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Environmental Challenges And The Impact Of Desertification On Vegetal Cover In Parts Of Jigawa State, Nigeria

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Abstract: Desertification describes circumstances of land degradation in arid, semi-arid and dry sub-humid regions resulting from the climatic variation and human activities. The present threat of desertification in the sahel region of Nigeria has reached an alarming stage where crops cultivation and animal rearing/grazing are no more productive. The objectives of the research paper were to map out and analyse the land cover changes at a scale 1: 100,000 from the satellite images of 1986, 1999 and 2009; to establish and appraise the relationship between rainfall and temperature on desertification and to assess the role of human activities to desertification of the study area. The materials and methods used included LandSat TM and ETM of various time periods, climate parameters of rainfall and temperature (i.e. forty-five years rainfall and temperature data) and data were also acquired from oral and written questionnaire administered. The data obtained from research questionnaire were analyzed using the SPSS. The study employed both descriptive and inferential statistical analyses to get frequency distribution tables, percentages to determine the proportion of the variables, and the variables were tested using correlation and chi-square contingency. The result of the investigation has revealed the extent (the rate of change) vis-à-vis desertification of the study area. The result of the human factor has remained the major cause of desertification. Most of the arable land had been over-cultivated and also the land reserved for animal grazing had been subsumed by farmers leaving no portion for animal grazing. Most of the trees are either cut down for crop cultivation or titled as means for cooking fuel. In conclusions anthropogenic and climatic factors are the principal causes of desert encroachment in Jigawa State. The desertification has led to sand encroachment and to accelerated development of dunes. The area has also been subjected to a vegetation cover transformation. Pastures have deteriorated in quality and quantity, but in many parts, the degradation is still reversible if land use is organized.

Keywords: Landsat Imageries, Desert encroachment, Land use, Climate Parameters and Windstorm

I. Introduction

Desertification of the arid lands of the world has been proceeding sometimes rapidly and sometimes slowly for more than a thousand years. It has caused untold misery among those most directly affected, yet environmental destruction continues. Until recently, few if any lessons seemed to have been learned from the past, in part because the problem was an insidious one that went unrecognized in its early stages or was seen as a local one affecting only a small population, and in part because new land was always available to start over again. As long as remedial action could be deferred by moving on to new frontiers, land conservation had little appeal. It was not until the last quarter of 20th century when easy land expansion came to an end that governments and people finally realized that continued careless degradation of natural resources threatened their future.

Study Area

Jigawa State is one of thirty-six States that constitute Federal Republic of Nigeria. It is situated in north-western part of the country between Latitudes 11.00°N to 13.00°N and Longitudes 8.00°E to 10.15°E. Kano State and Katsina State border Jigawa to the west, Bauchi State to the east and Yobe State to the northeast. To the north, Jigawa shares an international border with Zinder Region in The Republic of Niger, which is a unique opportunity for cross-border trading activities. Government readily took advantage of this by initiating and establishing a Free-Trade Zone at the Border town of Maigatari.

The State has a total land area of approximately 22,410 square kilometres. Its topography is generally characterized by undulating land, with sand dunes of various sizes spanning several kilometres in parts of the State. The southern part of Jigawa comprises the Basement Complex while the northeast is made up of sedimentary rocks of the Chad Formation.



Figure 1: Map of Jigawa Showing the Study Area

Source: Geography Department of Federal University of Technology Minna (2010)

The objective of this paper is to establish and to examine the relationship between rainfall and temperature as a causative factor of desertification. And to look at the effects of human activities also.

II. Conceptual And Theoretical Framework

Concepts and definitions

Desertification is a single word used to cover a wide variety of effects involving the actual and potential biological productivity of an ecosystem in the arid, semi-arid and dry sub-humid regions (Hillel and Rosenzweig, 2002). Le Houérou (1977) used the term 'desertization' to define the extension of typical desert landscapes and landforms to areas where they did not previously occur in the recent past. This process most often takes places in arid zones bordering the deserts with average annual rainfall of 100 to 200 mm.

The word 'desertification' is used to describe degradation of various types and forms of vegetation, including sub-humid and humid forest areas. It gained popularity following the severe drought that afflicted the Sahelian regions in Africa from the late 1960s to 1970s and again in the 1980s. During the period from 1958 to 1975 the mean annual rainfall diminished by nearly 50%, and the boundary between the Sahara and the Sahel shifted southward by nearly 100 km (Lamprey, 1975).

Assessing the Indicators of Desertification Using Remote Sensing

According to Enne (2000), the process of desertification manifests in many ways which could be used to assess the magnitude of degradation as also the vulnerability of an ecosystem to desertification. By indicator is meant something that provides information about the condition being investigated (FAO/UNEP, 1984).

Northern Nigeria and the Advancing Desertification

According to Nasiru (2003) Desertification as defined by Agenda 21 is the degradation of land in arid, semi-arid and sub-humid dry areas caused mainly by climatic changes and human activities. It is accompanied by a reduction in the natural potentials of the land, and depletion in surface and ground water resources. But above all, it has negative repercussions on the living conditions and the economic development of the people affected by it. Desertification affects about one sixth of the world's population, 70% of all drylands, amounting to 3.6 billion hectares, and one quarter of the total land area of the world. In Nigeria the dryland part of the country are more prone to desertification. This zone forms an undulating plain at a general elevation from about 450m to 700m. More than half of the region is covered by ferruginous tropical soils which are highly weathered and markedly laterised. A large proportion of the region is also characterized by sandy-fixed undulating topography.

The Impact of Desertification on Vegetation

According Wessels, (2006) Advanced Very High Resolution Radiometer (AVHRR), Normalized Difference Vegetation Index data (NDVI, 1 km², 1985–2003) and modeled net primary production (NPP, 8 km², 1981–2000) data were used to estimate vegetation production in South Africa (SA). The linear relationships of Log.Rainfall with NPP and Σ NDVI were calculated for every pixel. Vegetation production generally had a strong relationship with rainfall over most of SA. Therefore, human-induced land degradation can only be detected if its impacts on vegetation production can be distinguished from the effects of rainfall.

III. Research Methodology

Research Design

This chapter deals with the types of data collected and method of data analysis. The research methodology is very crucial in determining the success of any scientific investigation. All the methods used in this research are determined by the objectives of the study.

