SOIL EROSION IN KOHIMA DISTRICT , NAGALAND: A GEOGRAPHICAL ANALYSIS

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BY

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(A Central University established by an Act of Parliament No.35 of 1989)

(संसद द्वारा पारित अधिनियम 1989, क्रमांक 35 केअंतर्गत स्थापित केंद्रीय विश्वविद्यालय)

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DECLARATION BY THE CANDIDATE

I, Mr. Keneikhoto Yano, hereby declare that the subject matter of this thesis is the research work done by me, that the contents of this thesis did not form basis of the award of any previous degree to me or to the best of my knowledge to anybody else, and that the thesis has not been submitted by me for any research degree in any other university/institute.S

This is being submitted to Nagaland University for the award of the degree of Doctor of Philosophy in Geography.

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CERTIFICATE

This is to certify that the thesis entitled "Soil Erosion in Kohima District, Nagaland: A Geographical Analysis", submitted to Nagaland University in partial fulfillment of the requirements for the degree of Doctor of Philosophy (Ph.D.) in the Department of Geography, embodies the original research work carried out by Keneikhoto Yano, Registration Number 483/12, under my supervision and guidance.

Further, I certify that no part of this thesis has been submitted anywhere for any other research degree. The assistance and help received during the course of study have been duly acknowledged.

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Dated: **(KENEIKHOTO YANO)**

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CHAPTER 1
INTRODUCTION

The topmost layer of the earth which is productive in nature is considered soil. The soil covering the surface of the earth has taken millions of years to form and it supports a rich and wide diversity of terrestrial life. Soil is formed at a rate of only 1 cm every 100 to 400 years and it takes 3000 to 12000 years to build enough soil to form productive land.[1] It is formed slowly by physical, chemical, biological weathering of parent materials, and the soil particles are moved and sorted by winds and water until, in most natural ecosystems the counteracting processes of soil formation and loss reach equilibrium.[2] Soil is, thus, a non-renewable resource and once destroyed it is gone forever. It is the basis of production in agriculture and forestry, the nourisher of mankind and an important component of the human environment. Much more attention should, therefore, be given to the soil. And a great control with respect to its rational use, protection and improvement needs to be exercised. It is important therefore, to treat soil, especially topsoil, as a living entity.

Concern about the state of the world's soil and other resources has grown over the past few decades, culminating in the Brundtland Commission Report- Our Common Future (WCED).[3] After the green revolution of 1960s and 1980s became the 'Decade of Resources Crunch and Awareness' because of general decline and stagnation in soil productivity.[4] Food grains production per capita decreased significantly in some parts of Africa, the Near East and Asia during the 1980s. Although some of this decline was due to the increase of population and periodic drought, much of it was due to improper use and poor management and exploitive farming practices, resulting in land degradation by

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[1]Asres, Y., *et. al*., 2014.*Application of Neutron Activation Analysis Technique for the Analysis of Soil Samples from Farmlands of Yebrage Hawariat, East Gojjam, Ethiopia*, J. Agricultural Science and Technology A 4 p. 342-352.

[2] Greenland, D.J., 1977. *Soil Damage by Intensive Arable Cultivation: Temporary or Permanent?* Phil. Trans.Soc. London B281. p. 193-208.

[3]WCED (World Commission on Environmnet and Development), 1987.*Our Common Future*, Oxford University Press, Oxford and New York.

[4]Segal, J., & Abrol.I.P., 1994.*Soil Degradation in India: Status and Impact,* Oxford & IBH publishing Co. Pvt. Ltd., New Delhi 110001, India. p. 13.

wind and water erosion, nutrient depletion and overall decline in soil productivity.[5] Ecologists and environmentalists believe that accelerated erosion is a cancer on land that depletes rapidly the soil productivity capacity and causes pollution and eutrophication of natural waters.[6]Land degradation problems and the associated loss of soil productivity and declining of soil quality continue to be a subject of environmental concern attracting attention of the world's scientific community. It is a major concern for at least two reasons. First, soil degradation undermines the productive capacity of an ecosystem. Second, it affects global climate through alterations in water and energy balances and disruptions in cycles of carbon, nitrogen, sulphur, and other elements. Through its impact on agricultural productivity and environment, soil degradation leads to political and social instability, enhanced rate of deforestation, intensive use of marginal and fragile lands, accelerated runoff and soil erosion, pollution of natural waters and emission of greenhouse gases into the atmosphere. In fact, soil degradation affects the mere fabric of mankind.[7]

Ever since human beings settled on land and started cultivating it some 700 years ago, the problems of land degradation started emerging.[8] Although the problem was serious in the past, it was restricted to relatively small areas and in a few countries. But the environment has been changing because of increasing population resulting in food demands, environmental pollution, degrading soil quality and global warming. It is

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[5]*FAO., 1981. *Soil and water conservation COAG/81/8*, Presented to the 6th session of the Committee of Agriculture, Rome, Italy.
**Parr, J.F., *et. al*., 1990.*Global Assessment of Soil Degradation (GLASOD),* World Map of the Status of Human- induced Soil Degradation- An Explanatoty Note. ISRIC, Wageninggen. p. 27.
***Dregn, H.E., 1992.*Erosion and Soil Productivity in Asia*, J. Soil Water Conservation, 4. p. 8-13.

[6]Lal, R., 1988. *Soil Erosion by Wind and Water: Problems and Prospects*, in R. Lal (ed.), Soil Erosion Research Methods, Soil Water Conserv. Soc. Amer., Ankeny. IA, USA. p.1-6.

[7]Lal, R. and Stewart, B.A., 1990. *Soil Degradation: A Global Threat*, Advances in Soil Sci., 11: XIII-XVII.

[8]Lowdermilk, W.C., 1953. *Conquest of the Land through 7,000 years*, Agric. Inform. Bull No. 99: U.S. Dept. of Agric. Washington D.C.

estimated that about 80% of the current degradation on agricultural land in the world is caused by soil erosion due to water.[9]

Erosion control measures can be applied effectively only when the nature of the *erosion phenomena* and the effectiveness of measures under particular sets of conditions have been thoroughly studied. These questions are studied in recently established *science of soil erosion* or *soil erodology* with the aim firstly to add to current knowledge, generalizing from the knowledge gained by observation of erosion phenomena, also including the principle of soil conservation, and secondly, to determine the best methods of improving the properties of eroded soil. In practice, soil erosion control is connected to a greater or lesser with improvement, and from the practical standpoint it is, therefore, possible to speak of erosion control soil (*amelioration*).[10]

Soil erodology as a comprehensive assemblage of scientific information on erosion and erosion control is a young branch of science, yet the dangers of erosion and various methods of erosion control have been known to mankind since time immemorial. Up to the end of the 19th century this information was more or less empirical and confined locally. Only when a sufficient amount of practical and theoretical information had been collected, was it possible to develop a relatively comprehensive new theory in the form of a new scientific discipline.

The *development of erodology* as the concept of erosion in general has been difficult, and was accelerated by specialists in many other fields. The broadcast concept of erosion was developed by *geomorphologies, geographers and geologist,* who consider

[9] Angima, *et. al.,* 2003.*Soil Erosion Prediction using RUSLE for Central Kenya Highland Conditions*, Agric. Ecosys. Environ.,. p. 97, 295-308.
[10]*Kozmenko, 1954.*Principles of Soil Control* (in Russian), Sekhozgiz, Moscow.
*Ziemnieki, 1968. *Amelioration for the erosion control.*

erosion mainly in terms of the development of the Earth's surface under the influence of exogenous forces (Penek 1898, Davis 1898, 1902, Lazarervić 1973).[11]

Pedologists began to study erosion in more concrete terms. The first to point out the dangers of erosion was Dokuchaev (1877, 1879),[12] the founder of pedology. Wollny (1895)[13]conducted the first interesting experiments on the effects of atmospheric precipitation on soil and soil wash. Specific research on rill and sheet erosion was first carried out by Kozmenko (1909, 1910),[14] but the disastrous consequences of erosion for mankind were pointed out by the American soil conservationists Bennett and Chapline (1928),[15] the subsequent years saw the beginnings of broadly-based, organized soil erosion research.

The third contribution of information on soil erosion towards the incipient erodological discipline came from the principles of *torrent and avalanche control.* These originated in the Alpine countries in the second half of the 19th century. The first specialists in this field were French. They, too, were the authors of guidelines on soil conservation in mountain regions and on the control of torrential floods. In addition to the works of Surell (1842),[16] mention may be made of the classical works of Demontzey (1878, 1882)[17] which became the basis for the rapid development of torrent control in many European countries. The promulgation of the Austro-Hungarian Act No. 117 in 1884 concerning the harmless deflection of the water from the watershed is also linked with

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[11] *Penck, A., 1894. *Morphology of the Earth's surface.2 vols*, Engelhorn, Stuttgart.
* Davis. W. M., 1898.*Physical Geography, Boston*, (1902), Elementary Physical Geography, Boston.
* Lazarervvić, R., 1973. *Erosion in the SFR of Yugoslavia*. p. 105-123.

[12]Dokuchaev. V. V., 1877. *Ravines and their importance and in Cartography of Russian Soils (1879).*

[13]Wollny, E. 1895.,*Studies of the Behavior of the Atmospheric Precipitation to Plant and to the Ground,* Research from the field of Agriculturphysik 18. p. 335.

[14] Kozmenko, A. S., 1909 &1910.*Sunken Down, Landslide and Erosion Formations in the Northeastern part of the Novosilsk Rayon of the Tula Province* (in Russian), Zemlevedenie 111, IV, Moscow.

[15]Bennett. H H., Chapline. W. R., 1928.*Soil Erosion - a National Menace, U.S. Department of Agriculture,* Circular.p. 33.

[16]Surell, A., 1942. *Study on the Torrents of the Hautes-Alpes, 2nd ed*. 1870, Paris.

[17]Demontzey.P., 1878.*Treaty Practice Reforestation and Sodding Mountain*, J. Rothschild, Paris.

this work. Although the authors were mainly concerned with reducing load and protecting watercourse and watersheds against silt deposition, they gave a lot of attention also to the characteristics of erosion and to the erosion control.

1.1 Definition and Terms of Erosion and Soil Erosion

The word *erosion,* is a Latin origin being derived from the verb *erodere*- denotesto eat away (*rodere*-to gnaw) or to excavate. The term erosion was first used in geology to describe the forming of hallows by water, the wearing away of solid material by the action of river,[18] while surface wash and precipitation erosion was called ablation (Latin ablation - to carry away). The problems of river erosion and its contribution towards modeling of the Earth's surface were well understood by the end of the 19th century. Although the term *erosion* was in use in the 19th century, the term *soil erosion* was introduced later, at the beginning of the 20th century, and did not come into general use until the 1930's. The term was established and defined by Bennett, Fuller, Lowdermilk and Middleton in Anglo-American literature, Kozmenko, Ponkov, Gussak, Sobolev, and Zaslavskiî in Russian literature, Kuron, Schultze, Glander, and Flegel in German, and Baulig in French literature.

The term *soil erosion* generally means the destruction of soil by the action of water and wind. Most authors dealing with the problems of soil erosion include those phenomena related to the activity of man within the meaning of soil erosion. Some of the authors conceive soil erosion only as erosion caused by precipitation, while others include erosion caused by natural and man-made factors operating in the conjunction. In this study soil erosion is taken to mean the destruction of soil by water, animals and man.

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[18] Penek, A., 1894. *Morphology of the Surface of the Earth*, Published by Verlag von J. Engelhorn Nachf., Stuttgart.

In addition, the term erosion and ablation and a number of other terms were used to express geomorphological processes caused by water and wind. These included the established term *corrosion* (*corradere* in Latin – to scrape together), *corrosion* (*corrodere* in Latin – *to gnaw to pieces*), *abrasion* (*abrader* in Latin – to scrape off), and *denudation* (*denudere* in Latin – to strip), etc. Different authors have used these terms in different contexts and inter – changed them thereby causing much ambiguity. Many authors now used the term erosion to encompass any form of destruction of soil by water, and recommended that the term *deflation* and *abrasion* be used in cases of wind destruction.

The factors which contribute to soil erosion may be classified into *biotic* (*bios* in Greek - life), i.e. relating to life, and *abiotic* (inanimate). In addition to these two main forms of erosion caused by abiotic factors (*abiotic erosion*), the *organogenic* aspects of erosion (*organum* in Latin -*organum* in Greek -organism, *gennao* in Greek - I bear) may be distinguished and subdivided into *phytogenic* (*fyton in* Greek - plants),[19]*zoogenic* (*zoon* in Greek - animal), and man-made, i.e. *anthropogenic* (*anthropos* in Greek - man) erosion. The first two factors (plants and animals) do little more than nibble at the soil and substrate hence arrosion (Latin *arrodere* - to nibble).

In all situations, several types of erosion always occur simultaneously or in some chronological sequences, forming patterns which are typical of particular areas. The decisive factors are climate, relief, the nature of the surface, and the activity of organism, especially the activity of man which has been responsible in recent years for an increasing specific influence on erosion systems.

