MICRO-CLIMATE CHANGE IN ZAMBIA (CHIKUNI AREA)

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CHAPTER ONE:

INTRODUCTION

1.0 Background to the study area:

Of late, forest encroachment and deforestation have increased considerably in many parts of Zambia .In Southern province for instance, it is strikingly high, though there are several marked spatial anomalies and differences which can be attributed to the underlying local factors such as population size, cultivation methods, types and sources of energy.

In Chikuni area, much of the local forests have been wiped out due to the ever-increasing human population's demands for either virgin farmland or settlement, or simply for domestic energy such as firewood and charcoal. While the local have made all necessary efforts to increase their agricultural out-puts by cultivating in virgin farm-plots, the area has been hit with frequent droughts starting about 1970s. This has tended to reduce food security in the area due to repetitive crop failure. It is for this reason that the area has raised such great concerns and interest to investigate the for microclimate change. Further still the issue of climate change itself has triggered great global concerns today due to the assumed dangers it poses to the terrestrial life forms, especially humans. Thus, although there are still many uncertainties about the exact dangers associated with climate change due to the fact that man will always adapt to environmental changes through technology, it is just time the situation was taken stock of. This will at least help provide pragmatic guidelines to the appropriate adaptive measures that must be taken to counteract the climate change: a problem known is a problem half solved.

1.1 Statement of the problem:

Many deforested areas experience microclimate change such as rising temperatures and rainfall reduction resulting in less growth of vegetation regeneration and crop failure. Thus, the Chikuni area, being one of the most highly deforested areas with frequent droughts in the Southern province, has triggered great concern and interests to investigate and account for its local climate from 1950-2000: -to find out whether there is significantly any micro-climate change.

1.2 Aim of the study:

The overall aim of this research project is to find out as to whether there is a significant microclimate change in Chikuni area and also to investigate for the likely causes. In this case, temperature, rainfall and forest extent data form the basis for the investigation of effects: how forest extent affects both temperature and rainfall, and vice versa.

1.3 Objectives of the study:

The core objectives in this research are:

1. To investigate symptoms, signs or indicators of micro-climate change in Chikuni area.
2. To investigate for the likely causes of the assumed microclimate change.
3. To be able to predict the future micro climate on the basis of the identified causes.
4. To help lay the foundation on which future researches can build on, especially on land surveys for crops that will be able to tolerate the new climate.

1.4 Hypotheses:

1. There is a microclimate change in Chikuni area.
2. The microclimate change in Chikuni area is due to deforestation).

1.5 Rationale

It is hoped that the findings of this research project will not only help to guide

the local people adapt easily with informed choices to the new climate, but also help them identify their activities which lead to such changes in climate. This will facilitate for an increased awareness on some environmental conditions that help bring about crop-failure and hence identify mechanisms that avert climate change. This will help maintain food security in the area.

Furthermore, it is also hoped that this research will help facilitate for the integration of local development with issues of environmental concern based on the sustainable use of land and other natural resources. This in turn, it is hoped, will mitigate and avert those adverse impacts of climate change. All in all, the rationale of this research centres on the scope of sensitisation, by stimulating meaningful developmental and environmental policy making that are responsive to climate change.

1.6 Scope of the study:

This research seeks to investigate climate change, in the context of change that is induced by human actions or human activities rather than natural. Man induced climate change (climate modification) is more sudden than the changes that are induced by natural causes. The natural induced climatic changes may require a geological time scale: far beyond human lifespan while man induced can be within his lifespan and can actually be accelerated.

In our investigation, temperature and rainfall figures constitute the basis for the significant analysis, testing and evaluation for the detection of any significant changes the local climate of Chikuni from 1950-2000. These elements of weather changes regulate such other elements as humidity, air pressure, which in their own right regulate wind speed and its direction and hence the entire air mass movements.

Moreover, it is both temperature and rainfall changes that regulate evapotraspiration. Thus temperature and rainfall are among the major factors that determine the lack of vegetation growth regeneration and crop failure. All in all, any change in these elements will almost immediately trigger off a direct response on the local climate in question: the local climate will divert from the normal: the local climate will divert from the normal.

Conversely, climate change will provide a feedback: any change in climate will affect vegetation growth and regeneration.

1.7 Definition of terms:

According to Lamb (1972), weather makes climate. Weather is the totality of the atmospheric conditions at any particular time and place. It is the instantaneous state of the atmosphere, especially those elements of it that directly influence life forms of both animals and plants in their interacting ecosystems. Therefore, since climate emanates from weather, it can be described as the sum total of weather experienced at a place in the course of at least a 35-year period. It comprises not only those elements that can obviously be described as near average or normal, but also the extremes and all their variations (Lamb, 1972).

Building from the above definitions, climate change as Lamb (1972, further states, can be defined as a shift from the state of it that has been prevailing. It appears as changes in weather elements, such as the annual means of temperature and annual rainfall (which can either increase or decrease far beyond normal). It appears as changes of weather elements, such as the average level of temperature and rainfall. Microclimate change therefore involves the slowest, and the longest lasting processes of the sum total of weather change that climatologists are concerned within a small area or location rather than the whole region or country (Lamb, 1972)

1.8 Preview on the organization of the report:

In this report, Chapter Two is literature view, which provides a critical survey of literature on the topics related to issues of climate change.

In Chapter Three, the details of the study area (the geographical location, climate, and vegetation) are discussed.

The research methods used in the collection of data, are outlined in Chapter Four, whereas, the results or the research findings are analysed in Chapter Five. All relevant maps, graphs and tables are in this chapter.

Chapter Six contains the discussion. Here an attempt has been made demonstrate a critical appraisal of the findings in the light of the salient features of climate change as explicitly demonstrated in the literature review.

Conclusions and the recommendations that include a summary of the major findings are made in Chapter Seven.

CHAPTER TWO

LITERATURE REVIEW

The question as to whether climate is effectively changing is one of which both lay and expert opinion has changed over several years. There has been many studies of this matter and very few climatologist (if any) still doubt that the earth is long due for a general warming: only the exact timing of this event is uncertain (www.greenbase.g/atmos/atmos2908000013.html)

However, a reasonable 'best guess' is that temperatures will be higher than any other time in our historical time, and if no mitigative actions are taken, the earth will be getting progressively warmer with the rising temperatures. Such a temperature change will be accompanied by shifts of rainfall patterns, altered snow distributions and wind patterns (www.worldwatch.org/climatechange/hardnumbers.html).

While there are admittedly a number of uncertainties in the forecast of climate changes, climate change has inevitably become a matter of great global concern. This is because the impending hazards associated with climate change are already evident in many areas of the world today and in the majority of these areas, disasters have already been felt(www.worldwatch.org/climatechange.html).

According to Hayes and Smith (1997), the recent concerns of climate change have led to the formulation of a new set of questions regarding the impacts such a climate change would have on all life forms and their interacting ecosystems sensitive to climate change as most of them are –and also on the very structure of human societies and human survival. Thus, today it is no longer enough to talk of climate change in terms of weather conditions only; it must be described accounted and quantified in human terms. In this regard, following the United Nations Global Summit on Environment in Rio-de-Janeiro

Brazil in 1992, the factor of man was introduced in the delicate balance of forces that modify global climate. Today it is now general knowledge that certain human activities scientifically termed as anthropogenic factors, are the major factors that greatly modify climate (Intergovernmental Panel on Climate Change, 1995).

According to Chervin,(1990), and Zinyongela (1995), anthropogenic climate modifiers include mainly exhaust fumes from industries and motor vehicles, thermal pollution, water vapour changes, and land use changes such as deforestation.

However, it must be noted that climate modifiers are a complex mix of both human action and some physical or natural processes. For example, volcanic actions as a natural process emit gases that are also emitted from human actions. These include such gases as carbon dioxide, sulphur oxides and nitrogen dioxides: all of which increase atmospheric warming due to the depletion of the ozone layer while they may also produce acid rain(www.Eos-aura.gsfc.nasa.gov/atmosperic/chematters.html).

Changes in land use such as deforestation activities for say, cultivation or settlement do not only result in arid like environments but also disrupt various ecosystems and bio-diversity loss. Vegetation cleared areas have reduced moisture distribution and this eventually results in droughts. It is true however that drought is not a simple factor as it is not dependent solely on rainfall; it also depends on such other factors as evaporation rates, run-off, groundwater supplies, surface water storage, extent of re-cycling, cultivation practices and vegetation cover. At its simplest however, drought stems from the lack of water and the basic or crude element affecting it, is rainfall (Coombs,1994).

Schneider (2000) has further argued that vegetation cleared areas experience intensive modified albedo changes causing high surface reflectivity and temperature rise.

Exhaust fumes particularly the green house gases namely, methane (CH_4), Carbon dioxide ($C0_2$), Chloro floro carbons (CFCs) and Nitrogen Oxide (N_2O) are the major causes of global warming (Schneider, 2000).

In this respect therefore, the existing solutions to the known causes of climate modification may include not only energy conservation or energy sources efficiency to minimise green house gases in the atmosphere, but also to increase biosphere sink by afforestion and also stabilizing human population. As Gribbin (1998), argued that in any given area of a known forest cover extent. Atmospheric temperature increases with reducing vegetation cover. In other words $T \propto k/V$ where T is the atmospheric temperature, K is the constant and V is the vegetation cover extent in the area. Thus in mathematical terms, temperature is inversely proportional to the amount of vegetation (Gribbin, 1998).

With respect to rainfall, Gribbin (1998) argues that rainfall is directly proportional to the vegetation cover extent in the given area. Thus, $R \propto k\,(V)$, where R, is the amount of rainfall, k is a constant and V is the vegetation cover extent. According to this bio-geographical model, it is clear that vegetation affects climate.

