

**NATURE AND MAGNITUDE OF CLIMATIC
CHANGE IN TURKMENISTAN
WITH SPECIAL REFERENCE TO
TEMPERATURE AND PRECIPITATION**

DISSERTATION

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CERTIFICATE

Certified that the dissertation entitled "*Nature and Magnitude of Climatic Change in Turkmenistan with Special Reference to Temperature and Precipitation*", submitted by **Mr. Masoon Ahmad Beig**, in partial fulfillment of the requirements, is suitable and worthy for the award of **M. Phil. Degree** in the discipline of Geography to the approval of examiners. The scholar worked under my supervision on whole time basis for the period required under status and has put in the required attendance in the Centre. The receptivity and conduct of scholar has remained satisfactory.

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DECLARATION

I solemnly declare that the dissertation entitled, "*Nature and Magnitude of Climatic Change in Turkmenistan with Special Reference to Temperature and Precipitation*" submitted by me in the discipline of Geography under the supervision of **Dr. Abdul Rauf Shah** embodies my own contribution. This work which does not contain any piracy has not been submitted, so far, anywhere for the award of any degree.

MASOON AHMAD BEIG



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Dedicated to...

My

Beloved

Parents

&

Teachers

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CHAPTER NO – 1

INTRODUCTION

A Particular region is a bi-product of particular eco-habitat. It is basically an environmental spectrum that shapes and reshapes physical, social, cultural, biological and all ecological variables of micro or macro region with the broader perspectives of environmental ecology. The climatic factors play an important role for sustenance of biosphere at large.

Spatial Analysis of weather phenomenon in broader perspectives is the science of climatology. A climatologist as geographer deals with spatial and temporal aspects of weather elements of any region of the globe and as such significance of climatology gets exclusively important and broader accordingly. Weather phenomenon consequently have their impacts on ecology, temperature variations, seasonal cycles, biodiversity models, cyclic movement of nutrients in biosphere, ecological habitats and their significance extends latitudinally and longitudinally.

One of the serious problems faced by the mankind of today is the climatic change whose consequences are visible in our day to day life. Man is degrading his own environment at a terrifying rate in addition to an ever-increasing demand on natural resources. The cumulative effects of our advancing technology, massive industrialization and urban concentration have

all combined not only to create danger to the quality of human life but even to pose threat to life itself. Many species which were surviving few decades ago have now become extinct and some others are at the verge of extinction and have been listed as endangered. Our life supporting systems such as air, soil and water are not only going to be limiting but being poisoned by harmful chemicals¹.

The existing climatic scenario reveals that magnitude of climatic change is increasing because of human interference. As a result natural landscape often gets ecologically degraded through the process of porosity and eventual fragmentation. The consequences of such a change appears in the form of natural hazards, like pollution, floods, droughts, desertification etc. The impact of these hazards becomes much more serious due to endless increasing of population.

Environmentalism has become an overriding concern in national plans and policies among developed and developing nations. Today no developmental project is considered complete unless to go through environmental impact assessment. During the last few decades the global environment has gone through serious challenges and changes. Population pressure has escalated rapidly, consequently resources have dwindled. The earth has been denied of green cover hence climate change is inevitable².

Many man-made disasters viz droughts, floods, famines, desertification have affected many parts of the world. The anticipated changes in the world climate and rainfall patterns are causing deep anxiety. The greenhouse gases are being released into the atmosphere directly or indirectly. Either these may be produced by fossil fuel consumption where as natural processes also play a part. Agricultural operations, land use/ land cover changes and other activities performed by humans contribute a sufficient amount of methane and nitrogen oxides. While as industrial processes release chlorofluoro carbons, carbon dioxide, carbon monoxide, etc. into the atmosphere.

¹ Adaptation Policy frameworks for climate change. Developing strategies, Policy and Measures. Edited by Bolim, Cambridge University Press United Kingdom and New York, 2005.

² United Nations framework convention in climate change UNFCCC, Bonn 1992.

The carbon dioxide (CO₂) is largest single source of Green House Gas emission produced by burning of fossil fuels. It also produces nitrogen oxides, hydrocarbons, carbon monoxide. Which are not included in the category of green house gases but they disturb the bio-geo chemical cycles and change the chemistry of atmosphere.

Sulphur oxides are generated when sulphur reacts with oxygen; the resulting aerosols have an effect on atmosphere. Green house gases are also released by the extraction, processing, transporting of fossil fuels. These releases can be deliberate as when natural gas is flared or vented from oil wells emitting mostly carbon dioxide and methane. They can also result from audients, poor maintenance and small leaks in well heads and pipe fittings and pipelines. Hydrocarbons enter the atmosphere as a result of oil spills from Tanker ship or small losses during the routine fueling of motor vehicles³.

The second largest source of carbon dioxide is the deforestation as when the forests are cleared for development or agricultural purpose the carbon absorbing capacity decreases because of increase in albedo. The carbon dioxide emitted by various processes gets directly mixed with the fresh atmosphere. The earth`s climate is driven by a continuous flow of energy from the sun. Heat energy from the sun passes through the earth`s atmosphere and warms the earth`s surface. Deforestation creates disbalances in the atmospheric spectrum. It creates a vacuum in the continuous cycle of atmospheric phenomenon which consequently retards the ecology. Coupled with this the nature and magnitude of climatic changes gets disrupted and accordingly the biospheric mechanism assumes different changes.

As the temperature increase the earth sends heat energy (infrared radiations) back into the atmosphere some of the heat is absorbed by the gases present in the atmosphere such as CO₂, water vapors, methane, nitrous oxide, ozone.

These gases which are all naturally occurring act as a blanket, trapping the heat and preventing it from being reflected too far from the earth. They

³ Borisenkov, V.P., "*Climate and Human*", Moscow Nauka, 1982.

keep the earth's average temperature at 15° C warmer enough to sustain human life, plant and animal life. Without these gases the average temperature would be -18° C too cold for life forms. This natural warming effect is known as Green House effect. Carbon dioxide CO₂ which keeps the earth warm, four million years ago its concentration in atmosphere was much higher than today 80% compared to today's 0.03% but most of it was removed by photosynthesis⁴.

Many geographers, following the lead of meteorologists are adopting the concept of climate as a unifying conceptual framework for an analysis of environment, man induced changes in it and its management. This is the employment of the system approach as a method for conceiving a given environment as an integral whole, identifying the components and processes involved in climate change and for helping policy formulations to restore the same. Abstracting from particular forms of eco- disability problems one must go over to the general form and nature of ecological problems. Ecological problems stem from the interaction between human systems and natural systems.

The term climate has originated from the Greek word "*Klima*" referring to the supposed slope of the earth and approximating our concept of latitude. Climates exhibit both spatial and temporal variations. Weather and climate studies mainly focus on gaseous envelop surrounding the surface of earth. Continuous changes are taking place in this restless sphere. Although the changes took place in the atmosphere only but these changes are governed by the interferences and interaction taking place in other sphere viz lithosphere, hydrosphere, cyrosphere and in all biosphere⁵. Thus the interactions within the various spheres of the planet earth give rise to a complex climate system, which encompasses all the spheres of earth and also the interference of humans in this system?

Problems associated with environmental deterioration began with the dawn of civilization when humans started congregating in communities. Prior

⁴ Sellers, William D., *Physical Climatology*, Chicago: University of Chicago Press 1965.

⁵ Critchfield, H.J., *General Climatology*, New Delhi, Prentice Hall 1987.

to this period environmental degradation from primitive societies could be conventionally and unobtrusively rectified by taking the advantage of the natural self cleaning capacity of the environment. During this period the population density was low and plenty of land was available. Environmental problems thereafter, in the form of different types of pollution have arisen mainly because of many reasons.

The ever increasing population of human beings has become the biggest challenge to the quality of environment. An unprecedented threat to human survival has arisen from increased population. The soaring growth of population has created a multitude of problems that of hunger, malnutrition, poverty, economic and political instability. Population explosion is the characteristic of all developing countries of the world which do not have enough resources even to meet the present situation⁶.

There is a growing realization that unchecked rate of multiplication lies at the root of most vexing problem with which mankind is faced today. The destiny of the planet was changed by the man with the advent of modern technologies and industries along with agriculture hence man became the manipulator of the environment.

Man is exploiting valuable resources at a terrifying rate without caring for the laws of nature. The cumulative effects of our advancing technology, massive industrialization and urban concentration have all combined not only to create danger to the quality of human life but even to pose threat to life itself.

Our life supporting systems such as land, water and air has degraded to such an extent that in near future it will be impossible for us to recover from this impermissible loss. Many species of flora and fauna which were thriving since decades have now become extinct because of the climate changes of the past and some have been listed as endangered species list in the world Red

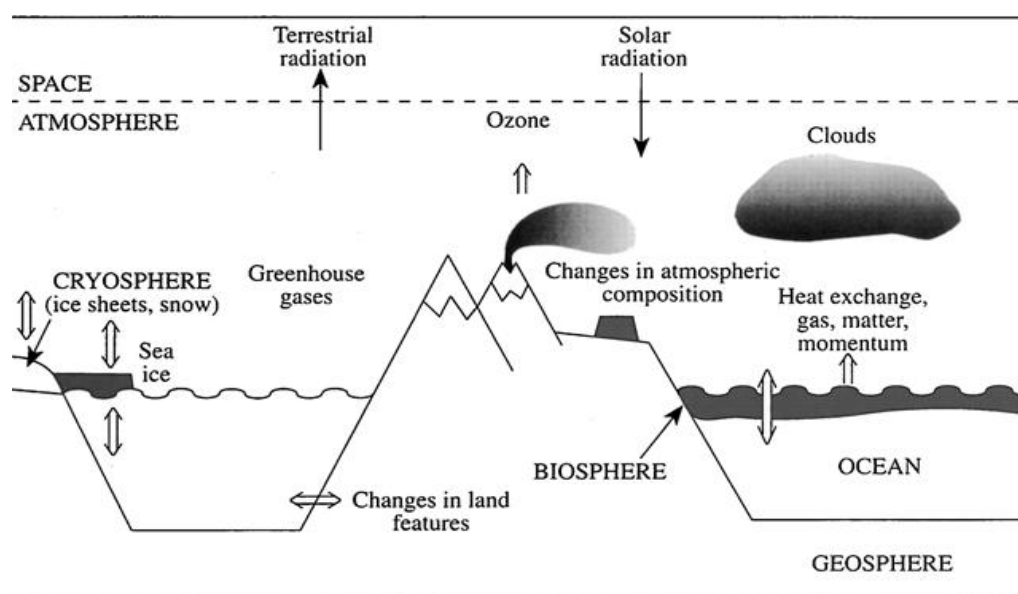
⁶ Sharma, P.D., *Ecology and Environment*, Rastogi Publication, Meerut, 2009, pp 11-12.

Book. The current climate change symptoms are the major threat to the present day mankind and also to the biomes of the world⁷.

The existing climate scenario reveals that magnitude of climate change is increasing as a result, the natural landscape often gets ecologically degraded because of changing climate and the consequences of such a changed climate situation appears in the form of natural hazards like desertification, landslides, floods, droughts, cyclones, winds, pollution etc. the impact of these natural hazards becomes much more serious in the desert ecosystems⁸.

The study of climate is based on recognition of the existence of atmospheric unit known as climate system. A climate system is relatively independent unit consisting of various gases in which different phenomenon or processes occur which interact each other and frame out climate. Within the atmosphere the cycling of the water takes place in presence of various gases and heat energy which gives birth to various forms of precipitation. The process like conduction, convection, evaporation, transpiration, condensation which will accomplish transfer of heat through movement of the air.

Climate System



⁷ Ibid pp 146-152.

⁸ Agarwal, R.K., Sangal, V.K, *Environmental Studies*, Krishna Prakashan Media (P) Ltd, 2008 pp 2-8.

Like other systems of the earth's environmental atmosphere possess feed-back mechanism to recover from modification. There is however, limits to the ability of atmosphere to recover from pollution stress whose intensity and frequency is greatly amplified by our technological factors.

Atmospheres all though have a well-defined carrying capacity or immunity to bear the stresses posed by man on it. Interference with atmosphere beyond this capacity leads to destruction and disintegration of all its components⁹.

Man possesses a unique position in this world as he can operate elsewhere; interfere with everything he likes within the bounties of nature. Hence, he cannot afford to assault this environment indiscriminately in the absence of this realization, we now faced with the problem of climate change resulting from pollution of air, land and water Problems associated with environmental deterioration in general began with the dawn of civilizations. When humans started the community life. This interference of human with nature has given birth to environmental problems. Among them climate change is one of the most serious and gloomy problem faced by the present day mankind¹⁰. Although there are evidence that climate change is a natural phenomenon as change is the law of natural but the human interference has ignited the problem to such an extent where from it is very difficult to recover.

From food gathering and agriculture stages, man with the help of technological development has brought a new revolution in the process of man-nature interaction by inventing a very powerful device known as "*machine*" with this invention man has now become able to interact with his surrounding environment with more impetus.

Man's lusty and greedy nature used this powerful device as a means of weapon to wage a war against the nature. The scientific and technological knowhow gave birth to industrialization which incorporated many ill-

⁹ Agarwal, R.K., Sangal, V.K, *Environmental Studies*, Krishna Prakashan Media (P) Ltd, 2008 pp 2-57.

¹⁰ Dhaliwal, G.S., Kukal, S.S. *Essentials of Environmental Science*, Kalyani Publishers, New Delhi, 2005 pp 3-5.

conceived and ill-logical philosophies of life first in natural science and later in all branches of social science. In a course of time these philosophies engrained on human mind that led to disintegration of striking balance which existed between different components of the environment. These philosophies created a race of competition among individuals and nations. This competition led to problem of materialism and mass consumerism which contributed a lot for the reckless exploitation of natural resources. Hence these philosophies replaced man`s soft and reverent nature with respect to this environment with vundalization and barbarism¹¹. The industrialization process gave spontaneous boost to process like combustion i.e., burning process of fuels which further degraded the quality of atmosphere and changed its chemistry. The chemicals get added to the pure air by this process which resulted in the change and disturbed climate system. The change in climate system resulted in what we call climate change. The imbalance which occurred in the atmosphere due to process of industrialization has created disturbance in the composition of atmosphere and this imbalance accompanied by other factors has led to variations and variabilities in the moisture and heat content.

These variations and variabilities has interfered with the atmosphere cycles which later on put their impact on temperature and precipitation trends lead this planet on the track of climate change.

The Republic of Turkmenistan has a very complex climatic scenario, being a non-tropical desert it is highly vulnerable to climate change . Located in central Asia between 35°08' and 42°48' N and 52°27' and 66°41' E. The prestigious Kopetdag Mountains stand guard in the north, between the Caspian sea in the west and Amu Darya in the east with total area of 488100 Km² it is the 50th largest country in the world.

The climate of Turkmenistan is sharply continental, with the exception of the inshore zone of the Caspian Sea and the mountains. Average annual air temperature along the whole territory is positive and ranges on plain part of

¹¹ Chatwal, C.R., Pandey D.K and Nanda, K.K., *Encyclopedic Dictionary of Envionment*, Anmol Publications, New Delhi, 1989 pp 237 - 39.

Turkmenistan from 12°C to 17°C in the north to 15°C – 18°C in the south east. January with the temperature of -6°C is the coldest month of the year while as July average temperature is 27 - 30°C like the other parts of the world. The Republic of Turkmenistan has experienced tremendous change in land use/land cover, social – economic and demographic profile. These changes in turn put their effects on climate of Republic¹². During the last century the variation in climatic scenario were visible in Republic as these climatic variations have put their impacts on ecology and biodiversity of the region. Some of the immediate symptoms of climate change are the desertification, droughts, soil erosion, water scarcity, heat intensity, decrease in agriculture production etc.

Turkmenistan being rich in terms of natural gas and hydrocarbons support the industrial enterprise. This industrial enterprise has led to carbon dioxide emission during the past few decades has steadily increased. It is conditioned by country wide gasification programme at that time and accordingly by sharp increase of the amount of natural gases consumed by the population. The total amount of fuel used in the country has grown and green house gas emission has accordingly increased.

The major contribution to the methane emission in the territory of Turkmenistan is made by oil and gas related activity. Although in the nineties of last century i.e., from 1994-1999 there was a decrease in methane emission which then rose again¹³.

According to the 2004 data the main fraction of GHG emission is related to oil and natural gas complex 51.8% then the population 19.4%, electric power industry 15.4%, residential (municipal) sector 5.3%, transport 4.5%, emission from other activities are insignificant.

For the production of heat and electricity in the Republic natural gas is a primary source while as other types of fuel constitute only 1%. Calculations were carried out for natural gas and fuel oil each of the following year 1994-2004 on the bases of the actual data, in 2004 GHG emission made up 22918

¹² Economic strategy of Turkmenistan: *Relying on the people, for the sake of people*, Turkmen state, Publishing Service, Ashgabat, 2010.

¹³ *Initial National Communication under UNFCCC Phase 2*, Ashgabat 2006, Turkmenistan: Capacity assessment for implementation of global U.N. Environmental conventions Ashgabat 2006.

Gg (CO₂ equivalent). The CO₂ is the major Green House gas emitted from fossil fuel combustion. The fraction of other gases in the total emission is insignificant. Taking into account the capacities of electricity production in Turkmenistan are being developed, increase of emission is expected in future¹⁴.

Transport and communication system of Turkmenistan plays an important role in the economic development of Turkmenistan. But on the other hand it is another source of Green house gas emission in atmosphere carbon dioxide (CO₂), methane (CH₄) and nitrous oxide, carbon monoxide, sulphur dioxide etc. which become a cause of emergence and aggravation of problem of regional atmospheric pollution. The variation in temperature and precipitation and their uneven distribution has framed out the various ecological zones of the Republic. In the northern regions where winters keep the temperature low, snow precipitation can be observed and the snow cover is stable from June to September. There is a lack of precipitation in this period, low precipitation is observed from 2.5-5.0mm. Maximum precipitation occurs in April (18.7mm) precipitation in summer months occurs mainly due to cyclone activity¹⁵.

The increasing temperatures and decreasing precipitation is going to put a great stress on the ecology and social-economic development of the country in future. It will affect the water management, health sector, agricultural sector as well as coastal zones of the Caspian Sea. This in turn will decrease the river flow of Amu Darya and its small tributaries. The Karakum canal will also get affected and the decrease in cotton and other cereal production is inevitable. The changes in temperature and precipitation will also put stress on ground water sites. The desertification and salinization process will be ignited by the climate change symptom¹⁶.

¹⁴ *Statistical year books of Turkmenistan Ashgabat* : Turkmenimilli Ashgabat 2000-2008.

¹⁵ *Environmental status of Turkmenistan Ashgabat* 1999.

¹⁶ *Climate change issues and sustainable development*. Ministry of nature protection of Turkmenistan Ashgabat 2003. Edit Akmuradov M.K., Comp. Durdiyev A.M.

SIGNIFICANCE OF THE STUDY:

Within the broader perspectives of environmental ecology the climate factors play an important role for the sustenance of biosphere at large. Cyclic movements of nutrients along with ecological balances prevailing at various stages in a biosphere are being governed by nature and magnitude of climatic changes, which are having different range of variations. Accordingly impact analysis on varying bi-products differs from region to region. Magnitude of climatic change determines nature of ecology. All related components of climatic factors including temperature, precipitation, sunlight, moisture etc, effects the various aspects such as occurrence, distribution, productivity and growth of flora and fauna. Besides this range of climatic factors encompasses wider centripetal and centrifugal forces of bio-geo chemical cycles¹⁷.

Assessing the magnitude of climatic change is an important component of human dimensions of climate change research. Vulnerability assessment of climate change helps to identify and characterizes who and what are sensitive to climate change risks. It also enables us to identify the opportunities for adaptation and to develop an understanding of the determinants of vulnerability and how they interact and identify opportunities to reduce the intensity and vulnerability and enhance adaptive capacity to current and future risks¹⁸.

Present study is concerned with the nature and magnitude of climatic change with special reference to temperature and precipitation. This type of study is important because it signifies interplay of physical and socio-economic factors operating in a particular region. Magnitude of climatic changes has their impact on temperature variations, season cycles, biodiversity models, ecological habitats and their significance extends latitudinally and longitudinally. Virtually all human activities are effected by magnitude of climatic change which may be defined as a condition of atmosphere for a given time period. As such study of nature and magnitude of

¹⁷ R.J. Chorley, *Atmosphere, weather and climate* (3rd ed.) London: Methuen & Company Ltd. 1973.

¹⁸ Budyko, M.I., *Climate and Life*, trans David H. Miller, New York: Academic Press inc. 1974.

climatic changes in their spatial content is a basic necessity for understanding geography of an area.

Atmospheric changes, omnipresence of weather, influence of physical environment ensures people's interest and concern for weather elements. High velocity winds, heat waves, cloud snaps, sunshine and cloudiness, heavy rain or its absence, snow, hail, thunder and lightning are few of the observes of nature and magnitude of climatic changes that occur in atmospheric envelope that surrounds the earth¹⁹. While analyzing and studying spatially such climatic changes, significance of the study goes much deeper.

The varying topography and latitudinal extend of the territory of Turkmenistan in the zone of non tropical deserts makes it more vulnerable to climate change. Hence this characteristic provides a base for having a spatial study of nature and magnitude of climatic changes with special reference to temperature and precipitation.

OBJECTIVES:

Keeping in view various dimensions of the work following objectives have been broadly outlined.

1. To examine the nature and magnitude of climatic change in Republic of Turkmenistan.
2. To study changes in temperature and precipitation variations in the country as a whole.
3. To have assessment in viewing out impacts of nature and magnitude of climatic change in Turkmenistan with special reference to temperature and precipitation.
4. To regionalize the country on the basis of varying climatic zones.

¹⁹ Hobbs, J.E., *Applied Climatology* Boulder, Colo: West view press 1980.

HYPOTHESES:

- 1 Components of climate are responsible for varying types of climatic zones in the Republic as a whole.
- 2 Favorable climate results in favorable climatic regions and unfavorable is giving rise to unfavorable regions.
- 3 Climatic change has a great impact on the biodiversity and ecology of Turkmenistan.

DATABASE:

AS the nature of problem is highly technical and requires a data about temperature and precipitation and it was not possible to have measurement for such complex things individually. Hence the data was collected from various weather stations situated in various regions of the Turkmenistan. This data was supported by satellite data retrieved from the website www.metsat.com.

Most of the data was obtained from different sources like books, journals, magazines, World Bank reports, statistical digests published by the government of Turkmenistan. The data of various departments associated with the Ministry of Nature Protection of Turkmenistan especially Ministry of Water Management, Institute of Land Management, State Committee of Statistics of Turkmenistan and National Institute of Desert Flora and Fauna was also taken into consideration for the analysis.

METHODOLOGY:

In the initial stage map of the study area was traced out. Data was collected, tabulated and analyzed. Results were inferred through relevant statistical and other techniques. The obtained results are highlighted through cartographic techniques. Changes in temperature and precipitation and for assessing their trends, regression method was taken into consideration. For further analysis of temperature and precipitation line of Best Fit Model was applied. For impact analysis of climate change on various eco-variables multiple regression method was applied.



CHAPTER NO -2

REVIEW
OF
LITERATURE

Literature Review discusses published information in a particular subject area within a certain time period. It can be just a simple summary of the sources but it usually has an organizational pattern and combines both summary and synthesis. A literature review is a body of text that aims to review the critical points of current knowledge including substantive findings as well as theoretical and methodological contribution to a particular topic. Literature review are secondary sources and as such, do not report any new or original experimental work²⁰.

The literature which is available in different forms like books magazines, journals, papers, etc. cover only broader aspects of climatic classification, climate impact on the biodiversity of various regions, climatic regionalization, factors of climate, etc.

It was only in mid Nineteenth century that various theories were put forth regarding the climate change.

Jean – Baptiste Joseph Fourier in 1824 hypothesized that the atmosphere retains heat, keeps the earth`s surface temperature far, higher than it would be if the earth has no atmosphere or if the atmosphere contained no water vapour

²⁰ Gautam N.C., Development of Research Tools, Shree Publishers and Distributors New Delhi, 2005.
Also See: Patnaik, K.A., Research Methodology in Social Sciences, Common Wealth Publishers New Delhi, 2001.

or carbon dioxide (CO₂). He also linked the heating action of atmosphere to the “hot house”.

Brucher and Julius Hann argued separately that human – induced climate was already occurring in Europe and America as a result of deforestation and other causes. Buchner’s study was based on observations and he thought that crop failure, economic crises and epidemics would result due to climate change.

John Tyndall in 1863 first calculated the radioactive potential of CO₂. His observations paved way for the Svante Arrhenius- Swedish scientist to make the first calculation of contribution of Carbon dioxide to the earth’s surface temperature in 1900.

Air pollution was held responsible by several authors for climate cooling in their meteorological literature, besides that they have also put forth various causes like volcanic activity and solar variations. Against this variety of proposed external influences on the climates, Namias in 1970 argued that the autonomous dynamics of air-sea interaction alone could be held responsible of what had been indeed the abnormally cold decade of 1960`s.

Reid Bryson 1975 in an article “*The Present Arctic Expansion*” published in the “*Nature*” report cited the observations that “ the growing season in England has diminished by two weeks”, “Mid summer frosts returned to the upper Mid-Western United States” the average temperature of Iceland has declined to its former (pre 1945)level and many others.

Damen and Kunen 1976 reported to have found a warning trend on the southern hemisphere they suggested that in the long run global warming as a result of green house gas effect might overtake cooling mechanisms in operation on the northern hemisphere.

Thomas Jefferson apparently believed that clearing land for agriculture altered the climate of early United States in favourable ways (Fleming 1998).

In 1979 at the first world climate conference, WMO scientists established the world climate programme to coordinate and develop climate research and climate data. The “*Nuclear Winter*” issue of early 1980`s and the

“*Antarctic Ozone Hole*” discovered in 1986 were the first events to elevate the general issue of anthropogenic atmosphere change to the level of front page news (Edwards and Lahsin, forth coming; Morrisette and Schneider 1989). Both issue created awareness that human actions were capable of causing sudden, potentially catastrophic changes in the atmosphere not at regional scale but globally.

Changnon in 1975 was serving as a president of Weather Modification Association argued for new and higher efforts in weather modifications, and he expressed his expectations that since an actual “*climate change in the sense of increased variability*” had been under way since 1971²¹.

Joanne Simpson, professor of environmental science at the university of Virginia by early 1970`s testified before the U.S. house of Representatives during hearing on the use of weather modification in Vietnam. A paramount hard fact about weather modification is that, that there are today only a half dozen programmes over the whole world that have conclusively demonstrated that the treatment works (Simpson 1975).

Golany in 1966 argued that cities have significant effects on regional climates. The urban heat islands that cities create can produce dramatic temperature gradients and precipitation in their region.

Newman (1991) has done a comprehensive research related to energy consumption for transportation. This research has compared the transport-related energy consumption for the cities around the globe. It was found that total transport energy consumption has adverse affects on the atmosphere.

Frank etal, 2000 carried out another research relating to green house emissions and was of opinion that green house gas emission is high in areas having high density of vehicles. He has done zoning of Portland on the bases of Green house gas emission and transport gas emissions climate change has also adverse effects on water resources. The GLRAP`s studies showed that atmospheric Green house gas concentration causes warming effects which leads to evaporation of lakes and drainage basins which ultimately leads to

²¹ Mudge, F.B., The Development of Greenhouse Throry of Global Climate Change from Victorian Times, 1997.

decrease in water level. Vegetative cover plays a vital role in mitigating the effects of climate change²².

Richard Grove (1997) has argued that some nineteenth century colonial forest policies were predicated on a “*dessicationist*” theory of relationship between deforestation and local, regional and even continental climate change.

Sexana H.M in his book “*Environmental Geography* 2nd edition 2004 has provided a close analytical scrutiny of various facts of environment, its degradation as well as management environmental problems like pollution, degradation and ecological crises has been also discussed. Besides that natural resources conservation, natural hazards and global environmental issues has also been analyzed in a systematic way.

Yadav B.S. in his book “*Recent Advances in Environmental Analysis (water, soil & Air)* 2006. Has done the pollution analysis in a logical sequence. He has also described about the various problems like global warming, ozone depletion, acid rain, and drought and in all air and water pollution. He has held industrialization and urbanization process responsible for the environmental problem especially global warming and ozone depletion.

Mishra S.P. published a book in 2004 entitled “*Environmental crisis*” in this he has examined the various dimensions and aspects of the environmental crises in all its nuances and explained how some of the ill effects of environmental mismanagement can be ameliorated. He has made an elaborate discussion on the desertification problem, ozone hole, changing rhythm of the season etc. he has not only discussed this environmentally but also politically, economically and ecologically²³.

Khan A, A Zoologist has brought various tools, techniques, models and concepts concerning resources management, ecological conservation etc. in his book, *A text book of environmental studies* (2006). He has made elaborate discussion on various issues related to environment viz global warming,

²² Prather et al., Chapter – 4, In Houghton et al., Climate Change, 2001.

²³ Mishra S.P., Environmental Crises, 2004.

climate change, acid rain, biodiversity loss, ecological problems caused by them in a nice manner²⁴.

Prakash R, An environmental biologist has analyzed the magnitude of various environment problems in his book "*Man and environmental Science*" (2004). He has studied the cause and effect analysis of various environment problems on the flora and fauna and argued that these problems really play an important role in the deterioration of ecology of any region²⁵.

Sharma H.S. and Khan T.I: Published the book in 2004 entitled "*Ozone depletion and environment impacts*" in which they have discussed the composition and stratification of the atmosphere. The book also contains the information related to the impacts of increased ultra violet rays on terrestrial and aquatic ecosystems and biogeochemical cycles. They argued that ozone depletion can cause most of the damage to plant and animal life²⁶.

Dhinwa P.S. Ajai and Mayank B. Carried out a work in the Ladakh region and published a paper entitled "*Combating desertification in dry agro-ecological region of cold desert using RS and FIS*" "A case study of fast and micro watershed, Ladakh district J&K in which they reveal that mass wasting process is dominant in the valleys and the anthropogenic factors and vegetal degradation are very prominent for desertification.

Singh S. has analyzed the geomorphologic indicators of climate change in a book "*Geomorphology and Environmental sustainability* 2005. In which he has selected some indicators by which we can trace the past climate situation of the earth or any region he has listed biological, geographical, cryogenic, tectonic, geomorphologic and also historical records for climate change study.

