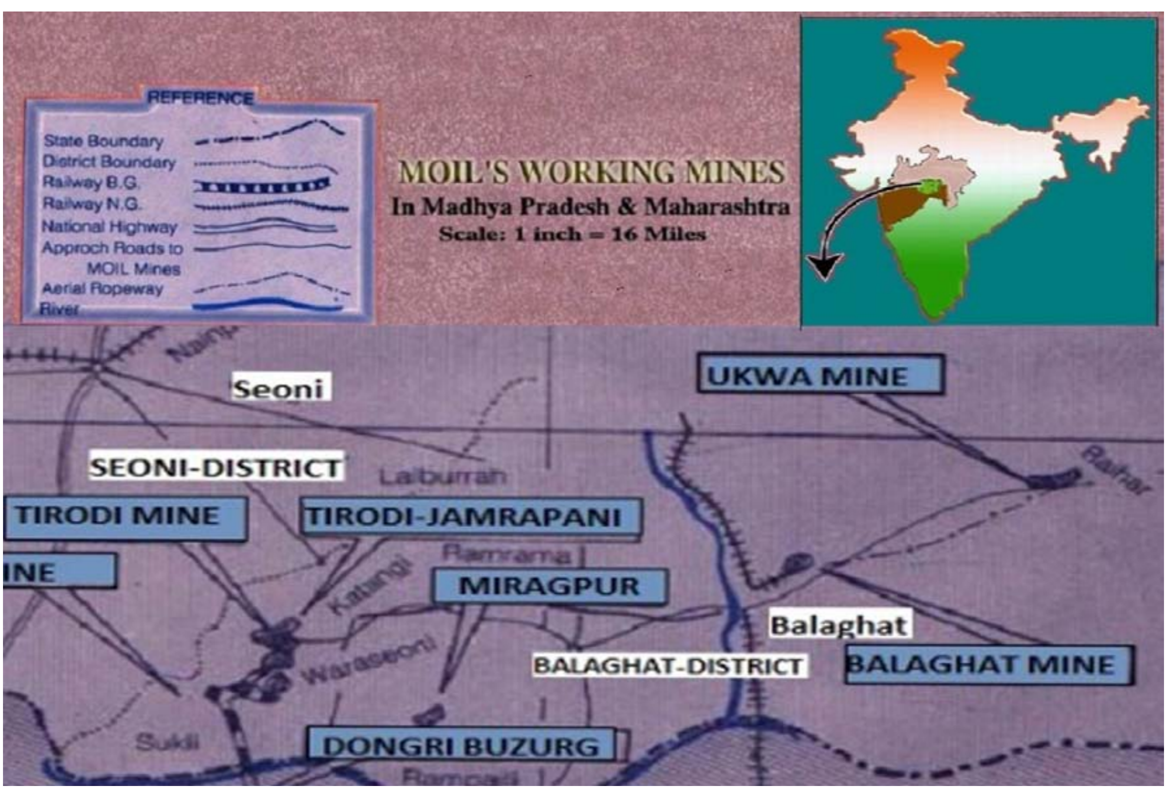
Table 1 : Stratigraphic succession of Sausar Group (Bandopadhyay, et. al., 1995, modified from Narayanaswamy, et. al., 1963)

FORMATION	LITHOLOGY
Bichua Formation	Dolomite, Marble, Calc silicate gneiss schist.
Junewani Formation	Metapelite (Mica Schist), Quartzite, granulite, biotite-Gneiss (Reworked basement).
Chorbaoli Formation	Quartzite, feldspathicSchists, Gneisses, Autoclastic Quartz, Conglomerate.
Mansar Formation	Metapelite (mica-schists and gneisses), graphitic Schists, Phyllite quartzite, major manganese deposits and gondite.
Lohangi Formation	Calc-Silicate Schists and gneisses, marble, Manganese deposits.
Sitasaongi Formation	Quartz mica Schists, Feldspathic Schists, mica gneiss, Quartzite, Conglomerate.
--	--
Tirodi Gneiss	Biotite gneiss, Amphibolite, Calc-Silicate Gneiss (Tirodi Gneiss), Granulites, Mica Feldspathic Schists.
………………………………………	Unconformity……………………………………………
Older Metamorphics	Charnockite, Orthogneisses and Granite Biotite Gneisses, hornblende Gneisses, Amphibolites and calc granulites