Anyhow the human activities that result in climate modification according to Hayes and Smith (1997), are distributed differently. In developing countries for example the major activities are deforestation, land degradation due to the increasing population size.

In developed countries however technological advancement is the major factor. Green house emissions that deplete the stratospheric ozone as well as acid rain formation have increased in these developed countries (Hayes and Smith, 1997).

However, research has shown that climate change can be averted by what Gribbin (1998), called ‘the no-regret policies’. These include planting trees, energy conservation, and CFCs emissions control and energy use efficiency.

Tree planting increases CO_2 absorption in the atmosphere and it can also improve rainfall distribution. Energy use efficiency and energy conservation on the other hand reduce the green house gases emissions (Mintzer and Leonard, and Giambelluca and Henderson 1996).

However, due to the survival questions and problems that man faces, it has been very difficult to avert climatic change caused by human activities. Thus with this fact the existing solution is the mere slow down of these changes (Kashihito, 1999). People only need to be re-educated to the importance of certain measures in such controversially sensitive situations.

In Southern Africa and in Zambia as Hulme et al (1996), and Munyati (1997), have both argued, climate change, especially drought is due to the El-Nino Southern Oscillation ENSO phenomena. There is a direct link between drought and El-Nino events in the entire region but of course with local variations such as local land use patterns. In Zambia particularly, the research by Munyati (1997), has clearly indicated rainfall fluctuations from year to year. However, the period from 1978 - 1996, rainy season appears to be a period of reducing rainfall compared to the period before 1978 (i.e. 1950-1977). According to Munyati (1997), although there have always been high and low total rainfall seasons in the past, the highest values of total seasonal rainfall were in the period before 1978, and the lowest ones were generally in the periods after in all the areas studied namely, Lusaka, Ndola and Kafue Polder.

With respect to temperature changes, all the three areas investigated indicated an increase over that period (i.e.1950-1996). Average annual temperatures have increased in Zambia by a fraction of a degree, though there are several marked differences from area to area due to different local conditions. Kruss (1992), found out that temperatures in Zambia were on the average close to 0.6°C warmer during the 1980s than the mean for the preceding two decades, compared to the mean warming for the same period over Southern African land masses which exhibited a 0.2°C increase. Such long-term mean analyses as Munyati (1997), has argued, seem to mask out extreme temperature trends.

Climate change has great complexities and it involves a lot of factors both natural and human induced.

CHAPTER THREE

STUDY AREA

3.0 Location:

Chikuni area is located in Monze District in the Southern Province of Zambia. The location of Monze District is shown in Figure 1

Chikuni is about 25 kms south –east of Monze town east of Chisekesi (see Figure 1.1) Figure 1.2 shows Chikuni area and its constituent villages.

Mochipapa area, which has been used as a control for this research project is about 10kms from Choma District. It is about 80kms southwest of Chikuni area. (See the Map in figure 1.1)

3.1 Relief and Drainage:

Chikuni area forms part of the plateau zone of the Southern Province. Physiographically, it can be grouped into three basic categories, namely:

a) The hilly areas with the average altitude of about 2000, for example, Singonya Hill (2100m).

b) The highland areas of average altitude between 900-1500m.

c) The lowland areas mainly dambos with average altitude of bellow 900m.

Numerous intermittent streams dissect the plateau, giving rise to a drainage pattern that drains northward into the Magoye river catchments area. Generally, these streams are characteristic of dambos. During the rain season, these dambos become waterlogged and remain waterlogged for a few weeks after the rain season. However, with the advent of the hot season, they gradually get progressively drier. With increasing encroachment of dambo zones by humans, most of them are often completely dry by April (Petulu, 1989).

3.2 Vegetation:

The vegetation of Chikuni area is an open park-like with one or two scanty small storeyed deciduous woodland savannah. Generally speaking, the vegetation is characteristic of scattered short trees 3-10m high in many areas with forklike, twisted and fire-trimmed crown. During the rainy season, short grass covers much of the ground and blossoms. To the contrary, much of it dries up, and in the some caress leaves the land bare, while in some cases, dry short and scanty grey grass may cover limited portions of the ground in the dry season (Petulu, 1989).

In the area major a major portion of the woodland has been encroachment by the increasing local population (jumping from 12,818 people in 1990 to 18716 people in 2000 (Central Statistical Office 2000) The woodland is almost wiped out, charcoal burning, clearing for either settlement or for cultivation are visibly evident.

3.3 Climate:

Chikuni experiences a sub- climate with three distinct seasons in the year. These are:

1) The hot-wet season (Nov-March).

2) The cold-dry season (March-August).

3) The hot-dry season (August-Oct).

With respect to temperature, the area records the highest temperatures in October and the lowest in July 17.3°C and 25.3°C respectively (Hutchinson, 1974 pp.35).

With reference to rainfall, annual totals range between 700mm –900mm.There is high rainfall variability as this area lies in the agro-ecological zone 1 of Zambia.

Rainfall normally started in November and ends in March (Hutchinson, 1974)

CHAPTER FOUR:

RESEARCH METHODS

With reference to methodology, both the primary and the secondary data sources were used to extract relevant data. Most of data is secondary in nature.

In terms of primary data sources, the questionnaire in Appendix 1 was used

To come up with data on especially the following things:

1) Methods of cultivation

2) Types of energy sources, land ownership and

3) Perception on climate change.

Since there are 12 villages in Chikuni area, a simple multistage random sampling was used to come up with 30 respondents. The first stage was to come up with 3 villages and the next stage, was to come up with 12 respondents in each of the randomly selected villages. In each case a register was used. The same procedure was used in the control area Mochipapa. Mochapapa has 5 villages and three were selected to come up with the same number of respondents as in the study area

In collecting primary data, the major problems encountered include long distances between households. Generally the Tonga people do not live close to each other because of their need for enough grazing land, hence household settlements are scattered.

With reference to secondary data, climatic data for the two areas were obtained from the historical records at the Meteorological Department Head Quarters of Zambia (Lusaka). Forest data for the two areas were obtained from the National Forest Head Quarters Lusaka and some from the Ministry of Agriculture and Fisheries (Choma). The data was then converted into percentages of the respective total areas for each area

Problems encountered include lack of proper records and lack of complete data.

In choosing the control area, the following criteria were used:

a) The area must have as close as possible the physical or environmental conditions to that of the study area, relief, altitude, and drainage should be as

similar as possible.

a) Location: the two areas must not be very far from each other so that their climatic conditions should not be far divorced from each other unless it involves other localised factors

b) The control area must have the same type of data to allow comparisons. thus in this research ,Mochipapa area was chosen as a control area because it meets the above criteria except differences in local land uses .In Mochipapa there is serious afforestation than in Chikuni area where there is deforestation and forest encroachment.

With reference to data analysis, ‘t’ test statistic has been used to test for the significance climatic change while simple linear regression has been used to analyse the relationship of vegetation on climate.

However, the analysis for significance does not tell us why the climate has changed or why it has not: it does not tell us why for example, rainfall has reduced or why temperature has increased. It simply indicates that there is a change.

Conversely, in terms of linear regression analysis, it is also fails to explain for instance, which of the two variables changes first. Furthermore, it also does not explain why such a relation exists. However, the t-test as well as the linear regression are very vital in research. This is so because, take an instance of a t-test; it helps the researchers make unbiased, scientific conclusion on the situation being assessed while the linear regression helps identify the relationship that exists between variables.

In terms of data sources, the vegetation cover extents are just mere estimations. There are likely to be human errors since compiling such data involves a great deal of estimation and all the analyses take in those errors. With respect to climatic data, the readings may not be accurate due to human error.

CHAPTER FIVE

RESEARCH FINDINGS

This Chapter presents the following main findings of the research in the two areas Chikuni (study area) and Mochipapa (the control area):

a) Rainfall distribution comparisons for both Chikuni and Mochipapa areas.

b) Temperature distribution comparisons for both Chikuni and Mochipapa areas.

c) Temperature and vegetation relationship; and also how rainfall relates to vegetation.

d) Comparisons on the types of energy sources in the two areas (Chikuni and Mochipapa).

e) Comparisons on the methods of cultivation in the two areas.

e) Perceptions of people on climate change: temperature and rainfall changes and other related findings.

Table1. **The relative Vegetation Cover extent in Chkuni (area1), and Mochipapa (area2) in km^2**

Year	1950	1955	1960	1965	1970	1975	1980	1985	1990	1995	2000
Area1	68.85	64.80	64.80	60.70	56.70	48.6	40.50	32.4	32.4	32.4	32.4
percent	85%	80%	80%	75%	70%	60%	50%	40%	40%	40%	40%
Area2	81.60	81.60	76.8	72.0	48.0	57.6	67.2	67.2	67.2	72.0	81.6
percent	85%	85%	75%	60%	50%	60%	70%	70%	70%	75%	85%

Source: MAFF (Choma HQ.), and National Forestry HQ. Lusaka.