Data collection

Data and information used for this study were collected from two main sources: The Primary and secondary sources.

The primary sources of data included data on rainfall and temperature which will help in achieving objective three (3) of this study. The first part of this section addresses objective 3 of seeking to assess the contributions of human activities to desertification in the area.

The secondary sources include consultation of various literature like books, internets, written publications or materials on the study area and other related project work.

Survey technique

A reconnaissance field survey was conducted during the period of this study by visits to a number of villages and livestock watering points, which are sites used by nomads during the dry period. All field trips were accomplished before the peak rainy season (mid-August), in order to avoid difficulties of travel. Questionnaires and open discussions were used at randomly selected villages. This was in an attempt to cover as many villages as possible in order to get a broad view about the current perception of the nomads and farmers concerning the changes in the vegetative cover and climate factors.

Data Acquisition

Landsat Thematic Mapper (TM) and Landsat Enhanced Thematic Mapper (ETM+) system have been successfully used in the mapping of land use and land cover map of the different parts of the earth surface. Thus, for this study, Landsat TM (Thematic Mapper) and ETM+ (Enhanced Thematic Mapper) satellite imagery

was acquired from Global Land Cover Facility (GLCF). The study area (Jigawa) cut – across twelve (12) different scenes on both the TM and ETM+ satellite imagery data.

Table 1: Satellite Imagery used in the Study

S/N	Data Type	Acquired Date	Pixels Size	Data Source
1	Landsat (TM)	1986 – 10 – 20	30m	GLCF
2	Landsat (ETM+)	1999 – 11 – 17	28m	GLCF
3	Landsat (ETM+)	2009 – 08 – 04	28m	GLCF

Source: Field Work, 2010

IV. Method of Data Analysis

The data obtained from the survey research questionnaire on the assessment of some impacts of desertification on vegetal cover and land use in Jigawa was analyzed using Statistical Package for Social Sciences (SPSS). The study employed both descriptive and inferential statistical analyses to get frequency and distribution tables for better understanding, percentages to determine the proportions of the variables and different pairs of variables formulated were tested using correlation and chi-square contingency table. The results of descriptive method employed by the study consisted of frequency classification of data in tables. The results of such classifications as well as bar charts were also given.

Correlation Analysis provides statistical information on whether two variables come from two similar or different populations or area of study. Where the P-value is less than the significance level (α), the independent variable does exert influence on the dependent variable. The application of statistical techniques within this study was guided by certain criteria. These were as follows:

- (i) the P-value for the selected test statistic
- (ii) the level of probability used

V. Results And Discussion

Land Cover Changes around the Study Areas

The objectives of this study forms the basis of all the analysis carried out. The results are presented in the form of classified maps, statistical tables. The results of the satellite image analysis in Figure 2 address objective 1 of the study, which states to map and analyze land image of the 3 time periods 1986, 1999 and 2009.

Jigawa State Land Cover in 1986

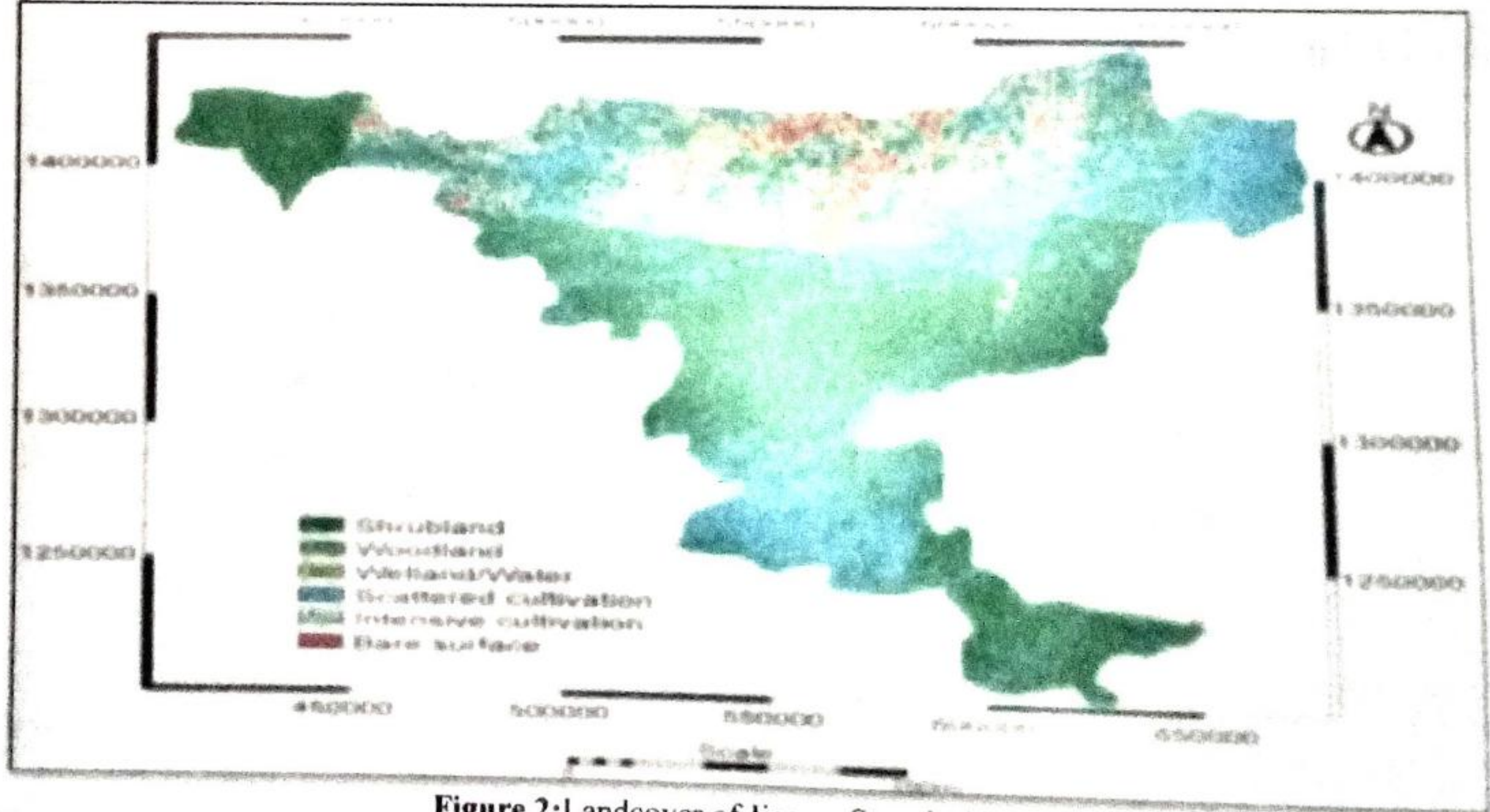


Figure 2: Landcover of Jigawa State in 1986

Source: Field Work, (2010)