Khan T. I, Published a paper entitled "*Greenhouse Effects, Global warming and climate change* in 2005 in which he has enlisted the effects of climate change, both probable and uncertain on the various spheres of earth.

²⁴ Khan A., Environmental Studies, 2006.

²⁵ Prakash R., Man and Environmental Science, 2004.

²⁶ Sharma H. S., and Khan T.I., Ozone Depletion and Environmental Impacts, 2004.

He has employed many models to assess the rise in the carbon dioxide emission and also their impact on various spheres of life.

Nick Bond N., Jim O. and Soreide N, carried out a study on Arctic and published a paper entitled, “*Study of climate change in the Arctic*, in which they have explained that how scientists study climate change viewing it by different angles. They have also studied the causes and effects of climate change and also the mechanism.

Dr. Mantua N, a researcher at the University of Washington, speaks about the pacific decadal oscillation (PDO) as “Even in the absence of a theoretical understanding, PDO climate information improves season to season and year to year climate forecasts for N. America because of its strong tendency for multi-season and multi-year persistence. From a societal impacts perspective recognition of PDO is importance because it shows that normal climate condition can vary over time periods comparable to the length of human`s lifetime²⁷.(Source www.arctic.noaa.gov/essay_bond.html)

Khan, T.I in his book “*Environmental Policies for Sustainable Development*” (2001) has placed the entire environmental scenario in its proper perspective and reviews the work of existing environmental agencies and also has pointed out the guidelines and has prepared the blue print that environmental policy makers should keep in mind while framing the environmental protection programmes²⁸.

Panday G.N. in his book “*Environmental Management*” has elaborated the impacts of development processes on the environment in as systematic way. He has besides urged that balance should be maintained between developmental scenario and environmental issues like air, land and water pollution. He has also analyzed that how industrialization, urbanization, technology, development have degraded our environment He has also urged for sustainable development²⁹.

²⁷ Source www.arctic.noaa.gov/essay_bond.html

²⁸ Khan T.I., *Environmental Policies for Sustainable Development*, 2001.

²⁹ Panday, G.N., *Environmental Management*, 2004.

Conventions on climate change issues:

A huge number of conferences were held at global level to provide a policy framework to deal with the global climate change.

The first conference was held in Geneva in 1979 which dealt with world climate in right and meaning full way.

On March 22, 1985 Convention was held at Vienna Austria for the protection of ozone layer: This convention was signed by 20 states and the EEC at a conference convened by UNEP. The main objective of the convention was the protection of environment and human health resulting due adverse effects of ozone layer depletion.

From October 9-15, 1985 in Villach Austria international conference on the assessment of the role of Co₂ and the other green house gases in climate variations and associated impacts.

In Villach Conference 29 countries recommended that the government and intergovernmental organizations should take into account the results of the assessment made in their environmental programmes and should favour the increase of public information effects on the global change issues. This conference was followed by workshops at Villach, Bellagio and Italy.

On September 16, 1987 in Canada Montreal Protocol on substances that deplete the ozone layer was held. The protocol was attended by 46 countries and signed only by 24 countries. Montreal seeks to inhibit the production, consumption and trade of ozone-depleting compounds. The protocol distinguished between two groups of countries, the more developed with relatively high levels of consumption of the controlled ozone depleting substances and the developing countries with relatively low levels of consumption.

From June 27-30, 1988 Conference on the Changing Atmosphere: Implications for Global Security was held in Toronto Canada. The conference was organized by Canadian government in which 300 scientists and decision makers from 45 countries and international organizations take part. The conference called for urgent work on the action plan for protection

of atmosphere, this action plan, complemented national actions, had addressed the problems of climate warming, ozone layer depletion, long-range transport of toxic chemicals and acidification.

Resolution of United Nations General Assembly on protection of global climate for present and future generations of mankind (Resolution 45/53 of December 1988 and 44/207 of December, 1959.

These resolutions urged the governmental and non-governmental organizations and scientific institutions to treat climate change as priority issue, to undertake and promote specific, co-operative action oriented programmes and research so as to increase understanding on all sources and causes of climate change including its regional aspects and specific time frame as well as the cause and effect relationship of human activities and climate change.

From March 5-7, 1989 in London, UK international conference on saving the ozone layer. 123 countries along with European community participated. The conference was initiated by United Nations in association with UNEP. The conference was aimed at strengthening support for the Vienna convention and the Montreal Protocol and at the examination of more radical proposals than were contained in those treaties.

On March 11, 1989 in Hague Netherland, international conference on the Protection of Global Atmosphere was held at the initiative of the French Prime Minister and the French Dutch, and the Norwegian government produced the Hague Declaration. Which called for the development within the UN framework of a new institutional authority either by strengthening existing institutions or by creating new institutions? The declaration also called for the creation of atmospheric fund to provide assistance for poor countries for protection of atmosphere.

From May 1-5, 1989 in Helsinki Finland first meeting of the parties to the Montreal Protocol on substances that deplete the ozone layer layer. The conference issued a declaration of intent for the complete elimination of the production and use of CFS`s by the year 2000. It also called for the financial

aid and technology for third world countries so that they can find alternative for CFC`s.

On July 14, 1989 in Paris France summit of group of seven industrialized countries in which the final statement related to environmental issue with particular attention to global climate change issues was advocated. The countries expressed a strong interest towards the safeguarding of environment.

On November 6 and 7, 1989 conference was held at Noordwijk Netherlands which issued a declaration for the decrease in Co₂ emissions as per the IPCC and world climate conference standards.

From April 16-18, 1990 White House Conference on science and economics research related to Global Change was held at Washington D.C USA. The conference was initiated by the US president sought to add an integrating focus for international thought on global change, by introducing the concept of Global Standard ship, it also emphasized a new dimension of the international dialogue on global change.

From May 14-16, 1990, At Bergen Norway Conference on Action for a Common Future. In this conference the Bergen Ministerial Declaration of Sustainable Development in the Economic Commission for European Regions was prepared covering the policies, objectives, principles and commitments in support of sustainable development and with particular emphasis on global aspects.

On October 5, 1991. A landmark agreement Madrid Agreement on Antarctica was signed by member nations of Antarctica treaty which banned the exploitation for oil and minerals on the icy continent to protect the ecosystem and also regulated the marine pollution and waste disposal³⁰.

Intergovernmental Panel on Climate Change (IPCC) which was formed by the WMO and UN Environmental Programme in 1988 which consists of experts on climate, ecology, environment and social impacts

³⁰ Katiyar, K.S., Environmental Concerns: Depleting Resources and Sustainable Development, Pointer of Publishers, 1999.

Also See: UN Climate Change Secretariat, A guide to climate change convention process 2002. Visit: <http://unfccc.int/resource/process/guidepross.pdf>.

from around the world. The first released report of (IPCC) in 1990 noted a qualified consensus on two points. First, greenhouse gas concentration was rising rapidly due to human activities. Second, if this trend continued, global average temperatures were likely to rise somewhere between 1.5° and 4°C by about 2050 A.D. In UN conference on environment and development (UNCED) held in 1992 IPCC played an important role producing a landmark Framework Convention on Climate Change (FCCC) signed by 165 Nations. It set voluntary goals for stabilizing greenhouse gas emission. More important, the FCCC requires signatories to prepare national greenhouse gas emission inventories and commits them to ongoing negotiations towards an international treaty on climate change (Bodansky 1993).

The IPCC continues to provide scientific input to the periodic conferences of parties to the FCCC. Hence an era of global atmospheric politics has dawned, with computer models at its very core (Bodansky & Donoghue 1994).

The Kyoto Protocol sets binding targets for 37 developed countries for reducing greenhouse gas (GHG) emission to an average of 5% against 1990 levels over a five year period 2008-2012.

In 2009 the Kyoto Protocol to prevent climatic change and global warming runs out, to keep the process on the line there was an urgent need for a new climatic Protocol. At the conference in Copenhagen 2009 last time on government level before the climate agreement need to be renewed. **The climate conference in Copenhagen was essential for the world's climate.** The main aim of this protocol was to prevent the global warming and climatic change³¹.

The Copenhagen accord was approximately supported by 140 countries. The agreement also includes landmark provisions for financial assistance to support clean technology development.

³¹ Kyoto Protocol, 1997. The Complete text of the Kyoto Protocol to the UN climate change convention available on line at <http://unfccc.int/re-source/docs/convkp/kpeng.pdf>

The latest summit regarding climate was the Cancun Climate Summit held in December 2010 in Mexico. It was in continuation of Copenhagen international climate negotiations. The Cancun climate summit focused on initiatives to curb global warming and includes a \$100 billion fund to help developing countries. The agreement signified some progress for finance, technology, adaptation and transparency, but is not viewed as a decisive boost for combating climate change³².

So, as far as Republics of Central Asia in general and Turkmenistan in particular is concerned a small amount of work has been done on climate studies. Baggs, S. A 1983 in his book, "*landscape planning*" has made environmental impacts and has spatially classified in wider aspects the climates of central Asian Republics.

International institute for recommendation and improvement, Washington (1990) has discussed integrated approaches to classifying land as ecosystem in the preceding of workshop on land evaluation for forestry³³.

Cole J. P, in his book "*Geography of Erstwhile USSR*" analyzes region wise study of economic, agriculture, industrial and mineral resources. He also makes an observation on climate classification of present Republics including Uzbekistan, Turkmenistan, Kazakhstan, Tajikistan and Kyrgyzstan³⁴.

Mir G. M 1993, in his book "*Regional Geography of Central Asia*" clearly demarcates resource potentiality in entire region. He also makes analysis of physical and climate factor, along with physiographic divisions³⁵.

Harris C. D. 1963, in his book "*Soviet Geography*" highlights favourable geographical habitats and correlates it with growth of economic development in erstwhile USSR. He explains at length physiographic regions of entire belt and makes a classification of climate regions with their impact on varying economic variables³⁶.

³² Indian Ocean Digest, Usmania University, Hyderabad, 2010-2011.

³³ Baggs, S.A., Landscape Planning 1983.

³⁴ Cole J.P., Geography of Erstwhile USSR, 1991.

³⁵ Mir, G.M., Regional Geography of Central Asia, 1993.

³⁶ Harris C.D., Soviet Geography, 1963.

Berg L. S., 1959, in his book “*Natural Regions of USSR*” attempts towards having a demarcated regionalization of erstwhile USSR. The author while defining natural regions of USSR takes into consideration all factors responsible for varying topography with magnitude of climate dimensions³⁷.

Victor.F and Khabibulla. A, in the book “*Biogeography and Ecology of Turkmenistan (Edn. I)*” has given a complete account of biogeography, animals, plants, ecology and conservation in Turkmenistan. The book includes both desert and mountain regions of the Turkmenistan and have discussed the various physical and ecological aspects but have not taken into consideration the magnitude of climate change.

Lal. R. , edited a book “*Climate Change and Terrestrial Carbon Sequestration in Central Asia*” 2007. The book brings together current knowledge of terrestrial carbon sequestration in central Asia along with technology, agriculture, environment, climate change in whole central Asia. The effects of irrigation schemes on secondary salinization, soil management and its relation to carbon dynamics, the relation between forest management and carbon dynamics, economics analysis of land use practices and also methodological issues arising from GIS, remote sensing, carbon budgeting etc³⁸.

Jianguo I. Q.and Evered, Kyle 2008, edited a book “*Environmental Problems of Central Asia and their Economic, Social and Security impacts.*” This book express the various problems associated with environmental problems such as economic loss, social impacts and also those environmental changes which lead to security concerns in the region. The book explores now technologies and adaptation strategies to mitigate these environmental changes with the ultimate goal of promoting sustainable and improved quality of life in the region.

³⁷ Berg L.S., Natural Regions of USSR, 1959.

³⁸ Lal R., Climate Change and Terrestrial Carbon Sequestration in Central Asia, 2007.

REPORTS

Central Asia - From Rio 1992 to 2012 and beyond: Sustainable Mountain Development - Report, 2011.

The present report aims to provide an easily understandable illustrated overview of trends and challenges in the sustainable mountain development of Central Asia since 1992, highlight selected achievements and lessons learned by various stakeholders and identify opportunities. It builds on information from the original experience and interviews with key actors, official and scientific sources and numerous news.

Environment and Security in the Amu Darya River Basin, 2011

The prime aim of this report is to identify the environmental stress points in the Amu Darya basin which have, or may have, security repercussions for the states and population. The report then suggests solutions to the challenges identified during the assessment. All in all, the field missions covered more than 3 000 km. Participants included experts from the region and from international organizations. Almost 100 experts were directly involved or consulted during the process.

Second Assessment of Transboundary Rivers, Lakes and Groundwaters in the UNECE region, 2011

The Second Assessment of Transboundary Rivers, Lakes and Groundwaters is the most comprehensive, up-to-date overview of the status of transboundary waters in the European and Asian parts of the UNECE region. It covers more than 140 transboundary rivers, 25 transboundary lakes and about 200 transboundary groundwaters. It has been prepared upon request by the Sixth “Environment for Europe” Ministerial Conference as an input for the Seventh Ministerial Conference in Astana in September 2011.

Climate Change in Central Asia, 2009

This booklet provides a synthesis of what climate change may mean for Central Asia. It builds upon the latest series of the official national communications on climate change by the Central Asian states under the UN

Framework Convention on Climate Change. This highly visual format seeks to communicate to decision makers and to serve education purposes alike.

Environment and Security in the Eastern Caspian Region, 2008

This report considers the role and impact of environmental factors in securing human safety and sustainable development of the eastern Caspian Sea region, including the parts of Kazakhstan and Turkmenistan opening onto the Caspian Sea.

Vital Caspian Graphics, 2007

In recent years the Caspian Sea has been the focus of increased global attention. The world-wide decline in oil and gas reserves and have heightened interest in an area where there is still growth potential in oil and gas exploration.

Environment and Security - Transforming risks into cooperation - The case of Central Asia, 2005

The assessment has been produced upon request of the countries of the Ferghana Valley - Kyrgyzstan, Tajikistan and Uzbekistan - and has widely benefited from their inputs. It shows how the Environment and Security initiative has helped identify both environmental threats to regional security and opportunities for cross-border dialogue.

Environment and Security: Transforming risks into cooperation - The case of Central Asia and South-Eastern Europe, 2003

This report focuses on the environmental stress affecting security in two case regions, Central Asia and South Eastern Europe. It provides maps with an overview on major environmental risks to human development and security. The maps are derived from information gathered at consultation workshops in Belgrade and Ashgabat, which were attended by local experts, government and non-government representatives³⁹.

The observer newspaper UK in its report on February 22, 2004 quoting George Bush “Climate change will destroy us” climate change is

³⁹ Detail of Report is available online at <http://www.sd.ca/Media/climate-atmosphere.htm>

knocking at our doors and its will cause havoc in the world someday and USA will become the victim of this change⁴⁰.

World Health Organization released a media report in December 2003 in which climate change and human health risks were brought forward. Human health will suffer a lot due to climate changes unless and until some adaptive measures should be taken to lesser the impacts of changing climate on human health⁴¹.

World Resources Institute published an article in their annual report of 2002 in which the emission status of greenhouse gases and ozone depleting substances were discussed and it was concluded that if the emission of harmful gases will continue it will definitely have adverse effects on all spheres of earth⁴².

Earth Policy Institute in 2002 analyzed the impact of shrinking forest cover on climate. The institute argued that shrinking of forest cover is a main indicator of climate change assessment. As forests act as greenhouse gas sinks so their role in climate change is important in viewing out the intensity of climate change⁴³.

Environmental News Services, December 18, 2003 in an article published that the year 2003 was the warmest year recorded. The temperature has remained above normal in the Northern Hemisphere⁴⁴.

The Guardian Newspaper London, April 20, 2002 published news about US and oil lobby that the oil lobby and US have replaced the climate change scientists. The US is the main contributor to the climate change but still they are trying to mitigate the effects of change in a sustainable way that means they are somehow taking care of their environment⁴⁵.

USA Today on December 15, 2004 in its UN report says that 2004 was the hottest year for the world since 1861⁴⁶.

⁴⁰ <http://oberverguardian.co.UK/international/story.html>

⁴¹ <http://www.who.int/mediacentre/release/2003/Pr91/en>

⁴² http://earthtrends.wri.org/pdf/Library/data_tables2002.

⁴³ http://www.earth_policy.org/indicators4.htm

⁴⁴ <http://www.climateark.org/articles/reader.asp?linked=27885>.

⁴⁵ <http://guardian.co.uk/oil/story.html>.

⁴⁶ <http://www.usatoday.com/weather/news.html>.

WWF, “The Implication of Climate Change for Australia’s Great Barrier Reef 2004” Witten by Hans Hoegh-Guldberg and Ove and published by conservation group WWF, this report considers the impact of global warming on coral reefs. Global warming is the big threat to the coral formation and also responsible for destroying the coral reefs and also in general a Great Coral Reef of Austria in particular⁴⁷.

International Institute for Sustainable Development in its media report 2005 explored that the climate change has now become a burning issues because of inclusion of politics in it. The report covers a wide range of stories on science and politics of climate change⁴⁸.

Business Week Magazine August 16, 2004 in its report highlights that “Global warming consensus is growing among scientists and the government and business and other stake holders must act fast to combat climate change⁴⁹”.

⁴⁷ <http://www.panda.org/newsfacts/newsroom/news>.

⁴⁸ http://www.iisd.ca/media/climate_atmopshere.htm.

⁴⁹ <http://www.publicintegrity.org/oil/report.aspx?aid=345>.

CLIMATE CHANGE IN HEADLINES

Arctic ocean to be snow-free in 10 yrs: Report

London, Oct 16: The Arctic Ocean could be largely ice-free and open to shipping during the summer in as little as ten years' time, a top polar specialist has said. "It's like man is taking the lid off the northern part of the planet," said Professor Peter Wadhams, from the University of Cambridge.

Professor Wadhams has been studying the Arctic ice since the 1960s.

He was speaking in central London at the launch of the findings of the Catlin Arctic Survey.

The expedition trekked across 435km of ice earlier this year. Led by explorer Pen Hadow, the team's measurements found that the ice-floes were on average 1.8m thick - typical of so-called "first year" ice formed during the past winter and most vulnerable to melting.

The survey route - to the north of Canada - had been expected to cross areas of older "multi-year" ice which is thicker and more resilient.

When the ridges of ice between floes are included, the expedition found an average thickness of 4.8m.

Professor Wadhams said: "The Catlin Arctic Survey data supports the new consensus view - based on seasonal variation of ice extent and thickness, changes in temperatures, winds and especially ice composition - that the Arctic will be ice-free in summer within about 20 years, and that much of the decrease will be happening within 10 years.

"That means you'll be able to treat the Arctic as if it were essentially an open sea in the summer and have transport across the Arctic Ocean."

According to Professor Wadhams, faster shipping and easier access to oil and gas reserves were among short-term benefits of the melting.

But in the longer-term, losing a permanent feature of the planet risked accelerated warming, changing patterns of circulation in the oceans and

atmosphere, and having unknown effects on ecosystems through the acidification of waters.

Pen Hadow and his companions Ann Daniels and Martin Hartley endured ferocious weather - including a wind chill of minus 70 - delayed resupply flights and starvation rations during the expedition from 1 March to 7 May.

Pen Hadow said he was shocked by the image of how "in my lifetime we're looking at changing how the planet looks from space." Agencies

Rivers of conflict...but also of peace Rich countries poor in supply of water: WWF

Water has been known for centuries to be a major cause of tension and conflict - within countries as well as among nations. Yet while its propensity to attract relations frequently makes headlines, the other side of the coin - water as an agent of cooperation - rarely gets sufficient attention.

With more than the 300 water basins in the world transcending national borders, it is hardly surprising that the situation is widely seen as being fodder for hostility.

There have been more than 500 conflicts over water in the past century, but it's also an agent of cooperation



All water? There are more than 3,000 declarations or conventions on water, including 285 treaties

3,000 unilateral, bilateral or multilateral declarations or conventions on water 285 are treaties, with 11 referring to over 500 international river basins.

There are examples of workable policies if they are to avoid conflicts over water, resolved even by state. The water treaty that is being like India and Pakistan, Israel and Jordan. Another example is that of the Northern Aral Sea, shared by Kazakhstan and Uzbekistan. It is being successfully restored after its surface has sunk to less than half its original size already losing the battle to its result of a massive diversion of water under the Soviet Union, which has governments talked about draining the two rivers feeding it and de-watering the surrounding environment.



Rich countries have to make drastic changes to their water supply. WWF

has been very difficult. In Europe, the report said, countries around the Atlantic are suffering from increasing droughts, while in the Mediterranean region water resources are being depleted by the loss of forests and irrigated agriculture.

In America, already the driest continent, scarcity had become a major threat to a large proportion of its farming areas, while in the US the rivers were being substantially more water than could be replenished.

Climate change? Barmer grapples with floods



In the Times of Andhra: A woman carries her child to safety in the flooded Andhra village of Rajasthan's Barmer district



30-prone Barmer?

30-prone Barmer? In the region died of dengue fever malaria. The state government's health department is set to make up to the situation.

place in Barmer; 600 people in the region died of dengue fever malaria. The state government's health department is set to make up to the situation.

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Water Wars: A father carries his son to safety as he wades through floodwater, after a three-day spell of heavy rain in Dhantala village, near Siltguri

Water Wars: A father carries his son to safety as he wades through floodwater, after a three-day spell of heavy rain in Dhantala village, near Siltguri

Greenhouse gases rising alarmingly

Ancient Air Bubbles Buried In Antarctic Ice To Shed More Light On Global Warming

It has happened in the North Atlantic and may happen again. According to scientists, global warming could lead to prolonged chill



ICE AGE cometh

Air pollution biggest killer in Southeast Asia, says WHO

A smoky haze that has blanketed parts of Southeast Asia this month is being caused by forest fires in Indonesia, the World Health Organization (WHO) says. The WHO says that air pollution is the biggest killer in the region, especially in the cities. It says that air pollution is responsible for about 3 million deaths each year. In Southeast Asia, the WHO says, air pollution is the biggest killer. It says that air pollution is responsible for about 3 million deaths each year. In Southeast Asia, the WHO says, air pollution is the biggest killer. It says that air pollution is responsible for about 3 million deaths each year.

Write an explanatory note on "global warming".



The research station for the European Project for Ice Coring in Antarctica.

did not get as far as humans have," said Richard Alley, a geosciences professor at Pennsylvania State University who is an expert on ice cores. "We're changing the world really quickly — way past where it's been for a long time."

James White, a geology professor at the University of Colorado, Boulder, not involved with the study, said that although the ice-age evidence showed that levels of carbon dioxide and the other greenhouse gases rose and fell in response to warming and cooling, the gases could clearly take the lead as well.



This file photo shows dead fish lying on the dried bottom of the Ding An reservoir in China's Hainan island. An island on the edge of the vast Pacific, Hainan gets a large part of its rain during the typhoon season. The problem is, for two years now, there has not been a single typhoon, and

Gangotri is shrinking 23m every year

Geneva: Himalayan glaciers, including the Gangotri, are receding at among the fastest rates in the world due to global warming, threatening water shortages for millions of people in India, China and Nepal, a leading conservation group said on Monday.

The World Wide Fund for Nature (WWF) said in a new study that Himalayan glaciers were receding 10-15 metres per year on average and that the rate was accelerating as global warming increases.



This image shows how the Gangotri glacier terminus has retreated since 1750. The contour lines are approximate. (Image by Jesse Allen, Earth Observatory, based on data provided by the ASTER Science Team)

In India, the Gangotri glacier is receding at an average rate of 23 metres per year, the study said. "Himalayan glaciers are among the fastest retreating glaciers globally due to the effects of global warming," the WWF said in a statement. "This will eventually result in water shortages for hundreds of millions of people who rely

on glacier-dependent rivers in India, China and Nepal," it said.

Himalayan glaciers feed seven of Asia's greatest rivers — Ganga, Indus, Brahmaputra, Salween, Mekong, Irrawaddy and Ayeyarwady.

The study says that the retreat of the glaciers is causing water shortages for millions of people in India, China and Nepal. It also says that the retreat of the glaciers is causing water shortages for millions of people in India, China and Nepal.



MELTING POINT: The Khumbu glacier, one of the longest in the world, flows in front of Mount Everest. There are some 1,600 glacier lakes in Nepal and many are growing fast due to rising temperatures. — PHOTO: AFP

Growing danger zones in the Himalayas

Fears rise of huge outburst flooding as glaciers melt due to climate change.

Suzanne Goldenberg

It's strangely calming to watch the Imja glacier lake grow, as chunks of ice part from black cliffs and fall into the grey-green lake below. But the lake is a high-altitude disaster in the making — one of dozens

not agree on whether to rate Imja as the most dangerous glacier lake in the Himalayas, or a more distant threat.

Mobilising international assistance for large-scale engineering projects during a global recession is also difficult. The Mountain Institute's initiative was to call in experts from

PAPERS

1. Arendt, A. J. Walsh and W. Harrison in their paper entitled “*Changes of Glaciers and Climate in Northwestern North America*” published in the *Journal of Climate* vol. 22 August 1, 2009 pp. 4117-4134. A study of 46 glaciers in Alaska and Canada found that 75% have been losing mass at an increasing rate over the period 1950-2002. They also used climate records for daily maximum and minimum temperature and total daily precipitation and aircraft altimetry to calculate time variation in mass balance⁵⁰.
2. Axford, Y. *et al* 2009 studied that *paleo records from a lake in the Canadian Arctic* and argued that recent changes in a remote Arctic lake are unique within the past 200,000 years. This report was published on line before print by *PNAS* on October 19, 2009. Paleo records from a lake in the Canadian Arctic show that 20th century environmental changes including warming are exceptional within the past 200,000 years⁵¹.
3. Box, J. E. L, Yang, D. H. Bromwich and L, -S.Bai 2009 published an article entitled “*Greenland Ice Sheet Surface Air Temperature Variability*” published in the *Journal of Climate* vol.22. The new analysis showed that although Greenland experienced a warming trend over the period 1994 -2007. The annual mean warming was 1 – 1.5°C cooler than that of Northern Hemisphere as a whole. They thus expected that the ice sheet melt rates and mass deficit will continue to grow in the early 21st century as Greenland climate catches up with the warming trend and the strong regional Arctic climate warming projected by global climate models⁵².
4. Chen, J. L., Wilson C.R., Blakenship, D. and Tapley, B. D. 2009, in their paper published in the *Nature Geosciences* 2: pp. 859-862 entitled “*Accelerated Antarctic Ice Loss from Satellite Gravity Measurement.*” The new satellite data indicate that ice sheet volume is currently declining over east Antarctica as well as west Antarctica. These results suggest that melting

⁵⁰ Journal of Climate vol. 22 August 1, 2009 pp. 4117-4134.

⁵¹ PNAS on October 19, 2009.

⁵² Journal of Climate vol.22.

Antarctica ice sheets may be contributing more to global sea level rise than estimated earlier⁵³.

5. Easterling, D. R and Wehner, M. F. 2009, in their research paper “*Is Climate Warming or Cooling?*” published in the Scientific Journal Geophysical Research Letters, challenge the conclusion by reiterating that climate system includes internal natural variability that constantly cause climate to vary about its mean state, causing one decade to be warmer and another to be colder. They also demonstrate through models simulation of the climate response to future changes in greenhouse gas and aerosol concentration that such natural variability will continue to affect the climate system as it warms⁵⁴.

6. Thomas, H. *et al* 2008 studied the changes in *the North Atlantic Ocean influences CO₂ uptake in the North Atlantic over the past 2 decades*. The study was published in the *Global Biogeochemical Cycle vol. 22*. The study has, that the observed recent decline in the uptake of CO₂ in some oceanic regions of the Northern Hemisphere is tied to changing surface conditions over short time period. These studies highlight that long-term, coherent ocean carbon observing systems are important in order to detect trend in CO₂ uptake associated with climate change⁵⁵.

7. S. S San, N. F Tandon, L. M. Polvani and D. W Waugh 2009. Published a paper “*Ozone Hole and Southern Hemisphere Climate Change*” published in *GRL vol. 36*. They argued that a change in stratospheric ozone level, over Antarctic has shown to have affected the entire atmospheric circulation in the Southern Hemisphere. The expected recovery of the ozone layer over the next fifty years is likely to have an impact on the future rate of climate change. The authors have showed that depletion of ozone has had far reaching impacts on Southern Hemisphere summer climate system⁵⁶.

8. Stine, A. R., P. Hybers and IY, Fung 2009 published an article with the theme “*Changes in the Phase of the Annual Cycles of Surface Temperatures*” which got published in the *Nature vol. 457*. Observations

⁵³ Nature Geosciences 2: pp. 859-862

⁵⁴ Scientific Journal Geophysical Research Letters

⁵⁵ Global Biogeochemical Cycle vol. 22.

⁵⁶ GRL vol. 36.

show a decrease in amplitude of the annual cycles of surface temperature and a shift towards earlier seasons. However, few of the global climate models presented in the IPCC Fourth Assessment Report can replicate these trends. They have also founded a decrease, globally, in the amplitude of annual cycle of land with a mean decrease of 2.5°C over the period that decrease represents the well known amplitude of winter warming in Northern regions. However in some regions like Western Europe and Middle East, the amplitude has increased associate to the warming in summer than in winter⁵⁷.

9. Tripathi, A. K., C. D. Roberts and R. A. Eagle 2009 carried out a study about “*Coupling of CO₂ and Ice Sheet Stability over Major Climate Transitions of the Last 20 Million Years.*” The study got published in the journal “Science” on December 4, vol. 326 No. 5958, pp. 1394-1397. The study had revealed that the close coupling between CO₂ and climate extends through major climate transitions of the past 20 million years and that CO₂ levels have not been as high as present (387 PPMV) since the mid-Miocene (15 million years ago). Decrease in CO₂ was coincident with major episodes of glacial expansion documented in other climate proxies. The results indicate that changes in CO₂ were closely related to the climate evolution of the middle and late Miocene and the late Pliocene and therefore likely played an important role in driving these transitions⁵⁸.