Note: Area 1 is 81km^2 and Area 2 is 96km^2

Figure 1.3 (a)

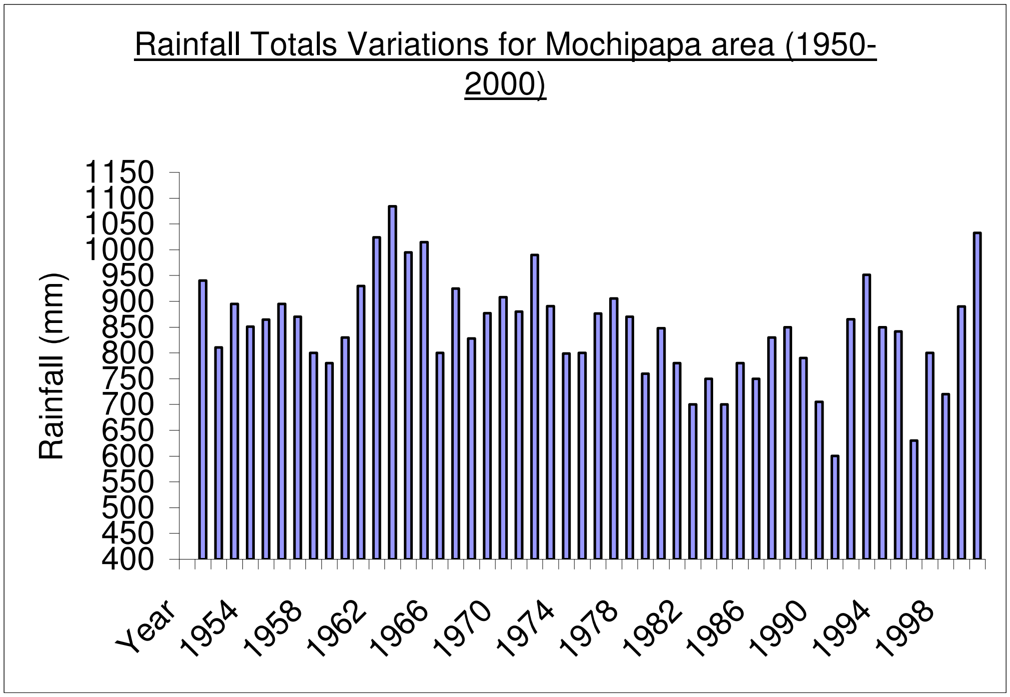


Figure 1.3(b)

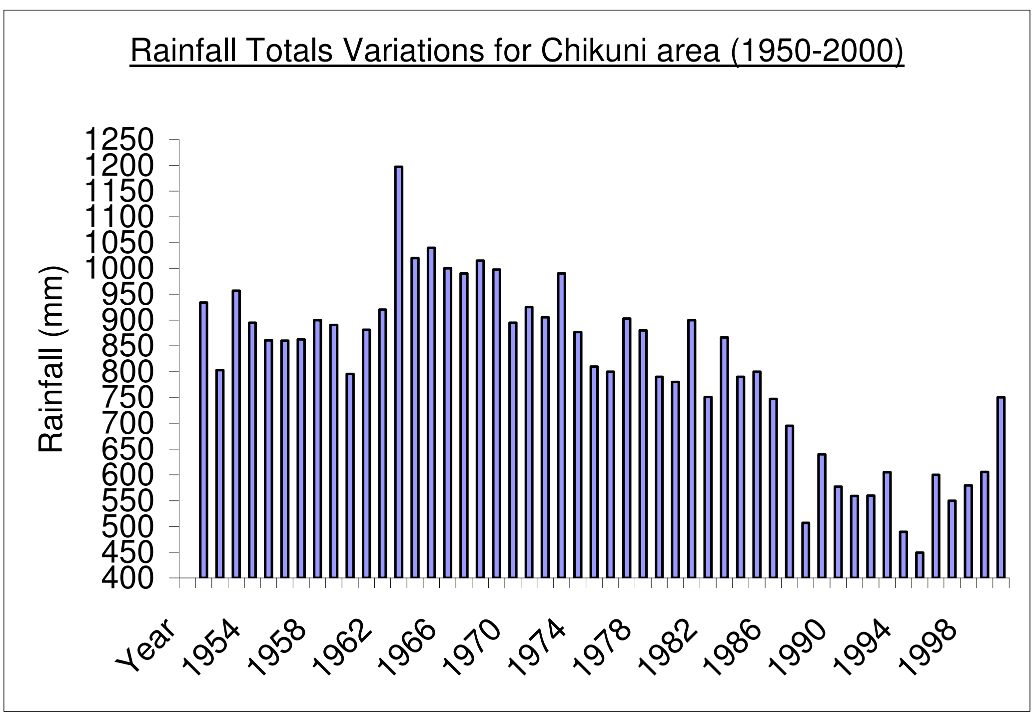


Figure 1.4(a).

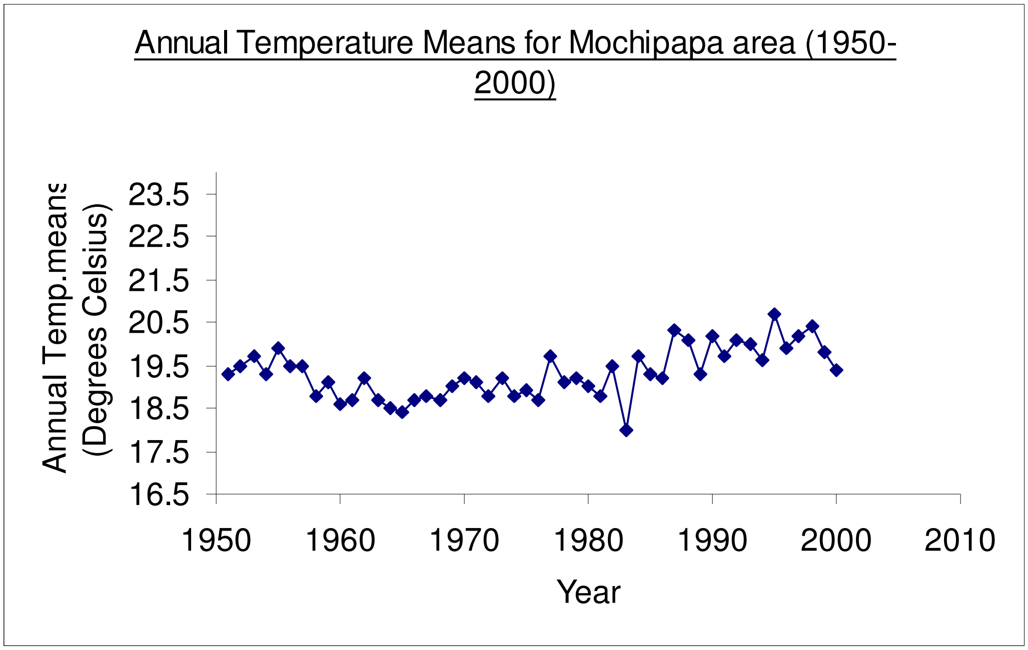


Figure 1.4(b).

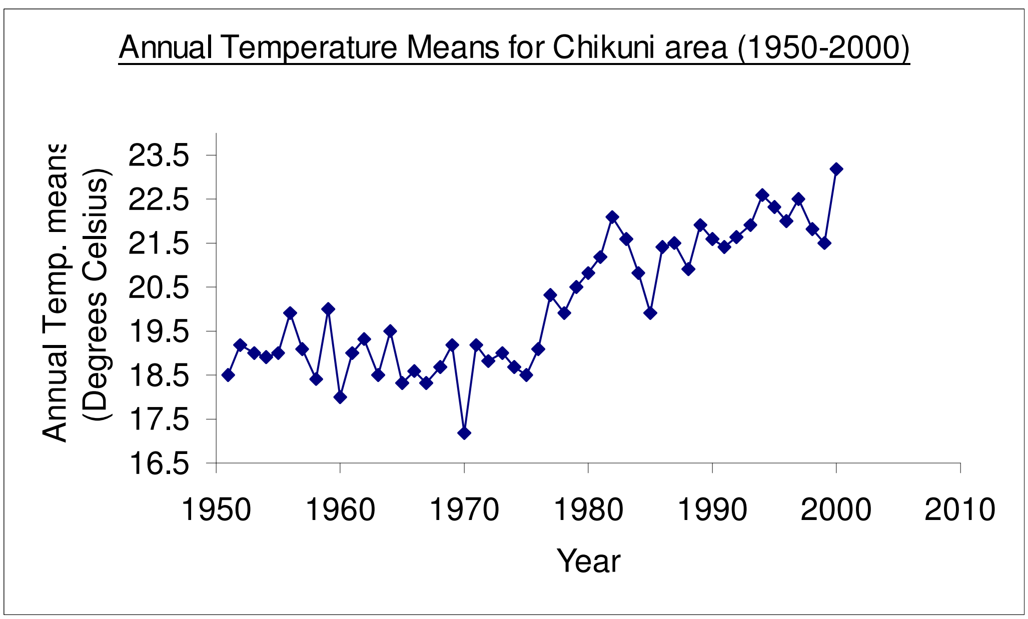


Figure 1.5(a)