Figure 2 illustrates the various Landcover classification of Jigawa State in 1986. It further reveals the areas covered by each category, for example, intensive cultivation, scattered cultivation and woodland has more than 43% of the total Landcover. Bare surface has 3,057.04km² that is about 12.8% and Shrubland has 7,377.35km² making 31%. Water bodies/wetland has 11% (2,662.12km²).

Table 2: Jigawa State Landcover Statistics in 1986

Landcover Type	Sq. km	Percentage (%)
Wetland/Water	2662.129	11.19
Woodland	2112.574	8.88
Scattered cultivation	5336.153	22.43
Shrubland	7377.357	31.01
Intensive cultivation	3244.99	13.64
Bare surface	3057.047	12.85

Source: Field Work, 2010

Table 2 is the statistical analysis of Figure 2. Table 2 reveals the rate of areal coverage of each category. For example, water bodies has 11.19%, woodland 8.8%, scattered cultivation 22.4%, shrubland 31%, intensive cultivation has 13.64% and lastly bare surface/sand dune has 12.85%.

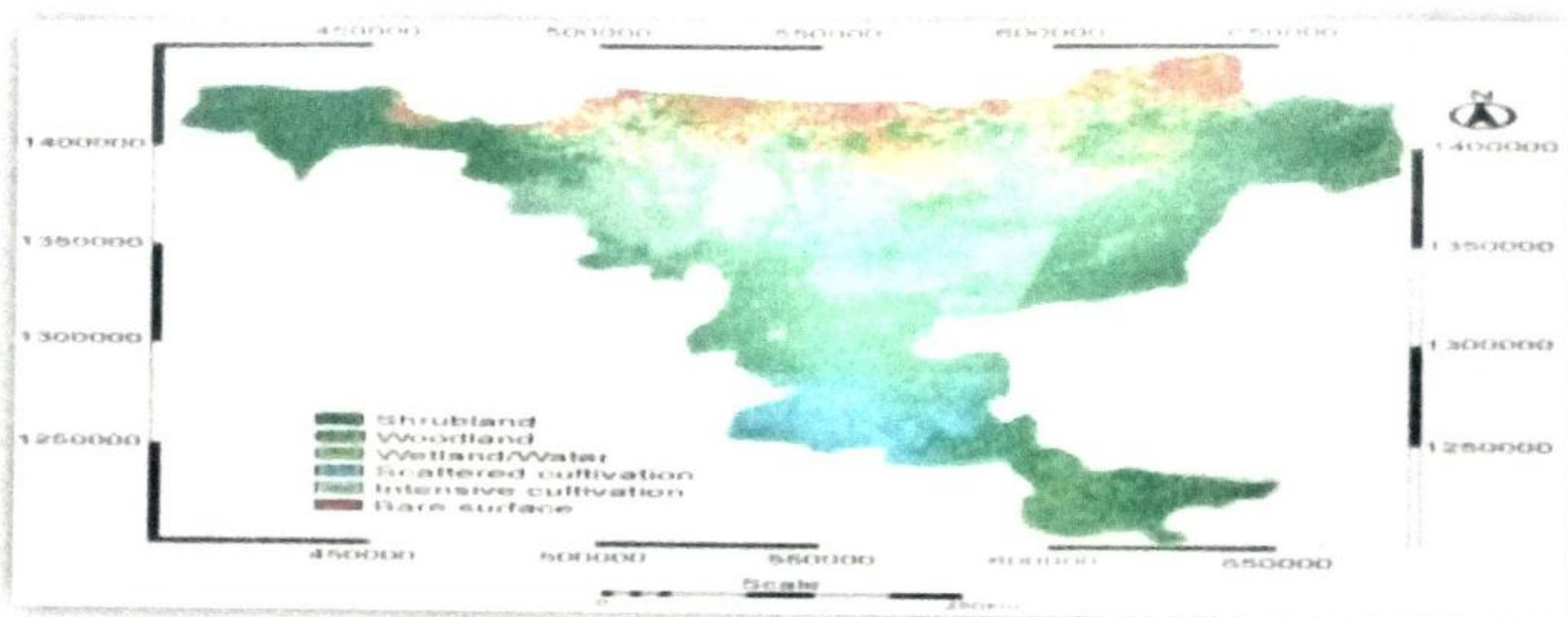


Figure 3: Landcover of Jigawa State in 1999

Source: Field Work, (2010)

Table 3: Jigawa State Landcover Statistics in 1999

Landcover Type	Sq. km	Percentage (%)
Wetland/Water	2181.566	9.17
Woodland	1467.859	6.17
Scattered cultivation	4313.173	18.13
Shrubland	6092.683	25.61
Intensive cultivation	3190.273	13.41
Bare surface	6544.698	27.51

Source: Field Work, (2010)

Figure 3 illustrates the Landcover area of Jigawa State in 1999. Bare surface has 6544.69km² making 27.51%. It has increased by about 15%, while water bodies have decreased from 2662km² to 2181.5km² i.e. about 2% decrease. Others like Shrubland and woodland have diminished from 7377km² to 6092km² and from 2112km² to 1467km². Also, intensive and scattered cultivation have decreased. Table 3 is showing the statistical analysis of Figure 3 level by level.