10. Archer, D. and V. Brovkin in 2008 published a paper “*The Millennial Atmosphere Lifetime of Anthropogenic CO₂.*” which got published in the *Climate Change Journal*, vol. 90 pp. 283-297. In this paper Archer and Brovkin set out to dispel what they claim is widely a half belief in both the public and scientific communities – that anthropogenic CO₂ won’t remain in the atmosphere more than about 200 years and that climate change impact will only persist for a few centuries. They also argued that the warming we have experienced so far is only 60% of the equilibrium warming expected at today’s atmospheric CO₂ value⁵⁹.

⁵⁷ Nature vol. 457.

⁵⁸ journal “Science” on December 4, vol. 326 No. 5958, pp. 1394-1397.

⁵⁹ Climate Change Journal, vol. 90 pp. 283-297.

11. Bony Sandrine et al, 2006, in his paper entitled “*How Well Do We Understand and Evaluate Climate Change Feedback Processes*” in which he reviewed the literature on the four physical feedbacks indentified as most important to the outputs of GCM’s. This was done in the context of the uncertainty created by difference between GCM’s with respects to the working of these feedbacks and focuses on the literature published since IPCC Third Assessment Report in 2001. The authors have made the generalization that recent studies have led to improvements in the understandings of feedbacks and the reasons why they differ between GCM’s. Furthermore they stated that further improvement will hopefully lead to the progress in narrowing the range of climate sensitivity estimates in the future⁶⁰.

12. Hale, R. C., K. P. Gallo and T. R. Loveland 2008 in their paper on “*Influences of Specific Land Use / Land Cover Conversions Climatologically Normal’s of Near-Surface Temperature.*” Published in the Journal of Geophysics vol. 113 in which they revealed that land use and land cover changes are shown to explain half the changes in the minimum temperatures, but had little effect on maximum temperatures at a subset of US stations for which information on proximate changes in land use / land cover was available. The rest of the changes in temperature trends are associated with other climatologically factors changes in near surface temperature over time can have more than one cause, one of which have been speculated to be changes in the characteristics of the land use / land cover changing LULC, for example from crop use to urban use can have an effect on surrounding temperatures. The results have shown that the majority of the changes in maximum temperature trends were not due to land use / land cover changes. On the other hand, about half of the changes in minimum temperature were attributed to land use / land cover changes. Interestingly, clear cutting of trees did not seem to have a significant impact on the temperature in areas of close proximity, as one might expect. This study hence supports the conclusion that

⁶⁰ IPCC Third Assessment Report in 2001.

the majority of the temperature trends at the stations are explained by other climatological factors, including warming due to greenhouse gases⁶¹.

13. Hegerl, G. C, T. J Crowley, W. T. He and D. J. Frame 2006 in their paper entitled “*Climate Sensitivity Constrained by Temperature Reconstruction over the Past Seven Centuries*” published in the *Nature* vol. 440, pp. 1029-1032. Hegerl and colleagues used multiple lines of evidence to assign some probabilities to range the climate sensitivity values. The authors report that there is less than 3% chance of the temperature increasing more than 7°C in response to CO₂ doubling, they also demonstrated that observational estimates of climate sensitivity can be tightened if reconstruction of Northern Hemisphere over the past several centuries is considered⁶².

14. Marinov, I. A Gnanaderikan, J. R Toggweiler and J. L Sarmiento 2006 carried out a study which got published in the *journal Nature on 22 June 2006 Vol. 441*. This theory “*The Southern Ocean Biogeochemical Divide*” has tried to elucidate the complex mechanism governing the Southern ocean carbon sequestration. There results had shown that nutrient depletion (thus carbon sequestration) is more efficient in the Southern most regions than in the Northern regions suggesting the existence of “Biogeochemical divide” in the Southern oceans. Thus for Marinov *et.al.* mechanism that attempts to explain the lower atmosphere CO₂ during the last glacial maximum should take into account difference in carbon sequestration efficiency between the Antarctic and Sub-Antarctic⁶³.

15. Piao, S., Friedlinstein, P., Ciais, P. *et al* 2006 published a paper entitled “*Effects of Climate and CO₂ Changes on the Greening of the Northern Hemisphere over the past Two Decades*” which got published in the *GRL journal* vol. 33, in which Piao and other scientists have concluded that almost half of the increased growth can be attributed to fertilization effects of the higher CO₂ concentration. Thus they discarded the statement that increases in

⁶¹ Journal of Geophysics vol. 113

⁶² Nature vol. 440, pp. 1029-1032.

⁶³ Journal Nature on 22 June 2006 Vol. 441.

the Northern Hemisphere biomass productivity attributed to rising CO₂ concentration and changing climate⁶⁴.

16. Robock, Alan and Li, Haibin, 2006 published a paper “*Solar Dimming and CO₂ Effects on Soil Moisture Trends*” in a Geophysical Research Letters 33. The authors have investigated the potential contribution of solar dimming and increasing carbon dioxide to this trend using the state-of-the-art land surface model (a modified version of community land model 3.0). When a slow dimming was applied to the model experiment using a 0.5% per year decrease in the solar insolation between 1961-1980 and 1960 level. Concentrations of atmospheric CO₂ resulted projected a 5% reduction in evapotranspiration for the Ukraine and 9% reduction for Russian. The authors concluded that summer soil moisture increase in Ukraine and Russia cannot only be explained by changes in precipitation and temperature⁶⁵.

17. Schuur, E. A. G., *et al* carried out a study on the responses of permafrost and ecosystem processes to thawing of previously frozen organic carbon and published a paper entitled “*Vulnerability of Permafrost Carbon to Climate Change: Implications for the Global Carbon Cycle*” published in the September 2008 edition of *Bioscience journal vol. 58 & No. 8*. The authors maintain that the potential for increased microbial decomposition of the global permafrost carbon pool constitutes a significant terrestrial feedback to the atmosphere in a changing climate. They have also calculated the projected offsets in a new boreal biomass in Alaska and found that they would be only one tenth of the projected carbon released from thawing permafrost⁶⁶.

18. Sitch, S., P. M. Cox, W. J. Collins and C Huntingford 2007. Published a paper “*Indirect Radioactive Forcing of Climate Change through Ozone Effects on the Land Carbon Sinks*” which got published on line on 25 July 2007 in the “*Nature*”. The paper has found that tropospheric (near surface level) ozone pollution reduces the ability of plants to absorb atmospheric carbon dioxide, increasing the importance of changes in the atmospheric

⁶⁴ GRL journal vol. 33

⁶⁵ Geophysical Research Letters 33.

⁶⁶ Bioscience journal vol. 58 & No. 8.

chemistry as driver of 21st century climate change. These results hence suggest that ozone effects on vegetation could double the effective radioactive forcing due to increase in O₃, significantly increasing the importance of changes in atmospheric chemistry as a driver of climate change of 21st century⁶⁷.

19. Baetling, M. B., M. Wild and D. Imboden 2007 prepared “A *climate change index*: Where climate change may be most prominent in 21st century published in *GRL vol. 34*. This climate change index (CCI) provides a single measure of the strength of the future climate change relative to today’s natural variability. The results indicate that climate will change most strongly relative to natural variability in the high latitude and in the tropics⁶⁸.

20. Crutzen, P. J. 2006 in an editorial essay “*Albedo Enhancement by Stratigraphic Sulphur Injections: A contribution to resolve a policy dilemma*” published in the *journal of Climate Change vol. 77 pp. 211-219* contemplates the use of geo-engineering to resolve earths warming issues. According to Crutzen artificially enhancing the earth’s albedo through stratigraphic Sulphur injection could help to cool the climate and counterbalance the warming caused by increased CO₂ emission. The paper received various comments from scientific community although opinion is mixed but the consensus was that priority should be on treating the cause not he symptoms⁶⁹.

21. Danielson, F. H. Beukema, N. D Burgers et al, 2008 published a comprehensive analysis about “*Bio-fuel plantation on Forested Lands: Double Jeopardy for Biodiversity and Climate*” published in the *Journal of Conservation Biology*. The authors argued that replacing high-carbon and high biodiversity forests or peat lands with bio-fuel plantation, in an effort to reduce the use of fossil fuels, will accelerate both climate change and biodiversity loss⁷⁰.

⁶⁷ Journal Nature online July 25, 2007.

⁶⁸ GRL vol. 34.

⁶⁹ Journal of Climate Change vol. 77 pp. 211-219

⁷⁰ Journal of Conservation Biology.

Present study is important from geographical point of view. Hence it is analyzing the nature and magnitude of climatic change in Turkmenistan, spatially and temporally with special reference to temperature and precipitation. Accordingly research based conclusion and suggestion have been framed as to how planners of the country can go ahead to mitigate the adverse impacts of climatic change in a sustainable way.

Chronology of Climate Change Issues:

1824 Fourier (France) first describes the greenhouse effect.

1861–3 Tyndall (United Kingdom) argues that water vapor and carbon dioxide are important for absorbing radiation and hence controlling climate.

1896 Arrhenius (Sweden) writes that burning coal will warm earth via an increase in CO₂ but that CO₂ will be absorbed by oceans.

1938 Callendar (United Kingdom) makes quantitative calculations of warming from anthropogenic CO₂.

C. 1940 The Northern Hemisphere's mean surface air temperature begins a slight decline that is not recognized until 1961.

1956 Plass (United States) revives the CO₂ theory of climate change and predicts a long warming trend due to fossil fuel burning.

1957 Revelle and Suess (United States) question the ability of the oceans to absorb all of the CO₂ from fossil fuels.

1958 Keeling (United States) begins nearly continuous monitoring of CO₂ in the atmosphere in Mauna Loa and the South Pole.

1967 Manabe and Wetherald (United States) begin numerical climate modeling including both radiative and dynamical effects.

1969 The Study of Critical Environmental Problems (SCEP) is held at MIT (United States).

1970 Concern heightens over potential global climatic cooling.

1970s The mean Northern Hemisphere surface temperature rises.

1971 SMIC (Inadvertent Climate Modification: Report of the Study of Man's Impact on Climate) is published.

1972 The U.S.-USSR Environmental Agreement is signed.

1975 Ramanathan (United States) focuses attention on the greenhouse effects of CFCs.

1975 WMO holds the International Symposium on Long-Term Climate Fluctuations.

1976 Keeling (United States) publishes a time series showing secular trends and seasonal variations of CO₂ for 1959 to 1973.

1979 The first World Climate Conference is held in Geneva.

1979 An NRC report (United States) revives concern over warming and estimates a response to a doubling of CO₂ at 1.5 to 4.5 °C.

1980 The first WMO/UNEP/ICSU meeting on CO₂- induced climate change is held in Villach.

1985 A later WMO/UNEP/ICSU conference in Villach establishes greenhouse warming as an international concern.

1987 Vostok ice-core data show strong correlations between CO₂ concentration and temperature for the last 160,000 years.

1987 The Beijer Institute (Sweden) sponsors workshops in Villach and Bellagio that increase the attention paid to global warming.

1988 WMO and UNEP establish the Intergovernmental Panel on Climate Change.

1988 The Toronto Conference on the Changing Atmosphere calls for a 20 percent reduction of global CO₂ emissions by 2005.

1989 The Regional Climate Change Conference is held in New Delhi.

1989 The Summit on Protecting the Atmosphere is held in the Hague.

1989 Noordwijk (Netherlands) Declaration on Atmospheric Pollution and Climate Change advocates a 20 percent goal for emissions reduction.

1980s Seven of the eight warmest years in this century occur in the 1980s, and 1990 was the warmest year on record.

1990 The White House Conference on Climate Change is held.

1990 The first report of Intergovernmental Panel on Climate Change (IPCC) is released.

1990 The Second World Climate Conference is held in Geneva.

1991–1992 Five Intergovernmental Negotiation Committee (INC) meetings are held.

1991 The Conference of Developing Countries is held in Beijing.

1992 The Framework Convention on Climate Change is signed at the United Nations Conference on Environment and Development in Rio.

1992 The IPCC Supplementary Scientific Assessment is released.

1994 The Climate Change Convention enters into force.

1995 The first Conference of Parties to the Climate Convention adopts the Berlin Mandate exempting developing countries.

1995 The second report of the Intergovernmental Panel on Climate Change (SAR of IPCC) is released.

1996 The Second Conference of Parties to the Climate Convention meets in Geneva.

1997 The European Community adopts a common target proposal and agrees on internal burden-sharing arrangements.

1997 Climate change is featured at the Denver summit of G7/G8.

1997 The third Conference of Parties to the Convention in Kyoto adopts legally binding targets for all greenhouse gases.

1998 Rotterdam Convention on Prior Informed Consent for Trade in Hazardous Chemicals and Pesticides.

2000 Ozone annex to the 1991 Canada-US Air Quality Agreement, reducing emissions that cause smog (especially NO-x)

2001 Bonn Framework Agreement for the Kyoto Protocol of the UN Convention on Climate Change

2002 Rio + 10: UN World Summit for Sustainable Development, Johannesburg

2005 Kyoto Protocol of 1997 comes into force

2006 Asia-Pacific Partnership on Clean Development and Climate

2007 UNFCCC- Bali Conference on Climate Change: post-Kyoto road-map

2009 Copenhagen Convention on Climate Change, from December 7th to 18th December 2009.

2010 Cancun Climate Summit, Mexico December 2010

SOURCE

This chronology is reprinted from the book Learning to Manage Global Environmental Risks – Volume 1: A Comparative History of Social Responses to Climate Change, Ozone Depletion, and Acid Rain, by The Social Learning Group (MIT Press, 2001).



CHAPTER NO –3

STUDY AREA

Turkmenistan is located at the centre of Eurasian continent, nearly equidistant from Atlantic and Pacific Ocean. Its latitudinal extend is 35°08' and 42°8' N and longitudinal extend is 52°27' and 66°41'E with total area of 488100 Km² it is the fiftieth (50th) largest country in the world. On its north it shares border with Kazakhstan and Uzbekistan. On its east lies Afghanistan and Uzbekistan. Southern part shares border with Iran and Afghanistan while as Azerbaijan through the Caspian Sea lies to its west. The total length of its borders is 5646 Kms. Turkmenistan is the plainest Republic of Central Asia. Almost 4/5 of its territory is within the Turan lowland occupied mainly by Karakum desert. Mountains, between the Caspian Sea in west and Amu Darya River in east. The length of country from east to west is 1100 kms and from north to south is 650 kms. The central part is mainly occupied by black sands of Karakum while as mountains and hills are mainly located in the southern part of the country. Besides Karakum desert, Caspian coastal desert and Ustyart plateaus are also sandy in nature. The country is divided into five (5) administrative districts called Valayats.

The river, Murgab entering the country in the southeast separates the Northern foothills of the Paropamiz heights, Badkhyaz (upto 1267m) and Karabil (upto 984m) in between Amu Darya and Syr- Darya there are south eastern Karakumy cellular- ridge and hilly sands are typical for these deserts. There are areas of Barkhan sand in the lowlands, Takyr and Sors.

According to official statistical data of Turkmenistan the desert grazing area is 38342 thousand hectares or 95.9% of the total land areas of the

country. Out of the total area of Turkmenistan only 17 million hectares are suitable for agriculture cultivation. Due to natural and climate circumstances forests occupy only 19761 hectares of land⁷¹.

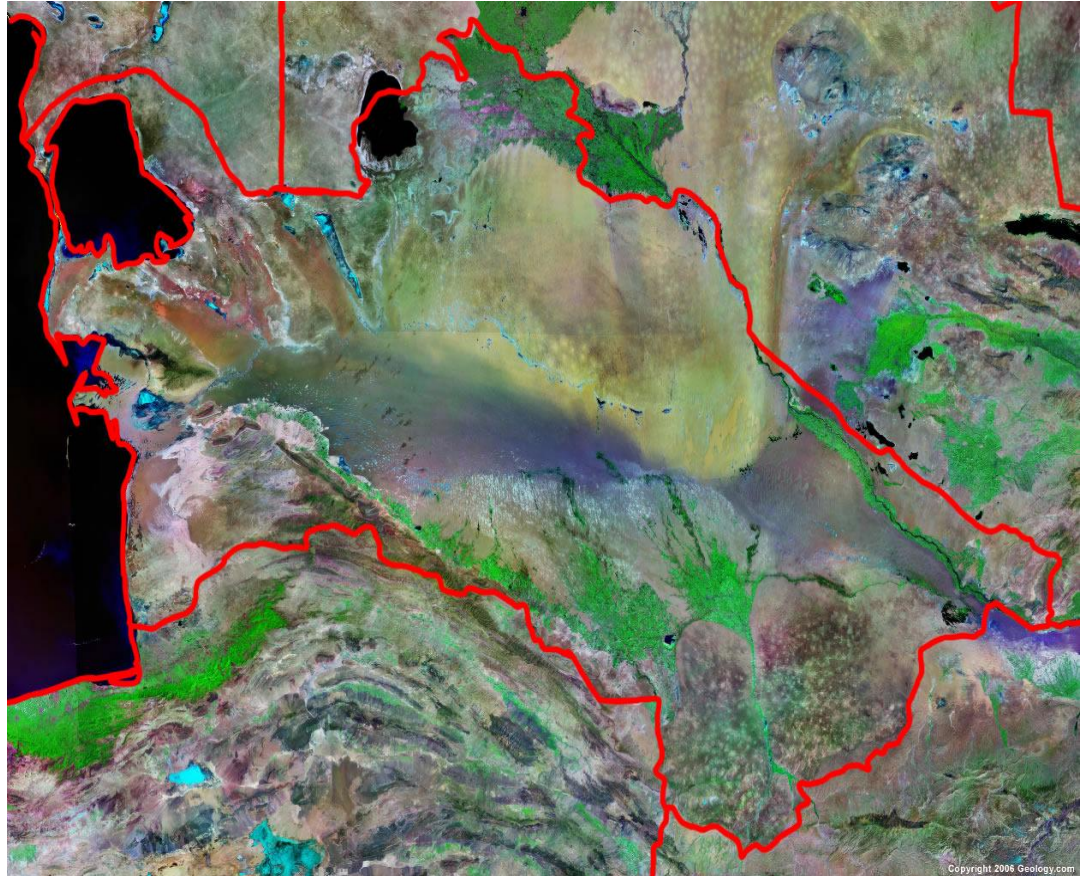
Fig: 3.1 Location Map of Turkmenistan



Source: <http://www.worldpress.Com>

⁷¹ Magtymov A., Durdiyev A.M., *Kopetdag Landscapes and their Evaluation*. Problems of Desert Development, 1998 No 6.

Fig 3.2 : Satellite Image of Turkmenistan



Source: [http// www.wikimapia.com](http://www.wikimapia.com)

Physiography: Republic of Turkmenistan is situated in the south west of Central Asia on the north it is bordered by Uzbekistan, to the North-west by Kazakhstan, to the west by Caspian Sea, to the south by Iran and to the south-east by Afghanistan. Turkmenistan is a land locked country with an area of 488100 sq. kilometers. The terrain varies from flat to rolling sandy desert about 80% of land is under Karakum desert which is one of the largest deserts in the world and occupies the whole central part of the country stretching upto Kazakhstan. Topographically Turkmenistan is plain. The southern part of the country is dominated by mountains and hills.

The mountains kopetdag (2942 mts ASL) are situated in the southern part of Republic. The two ridges Maly Balkhan (777 mts) and Bolshoi Balkhan (upto 1881 mts) are located in the north-west of the country. The foot hill plains that join the Prikaspisky lowlands in the west join the Kopetdag in the North. The Murgab river entering Turkmenistan in the south west separates the northern foot hills of the Paropamiz heights, the Badkhyz upto (1267 mts) and Karabil (upto 984m). the highest peak of the Republic is a spur of Gissar Ridge upto (3139 mts). Karashovodskoe plateau (upto 308m) is situated in the western part of the country and on the southern outskirts of the plateau Ustyurt, in the north west. In the North West the heights of Nebitdag (39mts), Boyadag (134m), Kumdag, Mondjukuly (27m) and others are raised within the Prikaspian lowlands. In the north and north east from the foot hills of Kopetdag lays Karakumy which are divided into the central and Zaunguzsk. In between Amu-Darya and Syr-Darya there are south eastern Karakumy. There are areas of Barkhan sands and in the low lands, Takyr and Sors. Small right side coastline of the Amu-Darya enters into Turkmenistan⁷².

According to the natural conditions, Turkmenistan is located in three main natural landscape zones viz deserts, oases and mountains. The plains occupy only 15% of area; mountains and foreland are spread over an area of 12% of land area of Republic. Water surface and non-soil formations (Talus,

⁷² Turkmenistan Travel guide retrieved from <http://www.addicestotravel.com/travel/guide>.

rocks precipices), occupy major part of the country i.e. 73%. The northern and central part is occupied by Karakum deserts (about 80%) of the territory.

Ayrybaba peak of Kugitang Mountains is the highest point in Turkmenistan with a height of (3139mts ASL). Akchakaya hollow is the northwest of the Zaunguz Karakum is the lowest point of territory with (81m below sea level). The length of a coastline of the Turkmen part of the Caspian Sea is 1200km.

Turkmenistan is a predominately flat country containing deserts, oases and mountains several of the mountain ranges reach a height of more than 300mts above sea level along the borders the borders of territory mainly in the south. About 96% of Turkmenistan is rain deficit and hence most arid of the five Central Asian countries⁷³.

Geology:

Some 30 million years ago the entire Karakum was a sea. In the southern parts of Turan mountain building processes took place and they resulted in the diminishing of a sea and ultimately the whole sea disappeared and the Karakum desert came into existence subsequently Amy Darya flowed across the desert land of Karakum which resulted in the deposition of alluvial and sediments into the region. About 40 different minerals are found in the sands of Karakum brought down from the mountains of south east. After the change of course by Amu Darya towards north to drain its water into Aral sea. The surface features of the Karakum then were carved out by the Amy Darya flow which account for today's land form diversity of the Republic of Turkmenistan.

Climate:

The climate of Turkmenistan is severely continental type with extremely hot summers and cold winters . The average temperature in January is 4°C but winter temperatures can fall upto -33°C. summer temperatures often reach to 50°C in south-east of Karakum desert. The average temperature monthly temperature in January varies from -6 °C in the north east upto +3 °C

⁷³ <http://wikipedia.org/wiki/file/Turkmenistan>.

in south east and +5° C in the end south west. Average monthly temperature in July in the territory between Murgab and Tedzen rivers and in the Central part of low Karakum exceeds 30°C. Temperature in the other territory is 27°C to 30°C decline towards the Caspian Sea shore in the mountains⁷⁴.

The coldest month is January with the average temperature from -6°C in the North east of Turkmenistan to 4°C in south east and 5°C in the end west . Average temperature of the hottest month July is 27-30°C. the absolute maximum reaches to 48-50°C in central and south – eastern parts of Karakum desert.

In the mountainous region the climate is arid and sharply continental and characterized by hot summer and cold winter and uneven distribution of precipitation. Karakum desert which occupies about 80% of the territory is characterized by long duration of solar radiations. The high aridity of climate with sparse natural vegetation.

Turkmenistan being one of the driest Republic of Central Asia where precipitation is very low most of the precipitation occurs in winter season while as summers remains almost dry because of the Peculiarities of atmospheric circulation. The average annual precipitation varies from 100 mm (Kara-Bogaz-Gol-Bay and northeast of the Republic) to 400mm⁷⁵.

⁷⁴ Fet, V., Atamuradov. H.(Eds)., *Biogeography and ecology of Turkmenistan*. Kluwer Academic Publishers, Dordrecht, Netherland, 1994.

⁷⁵ Orlovsky N., Climate of Turkmenistan in: Fet V. and Kh. Atamuradov (Eds). *Biogeography and ecology of Turkmenistan*. Kluwer Academic publishers, Dordrecht, p 23-48.

Table 3.1: General Climate of Turkmenistan

Average Temperature	16.3°C
Average temperature range	29°C
Highest monthly average temperature in July	36°C
Lowest monthly average temperature in January	-4°C
Average Annual Rainfall	210mm (8.3 inches)
Monthly average rainfall	18mm (0.7 inches)
Driest month August	1mm across 10 days
Wettest month March	44mm across 10 days
Average Annual relative humidity	53.8%
Humidity in July	32%
Humidity in January	78%
Average sunlight hours in January	3.6 hours
Average sunlight hours in July	11.5 hours

Vegetation:

Vegetation refers to the total floral cover of any region or a world as a whole. This vegetation cover differs from place to place owing to geographical condition. Climate plays a dominant role in determining the vegetative cover of any region or we may say that vegetation of any place is governed by the topography and climate of that place. So as we know different climatic zones appear on the earth's surface the regional change in vegetation cover is obvious.

So far as the Republic of Turkmenistan is concerned being desert the vegetation is of pronounced desert character except in Oases and mountain valleys. The flora of the Turkmenistan includes varied types of vegetation like unusual plants and forests. The Republic of Turkmenistan has a very small area under forests. Apart from that a total land area of Turkmenistan includes an area of 4.6 million hectares where reforestation is required. Besides that the country owns 4.2 million hectares of land which demands for seeding and planting. The flora of Turkmenistan includes bushes and small trees. The country has a rich diversity of flora with 2600 kinds of plants among which

grass is also prevailing kind of plant. Herbaceous plant goes very rapidly in country and hence it is a most popular plant of Turkmenistan. About 2137 species of herbaceous plant are found here, the flora also includes 47 kinds of trees, 44 low shrubs, 46 semi shrubs and 238 species of low height semi shrubs.

Among the total number of species found in Turkmenistan, 400 plant species has been recognized as economically useful plants. Karakum includes about 700 species of plants. The 2000 years old plant Turkmen Archa also known as Juniper is a most valuable plant and grows on the tops of Kopetdag Mountains⁷⁶.

The vegetation is quite varied consisting of grass, small shrubs, bushes and trees. In the mountain valley of the Kopet-Dag, wild grapes, Almonds, Figs and walnuts are found. On the open slopes Juniper and pistachio trees grow well black poplar, willow, reed and cane which constitute the Tugai forests stand on River banks and Islands.

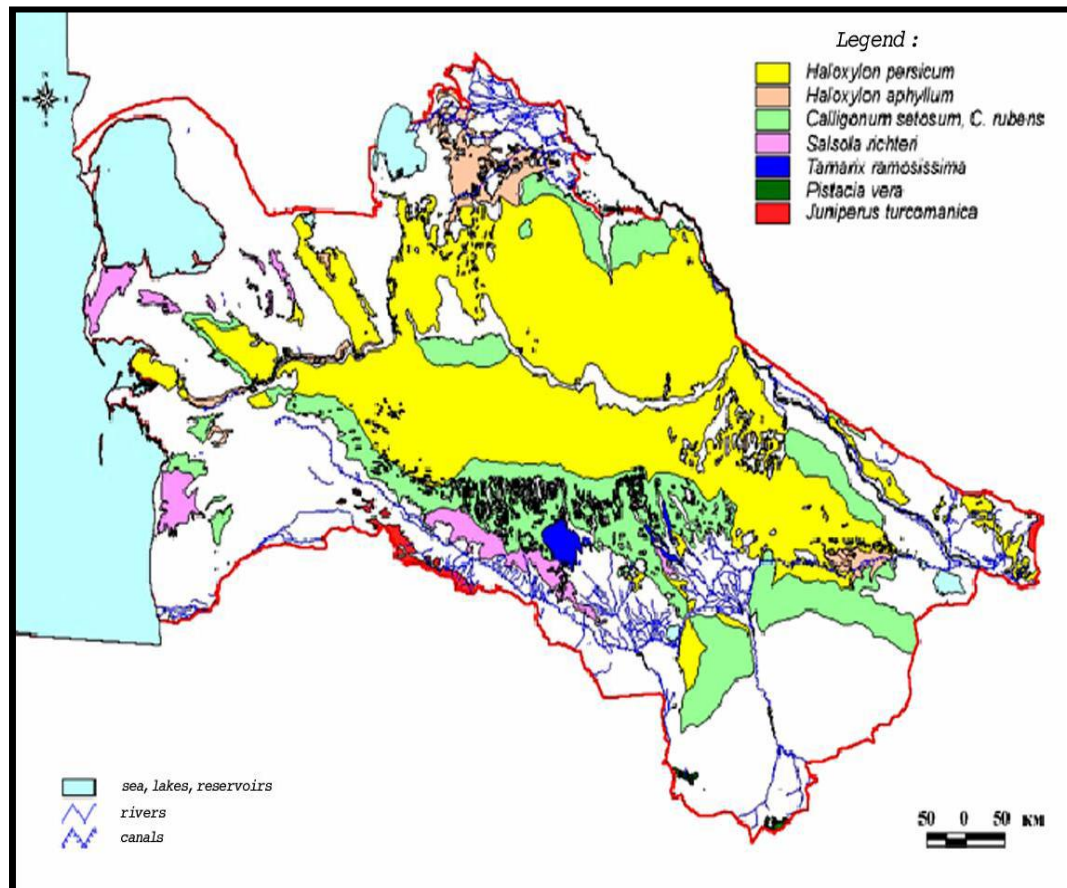
The desert is home of foxes, wild cats, gazelles and tortoises. The mountain ecosystems of Turkmenistan support goats, cheethas, lynx, snow leopards and porcupines, jackals, wild boars⁷⁷. Various species of birds and the rare pink deer inhabit the Tugai. Wild donkeys roam the Badkhyz and Garabil plateau. In the south west vast flocks of ducks, geese and snow swans make the east coast of the Caspian Sea as their winter home⁷⁸. Hence, it is obvious that Turkmenistan has a rich diversity of flora and fauna distributed systematically according to climatic conditions of the particular region.

⁷⁶ Allamuradov, A., Abdurakhimovm A., Kuleiev, A. Turkmenistan. Forest Resource Assessment for Sustainable Forest Management 2005.

⁷⁷ Annual report of WWF- Russian Moscow 2009.