Soil erosion, according to many authors, has occurred only as a result of man's engagement in agricultural activity. This concept of soil erosion is no longer acceptable

[19]Lazarevic, R., 1975. *Geomorphology*.Institute of forestry and wood industry, Belgrade.

either from the theoretical or practical point of view. It is well known that many soils were affected by erosion long before artificial changes began to be made. Academic research on erosion and soil erosion problems are the focus of several different disciplines, such as geography, soil science and also engineering, mathematics and physics. Scientific definitions differ significantly across these fields. It seems to be more appropriate to classify erosion in the broadest sense of the word into either natural erosion and erosion influenced by man, i.e. altered, or anthropogenic erosion. Some of the definitions used in soil erosion are:

'Erosion is a natural process leveling the relief of all landscapes. Erosion processes are dependent on climate and other environmental factors and are caused by wind and water.[20] Erosion is the process of detachment and transport of soil particles by erosive agents'.[21] According to Toy and Renard (1998), 'Soil loss refers to that material actually removed from the particular hill slope or slope segment which may be less than erosion due to onsite deposition in micro-topographic depressions'.[22] Morgan, *et al.*, (1998) refers soil erosion as to 'the natural erosion process and additionally incorporates processes caused by the anthropogenic impact on the land surface, such as agricultural practices or deforestation. The anthropogenic impact amplifies natural erosion'.[23] Ellison (1944) explain the term as a composed of a complex processing including soil detachment by raindrop impact and surface flow, and soil particle transport by rain splash and surface flow during rainfall event.[24] Soil erosion is also defined as the wearing away of the land surface by physical forces such as rainfall, flowing water,

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[20]Richter , G., 1998.*Soil Erosion and Cultural Landscape*, in Richter , G. (eds.).*Soil erosion - Analysis and the Balance Sheet of an Environmental Problem*.Darmstadt .

[21] Ellison Ellison, W.D., 1944. *Two devices for Measuring Soil Erosion.*Agricultural Engineering 25.p.53–5.

[22]Toy, T. J. & Renard,K. G., 1998.*Introduction*. p. 1-1 - 1-12, in Toy, . T. J. & Foster, G. R. (eds.).*Guidelines for the Use of the Revised Universal Soil Loss Equation (RUSLE) Version 1.06 on Mined Lands, Construction Sites and R.*

[23] Morgan, R.P.C., *et al.*, 1998.*The European Soil Erosion Model (EUROSEM): a Dynamic Approach for Predicting Sediment Transport from Fields and Small Catchments*, Earth Surface Processes and Landforms 23. p. 527–44.

[24] Ibid.

wind, ice, temperature change, gravity or other natural or anthropogenic agents that abrade, detach and remove soil or geological material from one point on the earth's surface to be deposited elsewhere.[25] Ngai and Chan (2005) refer soil erosion as one form of soil degradation along with soil compaction, low organic matter, loss of soil structure, poor internal drainage, salinization, and soil acidity problems.[26]

Erosion and soil erosion can only be differentiated through detailed investigation in the field and thus, the term 'erosion and soil erosion' is used for both, environmental and anthropogenic processes. Erosion and soil erosion damages are the results of erosion and soil erosion processes. Damages from the following processes have been investigated.

Sheet erosion is a process caused by surface runoff, where 'runoff actually is concentrated in many small rivulets of water'.[27] Overland flow is of very high frequency and very low magnitude, and thus, occurs area-wide between rills (Hogg, 1982). This area is also called the inter-rill area and erosion occurring here is defined as inter-rill erosion (Toy *et. al.*, 2002). Sheet erosion and inter-rill erosion are, therefore, synonymously used in this context.

Rill erosion is a process caused by the concentration of surface runoff. Rills are small rivulets on hill slopes where runoff is concentrated while the areas between the rills are the inter-rill areas (Toy *et. al.*, 2002).Rill erosion is of lesser frequency but higher

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[25] *Jones, R.J.A., *et. al.*, 2006.*Identifying Risk Areas for Soil Erosion in Europe,* in W. Eckelmann *et. al.* (eds.), *Common Criteria for Risk Identification according to Soil Threats*, European Soil Bureau Research Report 20, EUR 22185 EN, 23-33, Office for Official Publications of the European Communities, Luxembourg.
*Soil Science Society of America. 2001. *Glossary of Soil Science Terms. Soil Science Society of America*, Inc., Madison WI.p. 140.

[26] Ngai, E.W.T., Chan, E.W.C., 2005. *Evaluation of Knowledge Management Tools using AHP,* Expert Systems with Applications, 29. p. 889–899.

[27]Toy, T. J., *et. al.*, 2002.*Soil Erosion: Processes, Prediction, Measurement, and Control,* New York: John Wiley and Sons.

magnitude than sheet erosion. Areas of both, rill erosion and inter-rill erosion 'make up the overland flow areas of landscapes' (Toy *et. al*., 2002).

The moment rill erosion concentrates gully erosion can start to develop. Hudson (1995) defines a gully as 'a steep-sided eroding watercourse which is subject to intermitted flash floods'.[28] Morgan (1996) provides a detailed description of gullies, their origin and shape characteristics.

Badland erosion takes place where gullies concentrate into clusters or where the area-wide frequency of rills is preventing the establishment of any vegetation cover (Boardman *et al*., 2003).[29] Within the context of this research, badlands are defined as areas of high rill frequency and area-wide inter-rill erosion and a more or less entirely bare of vegetation cover.

Barren degraded land is defined as an area where different erosion processes are causing area-wide degradation. These degradation forms are generally flat at the bottom and boundaries to non-degraded areas are determined by a sudden and severe change in the landscape level.

1.2 Process of Soil Erosion

The process leading to soil erosion is generally triggered by pressure on land to meet the demands of the rapidly growing population for food, fodder and fibre. This leads to over exploitation of natural resources with little consideration for maintaining the eco-balance sustainability.

Challenging problems in soil conservation arise from the rapid growth of the world population and the ensuing requirement for increased food production on the one hand

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[28] Hudson, N., 1995. *Soil Conservation*. Iowa State University Press,Ames, Iowa (http://edocs.fu-berlin.de/diss/servlets/MCRFileNodeServlet/FUDISS_derivate_000000002786/03_Definitions.pdf;jsessionid=7D4217C86F58F3DC5336F55951555BDF?hosts= access on 3/2/2015).

[29] Boardman, J., *et. al*., 2003.*Development of Badlands and Gullies in the Sneeuberg, Great Karoo, South Africa,* Catena 50. p. 165-184.

and on the other from rapid technical process giving rise to further industrialization and urbanization which involve the deterioration, destruction, intoxication, and contamination of the environment by industrial fumes and various chemical substances.

Various anthropogenic activities such as construction of roads, deforestation, expansion of towns and villages, unsustainable practices of agriculture, etc., lead to accelerated soil erosion. These processes, in turn, reduce agricultural productivity leading to social insecurity and political instability. The effects of degradation processes on the overall global environments resulting from emission of greenhouse gases into the atmosphere, through alteration of water and energy balances are a matter of serious concern to the global scientific community. Soil erosion is considered the single most destructive force diminishing the world's soil resource base.

Over the past few decades, soil erosion processes have been greatly accelerated in different parts of the country. Agricultural activities being the main sustenance of the people, our production systems are seriously at stake. There is, therefore, an urgent need to develop and extend technological measures and sustainable practices to the potential user. Any such attempt requires knowledge of the extent, kind, degree and severity of soil erosion problems to enable us to take appropriate measures for their control.

1.3 Soil Erosion: Global Context

Archaeological evidences have shown that soil degradation was responsible for the extinction of the Harappan civilization in Western India, the Mesopotamian civilization in Western Asia, and the Mayan culture in Central America.[30] Soil erosion costs the US economy between US$ 30 billion[31] and US$ 44 billion annually.[32] The annual cost in

[30] Olson, G.W., 1981. *Archaeology: Lesson on Future Soil Use*,J. Soil water Conserv. 36. p. 261-264
[31]Uri, N.D. and Lewis, J.A., 1998.*The Dynamics of Soil Erosion in US Agriculture*,Science of the Total Environment218. p. 45–58.
[32] Pimental,D.,*et al*., 1993. *Soil Erosion and Agricultural Productivity*, in Pimental, D. (ed.), World soil erosion and conservation. Cambridge University Press, Cambridge.p. 277–92.

UK is estimated at £90 million (Environment Agency 2002). In Indonesia, the cost is US$ 400 million per year in Java alone.[33] The costs result from the effects of erosion is both on- and off-site.

On-site effects are particularly important on agricultural land where the redistribution of soil within a field, the loss of soil from a field, the breakdown of soil structure and the decline in organic matter and nutrient result in a reduction of cultivable soil depth and a decline in soil fertility. Erosion also reduces available soil moisture, resulting in more drought-prone conditions. The net effect is a loss of productivity, which restricts what can be grown and results in increased expenditure on fertilizers to maintain yields. For instance, if fertilizers were used to compensate for loss of fertility arising from erosion in Zimbabwe, the cost would be equivalent to US$ 1500 million per year,[34] a substantial hidden cost to that country’s economy. The loss of soil fertility through erosion ultimately leads to the abandonment of land, with consequences for food production and food security and a substantial decline in land value.

Off-site problems arise from sedimentation downstream or downwind, which reduces the capacity of rivers and drainage ditches, enhances the risk of flooding, blocks irrigation canals and shortens the design life of reservoirs. Most hydro-electricity and irrigation projects have been ruined as a consequence of erosion. Sediment is also a pollutant in its own right and through the chemicals adsorbed to it can increase the levels of nitrogen and phosphorus in water bodies and result in eutrophication. Erosion leads to the breakdown of soil aggregates and clot into their primary particles of clay, silt and sand. Through this process, the carbon that is held within the clays and soil organic, content is released into the atmosphere as CO_2. Lal (1995) has estimated that

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[33] Magrath,W.B. and Arens, P., 1989. *The Cost of Soil Erosion on Java: a Natural Resource Accounting Approach*, Environment Department Working Paper 18, World Bank Policy Planning and Research Staff,World Bank,Washington, DC.

[34]Stocking, M.A., 1986.*The Cost of Soil Erosion in Zimbabwe in terms of Loss of Three Major Nutrients,* FAO Consultants Working Paper 3, AGLS, Rome.

global soil erosion release 1.14PgC annually to the atmosphere, of which some 15 TgC is derived from the USA.[35] Erosion is therefore, a contributor to climate change, since increasing the carbon dioxide content of the atmosphere enhances the greenhouse effect.

The on-site costs of soil erosion are necessarily borne by the farmer, although they may be passed on in part to the community in terms of higher food prices as yields decline or land goes out of production. The farmer bears little of the off-site costs, which fall on local authorities for road clearance and maintenance, insurance companies and all the land holders in the local community affected by sedimentation and flooding. Offside costs can be considerable. Erosive runoff from arable land in four catchments in the South Downs, England, in October 1987 caused damage equivalent to £660,000.[36] Sedimentation ponds to trap sediment and runoff generated from arable land in an area of 5516km^2 in central Belgium cost 38 million to construct and 1.5 million annually to maintain.[37]

Although soil erosion is physical process with considerable variation globally in its severity and frequency (Table 1.1), where and when erosion occurs is also strongly influenced by social, economic, political and institutional factors. Conventional wisdom favours explaining erosion as a response to increasing pressure on land brought about by a growing world population and the abandonment of large area of formerly productive land as a result of erosion, salinization or alkalinization. In the loess plateau region of China, for example, annual soil loss has increase exponentially since about

[35] Lal, R., 1995. *Global Soil Erosion by Water and Carbon Dynamics,* in Lal, R., *et. al*., (eds), *Soils and Global Change,* CRC/Lewis, Boca Raton, FL. p. 131–41.
[36]Robinson, D.A. and Blackman, J.D., 1990.*Some Costs and Consequences of Soil Erosion and Flooding around Brighton and Hove, autumn 1987*, in Boardman, J., *et. al*. (eds), *Soil Erosion on Agricultural Land*. Wiley, Chichester. p. 369–82.
[37] Verstraeten, G. and Poesen, J., 1999. *The Nature of Small Scale Flooding, Muddy Floods and Retention Pond Sedimentation in Central Belgium*.Geomorphology 29. p. 275–92.

220 BC in a simple relationship with total population.[38] Population pressure forces people to farm more marginal land, often unwisely, especially in the Himalaya, the Andes and many mountainous areas of the humid Tropics. In other parts of the world, however, erosion can be seen as direct response to abandonment of the land associated with rural depopulation. A dramatic example comes from the terrace mountain slope of the Haraz in Yeman, where land abandonment occurred following droughts in the 1900s, the 1940s and between 1967 and 1973, and then increased markedly in the 1970s as people migrated to Saudi Arabia and the Gulf States. With fewer people on the terrace mountain slope which are collapsing and erosion is reducing the soil depth of the already shallow depth by 1-3 cm yr^{-1}.[39]

Table 1.1
Global Extent of Soil Erosion

Region	Land Land area affected by soil erosion (Mha)	Percent of total land
Africa	267	16
Asia	407	15
South America	93	6
Central America	50	25
North America	78	7
Europe	132	17
Oceania	20	3
World	1047	12

Source: after Oldeman, 1994[40]*& Scherr, 1999.*[41]

[38]Wen, D., 1993.*Soil Erosion and Conservation in China*, in Pimental, D. (ed.), *World Soil Erosion and Conservation,* Cambridge University Press, Cambridge. p. 63–85.
[39] Vogel, H., 1990. *Deterioration of a Mountainous Agro-Ecosystem in the Third World due to Emigration of rural ,Labour,* in Messerli, B. and Hurni, H. (eds), *African mountains and highlands: problems and perspectives*. African Mountains Association, Bern. p. 389–406.
[40]Oldeman, L.R.,1994. *The Global Extent of Soil Degradation,* in Greenland, D.J., Szabolcs I, editors. *Soil resilience and sustainable land use,*Wallingford: CAB International. p. 99-118.
[41]Scherr, S., 1999.*Soil Degradation: a threat to Developing Country Food Security by 2020,* IFRI Food, Agric. and Environment Discussion Paper 27, Washington, DC. p. 63.