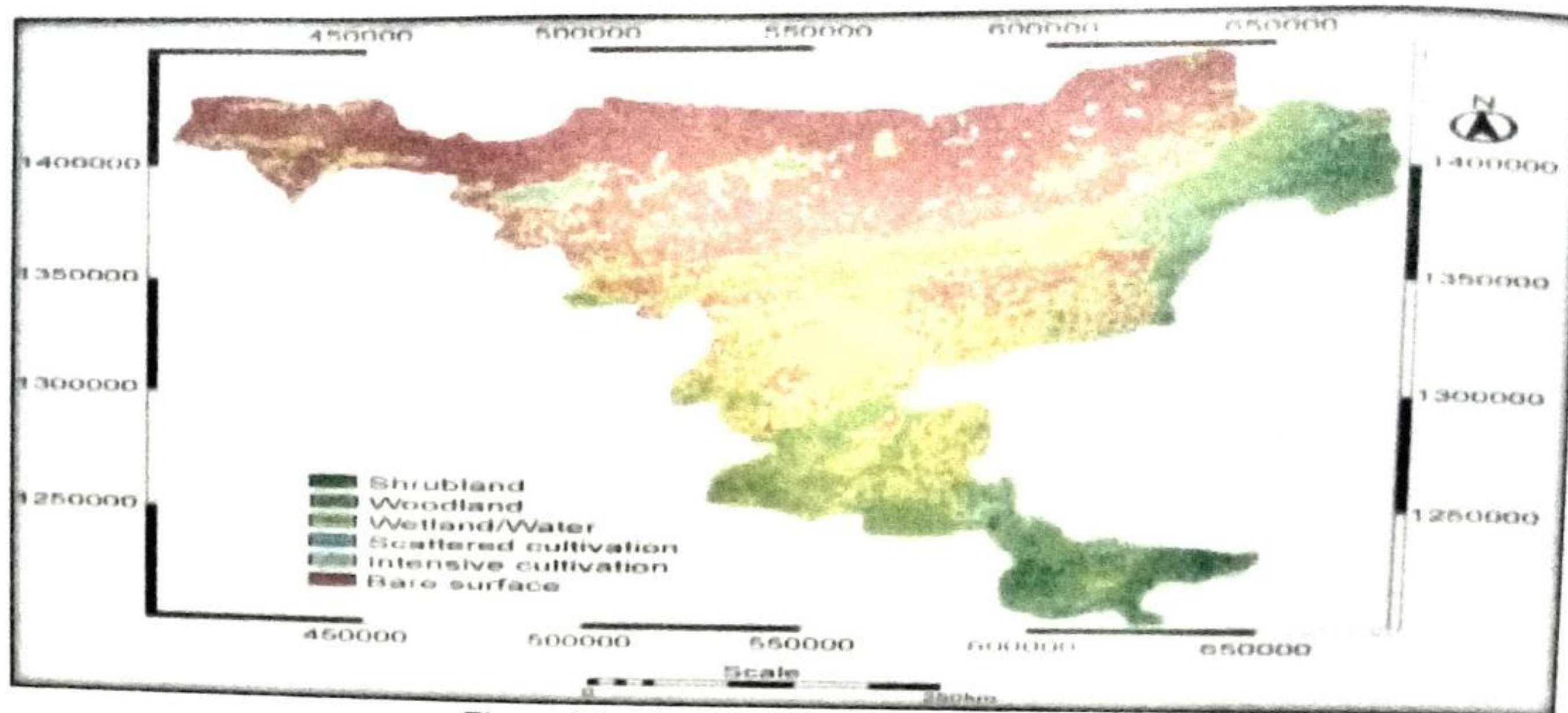


Figure 4: Landcover of Jigawa State in 2009

Source: Field Work, (2010)

Table 4: Jigawa State Landcover Statistics in 2009

Landcover Type	Sq. km	Percentage (%)
Wetland/Water	1577.294	6.63
Woodland	953.9891	4.01
Scattered cultivation	6825.423	28.69
Shrubland	4358.374	18.32
Intensive cultivation	1693.866	7.12
Bare surface	8381.306	35.23

Source: Field Work, (2010)

Table 4 describes Jigawa State landcover statistics in 2009. There is an increase in the bare surface from 27% in 1999 to 35% in 2009. With the figures in 1999 at 6544.70km² to 8381.31km² in 2009. There is a decrease in water bodies and the woodland. It is an indication that the rivers and lakes are shrinking and the woodland are diminishing due to human activities.

Table 5: Summary of Landcover for Jigawa State in 1986, 1999 and 2009

LANDCOVER TYPE	YEARS			DIFFERENCE	
	1986	1999	2009	1986/1999	1999/2009
Wetland/Water	2662.129	2181.566	1577.294	-480.563	-604.272
Woodland	2112.574	1467.859	953.9891	-644.715	-513.87
Scattered cultivation	5336.153	4313.173	6825.423	-1022.98	2512.25
Shrubland	7377.357	6092.683	4358.374	-1284.67	-1734.31
Intensive cultivation	3244.99	3190.273	1693.866	-54.717	-1496.41
Bare surface	3057.047	6544.698	8381.306	3487.651	1836.608

Source: Field Work, (2010)

Table 5 is the summary of Landcover for Jigawa State in 1986, 1999 and 2009. The summary shows the various classification levels between 1986, 1999 and 2009 with the difference in land area between 1999 and 1986 and 2009 and 1999. The difference in the bare surfaces in 1986 and 1999 is 3487.65km² representing 27.5% and that of 1999 and 2009 is 1836.60km² making it 35.2%.