The whole of this gritty formation as well as the gneisses at its contact show effects of intense crushing and mylonitisation and represent a thrust zone. The feldspathoids schistose pebbly grits grade into sericitic gneisses at places in the present study area. Rocks occurring below the manganese ore beds in this area consisting of conglomerates, pebbly grits and quartzites with minor amounts of quartz-sericite muscovite schist, often feldspathoids were grouped as Mansar Formation. The Bharweli outcrop above thementioned zone of conglomerates and pebbly grits is well developed in Bharweli, Malegaon and Langur areas. Thickness of this conglomerate and gritty zone at Bharweli is around 3 metres. The contact between the pebbly grits and the granitic gneisses on the hill slope, north-west of Malegaon, however runs almost North-South. The grit in the Bharweli ridge and in the Malegaon hills is feldspathic, sericitized and contains small rounded to sub rounded pebbles of quartz and fresh pink orthoclase, plagioclase and tourmaline, large microcline and albite. The grits usually grade downwards usually into coarser conglomerate with larger pebbles of quartzite and granite. Occasional pebbles of Iron-Ore (Specularite) are also found. At most of the places the conglomerate bed comprises of around 40-50 cm boulders of granites, gneisses and slates derived out of weathering of the local lithology. The dominant minerals of the boulders are quartz, orthoclase, plagioclase and tourmaline at some places.

Table 2 : General stratigraphic sequence of central Belt, Sausar Group





(Source: MOIL)

Figure 1 : Location Map of Manganese mines in the Balaghat District, M.P., India.

IV. Observation

The present field trip was interestingas fairly coarse crystals of corundum (precious variety) were encountered in the conglomerates of the Mansar Formation. The outcrops of conglomerate are fractured with parallel siliceous veins along the NNE flanks of the canal side of Bharweli (Figure 2 and 4). This fracture is tectonic and the veins are syntectonic and syn-depositional features. The crystals are mostly of almond size and deep violet in colour (Fig. 2 and 4) and concentrated at one place in the locality. The region requires further prospecting to evaluate the total resource. The corundum crystals are of pure variety and are of meta-sedimentary origin (Burhamuddin, et. al., 2013 and Siddiquie, 2010).

Figure 2 : Photograph showing Corundum crystals in the Conglomerate bed near Malegaon Magjin, Bharweli, Balaghat dist., M.P.

Figure 3 : Photograph showing Conglomerate near Malegaon Magjin, Bharweli , Balaghat dist., M.P.

Figure 4 : Photograph showing enlarged Corundum crystals in the Conglomerate bed near Malegaon Magjin, Bharweli, Balaghat dist., M.P.

V. Discussion and Conclusion

Narayanaswami et al. (1963) considered the Tirodi gneiss as the basement ofSausar Group. Although the contact between the Tirodi gneiss complex and the Sausar is mostly tectonized at most places, recently a polymictic conglomerate has been reported at the contact of Sausar and Tirodi gneiss from the locality of Mansar (Mohanty, 1993), confirming that the Tirodi gneiss is a basement to the Proterozoic Sausar Group.Both the Tirodi gneiss complex and the Sausar Group rocks are intruded by granite pegmatite and quartz veins of different generations (Siddiquie, 2004).PitchaiMuthu (1990) previously reported corundum-bearing sillimanite schists in the Mansar formation from the Tirodi area.