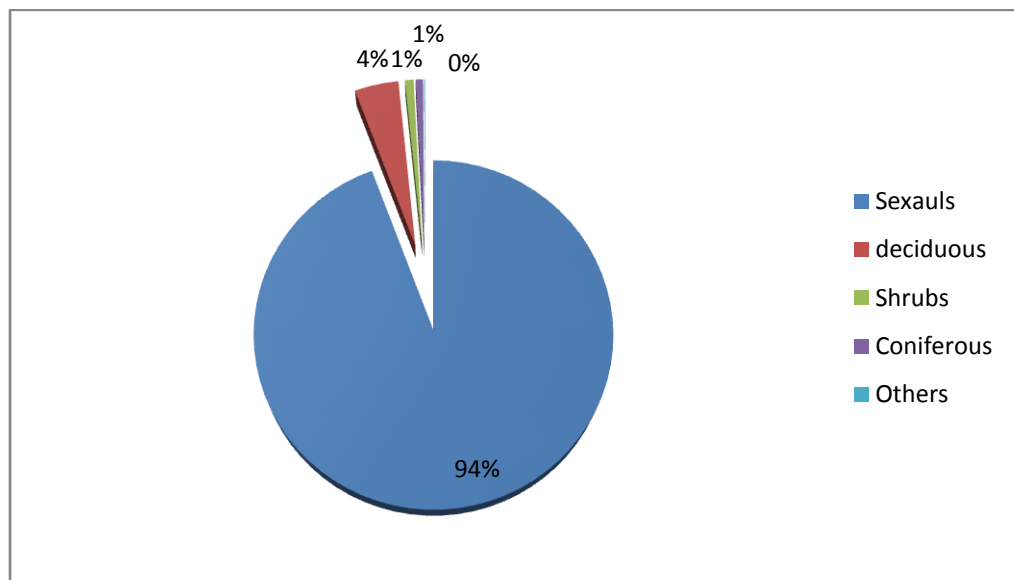
⁷⁸ Ataev, ch. A., Reptiles of Turkmenistan Mountains, Ashgabat, xylm 1985.

Fig 3.3 Forest Map of Turkmenistan



Source: *Department of Forests Turkmenistan*

Fig:3.4 Main Forest Types in Turkmenistan



Drainage:

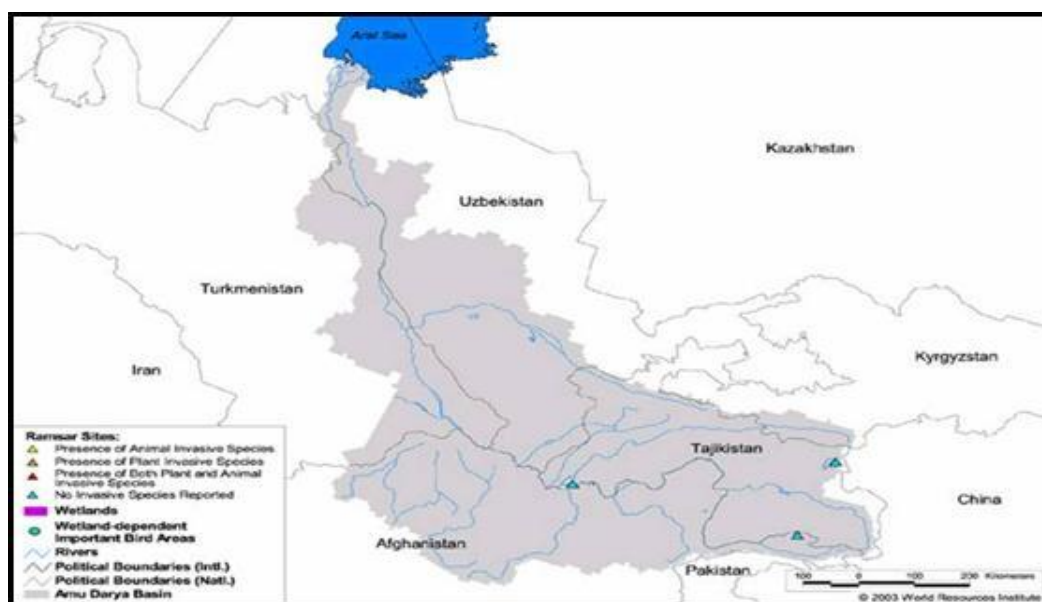
In terms of geographical context, drainage refers to a collection of streams, all of which empty into much larger water body such as the sea or ocean. It may be natural or artificial used to remove or drain the surface and sub-surface water from any area. The Republic of Turkmenistan being one of the driest and water deficit regions of Central Asia lacks a constant source of surface water flow. The scarcity of fresh water also prevails there. The mountain streams of Turkmenistan dry up and disappear when they reach the arid sand and parched clay of Karakum. The rivers flowing through the Turkmenistan have their origin source in other countries⁷⁹.

Amu Darya (Ancient Oxus River) constitutes one of the important rivers with a length of 2,540 kilometers from farthest tributary making it the longest river in Central Asia. After originating from the Pamir region of Tajikistan east of Turkmenistan and forms a part of country`s border with Uzbekistan. The river`s average annual flow is 1940 cubic meters per second. The second important river of Turkmenistan is Murgab also spelled as Murgab rising in the north western Afghanistan in a basin bounded on the

⁷⁹ Baber A. and M. Kolodin., The water Resources of Turkmenistan. Problems of Desert Development, 4: p 18-23.

north by Turkestan Mountains and on the south by Safid mountain range. The river generally flow west and then north passing through the Town Bala Murgab just beyond which it forms border between Afghanistan and Turkmenistan and is joined by its only tributary Kushk at Dashkopri. Dams control irrigation water at Dashkopri and Yoloten⁸⁰.

Fig: 3.5 Drainage Map of Turkmenistan



Source: *Ministry of Water Management Turkmenistan*

Besides that these two important rivers act as life lines of the country because they play a significant role in the irrigation potential. The water from both the rivers viz Amu Darya and Murgab has been diverted towards Karakum canal (built during the Soviet period) to supply water to the arid southern parts of Turkmenistan while as other canals supply water to northern parts of the country.

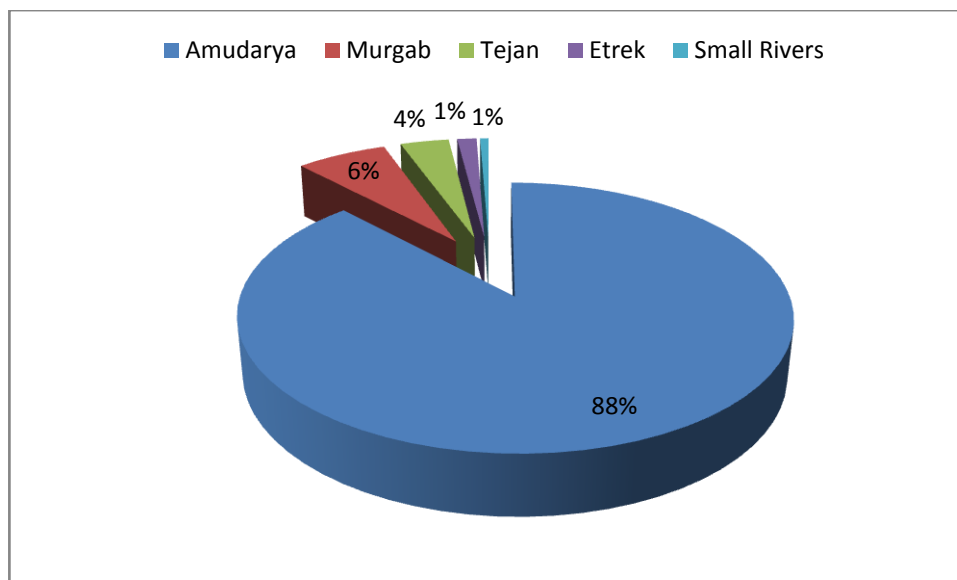
Other than Amu Darya many small rivers which include Tejan with total length of 1,124 kms, Murgab (852) kilometers and the Atrek 660 kilometers also add to the drainage system of Turkmenistan.

The one more important water body of the Turkmenistan is the Caspian Sea, a landlocked salt lake which forms the entire western border of Turkmenistan. Along the Caspian shoreline a prominent features known as Garabogazkol Gulf occupies north western portion of Turkmenistan. The

⁸⁰ IBid P 30-45.

Caspian Sea is fed up by the various rivers flowing through the Republic. Since the last decade the Caspian Sea level is decreasing because of the decrease in the annual flow of rivers⁸¹.

Fig. 3.6 Surface Water of Turkmenistan



Source: *Ministry of Water Management Turkmenistan*

Soil:

Soil may be defined as the thin layer of earth's crust which serves as natural medium for growth of plants. It is the unconsolidated mineral matter that has been subjected to, and influenced by genetic and environmental factors – parent material, climate, organisms and topography all acting over a period of time. Soil differs from parent material in the morphological, physical, chemical and biological properties. Also soil differs among themselves in some or all the properties depending on differences in the genetic and environmental factors. Thus some soils are red, some are black, some are deep and some are shallow, some are coarse textured and some are fine textured. They serve as a reservoir of nutrients and the water for the

⁸¹ Leshchinsky G. and B. Kirsta., The water Resources of Turkmenistan desert. Trudy of Ashkhabad, Hydrometeorological observatory, 5 p 5-17.

crops. Provide mechanical anchorage and favorable tilth. The components of the soil are mineral matter, organic matter, water and air.

Desert soils are downright unusual. They vary tremendously in texture, many are sandy and gravelly while others contains layers of sticky clay or even hard rock, while limy layers. Desert soil may be gray coloured, brown or even brick red. In some deserts soils are covered by layers of small stones⁸².

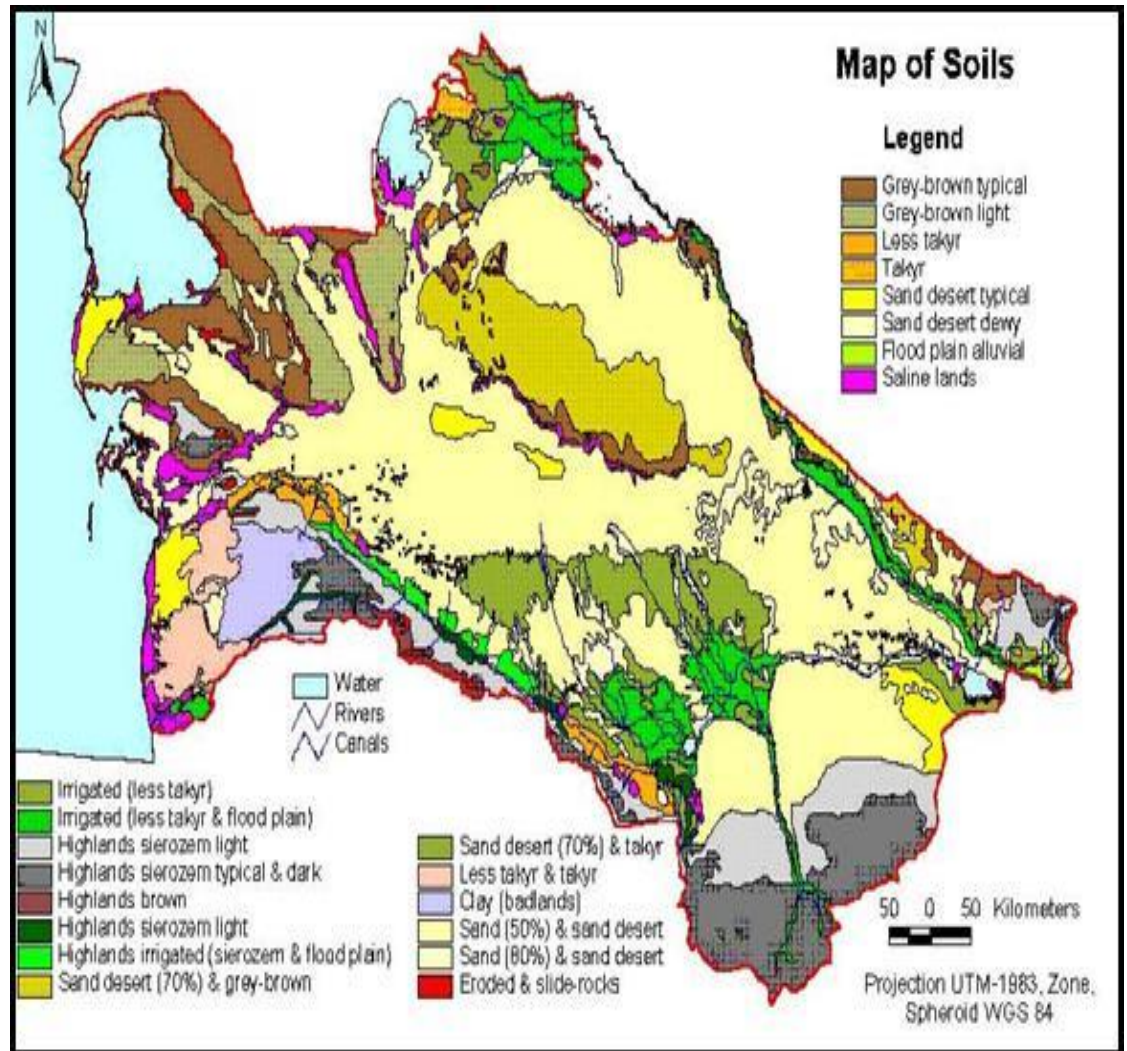
The land area of Turkmenistan is characterized by their major soil types. Sandy deserts and grey brown soils occupy large area. Other soils include gray and brown soils which occupy the plateau of Ustyurt, Karasnovodskoe and Zuanguzskoe. On the foot hill plains light grey desert soil is widely spread. In the low mountain zone- typical grey desert soil and in the high mountain zone black gray desert soils are found. At the highest parts of the mountain plateau and ridges of Kopetdag and Kugitangtau mountains. In the considerable area of Karakum consolidated (fixed) sands are wide spread alkali soils, Takyr and Takyr type soils are found in the low lands⁸³.

⁸² Sexena, H.M., Environmental Geography, 2nd Edition Rawat Publications., Jaipur 2004.

Also See: Sharma, P.D., Ecology and Environmental, Rastogi Publications, Meerut, 2010.

⁸³ Orlovsky N. and L. Orlovsky., Irrigation and Desertification: Ecological consequences of arid land reclamation in the Aral Sea basin and land degradation control in: Proceedings of 12th international soil conservation organization

Fig. 3.7 Soil Map of Turkmenistan



Source: *Institute of Land Management Turkmenistan*



CHAPTER NO -4

*NATURE
OF
CLIMATIC CHANGE*

Climatic Spectrum:

Climate is the outcome of various phenomenon which take place in the sphere of earth- known as atmosphere. This atmosphere is again a complex system which consisting of other elements. So there exists a system within systems which has to be studied in various aspects so that we get a comprehensive idea about the climate of any place or world as a whole.

Atmosphere is a gaseous sphere along with solids and liquids which are present in a suspended form. It wraps up the entire earth. It is not only the air sphere which is included in atmosphere but the existence of ionized and magnetic spheres make the atmospheric system more complicated. It is the mobile compressible and expandable sphere of the earth. It has a capacity to hold some radiations coming from sun, but due to transparency some radiations pass this sphere easily. From the total mass of the atmosphere half of it lies below 5.5 kms. Life is totally impossible without this sphere as this sphere gives unique status to the earth among all planets. Weather which is a bi-product of winds, clouds, storms, etc will not prevail without this cover. So when there is no weather how could be the climate possible so one cannot assume the climate without the existence of atmosphere. It is the key and generating house for climatic system. The weather phenomenon which takes place in this movable sphere makes it possible to trace out the nature of climate⁸⁴.

The interference taking place in this sphere results in drastic changes in the climate over the surface of earth. The present atmospheric gases are not residues but are evolutionary in nature and are product of natural and man-induced processess. The natural will include chemical breakdown of material, earth`s eruptional activities, biological activities and also the human induced activities⁸⁵.

⁸⁴ Anthes, Richard A., *et al.*, *The Atmosphere 3rd ed.* Columbus, Ohio: Charles E. Merrill publishing Company 1981.

⁸⁵ Breuer, Georg, *Weather Modifications: Prospects and Problems*, New York: Cambridge University Press 1979.

The atmosphere constantly gets renewed by the interaction between various spheres like land, water and air, hence bio-geochemical cycles take birth and then the inter and intra exchanges of material and energy takes place. So a balance is maintained within the atmosphere. The gaseous composition of the atmosphere is also of varied nature; neither is it single gaseous element nor a chemical compound. Continuous churning and diffusion of major constituents in the lower atmosphere maintain essentially the same proportions at different places and time. The four major gases of atmosphere are nitrogen, oxygen, Argon and carbon dioxide which constitute about 99% of dry air. Nitrogen constitutes about four-fifth by volume while as oxygen constitutes only one-fifth, argon, neon, helium, krypton and xenon are also present in traces⁸⁶.

Oxygen which is necessary for the performance of various metabolic activities including physical and chemical process is retained in the atmosphere continuously by the process of photosynthesis in plants, while as carbon dioxide whose main source is the combustion and animal exhalation. The global energy budget is affected mainly by the CO₂ as this gas is naturally active for absorbing of long wave radiations of the earth hence it act as one of the factor of climate change. Nitrogen being one of the major constituent of atmospheric gases and is involved in various bio-geochemical cycles, hence playing a significant role in the atmospheric combination and climate⁸⁷.

The possible agents of climatic change are mainly the gases like ozone, carbon monoxide, hydrocarbons, nitrogen oxides, sulphur and other trace gases. Ozone the absorber of the ultra violet radiations plays a significant role in framing out the climate of any place. The ozone density gets reduced by the chlorofluoro carbons produced by reaction between ozone and nitrogen oxides.

Water vapours have a considerable importance in weather and climate. Precipitation is the function of this very important ingredient of the

⁸⁶ Riehl, Herbert, Introduction to Atmosphere (3rd Ed.) New York: Mc Graw-Hill Books Company 1978.

⁸⁷ iBid PP 36-43.

atmosphere. It is the sole determinant of the climate as it has a ability to change in various forms viz solid, liquid and gases and hence all the three forms act differentially and lead to dynamic changes in the climate system because of the latent heat produced by vapours during the change in state⁸⁸.

The other suspended particles in the atmosphere are the aerosols which come from various sources. They get added to the atmosphere in two ways i.e., natural and human induced. They blow from land surface in the dry and desert areas. Besides that aerosols come to the atmosphere by the industries, automobiles, hence sometimes referred as industrial haze as the haze is mostly present in industries areas.

Components of Climate

Climate is a major component constituting the environment of living biota. It is an outcome of inter and intra changes within the spheres of earth viz, lithosphere, hydrosphere, cryosphere and atmosphere. The variations in exchange of heat and moisture along with other elements frame out the climate of any place; hence the climate differs both in time and space. Climate is the outcome of many phenomenon taking place on the surface of earth along with hydro and air sphere.

Air sphere is considered as a major component of the climate as most of the exchange of mass and energy takes place in this sphere. It is the atmosphere interactions which shapes and reshapes the climate. Although climate is the outcome of various phenomenon occurring in the atmosphere over a period of time by this intermingling of heat and moisture which in turn are influenced by latitude, altitude, water and land spheres along with topography, atmospheric conditions like winds, air masses and pressure centers⁸⁹.

⁸⁸ Pittock, A.B., *et al.*, eds., Climate change and variability: A Southern Perspective New York Cambridge University Press 1978.

⁸⁹ Walker James C.G., Evolution of the Atmosphere. New York: Macmillan Publishing Co., inc., 1977. Pp 112-116.

The climate system is a single world with broader perspective. It is a system with different attributes contributing to the formation of complex and comparative phenomena known as climate. Different elements interacting with each other within the sphere of universe given birth to climate. There exists a deep inter relationship between climate and atmosphere.

Temperature

Temperature which plays a vital role in this whole system is a core component of climate striking of solar radiations or radiant energy with the earth is known as insolation. The solar radiated energy strikes the earth's surface via atmosphere and gets converted into thermal energy and hence produce heat, only a small amount of this gets absorbed which in turn produce heat or chemical energy in negligible proportion. The transferring of energy between the spheres of earth is ignited by conduction, convection and radiation processes. While as exchange of heat in various atmospheric spheres is controlled by evaporation and condensation hence act as agents of climate⁹⁰.

Besides that insolation also varies which is governed by transparency of atmosphere, days duration and also the angle at which rays strike the earth's surface. The ellipticity of the insolation is directly proportional to transparency of the atmosphere. It has been noted that the clouds, dust, water vapors and other constituents of the atmosphere hinder the process of reflection, scattering and absorption to a large extent. Transparency is also governed by the latitude and the effect also varies seasonally.

The striking of solar radiations with the earth's surface also depends upon the morphology of landforms. Hence temperature and climate has a close relationship which cannot be studied apart. Temperature is a functional unit of climate which frames and reframes the overall climate of any region which later on influences the whole climate system⁹¹.

⁹⁰ Stringer, E.T., Foundations of Climatology. San Francisco: WHO. Freeman and Comapany Publishing 1972 pp 81-92.

⁹¹ Ibid pp 101 – 109.

Moisture:

Irregularity in the land and water distribution over the surface of the earth results in the contrasts and dynamic nature of climate, another component i.e., water cycle gains status. The cyclic nature of the water and its interaction with other elements of the atmosphere result in moisture/precipitation which plays a pivotal role and carves out the climate system.

Moisture content of the atmosphere affect the transmission of incoming as well as outgoing solar radiations. Evaporation process acts a heat exchanger in the atmosphere. After the intermingling and complex intervention taking place in the atmosphere in the form of evaporation, condensation and precipitation, balance is maintained in the water content of the atmosphere.

During the completion of water cycle a number of processes took place in the atmosphere ignited by other elements give rise to this complex system. Water vapors present in the air referred as moisture content or humidity encompassing and interacting with air by evaporation and condensation processes⁹².

On the other hand evopotranspiration taking place in plants also enacts as a major component of the moisture content of the atmosphere though the role of evopotranspiration is very little but still its role cannot be ignored at all, because in flora rich regions of the world this process acts as an igniter in the weather phenomenon which later on acts as a climate forming element along with other processes.

Atmospheric Circulation:-

The atmosphere and hydrosphere which are associated with earth's surface by gravitational force, hence produce a complex system and become a part of climate system. In the climate these acts as an important constituent

⁹² Mason, B.J., Clouds, Rains and Rainmaking (2nd ed.) New York: Cambridge University Press 1975.

called air pressure which is a main link between solar energy and motion. This pressure along with other forces activates or cause the wind motion that transfer energy and moisture from one place to another. Atmosphere and oceanic movements responds to the earth`s rotation, but the effect varies with speed of movement and latitude. The other barriers like mountains, frictional influence and speed and direction of air streams make the system more complicated. Advection which refers to the horizontal transfer of atmospheric properties such as heat, moisture or momentum. In local convection currents and turbulent eddies occurs a vertical movement of small scale, while as convergent ascent, orographic, lifting and subsidence are more evident in large – scale circulations. The three dimensional motion of atmosphere is a net product of differential heat of the earth by insolation. The global circulation is maintained by the energy coming from tropical oceans due to the transfer of large amount of latent heat into air by process of evaporation. The circulation of the global atmosphere is affected even at regional level because of local latitude and topography. Even though there exists a close relationship between the atmospheric circulation and the other elements of climate, as they are dependent on each other so that these elements in combination with each other play a vital role in formation of climate system. The atmospheric observations are essential for the analysis of world climatic phenomena. So the study of these elements in association with other components of climate will be helpful in studying the comprehensive climatic nature⁹³.

Factors of climate change:

The climate earth`s surface shows fluctuation and is changing both spatially and temporally, the causes of which are a source of considerable speculations and controversies. Natural factors such as changes in solar radiations, sun spots, and atmospheric circulation along with human activities

⁹³ Chang, Jen-HU, Atmospheric Circulation Systems and Climates. Honolulu: Oriental Publishing Company 1972.

contribute to climate change. The earth's climate system is extremely complex and the mechanism of climatic processes are not yet completely understood (Rampino et al 1987).

In the past many theories were put forth to detect the climate change. The quality and quantity of solar radiations coming to earth's surface were mainly cited responsible for climate change.

Volcanoes inject enormous quantities of dust and gases into the upper atmosphere. Large amount of sulphur dioxide are included, which through photochemical reactions using the sun's energy are transformed to sulphuric acid and sulphate particles typically these particles remain in the stratosphere for several years before they fall into the lower atmosphere and are washed out by rains. During this period they disperse around the whole globe and are cut out some of the radiations from the sun thus tending to cool the lower atmosphere. The human race of the earth is conducting uncontrolled, unintended and pervasive experiments that will result in devastating consequences than that of nuclear war. The earth's atmosphere is being changed at an alarming rate by the human activities. Humans are playing with the nature and altering this system. The unprecedented rate of pollutants, wasteful fossil fuels use and the effects of population explosion in various regions are the major threat to global climate. Carbon dioxide concentration along with other green-house gases has major effects on the ozone⁹⁴.

Thus damaged ozone allows ultra violet radiations to the earth's surface which indicate potentially serve ecological, social, economic dislocation of the future generation and future climate. Global warming has reached to such a level that we can ascribe with high degree of confidence a cause and effect relation between the green house effect and the climate change. Carbon dioxide is the single important green-house gas. Five to six billion tons of carbon are being released into the atmosphere annually from fossil fuel use and an unknown amount of deforestation and from increased biotic respiration

⁹⁴ Houghton, Richard and George Woodwill 1989, "Global Climate Change", Scientific American, April 36.

resulting from global warming has already taken place while the total CO₂ release are not well known. We do know that the atmosphere concentration of CO₂ is increasing by 0.4% annually and about 3 billion tons per year is being retained in the atmosphere annually. The rest of the CO₂ is being removed, presumably into the oceans.

The most useful indicator for studying magnitude of climate change is the average global surface temperature. In terms of regional implications, however a global average conveys rather little information what is required in the spatial analysis. It is in the regional or local change that the effects and impacts of global climatic change will be felt with respect to regional change. It is important to realize that because of the way the atmospheric circulation operates and the interactions that govern the behavior of the whole climate system⁹⁵.

The variations in the incoming solar radiation has resulted due to change in earth`s orbit . The solar incident radiations at 60° N in July has decreased by about 35 Wm⁻² over the last 10,000 years. But over the last one hundred years the change is only at most a few tenths of a watt per square meter which is much less than the changes due to increase in green house gases. The total energy reaching the earth`s surface is hardly effected by the orbital changes, but the orbit change alter the distribution of the solar radiations coming to earth`s surface. The immediate matter of concern is that the solar energy output may change with time, but it is again estimated that it will be very little as compared to the change caused by increasing green house gases on the surface of earth.

There are also chances of climatic change on earth because of changes in the solar ultra violet radiations which influence the atmospheric ozone and hinder the climate of the planet earth⁹⁶.

Another possibility is that the galactic cosmic ray flux modified by the varying suns magnetic field could influence cloudiness and hence climate.

⁹⁵ Critchfield, H.J., General Climatology, New Delhi, Prentice Hall 1987.

⁹⁶ Ibid pp. 240-245.

From studies these possible mechanisms there is as yet insufficient evidences of significant climate effects.

To infer it is evident from the above facts that green house is highly responsible for climate change. The rate of change is likely to be larger than any the earth has seen at any time during the past 410,000 years.

The changes in the frequencies will intensify the climatic extremes especially floods and droughts. The fossils fuel combustion has changed and is changing the chemistry of the atmosphere. The addition of toxic gases continuously in the air will lead to the climatic change to such an extent and will have unpredictable and unexpected features⁹⁷.

Climate Change Theories:

The climatic variability is taking place on the the earth`s surface since its evolution. As the earth came into existence along with some specific atmospheric condition which formed the climate of this planet at that time, since then the climate of the planet has changed many times. The atmospheric balancing act that makes our planet habitable also means it is sensitive to even small changes in the gases that maintain our current temperature. This planet has an ability to become hotter and cooler for the survival of flora and fauna on its surface.

Climate of the earth is vulnerable to change because of unrest and unstability characteristic of atmosphere. The variations and variability`s of weather in both terms of space and time which tend to change the climate. The variations and variability which take place in weather conditions over any specific area for a specific time period and hence tend to change the climate type is known as climate change. The changes which took place in the moisture content, heat balance, precipitation, cloudiness, etc, have a definite cause which may be natural or human induced. The climochronology or history of paleo climates reveals the fact that climates have changed in the

⁹⁷ Ibid pp. 234-238.

past, are changing now and there is every reason to expect that they will change in future (Hobb`s 1980).

Another concept of climate change is that cyclic nature of climate changes which is supported by the concept of uniformitarianism by James Hutton. Hence the climates of various geological periods are the clear evidences that climate change has taken place and is still dynamic vulnerable to change any time⁹⁸.

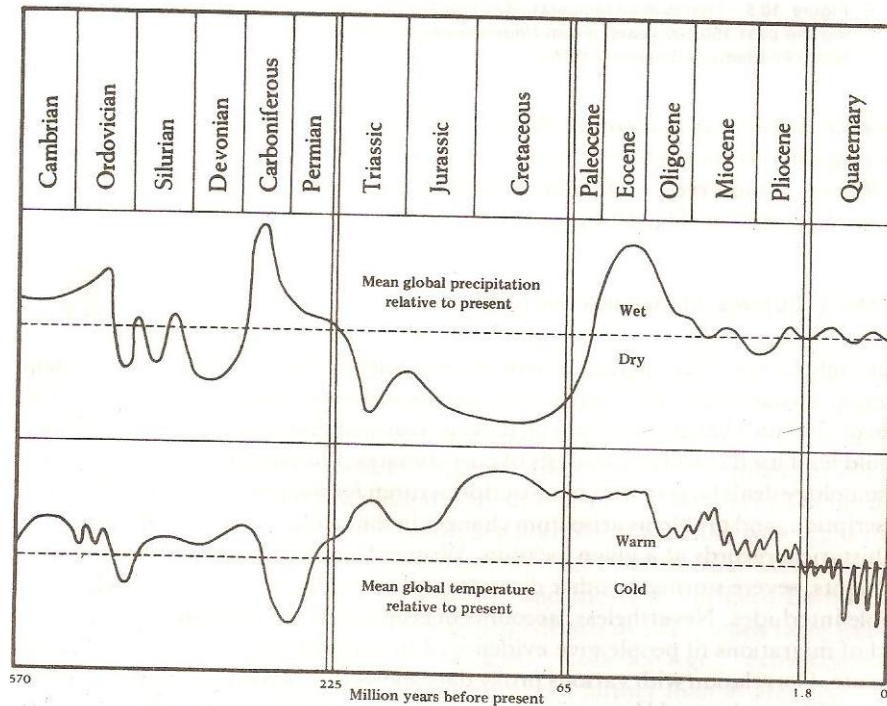
The climatic change may be gradual or rapid depending upon the intensity of the cause. It may be spontaneous because of unusual magnitude of natural force which may imbalance or cause catastrophe in the jiffy of an eye e.g., Jurassic climate change was rapid because of collision of earth and a giant meteor and the release of huge amount of dust in the atmosphere. Hobbs`s in 1980 observed that the cool period of earth`s history are periods are periods of greater than normal climatic instability. The dynamic nature of the present weather conditions prevailing over the earth`s surface is clear evidence that the climate will change in near future and it will be a great disaster for world community. Though its intensity may vary from one place to another but at the end of the day the whole world will reap the consequences of their own deeds⁹⁹. Whatever the cause may be climate change is reality.