Analysis of Results of Rainfall and Temperature in Jigawa State as a Factor of Desertification

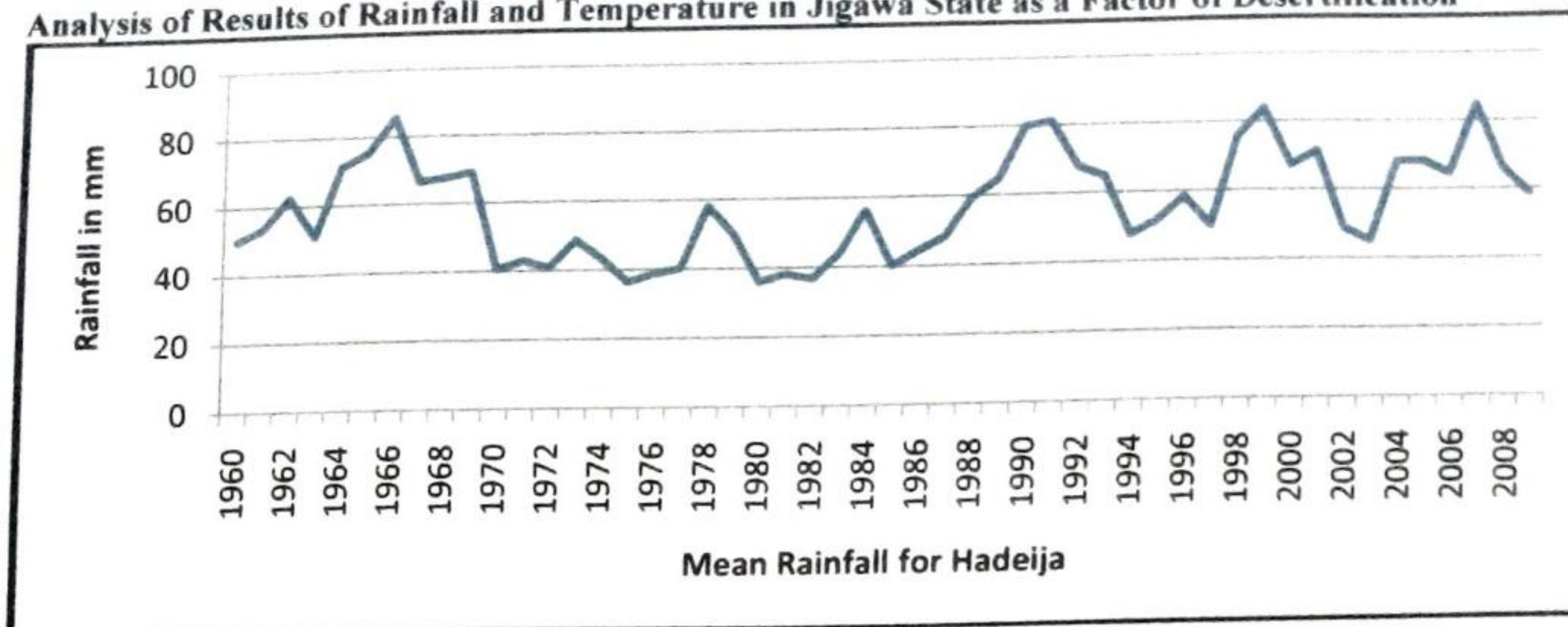


Figure 5: Mean Rainfall for Hadeija

Source: Field Work, (2010)

Figure 5 illustrates the mean rainfall for Hadeija Station. The mean rainfall of Hadeija also confirms the dryness of the area between 1970 – 1989. It also shows that from 2002 there was more rainfall and thereby sustaining agric and livestock holdings.

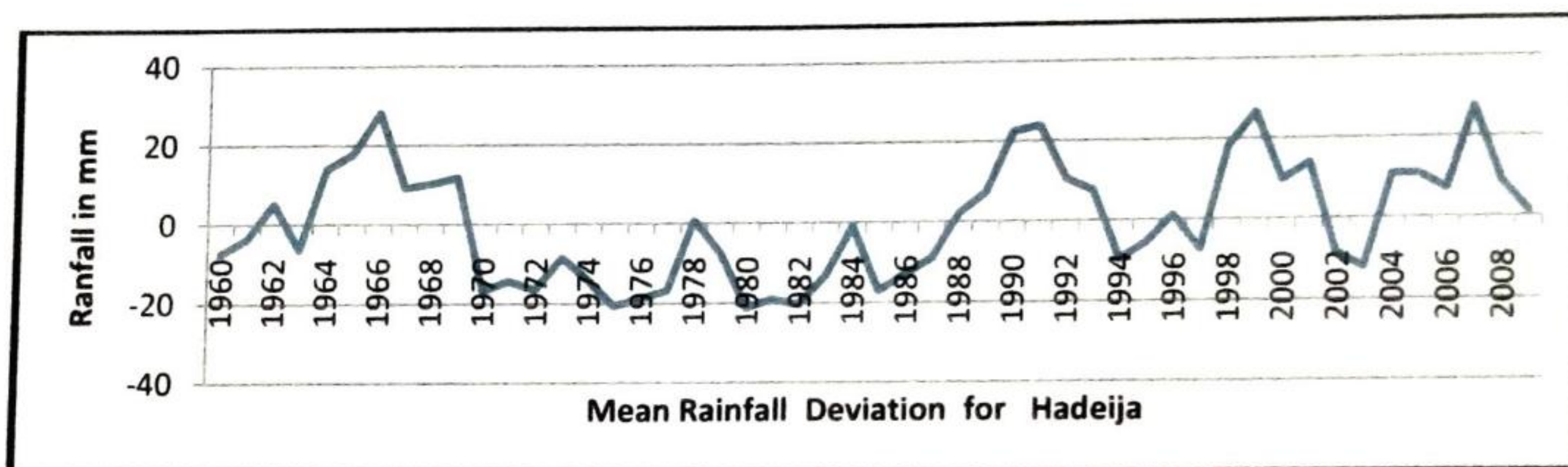


Figure 6: Mean Rainfall Deviation for Hadeija

Source: Field Work, (2010)

Figure 6 illustrates the mean rainfall deviation for Hadeija Station. There was abundant rainfall from 1998 – present except in the 2002 when there was shortfall of rainfall. The implication is that drought/dryness of the area between 1970 – 1988 has vanished and replaced by wetness.

Figure 7 illustrates the total rainfall for Dutse Station. This figure shows that there was rainfall deficit from 1972 – 1990 and this confirms the total rainfall for the study area (Dutse). There was rainfall surplus from 1992 to 2010. In Dutse and its immediate environment experiences pretty good rainfall, except for areas in the Northern parts of Jigawa State. For instance, Maigatari, Gwiwa, Guri and SuleTankarkar are very dry and experiencing low rainfall.