In much of Mediterranean Europe, policies to reduce the number of people employed in agriculture and to increase farm size and the level of mechanization have had a twofold effect. First, traditional terrace structure are left to decay. Secondly, the increase in farm size is often accompanied by large-scale earth moving and land leveling, which makes the soil more erodible. Almost everywhere that land consolidation programmes have been carried out; rates of soil erosion have increased.[42] In Africa, the situation has so deteriorated that a new word 'desertification' has been used to describe the creation of human-induced desert-like condition. The problem is not confined to the developing world. Even advanced countries, like the USA, face serious problems of soil erosion resulting in loss of nearly six billion tons of soil every year.[43]

Soil erosion is a major environmental problem in many parts of the world,[44] with India being one of the most affected countries. In India, a large proportion of the land area shows clear evidences of soil degradation which, in turn, is affecting the country's productive resource base. The socio-economic and ecological consequences of land degradation are far-reaching, affecting over 50 per cent of the total geographical area of the country.[45]It has been estimated that a total of more than 5000 million tonnes of top soil is being eroded every year. Dhruvanarayana and Rambabu (1983)[46] have estimated that in India about 5,334 Mt (16.4 t ha^{-1}) of soil is detached annually; about 29% is carried away by river into the sea and 10% is deposited in reservoirs resulting in the

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[42] Morgan, R.P.C., 2005.*Soil erosion and conservation,* 3rd edition.p. 2.

[43]Napier, T. L., 1986. *Socio-Economic Factors Influencing the Adaptation of Soil Erosion Control Practices in USA,* Workshop on Erosion Assessment for EEC- Methods and Models, Brussels, Belgium, Dec., 1986.

[44] Hitzhusen, F. J., 1993. *Land Degradation and Sustainability of Agricultural Growth. Some Economic Concepts and Evidence from selected Developing Countries*,Agric Ecosystem Environment. 46. p. 69-79
*Mitra, B., *et. al*., 1998.*Application of Fuzzy Logic to the Prediction of Soil Erosion in a Large Watershed,* Geoderma 86. p. 183-209.

[45] Abrol, I.P. and Sehgal, J., 1992. *Degraded Lands and their Rehabilitation in India,* in Greenland, D.J. and Szaboles, I. (eds.),*Soil Rsilience and Sustainable Land Use*, Presented Intern. Conf. on Soil Resilience and Sustainable Land Use, held at Bucharest (Hungary).p. 129-144.

[46]Dhruvanarayana, V.V. and Babu, R., 1983.*Estimation of Soil Loss in India*, J Irrig Drain Eng 109(4). p. 419–433.

considerable loss of the storage capacity. River basin in many parts of the world suffers large amount of soil loss due to natural and human induced processes. A comparison of the estimated annual soil erosion within the drainage basins of rivers of several countries[47] shows that the drainage basins of India have extremely high erosion values (Table 1.2). Unless urgent measures are taken to arrest the degradation process and to restore productivity of degraded lands, we shall not be able to produce more food to fulfil our obligation to leave a better heritage for prosperity.

The mountainous regions, such as the Himalayas and the Andes, suffer from the world's highest erosion rates (Ismail and Ravichandran, 2008).[48] The rivers emerging out from the Himalayan region transport the sediment at a very high rate. Himalayan and Tibetan region cover only about 5% of the Earth's land surface, but they supply about 25% of the dissolved load to the world oceans (Raymo and Ruddiman, 1992).[49]The Himalayan region of India is highly susceptible to erosion hazard. This is because of its fragile environment, high degree of slope, large scale deforestation[50] and unsustainable utilization of land resources (Dhrubnarayan, 1987).[51]Moreover, the unstable and loose geological material that leads to gully erosion and mass movement add to the soil erosion hazards. The annual soil loss from the Himalayan hills was estimated to be 28.2 t $km^{-2}yr^{-1}$.[52] Garde and Kothyari[53] reported that the soil erosion rate in the Northern Himalayan region is high and in the order of 2000 to2500 t km^{-2} yr^{-1}.The Yamuna river

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47 El-Swaify, S.A., *et. al.,*1982.*Soil Erosion by Water in the Tropics,* Research and Extension Series 024, Hawaii Institute of Tropical Agriculture. University of Hawaii Press, Honolulu.

48 Ismail, Jasmin and Ravichandran, S., 2008.*RUSLE2 Model Application for Soil Erosion Assessment Using Remote Sensing and GIS*, Water Resource Management 22.p.83-102.

49 Raymo, M. E. and Ruddiman, W. F., 1992.*Tectonic Forcing of Late Cenozoic Climate*, Nature, 359. p. 117-122.

50 Jain, S. K., *et. al*., 2001.*Estimation of Soil Erosion for Himalayan Watershed Using GIS Technique*, Water Resources Management 15.p.41-54.

51 Dhruvanarayana, V.V., 1987.*Downstream impacts of Soil Conservation in the Himalayan Region,* Mountain Research and Development, Vol. 7, No. 3, 1987. p. 287-298.

52 Singh, D. R. and Gupta, P. N., 1982. *Assessment of Siltation in Tehri reservoir,* Proc. International Symposium on Hydrological Aspect of Mountainous Watershed, University of Roorkee, Roorkee (Nov. 4-6, 1982) Mangalik Prakashan, Saharanpur, pp. VIII-60 to VIII-66.

53 Garde, R. J. and Kothyari, U. C., 1987.*Sediment Yield Estimation*, Journal Irrigation and Power (India) 44(3), p. 97-123.

alone contributes annually about 65 million tonnes of sediments to the Ganges river system and has a sediment erosion rate (total sediment load divided by basin area) of about 400 t $km^{-2}yr^{-1}$.[54] Thus, soil erosion in Himalayas has continuously caused sedimentation problem in the lower reaches of the valley.[55]

Table 1.2
Estimated Annual Soil Erosion within Drainage Basins of Selected Rivers

River	Countries within Drainage Basin	Drainage Basin (10^3 km^2)	Estimated annual soil erosion (t/ha)	Rank
Kosi	India	62	555	1
Damodar	India	20	284	2
Ganga	India, Bangladesh	1076	270	3
Red	China, Vietnam	120	217	4
Irrawaddy	Burma	430	139	5
Caroni	Venezuela, Columbia	91	105	6
Mahanadi	India	132	93	7
Mekong	China, Thailand, Laos, Tibet, Kampuchea, Vietnam, Burma	795	43	8
Chaophraya	Thailand	106	21	9
Orinoco	Venezuela, Columbia	950	18	10
Amazon	Bolivia, Brazil, Ecuador, Colombia, Peru, Venezuela	5776	13	11
Nile	Uganda, Kenya, Zaire, Ethiopia, Tanzania, Sudan, Egypt, Rawanda, Burundi	2978	8	12
Congo	Angola, Congo, Zaire, Cameroon, Central African Republic	4014	3	13
Niger	Cameroon, Guinea, Dahomey, Chad, Ivory Coast, Nigeria, Niger Mali	1114	0.8	14

Source: After El-Swa1fy,et.al., 1982.[56]

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[54]Subramanian, V., *et. al.,* 1985.*Rate of Sedimentation in the Yamuna river Around Delhi using the* $_{226}$*Ra* ^{210} *PB method,* Journal of Radio analytical and Nuclear Chemistry, 90{2). p. 271-276.
[55]Byers, A., 1986.*Landscape Changes and Man Accelerated Soil Loss: the case Sagarmatha, Nation Park Khunbu, Nepal,* Mountain research and development. 7(3). p. 209-216.
[56] Op. cit.,

North Eastern Hill (NEH) region of India comprises 8 states namely Assam,Arunachal Pradesh, Manipur, Meghalaya, Mizoram, Nagaland, Tripura and Sikkim. Thearea is dominated by three land forms associated viz., (1) The Greater Himalayas (2) strong dissected high lands and (3) low lying riverine plains. The annual rainfall of the region varies from 2,000 to 10,000 mm. The topography and climate of the region is conducive to accelerate soil erosion, which has been recognized as a serious threat to environment.[57]Over 600 million tonnes (mt) of soil accompanied by 1.5 mt of nutrients (NPK) get eroded every year due to the steep slopes in North East Region of India and rainwater mismanagement. A greater frequency of high-intensity rainfall can further increase these losses. The possibility of high temperature-induced increases in transient salinity, denitrification and nutrient loss due to volatilization cannot be overlooked, so also the loss of nutrients through enhanced leaching under high intensity rainfall.[58]Singh (1999)[59]estimated by the application of USLE for the hill of Arunachal Pradesh that the total amount of 669.35 million ton of soil is eroded annually with an average rate of 90.9 t ha^{-1} $year^{-1}$. It occupies a major portion in the Himalayan mountains which are relatively a younger formation and geologically, a very complex range. In the wet tropical and sub-tropical climate which prevails in most part of Arunachal Pradesh, there is a usual phenomenon of erosion and land degradation by the action of water. Sharda *et. al.,* (2012) estimated that 84% of the total geographic area of Nagaland which is 16,579 km^2 eroded and are listed under high priority for soil conservation.[60]

The prevention of soil erosion, which means the rate of soil loss to approximately that which would occur under natural conditions, relies on selecting appropriate strategies

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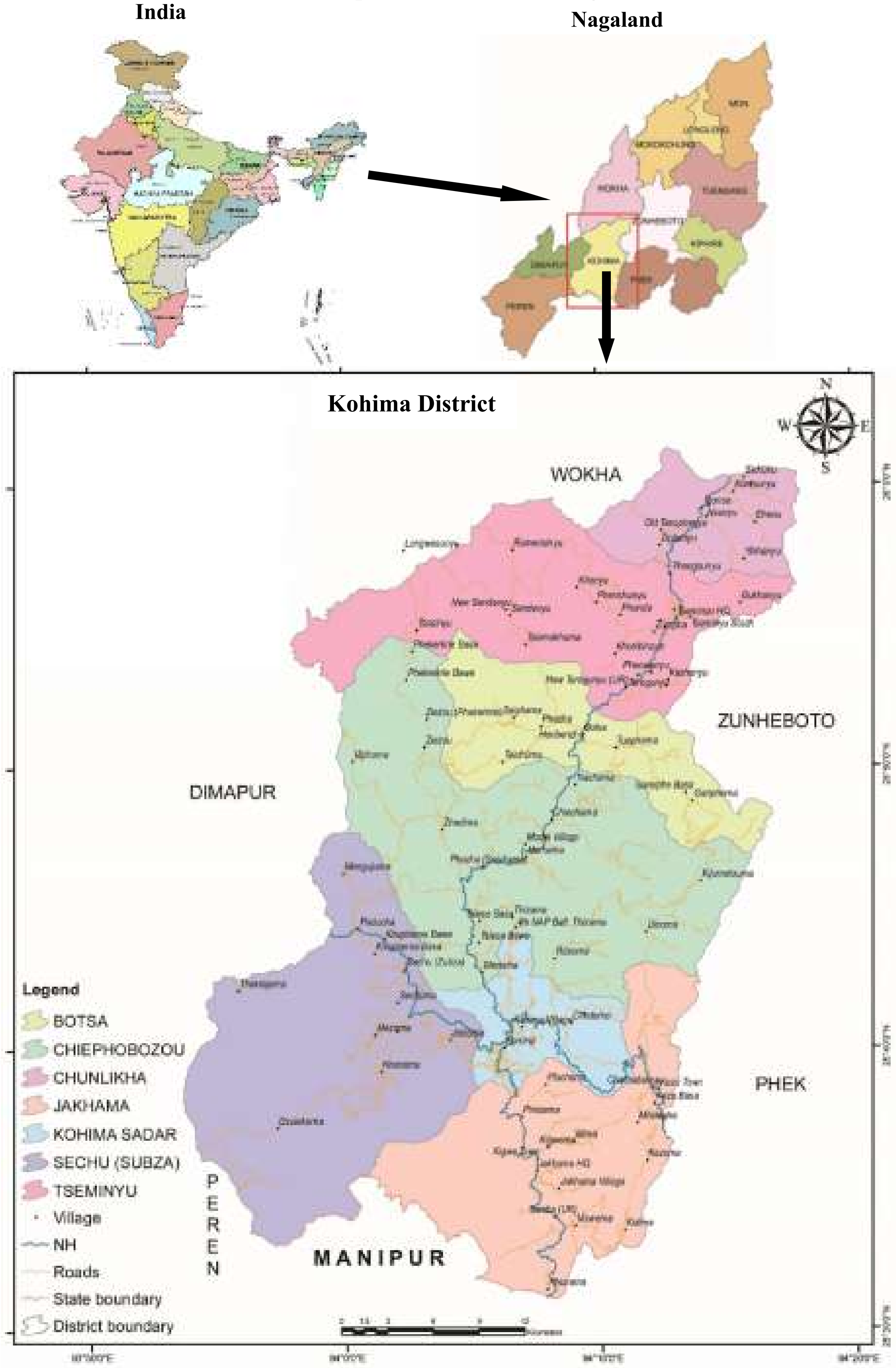
[57] Solanki, R. C., Singh, A., 1996. *Soil Rrosion Research on Steep Slopes in North-Eastern Hill Region of India—a review*, Indian J Soil Conserv 24(3). p. 187–192.
[58]Kumar, M., 2010. *Soil Responds to Climate Change: Is Soil Science in India responding to?*Curr.Sci., 99.p. 892– 894.
[59]Singh, S., 1999.*A resource Atlas of Arunachal Pradesh*, Government Publication, Government of Arunachal Pradesh, Itanagar.
[60] Sharda, V.N., *et. al.,* 2012.*Identification of Soil Erosion Risk Areas for Conservation Planning in different States of India,* Journal of Environmental Biology, March 2013. p. 222-225.