As the evidences of the climate change in the past, which are utilized for reconstruction of climochronology (history of Paleo climates) are called indicators of past climatic change. The reconstruction of past climates is basically a puzzle and solution totally depends on proxy data.

⁹⁸ Strahler, H., Physical Geography, New York, John Wiley and Sons 1996.

⁹⁹ S. Christopher "Global Warming: Personal solutions for healthy planet 2005.

Fig. 4.1 Precipitation and Temperature fluctuations since the Precambrian



Source: H.H.Lamb, *Climate: Present, Past and Future, Vol 2, 1977*

To reveal the climates of past Hutton's theory of uniformitarianism (1785) which is based on two concepts (i) Present is key to the past and (ii) No vestige of a beginning, no prospect of an end helps to some extent to trace out the climates of the past, but not provides a full and fact based details hence again proxy comes in between the facts and myths¹⁰⁰.

Fuel consumption and climate change:-

The continuous increase in the levels of green house gases has given a birth to a big and threatening problem known as climate change. Although it was taking place even in the past but the last 100 years (Century) has witnessed drastic change in the world climate. The concentration of carbon dioxide, methane and nitrogen oxides has increased since pre-industrial era by 30%, 145% and 15% respectively because of exploitative use of fossil fuels and due to change in land use/ land cover throughout the world. The global

¹⁰⁰ lbed pp 15 -26.

mean surface air temperature i.e., earth's surface temperature in the last 100 years has increased between 0.3°C – 0.6°C. as per the predictions made by inter governmental panel on climate change (IPCC). It has been estimated that by the year 2030. The global mean surface temperature would be 2°C above pre-industrial levels while as it may be 4°C by 2090 i.e., end of 21st century. After analyzing current trends of energy use and fossil fuel burning it has been predicted that world's use of fuel energy is set to almost double in the first 30 years of this century with about 90% of the growth likely to be met by gas, oil and coal. So fossil fuel emission will remain at the top for creating havoc of climate change from the last 100 years. Oil, gas, coal or we may say in one term i.e., fossil fuel have done a great job for the prosperity of human race on the one hand, it could be the time of celebration. But on the other hand it is a grave matter of concern especially for developing countries¹⁰¹.

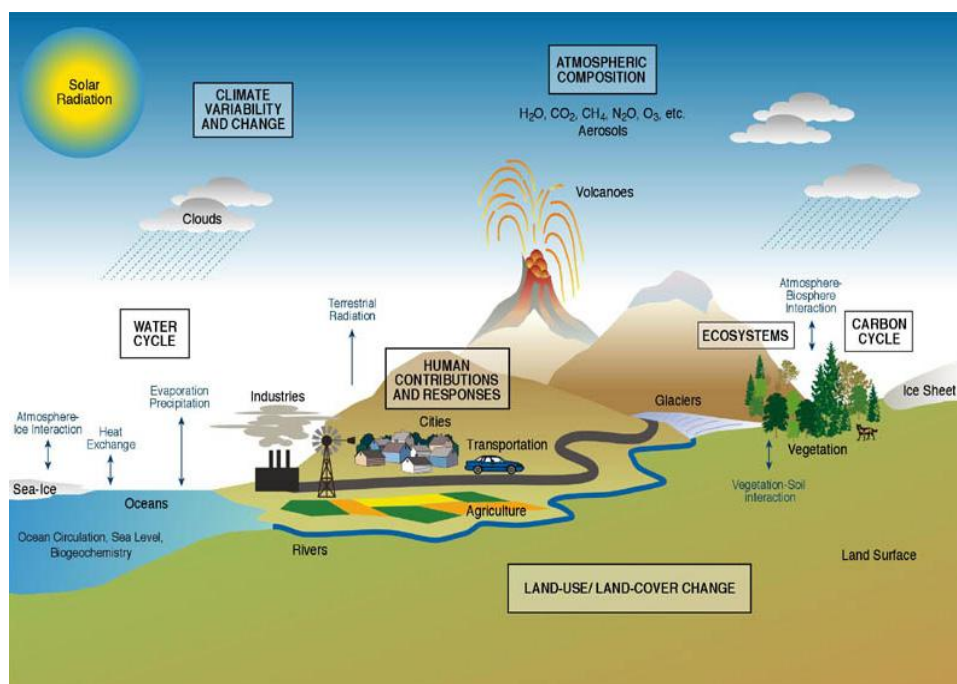
The third world countries have to put pace with the global economy in these times of globalization, but in order to achieve this goal they are rustly exploiting their nature resources which in turn will bring them the disaster like global warming which in turn will put its impact on climate system and the change in climate system has disturbed the weather conditions and made the planet vulnerable to climate change which has put and is putting great impact on flora and fauna of the planet in one way or the other and the main victim of this change is again human community – the creator of the change. Hence nature of climate change is cyclic and both natural and human induced phenomenon act as a centripetal and centrifugal forces respectively and man is becoming victim of his own success.

Are we now really curious about the future climate of our planet obviously No! even these days the experts are dubious about the climate change which have created a sense of confusion in the scientific community. Some are of view that climate change is a “Myth” while as others took it as a

¹⁰¹ House, J. I., et al., Reconciling apparent inconsistencies in estimates of terrestrial CO₂ sources and sinks. *Tellus*, 55B pp 345-63.

fact. Numerous experts have tackled with the issue of climate change but with different inspirations and enthusiasms¹⁰².

Fig. 4.2 Causes of Climate Change



Source:<http://www.tenir.nl/airpollution>

It was only in 2001 when the world's leading team of experts, the inter governmental panel on climate change (IPCC) signed off on their latest document of 3000 pages third assessment report. The panel made it clear that there is a widespread consensus within the scientific community on global warming. The views of the (IPCC) need to be taken serious for a start, it is far and away the world's most respected source of information and analysis of climate change. The IPCC aims to provide regular assessments of every aspect of climate change, ranging from how and why it is happening, to what can be expected in future, although the predictions and findings of IPCC include many "ifs" and "maybes" but when about 2000 experts of different countries supported the fact that the warming is taking place and last century has witnessed change in temperature and precipitation, confidence over the models of future climate has increased and the computers are providing reliable data which help in prediction of future climate¹⁰³.

¹⁰² S. Christopher., Global warming: Personal Solutions for Healthy Planet 2005.

¹⁰³ Ibid pp. 8-12.

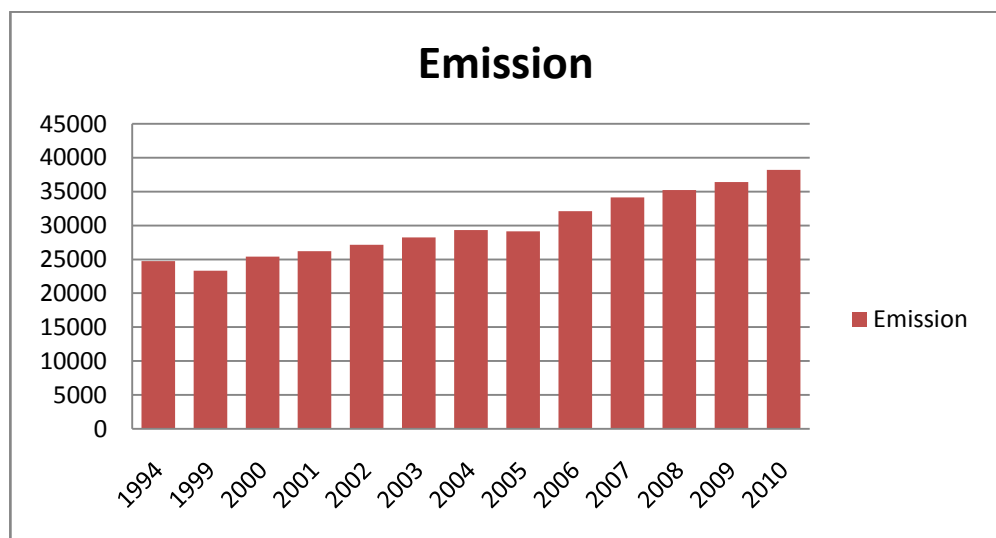
The Republic of Turkmenistan being rich in natural gas and hydrocarbon production contributes to the GDP and GNP of the country. Besides export of hydrocarbons and natural gases the internal consumption is also high. The energy activities especially fuel consumption for industries and domestic purposes has led to the increase in green house gas emission, like carbon dioxide (CO₂), methane (CH₄), nitrogen oxide (N₂O) and ozone (O₃).

As per the report of ministry of energy and industry the carbon dioxide emission from natural gas consumption was 24 thousand ton which has raised to 25 thousand tons in year 2000. From the year 2000 the CO₂ emission has shown increasing trends which is evident from the table 4.1:

Table 4.1 CO₂ emission from natural gas consumption (tons)

Year	Emission
1994	24722
1999	23318
2000	25412
2001	26216
2002	27128
2003	28215
2004	29323
2005	29153
2006	32122
2007	34116
2008	35239
2009	36416
2010	38211

Fig :4.3 CO₂ emission from natural gas consumption (tons)



Source: *Initial National Communication on Climate Change Turkmenistan*

Thus from the table it is now clear that the CO₂ emission from natural gas consumption has increased at an alarming rate¹⁰⁴. If the same trend will continue it will put adverse impacts on the climate of Turkmenistan and will result in the dangerous consequences which may include threats to whole biodiversity of the country in general and the humans in particular. So there is a need that the natural gas consumption should be brought down and strategies should be implemented in order to reduce emission of harmful gases in future so that we can mitigate some consequences of climate change in the Republic of Turkmenistan¹⁰⁵.

Now when we look at the overall CO₂ emission from year 1992-2007 it has again shown the increasing trend with some fluctuation in year 1996 and 1997. In the year 1992 the CO₂ emission was 28067 thousand metric tons which have raised to 45808 metric tons in 2007 the table below represents the carbon dioxide emission in the territory of Turkmenistan. This emission includes the emission from all CO₂ producing sources like energy activities, industrial processes, methane and the another green house gases are also produced in Turkmenistan by various activities which include Fugitive emissions like extraction, transportation and oil and gas refinery. Besides that the emission of methane includes the agriculture and live stock emissions like enteric fomentation cattle, sheep breeding, poultry forms and camel breeding produce methane. Decomposition of organic substance at periodically flood rice fields cause thousands of tons of methane emission¹⁰⁶.

From the year 1992-2010 the methane emission has increased due to high extraction of hydrocarbon materials.

¹⁰⁴ Greenhouse Gas Inventory working group// Revised Guides of National Greenhouse Gases inventories IPCC 1996 vol. 2.

¹⁰⁵ Borzenkova I.N., Budyko M.I., Butnet E. K., et. Anthropogenic climate changes. L: Gydro metoizdat, 1987.

¹⁰⁶ Ministry of Nature Protection Turkmenistan 2007.

Fig. 4.4 Direct Green House gas emission by sectors.

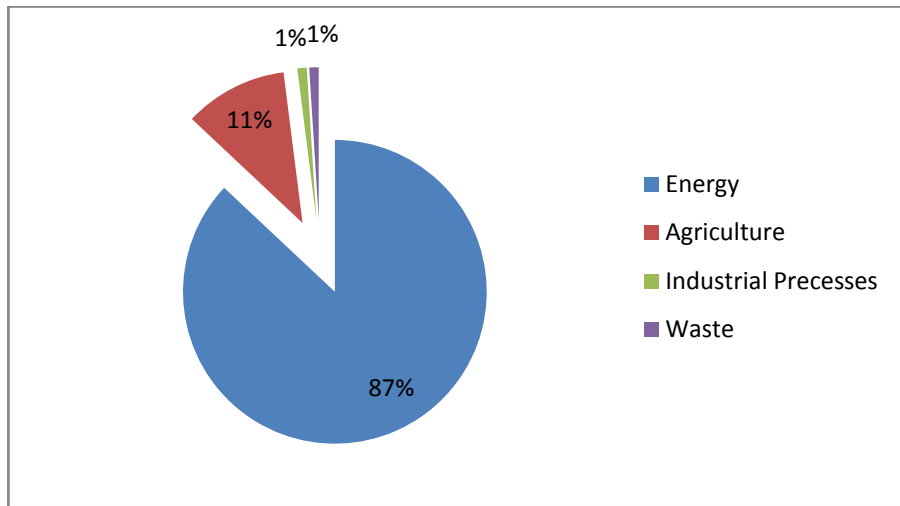
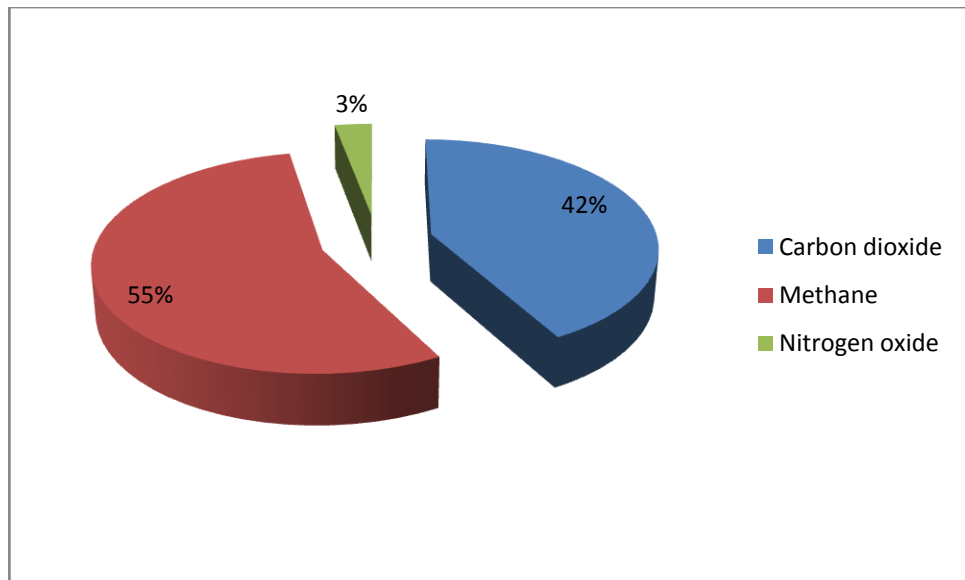


Fig. 4.5 Direct Greenhouse gas emissions



Source: *Initial National Communication on Climate Change Turkmenistan*

Ozone Hole and Climate Change:-

Is ozone hole responsible for climate change is a contradictory issue? Some correlate it with green house effect and some say opposite of it i.e., ozone hole and global warming are two distinct issues. The ozone layer protects the earth`s surface from intensive heat radiations and act as a shield for ultra violet rays. Now whatever the fact may be, but it is obvious that the

destructured ozone layer is allowing ultra violet radiations and more heat to enter into atmosphere, hence warming up the atmosphere and causing global warming. This global warming disturbs the climate system and causes climate change both at regional and global level. The experts studying the causes of ozone hole have realized that the hole is widening with every passing day and the density of ozone gas in stratosphere is diminishing¹⁰⁷.

The first fact that how the hole was created, scientists held responsible man-made chemicals called halocarbons which mainly include chlorofluoro carbons (CFC`s) which come from refrigerators, air conditioners and as propellants in aerosol spray cans. As the concentration of CFC`s increases in the atmosphere they get mixed and reacts with their component molecules and form chlorine and bromide are lethal to ozone and hence thinning the layer.

Besides that the other gases produced by the human activities which include methyl bromide (insecticide) and carbon Tetrachloride (used for dry cleaning). More fastening scientists have discovered other chemicals and gases produced by various human activities such as burning of fossil fuels in homes, factories, transport, offices etc. thus the CO₂ along with methane, sulphur dioxide, carbon monoxide etc. had affected the ozone to a large extent¹⁰⁸.

Mostly in colder areas where the temperature is low ozone depletion is more that is why colder area of Antarctica became the first victim. Now when the percentage of Green House gasses is increasing in atmosphere the thinning of the ozone layer is at alarming rate.

Thus ozone depletion and climate change are related to each other and former has a potential to affect later. CFC`s kill The ozone and also have a tendency to trap the heat like CO₂ and warming the atmosphere. So it is right to say that humans have brought ozone depletion and ozone depletion has a potential to cause climate change. Climate change is already affecting our weather patterns, causing fluctuations in temperature, rainfall, snowfall and

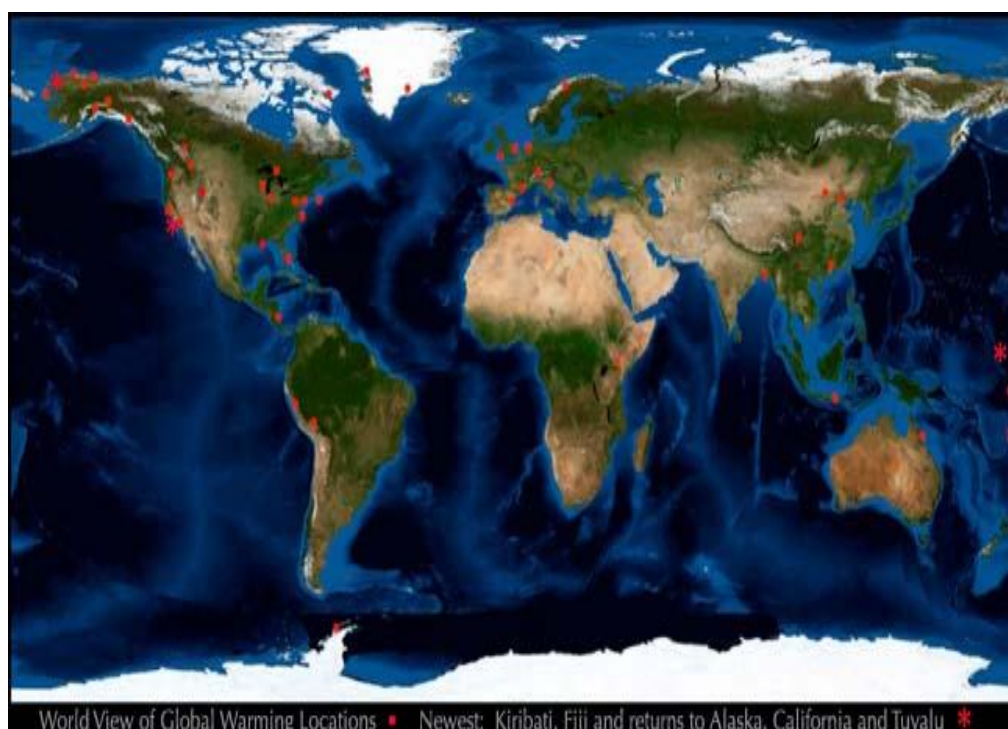
¹⁰⁷ The Ozone Hole inc. 2008. The Ozone hole History available at www.theozonehole.com

¹⁰⁸ Tropospheric Emission Monitoring Internet Service 2008. Available at www.temis.nl/airpollution

sea level. It is also makes our weather more extreme, increasing the incidence of storms, floods, heat waves, droughts, hurricanes, tornadoes, etc. in today's trends there is a noticeable depletion of ozone layers, it is popularly known since 1970 that a substance called chlorofluorocarbon (CFC) is threatening the layer. This is true not only at global level but at regional level as well¹⁰⁹. Taking the Turkmenistan into consideration here the ozone layer depleting gases emitted by various activities have also shown some signs of ozone depletion over the country which is evident from the facts that the consumption of ozone- depleting substances have increased since 1990.

Thus these substances contained in refrigerators, coolants and aerosol spray, etc are continuously depleting the ozone layer. Besides that some other substances like bromide hydrocarbons and nitrous oxides are also possible threats. The thin ozone layer has allowed ultra violet rays which have brought increase in the temperature trends of Turkmenistan and have thus increased the risk of warming and climate change in the Republic of Turkmenistan.

Fig. 4.6 World View of Global Warming



Source: <http://envirolink.org/envirowebs.html>.

¹⁰⁹ Lohani, B.N. An Air pollution index based on Factor Analysis. Journal of the IPHE.



CHAPTER NO –5

***MAGNITUDE
OF
CLIMATIC CHANGE***

Previous chapter presented an overall view of the nature of climatic change and the causes responsible for it, Global view of climate change as well as the regional view with special reference to the Republic of Turkmenistan. Temperature and precipitation trends provide useful information to assess the magnitude of climatic change. The variations in temperature and the fluctuations in the precipitation give an actual detail about the magnitude of climatic change in Turkmenistan. The regional variations in both temperature and precipitation and their spatio-temporal analysis are useful for climatic regionalization of Turkmenistan. With regard to regional change, it is important to realize that, because of the way the atmospheric circulation operates and the interactions that govern the behavior of the climatic system¹¹⁰, climate change over the globe will not be uniform. Same is the case of Turkmenistan. There exist variations in temperature and precipitation even at micro level because of topographical features. The desert on the one hand has a high temperature which even touches thermometer up to 50⁰C in south-eastern parts. While as the mountain regions have a severe low temperature which in winter falls even up to -33⁰C. Precipitation being another important indicator of climate change. With warming of earth's surface there is increase in the evaporation process from water bodies leading

¹¹⁰ Critchfield J.H., General Climatology (4th edition), Prentice Hall India, 2002.

to the increase in the water vapor content and therefore on average precipitation increases. Since the water holding capacity of air increases by about 6.5% per degree Celsius¹¹¹, the increase in precipitation as surface temperature rises can be expected to be substantial. In fact, model projections indicate increase in precipitation broadly related to surface temperature increase of about 3% per degree Celsius¹¹².

But the case is totally inverse in Turkmenistan. Here the precipitation has decreased from the last century and temperature has increased. It is because of the local factors or the latitudinal location and extent of the region. Since the largest component of the energy input to the atmospheric circulation comes from the release of latent heat of water vapors on condensation, the energy available to the atmospheres circulation will increase in proportion to the atmospheric water content, a characteristic therefore of anthropogenic climate change due to increase of green house gases will be more intense. Hydrological cycle, which again puts effects on the precipitation scenario of the Republic of Turkmenistan.

TEMPERATURE TRENDS:

Different people have different concepts of temperature. The meaning of temperature varies from subject to subject. The definition of temperature to a chemist is different from the geographer. But the typical of temperature in general includes “how hot or cold it is” relating to how they feel. In geographical perspective we associate sunny days with warmer weather and cloudy or rainy days with cooler. Therefore, an improved concept of temperature and associated observation becomes important and gains status.

The temperature of the air is directly associated to the amount of energy which is derived from suns solar radiations. The higher the amount of

¹¹¹ Related through *the Clausius clapeyron equation* $e^{-1} de/dt = L/RT^2$ where (e) is the saturation vapour pressure at temperature “T” L, the latent heat of evaporation and R is the gas constant.

¹¹² Allen, M.R., Ingram, W.J. 2002. *Nature*, 419 pp. 224-32.

energy in the air, the higher will be the temperature. Measurement of the air temperature is taken away from the direct sunlight or its reflected radiations. Temperature can be estimated by how comfortable or uncomfortable you feel at certain temperature. By associating what you feel or what you observe on a thermometer. However you must consider the following situations which can affect your perceptions of what the actual temperature.

On high solar radiation days, it may feel that the temperature is higher than that is actually measured by thermometer, conversely, days that are generally cloudy are associated to the cooler, however it is possible for temperature to reach above 30⁰C even on cloudy days the higher the percentage of moisture in air the warmer it may be. But winds affect perception of temperature that higher the wind strength the cooler it may be. Depending on the climate, temperature can change very quickly taking the people to surprise. It is not uncommon for temperatures to drop more than 10⁰C under certain conditions. In Turkmenistan, some places have recorded conditions changing from sunny and warm to blizzard condition within a short span of time. To infer it is obvious now that temperature is most commonly measured weather parameter. Most specifically, temperature describes the kinetic energy of motion, of the gas molecules that make up the atmosphere. As gas molecules move more quickly, air temperature increases. Air temperature play a significant role as it affects other parameters of the weather. For example air temperature affects relative humidity, rate of evaporation, precipitation patterns, types and also directional speed of winds.

The variations and fluctuations in the temperature of Turkmenistan is common, hence most sensitive is characterized by changes in climate continuity throughout the year. The climatic differences are significant as they vary from northern to southern parts of the country. The northern areas which come under the influence of Siberian anticyclone are characterized by frost, snow cover and hence long severe winters. While as summer with low precipitation prevail for a short time period. The southern parts of the territory

show fluctuations in air temperature. Sometimes it goes high and sometimes very low so the permanent snow cover does not prevail there and hence the winters on those parts are mild. The atmospheric circulation is characterized by frequent meridian processes in the territory throughout the whole year.

Although, they are noticeable during the cold period of year and change the weather abruptly followed by fall in temperature, winds and precipitation. The warm winter sometimes become severe and lasts for a small period of time.

The differences of temperatures in the northern and southern parts of the Republic of Turkmenistan are governed by certain atmospheric circulations. The strong Siberian anticyclone is responsible for bringing severe cold and a drastic decrease in daily temperatures. In the southern parts the winter temperatures are of mild type with some warmness and the temperatures can sometimes become severe because of the affects of Siberian anticyclone which hinders the radiation inflow to the region. The January mean temperature varies latitudinally and is recorded as 1.1°C in the east and -1.6°C in the west. The temperature in some regions can fall even up to -33°C . The summer temperatures especially in the month of July the average temperature remains 28°C and can rise up to 50°C in the south-eastern parts of Karakum desert. The hot dry winds are frequent in the semi-arid zones of Turkmenistan.

Observed Temperature Changes:

Temperature data collected from the twelve weather stations (given in Annexure) of the Republic of Turkmenistan were analyzed. The stations are located in different Velayats with different latitudinal and longitudinal extents. The comparison was made between average temperatures for about 30 year's i.e. from 1980-2010. From this data it was observed that the three decade temperature has shown increasing trend with some fluctuations.

Table: 5.1 Temperature Trends in Turkmenistan from (1980-2010)

Year	1980	1985	1990	1995	2000	2005	2010
Temperature °C	15.3	15.6	15.8	15.9	16.1	16.2	16.3

Source: *Calculated by Researcher from data of www.allmetsat.com*

The temperature from 1980-2010 has shown an average increase of 1⁰C. The temperature regimes also vary from east to west. The eastern parts and the foothills of Turkmenistan have shown increase of 0.3⁰C while as the western parts has shown the 0.4⁰C increase in temperature. Temperature above 40⁰C was observed at some stations which include Ashgabat, Serdr and Takhtabazar. The data also shows that the year 1995 was the hottest in the three decades with a temperature of 16.8⁰C while as the year 1985 was the year of lowest temperature with the temperature of 14.9⁰C.

Upon the results of the work done it may be concluded that the quantity of days with higher temperatures have increased. Although the increasing trend was uniform but year 1985 has shown an abrupt decrease in temperature while as year 1990 has shown abrupt increase in temperature. The overall temperature regime of the Republic of Turkmenistan is confusing owing to its latitudinal extent. The Siberian anticyclone and the changes in Arabian Sea are responsible for the fluctuation taking place in the temperature. Thus it rejects the idea that the climate of Turkmenistan is more or less constant.

The present works has revealed that the temperature is showing increase trend due to the increase in the carbon content and other green house gases in the atmosphere of Turkmenistan. There exists a positive correlation between the gas emission and temperatures in the Republic of Turkmenistan.