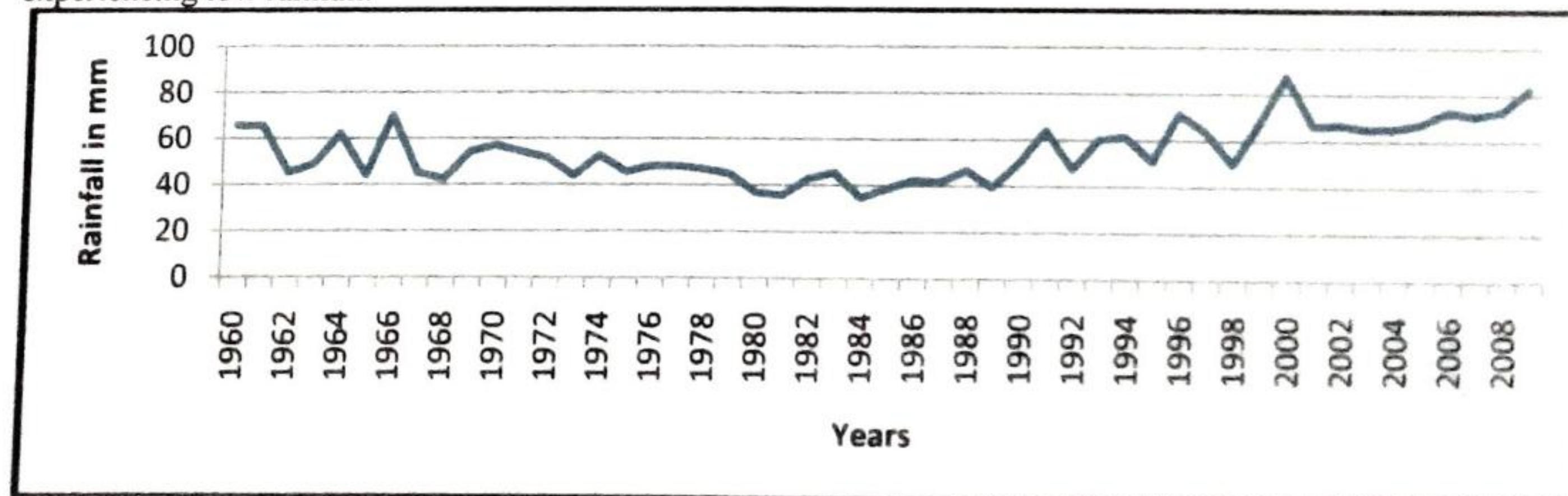


Figure 7: Mean Rainfall for Dutse

Source: Field Work, (2010)

Figure 7 illustrates the mean rainfall for Dutse Station. It further shows the simplification in the mean deviation which gives the precipitation index. From 1998 to date, there was enough precipitation in the central and southern Jigawa State.

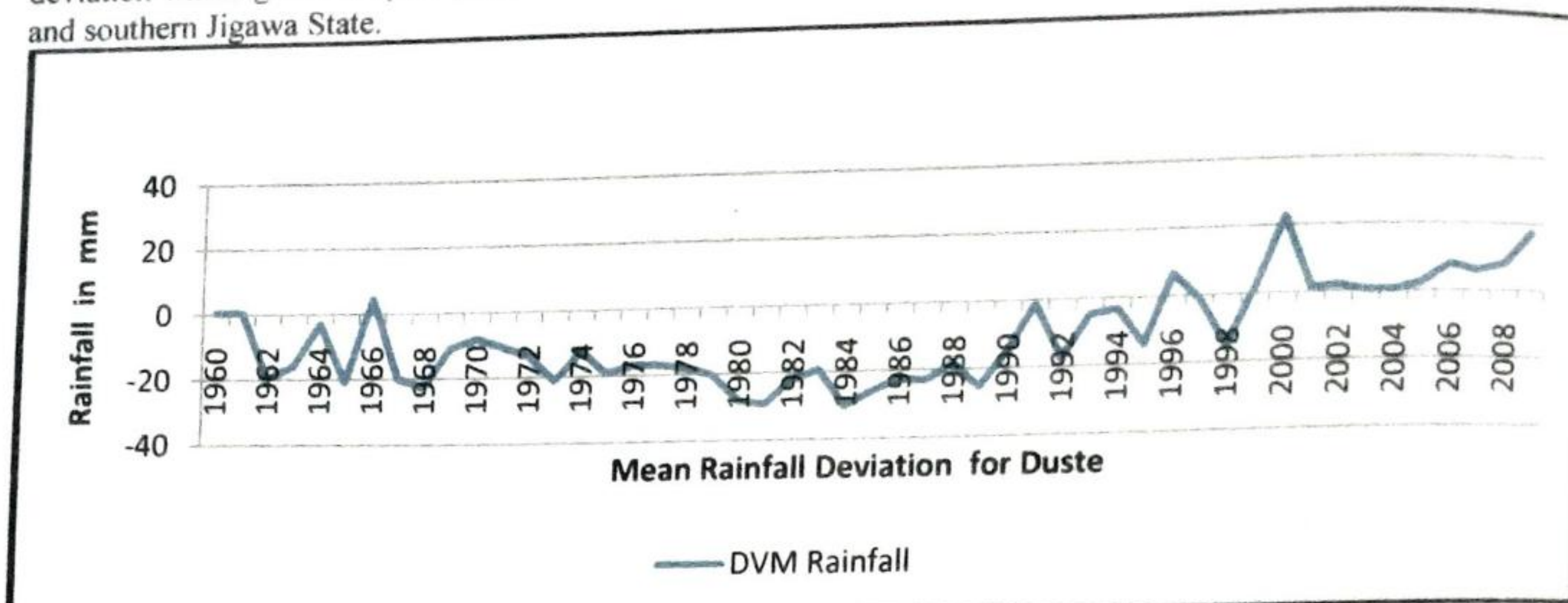


Figure 8: Mean Rainfall Deviation for Dutse

Source: Field Work, (2010)

Figure 8 illustrates the mean rainfall deviation for Dutse Station. This has shown that there has been rainfall deficit in Dutse from 1968 to 1997. This has helped in the aggravation of desertification of the study area. Except recently from year 2000 to present, rainfall has been above mean and thus, helps in regreening of the lost vegetation. Even between 1998 and 2009, the rainfall surplus is not only in Dutse and its surrounding but in the extreme North of Jigawa bordering Niger Republic.