for soil conservation, and this, in turn, requires a thorough understanding of the processes of erosion. The factors that influence the rate of erosion may be considered under the three headings: energy, resistance and protection. The energy group includes the potential ability of rainfall, runoff and wind to cause erosion. This ability is termed erosivity. Also included are those factors that directly affect the power of the erosive agents, such as the reduction in the length of runoff or wind blow through the construction of terraces and wind breaks respectively. Fundamental to the resistance group is the erodibility of the soil, which depends upon its mechanical and chemical properties. Factors that encourage the infiltration of water into the soil and thereby reduce runoff decrease erodibility, while any activity that pulverizes the soil increases it. Thus, cultivation may decrease the erodibilty of clay soils but not that much in sandy soils. The production group focuses on the factors relating to plant cover. By interpreting rainfall and reducing the velocity of runoff and wind, plant covers can protect the soil from erosion. Different plant cover affords different degrees of protection and depending upon the land use pattern, human beings can control the rate of erosion to a considerable extent.

1.4 Study Area: Kohima District

Kohima district is located in the southern part of the Nagaland which lies between $94^0$5’11’’to $94^0$7’12’’and $25^0$28’20” to $25^0$31’51”. It has a total geographical area of 1463 sq. km. according to the 2011 census of Nagaland. It is a hilly district sharing its borders with Assam State and Dimapur District in the west, Phek District in the east, Manipur State and Peren District in the south and Wokha District and Zunheboto District in the north (Fig 1.1).

Fig 1.1
Location Map: Kohima District Nagaland



National Highway 39 runs from west connecting Kohima with Assam in the west and Manipur towards the south of the district. Also National Highway 61 connects it with the northern districts of the State. The district has a tropical monsoon climatic condition, with average rainfall varying from 150cm to 280cm, and the temperature varying from 4°C in winter to 29°C in the summer. The altitude varies from 150 m to nearly 3100 m. The district is divided into three regions basing on their location from the main town of the capital city namely northern, western and southern area, where the different villages make up these regions. According to the census of India 2011, the district has 105 villages scattered in an altitude range of 600 MSL to 3048 MSL. The district is divided into 4 (four) Blocks namely, Kohima, Jakhama, Chiephobozou and Tsemenyu Blocks.

1.5 Statement of the Problem

Kohima district has an ideal physio-geographic location with its equable climatic condition which not only makes the region rich in biodiversity but also makes it amenable to any sort of socio-economic development activities. The soil does contain high degree of fertility. As a result, nearly 70% of the region is covered by forest and has many bountiful fauna, having important economic value. Agriculture being the main type of farming, almost all the socio-economic activities of the region is thus, directly linked to the soil. Nevertheless, the area under study being characterized by hill slopes, ridges and steep slopes of the mountains, is vulnerable to seismic occurrences and to natural and man-induced calamities.

Till the recent past, the people of the region could manage to retain the balance of the relationship between environment and man, obtaining their requirements from the nature and conserving the environment with their traditional knowledge in a sustainable way. For centuries the people of the region have sustained from the simple methods of farming but due to increasing pressure on the land and food coupled with advancement in technological knowledge, the thin layer of the soil is deteriorating, putting a threat on the productivity of the land and also on the sustenance of the people. Moreover, the insecurity caused by the increasing population and declining productivity is looming large on the horizon. Therefore, the maintenance of the soil health has become the pressing need of the hour for increasing crop production and also for retaining productivity of the soil for the 'food security'. Majority of the people in the region who are dependent on the cultivation, knowingly or unknowingly, put the threat to the vital source of their life through their actions particularly of agricultural practices. There is a lack of knowledge and awareness with regard to the upkeep of the fragile soil condition. Moreover, it appears that the new acts and laws adopted by the government and which are being encouraged through various governmental programs seem to be not so fitting to the soil system of the region.

1.6 Objectives

1 To identify the different types of land use.

2 To analyze the impact of socio-economic activities on the soil.

3 To study the physical and human impact on the area so as to evaluate the requisite conditions for soil management.

4 To estimate the soil loss in the study area

5 To asses and develop appropriate planning for effective soil management.

6 To encourage people's participation in different agricultural land use for sustainable soil management.

1.7 Hypothesis

1 The human and socio-economic activities cause irreplaceable damages to the soil leading to soil erosion.

2 Jhum practices cause soil erosion, adversely affecting the productivity of the land.

3 Terrace cultivation has less negative impact on the soil erosion than the Jhum one.

1.8 Methodology

The study is based on both primary and secondary data. Collections of information through interviews, questionnaires and visit to the field areasso as to collect the relevant information constitute the main body of information. The sites visited are mostly located in the zone of soil erosion or natural calamities and the prone-areas to the phenomenon.

Secondary source of information has been collected from authentic government publications, official documents, relevant literature books, journals and magazines, newspapers, internet, both published and unpublished research paper and survey conducted by various organizations, viz; census and reports. Satellite images acquired from the National Remote Sensing Centre, Hyderabad have been used for the study. Toposheet maps in the Department of Geography, Nagaland University, Lumami have been used and consulted as references.

Statistical Data such as sampling techniques and cartographic representation of data have been used to analyze the information collected. Remote sensing and Geographic Information System (GIS) also form a major part of the technique for mapping and for the collection of accurate data on the recent environmental changes.

1.9 Review of Literature

Soil plays significant role in the growth and development of the plant. It provides the habitat for decomposer organisms, which have an essential role in the cycling of carbon and mineral nutrients, the basis for economically significant ecological functions. Soil acts as buffer for the temperature change and for the flow of water between the atmosphere ground water through various chemical and microbiological activities. It also provides the basic requirement for the seed germination and hence, a crucial help for the management of the natural ecosystem. The mankind simply depends upon soil for all activities, whether it is agriculture, industry, infrastructure or any recreational purpose. Thus, soil is one of the fundamental natural resources, according to Kumar (2004). More than 79% of the world's food comes from the land rather than ocean and other aquatic system, says Pigmental (1993). Thus, soil needs special attention. The soil has been used in many senses that its meaning is sometimes obscure, in the opinion of Dasmann (1884). According to Ramann (1917), 'soil is the form of rocks that have been reduced to small fragments and have been more or less changed chemically, together with the remains of the plants or animals that live in it'. Joffe (1949), has defined that 'the soil is a natural body of animal, mineral and organic constituents differentiated into horizons of variable depth, which differ from the material below in morphology, physical make-up, chemical properties and composition, and biological characteristics'. In his study on 'Economics of Soil Erosion', Kumar (2004), defined soil as 'the top 15 centimeters thick mixture of clay, silt, organic matter, air, sand, minerals and water which provide invaluable ecosystem services function to the mankind. The mankind simply depends upon soil for all its activities, whether it is agriculture, industry, infrastructure or any recreational purposes'.

Human beings are dependent on soil by design or by accident; people have brought many changes in the physical, chemical and biochemical nature of the soil and altered its structure, fertility and drainage. In the recent years, this precious natural resource 'soil' has been dwindling because of its erosion due to the intervention of both nature and anthropogenic processes. Strahler and Strahler (1976), pointed out that 'slow removed of soil is a part of the natural geological processes of denudation is both in evitable and universal'. Accelerated erosion refers to the increased rate of erosion caused by various land use changes affected by man. Hence, soil erosion normally means accelerated erosion which is also called as man- induced soil erosion because of greater impact of human activities than the natural factors on soil erosion. According to Turk and Turk (1988), soil erosion is an extreme form of soil degeneration in which natural geomorphological processes are accelerated so that soil is removed in rates ten and sometimes several thousand times faster than is the case under the condition of natural vegetation, and sometimes faster than rates at which new soil forms'. Soil erosion, therefore, in other words means the removal of top layer of the soil at a rate higher than the rate of occurrence of new soil, so that the soil depth is reduced and the most top layer of the soil is removed.

Getis *et. al.* (2004) in their study stated that soil erosion is one of the most important causes of soil degradation hazards. Andrew Goudie (2006) in his analysis of 'The Human Impact on Natural Environment' states that the loss of soil humus, whether as a result of fire, drainage, deforestation or plowing, is an especially serious manifestation of human alteration of soil. Carl's O Sauer (1938) too said that soil erosion is a major serious aspect of the human role in the environmental changes, and is not to be doubled. In terms of explanation of erosion, the greatest need is for full recognition of the importance of socio-economic drivers. According to Broadman (2006). B. Singh (1995), in a tropic dialogue, 'Natural resource constitutes the real wealth', argue that, 'We are facing a great crisis. World is becoming ecologically unstable, socially alienated and economically nonviable. These problems have two dimensions: ecological and socio-economic'. Malhotra (2009) also states that, economic development accelerates with the infestation of agriculture and other resource extraction and the takeoff of industrialization, the waste generation increases in quantity and toxicity'. Man induced erosion is globally pervasive. In the past, this induced erosion had been one of the most potent factors causing the downfall of civilization and empires. The ruined cities now lie buried as barren wastes, which were once the world's most fertile lands says Jacks and Whyte (1939). The rapid rate of soil erosion at local, regional and global scale caught the eyes of Jacks and Whyte who presented a picture of soil erosion at world level through their research, 'the rape of the earth' (1993), identified the role of man accelerating the rate of soil erosion, and suggested that the need for soil conservation and control measure against soil erosion. From time immemorial, soil erosion has been a natural occurring process according to OMAFRA, (2003). Ananda and Herath, (2003) also says, that at present, it is the single most important environmental degradation problem in the developing world.

Mayers (1988) has well summarized the scale of accelerated soil erosion that has been achieved by human activities; 'Since the development of agriculture some 12,000 years ago, soil erosion is said to have ruined 4.3 million km squares of the agricultural land, or an area equivalent to rather more than one third of the today's crop-lands. The amount of degradation can already be put at a minimum of 200,000 km^2per year'.

Judson (1965) was one of the first geologists to assess the world soil erosion. He estimated that the amount of river-borne soil carried into the oceans had increased from9.9 billion tonnes a year before the introduction of agriculture, grazing and related activities, to the present rate of 26.5 billion tonnes. Hydrologists estimated that one-fourth of the soil lost through erosion in watershed actually makes it to the ocean as sediment (FAO/UNEP, 1978). The remaining three forth is deposited on foot hill slopes, in reservoirs, in river plains and other low-lying areas or in the river-bed itself, which often causes channel shift and floods.

In an overview of global erosion and sedimentation, Pimental *et. al.*(1995) further stated that more than 50% of the world's pasture land and about 80% of agricultural land suffers from significant soil erosion. Vohra (1985), estimate the loss of top soil by water action at 1200 million tonnes every year. More than 16% (52 million ha) of the total land area of the EU and 35% in the EU accession countries are estimated to be affected by some kind of degradation process (Commission of the European, 2002). According to the estimate made by the experts of European Environment Agency (1998) approximately 12% (115 million ha) of the total European land area are affected by water erosion and another 4% (42 million ha) by wind erosion. Detailed 15 observations have shown that the extent of global soil erosion has increased to almost 100 million tons per year as against 45 million tons per year in 1960 and just 16 million tons per year.

Evans (1982) states that 21% of the arable land in England and Wales has a risk of soil erosion. When rill erosion is included, mean annual rates in the United Kingdom rose to 44 tons/ ha/ year on bare sandy soils and 20 tons/ha/ year on sandy loam soils under cereals (Morgan, 1978).

Jiang, Qi and Tan (1974) states that the rates of erosion for the Huang He catchment, China, are among the highest in the world. The mean annual rate for the 30,217 km^2 drainage area upstream of Chuankou is 90 tons/ha/ year. Much higher rates are recorded on small gullied watersheds 185 tons/ha/year in the Shejia gully and 196 tons/ha/year in the Tuanshan gully, mean annual rates as high as 708 tons/ha/year are recorded on gully beds, 362 tones/ha/year on farm roads and 265 tons/ha/year on steep slopes affected by landslides. Rates due to splash, rill and shallow gully erosion on farmland ranges from 158 to 199 tons/ha/year. According to Giordano and Marchisio(1989),the soil erosion is one of the main problems of agriculture in the Mediterranean countries of EU. Several works have been done about erosive status mapping at regional scales in Spain and other places (Bougonoviae *et. al*., 1999). Bellinfamte *et. al.* (1999), Martinezzavala et al. (2000) and Jordon *et. al.* (2000) has carried out some interpretations of the erosive process of geomorphologically active in the area as well as their intensity in connection with the erosion risk. Whitllow (1984) state that the environmental deterioration which has taken place in communal lands and elsewhere in Zimbabwe poses serious ecological effects in the form of rapid silting up of reservoirs, drying up of wells and declining crop yields.