The lithological ensemble of the Bhandara-Balaghat granulite (BBG) domain is subdivided into 4 distinct components: (i) a large migmatitic felsic gneiss terrain, locally with garnet, (ii) enclaves or isolated bands of garnet-cordierite gneiss, BIF, quartzite, corundum-bearing and felsic granulite within the Tirodi gneisses, (iii) a mafic-ultramafic magmatic suite of metagabbro-metanorite and gabbro metanorite and metaorthopyroxenite, occurring as concordant sheets in the felsic gneisses, and (iv) metabasic dykes and amphibolites. The gabbroic suite of rocks is particularly dominant in the southern part of the BBG domain where it is interlayered with felsic and aluminusgranulites. By contrast, norites and meta-orthopyroxenites are quite common in the northern part where they are associated with garnet-cordierite gneiss (Sharma, R.S., 2009)

Coglomerates and pebbly grits are the most prominent outcrops forming the bottommost member of the Sausar Group in the Bharweli mine, which also shows effects of intense crushing and mylonitisation and represents a thrust zone. Conglomerate contains small rounded to sub rounded pebbles of quartz and fresh pink orthoclase, plagioclase and tourmaline, large microcline and albite (Siddiquie et. al., 2015).At most of the places the conglomerate bed comprises boulders (40-50 cm) of granites, gneisses and slates derived fromlocal lithology. The dominant minerals of the boulders are quartz, orthoclase, plagioclase and tourmaline at some places. Beautiful crystals of corundum are also seenin the conglomerates of the Mansar formation at one place. The crystals of corundum are ofalmond size and deep violet in colour, concentrated along the NNE flank of canal in Malegaon Magjin, Bharweli mine area.

VI. Acknowledgements

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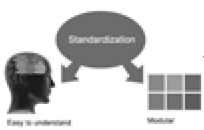

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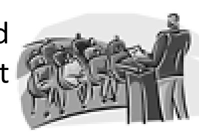

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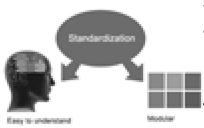

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Author Guidelines:

1. General,

2. Ethical Guidelines,

3. Submission of Manuscripts,

4. Manuscript’s Category,

5. Structure and Format of Manuscript,

6. After Acceptance.

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- As always, give awareness to spelling, simplicity and correctness of sentences and phrases.

Procedures (Methods and Materials):

This part is supposed to be the easiest to carve if you have good skills. A sound written Procedures segment allows a capable scientist to replacement your results. Present precise information about your supplies. The suppliers and clarity of reagents can be helpful bits of information. Present methods in sequential order but linked methodologies can be grouped as a segment. Be concise when relating the protocols. Attempt for the least amount of information that would permit another capable scientist to spare your outcome but be cautious that vital information is integrated. The use of subheadings is suggested and ought to be synchronized with the results section. When a technique is used that has been well described in another object, mention the specific item describing a way but draw the basic principle while stating the situation. The purpose is to text all particular resources and broad procedures, so that another person may use some or all of the methods in one more study or referee the scientific value of your work. It is not to be a step by step report of the whole thing you did, nor is a methods section a set of orders.

Materials:

- Explain materials individually only if the study is so complex that it saves liberty this way.
- Embrace particular materials, and any tools or provisions that are not frequently found in laboratories.
- Do not take in frequently found.
- If use of a definite type of tools.
- Materials may be reported in a part section or else they may be recognized along with your measures.

Methods:

- Report the method (not particulars of each process that engaged the same methodology)
- Describe the method entirely
- To be succinct, present methods under headings dedicated to specific dealings or groups of measures
- Simplify - details how procedures were completed not how they were exclusively performed on a particular day.
- If well known procedures were used, account the procedure by name, possibly with reference, and that's all.

Approach:

- It is embarrassed or not possible to use vigorous voice when documenting methods with no using first person, which would focus the reviewer's interest on the researcher rather than the job. As a result when script up the methods most authors use third person passive voice.
- Use standard style in this and in every other part of the paper - avoid familiar lists, and use full sentences.

What to keep away from

- Resources and methods are not a set of information.
- Skip all descriptive information and surroundings - save it for the argument.
- Leave out information that is immaterial to a third party.

Results:

The principle of a results segment is to present and demonstrate your conclusion. Create this part a entirely objective details of the outcome, and save all understanding for the discussion.

The page length of this segment is set by the sum and types of data to be reported. Carry on to be to the point, by means of statistics and tables, if suitable, to present consequences most efficiently.You must obviously differentiate material that would usually be incorporated in a study editorial from any unprocessed data or additional appendix matter that would not be available. In fact, such matter should not be submitted at all except requested by the instructor.