Trend Analysis of the temperature data in Turkmenistan

Year (x)	Temperature (y)	X = (x – 1995)	X ²	XY
1980	15.3	-15	225	-229.5
1985	15.6	-10	100	-156
1990	15.8	-5	25	-79
1995	15.9	0	0	0
2000	16.1	+5	25	80.5
2005	16.2	+10	100	162.0
2010	16.3	+15	225	244.5
Total	∑ Y = 111.2	∑ X = 0	∑ X² = 700	∑ XY = 22.5

Let the linear trend equation be

$$Y_t = a + bx \dots\dots\dots (1)$$

Subjected to the given normal equation

$$\sum Y = Na + b \sum X$$

$$\sum XY = a \sum X + b \sum X^2$$

Sub. All the above calculated value in

$$111.2 = 7a + 0.b \dots\dots\dots (2)$$

$$22.5 = 0.a + 700 b \dots\dots\dots (3)$$

From eq. (2), we get

$$111.2 = 7a$$

$$A = \frac{111.2}{7}$$

$$A = 15.88$$

From eq. (3),

$$22.5 = 700 b$$

$$b = \frac{22.5}{700}$$

$$b = 0.03$$

Sub. The value of a and b in eq. (1), we get

$$Y_t = 15.8 + 0.03X$$

Now, Computation of trend value of

$$Y_t = 15.8 + 0.03X$$

Year	X	$Y_t = 15.8 + 0.03X$	Y_t (Trend values)
1980	-15	$15.8 + 0.03(-15)$	15.35
1985	-10	$15.8 + 0.03(-10)$	15.5
1990	-5	$15.8 + 0.03(-5)$	15.65
1995	0	$15.8 + 0.03(0)$	15.8
2000	+5	$15.8 + 0.03(5)$	15.95
2005	+10	$15.8 + 0.03(10)$	16.1
2010	+15	$15.8 + 0.03(15)$	16.25

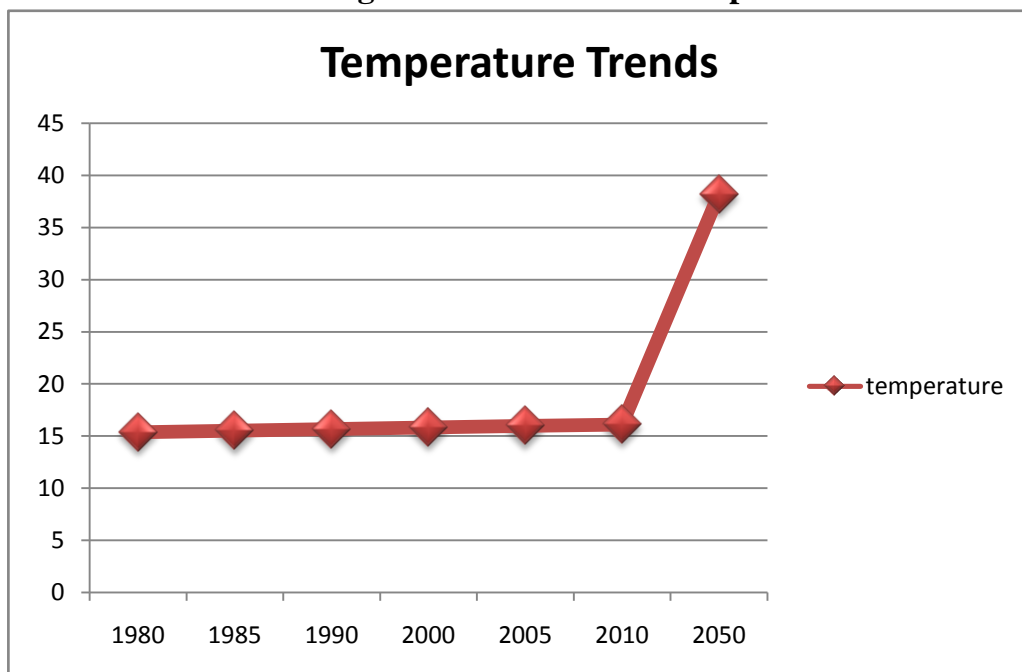
From the graph, we notice that the temperature for the year 2050 could be (38.2)°C, Also from the trend lines

$$Y_{2050} = 15.8 + 0.03(220)$$

$$Y_{2050} = 15.8 + 22.4$$

$$Y_{2050} = 38.2 \text{ } ^\circ\text{C}$$

Fig 5.1: Trend Line of Temperature



PRECIPITATION TRENDS:

In geographical terms precipitation refers to the one of the classes of hydrometeors, which is the atmospheric water phenomenon. It is the product of condensation of atmospheric water vapors that fall under gravity¹¹³. The main forms of precipitation include rain, drizzle, snow, sleet, graupel and hail. It occurs when a local portion of the atmosphere becomes saturated with water vapors and the water condenses¹¹⁴. Two processes, possibly acting together, can lead to air becoming saturated: cooling the air or adding water vapor to the air. Generally the precipitation will fall to the surface; an exception is “virga” which evaporates before reaching to the earth’s surface. Precipitation is formed by the collision of rain drops or ice crystals within the cloud. Rain drops range in shape and size from oblate, pancake-like shapes for larger drops to small spheres for small drops. Unlike raindrops snowflakes grow in variety of different shapes and patterns, determined by the temperature and humidity characteristic of air the snowflakes moves through on its way to the ground. While snow and ice pellets require temperatures close to the ground to be near or below freezing, hail can occur during much warmer temperature regimes due to process of its formation.

Moisture overriding associated with weather fronts is an overall major method of precipitation production. If enough moisture and upward motion is present, precipitation falls from convective clouds such as cumulonimbus and organize into narrow rain bands.

The regions or an area where relatively warm water bodies are present for Example Lake, pond, lake effect snowfall becomes a concern downwind of the warm lakes within a cold cyclonic flow around the backside of the extra tropical cyclones. Lake-effect snowfall can be locally heavy. Thunder snow is possible within the cyclone’s comma head and within the

¹¹³ “Precipitation” *Glossary of Meteorology*. American Metrological society 2009.

¹¹⁴ The weather world 2010 Project (1999). *Precipitation: Hail, Rain, Freezing rain, sleet and snow*. University of Illinois.

lake effect precipitation bands¹¹⁵. This process takes place in the Turkmenistan in the coastal areas of Aral sea where under the influence of Siberian anticyclone this type of precipitation takes place during the winter months.

In mountainous areas heavy precipitation is possible where upslope flow is maximized within windward sides of a terrain at elevation. On the leeward side of mountains, desert climate exists due to dry air caused by compression heating. The mountainous areas of Turkmenistan which include Kopetdag situated in the southern parts of the country and the two ridges Mely Balkhan and Bolshoi located to north-west of country receive much precipitation due to the upward flow of hot air from the dry and humid dry areas located near the foothills which join the Prakaspisky lowlands on the western side.

Diamond dust also known as ice needles or ice crystals formed at temperatures approaching -40°C due to air with slightly higher moisture from aloft mixing with colder surface based air¹¹⁶. They are made of simple ice crystals that are hexagonal in shape. Affected by the cold Siberian anticyclone this type of precipitation occurs at higher altitudes during severe chill of winter and lasts only, for few hours. It brings the wave of severe and unbearable biting cold.

Now it is a clear fact that precipitation formation is a very complex process governed by the changes in air pressure, temperature, local effects, and mountain slope and water bodies. Now keeping in view these facts the topography of the Republic of Turkmenistan is very complex. It consists of huge mountains on the southern side to the rolling sandy deserts. The continental type of climate is hence framed by the topographical features along with other elements such as temperature, air pressure, precipitation etc.

¹¹⁵ Dr. Chowdhury's *Guide to Planet Earth* (2005).

¹¹⁶ Dr. Michael Pidwirny 2008. Chapter 8: *Introduction to Hydrosphere, Cloud formation processes physical geography* 2009.

Taking the precipitation scenario of Turkmenistan into consideration it is of varied nature. Most of the precipitation occurs during the winter months while as summers are almost dry. Besides this the variations also occur at micro regional level of the country. During winters due to low temperature in the northern regions stable snow cover is observed. Little precipitation is recorded from the month of June to September. During these summer months the precipitation is mainly caused by the cyclonic activity when the level of convection reaches the level of condensation which is located at an altitude of about 1.2 - 1.4Kms. Precipitation in this part of territory is also caused by a high level of the relative air humidity in low troposphere layer. Much of the precipitation occurs in the month of April and March and in the cold period of the year from October to February about 45.2% of the annual precipitation is recorded. The warm period is characterized by very low precipitation and its amount over the four months is 3.4mm that is 8.4% of the annual amount¹¹⁷.

In the western zone maximum precipitation is observed in March (23mm). Low precipitation during the warm season occurs frequently less than 19.7mm that is 13.5% of the annual amount. During the cold period maximum precipitation days are observed on the plains of the territory.

Due to growing activity of cyclone during the second half of winter and in spring in southern region maximum number of precipitation days is recorded. The desert area of Turkmenistan which consist of sandy soil of Karakum desert there are 5-8 days of precipitation every month during winter season only, while as the summers remain almost dry due to intense heat¹¹⁸. All mountain regions of the territory are characterized by high frequency of precipitation during the entire year. These rains sometimes cause mud torrents which cause destruction to life and property. In the foot hill areas heavy precipitation is observed and the number of days with precipitation greater

¹¹⁷ *Turkmenistan country Analysis*. United Nations 2008.

¹¹⁸ *Turkmenistan: Initial National Communication on Climate Change*, 1998.

than 20mm is 3-8 in southern regions¹¹⁹. The precipitation is influenced by the wind during the warm period because at this time it is typical for air mass to blow from marginal northern latitudes of the continent to the central region. Based on these conditions Turkmenistan has the north-western, northern and north-eastern winds which one way or the other way play a role in the climate of Turkmenistan territory as a whole¹²⁰.

West winds moderate the climatic effects of northern location considerably. Temperatures average above freezing and harbors are ordinarily ice-free in winter. But away from the direct influence of the west winds, winter temperatures average below freezing and particularly severe at elevated interior and northern location. In summer the ocean tends to be a cooling rather than a warming influence, and most of northern portion has Fahrenheit temperatures in July. High lands have temperatures sufficiently low that a number of glaciers exist. Despite the overall moderation of the climate as compared with what to be expected from the latitude, the population tends to cluster in the southern sections.

Observed Precipitation Changes:

The precipitation data was collected from the twelve stations (given in Annexure) of Turkmenistan was analyzed and the mean precipitation trends were calculated for a period of 30 years i.e. from 1980-2010. Year wise data of precipitation was computed and average mean of five years was also calculated. The analyzed and computed data reveals that the fluctuations have occurred in the precipitation scenario. During the thirty years period there has been increase in winter precipitation in the northern parts of the country including foothill areas of Kopetdag Mountains. Decrease in precipitation during summer months was observed in whole territory of Turkmenistan increase in precipitation was observed by many stations in the northern and western parts while as other stations have shown decreasing trend.

¹¹⁹ Ibid.

¹²⁰ *Turkmenistan country Analysis*: United Nations 2008.

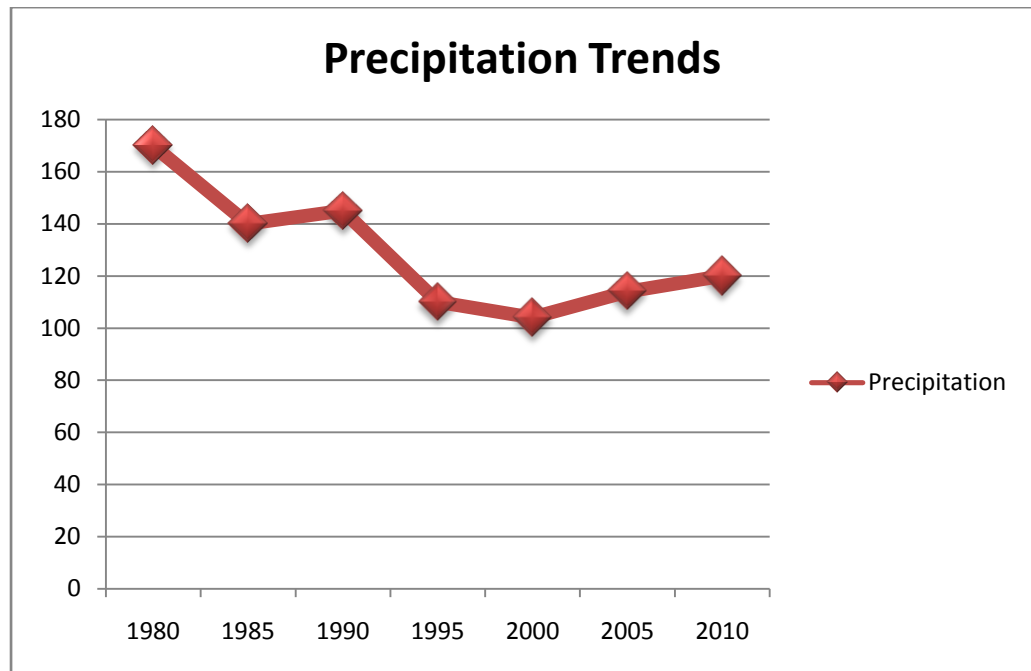
Table: 5.2 PRECIPITATION TRENDS

Year	1980	1985	1990	1995	2000	2005	2010
Temperature (mm)	170	140	145	110	104	114	120

Source: Computed by researcher from the data of www.allmetsat.com

From the table 5.2 showing precipitation trends in the Republic of Turkmenistan for the period of 30 years (1980-2010) it should be pointed out that the precipitation has shown fluctuations but on an average the decreasing trend in precipitation regime has occurred due to which some areas of the country has been hit by severe droughts which has put its impact on the crop production and on other ecological balance especially biodiversity. The average lowest precipitation (104mm) was observed in the year 2000. While as highest average precipitation (170mm) was recorded in 1980. This show how there has been decrease in precipitation in these two decades.

Fig 5.2: Trend Line of Precipitation



Trend Analysis of the Precipitation data in Turkmenistan

Year (x)	Precipitation (Y)	X = (x - 1995)	X ²	XY
1980	170	-15	+225	-2550
1985	140	-10	+100	-1400
1990	145	-5	+25	-725
1995	110	0	0	0
2000	104	+5	+25	+550
2005	114	+10	+100	+1040
2010	120	+15	+225	+1800
Total	∑ Y = 903	∑ X = 0	∑ X² = 700	∑ XY = 1285

Let the trend line is

$$Y_t = a + bX \dots\dots\dots (1)$$

Subject to the given normal equation

$$\sum Y = Na + b \sum X$$

$$\sum XY = a \sum X + b \sum X^2$$

Subjected the calculated values above is

$$9.3 = 7a + 0.b \dots\dots\dots (2)$$

$$1285 = 0.a + 700 b \dots\dots\dots (3)$$

From eq (2), we get

$$903 = 7a$$

$$a = \frac{903}{7}$$

$$a = 129$$

from eq. (3), we get

$$1285 = 700b$$

$$b = \frac{1285}{700}$$

$$b = 1.83$$

Substitute the value of a and b in eq (1)

$$Y_t = 129 + 1.83x$$

Therefore the equation of the straight line trend is

$$Y_t = 129 + 1.83X$$

Hence, the trend value for different years will be as under:

For 1980 when $X = -15$; $Y_{1980} = 129 + 1.83 (-15) = 101.55$

For 1985 when $X = -10$; $Y_{1985} = 129 + 1.83(-10) = 147.3$

For 1990 when $X = -5$; $Y_{1990} = 129 + 1.83 (-5) = 119.85$

For 1995 when $X = 0$; $Y_{1995} = 129 + 1.83 (0) = 130.83$

For 2000 when $X = 5$; $Y_{2000} = 129 + 1.83 (5) = 138.15$

For 2005 when $X = 10$; $Y_{2005} = 129 + 1.83 (10) = 147.3$

For 2010 when $X = 15$; $Y_{2010} = 129 + 1.83 (15) = 156.45$

Trend value for 2050

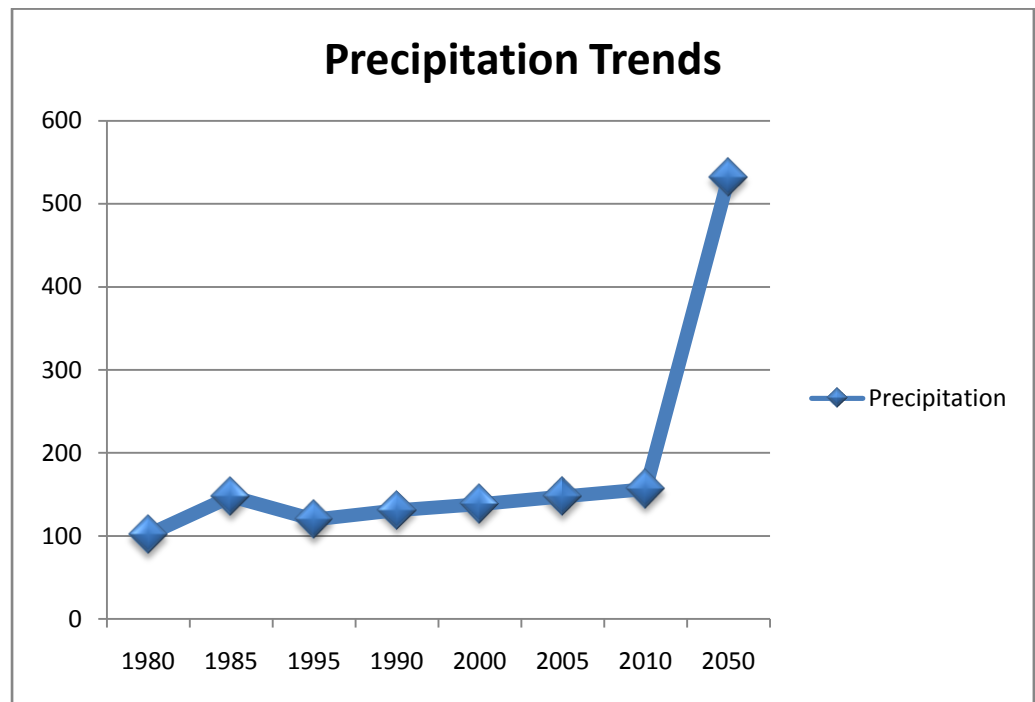
Since the origin is 1995, the value X for the year 2050 will be 220

Therefore, $Y_{2050} = 129 + 1.83 (220)$

$$Y_{2050} = 531.6$$

The trend of precipitation could be 531.6(MM) in 2050.

Fig. 5.3: Trend Line of Precipitation



Such drastic changes in precipitation are the clear indicators that symptoms of climatic changes are prevailing over the territory. The prediction done by various models have also warned about the changes in climate in the Republic of Turkmenistan. The increasing temperatures and the decreasing precipitation is the matter of concern for the territory. So the need of the hour is that there must be curb on the carbon emission and other green house gases, so that the territory of Turkmenistan will be saved from the ill effects of climate change.

Seasonal variation:

Seasonal variation here refers to the changes in temperature and precipitation regimes throughout the year. In general the high temperatures and low precipitation is recorded during summer season i.e. from May-October and the high precipitation is recorded in the winter months i.e. from November to April. The overall climatic/weather scenario of Turkmenistan in terms of temperature, precipitation, humidity, sunlight hours for the year are as follows:

1. The average temperature in Turkmenistan is 16.3⁰C or 61⁰F.
2. The average temperature range is 29⁰C.
3. The highest monthly average high temperature is 36⁰C in July.
4. The least monthly average low temperature is -4⁰C in January.
5. Turkmenistan's climate receives an average of 210mm (8.3in) of rainfall per year or 18mm (0.7in) per month.
6. On an average there are 69 days per year with more than 0.1mm of rainfall (precipitation) or 5.8 days with a quantity of rain, sleet, snow etc per month.
7. The driest weather is in August when an average of 1mm of rainfall (precipitation) occurs across a 1 day.
8. The wettest weather is in March with an average of 44mm (1.7in) of rainfall (precipitation) occurs across 10 days.
9. The average annual relative humidity is 53.8% and the average monthly relative humidity ranges from 32% in July and August to 78% in January.
10. Average sunlight hours in Turkmenistan range between 3.6 hours per day in January and December and 11.5 hours per day in July.
11. There is an average of 2712 hours of sunlight per year with an average of 7.4 hours of sunlight per day.
12. In Turkmenistan, 6 locations are cooler, 6 are warmer, 12 locations are drier and 0 locations are wetter.

Table:5.3 Weather Averages (Turkmenistan)

Month	Average Min. Temp °C	Average Max. Temp. °C	Average Temp. °C	Average Precipitation (mm)	Wet days >0.1 mm	Average Sunlight Hours/day	Relative Humidity %	Average wind speed (Beaufort)	Average No. of days with Frost
January	-4	03	02	22	10	3.6	78	02	Nil
February	-1	08	05	21	09	4.3	71	02	-
March	04	13	09	44	10	4.8	70	02	-
April	09	21	16	38	09	6.5	57	02	-
May	16	23	23	28	07	9.3	45	02	-
June	19	33	29	06	02	10.9	34	02	-
July	22	36	34	02	01	11.5	32	02	-
August	19	35	29	01	01	11.4	32	02	-
September	14	30	24	03	01	9.8	37	02	-
October	08	22	16	11	04	7.9	48	02	-
November	03	14	08	15	06	5.3	65	02	-
December	0	08	03	19	09	3.6	77	02	-

Source: www.climatete.p.info/graph/Ashgabat/Turkmenistan



CHAPTER NO –6

*IMPACT ANALYSIS
AND
CLIMATIC
REGIONALIZATION*

IMPACT ANALYSIS:

Climate change has many long term impacts on every sphere of earth like land, water and air. The changes in one sphere cause changes in another, the table shows potential climate change effects on various ecosystems of the earth's surface.

Table 6.1 Potential Climate Change Effects on various Systems.

System	Potential Effect
Forests and terrestrial vegetation	Migration of vegetation, reduction in inhabited range; altered ecosystem composition.
Species diversity	Loss of diversity; migration of species; invasion of new species.
Coastal wetlands	Inundation of wetlands; migration of wetlands.
Aquatic Ecosystem	Loss of habitat; migration to new habitats; invasion of new species.
Coastal resources	Inundation of coastal development; increased risk of flooding.
Water resources	Changes in supplies; changes in droughts and floods; changes in water quality and hydropower production.
Agriculture	Changes in crop yield; shifts in relative productivity and production.
Human health	Shifts in range of infectious diseases; changes in heat-stress and cold-weather afflictions.
Energy	Increase in cooling demand; decrease in heating demand; changes in hydropower output.
Transportation	Fewer disruptions of winter transportation; increased risk for summer inland navigation risks to coastal roads.

Source:- Office of Technology Assessment, U.S. Congress.

The temperature intensity along with decreased precipitation has put serious effects on the land of Turkmenistan. Turkmenistan being the land with continental climate, the arid conditions ignite the process of land degradation and desertification. The winds and storms occurring over the land of Turkmenistan along with high temperatures and arid conditions, spars

vegetation makes the land surface more susceptible to land degradation and desertification. About 80% of the territory is occupied by Karakum desert characterized by long duration of high intensity solar radiations. The annual sum of atmospheric precipitation fluctuates in the Karakum desert from 24-568mm. The high aridity of climate, mobility of soil substrate, thin vegetative cover support the deflation process characterized by sand drifting and dust storms. Dust storms are observed round the year over the territory of Turkmenistan with highest occurrence in spring and summer.

An important factor underlying the development of desertification is the dust content of the atmosphere. The institute of the desert, flora and fauna of Turkmenistan has compiled a map based on the following classifications of the deserts: 1. Degradation of the vegetative cover. 2. Deflation in sand deserts. 3. Water erosion of hill sides. 4. Salinization of irrigated lands. 5. Salinization of soil caused by the lowering of Aral sea level. 6. Technological desertification. 7. Swamping of pastures in the zones of discharge of collector and drainage water. Desertification has also affected the Caspian Sea region because of the aridity due to lack of rainfall and extensive summer evaporation. The table 6.2 below gives the detail of incidence of land degradation and desertification over the territory of Turkmenistan. The regions adjoin to the river valleys and foot hills are subjected to the increased human activity. From the table it becomes clear that the greatest area is of degraded lands in Turkmenistan is due to the degradation of vegetative cover. In remote areas the human interference is low hence the degradation of land in such areas is mainly controlled by natural processes. More than 80% of the gullies on the territory of Turkmenistan are found in the foot hills and mountain of Kopetdag, Kugitang, greater and lesser Balkhan and in the plateaus of Badkhyz and Karabil. Only in the piedmont part of the Kopetdag and greater Balkhan there are about 120 gullies with a total length of 85km within the radius of one kilometer. During storms the takyr with slope more than 2^0 and the hills are subjected to small groove erosion.

The human impacts on the desert environment of Turkmenistan have sharply increased by exploitation of oil and gas. Hence risk of desertification has also increased. By this activity plant cover is destroyed and the new tracts of moving sands appear which lead to desertification. In Turkmenistan widespread erosion takes place in the hilly region because of sloppy tracks and scarce shrub and tree vegetation. While as in arid parts wind plays a significant role in the process of desertification. The man's interference further intensifies the process. The Turkmenistan has a total sand cover of 300,000sq.kms including loamy sands and over 40% of the territory is under the cover of weathered sands.

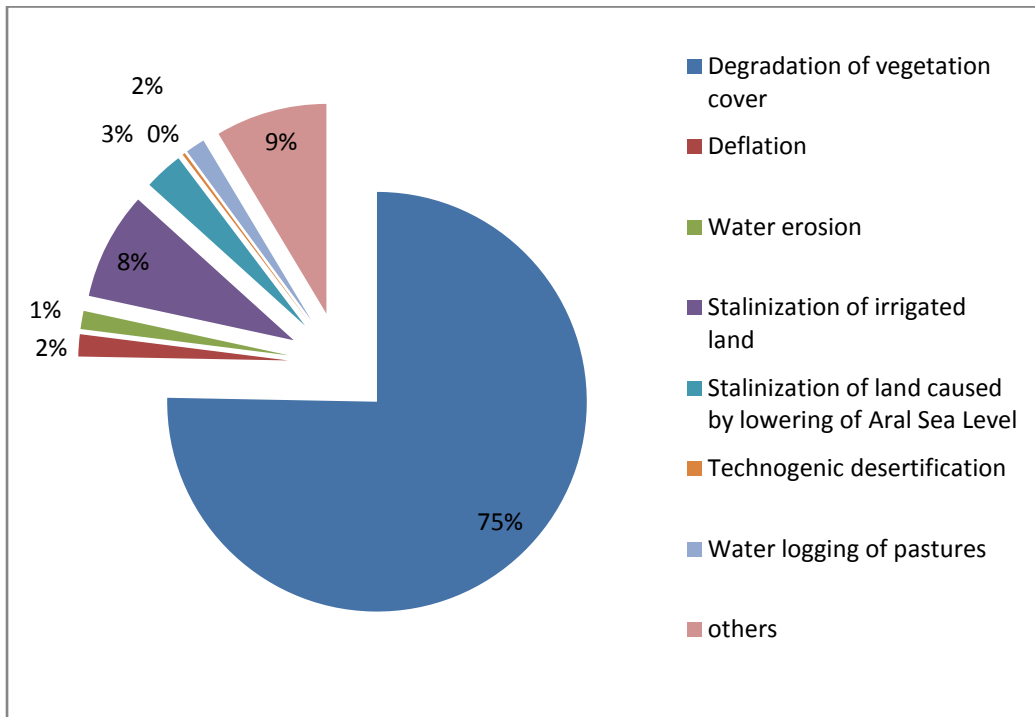
Desertification process is negative in nature hence destroys the vegetative cover, agriculture production and productivity, leads to erosion, salinization and overall it leads to economic loss.

Table 6.2 Incidence of Land Degradation in Turkmenistan. By type and intensity (%age)

Types of degradation	Class of degradation			
	Slight %age	Moderate	Severe	Total
Degradation of vegetation cover	66.2	10.0	0.1	75.3
Deflation	0.5	0.4	0.8	1.7
Water erosion	1.4	-	-	1.4
Salinization of irrigated land	1.3	5.2	1.8	8.3
Salinization of land caused by lowering of Aral Sea Level	-	-	3.0	3.0
Technogenic desertification	-	0.2	-	0.2
Water logging of pastures	-	1.1	0.4	1.5
Total	76.0	17.3	6.7	100%

Source: Babava,A.G."Problems of Arid Land Development",1996,p.227

Fig 6.1: Incidence of land Degradation in Turkmenistan. By type and intensity (%age)



The possible consequences of desertification may include loss of biodiversity, genopool loss of plants and animals and decrease of living standard of people.

In Turkmenistan 30,000 hectares of rangelands fully loss their productivity annually. The mean productivity of range lands is 0.108MT per hectare. So the total loss of forage is 3240.0MT per year. By mean annual rate of forage 0.81 totals 4,000 heads. According to Standard rangeland management system used in Turkmenistan 4,000 heads of sheep could produce 31,860 kgs of meat, 13004 kgs of wool and 1344 Karakul skins. So in terms of money that totals 1606 thousand US dollars(\$)

Desertification puts a direct impact on the productivity of crop because of land losses, fertility due to salinization and erosional processes. The main agriculture crop of Turkmenistan is cotton which has been affected by the degradation process.

The table 4.6: shows the economic loss due to decrease of cotton yield on irrigated farmlands of Turkmenistan in 1993, US\$.

Table 6.3: Desertification impacts on productivity in Turkmenistan

Desertification type	Productivity (%age)	
	Cotton	Pastures & Forests
Slight	15%	25%
Moderate	15-40%	25-50%
High	Above 40%	Above 50%

Source: *Computed by author from Data of Desert Research institute Turkmenistan, 2010.*

Water scarcity:

Water being one of the important natural resource plays a significant part in the development of a country. Agriculture is wholly and solely dependent on this natural resource. One can't imagine the agriculture without the significant source of water. The production and productivity of the crops is totally dependent on the availability of water.

But the main source of the water is the precipitation. As we know that the climate change and the increase in temperatures lead to the dryness of water bodies which later on causes serious effects on the other sectors of economy especially agriculture and hydropower generation.

About 80% of the territory of Turkmenistan lacks a constant source of surface water flow. Freshwater sources are scant in Turkmenistan the intensity and flow of the mountain streams of the Republic of Turkmenistan become weaker and disappear upon reaching the arid sands and parched clay (dry clay) of the Karakum. Most of the water resources especially rivers originate in other neighboring Republics of the country¹²¹.

¹²¹ Babaev A. and M. Kolodin., *The use of the local water resources of Turkmenistan*. Problems of Desert Development, 2: p 3-8.

Aridification of climate is an observed trend of climate change in Turkmenistan, posing serious threats to water availability and land productivity. Climatic observations have shown that the air temperature is steadily increasing in Turkmenistan while as precipitation has shown decreasing trend which have in turn increased the frequency of droughts and dry spells.

About 30% of glaciers feeding the waters of Turkmenistan have already been lost during the past century as a result of global warming¹²². This is alarming for a country whose water run-off is fully dependent on glaciers and precipitation contributes to only 1%. Tran's boundary river Amu Darya is main source of irrigation for Turkmenistan. About 92% of all surface waters available in the country (2% commercial and 6% industry). The situation has become critical because of the anticipated climate change which has resulted in reduction of average runoff by 10%, but during the vegetation period it reaches even up to 30-40%. 15% of reduction in Amu Darya flow by 2030 will have dramatic impacts on agriculture¹²³. Despite this inherent water scarcity. Turkmenistan has among the highest water consumption per capita in the world¹²⁴. Indeed some 28% of Turkmen are without access to potable water. Climate variability and change is likely to exacerbate the already existing gap between supply and demand¹²⁵.

The analysis of influencing of monthly average temperatures and calculated sums of precipitation has shown variations in Turkmenistan river resources. Regression equation of dependence of average annual flow of the Tedzhen river and sums of annual precipitation has been calculated. The estimated annual consumption of Tedzhen river made up 21.14m³/s. The precipitation decrease will decrease the water resources of the three rivers Tedzhen, Atrek and Murgab by 36%, 51% and 17% respectively. In the

¹²² The First National Communication to UNFCCC Turkmenistan 1998.

¹²³ The GFDL Model Scenario (*equilibrium model of Geophysical Fluid dynamic laboratory*) University of Princeton USA.

¹²⁴ Oleg Guchgeldiyev, Manager of the project of the Ministry of Nature Protection of Turkmenistan entitled "*Conservation and sustainable use of globally significant Biological Diversity in Hazar State Reserve on the Caspian Sea Coast,*" 16 Oct. 2009.