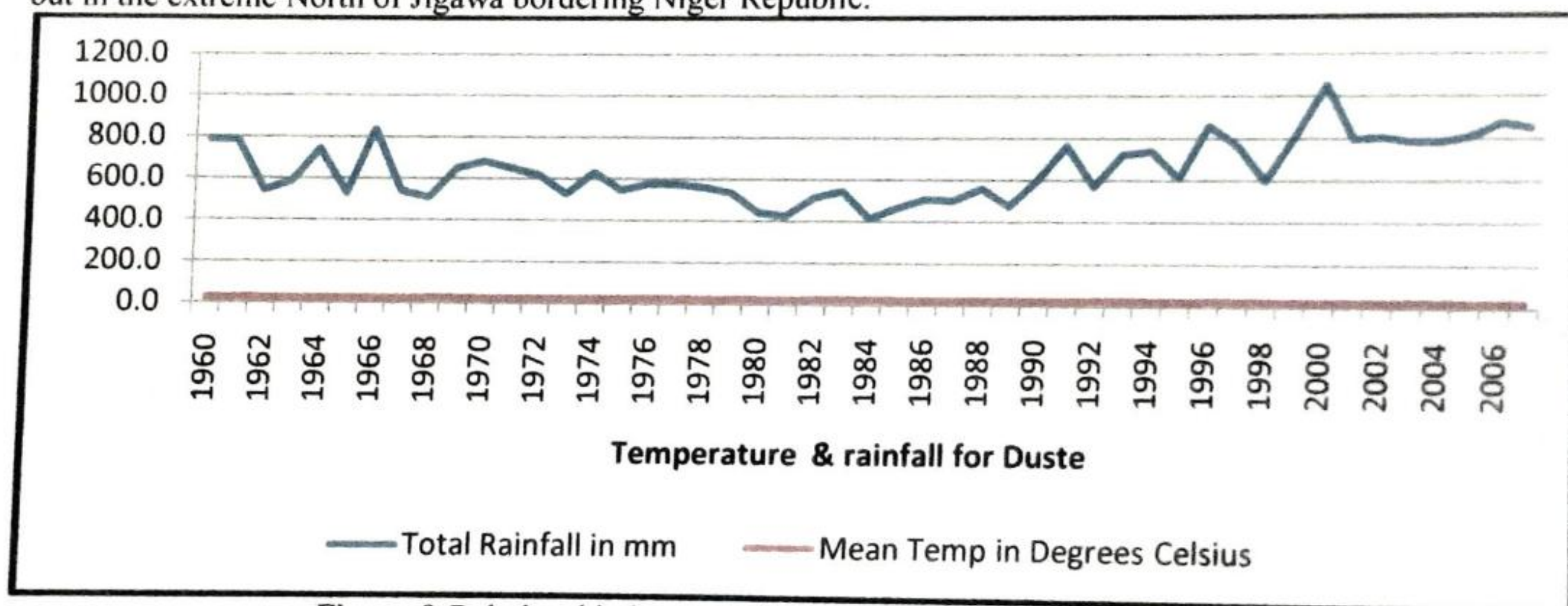


Figure 9: Relationship between Temperature and Rainfall for Dutse

Source: Field Work, (2010)

Figure 9 shows the relationship between the two parameters, there are moderate temperatures between 2000 to 2009, with rainfall above 750mm per annum. This is in Dutse and environs, but areas like Sule Tankarkar and Maigatari, the story is different with low rainfall and high temperatures.

Table 6 provides a summary of cross tabulation for rating of crop cultivation as a problem in the study area and the changes in land use. The changes in the land use brought by crop cultivation rated 'poor' has the highest frequency of 40 representing 50.0%, followed by those brought by crop cultivation rated 'very poor' with a frequency of 25 representing 31.3% while those brought by crop cultivation rated 'good' has the least frequency of 2 accounting for about 2.5%. In contrast, it is also clear from the table that no changes in the land use resulting from crop cultivation rated 'very poor' and 'poor' have a frequency of 2 representing approximately 50.0% each while no changes in the land use coming from crop cultivation rated as 'good' and 'very good' have a frequency of 0 accounting for 0.0% each.

Table 6: Cross Tabulation for rating of crop cultivation as a problem in the study area and the changes in land use

Rating of crop cultivation as a problem in the study area		Changes in land use				Total (%)
		Agree	%	Disagree	%	
Rating of crop cultivation as a problem in the study area	Very Poor	25	31.3	2	50.0	27 (32.1)
	Poor	40	50.0	2	50.0	42 (50.0)
	Good	13	16.2	0	0.0	13 (15.5)
	Very Good	2	2.5	0	0.0	2 (2.4)
Total		80	100.0	4	100.0	84 (100.0)

Source: Field Work (2011)

Table 7 provides a summary of Spearman's Correlation Analysis to test the relationship between rating of crop cultivation as a problem in the study area and changes in land use. The analysis suggests a strong positive relationship between rating of crop cultivation as a problem in the study area and changes in land use. The p-value of 0.001, which is less than α (0.05), shows that there is a significant relationship between these variables.

Table 7: Chi-Square tests for rating of crop cultivation as a problem in the study area and changes in land use

	Value	df	Asymp. Sig. (2-sided)	Sig.
Pearson Chi-Square	1.167 ^a	3	.761	
Likelihood Ratio	1.822	3	.610	
Linear-by-Linear Association	1.081	1	.299	0.001
N of Valid Cases	84			

a. 5 cells (62.5%) have expected count less than 5. The minimum expected count is .10.

Source: Field Work (2011)

Table 8 gives a summary of cross tabulation for rating of animal grazing as a problem in the study area and changes in land use. That the changes in the land use brought by animal grazing rated 'poor' has the highest frequency of 44 representing 57.1%, followed by those brought animal grazing rated 'poor' with a frequency of 20 representing 26.0% while those brought by animal grazing rated 'very poor' has the least frequency of 20 accounting for about 26.0%. In contrast, it is also understandable from the table that no changes in the land use arising from animal grazing rated 'poor' has a frequency of 3 representing approximately 75.0% followed by no changes in the land use coming from animal grazing rated as 'very poor' has a frequency of 1 accounting for 25.0% each. No changes in the land use arising from animal grazing rated 'good' and 'very good' have the same frequency of 0 representing approximately 0.0%.