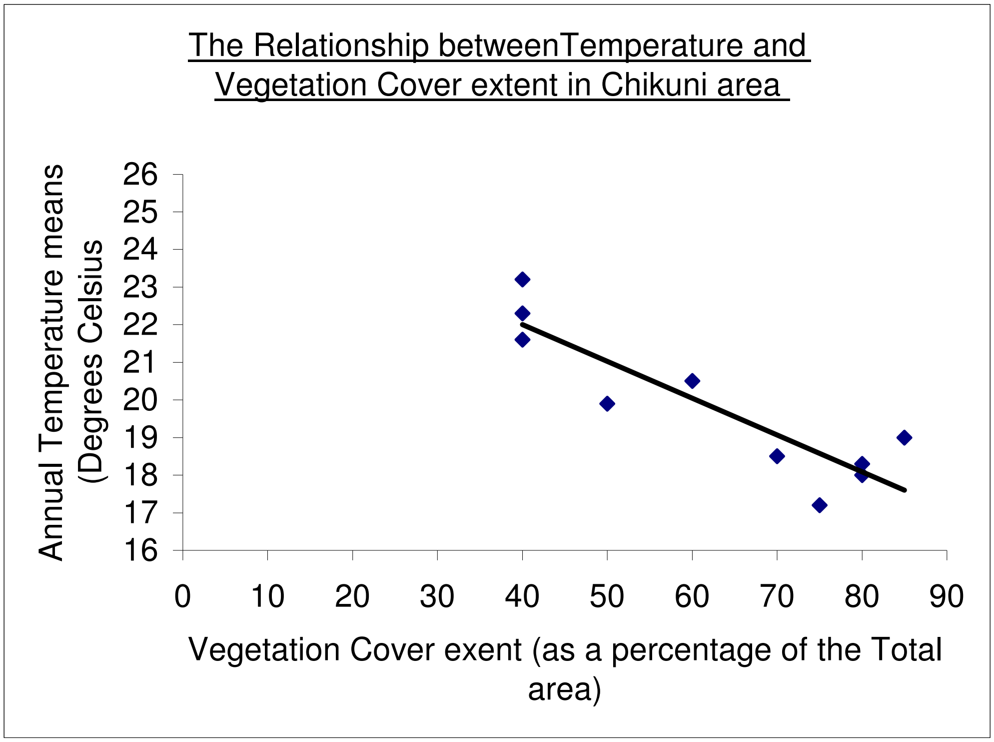
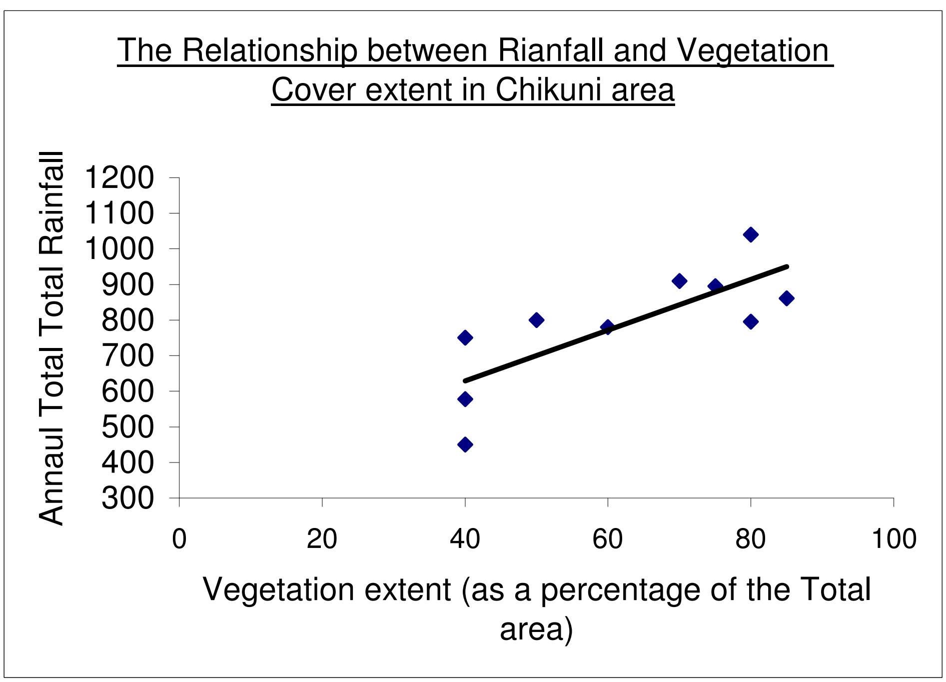


Figure 1.5(b)



In terms of the local people's domestic energy sources, their cultivation methods, and their perception on climate change, the pie charts bellow summarise the information obtained from 30 respondents in each area (Chikuni and Mochipapa).

Types of Cultivation Methods:

Figure1.6(a)Chikuni area

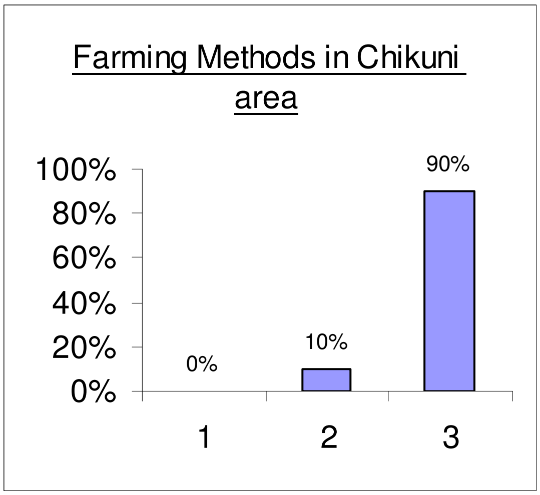
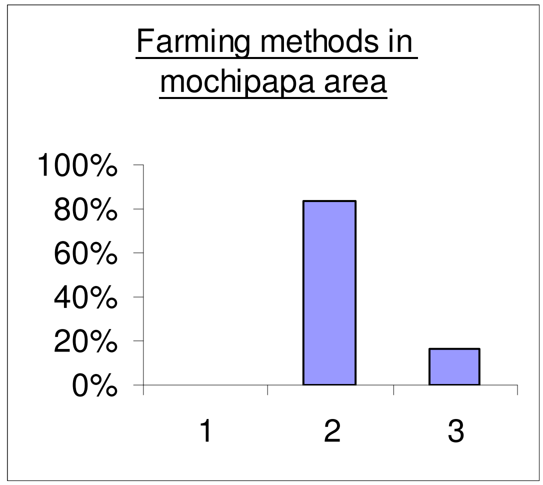


Figure1.6(b) Mochipapa area



Key: 1=Traditional methods, 2=Modern methods only, 3=Traditional methods only

People's major Sources of Domestic Energy:

Figure 1.7 (a) Chikuni area

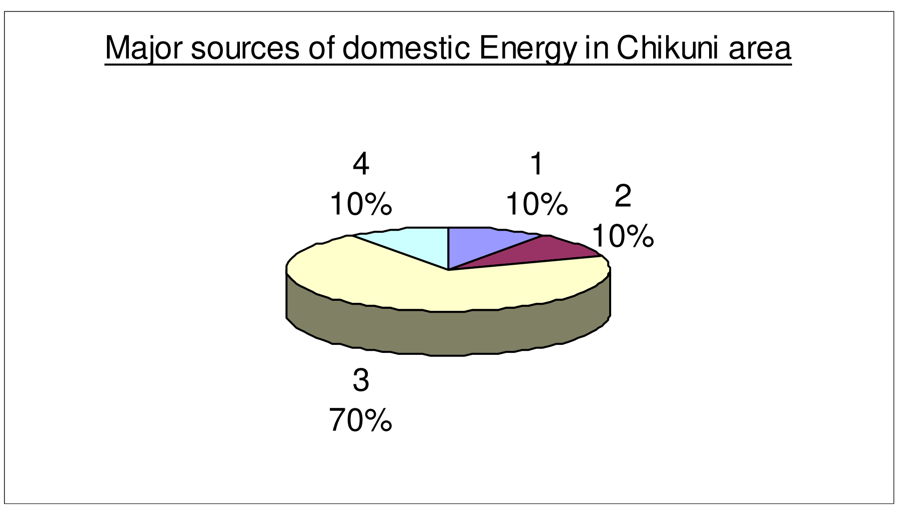
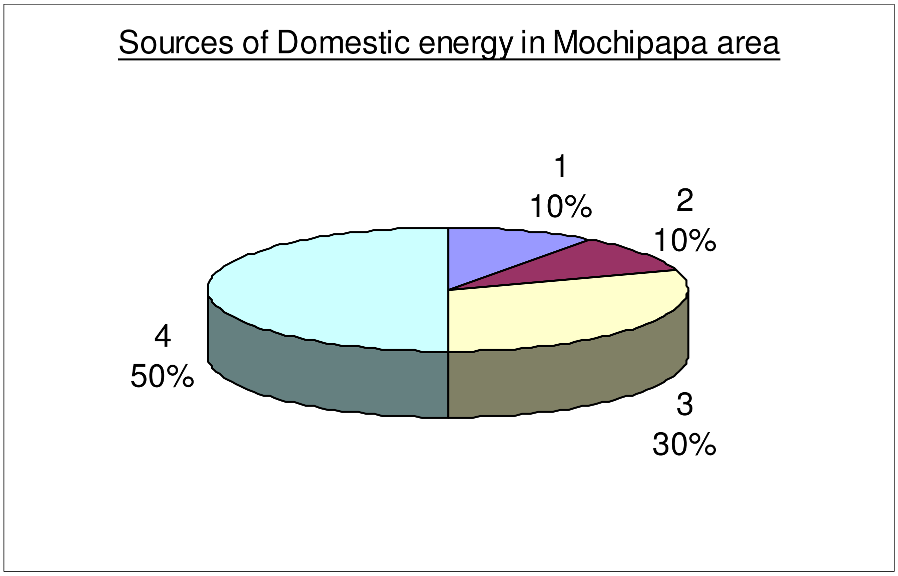


Figure1.7(b) Mohipapa area



***Key*:**1= Firewood only, 2= Charcoal only, 3=Firewood &Charcoal, 4=Electricity

Perception on Climate Change:

Figure 1.8(a) Chikuni area

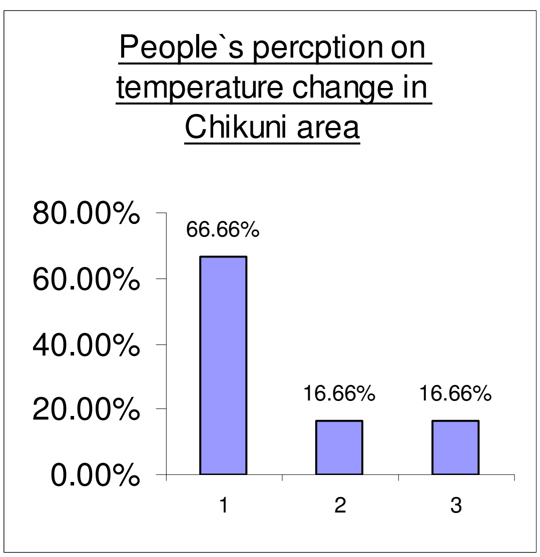
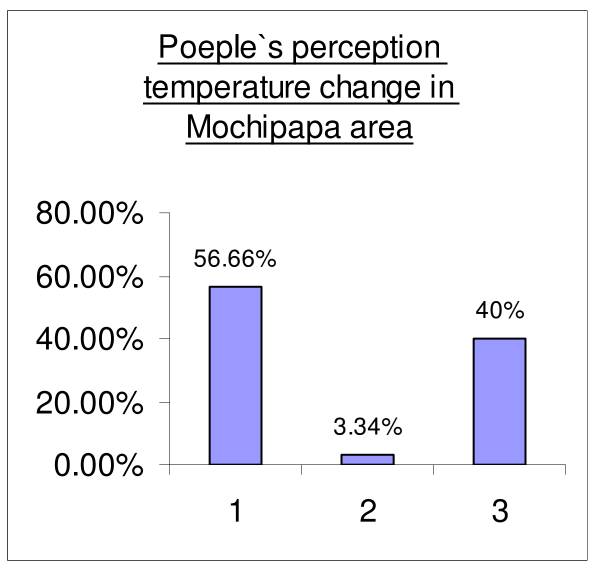


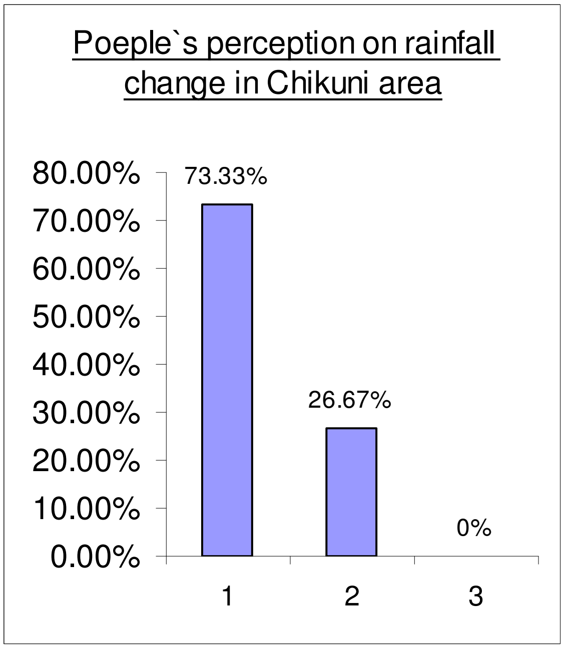
Figure1.8 (b) Mochipapa area

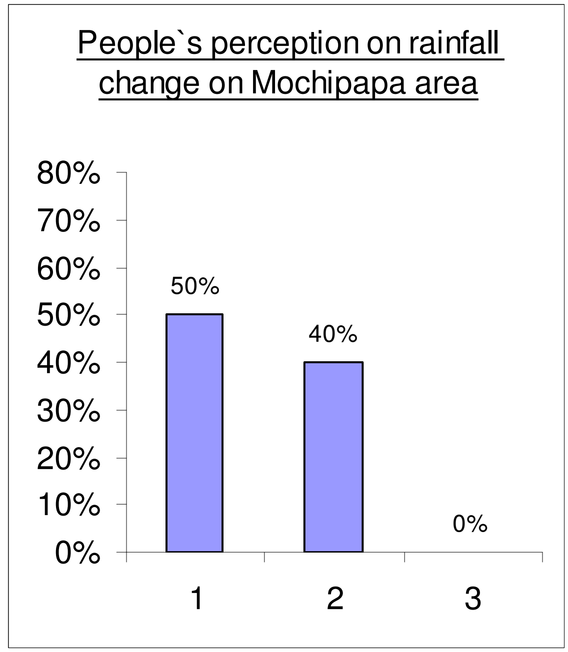


Key: 1=Temperature has increased, 2=No-idea 3=Temperature has reduced

Figure 1.9(a) Chikuni area

Figure 1.9(b) Mochipapa area





Key:1=Rainfall has reduced , 2=Rainfall has increased, 3=No-idea

CHAPTER SIX: DISCUSSION.

This Chapter looks at the implication of the results or findings .It discusses in great detail those findings that can de refuted as well as those that can reasonably be inferred within the context of climate change.

6.0 **Climate Change:**

6.01 Temperature in Chikuni and Mochipapa

With respect to temperature in Chikuni area, there is a clear indication that it has generally been increasing as is almost evident in Figure 1.4 (b). That is, there is a change in the annual temperature means in the period under investigation in Chikuni. More-over, the significant test to compare the annual temperature means for the two areas Chikuni (the study area) and Mochipapa (the control area), indicate a major difference between 1950-2000) [see appendix 2 (a)].

Going by the t-test, the rule states: reject the Null Hypothesis and accept the Alternative Hypothesis at the chosen Significant level if t-observed > t-critical. Or reject the Alternative Hypothesis and accept the Null Hypothesis if t-observed < t-critical.

Thus: the Null Hypothesis which states that 'the temperature increases in both Chikuni and Mochipapa areas were significantly the same in the period between 1950-2000' was rejected at the chosen significant level. In other words, the states that reject the Null Hypothesis and accept the Alternative Hypothesis at the chosen significant level if the observed t-value is greater than the critical t-value. Thus in this analysis, the Null Hypothesis was rejected, since t-observed (3.37) is greater than t-critical (2.36) at 0.01 significance level at the degree of freedom 98 for a one tailed test. Thus, the Alternative Hypothesis was rejected. Hence, there was significantly more temperature increase in Chikuni area than in Mochipapa area in the period between 1950-2000.

In terms of inter- periodical testing, i.e. dividing the 50year period into halves (1950-1975 and 1975-2000), the significance test, indicated a no significant difference between the two areas in the period between 1950-1975. However the significant difference was in the period between 1975-2000 between the two areas.

In the 1950-1975 period the Null Hypothesis which stated that 'the temperature increases in both Chikuni and Mochipapa areas in the period between 1950-1975 were significantly the same', was accepted and the Alternative Hypothesis rejected (going by the rule) at 0.01 significant level because the t-observed (1.71) is less than t-critical (2.42) at 48 degrees of freedom for one tailed test. [See details in Appendix 2 (b)]

For the 1975-2000 period, the significant test indicated a significance difference in the two areas. The Null Hypothesis which stated that 'the temperature increases in both Chikuni and Mochipapa areas were significantly the same in the period between 1975-2000' was rejected at 0.01 significance level at 48 Degrees of Freedom (going by the rule) t-observed 7.92 > t-critical 2.42. The Alternative Hypothesis was accepted i.e. there is significantly more temperature increase in Chikuni area than in Mochipapa area in the period 1975-2000.[See Appendix 2(c)].

6.02. <u>Rainfall Variations in Chikuni and Mochipapa:</u>

With reference to rainfall distributions, the significant test indicated a no difference on the long term (i.e. 1950-2000) between the two areas. According to the graphic displays, [Figure 1.3 (a) and (b)] there is visual impression of a difference. There seems to be a more rainfall reduction in Chikuni area than in Mochipapa area especially starting at about 1988 on ward to 2000. However, this does not agree with the significant test. [See Appendix 3(a)]. Thus, going by the rule since the t-critical value (2.36) is greater than the observed t-value (1.34) at the 0.01 significance level at the Degree of Freedom 98 for a one tailed test, the Null Hypothesis was accepted and the Alternative Hypothesis rejected. Therefore, there is no significance differences in the rainfall decrease in both Chikuni and Mochipapa areas in the period between 1950-2000.This is probably due other external factors that influence the Southern African rainfall such as winds and ENSO in particular. Besides, rainfall is unlikely to differ on the long-term analysis in the same ecological zone.

However, the inter area periodical testing (the short term comparisons: 1950-1975 and 1975-2000 between the two areas) indicated a significant difference between the areas in the later period(i.e. 1975-2000.) For the 1950-1975 period, there is no significant difference. This can also be seen in the graphic displays in Figure 1.3(a) and 1(b).

Thus for the 1950-1975 period the Null Hypothesis which stated that 'the rainfall decreases in both Chikuni and Mochipapa areas in the period 1950-1975 were significantly the same' was accepted and the Alternative Hypothesis was rejected at 0.01 significance level at Degree of Freedom 48 (i.e. t-observed 1.75< t-critical 2.42 and as such, going by the rule the Null Hypothesis is accepted and the Alternative Hypothesis is rejected). [See Appendix 3(b) for details].

However, unlike in the 1950-1975 period, the 1975-2000 period indicated a significant difference. [see Appendix 3(c)] There is more rainfall decrease in Chikuni area than in Mochipapa area in the period. Thus, the Null Hypothesis which stated that ' there is no significance difference in the rainfall decrease in both Chikuni and Mochipapa areas in the period between 1975-2000' was rejected at the 0.01 significant level at 48 Degrees of Freedom for a one tailed test and the Alternative Hypothesis accepted.(i.e. t-observed 3.43>2.42 t-critical) Therefore there is more rainfall reduction in Chikuni area than in Mochipapa area in the period between 1975-2000.

In terms of comparisons between periods within Chikuni area in terms of temperature and rainfall changes, the significant tests indicate that there is a significance difference.

With reference to temperature, the significant test (Appendix 2(b)) as well as the graphic displays (Figure 1.4) has indicated a general increase in temperature.