England and Lessene (1962) studied the effect of single crop cover on run-off and soil losses, wherein they observed some interesting and useful changes in physical properties of soil related to movement of water and the information was useful for making maximum use of water for protecting soil from erosion or flood damage. Quansah (1982) designed a series of laboratory experiments specifically to investigate interactions. He found that the detachment of the soil particles by raindrop impact was influenced by a soil rainfall interaction, it increased with slope steepness more rapidly on clay soils where the particles are carried. These interactions are not accounted in field experiments using erosion plots. A great deal of attention has been directed towards quantifying general relationships between basin sediment yield and climate (Langbein and Schumm, 1958; Fournier, 1960; Douglas, 1967 and Wilson, 1973). The climatic parameter generally used was mean annual runoff and air temperature. Leopld *et. al.* (1971) demonstrated how various techniques for measuring hill slope erosion processes could be used to obtain a sediment budget for a small rangeland catchment. A major problem with all field methods which involve installing even simple equipment, however, is susceptible to theft or disturbance. Evans (1980) reported that the factors contributing to soil erosion in lowland England, landforms appeared to be the critical factors controlling its incidence. Erosion generally occurs on slopes steeper than three degrees associated with marked convexity between the ridge crest, where water is stored and the valley side, where runoff begins. Eroded soil is deposited on the foot slope concavity. Lutz (1934) and Peel *et. al*. (1937) investigated aggregate stability and soil properties including the clay in the soil observed them related to soil erosion.

The importance of the characteristics of the rainfall in relation to erosion problems in tropical zones has been stressed by several authors (Roose, 1972; Hudson, 1975). Duley (1939), Pereira (1956), Rose (1960, 1961, 1962), Jones and Wild (1975) and Panabokke (1977) studied on the process of destruction of aggregates on the soil surface by raindrop impact in tropical soils, showing its relationship with some physical and mineralogical characteristics of the soil and its influence on runoff and erosion. Simulated rainfall has been used by several investigators in these studies (Pereira, 1956; Rose, 1960; Hudson, 1961; Moldenhouer, 1965; Meyer, 1965; Bruce-Okine and Lal, 1975; El Swaify, 1977; De Meester *et. al.,* 1977).

Soil erosion in India has been severe for centuries, but its impact on regional and national economy has only been acutely felt during recent decades. The high rate of population growth (Anon, 1975) and livestock has resulted in over exploitation of natural resources to meet the ever increasing demand for food, fodder and fuel. Dhuva Narayan and Sastri (1985) stated that in India, out of the total geographical area of 328 million hectares, 175 million hectares of land are degraded in one form or other. According to the UNDP, 1997 report about 6-7 million hectares are being lost annually due to soil erosion. At 16.35tons per hectare a year, India’s increase in the rate of total soil erosion in the world can be attributed to the natural processes as much as to the result of man influences. M. Sudhakaran Pillai (2007) highlights that in India, it is estimated that 27% of land area is subjected to soil erosion leading to a loss of about 6000 million tonnes of top soil annually. An estimated 175 Mha of land in India, constituting about 53% of the total geographical area (329 Mha), suffers from deleterious effect of soil erosion and other forms of land degradation. Active erosion caused by water and wind alone accounts for 150 Mha of land, which amounts to a loss of about 5.3 Mt of sub-soil per year. In addition, remaining 25 Mha lands have been degraded due to ravine, gullies, shifting cultivation, salinity, alkalinity, and water logging. Dhruvanarayana and Rambabu (1983) have estimated that in India about 5,334 Mt (16.4 t ha−1) of soil is detached annually; about 29% is carried away by river into the sea and 10% is deposited in reservoirs resulting in the considerable loss of the storage capacity.

Thirunaranan's (1936) study of soils was probably the first geographical account of soil formation in India. It was, however, only after the turn of the mid-century that the subject received considerable attention and a number of studies covering different parts of the country appeared in quick succession. The works done on the concerned topics in different areas are by S.K Mukerji on Bengal, K.L Khana and B.N Mukerjee on Uttar Pradesh, J.K Basu (In collaboration with V.D Tagore) and R.V. Joshi in Gujrat and Maharashtra, R.S Gupta and K.M Mehta on Rajasthan and O.P Bharadwaj on Punjab. These and other similar studies made during the fifties and sixties are mainly concerned with the classification of soils into different types and their regional distribution, underlying the relationship with features of structure, topography and climate on the one hand with the aspects of agricultural system and products on the other.

The works of Puri (1956), Bharadwaj (1961) and Nigam (1968) deal with the north-western region of the country. The problem of soil erosion in Uttar Pradesh has been studied by Khan (1955) and Mukherjee and Mukherjee (1957). Verma (1966) examined the extent and causes of soil erosion in Madras State and Sagar district respectively. Kayastha (1965) attempted survey of soil erosion menace in India as a whole. All these studies have analyzed the factors and causes of soil erosion such as unplanned deforestation, steep gradient, torrential rains, faulty agricultural practices and over grazing and have emphasized various remedial measures such as gully reclamation, terracing of slopes and highlands, control of cultivations, construction of reservoirs and levees, control and regulation of water in catchment areas, check on indiscriminate felling of trees and planned afforestation.

Singh, *et. al*. (1992) conducted a study on soil erosion rates in India, in an attempt to prepare a country wise maps of soil, rainfall, erosivity, slope, landuse, forest vegetation, degraded land, sand dunes and irrigation were used. Soil losses for a number of places were estimated using the universal soil loss equation (USLE). Based on these 21 observed and 64 estimated soil data points spread over different resource regions of the country and by superimposing 8 above mentioned maps, iso-erodent rate lines were drawn. An annual erosion rate due to water is less than 5 mg/ha/year (2.2 tonnes per acre) for dense forests (above 40% canopy), cold desert regions and arid regions of India. The area revealing severe erosion more than 20 mg/ha/year, includes the Shiwalikh hills, northern Himalayan regions, ravines and shifting cultivation areas.

Sharma, *et. al.* (1994) prepared a soil erosion map of Gujarat classifying the area under four qualitative erosion classes of slight, moderate, severe and very severe. The estimation of soil loss has been made by evaluating the various parameters of universal soil loss equation (USLE). In India, Ram Babu and others used this equation to obtain positive correlation between various quotients of this equations and measured soil loss at Dehradun in North India. The USLE is considered good enough to predict soil erosion in a manner to the process bases models like RUSLE and WEPP (Laflen,*et. al.,* 1997). Das,*et. al.,* 1981 reported that 28-77 percent of catchment of Himalayan rivers are in need of urgent treatment for sediment control. Giri river, a major tributary to Yamuna river system contributes about 2.49 million tonnes of suspended sediment annually, posing a serious threat to the soil resources (Chaudhary and Sharma, 1998).

Bhattacharya (1997) observed that more than 15,000 tons/ha/year of soil is under high potential soil erosion in north western hilly part of the Rakti river basin. Gupta (1993) studied the soil erodibility under different land uses and concluded that erodibility of the soil under different land uses had been of the order of bare cultivated pasture and forest land use soils.

Soil erosion in India has been progressing for centuries. The National Commission of Agriculture (Anonymous, 1975) has given an estimate of erosion on the basis of available information, stating that out of the total area of 328 million hectares, the area subject to serious water and wind erosion is 175 million hectares, and the area at critical stage due to erosion is 69 million hectares, area subjected to wind erosion is 32 million hectares, area affected by gullies and rain is 4 million hectares, area under shifting cultivation is 3 million hectares and the area under rain fed farming is 70 million hectares.

The studies made by Bhattacharya (1956), Pathak and Verma (1958), Acharya (1958) and Roy (1942) for the eastern regions of India are worthy to be mentioned.Assessment of soil erosion in Dikrong river basin of Arunachal Pradesh (India) was carried out using the USLE method by Dabral P. P.,*et.al.,* (2008). Rawat,J. S., *et. al.,*(2013) estimated the erosivity index and soil loss under different land uses in the tropical foothills of Eastern Himalaya of Arunachal Pradesh. Climate change impact on soil erosion in the Mandakini River Basin, North India was studied by Khare, D, *et. al.,*(2016). Assessment of soil Loss of the Dhalai River Basin, Tripura, India using USLE by Kapil Ghosh, Sunil Kumar De, Shreya Bandyopadhyay and Sushmita Saha (2013). Poreba,G. j., and Prokop,P.,(2010) estimated the soil erosion on cultivated fields on the hilly Meghalaya plateau, north-east India. Dr. Chadha (2005) in his research on ‘Ecology of the Naga Hills of the eastern Himalayas- a case study of alder tree’, states that the deforestation of the tree cover in the Naga hills of the eastern Himalayas has adversely affected the climatic pattern, fuel supply, water in the catchments areas, soil erosion, fresh floods etc. Further he stated that the naked hill, devoid of flora is no longer capable of absorbing the rain water and sustains any productive vegetation. Even the plains due to excessive irrigation have become alkaline or saline and have become useless for cultivation. In the wake of development of the area, the precious wealth of the state is being destroyed. If attention is not paid to this aspect of the state the economic development and the industrial growth is bound to be retard.

The consequences of such large scale soil erosion are causing serious concern to the very question of sustainable development. Nevertheless, some scientist believed that man is responsible for more than 50% of the total erosion. According to UNESCO "Nature and Resource" (1983), even if this average figure is rather a rough estimate, it is evident that in some environments man-induced erosion is definitely predominant'. Needless to say that we are greatly affected by erosion, soil erosion, in particular, represent a major thread, and it is a process in which we ourselves often play a major part.

Misra in the research on ' Law and Environmental Ethics' mentions that human himself is a part of nature and when he manipulates the nature beyond his needs than life existence is threatened. Soil erosion is not only caused by agricultural activities but also by the rapid growth of urbanization without proper planning for development. Madebwe (2005) mentions that high urbanization rate and correspondingly high demand for urban infrastructure has placed a great demand on available land resulting in competition between land uses. Growth of population also plays an important part in accelerating soil erosion. Getis, *et. al.,*in the book 'Introduction to Geography' also mentions that increasing population members are largely responsible for accelerating soil erosion.

Funnell and Parish (2001) give the reason how growth of population causes soil erosion by stating that 'the growing population increases the demand for fuel, construction timber and fodder requirements. In addition forest and scrubland are cleared to provide more land for cultivation. This resulted in the great pressure on the forest covers'. In other dimension, Schess and Yadav argue that by the year 2020, soil erosion may pose a serious threat to food production and rural livelihood. Significant in this is that as soil gives away its fertility, human beings lose their fundamental living source they rely on. On May 28, 2002, the Beijing Time mention that this is the reason why soil erosion has been identified as the direct cause of environmental deterioration and poverty in many parts of the world. Soil erosion can have a devastating impact on the vast numbers of rural people who depend on rain-fed agriculture in the mountain and hillside areas.

Dr. Das (2000), in a research paper mentions that though the techniques for increasing production and conserving soil and water resources are already available yet are not widely used or systematically applied. A systematic approach is needed for identifying land uses and production systems that are sustainable in each land and climatic zone, including the economic, social and institutional mechanism necessary for the implementation. In 1992, the UNCED (Rio) also raised concerned about the issue of the soil erosion and land degradation. In its agenda 21, it is stated;

> 'Land is a finite resource, while the resource it supports can carry over time and according to the management condition and uses. Expanding human requirements and economic activities are placing over increasing pressures on the land resources creating competition and conflict and resulting in sub-optimal use or both land and resources. If, in the future human requirements are to be met in a sustainable manner, it is now essential to resolve these conflicts and

move towards more effective and efficient use of land and its natural resources' (1992).

Soil erosion is a matter of concern for all including the scientist, policy makers, administrators, etc. Besides affecting food production and siltation of reservoirs, it is the basis of environmental degradation. According to Pirazizy (1992), the proper measures regarding soil conservation depend incomprehension of intricate relationship between land, its uses, its users, socio-economic and socio-temporal environment. Government organizations and policy makers have been implementing many policies for the conservation and management of soil but most of the laws and policies fail at the local and regional level as well. The failures are to be blamed either for being uncritical or for being too general as argued by Young (1989). Hudson (1992) states that current approaches to soil conservation give more attention to reducing soil erosion by improving soil cover rather than the construction of physical structures. Rao (2001) in his book 'Sustainable Development, Economic policy', mention that the problem must be viewed in terms of their implication on the sustainability of productivity of land, considering the projection that the global demand is expected to increase. In a seminar paper submitted to 'Organization & Environment', Levidow (2004), mentions that the term 'sustainability' encompasses divergent accounts of the problem to be solved and this is very true as term 'sustainability' is very broad. Principle 8 of the Rio Declaration on Environment and Development also states that, 'To achieve sustainable development and higher quality of life for all people, status should reduce and eliminate unsustainable patterns of production and consumption and promote appropriate demographic policies'. Approach to the Eight Plan Document in India mentions that every effort need to be made to promote grass root level participation in the task as part of a larger approach to the local area planning and development. In a three day training program on 27th Nov.2009 on Integrated Plan Nutrients Management (INM) and on various aspects of soil fertility management for sustainable soil and crop production in Nagaland led by a team from Division of soil chemistry and fertility, Indian Institute of Soil Science (IISS), Bhopal come into conclusion that the increasing population and declining productivity of food crops had indicated looming food insecurity in the days to come and therefore the maintenance of soil health was the pressing need of the hour for increasing crop production and also for retaining productivity of soil for the 'food security'. Further, it states that the foremost important consideration for food security was the INM. Schaller (1993), states that 'Conservation cannot be imposed from above. Any conservation effort must involve the local people, based on their interest and it must initiate programs that offer them spiritual and economic benefits'.