¹²⁵ Ibid.

longer perspective the amount of water resources can be decreased by 252 million cubic meters. So from above it can be inferred that climate change is posing severe effects on the water resources and the situation will become more critical in near future and can render the country waterless.

The predicted climate change impacts were prepared by the intergovernmental panel on climate change (IPCC) from general atmospheric and ocean circulation models.

The various models include:

1. GISS Model: equilibrium Model of Goddard institute of space studies USA.
2. CCC Model: Equilibrium model of the Canadian climate center.
3. UK 89 Model: Equilibrium model of the United Kingdom's meteorological Agency.
4. GFDL Model: Equilibrium model of Geophysical fluid dynamics laboratory, University of Princeton, USA.
5. GFDL – T Model – Non – equilibrium Model of Geophysical Fluid Dynamics Laboratory, University of Princeton, USA.

Table 6.4: Change of Average Annual Air Temperature (ΔT) and Precipitation (ΔR) in Turkmenistan.

Model	ΔT °C	ΔR %
GISS	4.6	-56
GFDL	4.2	0.0
UK89	5.5	-17
CCC	6.1	-15

Source: IPCC

Based on these models the predicted climate change impacts in the territory of Turkmenistan will be as follows:

An increase in the average annual temperature of between 4.2 and 6.1⁰C by 2050, which will include an increase in the number of extremely hot days (i.e. days over 40⁰C). A reduction in annual average rainfall of between 15% and 56% by 2050.

An increase in average regional evaporation rates of 48% by 2050.

An increase in the frequency and intensity of drought and flood spells.

The maximum warming is observed by CCC Scenario Model while as minimum warming is observed by GFDL model scenario. Majority of the scenarios provide excessive increase of precipitation values. In comparison to the other scenarios, GFDC provides the more realistic picture of precipitation. The doubling of CO₂ concentration in atmosphere will take place by the middle or by the end of next century which can cause the increase in average annual seasonal air temperatures in the territory of Turkmenistan¹²⁶.

Drought:

A drought is an extended period of months or years when a region notes a deficiency in its water supply. This generally occurs when a region receives the consistently below average precipitation. It can have a substantial impact on the ecosystem and the agriculture of the effected region. Although the drought can persist for several years, even a short, intense drought can cause significant damage and harm local economy¹²⁷. Drought is a normal, recurring feature of the climate in most parts of the world. It is among the earliest documented climatic events. Generally, rainfall is related to the amount of water vapor in the atmosphere, combined with upward forcing of the air mass containing that water vapor. If either of these is reduced, the result is drought. This can be triggered by an above average prevalence of high pressure system, winds carrying continental rather than oceanic air masses (i.e. reduced water content) and ridges of high pressure areas form

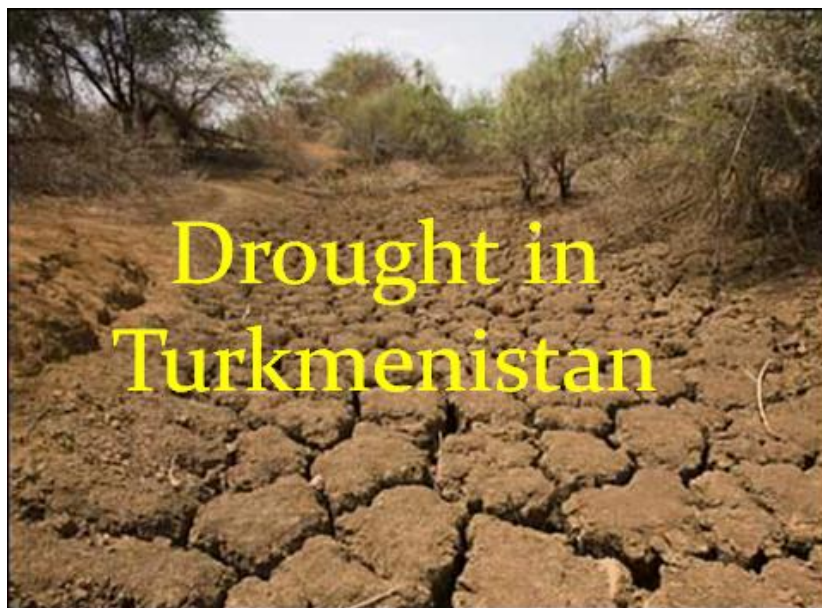
¹²⁶ Turkmenistan *Greenhouse Gases sources and sinks inventory* Ashgabat 1999.

¹²⁷ *National Research Council, Climate and Food*, Washington D.C. National Academy of Science, 1976.

with behaviors which prevent or restrict the developing of thunder storm activity or rainfall over any certain region¹²⁸.

Decreasing precipitation has lead to drought situations in the Republic of Turkmenistan and has created the ecological catastrophes prompting massive shortage, desertification and salinization. By far the drought in various parts of the Karakum desert and the semi arid lands of Turkmenistan. Ecological damage was caused by drought in the Caspian sea area by the decreasing level of Caspian water and Aral sea. The Aral sea catchment areas have received a very less amount of precipitation due to intensive climatic conditions. The high temperatures of the south-east region of Karakum have resulted in the decrease of water level in the Amu Darya and other tributaries. The Republic of Turkmenistan have faced many minor droughts from time to time but the drought of 2000-01 and 2008-2009 have put worst effects on agriculture and pasture lands. The range lands in Turkmenistan lost much of their vegetative cover and the grazing problems for livestock are inevitable. Many pastures have lost their grazing potential and the fodder productivity got decreased.

Fig.6.2 Image of Drought in Turkmenistan



¹²⁸ Cole, Franklyn W., *Introduction to Metrology* (3rd edu.) New York: John Willey & Sons Inc. 1980.

The drought of 2000-01 and 2008-09 reduced the agricultural productivity of both major crops cotton and wheat. In 2008 farmers managed to water their crops only twice instead of regular practice of 4 times due to low levels of water across irrigation parameters, largely as a result of drought. The official data of Turkmenistan maintain that wheat production for 2008/09 will meet the country's needs. Weather data and satellite imagery indicate a reduction of at least 0.4 million tons from the last year's USDA estimate of 1.6 million tons. But due to excessive dryness it is to be noted the official agricultural statistics for Turkmenistan are notoriously unreliable and the USDA wheat production estimates typically run 40-50% lower than official statistics. The data about the reduction or decrease in cotton and wheat production is given in the table (6.5).

Table

Table 6.5 Reduction in Cotton Production (%age)

Year	Expected %age	Actual Production %age	Reduction %age
2000	100%	79%	21%
2001	100%	63%	37%

Source: Department of Agricultural, Turkmenistan

Table 6.6 Turkmenistan Wheat Production (million tones) Reduction.

Year	Production	Change from last year	%age change
2007-08	1.60	-0.40	-2.5%
2008-09	1.20		

Source: USDA (United States Department of Agriculture)

From table 6.5 it is obvious that the wheat production in 2007-08 was 1.6 million tons but due to the 2008-09 drought conditions over the territory

the production came down to 1.20million tons. Hence the change of -0.40 tons was recorded or in terms of percentage it is -2.5%.

Accordingly the reduction in cotton was recorded in the year 2000. Although the expected production of 100% got decreased to 79% only hence the decrease of 21% was recorded for the year 2000. While the drought of year 2001 intensify its impacts and decreased the cotton percentage by 37%.(Table 6.6)

Thus we can conclude that the drought in Turkmenistan have put its impacts on all ecosystems and agricultural production. Due to the severe hydrological drought water requirement for crops will raise 30-40% due to higher evaporation rates. Unless the efficiency of irrigation system climbs from 57% at present to 75% by 2050. There will be water deficiency of 14km³ in irrigated agriculture. Humidity deficits will also put its impact on pasture land productivity.

Droughts have occurred in all climatic zones of Turkmenistan, however, the characteristics vary from region to region. Drought usually have resulted due to water shortage that have seriously interfered with human activities small water reservoirs have dried up, water flow has decreased in all rivers and the crops have been damaged and production has decreased.

Although drought cannot be reliably predicted but certain precautions can be taken in drought prone areas of Republic. These may include construction of reservoirs to hold water for emergency use. People should be educated about the ill effects of over cropping, overgrazing and deforestation. But despite the water scarcity and chronic deficit the govt. has not taken any incentive measures for efficient management of water but the administration is forcing farmers to plant more crops and use irrigation water excessively which is totally impossible because of water deficiency¹²⁹. So there is a need for revision of 2004 water code of Turkmenistan so that water may be used

¹²⁹ World Bank, *Drought Management and Mitigation Assessment for Central Asia and the Caucasus*, Regional and Country Profile and Strategies 2006.

sustainably and can protect the Republic of Turkmenistan from ill effects of drought.

Soil salinization:

Salinization is the accumulation of soluble salts of sodium, magnesium and calcium in soil to the extent that soil fertility is severely reduced. The process of salinization leads to an excessive increase of water-soluble salts in the soil. The accumulated salts include sodium, potassium, magnesium and calcium chloride, sulphate, carbonate and bicarbonate.¹³⁰ A distinction can be made between primary and secondary salinization processes. Primary salinization involves salt accumulation through natural processes due to a high salt content of a parent material or in groundwater. Secondary salinization is caused by human interventions such as inappropriate irrigation practices e.g, with salt-rich irrigation water and or insufficient drainage. Salinization is also known as alkalization or sodification is often associated with irrigated areas where low rainfall, high evapotranspiration rates or soil textural characteristics impede the washing out of the salts which subsequently build up in the surface layers.¹³¹

Hundreds of thousands of hectares of productive lands are lost annually due to salinization. This triggers the destruction of soil fertility and causes a marked deterioration in food stocks. Social and economic repercussions of soil salinization impact most severely on the populations of arid zone regions.

The Republic of Turkmenistan characterized by high temperatures and low precipitation the evapotranspiration is also high. Mainly the desert areas where evaporation exceeds precipitation. The salts get accumulated into the soil and lead to the problem of salinization which has become a most widespread problem in the territory. Every year hundreds of hectares of land get effected by the salinization. The Caspian Sea Basin has also become the

¹³⁰ Sharma P.D. ,*Ecology and Environment*. Rastogi Publicationns Meerut INDIA 6Th Edition 1991.

¹³¹ Ibid pp67-71

victim of this process. Salt affected soil of Turkmenistan often exhibit a white or grey salt crust on the ground. (photo of salinization).

Fig: 6.3 Image of Salinization



In the Republic of Turkmenistan salt accumulation is caused due to arid climate or due to hydro-geological conditions. But due to the high temperature regime the process gets more intensified. This accumulation of salts, particularly sodium salts is one of the main threats to ecosystems of Turkmenistan. Salt content has disturbed the metabolism, water quality and nutrient uptake of plants and soil biota. Salinization has severely affected the productivity of agriculture¹³². Salinization of the ground gets intensified by the application of chemical fertilizers to farm lands and also by the household and industrial waste. The chemicilization has also diluted the waters of an important Amu Darya. According to the ministry of environment, the river Amu has been listed among the most polluted water bodies of Central Asian Region.

At present about 411,300 hectares of land are potentially prone to water logging and salinization. Salinization of soils in Turkmenistan mainly occurs due to saline surface and the rising temperatures act as catalysts and thus enhance the rate of salinization.

So salinization process in Turkmenistan is caused due to human activities and natural agents. The saline characteristic of the land and the

¹³² UNDP in Turkmenistan on UNDP Website.

technological factors accelerate the rate of salinization. This salinization has put its impact on the fragile ecology of the country and is causing the shortage of food, loss of vegetative cover and pollution of the water bodies. The most hit areas are agriculture and rangelands of the Republic of Turkmenistan because here the problem of water logging and high rate of evaporation accelerate the process of salinization. The immediate task in combating soil salinization is the construction of modern drainage installations. Setting up of network of model farms and the experimental centers for investigating local salinization is the need of the hour. Besides that regional programmes for the study and treatment of salinization should be carried within United Nations Environmental Programme, Food and Agricultural Organization (FAO) and UNESCO.

In Akhal Velayats highest rate of ground water salinity was observed (more than 10g/l) on 37% of its area while as low salinity of ground water in irrigated lands was found in Dashoguz and Lebap Velayats. In 1998 about 95.9% of irrigated lands were affected by secondary salinization. From this 57.2% was moderately salinized and about 11.6% was highly salinized. The heavy salinized area has increased by 225,000 hectares during 1988-1999. The area of non-salinized soils has reduced from 10.5% to only 4.1% of the total arable lands. Soil salinization has effected Balkan and Dashoguz Velayats and the area of slightly salinized soils have decreased by more than 45,000 hectares between 1987 and 1997 (O Hara, et al 1999).

Table 6.7 Percentage of area affected by secondary salinization

Region	Area Affected (% age)
Southern Region	76.6
South-Eastern Region	46.0
North – Eastern Region	51.7
Northern Region	86.6

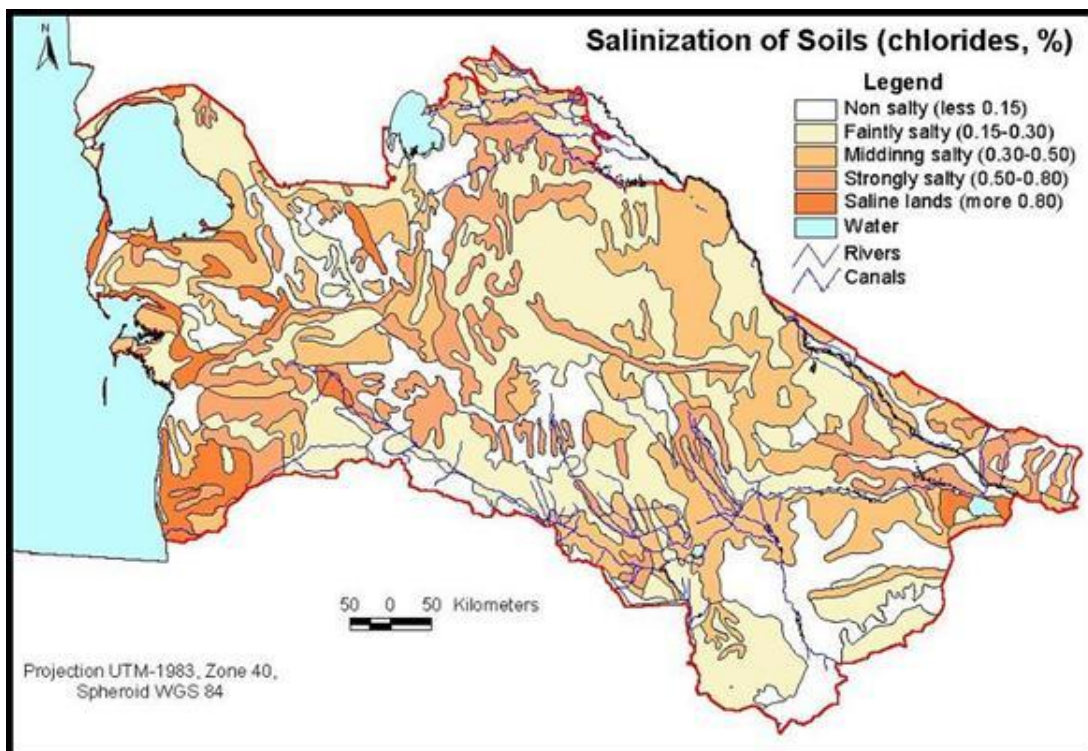
Calculated by Researcher from Nasonov and Ruziev 1998

Table 6.8 Area Affected and Economic Loss Of Salinization

Degree of Soil Salinization	Size of Area (Hectares)	Decrease of cotton yield (%age)	Loss of Raw Cotton Fiber (MT)	Economic loss (US \$)
Slight	166.586	15	49.976	17, 057,8
Moderate	314.407	30	188, 428	64, 316, 4
Severe	76, 503	60	91, 816	31, 339
Total			330, 210	112, 713, 7

Source: Turkmenistan Country Situation Paper

Image 6.4 Salinization Map of Turkmenistan



Source: *Desert Research Institute of Turkmenistan*

Climatic Regionalization

There are several reasons why the study of regionalization appeals to geographers. For one it is related to their interest in describing the world. More importantly it is an extension of their interest in the ways-the physical and ecological elements of the environment are integrated and expressed. In defining any region the geographer examines the features that give the area its unity and that differentiates it from other regions. He may also look at a region as a whole. That is, he may analyze a region as a total environment in which the Earth's systems are interacting. Thus through regionalization, the study of natural, cultural or economic regions; the geographer is able to examine the interaction of various functioning systems as they work together in a real life situation¹³³. It is this total view of a working, integrated regions that help us to distinguish one region from another. For instance to distinguish between the various micro ecological region of desert is based on the description of the interrelationship between climate, vegetation, soils, land forms and even animals found in that region. So, too we distinguish the humid continental climate with a long hot summer(Dfa) from that a warm or moderate summer (Dfb) not only on the basis of climatic parameters but also through differences expressed in associated natural elements of environment (especially vegetation and soils)¹³⁴.

A particular region is a byproduct of particular eco-habitat. It is basically an environmental spectrum which shapes the ecological variables of any region. Ecology plays an important role in agriculture, grasslands, forests, wildlife, and water. Besides those international problem of environmental pollution also needs ecological assistance. Ecological balances prevailing at various stages in any ecological region are governed by the natural climate

¹³³ Minshull, Roger . ,*Regional Geography:Theory and Practice* London, Hutchison University Library,1967.

¹³⁴ Whittaker , R.H . , *Communities and Ecosystem*. 2nd edition, Macmillan N > York 1975.

prevailing in those particular regions¹³⁵. All related components of climatic factors including temperature, precipitation; sunlight, moisture, etc affect the various aspects such as occurrence, distribution, productivity and the growth of flora and fauna. Besides that the range of climatic factors encompasses wider centripetal and centrifugal forces on the ecological habitats and biodiversity of a particular region¹³⁶. An ecological region includes the whole biotic community in a given area including its abiotic environment. It thus includes the physical and chemical nature of soil water and gases as well as all the organisms. Eco-habitat or ecosystem ecology emphasizes the movement of energy and nutrients hence playing a major role in determining the energy transfer from one community to another. This flow of energy is again governed by the physical or environment conditions prevailing in an ecological region. These climatic patterns emphasize that close relationship between climate, weather elements viz. temperature, moisture, precipitation, winds, etc and the climatic control.

The order and pattern of climatic regions or ecological zones in Turkmenistan are based first on the patterns produced by the sun in relation to surface of the region. The exception to those patterns are the results of uneven distribution and irregular shapes and sizes of land forms, water bodies, winds, and of interruption by mountain barriers¹³⁷. The overall climate of Turkmenistan is characterized by hot summers and severe cold winters, thus continental in nature. The mountain barriers lie along its borders mainly in South which result in limited rainfall. 96% of Turkmenistan is characterized as arid land¹³⁸. The climate is characterized by long duration of solar radiation. The annual sum of atmospheric precipitation fluctuates in the Karakum desert from 24-568mm. the annual precipitation varies from 100mm in Kara-Bogaz-Gol Bay and north-east of Turkmenistan to 400mm in the Koine-Kesir in the Kopetdag Mountain. Rainfall occurs during the winter

¹³⁵ Odum E.p . , Fundamentals of Ecology, 3rd edition. , W.B Saunders and Co. Philadelphia, 1971.

¹³⁶ Ruseell, E.W. Soil Conditions and Plant Growth. 10th edition Longman, London 1973.

¹³⁷ Turkmenistan country situation paper, Prepared by DC, Dr. M. Nepesov. And UNDP in Turkmenistan on the UNDP website.

¹³⁸ Academy of Sciences of the Turkmen SSR, Institute of Deserts, 1987.

season, mainly in October and April. The amount of precipitation in the cold period of the year is two or three times greater than in the warm one (Orlovsky, 1994)¹³⁹.

On the basis of climatic variation especially temperature and precipitation trend the territory of Turkmenistan can broadly be divided into three climatic zones which has resulted in the varying ecology and biodiversity of the respective regions. So firstly the temperature variation of the three zones is based on the temperature observation made by the weather stations situations in respective regions.

Table 6.9 Monthly Average Temperature and Precipitation Days

Ashgabat

Month	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.	Average
Temp. °C	3.3	5.0	9.4	17.7	23.8	28.8	31.1	30.0	23.3	16.6	9.4	5.5	16.9
Average Rain Days	5	4	6	4	3	1	1	0	1	3	4	3	2.91
Average Snow Days	2	3	0	0	0	0	0	0	0	0	0	1	0.5

Source: Calculated by Researcher from www.climatezone.com/Turkmenistan/Ashabad

Table 6.10 Monthly Average Temperature and Precipitation Days

of Kerki

Month	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.	Average
Temp. °C	4.4	6.1	11.1	19.4	25.0	29.4	30.5	28.8	22.2	16.6	10.0	6.1	17.4
Average Rain Days	4	4	5	3	1	0	0	0	0	1	3	2	1.91
Average Snow Days	2	1	0	0	0	0	0	0	0	0	0	0	0.25

¹³⁹ Orlovsky N. Climate of Turkmenistan in : Fet V. and Kh. Atamuradov (Eds.).

Source: Calculated by Researcher from

www.climatezone.com/Turkmenistan/Kerki

**Table 6.11 Monthly Average Temperature and Precipitation Days
of Dashkhovuz**

Month	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.	Average
Temp. °C	-2.7	0.0	5.5	16.1	22.2	27.7	28.8	27.2	20.0	12.7	10.5	-0.5	13.9
Average Rain Days	2	1	3	2	3	2	1	0	1	2	3	1	1.75
Average Snow Days	5	2	1	0	0	0	0	0	0	0	0	1	0.75

Source: Calculated by Researcher from

www.climatezone.com/Turkmenistan/Dashkhovuz

**Table 6.12 Monthly Average Temperature and Precipitation Days
of Krasnovodsk**

Month	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.	Average
Temp. °C	2.7	3.8	7.2	14.4	20.0	24.4	27.7	28.3	22.2	15.0	8.8	5.0	14.95
Average Rain Days	3	2	4	2	1	1	0	0	1	3	4	2	1.91
Average Snow Days	0	1	0	0	0	0	0	0	0	0	0	0	0.08

Source: Calculated by Researcher from

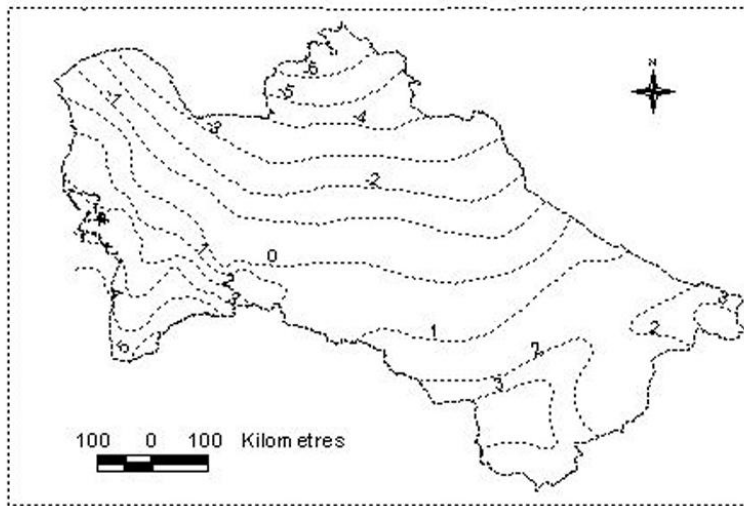
www.climatezone.com/Turkmenistan/Krasnovodsk

Fig: 6.5 Precipitation Map of Turkmenistan

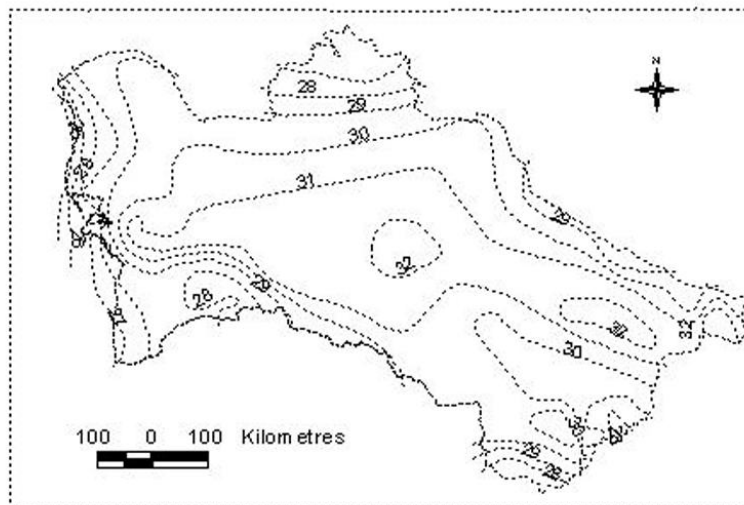


Source: <http://www.climatezone.com/Turkmenistan>

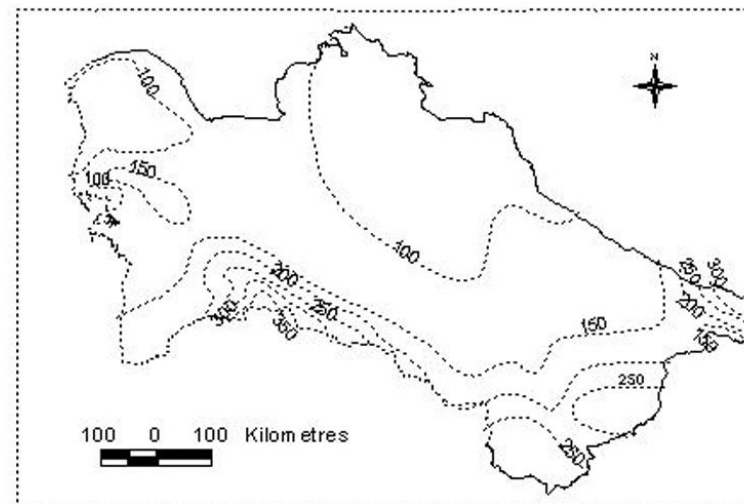
Fig. 6.6: Isotherm Map of Turkmenistan



Average January temperatures (isotherms, degrees Celsius)



Average July temperatures (isotherms, degrees Celsius)



Average annual rainfall, mm

Source: <http://www.climatezone.com/Turkmenistan>

1. South Mountainous Zone:

This zone lies in the southern Turkmenistan and consists of Kopetdag mountains hence represent the mountainous zone of country. The climate of this region is arid sharply and is characterized by mild hot summers and severe cold winters. The relative severity of the winter period with low temperatures and infrequent than and in the region is because of strong Siberian anticyclone hence long winters prevail with stable frost and continuous snow cover. The region receives a good amount of precipitation i.e., above 250mm which includes rain, frost and snow¹⁴⁰.

Soils are mainly of mountainous origin formed by weathering process. Black, grey and mountain soils are found in this region. The soil support the varied vegetation of the region and the vegetation in this region include the Juniper the basic specie. As for the Circassian walnut is concerned it grows mainly in the western Kopetdag and in the valleys of river Sumbar and Arvaz. Pistachio plays an important role in biodiversity conservation and is feed source for many herbivores and predatory animals. The main plant species of this region include Juniperus, Turkomanica, maple Turkmenistan, hawthorn, almond tree, barberry, dog-rose, zizyphus etc¹⁴¹. on the open slopes Juniper and Pistachio trees grow well, black poplar, willow reed and cane are also grown. The fauna or animal diversity includes goats, cheethas, lynx, snow leopards and porcupines etc.

So it is obvious that this region is mountainous and hence the ecological diversity is very rich represented by 1900 species of wild plants.

2. South Eastern Zone:

This zone constitutes the foot hill area of territory. The region is characterized by mild winters with occasional snow cover and frequent transitions from cold weather to positive values of air temperature. Warmer period conditions also vary. The zone is effected by the invasion of cold

¹⁴⁰ Magtymov A., Durdiyev A.M., "Kopetdag Landscapes and their Evaluation. Problems of Desert Development 1999. Pp 80-82.

¹⁴¹ Department of Forests Turkmenistan 2007.

continental air mass relatively warm winters with little snow fall can sometimes become severe and harmful for heat loving plants, although the cold periods last only for several days.

The region receives a precipitation of about 200-250mm annually¹⁴². The soils are acidic, regolith, pedolised, thin and poor in fertility. The vegetation includes willow, birch and dwarf shrubs. Due to infertile soil the rich vegetation is not supported and also the frequent temperature changes put adverse impacts on the vegetation cover of the zone¹⁴³. However, high Mesophile grass species such as *Arunda donax*, *imperata cylindrica* and *Eriaxthus ravennae* comprise complex with hygrophilous biocenosis, tamarix comprises biocenosis of annual plants with peculiar species and vegetation. Jackals, wild boars, various species of birds and the rear pink deer inhabit the region.

This region is also ecologically important as it also represents a huge amount of vegetation types along with wild herbs and valuable plants. The climate regime has framed out this region and is distinguishable from other region by its ecology and biodiversity and hence it is a well developed ecological region of the Republic of Turkmenistan.