Conversely, with reference to rainfall, there is also an indication of a general decrease as evidenced in the graphic display in Figure 1.3 (b). This is confirmed in the significant test. There is more rainfall reduction in the period 1975-2000 than in the period 1950-1975 in Chikuni area. [See Appendix 2(c)]

6.03 **Causes of Climatic Change in Chikuni area**;

It is very difficult to pin point to an exact cause of say, temperature increase or rainfall reduction as literature indicated some great complexities about the causes of climate change. Causes are numerous and these interact in a more complex fashion than humans know, so that it becomes difficult to attribute any change to only one factor. However, from what is at-least known, each factor that influence climate, may influence it, at least in one way and only that way: the other ways may be due to interaction with other variables. Take temperature increase for example; this can be due to carbon-dioxide accumulations in the atmosphere as well as the other green house gases. For rainfall decrease it could be a change in the wind patterns that is caused by shifts in air pressure.

Anyhow, with reference to deforestation as the probable cause of climate change in Chikuni area, interview results indicate that there is a high likelihood that deforestation has caused microclimate modification. This is because 70% of the interviewed population in Chikuni area rely on charcoal and firewood for domestic energy as compared to only 30% in Mochipapa area [See Figure 1.7(a and b). In terms of afforestation only 10% of the interviewed population are involved in some form of tree planting as compared to 40% in Mochipapa. With reference to cultivation methods, 10% of the interviewed people use traditional methods in Chikuni area as compared to 88.33% in Mochipapa area. [See Figure 1.6(a and b).

Figure 1.5(a) shows how temperature has been influenced by vegetation in Ckikuni area.

Thus, with reference to Figure 1.5(a), the higher the amount of vegetation in the given area, the higher the chances that the mean temperatures will be moderated and hence will be relatively lower than on the bare land. This is because the diurnal range of temperatures will be relatively lower in vegetated areas than in those that are not.

Going by the analysis in Figure 1.5(b) the regression equation '$y = 26.1 – 0.10 x$' means that when all other factors are held constant but vegetation alone: for every unit increase in vegetation cover extent, there is a 0.10 °C reduction in annual temperature means in Chikuni area. Conversely any unit decrease in the vegetation cover extent, there is an annual temperature mean increase of 0.10°C.

Thus, it is true that temperature (T) is inversely proportional to the vegetation cover extent (V) where k is a constant. i.e. it is true that $T \propto k/V$, and using this, the equation $y = 26.1 – 0.10x$, the annual temperature means at any given vegetation cover extent can be predicted. Take an example of a 100% vegetation cover extent; the annual temperature means can drop to 26.1°C. To the contrary, if there was say, completely no vegetation cover extent (0%) the annual means of temperature would raise to 26.1°C, that is, when all other factors are held constant.

With references to rainfall and how it is influenced, Figure 1.5(b) indicates a direct relationship between the two variables rainfall (R) and vegetation cover extent (V) In mathematical terms it is true that $R \propto k (V)$ where k is a constant.

The equation show that $y = 343.50 + 7.14 x$ which means that for every unit increase in the vegetation cover extent, there is an annual total rainfall increase of 7.14 mm., or alternatively any unit decrease in the vegetation cover extent, there is a 7.14mm decrease of rainfall. Take an example, say, the area is completely covered with vegetation, i.e. there is a 100% vegetation cover extent; annual total rainfall y would be 1057.5mm. Conversely if there were completely no vegetation cover in the area (i.e.0%), there would be annual rainfall totals of 314.50mm that is when all other factors are held constant.

CHAPTER SEVEN

CONLUSIONS AND RECOMMENDATIONS

7.0 Conclusions:

According to these findings, it is clear that there is a general temperature rise as well as rainfall reduction in Chikuni area. This is evident in both climatic models and graphic displays of both rainfall and temperature. Further still, comparisons by significant tests have indicated that there is an indisputable climatic change in Chikuni area in the period under investigation although changes are more notable in the years after 1975.

Thus, it can be safely concluded, basing such conclusions on the annual rainfall totals and annual temperature means, that there is microclimate change in Chikuni area in the1950-2000 period. Other indirect indicators of climatic change include the disappearances of some simple wildlife species and the appearance of new strange species. Some of the disappeared life forms include, the big butterfly (supposedly Queen Alexander's bird wing), some red ants (or Ng'ombe Isubila as called in the local language Tonga), porcupine, and birds such as owl parrots (these nest under tree roots) and pelican birds according to the interviewed persons

New appearances include a frilled lizard, tiny ant eater, and a small yellow butterfly

In terms of what exactly is responsible for change in the microclimate of the Chikuni area, it is quite difficult to make conclusive and concrete remarks. However, certain conclusive remarks (though with low confidence) can be passed, based on the regression analyses. Since vegetation has shown that it affects rainfall by 0.10 or 10%, while 7.14 or 714% one can conclude that deforestation is one of the factors that have led to climate modification in Chikuni area.

8.0 Recommendations:

Following the findings in this study, the following recommendation can be made:

1. There is a need to sensitise the local people in Chikuni area to the importance of tree planting. Trees will not only help moderate day temperatures and the general temperature rise, but it will also help improve and increase rainfall distribution.

   Besides, trees help reduce carbon dioxide in the atmosphere by absorbing it through the photosynthesis process.

2. There is a need to educate the population to the recommended methods of cutting down trees to allow regeneration of trees. Methods include pollarding, coppicing and lopping.

3. Farming methods are very unsustainable in Chikuni area. With the increased prices of fertiliser, the local people have resorted to the old farming methods

where trees are cleared and burnt down as manure. To avert this, there is a need to introduce agro-forestry such as the use of leguminous trees like Sesbania-sesban, Cresedia-ceduim etc. This, it is hoped, will not only reduce chances of clearing new forest lands, but it will also reduce expenditure incurred on artificial fertilisers. Besides, these leguminous trees can also be used as firewood when they have been cleared to pave way for crop planting.

4. Most of the people in the area grow maize in dambos where they dig deep water holes in dry season. Most of this maize in these dambos does quite well. This can be taken advantage of and can be reinforced by introducing irrigated winter maize production at a larger scale. The area has dams where water for irrigation can be obtained. Deeper water wells can also be dug to supplement the dams.

5. There is also a need to diversify crop production. The people on Chikuni area rely entirely on maize production and there have been frequent periods food shortages due poor rainfall. Other crops that are drought resistance such as cassava can be introduced in the area.

6. Population is also quite high in the area. It has increased rapidly resulting in the high demand for both resettlement and extra farmland. This has tended to more pressure on the forestland. Thus, there is a need to control such population growth by not only sensitising the local people to the importance and to the benefits of small families, but also availing them with the appropriate family planing methods and techniques.

7. There is need for further research. This will help reveal all climate-modifying actions in the area. It is when all the climatic modifiers are identified that meaning mitigation measures and actions plans can be implemented

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http://www.worldwatch.org/climatechange/hard numbers/html

National Aeronautic Space Administration(NASA)

http://www.Eos-aura.gsfc.nasa.gov/climatechange/atmospherric/chemmaters.html

United Nations World Heritage:

http://www.greenbase.g13/atmos/atmos/2908000013.html.

APPENDICES

APPENDIX 1: Questionnaire

The University of Zambia
School of Natural Sciences
Geography Department

Scheduled Structured Interview to identify the causes of microclimate change in Chikuni area (Administering to both Chikuni and Mochipapa residents).

Dear respondents,

I am a final year student at the above named institution conducting research to identify the causes of climate change in your area. You have been selected at random; please answer the following questions as honestly as possible. Be lest assured that the information being sought is not for publicity in any way, but for academic purposes and further scientific researches only. The information you will give will be strictly confidential.

SECTION A (Personal details)

0.0. Occupation (Please specify)…………………………………………

1.0. Marital status (Please tick) [ ]-single [ ]-married.

1.1. If your answer to Question '1.0' is married, please tick where applicable

a) Number of wives [ ]-one [ ]-between two and four [ ]-five or over.

b) Number of children [ ]-between one to five [ ]-six to ten [ ]-above ten

1.2. If your answer to Question '1.0' is 'single' do you have children? Please tick.

[ ]-yes [ ]-no

1.3. If 'yes' to Question '1.2', please specify the number of children……………

SECTION B (ownership: property and land)

1.4. Types of land ownership, please tick [ ]-communal [ ]-private [ ]-leasehold.

1.5.If your answer to Question '1.4' is 'leasehold' please specify the tenure of

Ownership………………..

1.6. How many grazing animals do you have? Please tick, [ ]-less than 10

[ ]-between 10 and 20 [ ]-above 20

1.7.If your answer to question ‘1.6’ is ‘above 20’ please specify the number

Of grazing animals………………………………………………

SECTION C (Methods of Cultivation)

1.8. What method of cultivation do you use? Please tick

[ ]-traditional [ ]-modern [ ]-both traditional and modern

1.9. If your answer to question ‘1.8’ is either ‘traditional’ or ‘both traditional and modern’ please specify on the traditional methods as to what kind………

SECTION D (Types of energy sources)

2.0. What is your major source of domestic energy? Please tick

[ ]-fire wood only [ ]-charcoal only [ ]-fire wood and charcoal [ ]-electricity only.