The above, no doubt, deals with various aspects of soil erosion prevalent at various regions on a large scale. The review of the studies conducted by different scholars on the degradation of soil condition and the factors leading to it exposes one to greater depth of the subject matter. It also enlightens one on the methods and techniques employed in this kind of study. However, coming to the specific area considered for the present study, mention maybe made that so far none has done any study on the proposed area in the real sense. Whatever literature is found and being published on the state of Nagaland hardly is there any detail study on soil erosion which is becoming a great concern for some parts like Kohima district of Nagaland. Therefore, the present work shall be a kind of pioneering endeavor so as to ascertain the vulnerability of the area to soil erosion due to myriad factors and to find the measures for the amelioration of the same.

CHAPTER 2
PHYSICAL FRAMEWORK OF THE STUDY AREA

2.1 Kohima District: Study Area

Nagaland became a full-fledged state on December 1, 1963 under the State of Nagaland Act, 1962 (Act No. 27 of 1967) as the 16th state of India Union comprising the erstwhile territory known as "Naga Hills Tuensang Area". Spreading over an area of 16,579 sq. km. the state of Nagaland, the 16th state under Indian Union is gorgeous with striking hills and beautiful mountain ranges. It is located between 25^0 6' N and 27^0 4' N latitude and between the longitudinal lines $93^0$20' E and $95^0$15' E. The state is bounded by the states of Arunachal Pradesh in the north, Manipur in the south, Assam in the west and it shares an international border with Myanmar on the east. It is blessed with great valleys, meandering streams and runnels, high mountains, deep gorges and rich valleys of flora and fauna. Saramati (3840 m) is the highest peak where the Naga Hills merge with Patkai range in Myanmar. Japfu(3048 m), Zanubou (2750 m) and Kupamedzu (2620 m) are some of the other important high peaks of the state. Dhansiri, Doyang, Dikhu, Milak, Tizu and Zungki are the main rivers that flow through the state. Of the rivers, Doyang is the largest as well as the longest.

The entire administrative area was then divided into 3 districts, namely, Kohima, Mokokchung and Tuensang. During the period of 1971-81, four more districts were created by the state government under its notification no. APA.15/12/17, dated 19.12.73. The districts were Phek, Wokha, Zunheboto and Mon. Dimapur was added as a district in 1997 out of the district of Kohima vide Government of Nagaland, Home department notification on GAB-5/29/78 (pt.) dated 02.12.1997. Thereafter, three more new districts were formed in the State in the year 2003, viz, Longleng, Kiphire and Peren through Government of Nagaland, Home Department Notification no. GAB-3/5/93 (pt-II) dated 24th October, 2003. Longleng and Kiphire were formed by transferring the administrative circles out of Tuensang district and Peren out of Kohima district. Now the state has a total of eleven (11) Districts.

Kohima became the headquarters of the Naga Hills under British administration in1878. It, falling under the Kohima district then became the capital of Nagaland in 1963 when the State was formed. Since then, parts of Kohima district have been sliced off thrice - the first in 1973 when Phek District was created, then in 1997, Dimapur was carved out and declared as a separate district and it was in 2003 for the third time that Kohima district once again gave birth to one of the youngest districts in the state i.e. Peren. At present, Kohima district has an area of 1463 sq. km. representing8.82 percent of the total area of the state of Nagaland (2011 census). In terms of area, the district occupies the seventh place among the eleven districts of the state. The district has four Rural Development Blocks namely; Kohima, Chiephobozou, Jakhama and Tseminyu and eight circles: Tseminyu,Tsogin, Chiephobozou, Botsa, Kezocha, Jakhama, Kohima Sadar and SechuZubza. The district has 105 villages in 2011Census which are all inhabited predominantly by Angami and Rengma Nagas. It has two statutory towns, namely, KohimaTown and Tseminyu Town and one Census Town namely, Kohima Village. Tseminyu Town as a statutory town was notified after Census 2001.[61]

The ancient history of Nagaland as a whole is shrouded in obscurity. The oral tradition is the only main source through which their history has been passed down through generations. The Nagas are Mongoloid by race which spread all over the world as far as China and South America. Nuh states that, *"History unveils that the Nagas are from a higher civilization which flourished somewhere in South East Asia from time immemorial".*[62] In *'The Angami Nagas'*, Hutton says that the second migrationwave from northwest China originating between the upper Yangtzeand the Ho-ang-ho river is mentioned as the Tibeto-Burman-*speaking* peoples.[63] A tradition in vogue amongst the

[61]District Census Handbook Kohima, 2011. *Series-14 PART XII-B*.p. 11-12.
[62]Nuh, 2002.*My Native Country: The Land of the Nagas*, Delhi & Guwahati: Spectrum Publications for Research Department, Council of Naga Baptist Churches. p. 2-3.
[63]Hutton, J. H., 1921. *The Angami Nagas,* London: Macmillan. p. 6-9.

Angami, the Rengma, the Lotha and the Sema is that, their fore-fathers came almost together in one group of migration via Manipur from Myanmar. Another belief holds that the Angami and the Karen tribes were close kinsmen who were living together. An Angami tradition corroborates it and says that Piphema village (which is now under Dimapur district) and Kigwema village were among the original Karen villages but because of the Angami preponderance the Karen diffused elsewhere.[64]

2.2 Geomorphologic Characteristics

Geomorphology is the science dealing with the study and interpretation of the origin and development of landforms and the earth's surface. It includes the study of the landforms and of the processes operating on them. The primary areas covered are weathering, hill slope, mass movement, fluvial features, glacial features, aeolian feature, coastal and karts landforms. Therefore, it involves the study of specific landforms and how each landform is related to others in space and time. The most important concept in geomorphology is the cycle of erosion known as geomorphic cycle. The soil from the land surface is eroded by wind or water action and the eroded material is transported through gullies and streams and then to the sea. In this process the land slope gradually decreases and the continually eroding land mass passes through various stages known as youth, maturity and old age. The change of landform with time is referred to as the stage of development of the land form. Ultimately the entire land mass reduces to near sea level called peneplain.

It may be recorded that geologists, hydrologists, penologists, ecologists and geographers have stepped into the field of geomorphology with a view to solving diversified problems of landforms in relation to man. Davis (1969) in his *'forward looking'* concept says that geomorphology has been keeping pace with the changes in other earth sciences

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[64]Kumar, B. B., 2005. *Naga Identity (1st edition)*, Concept publishing company, New Delhi-110059, ISBN 8180691926.p. 101.

in terms of techniques, concepts and aims.[65] The most significant change has been the input of morphometric and quantitative methods by Davis (1922) especially in the field of terrain evaluation.[66] The classic power of Horton (1945) surely constitutes a break-through in fluvial geomorphology.[67] Following the modification of Horton's (1945) morphometic analysis, the geomorphic relation among different landscapes and the functional behaviors of the geomorphic variables of drainage basins are well documented in the works of Strahler,[68] Schumm[69] and Chorley.[70]

Nagaland, which was once submerged in the deep Tythyan Sea, presents complicated structural and physical features and the formation of landmass may be co-relatable with the young fold mountains of the Alpine Himalayan orogeny. As a result, its topography is similar to that of any other young mountain terrain features with hills, sharp ridges, deep gorges and narrow valleys. The hills are a continuation of the Burmese arc being joined with the sub-Himalayan ranges in the north. The ranges stretch in general from north-east to south-west.

The study region has its own uniqueness. The relief of the dissected hills, worn down hillocks, the plains, the slope and drainage characteristics of the region have their own uniqueness (Fig. 2.1). So far relief and geological foundation are concerned, the region is an 'epitome' of India as it has steep hill slopes of tertiary Himalayan origin in the south and west, hills and hillocks of Precambrian rock types in the northern parts and alluvial plains of the sub–recent and recent origin in the western margin. The plain

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[65]Rahim Hamood, R., 2009. *In Cycle of Erosion propounded by Davis and Penk Computerative Study*, AL-Fatih Journal .No.38.p. 29.http://www.iasj.net/iasj?func=fulltext&aId=16936,access on 8/2 /15.

[66] Davis, W. M., 1922. *Peneplains and the Geographical Cycle,*Bull. Geol. Soc. Soc. Am., 33. p. 587-598.

[67] Horton, R.E., 1945. *Erosional Development of Streams and their Drainage Basin: Hydrophysical Approach to Quantitative Morphology*. Geol. Soc. America Bull., v. 56. p. 275-370.

[68] Strahler, R. L., 1957. *Quantitative Analysis of Watershed Geomorphology,*Am. Geophys. Un Trans., 38. p. 913-920.

[69] Schumm, S. A., 1956. *Evolution of Drainage Systems and Slopes in Badlands at Perth Amboy*, New Jersey: Geol. Soc. America Bull. V. 67. p. 597-646.

[70] Chorley, R. J., 1957.*Illustrating the Laws of Morphometry*, Geological Magazine, v. 94.p. 140-150.

shows depositional features of much geomorphic significance in the western foothill zone while on the northern and southern margins, the area is marked by erosional platform as well as colluvial deposits. The area is being drained by many sub tributaries of some major river systems of Nagaland and also by rivers like Dima or Dhansiri and Sidzu (extreme northern part is called Doyong) from south to north, Japfu or Barak river from east to south-west direction. There are many tributaries originating from the southern and middle highland areas which traverse the study area joining the two main drainage systems (Goswami, 1985).[71] It is interesting to note that water in all the rivers rises up rapidly during the rainy days but abruptly falls when the rainfall subsides. Therefore, most of the streams remain dry or almost dry during the dry season. This may be due to steep slope and high degree of porosity of rock in the area. The porous nature of rocks gives rise to a large number of temporal seepages which cause gully erosion and massive landslides here and there. Folds, faults, dissected plateaus, interlocked ridges, domes, steep hilly sides and landslides are among the geomorphic features of the hilly area. On the contrary, the swamps, marshes and beels are the regular features in the plain section on the western part of the district. In keeping with the theme of the study, the terrain of the study area which has its own role to play in the economic activities of the people can be broadly divided into five categories.

Alluvial plain: This division, the lowest part of the district, occupies the low lying western part ranging in elevation from 140-100 meters. It accounts for only 2 per cent of the total area of district. It is composed of new and old alluvium and spreads out randomly in the low lying area at the base of the mountains, near the streams and rivers. Generally, the slope in this division is not more than 8^0.

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[71] Goswami, D. C.,1985. *Brahmaputra River, Assam, India: Physiography, Basin Denudation and Channel Aggradation,* Water Resource Research, 21. p. 959-978.