Northern zone:

This region stretches from Aral sea including the North-eastern parts of Karakum desert. The region comprises mainly of black sands of Karakum with high temperature and less precipitation characters. Continentality of climate and exceeded evaporation, soil salinization, hot summers, dryness of air are the characteristics of the region. The coldest temperature of Jan varies from -3.2 – 4.8 but can sometimes rise up to 12 – 22° C. About 60-84% of precipitation of its annual is received during winter months. The winters are characterized by instability and variability of weather particularly in northern

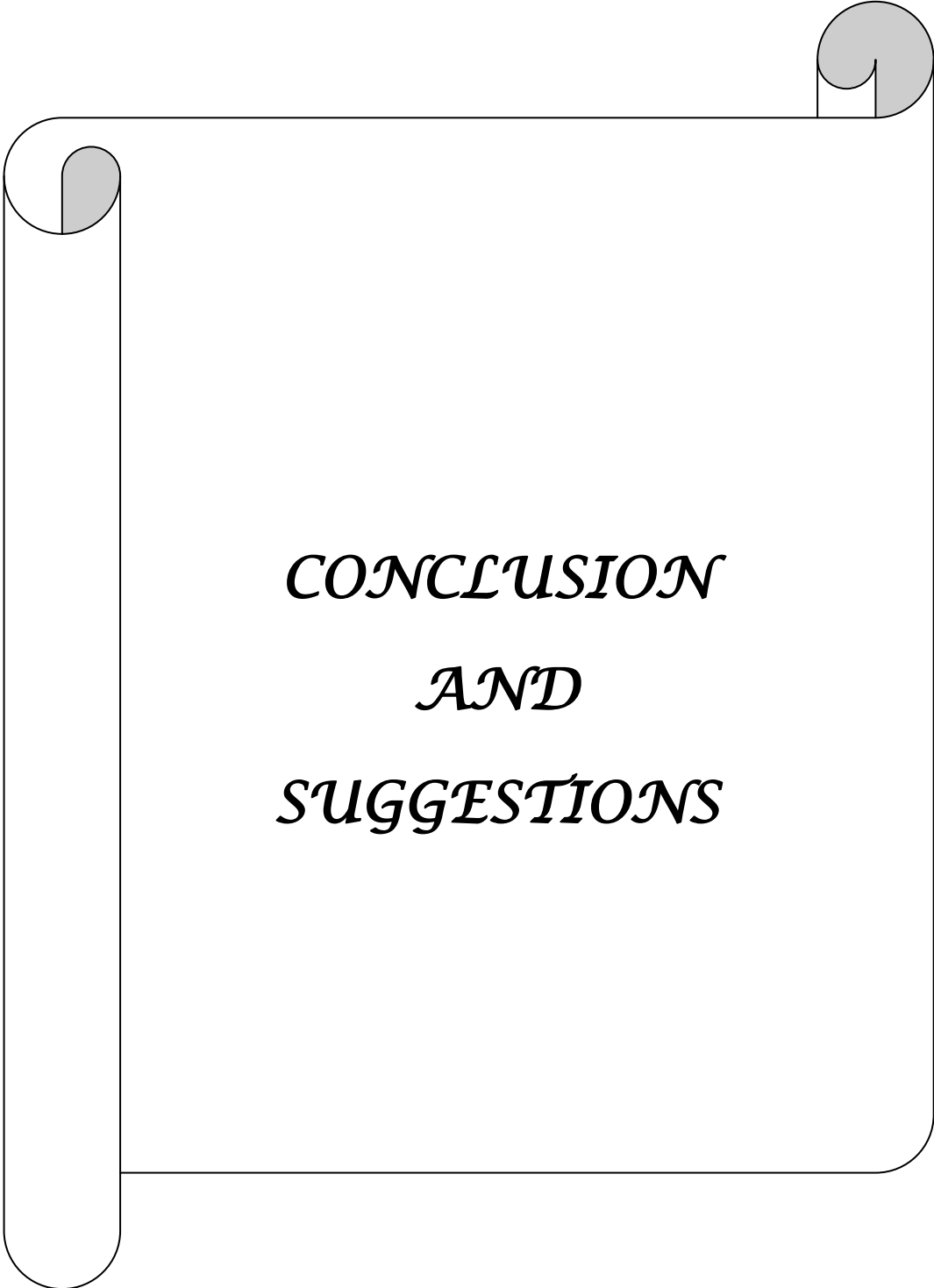
¹⁴² Fedorov U.N., Atamuradov H.I., Ballyer B.B. Report on Environment State of Turkmenistan Oslo UNEP/GRID – Arendal 1998.

¹⁴³ Nurberdiev M., Hurbanmuradov K. "Influence Temperature and Precipitation on Greengrass Productivity of plain Karakum// Problems of desert development 1999.

part around the Aral sea because of Aral sea influences where sub zero and above zero temperatures are frequently shifted. The region receives less than 150mm of precipitation annually¹⁴⁴. Hence the moisture deficiency prevails in the region. The soils are saline especially in the Aral sea basin. The soils are mainly affected and get salinized by high evaporation rate in the region. Vegetation of the region is typical Xerophilous with large endemic diversity of species. The main wood and shrubby species include Saxaul White, Saxaul black, *Salsola richteri*. A significant part of desert vegetation is represented by perennial herbs. The Saxaul family is spread over 688100 hectares including 15000 hectares of young growth, 284100 hectares of middle aged stands and 320700 hectares of ripening stands and 67900 hectares of ripe and overripe ones¹⁴⁵. The forests of this ecological region has a great significance as they supply fodder and grass for livestock rearing. The region is the home of many desert reptiles, climate variation vary from region to region in Turkmenistan which gives a unique status to this region also. The zone which is considerably of desert nature covers the maximum area of the region. Also the rich floral and faunal diversity of this northern region provides a base for its delineation.

¹⁴⁴ Fedorov U. N., Atamuradov H.I., Ballyev B.B Report on Environment State of Turkmenistan Oslo UNEP/GRID – Arendal 1998.

¹⁴⁵ Department of Forests Turkmenistan 2007.



*CONCLUSION
AND
SUGGESTIONS*

CONCLUSION

The assigned work has been carried out in a comparative methodology framework and deals with the nature and magnitude of climatic changes within the Republic of Turkmenistan. The magnitude of climatic change points out trends in various phenomenon of climate and associated causes responsible for such changes. However following main observations have been deduced.

This brief study of the climatic change scenario reveals the fact that climatic change is a natural phenomena which has been taking place right from the evolution of the earth`s surface. Although it has been changing with a slow pace taking centuries, or all of sudden in a jiffy. Climatic change is the major, overriding environmental issue of our time and the single greatest challenge facing environmental regulators. It is a growing crisis with ecological, economic, health and safety, food production, security and other dimensions.

The climatic change is leading to an irreversible change in the climatic systems which has put and is putting adverse effects on the world ecosystems.

The nature and magnitude of climatic change in the Republic of Turkmenistan coincides almost with the world scenario. The desert nature and the location of the country in the non-tropical zone make the territory more vulnerable to the climatic change. The climate is sharply continental with the exceptions of the inshore zone of the Caspian Sea and the mountains.

From the last century in general and from 1980 to present day the variations in the climate scenario and the fluctuations in the weather elements especially heat intensity and moisture deficiency has put the country in the category of climatic change which is a matter of grave concern. It was only because of this that the country signed the United Nations Framework Convention on Climate Change (UNFCCC) on May, 01, 1995. With the aim that the National Communication will provide information regarding the natural conditions of the country, report of Green House Gas (GHG) emission and other related aspects of climatic change.

The increase in the Green House Gas emission has resulted in climatic disturbances over the territory and the symptoms of this change are visible and the potential would have long term risks of ecological, economic and social disturbances. However there exists a considerable uncertainty with regard to ultimate magnitude of change, it's timing and also regional impacts. In addition to this there is a great uncertainty about the changes in climate variability as is evident from the temperature and precipitation trends. The temperatures area showing increasing trends as discussed in chapter 5. (Magnitude of Climatic Change).The precipitation trends are also discussed in the same chapter . The predicted values for the year 2050 are 38.2° C and 531mm for temperature and precipitation respectively.

In general 1° C increase in temperature has been observed during the last three decades with variations from eastern to western parts of the territory. e.g in eastern parts an increase of 0.3° C has been recorded while as western parts have shown an increase of 0.4° C in the temperature regime. The year 1995 with an average temperature of 16.8 °C was the hottest year during the three decades while as 1985 with average temperature of 14.9 °C was recorded as the year of lowest temperature.

From the results of the work done it is now obvious that the quantity of days with higher temperature have increased. Although the trend was almost uniform but fluctuation in the temperature were also recorded for which Siberian anticyclones and changes in Aral Sea are responsible and also the latitudinal extend plays a significant role.

Precipitation formation is a very complex process governed by the changes in temperature, slope and water bodies. Owing to the scenario is also of varied nature winters are most while as summers are extensively dry. Besides that micro regional level variations in the precipitation are also prevalent. In Northern region during winter a stable snow cover is observed in western region maximum precipitation is recorded in the month of March. During the cold period maximum precipitation days are observed on the plains of territory.

Summer precipitation is mainly caused by the cyclonic activity while as west winds moderate the climatic effects of northern location.

Like temperature, precipitation has also shown fluctuations in the Republic of Turkmenistan. During the three decades i.e (1980 – 2010). The lowest precipitation was recorded in the year 2000 while as highest precipitation 170 mm was recorded in the year 1980. The predications done by the various models have also shown decrease in the precipitation trends. While as the analysis of the trend values of the precipitation, the predicted value of precipitation for the year 2050 has been calculated as 531 (mm) which is also confusing and is totally opposite to the model predications.

Climatic change is one of the major threat faced by the present day a mankind. It has long term impacts and adverse affects on the various sphere of life. The changes in one sphere effects the other and a chain of impacts is formed. The climatic change has proved very disastrous for the Republic of Turkmenistan the land which is an important resource has got degraded by the process of desertification which later on has put direct impacts on the fertility of soils and hence loss of crop productivity water scarcity is also a product of this climatic change the decreasing trend Of precipitation has led to the water scarcity in the territory. The water level in the Amu Darya and in its tributaries has decreased during the last three decades. The glaciers in the Tien Shan have recessed which have put a great threat to the water budget of the territory. The agricultural sector is most affected which has resulted in the reduction of food crops because of drought conditions. In year 2000-01 37% reduction in wheat production was recorded. Similarly in year 2008-09 reduction of 0.40 million tons in wheat production was recorded. The intensity of temperatures has resulted in higher rate of evaporation which in turn has resulted in salt accumulation in the soils of territory. Thousands of hectares of productive land have got salinized which have triggered the destruction of soil fertility and have caused shortage of food and fodder stock .Thousands of plant and animal species have become of salinization process. At present 411300 hectares of land are potentially prone to water logging and

salinization. Highest ground water salinity was observed in the Akhal velayat. So it is obvious that the climatic changes have brought ill effects on the land resources of Republic of Turkmenistan. From the problem of desertification to the process of salinization all is the result of climatic change caused due to fluctuations in temperature and precipitation.

The conducted research has relieved many facts about the climatic change scenario in the Republic of Turkmenistan. Firstly the latitudinal extent and location of territory makes it vulnerable to climatic change. Besides that the modification of the atmospheric content by the emission of green house gases especially carbon dioxide and methane has ignited the phenomenon of climatic change in Turkmenistan. That is why temperatures are increasing while as precipitation is decreasing over the territory of Turkmenistan from the last 30 years (1980-2010).The climatic change has put great stress on ecological, economic, social and other sectors. The biodiversity of the territory has been affected severely by the intensity of climatic change. So to overcome this problem there is a need to have the policies and mutual understanding among various stake holders so that mitigation programmes should be launched, which will be a positive step towards sustainable development of the Republic of Turkmenistan.

SUGGESTIONS

The climatic fluctuations in terms of temperature and precipitation are really alarming. The changing trends in climate have resulted in disturbance and various changes in ecological, economic and social systems. So there is a need for making few changes and to favour the climate friendly habit and life styles. Some of the suggestions which will help to mitigate the climate change in the Republic of Turkmenistan are as under.

1. The intensity of climate change varies from region to region in the territory. The topography along with human induced factors have led to the climatic fluctuations at regional level which has in turn resulted in unbalance of climate system .So there is a need for development of climate monitoring systems (CMS) at regional level so that the assessment of fluctuations at micro level should be made and appropriate models should be suggested to overcome or to mitigate the climate change fluctuations.
2. The water scarcity is the major concern in the Republic of Turkmenistan. The decreasing trend of precipitation had put its devastating impacts on the water sources and has intensified the problem of water scarcity. So there is an immediate need for improved water resource management which can be achieved by a number of ways. Renovation of ponds and tanks for ground water recharging would be helpful to some extent. Besides that water shed management is also a technique for this cause. The crucial bio-physical elements of rain water conservation and socio-economic paradigms are a central point for this all encompassing strategy. This can be achieved by water spreading technique of vegetative barriers, digging trenches, recharging pits, water spreaders, countour field bunding, land shapping,terracing, etc.in the micro catchment of Amu and Syr rivers along with their tributaries. The seepage from the canals should be controlled by latest techniques.
3. The Republic of Turkmenistan has a good potential for renewable energy sources especially in terms of solar and wind energy. The Karakum desert should be utilized for generation of solar power while as other parts of the

country which are prone to winds due to air pressure differences should also act as substitute to produce wind energy. Hence the installation of solar energy trapping instruments and the assessment of wind and solar energy over the territory is the need of the hour. So that this eco-friendly use of energy will be helpful to cope up with the changes caused by climatic change intensities.

4. One of the major factors of climate change in Turkmenistan is the green house gas emission. The emission has shown and is showing an increasing trend so there is a need for reduction of these gases which can be achieved encouraging energy efficient and other climate friendly trends in both supply and consumption of energy. Key consumers of energy include industries, homes, offices, vehicles and farms efficiently can be improved in large part by providing an appropriate economics and regulatory framework for consumers and investors. This framework will promote cost effective actions. The best current and future technologies and no regrets solution that make economic and environmental sense irrespective of climate change. Taxes tradable emission permits, information programmes, voluntary programmes and a phase-out of counterproductive subsidies can play a role in reduction of green house gas emission in the country as a whole.
5. Forest cover of the country can play a significant role in the reduction of carbon emission, as they act as carbon absorbing sinks. Sustainable forest management can also generate forest biomass as a renewable resource. Some of the biomass can be substituted for fossil fuels. This approach has a greater long term potential for reducing net emission than does growing trees to store carbon. So establishing forests on degraded and non forested lands adds to the amount of carbon stored in trees and soils .In addition to this the use of sustainably grown fuel wood in place of coal, oil and hydrocarbons can help to preserve the hydrocarbon reservoir left unneeded underground.

6. Nitrogen oxide and methane emission from the agriculture activities is also another serious problem in the Republic of Turkmenistan. Agricultural soils could be made into a net sink through improved management practices designed to increase agricultural productivity. In the semiarid regions of Turkmenistan the need for summer fallow could be reduced through better water management or by introducing perennial forage crops and drought tolerant species. Nitrogen oxide emission from agriculture could be minimized with new fertilizers and practices. For example fertilizers interaction with local soils and climatic conditions can also be influenced by optimizing tillage, irrigation and drainage system. Methane emission from live stock could be cut with new feed mixtures and methane from cotton cultivation can be reduced significantly through changes in irrigation and fertilizer use.
7. The physical attributes and structures of cities cause heat generation in several ways in the territory of Turkmenistan. Clearing land for development decreases the amount of natural land cover that absorbs heat. A deficiency of trees in and around urban areas of Turkmenistan has generated a greater area of un-shaded surface which absorbs more radiant heat. Built environment has contributed to increased heat temperatures and insufficient energy consumption. Keeping in view the above facts there is a need for development of greenery in the cities and also the creation of green belts around cities will have better results in mitigating the climate change in the barren Republic of Turkmenistan.
8. In the territory of Turkmenistan man's role in bringing the climatic change is evident. People are utilizing the land and are exploiting natural resources ruthlessly. The ill water management and agricultural practices have intensified the process of salinization. The use of hydrocarbons for domestic purposes along with other fossil fuels have ignited the climatic change phenomena by disturbing regional climate systems. So to overcome this public should be made aware by organizing the seminars. Annual Earth Day events will publicize the climate protection plans. The

sustainable life style campaigns will maintain neighbourhood “Eco-Teams”. Members of Eco-Teams try to reduce their neighbourhood energy consumption of water and energy, minimize waste and promote use of alternative transportation. The public must be informed about the facts that climate change will put great effects on their agriculture, economy and health. So that they will reduce the emission of green house gases at their own level which will yield better results in a long run.

9. The rising temperatures and decreasing precipitation in the territory of Turkmenistan has put a great stress on the Caspian and Aral Sea basins. The salinization process has intensified in the coastal areas of these water bodies. So there is a need for assessment of vulnerability of the Aral Sea basin water resources taking into account the agriculture and water economy development. Besides that there is a need for coastal zone vulnerability assessment which are result of fluctuations in the Caspian Sea level. Salinization in the Aral Sea basin can be overcome by a better water management in the region. e.g concrete water canals for irrigation purposes can prove fruitful in this aspect. Besides filling of land which is vulnerable to water logging will help in controlling the effects to some extent. There is a need to reduce anthropogenic pressure on the sea basins of republic of Turkmenistan.

To infer it is now obvious that magnitude of climatic change is really furious in the republic of Turkmenistan. Hence to mitigate and to lessen the impacts and vulnerability of climatic change, there is a need for redressal in the various systems. The development of climate monitoring systems at regional level along with water resource management, usage of renewable energy, reduction in green house gas emissions, development of greenery and gardening, creation of green belts, organizing of awareness camps regarding climate change impacts, Caspian and Aral Sea fluctuation monitoring system is the need of the hour so that the territory of Turkmenistan will be saved from devastating hazards caused by climatic change.



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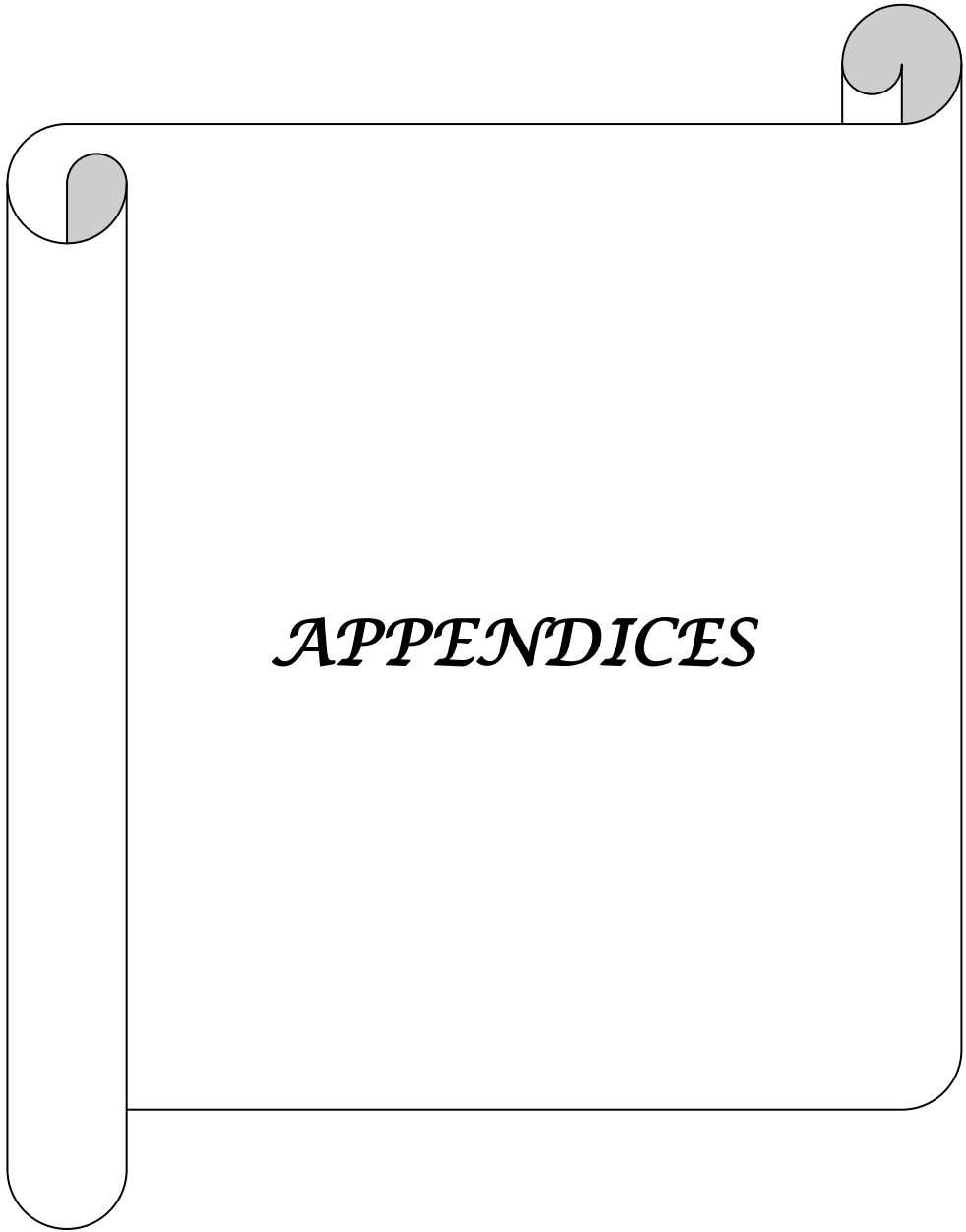
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APPENDICES

ANNEXURE

**Ashgabat Turkmenistan Latitude 37 to 58 North, Longitude 58 to 20
East, elevation 268 meters.**

Month	Temperature Degree Cel. Min.	Temperature Degree Cel. Max.	Temperature Degree Cel. Average	Precipitation (mm)
January	-2	7.5	2.7	21.1
February	0	9.0	4.5	26.1
March	5	15.1	10.0	39.0
April	10.3	24.6	17.4	44.2
May	15.2	29.9	22.5	26.3
June	20.0	35.1	27.5	4.0
July	22.2	38.2	30.2	3.6
August	20.1	37.1	28.5	1.1
September	15.1	31.0	23.0	4.0
October	9.3	23.6	16.4	14.0
November	4.6	16.1	10.3	19.8
December	0.1	10.0	5.0	20.2

Source:- Computed from the data of www.allmetsat.com

**Keneurgench, Turkmenistan Latitude 42 – 18 N, Longitude 59 – 08 E,
elevation 71 meters.**

Month	Temperature Degree Cel. Min.	Temperature Degree Cel. Max.	Temperature Degree Cel. Average	Precipitation (mm)
January	-7.7	0	-3.8	9.1
February	-6.1	2.5	-1.8	8.0
March	-0.2	10.1	4.9	16.8
April	7.2	20.1	13.6	19.0
May	14.8	29.0	21.9	14.0
June	18.8	34.1	26.4	4.2
July	20.2	35.0	27.6	3.0
August	18.1	32.5	25.3	3.0
September	11.2	26.2	18.7	3.0
October	4.8	18.2	11.5	9.0
November	0.0	10.1	5.0	10.0
December	4.9	4.0	4.4	11.8

Source:- Computed from the data of www.allmetsat.com

**Bayram – Ali, Turkmenistan, Latitude 37 – 36 N, Longitude 62 – 11 E,
Elevation 240 m**

Month	Temperature Degree Cel. Min.	Temperature Degree Cel. Max.	Temperature Degree Cel. Average	Precipitation (mm)
January	-2.5	8.8	3.1	29.0
February	-1.0	10.1	4.5	21.1
March	5.0	16.3	10.6	34.3
April	11.2	25.0	18.1	26.7
May	16.1	31.1	23.6	14.0
June	20.0	36.0	28.0	1.0
July	22.5	37.9	30.2	0.00
August	19.8	35.0	27.4	0.00
September	14.2	30.9	22.5	1.0
October	8.1	24.7	16.4	9.1
November	3.8	17.3	10.5	14.2
December	0.1	10.2	5.1	23.9

Source:- Computed from the data of www.allmetsat.com

**Saragt, Turkmenistan, Latitude 36 – 32 N, Longitude 61 – 13 E,
Elevation 275 Meters.**

Month	Temperature Degree Cel. Min.	Temperature Degree Cel. Max.	Temperature Degree Cel. Average	Precipitation (mm)
January	-1.1	10	4.4	31.2
February	0.0	11.1	5.5	31.8
March	5	16.2	10.6	40.0
April	11.1	25	18.0	34.9
May	15.9	30.8	23.3	14.1
June	20.0	36.1	28.0	0.02
July	22.2	38.2	30.2	0.0
August	20.0	35.4	27.7	0.0
September	15.0	31.6	23.3	0.1
October	9.8	25.0	17.4	5.8
November	4.9	18.8	11.8	11.0
December	0.2	11.6	5.9	25.7

Source:- Computed from the data of www.allmetsat.com

**Repatek, Turkmenistan Latitude 38 – 34 N, Longitude 63 – 11 E,
elevation 185 m.**

Month	Temperature Degree Cel. Min.	Temperature Degree Cel. Max.	Temperature Degree Cel. Average	Precipitation (mm)
January	-4.0	7.0	1.5	19.0
February	-1.1	10.0	4.4	14.0
March	4.0	16.5	10.2	26.5
April	10.7	25.0	17.8	20.0
May	14.9	31.6	23.2	9.1
June	17.5	37.1	27.3	1.3
July	20.7	39.8	30.2	0.01
August	18.7	38.1	28.4	0.01
September	11.2	31.6	21.4	0.6
October	5.0	24.0	14.5	5.0
November	1.6	16.1	8.8	10.0
December	-1	10.0	4.5	16.3

Source:- Computed from the data of www.allmetsat.com

Serdar, Turkmenistan Latitude 38 – 59 N, Longitude 56 – 17 E.

Month	Temperature Degree Cel. Min.	Temperature Degree Cel. Max.	Temperature Degree Cel. Average	Precipitation (mm)
January	-3.0	5.0	1.0	20.5
February	1.1	7.1	4.1	20.5
March	3.9	14.9	9.4	24.0
April	10.0	22.8	16.4	25.0
May	16.1	30.0	23.0	21.6
June	21.0	35.1	28.0	8.1
July	24.9	38.0	31.4	10.0
August	23.7	37.8	30.7	3.2
September	19.2	30.6	23.4	5.3
October	9.4	21.9	15.6	14.0
November	4.7	14.9	9.8	17.5
December	0.0	7.5	3.7	24.0

Source:- Computed from the data of www.allmetsat.com

**Turkmenabat, Turkmenistan, Latitude 39 – 05 N, Longitude 63 – 36 E,
Elevation 190 m.**

Month	Temperature Degree Cel. Min.	Temperature Degree Cel. Max.	Temperature Degree Cel. Average	Precipitation (mm)
January	-4	6.1	1.0	17.8
February	-4.9	9.8	2.4	14.1
March	4.2	15.7	9.9	25.0
April	6.1	24.9	15.5	23.1
May	15.1	30.0	22.5	8.7
June	19.0	35.0	27.0	1.2
July	14.9	36.2	25.5	0.01
August	18.2	34.9	26.5	0.01
September	13.1	30.0	21.5	0.03
October	6.1	22.3	14.2	5.0
November	1.8	15.0	8.4	10.0
December	-1	9.2	4.1	16.9

Source:- Computed from the data of www.allmetsat.com

**Balkanabat, Turkmenistan Latitude 39 – 30 N, Longitude 54 – 20 E,
elevation -8 meters.**

Month	Temperature Degree Cel. Min.	Temperature Degree Cel. Max.	Temperature Degree Cel. Average	Precipitation (mm)
January	-1.1	8.8	3.8	11.1
February	0.0	10.0	5.0	14.0
March	5.0	15.1	10.0	21.2
April	11.8	24.2	18.0	19.6
May	17.5	30.0	23.7	17.1
June	22.7	35.0	28.8	5.0
July	25.2	37.2	31.2	7.9
August	25.0	36.9	30.9	2.1
September	19.0	32.7	25.8	3.8
October	12.2	24.2	18.2	11.7
November	7.2	16.1	11.6	14.0
December	2.3	10.1	6.2	16.0

Source:- Computed from the data of www.allmetsat.com

Essenguly, Turkmenistan, Latitude 37 – 28 N, longitude 53 – 58 E,

Elevation -22 meters

Month	Temperature Degree Cel. Min.	Temperature Degree Cel. Max.	Temperature Degree Cel. Average	Precipitation (mm)
January	0.0	11.2	5.6	21.2
February	0.2	11.9	6.0	19
March	4	15	9.5	30
April	10.1	21	15.5	17.7
May	15	25.3	20.1	11.8
June	19.2	29.1	24.1	3.1
July	23.5	31.2	27.3	8.3
August	22.9	32.1	27.5	7.1
September	19.01	29.2	24.1	12.7
October	11.5	24.3	17.9	21.6
November	5.2	18.7	11.9	24.2
December	3.1	13.4	8.2	27.1

Source:- Computed from the data of www.allmetsat.com

Gyzyletek, Turkmenistan/ Latitude 37 – 37 N, Longitude 54 – 47 E,

Elevation 29 meters.

Month	Temperature Degree Cel. Min.	Temperature Degree Cel. Max.	Temperature Degree Cel. Average	Precipitation (mm)
January	1.2	11.1	6.1	22.8
February	1.8	11.9	6.8	21.7
March	5.1	16.3	10.7	32.6
April	10.2	24	17.1	21.01
May	15	29.9	22.4	14.3
June	20	34.8	27.4	3.1
July	22.7	35	28.8	3.9
August	22.1	34.8	28.4	4.9
September	19.2	31.9	25.5	7.6
October	11.7	25.1	18.4	14.1
November	6.1	19.3	12.7	20.8
December	4.2	14.5	9.3	21.9

Source:- Computed from the data of www.allmetsat.com

**Turkmenbasy, Turkmenistan, Latitude 40 – 03 N, Longitude 53 – 00 E,
Elevation -13 Meters.**

Month	Temperature Degree Cel. Min.	Temperature Degree Cel. Max.	Temperature Degree Cel. Average	Precipitation (mm)
January	-1.5	6.1	2.3	11.0
February	-1	7.2	3.1	11.5
March	2.5	12.1	7.3	24.0
April	7.7	19.8	13.7	16.1
May	14.3	25.9	20.1	16.1
June	19.0	30.2	24.6	2.5
July	21.0	34.6	27.7	2.5
August	20.8	34.1	27.4	5.0
September	15.7	29.0	22.35	4.0
October	9.8	20.0	14.9	10.0
November	4.9	14.7	9.8	15.8
December	1.1	9.0	5.0	14.0

Source:- Computed from the data of www.allmetsat.com

Erbent, Turkmenistan Longitude 39 – 19 N, Longitude 85 – 36 E

Month	Temperature Degree Cel. Min.	Temperature Degree Cel. Max.	Temperature Degree Cel. Average	Precipitation (mm)
January	-4.5	5.0	0.25	12.5
February	-2.5	8.9	3.2	11.1
March	4.1	15.1	9.6	22.0
April	10.8	24.9	17.8	22.0
May	16.1	31.0	23.5	13.1
June	21.3	36.1	28.7	4.0
July	24.9	39.0	31.9	2.0
August	21.2	37.2	29.2	1.1
September	15.1	31.1	23.0	1.9
October	8.9	22.5	15.7	5.8
November	4.1	15.0	9.5	10.0
December	-1	8.8	3.9	12.9

Source:- Computed from the data of www.allmetsat.com