2.1.Do you plant trees on you land? Please tick [ ]-yes [ ]-no

SECTION C (Perception in climate elements)

2.2. Do you feel any change in the following climatic elements as compared to olden days when you were growing up? Please tick where applicable

a) Temperature [ ]-yes [ ]-no

b) Rainfall [ ]-yes [ ]-no

2.2.If your answer to question ‘2.2’ is ‘yes’ to any one of either (a) or (b), please tick where applicable

a) Temperature has i) increased [ ] ii)decreased [ ]

b) Rainfall has i) increased [ ] ii)decreased [ ]

2.4. In relation to question 2.2, when do you experience greatest climatic changes in the year? Please tick

[ ]-hot dry season

[ ]-cold dry season

[ ]-hot wet season

2.5. What methods do you use to cool down temperatures when they increase?

Please tick

[ ]-electric fans

[ ]-tents

[ ]-natural tree shades

2.6. Do you experience more warm days than cold days? Please tick

[ ]-yes [ ]-no

2.7. Is there any simple wildlife that has disappeared in your area? Please tick

[ ]-yes [ ]-no

2.8. If your answer to 'question 2.7' is 'yes' please specify the type of wildlife

....

....

2.9. Any simple wildlife that has appeared but was not there before?

[ ]-yes [ ]-no

3.0.If your answer to 'question 2.9' is 'yes' please specify the type of wildlife

....

....

3.1. How do you think rainfall can be improved in your area?

……………………………………………………………………………………………
……………………………………………………………………………………………
……………………………………………………………………………………………
……………………………………………………………………………………………
……………………………………………………………………………………………
……………………………………………………………………………………………

TANK YOU FOR YOUR TIME!!

APPENDIX 1(a)

Temperature Comparisons Between Chikuni and Mochipapa areas in the Period between 1950-1975

Hypothesis:

Null Hypothesis: The temperature increases in both Chikuni and Mochipapa areas in the period between 1950-1975 are significantly the same.

Alternative Hypothesis: There is more temperature increase in Chikuni area than in Mochipapa area in the period between 1950-1975. Thus, by using t-test:

NOTE: that t =is the ‘t’ test statistic,

$|x - y|$ = is difference between the mean of x and y

x = is the mean value of the x-sample,

y = is the mean value of the y-sample,

x^2 = is the squared value of the x-sample,

y^2 = is the squared value of the y-sample,

n_x =is the sample size of x,

n_y = is the sample size of y,

$\sum x^2$ = is the sum of the squared values of x and

$\sum y^2$ = is the sum of the squared values of y

$$t = \frac{\left|\bar{x} - \bar{y}^1\right|}{\sqrt{\frac{\left(\sum x^2 / n_x\right) - x^2}{n_x - 1} + \frac{\left(\sum y^2 / n_y\right) - y^{-2}}{n_y - 1}}}$$

$$t = \frac{\left|19.076 - 18832\right|}{\sqrt{\frac{(9101.27/25) - 363..89378}{25 - 1} + \frac{(8874.4/25) - 354.64422}{25 - 1}}}$$

$$t = \frac{0.244}{\sqrt{\frac{364.0508 - 363.89378}{24} + \frac{354.976 - 354.64422}{24}}}$$

$$t = \frac{0..244}{\sqrt{\frac{0.15702}{24} + \frac{0.33178}{24}}}$$

$$t = \frac{0.244}{\sqrt{0.065425 + 0.0138242}}$$

$$t = \frac{0.244}{\sqrt{0.02036667}}$$

$$t = \frac{0.244}{0.142712}$$

$$\underline{t = 1.7097371}$$

TEST FOR SIGNIFICANCE:

(a) Degree of Freedom(df) $= (n_x - 1) + (n_y - 1)$
= (25-1)+ (25 –1)
= 24 +24
= 48

$t_{0.01,}$ df 48, one-tailed test =2.42
t- observed < t-critical
1.71 < 2.42

Rule: Reject the Alternative Hypothesis and accept the Null Hypothesis if t-observed is less than t-critical at the chosen significant level.

DECISION:

The alternative Hypothesis is rejected and the Null Hypothesis accepted because t-observed is less than t-critical.

CONLUSION: The temperature increase in both Mochipapa and Chikuni areas in the period between 1950-1975 are significantly the same.

APPENDIX (1b) **Temperature Comparisons in Mochipapa and Chikuni areas between 1975-2000**

Hypothesis:

Null Hypothesis: The temperature increase in both Mochipapa and Chikuni areas in the period between 1975-2000 are significantly the same.

Alternative Hypothesis: There is more temperature increase in Chikuni area than in Mochipapa area in the period between 1975-2000

$$t = \frac{|x - y|}{\sqrt{\frac{\left(\sum x^2 / n_x\right) - x^2}{n_x - 1} + \frac{\left(\sum y^2 / n_y\right) - y^2}{n_y - 1}}}$$

$$= \frac{|19.596 - 21.374|}{\sqrt{\frac{(9609.13/25) - 384.00322}{25 - 1} + \frac{(11442.3725/25) - 456.847876}{25 - 1}}}$$

$$= \frac{1.778}{\sqrt{\frac{384.3652 - 384.00322}{24} + \frac{457.6949 - 456.847876}{24}}}$$

$$= \frac{1.778}{\sqrt{\frac{0.36198}{24} + \frac{0.847024}{24}}}$$

$$= \frac{1.778}{\sqrt{0.0150825 + 0.035292666}}$$

$$= \frac{1.778}{\sqrt{0.050375166}}$$

$$= \frac{1.778}{0.22444128}$$

$= 7.921893869$

$= 7.92$

<u>SIGNIFICANCE TESTING</u>

Degree of Freedom (df) $= (n_x - 1) + (n_y - 1)$ $t_{0.01}$,df 48, one-tailed test =2.42

=(25 –1) + (25 –1) t-observed > t-critical

=24 +24 <u>7.92 > 2.42</u>

= <u>48</u>

Rule: Reject the Null Hupothesis and accept the Alternative Hypothesis if the t-observed is greater than t-critical at the chosen significant level.

DECISION: The Null Hypothesis is rejected and the Alternative Hypothesis accpted because the t-observed is greater than the t-critical.

CONLUSION: There is more temperature increase in Chikuni area than in Mochipapa area in the period between 1975-2000.

APPENDIX 2(a) **Temperature Comparisons within Chikuni area between 1950-1975 and 1975-2000**

<u>Hypothesis</u>:

Null Hypothesis: The temperature increase in Chikuni area between periods 1950-1975 and 1975-2000 are significantly the same

Alternative Hypothesis: The temperature increase in Chikuni area between the periods 1950-1975 and 1975 –2000 are significantly the same.

$$t = \frac{|x - y|}{\sqrt{\left(\sum x^2 / n_x\right) - x^2 + \left(\sum y^2 / n_y\right) - y^2}}$$

$$t = \frac{18.832 - 21.374}{\sqrt{\frac{(8874.4/25) - 354.64422}{25-1} + \frac{(11442.3725/25)25 - 456.847876}{25-1}}}$$

$$t = \frac{2.542}{\sqrt{\frac{354.976 - 354.64422}{24} + \frac{457.6949 - 456.847876}{24}}}$$

$$t = \frac{2.542}{\sqrt{\frac{0.33178}{24} + \frac{0.847024}{24}}}$$

$$= \frac{2.542}{\sqrt{0.013824166 + 0.035292666}}$$

$$= \frac{2.542}{0.221623177}$$

= 11.4699195

= <u>11.50</u>

<u>SIGNIFICANCE TESTING</u>

Degree of Freedom (df) $= (n_x - 1) + (n_y - 1)$
= (25-1) + (25 –1)
= 24 +24
= <u>48</u>

t-0.01, df 48, one-tailed test=2.42
t-observed > t-critical
<u>11.50 > 2.42</u>

Rule: Reject the Null Hypothesis and accept the Alternative Hypothesis if the observed t-value is greater than the t-critical value at the chosen significant level.

DECISION: The Null Hypothesis is rejected and the Alternative Hypothesis accepted because t-observed is greater than t-critical.
CONLUSION: There is more temperature increase in the year between 1975-2000 than in the period 1950-1975 in Chikuni area.

APPENDIX 3 (a) **Rainfall Comparisons between Chikuni and Mochipapa areas in the period 1950-2000**

Hypothesis:

Null Hypothesis: The rainfall decreases in both Chikuni and Mochipapa areas from 1950-2000 period were significantly the same**.**
Alternative Hypothesis: There is significantly more rainfall decrease in Chikuni area Mochipapa areas.

$$t = \frac{|x - y|}{\sqrt{\frac{(\sum x^2 / n_x) - x^2}{n_x - 1} + \frac{(\sum y^2 / n_y) - y^2}{n_y - 1}}}$$

$$t = \frac{|847.318 - 809.98|}{\sqrt{\frac{(36,387,931/50) - 717947.79}{50 - 1} + \frac{(34,187,834/50) - 656067.6}{50 - 1}}}$$

$$= \frac{37.338}{\sqrt{\frac{727758.62 - 717947.79}{49} + \frac{683756.68 - 656067.6}{49}}}$$

$$= \frac{37.338}{\frac{9810.83}{49} + \frac{27,689.08}{49}}$$

$$= \frac{37.338}{\sqrt{200.22102 + 565.08327}}$$

$$= \frac{37.338}{\sqrt{765.30429}}$$

$$= \frac{37.338}{27.664134}$$

t = 1.3496898

<u>TEST FOR SIGNIFICANCE:</u>

Degree of Freedom (df)= $(n_x - 1) + (n_y - 1)$

= (50 – 1) + (50 – 1)

= 49 + 49

= <u>98</u>

$t_{0.01}$, df 98,one-tailed test=2.36

t-observed < t-critical

<u>1.35 < 2.36</u>

Rule: Reject the Alternative Hypothesis and accept the Null Hypothesis if observed t-value is less the t-critical value at the chosen significant level

DECISION: The Alternative Hypothesis is rejected and the Null Hypothesis is accepted because the t-observed value is less than the t-critical value

CONLUSION: The rainfall decreases in both Ckikuni and Mochipapa areas were significantly the same in period 1950-2000

APPENDIX 3(b) **<u>Rainfall Comparisons between Chikuni and Mochipapa areas in the period 1950-1975</u>**

<u>Hypothesis:</u>

Null Hypothesis: The rainfall decreases in both Chikuni and Mochipapa areas in the period between 1950-1975 were significantly the same.