Soils consist of sand, clay and silt. Its colour is mostly brown, dark-grey and yellowish-red.[72]

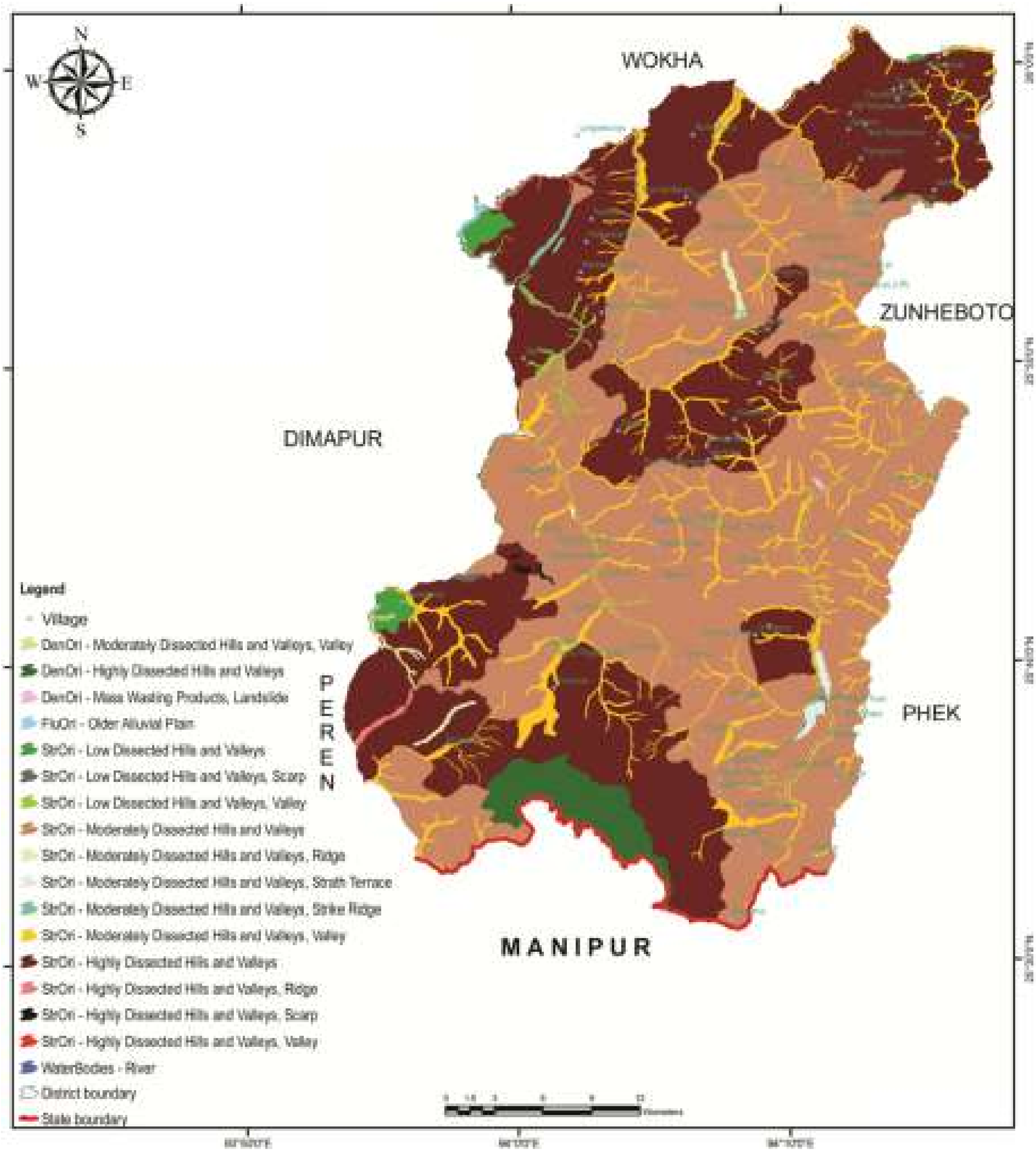
Undulating zone: These gentle lower hills extend prominently on the western part next to the alluvial plain and continue to stretch far to the north-east and south-east of the district in narrow strips. It is the most extensive zone and occupies 50 percent of the district. Its elevation ranges from 300-900 meters. As it is the most extensive one, the slope angle varies widely from 8^0 to 22^0. This gently sloping zone includes the broad belt of western Medziphema sub-division, Piphema areas and valleys of the major river systems in the district in a NNW and NEW direction. The area is formed of massive sandstones with subordinate clays and shales over the lower part on one hand and unconsolidated mass of boulders and pebbles interspersed with clay and soft sand relatively higher parts on the other that belongs to Mio-Pliocene age. Major rivers draining the area are Barak, Dzuku, Sidzu, Dzuli, Dzudza and Diphupani. Bluish grey and mottled clay soils are very common here.

Piedmont Zone: It extends from elevation 900–1500 metres which runs prominently except at the central part with a narrow band. In northern and southern part of the district this zone displays extensively eastward of the district. This relief unit covers an area of 31.51 per cent of the total area and it belongs to the Disang group extending from the Upper Cretaceous to Upper Eocene. It is characterise by well-bedded splintery, dark-grey shales intercalated with thin, fine-grained and well cemented flaggy sandstones. The areal extent covers Zubza, Kohima town and adjacent areas, Chephobozu and central part of Tseminyu area. So, this relief unit has the second highest population and settlement including the capital town of Kohima. Slope in this area is roughly

[72] Kunte, S.V., 1988. *Geomorphic Analysis of Upper Assam Plains and Adjoining areas for Hydrocarbon Exploration,* Journal of Indian Society of Remote Sensing 16. p. 15–28.

between 5^0-30^0. At the base of the hills, landside hummocks are usually developed which have rough rounded surfaces.

Fig. 2.1
Geomorphological Map: Kohima District



Source: GIS Centre, Nagaland.

Dissected highland Plateau: It is a broken strip of land scattered over the highland areas. The plateau extends in a massive way only in the southern part of Kohima district, i.e. North of Manipur. Its elevation runs from 1500-2100 metres and covers an area of 10.20 per cent of the total area. The rocks are of

Barail group which consists of Moliassic sediments. It ranges in age from Upper Eocene to Oligocene. The rocks are massive, uniformly hard, ferruginous sandstones which are very thick-bedded and intercalated with minor shale. The drainage density is highest here with 302 km/km^2. Areas drained primarily by insequent streams show lack of any preferential courses with many random bends. Tributaries enter large streams usually at an acute angle to the general direction of regional flow which is determined by regional slope. The pattern produced is like the complex branching of a tree and because of this it is termed dendritic. Dendritic drainage patterns are characteristic of terrains showing lithological, structural and topographic homogeneity (Drury, 1987)[73] such as flat-lying sedimentary rocks and granite. Slope of this zone varies between 29^0-36^0 and dips in the NS-EW direction.

Structural Hills and Mountains: This region of high mountains covers only 3 percent of the total area land but represents the most prominent topographic expressions due to the presence of deep gorges influencing high rate of erosion caused by heavy rain, steep slope and high absolute relief. It includes the second highest peak, Japfu (3048 m) in Nagaland. This zone comprises mainly Japfu and Barail ranges. The rocks are of Barail group with sedimentary structures such as ripple marks, load casts, flute casts, current bedding, etc. The rocks are massive, uniformly hard, ferogenous sandstones which are very thick bedded and intercalated with carbonaceous shales. This landform is the most precarious one having cliffs and bare rocky faces especially on Japfu and Barail mountain chains. Hogback develops on the south-western face of Japfu and south eastern part of Barail mountain chains. Japfu and Dzuku rivers have their sources in this

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[73] Drury, S. A. (1987). *Image interpretation in Geology*. Allen and Unwin. London.

mountain chain. V-shaped valleys, deep gorges emerge out of steep slope (above 36^0) due to heavy rain, high surface runoff and high erosivity.

2.3 Geological Setting

Geologically, the Northeast India represents northern part of an Orogenic province, termed as Assam-Arakan. Two orogenic belts warp around its northeastern corner marking the zone of plate convergence. The Himalayan belt on the north marks the collision zone and the Assam-Arakan belt (IBR) on the southeast marks the collision front of the Indian plate with the amalgamated Indo-Sinian and Malaysian plates.[74]The Naga-Hills being a part of the Tethyan Orogenic belt present a complicated structural and tectonic history of its development which is characterized by multi-phases of deformation, metamorphism and igneous events. The rocks are comparatively young of tertiary origin. According to geo-scientist, 'this region was under a sea which existed between India and Myanmar till the tertiary period. The land which now joins India and Myanmar did not exist at that time but came up much later'.[75]

Marine deposition took place on that sea floor layer after layer which is not represented by Disang group formation giving rise to shale, and stone, phyllite, slate and lime stone. The areas remained submerged for nearly 65 million years, till the Eocene period, when a powerful crustal movement initiated the first phase of mountain building activity. The sedimentary and volcanic rock layers were finally uplifted due to compressive forces from the sea floor, thus forming the first folded mountain. During this process the water receded to the south into the present Bay of Bengal.

The first Orogenic movement was partial, between the newly formed mountain chains and the sea water continued to remain. Again on this basin sedimentation took place

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[74] Acharyya, S. K., 1991.*Late Mesozoic to Early Tertiary basin evloiution of the Northern and Eastern Collision margins of the Indian Plate,*Journal of Himalayan Geology, 1. p. 75-91.
[75] Ghosh, B. B., 1982.*History of Nagaland*, S Chand and Co. Ltd. New Delhi.p.5.

which is today known as the Barail group formation. After the formation of Barail, Surma and Tipam groups of rocks, a second Orogenic movement took place in this region which gives rise to the more north-east, south east trending hill ridges and valleys. The hills of this Orogenic movement are higher than the previous one. This movement took place during the periods of Oligocene, Miocene and Pliocene (Table 2.1). The third Orogenic movement occurred during the Pleistocene and recent periods and it shaped the present topographic features. It may be noted that all these three major Orogenic movements were contemporaneous to the great Himalayan Mountain building activities.

Facing Himalayan ranges across the Brahmaputra valley and stretching NE-SW along the eastern margin of Northeast India and bordering Myanmar, lies the Naga Hills. It represents the northern extension of the Indo-Burma Ranges (IBR) linking the Arunachal Himalaya to the north and Andaman-Nicobar Islands to the south. The N-S trending Patkai, Barail and associated ranges with their varied structural styles impart youthful geomorphology to the Naga Hills. The cenozoic sedimentary cover in Nagaland accounts for nearly 95 percent of the area whereas the rest is being occupied by igneous and crystalline rocks of mesozoic-cenozoic age. These exhibit a general trend of NNE-SSW with moderate to steep dips towards NW and SE. Based on the morphotectonic elements, the Naga Hills has been longitudinally divided from west to east into three distinct units;

a. The belt of Schuppen in the north-west bordering the Assam plains

b. The Inner Fold Belt

   i). The Patkai Synclinorium in the south east along the middle part of the intermediate hill range

   ii). Kohima Synclinorium in the south and south east of Kohima town

c. The Ophiolite Belt.

Table 2.1
Tertiary Succession: Kohima District

	Recent	Newer or low level	clay, sand, silt and shingle
	Unclassified	Alluvial	…………………………..
	……………..	Unconformity	…………………………..
Q			
U			
A			
T	Pleistocene	Older or high level	Clay, coarse sand, shingle,
E			
R			
N	……………	Unconformity	…………………………..
A	Pliocene	Dihing Dihing	Pebble bed, soft sandy clay, Clay, conglomerate, Grit and
R			
Y	Pleistocene	group formation	Sandstone
	…………..	Unconformity	…………………………….
	Mio-Pliocene	Dupitila Namsang Group formation	Sandstone, mottled clay, grit and conglomarate
	…………..	Unconformity	……………………............
	Tipam Group and subordinate gritty sandstone.	Girujam formation	Mottled clay, sany. Shales
	Mocens Formation	Tirnm sandstone coarsy to gritty false beddeg,	Bluish grey to greenish terru-genous sandstone, clay, shale and conglomerate.
T		Joka Bil formation	Shale, sandy shale, siltatone, Mudstones and lenticuiar coarse
E			
R	Suama Group		ferruginous sandstone.
T		Bhuban formation	Alternations of sandstones, sandy shale and thin conglomerate and shle in middle part.
I			
A	…………………………	Unconformity	……………………………………..
R		Renji formation	Missive and bedded
Y	Upper Eocene Oligocene Barail Group	Jenum formation	Shale, sandy shale and carbona-ceous shale with interbedded hard sandstone.
		Laison formation	Well, bedded, compact flaggy sandstone sand subordinate shale.
Upper Cretaceom Lowered Middle Eocene	Disang Group		Splintery dark grey shales and thin sandstone beds.

Source: Geological survey of India (GIS).

A belt of about 20 km broadens with its northwestern edge following closely the boundary of Assam valley alluvium and the north east edge along the Disang thrust which is known as ‘Belt of Schuppen’. Of the north-western flanks of the Naga Hills, the belt of Schuppen consisting of eight or more over-thrusts overriding one above the other forming an imbricate pattern. Along this thrust the Naga Hills region has moved north-westwards relative to the foreland spur. The north-western margin which for many kilometers follows the boundary along the outer fringe of the Naga Patkai ranges is conventionally called the Naga Thrust separating the sharply folded sediments of the “Belt of Schuppen” from the little affected flat to gently dipping beds lying north of this belt.

The Inner Fold Belt occupies the central part of Naga Hills and extends up to Pangsau pass in Arunachal Pradesh. A large spread of Disang rocks with isolated covers of Barail as well asDisang-Barail Transition sequences characterizes the geological setting of this belt. The Palaeogene rocks have been folded into series of anticlines and synclines and are confined within two major tectonic zones viz. Haflong- Disang thrust to the west and the Ophiolite Disang thrust to the east. According to Mathur and Evans (1964), the Inner Fold Belt is occupied by two major synclinoria, namely; the Kohima Synclinorium to the south and Patkai Synclinorium to the north, the Mokokchung and adjoining areas being the culmination point of the two.