Table 8: Cross Tabulation for rating of animal grazing as a problem in the study area and changes in land use

Rating of animal grazing as a problem in the study area		Changes in land use				Total (%)
		Agree	%	Disagree	%	
Rating of animal grazing as a problem in the study area	Very Poor	20	26.0	1	25.0	21 (25.9)
	Poor	44	57.1	3	75.0	47 (58.0)
	Good	12	15.6	0	0.0	12 (14.8)
	Very Good	1	1.3	0	0.0	1 (1.3)
Total		77	100.0	4	100.0	81 (100.0)

Source: Field Work (2011)

Table 9: Chi-Square Tests for rating of animal grazing as a problem in the study area and changes in land use

	Value	df	Asymp. Sig. (2-sided)	Sig.
Pearson Chi-Square	.886 ^a	3	.829	
Likelihood Ratio	1.510	3	.680	0.000
Linear-by-Linear Association	.247	1	.619	
N of Valid Cases	81			

a. 5 cells (62.5%) have expected count less than 5. The minimum expected count is .05.

Source: Field Work (2011)

VI. Summary And Conclusion

Generally, a number of factors have increased degradation and the vulnerability of the semi-arid region to desertification. Increased sedentary population and pressures on cultivated land have led to a shortening of the fallow period in the shifting cultivation cycle and the extension of cropping into the more precarious drier regions. Crop harvests became less reliable and more variable as the desert edge was approached.

Over-grazing inadvertently was made worse, particularly in the sahel, as forage conditions became deteriorated at the northern parts of the study area. Local authorities did not or could not impose a control system that would allow forage plants to recover from heavy grazing.

Solutions to desertification problems in Nigeria are known and in general can be implemented readily if resources are available to do so. Due to the exploding population in the developing countries, land pressures will continue to build. There is little likelihood that marginal dry farmlands will be returned to pastoral use unless production on the better lands is increased enough to offset the loss of cultivated land.

Destruction of woody vegetation has been hastened by the ever-increasing need for firewood to meet the demands of the larger population. The destruction is especially noticeable around the rapidly growing urban centers, where the circle of deforested lands gets larger every year (Delwaulle, 1973). While desertification was a long-standing problem even in the absence of droughts, the gradually increasing vulnerability of the land made the impact of the inevitable droughts worse than ever (Dahl and Hjort, 1979). The factors responsible for that vulnerability are still operating and therefore, desertification is continuing. The researcher will conclude with a West African adage: "Poor people make poor land and poor land makes poor people".

Satellite Image Result: It is addressing objective one (1) of the research, Figure 2 shows the extent of Landcover in the study area in 1986 and Table 2 shows the statistical analysis of each classified landuse. In the Table 3 wetland/water bodies has 16342.80km². Wood land has 18462.20km² of area coverage. Both cultivation, scattered and intensive account for 47,140.87km² while, Bare surface/sand dunes has 19,743km². This was the extent of the land cover in the study area (Jigawa State).

Figure 3 indicates the overall Landcover of the study area in 1999 as shown by satellite image of 1999. Table 3 indicates statistics of the land cover area of figure 3. It shows that wetland/water bodies have diminished from 16,342.81km² to 11,948.50km². This could be attributed to climate change that is affecting the water bodies. The data on rainfall shows that there is more rainfall in the 1990s to present than in the 1980s. Another factor to this drying up of most water bodies in the study area could be as a result of desert-like conditions that are fast spreading from Niger Republic which is sharing border with the study area. Table 3 further revealed that the woodland has reduced from 18462.20km² to 11694.50km². Scattered cultivation has also declined from 33443.47km² to 11694.5km² while intensive cultivation has increase from 13697.40km² to 21273.6km². Here there is declined in the scattered cultivation because of the drying of the water bodies/wetland. While there is increase in the intensive cultivation sector as a result of attention being diverted to irrigation agriculture. The farming is mostly intensive at the riverine areas; where irrigation is intensively practiced. For example in Hadejia-Jamaare river Basin. The Bare surface/sand dunes have increased from 19,743km² in 1986 to 29,747km² in 1999. This has shown that the study area is becoming drier with more Landcover giving up for desertification.

Figure 4 revealed the extent of desert encroachment of the study area in 2009. The classified satellite image shows how fast the desert encroachment is moving southwards of the study area.

Table 4 is explaining the satellite image in a statistical format. Table 4 shows that wetland/water bodies has further shrunk from 11948.5km² to 8,991.3km². There is loss of wetland area to bare surface/sand dunes. This has shown that about 38.14% of the wetland is lost to the multiplying effect of desertification. The woodland has decreased from 18,462.2km² in 1986 to 8,991.3km² in 1999. The decrease in the woodland area coverage could be as a result of cutting down of trees for charcoal and firewood. This could also be correlated with result of questionnaire distributed and retrieved in page 165/table 6.28 which shows that 74.7% used firewood as a cooking fuel. The bulk of the population used firewood as a means of cooking and construction of houses.

Figure 5 to Figure 9 discuss the result of objective two (2) of this research. It is appraising the relationship between rainfall and temperature on desertification.

Figure 5 is the line graph showing deviation from median. These periods are from 1971 to 1989 and between 1991 to 1997. Figure 7 is the line graph indicating the total rainfall in Dutse station (Jigawa) between 1960 – 2009. It has the highest peak in the year 2000 with 1052.4 mm and the lowest in 1984. And in fact 1980 to 1984 were years with very low rainfall. This is confirming the drought of these years in the study area. Figure 8 shows the rainfall mean deviation for Dutse. There has been low rainfall from 1960 through to 1990. It is accounting for stunted growth for the vegetation and thus desertification push southward of the study area.

Additional pressure is put on the pasture resources by livestock from other neighbouringsahel countries, especially from Niger, Chad and Cameroon. Livestock from these countries is attracted to the study

area because of the fodder around the patches of the wetland area of Lake Chad, River Koumandougou in Yobe and Jama'areHadeija River. The overall consequence of this is increasing rate of desertification.

In conclusion, the researcher found that the most usual, but probably not the least traumatic response to desertification is migration. A major consequence of desertification-induced migration is separation of families as male folk usually abandon the women and children to seek for casual labour at the urban centres.

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