Alternative Hypothesis: There was more rainfall decrease in Chikuni area than in Mochipapa area in the period between 1950-1975.

$$t = \frac{|\bar{x} - \bar{y}|}{\sqrt{\frac{(\sum x^2 / n_x) - \bar{x}^2}{n_x - 1} + \frac{(\sum y^2 / n_y) - \bar{y}^2}{n_y - 1}}}$$

$$= \frac{891.572 - 932.864}{\sqrt{\frac{(20{,}032{,}500/25) - 794{,}900.63}{25-1} + \frac{(21{,}931{,}518/25) - 870235.24}{25-1}}}$$

$$= \frac{41.292}{\sqrt{\frac{801{,}300 - 794{,}900.63}{24} + \frac{877260.72 - 870235.24}{24}}}$$

$$= \frac{41.292}{\sqrt{\frac{6399.37}{24} + \frac{7025.48}{24}}}$$

$$= \frac{41.292}{\sqrt{266.64042 + 292.72833}}$$

$$= \frac{41.292}{\sqrt{559.36875}}$$

$$= \frac{41.292}{23.650978}$$

$$= \underline{1.7458897}$$

SIGNIFICANCE TESTING:

Degree of Freedom(df) = $(n_x - 1) + (n_y - 1)$
=(25 – 1) +(25 –1)
=24 + 24
= 48

$t_{0.01}$, df 48, one-tailed test=2.42
t-observed < t-critical
1.75 < 2.42

Rule: Reject the alternative Hypothesis and accept the Null Hypothesis if the t-observed value is less than t-critical at the chosen significant level

DECISION: The alternative Hypothesis is rejected and the Null Hypothesis accepted because the t-observed is less than t-critical.

CONLUSION: The rainfall decrease in both Chikuni and Mochipapa areas were significantly the same.

APPENDIX (3c)**Rainfall Comparisons between Chikuni area and Mochipapa area in the 1975 –2000 period.**

Hypothesis:

Null Hypothesis: The rainfall decrease in Chikuni and Mochipapa areas in the 1975 – 2000 period were significantly the same.

Alternative Hypothesis: There was more rainfall reduction in the Chikuni area than in Mochipapa area in the period between 1975 -2000

$$t = \frac{|\bar{x} - \bar{y}|}{\sqrt{\frac{(\sum x^2 / n_x) - \bar{x}^2}{n_x - 1} + \frac{(\sum y^2 / n_y) - \bar{y}^2}{n_y - 1}}}$$

$$= \frac{|803.064 - 687.096|}{\sqrt{\frac{(16,355,520/25) - 644911.79}{25-1} + \frac{(12,256,316/25) - 472100.91}{25-1}}}$$

$$= \frac{115.968}{\sqrt{\frac{654220.8 - 644911.79}{24} + \frac{490252.64 - 472100.91}{24}}}$$

$$= \frac{115.968}{\sqrt{\frac{9309.01}{24} + \frac{18151.73}{24}}}$$

$$= \frac{115.968}{\sqrt{387.87542 + 756.32208}}$$

$$= \frac{115.968}{\sqrt{1144.1975}}$$

$$= \frac{115.968}{33.825988}$$

= 3.4283699

SIGNIFICANCE TESTING:

Degree of Freedom (df) = (n_x –1) + (n_y –1)
=(25 –1) + (25 –1)
=24 + 24 = 48

t-observed df 48, onetailedtest=2.4
t-observed > t-critical
3.43 >2.42

Rule: Reject the Null Hypothesis and accept the Alternative Hypothesis if the t-observed is greater than the t-critical at the chosen significant level.

DECISION: The Alternative Hypothesis is accepted and the Null Hypothesis is rejected because the t-observed is greater than the t-critical.

CONLUSION:There was more temperature increase in Chikuni area than in Mochipapa area in the period between 1975-2000.

APPENDIX 3(d) **Rainfall Comparisons within Chikuni area in the periods between 1950-1975 and 1975-2000.**

Hypothesis:

Null Hypothseis: The rainfall decrease in Chikuni area in the periods between 1950-1975 and 1975 – 2000 were significantly the same.

Alternative Hypoyhesis. There is more rainfall reduction in the period 1975 -2000 than in the period 1950-1975 in Chikuni area.

$$t = \frac{|\bar{x} - \bar{y}|}{\sqrt{\frac{(\sum x^2 / n_x) - \bar{x}^2}{n_x - 1} + \frac{(\sum y^2 / n_y) - \bar{y}^2}{n_y - 1}}}$$

$$= \frac{|932.864 - 687.096|}{\sqrt{\frac{(21{,}931{,}518/25) - 870235.24}{25-1} + \frac{(12{,}256{,}316/25) - 472100.91}{25-1}}}$$

$$= \frac{245.768}{\sqrt{\frac{877260.72 - 870235.24}{24} + \frac{490252.64 - 472100.91}{24}}}$$

$$= \frac{245.768}{\sqrt{\frac{7025.48}{24} + \frac{18151.73}{24}}}$$

$$= \frac{245.768}{\sqrt{292.72833 + 756.32208}}$$

$$= \frac{245.768}{\sqrt{1049.0504}}$$

$$= \frac{245.768}{32.389048}$$

= 7.587997

SIGNIFICANCE TESTING:

Degree of Freedom (df) = (n x – 1) + (n y – 1)
= (25 – 1) + (25 –1)
= 24 + 24
=48

t 0.01,df 48,onetailed test=2.42
t-observed > t-critical
7.59 > 2.42

Rule: Reject the Null Hypothesis and accept the Alternative Hypothesis if the t observed is greater than the t-critical at the chosen significant level

DECISION: The Null Hypothesis is rejected and the Alternative Hypothesis is Accepted because the t-observed is greater than t-critical.

CONLUSION: There is significantly more rainfall reduction in the period 1975 -2000 than in the period 1950- 1975.

APPENDIX 4(a) **Vegetation Cover and Annual Temperature Means in Chikuni area**

year	y Temperature (◦C)	y^2	x Veg. cover extent(%)	xy
1955	19.0	361	85	1615
1960	18.0	324	80	1440
1965	18.3	334.89	80	1464
1970	17.2	295.84	75	1290
1975	18.5	342.25	70	1295
1980	20.5	420.25.	60	1230
1985	19.9	396.01	50	995
1990	21.6	466.56	40	862
1995	22.3	497.29	40	892
2000	23.2	538.24	40	928
	$\sum y = 198.8$		$\sum x = 620$	$\sum xy12013.0$

$\bar{y} = 19.88$ $\sum x^2 = 41450$

n=10 $\bar{x} = 62$

<u>By linear Regression Analysis: y =a + bx</u>

$b = \frac{n(\sum xy) - \sum x \sum y}{n \sum x \ - (\sum x)^2}$ $a = \bar{y} - b\bar{x}$ y =a +bx

$= \frac{10(12013) - 620 \times 198.8}{10(41450) - 620^2}$ a = 19.88 – (-0.10)62 = 26.1+(-0.10)x

$= \frac{120310 - 123{,}256}{414{,}500 - 384400}$ = 26.08 =26.1-0.10x

$= \frac{-3126}{30{,}100}$ = 26.1 (intercept on y-axis)

=-0.10385382

=-0.10 (gradient of the equation)

Note: Since y=a+bx, our final simple linear regression equation will now be read as y=26.1-0.10x; which implies that 26.1 is the point at which the equation line intercepts the y-axis and thus, for every unit increase in vegetation cover extent (in this case, for every unit decrease in vegetation cover extent), there is an annual Temperature mean increase of 0.10º C. In other words, any unit increase of vegetation cover extent, there is an annual temperature mean decrease of 0.10 ºC

(See the graph in figure 1.5(a)).

APPENDIX 4(b) **Vegetation Cover extent and the Annual Rainfall Totals in Chikuni area**

Year	y Rainfall(mm)	y^2	x Veg Cover(%)	xy
1955	860.8	740976.64	85	73168
1960	795.5	632820.25	80	63640
1965	1040	1081600	80	83200
1970	895	801025	75	67125
1975	910	828100	70	63700
1980	780	608400	60	46800
1985	800	640000	50	40000
1990	577.6	333621.76	40	23104
1995	449.8	202320.04	40	17992
2000	750.5	563250.25	40	30020
	$\sum y = 7859.2$	$\sum y^2 = 6432113.94$	$\sum x = 620$	$\sum xy 508749$

$\bar{y} = 785.95$ $\sum x^2 = 41450$

$\bar{x} = 62$

n=10

<u>By Simple linear Regression Analysis: y = a +bx</u>

$$b = \frac{n(\sum xy) - \sum x \sum y}{n\sum x^2 - (\sum x)^2}$$

$$= \frac{10(508749) - 620(7859.2)}{10(41450) - 620^2}$$

$$= \frac{5087490 - 4872704}{414500 - 384400}$$

$$= \frac{214786}{30100}$$

=7.135747508

=<u>7.14</u>

$$a = \bar{y} - b\bar{x}$$

=785.92-(7.14)(62)

=<u>343.50</u>

y =a +bx

<u>y =343.50 +7.14x</u>

Note: Following the above results, our simple linear regression equation will be y =343.50+7.14x, which implies that 343.50 is the intercept,7.14 is the gradient and x would be any independent variable of our choice. Thus, this regression equation means that for every unit increase in vegetation cover extent, there will be an annual total increase of 7.14mm in rainfall.(See the graph in figure 1.5(b).