Content

- Sum up your conclusion in text and demonstrate them, if suitable, with figures and tables.
- In manuscript, explain each of your consequences, point the reader to remarks that are most appropriate.
- Present a background, such as by describing the question that was addressed by creation an exacting study.
- Explain results of control experiments and comprise remarks that are not accessible in a prescribed figure or table, if appropriate.
- Examine your data, then prepare the analyzed (transformed) data in the form of a figure (graph), table, or in manuscript form.

What to stay away from

- Do not discuss or infer your outcome, report surroundings information, or try to explain anything.
- Not at all, take in raw data or intermediate calculations in a research manuscript.
- Do not present the similar data more than once.
- Manuscript should complement any figures or tables, not duplicate the identical information.
- Never confuse figures with tables - there is a difference.

Approach

- As forever, use past tense when you submit to your results, and put the whole thing in a reasonable order.
- Put figures and tables, appropriately numbered, in order at the end of the report
- If you desire, you may place your figures and tables properly within the text of your results part.

Figures and tables

- If you put figures and tables at the end of the details, make certain that they are visibly distinguished from any attach appendix materials, such as raw facts
- Despite of position, each figure must be numbered one after the other and complete with subtitle
- In spite of position, each table must be titled, numbered one after the other and complete with heading
- All figure and table must be adequately complete that it could situate on its own, divide from text

Discussion:

The Discussion is expected the trickiest segment to write and describe. A lot of papers submitted for journal are discarded based on problems with the Discussion. There is no head of state for how long a argument should be. Position your understanding of the outcome visibly to lead the reviewer through your conclusions, and then finish the paper with a summing up of the implication of the study. The purpose here is to offer an understanding of your results and hold up for all of your conclusions, using facts from your research and generally accepted information, if suitable. The implication of result should be visibly described. Infer your data in the conversation in suitable depth. This means that when you clarify an observable fact you must explain mechanisms that may account for the observation. If your results vary from your prospect, make clear why that may have happened. If your results agree, then explain the theory that the proof supported. It is never suitable to just state that the data approved with prospect, and let it drop at that.

- Make a decision if each premise is supported, discarded, or if you cannot make a conclusion with assurance. Do not just dismiss a study or part of a study as "uncertain."
- Research papers are not acknowledged if the work is imperfect. Draw what conclusions you can based upon the results that you have, and take care of the study as a finished work
- You may propose future guidelines, such as how the experiment might be personalized to accomplish a new idea.
- Give details all of your remarks as much as possible, focus on mechanisms.
- Make a decision if the tentative design sufficiently addressed the theory, and whether or not it was correctly restricted.
- Try to present substitute explanations if sensible alternatives be present.
- One research will not counter an overall question, so maintain the large picture in mind, where do you go next? The best studies unlock new avenues of study. What questions remain?
- Recommendations for detailed papers will offer supplementary suggestions.

Approach:

- When you refer to information, differentiate data generated by your own studies from available information
- Submit to work done by specific persons (including you) in past tense.
- Submit to generally acknowledged facts and main beliefs in present tense.

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Introduction	Containing all background details with clear goal and appropriate details, flow specification, no grammar and spelling mistake, well organized sentence and paragraph, reference cited	Unclear and confusing data, appropriate format, grammar and spelling errors with unorganized matter	Out of place depth and content, hazy format
Methods and Procedures	Clear and to the point with well arranged paragraph, precision and accuracy of facts and figures, well organized subheads	Difficult to comprehend with embarrassed text, too much explanation but completed	Incorrect and unorganized structure with hazy meaning
Result	Well organized, Clear and specific, Correct units with precision, correct data, well structuring of paragraph, no grammar and spelling mistake	Complete and embarrassed text, difficult to comprehend	Irregular format with wrong facts and figures
Discussion	Well organized, meaningful specification, sound conclusion, logical and concise explanation, highly structured paragraph reference cited	Wordy, unclear conclusion, spurious	Conclusion is not cited, unorganized, difficult to comprehend
References	Complete and correct format, well organized	Beside the point, Incomplete	Wrong format and structuring

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