The Kohima Synclinorium, a part of which comes within the present study, is one of the most prominent structural units in the inner fold belt of Naga Hills and it occurs near to the south-west of the Patkai Synclinorium with a little southerly pitch. This Synclinorium lies mainly within the Disangs but towards the Surma Valley, higher groups of rocks have been found. It is bounded in the north-west by the Disang thrust and in the south it merges into the eastern end of the Surma valley. Its western and eastern limits are defined by Haflong-Disang thrust and Changrung-Zungki-Lainye thrust respectively. The northern limb of this Synclinorium forming the Barail ranges of North Cachar, extends south-westward below Haflong and west ward, fringing the eastern flank of Maghalaya plateau. The southern limb extends into West Manipur, East Cachar and East Mizoram. The Surma Basin forms the core of this Synclinorium. According to Nandy,*et. al.* (1975), there exist no lithological similarity in the two limbs.[76] While Barail rocks of the Barail range are dominantly sandstone, shale constitutes the predominant units in the southern limbs. The underlying Disangs form the outer ring of Kohima Synclinorium south of Haflong and display a sequence of splintery shales with minor sandstones.[77] It needs to be pointed out here that problems concerning litho-stratigraphic intricacy and regional correlation of Disang-Barail sequences are yet to be resolved. Since fossil records of the region are equivocal, a careful and detailed lithostratigraphic mapping may be the only way to understand and solve the stratigraphic problems.[78]The Barail range enters the district at the south-west corner and runs in a north-easterly direction beyond Kohima to merge with the Patkai. Japfüwhich lies to the south of Kohima is the highest peak of the Barail Range and attains a height of 3804m above mean sea level. At this, the range is met by the meridinal axis of elevation prolonged from the Arakan-Yoma (major mountain system of Myanmar) and thereafter, the main range runs in a north, north-easterly direction. On account of the sudden rise of the Barail Range of its northern face, about 12 km wide miniature type of valley is formed in between the Barail Range and Samaguling Hills. Kohima and Naga Hills are located further east. The Patkai Range forms a watershed which constitutes the international boundary between India and Myanmar. Saramati with a height of 3840 m is situated in Kiphire district is the highest peak in Nagaland.

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[76] Nandy, D.R.,*et. al.,*1975,*Geology of the NEFA Himalaya,* G.S.I., Misc. Pub.24(1). p. 91-144.

[77] Rao, A., 1983.*Geology and Hydrocarbon Potential of a part of Assam-Arakan Basin and Adjacent Regions,* Petroleum Asia Journal. p. 127-158.

[78]Chakrabarti, D. K. and Banerjee, R. M., 1988.*Evolution of Kohima Synclinorium Areappraisal,* Records of the Geological Survey of India, 115 pts. p. 3-4.

There are other ranges that connect the Barail and Patkai ranges. One of the ranges thatconnects Barail with Patkai is in the vicinity of Kohima and Ukhrul, up to Mao, trending from south-east to north-west direction. From Mao onwards, the range takes an eastward trend and continues in this direction for about 34 km and then follows a southward direction. The other linking range also follows a zigzag course. It joins the first range at Mao and crosses the Patkai range slightly east of Tuensang. Similar to the main hills of Nagaland these ranges also send out many ridges, spurs and small branches. The ramification of numerous mountain ranges, ridges and spurs have made the topography and geomorphic features of the state quite complicated and these relief features have played a vital role in the location and development of human settlements. The macro-fracture system of Naga Hills is dominated by two sets of distinctive faults. The earlier set trending nearly NE-SW and conformable with the regional trend of the early folds, has disturbed the litho-formations in a longitudinal and imbricate manner. A vivid expression of such wreckage of tectonic slicing is reflected in the 'Belt of Schuppen' which is a major morpho-tectonic unit of Nagaland in the western part, where the tectonic realm can be viewed as a close proximation to the 'Alpine type'. Many of the major topographic lineaments in the intermediate hill ranges and the eastern high hill areas (viz, Tizu, Zungki, Lanye Rivers, etc.) are controlled by these longitudinal faults. The eastern and western boundaries of the Ophiolite belt are marked by two such longitudinal lineaments. The individual litho-members of the Ophiolite complex also have longitudinal tectonic contacts. The later set of faults which offset the earlier ones has WNE-ESE to EW trend and is mostly reverse-cum-wrench type. The interference of these two types of macro-fractures has given rise to the development of large tectonic blocks similar to horst and graben like structure at certain places of Nagaland such as Lacham lake area, Ghaspani valley etc.

The NE- SW trending Ophiolite belt of Naga Hills extends along the eastern margin of Nagaland for nearly 200 km bordering Myanmar. It is characterized by dismembered tectonic slices of serpentinites, cumulates and volcanic. The associated pelagic sedimentsinclude mainly chert and limestones that are often inter-bedded with the volcanic. Cherts are usually bedded and contain radiolarians. The fossil assemblages from the limestone inter-bands have suggested an Upper Cretaceous to Lower Eocene age for the Ophiolites. These Ophiolitesuit of rocks are unconformably overlain by an Ophiolite derived volcaniclastic and open marineto paralic sedimentary cover which have been designated as Phokphur Formation.

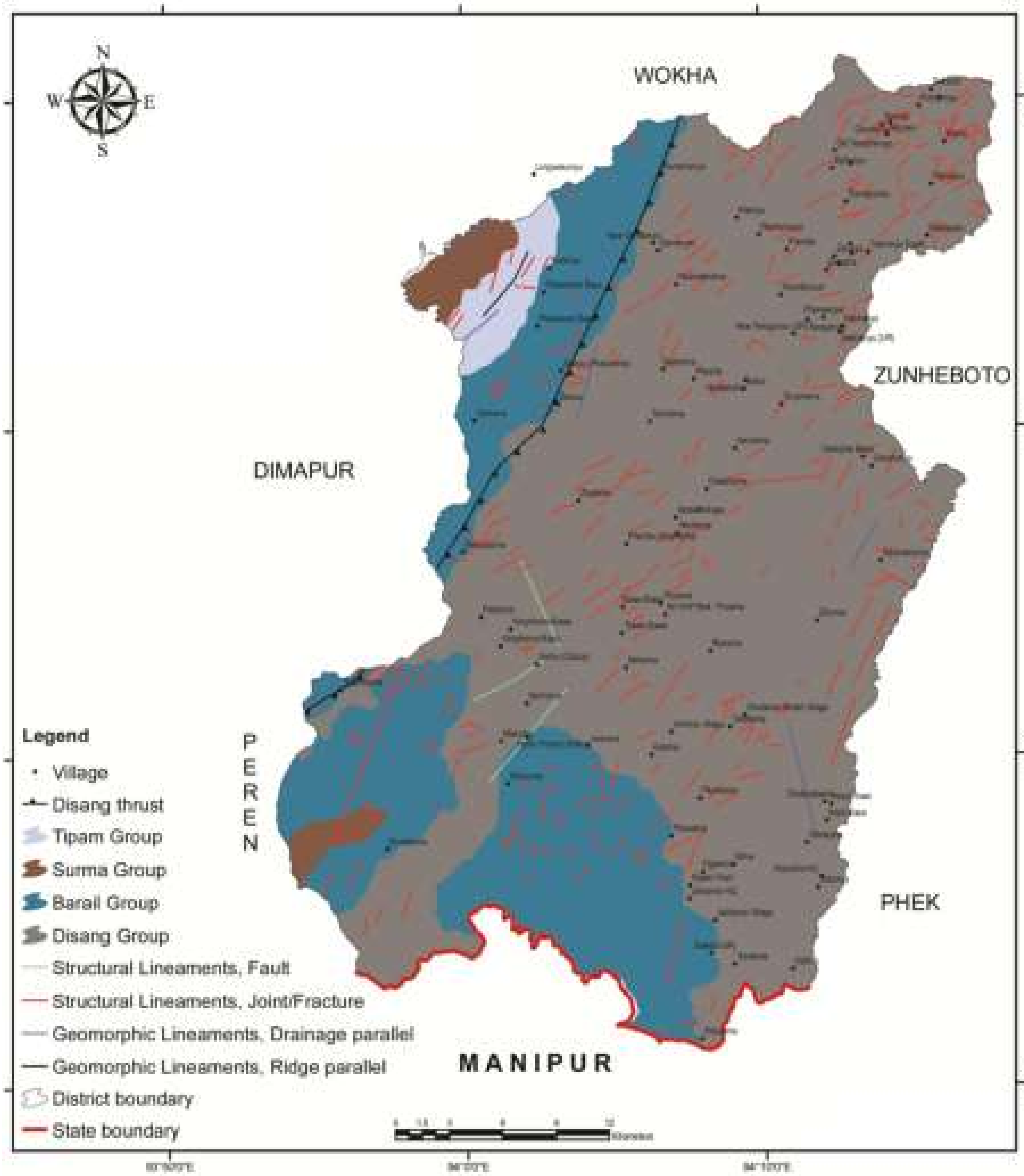
2.4 Geological Formation

The district is covered by semi-consolidated Tertiary group comprising Disang, Barail, Surma and Tipam formation (Fig 2.2).

Disang Formation: This formation consists mainly of rocks like shale, sandstone. The shales are grey in colour and splintery in nature with inter-bedded sandstone. At places shale has been changed into slate due to metamorphism. Different scholars have assigned different age for the formation the rocks representing the whole of Eocene age with the lower part extending down to Upper Cretaceous. Thus, the sediment of Disang group marked by trench facies with an age of Upper Cretaceous to Middle Eocene. Due to tectonic activity experienced during the past geological periods, the rocks developed fractures and joints. This forms secondary porosity and the recharge to ground water takes place through these fractures and joints.

Barail Formation: It consists of arenaceous sediments like massive sandstone, shale and sandy shale. The fossil content is poor in this type of formation though they are of marine to estuarine origin in large parts. The rocks are of Upper Eocene to Oligocene in age. The top of the Barail formation is marked by a pronounced unconformity indicating upliftment and erosion. Due to tectonic disturbances the rocks have developed secondary porosity and fissured medium which holds ground water.

Fig. 2.2
Geological Map: Kohima District



Source: GIS Centre, Nagaland.

Surma Formation: This formation is characterized by low to moderate structural hills consisting of clay, shale, siltstone, mudstone and ferruginous sandstone with sandy shale and conglomerate. In this formation ground water is restricted to weathered mantle and fractures.

Tipam Formation: This formation is made up of rocks like clay, shale, coarse to gritty ferruginous sandstone and conglomerate. They form moderate structural hills and the valleys underlain by Tipam sandstones form good yielding aquifer zones at greater depths.

Geomorphologically, about 70% of the area under study is hilly and the terrain is rugged and slopes are generally steep. Endogenetic and exogenetic processes are the two principle geomorphic processes that operate throughout the land formation. The primary surface processes responsible for the present topographic features of the study area are weathering, mass wasting and movement, running water, folds and to greater or lesser degree tectonics and volcanism such as earthquake. The different types of weathering such as the physical or mechanical weathering, chemical weathering and the biotic weathering result in the wears and tears of the rocks, lands and vegetation through various agents such as climate, chemicals, winds, anthropogenic activities. The abrasive action of sediments is also a prominent process for the landscape development in Nagaland in general and Kohima district in particular. The fluvial landforms are the works of running water in the form of surface runoff or overland flows and streams are one of the most important exo-genetics or planation processes in the landforms. The erosional landforms and the depositional landforms are the two significant types of fluvial landforms. V-shaped valleys, waterfalls and rapids, pot holes, meanders, etc. are some of the erosional landforms resulting from fluvial erosional landforms in the study area. Streams and rivers are in the juvenile stages of cycle of erosion with deep and narrow V-shape valleys indicating high erosive force and vertical erosion. The valleys are gradually widened due to lateral erosion along the rivers and bigger streams. The depositional landforms formed by rivers and bigger streams in the district are alluvial fans and cones, sand banks and small natural levees where the river meanders and the tributaries meet the main stream after leaving the mountains. Sand banks and small natural levees are found in the valley plains where sands are deposited along the banks of the streams and rivers.

Nagaland is situated in one of the most severe seismic zones in the country and thus, highly prone to earthquake and landslide. Due to subduction of the Indian plates into Myanmar plates along the Naga hills range in the east and the continued intense collision of the Indian plate with the Eurasian plate in the Himalayan range in the north, the region is seismically very active. Geologically, the study area comes under the Inner fold belt of Nagaland which comprises two synclinoria, namely, the Kohima synclinoria to the south and the Patkai syclinoria to the north. The former is characterized by Disang-Barail sequences only. The Disang groups of rock over a large part of the belt do not exhibit significant variation in lithology. Rather, a monotony of shale-siltstone succession characterizes the Disang sequences. Dominance of sandstone members marks the beginning of Barail groups in the study area and the isolated exposures of Disangs offer great constraints in identification due to mixed Disang-Barail lithology. The Disang Group of rocks is characterized by monotonous sequences of splintery shales and the rocks are classified as geosynclinal facies comprising flysch sediments that range in age from Upper Cretaceous to Eocene. They spread over about half the surface area of Nagaland. These rocks occupy the intermediate hill region of Nagaland to the east of the Disang Thrust. The shales of the Disang Group of rocks are very fine grained, finely laminated and commonly exhibit curved or concentric surfaces. These are weak rocks and cover greater part of Nagaland.

The Barail group of rocks comprises thick sequences of sandstones intercalated with very thin beds of shales and conformably overlies the Disang. Though they are hard and compact, they occupy only a few tracts of the state. Alluvium and High-level terraces cover extensive portions of Nagaland. The High-level terraces are dominantly boulder beds with coarse sands, gravels and un-assorted clays at various levels above the present rivers. Generally, the area being highly seismic zone and hilly fraught with numerous streamlets and tributaries, composed of fined grained rock on the one hand and windstorms, thunder, lightning, hailstorm, intensive rainfall annually and different anthropogenic activities on the other hand, the area is susceptible to different erosional activities such as rills and gully erosion, landslide, and land degradation.

2.5 Climatic Condition

Climate, considered the most important natural element is the fundamental factor in establishing a physical environment. Other natural elements such as vegetation, animal life habitat, water features, human welfare, etc. are determined by it. In fact, it acts as the stage upon which all physical, chemical properties and a biological process operates. Even landform features and soils are strongly affected by climate. According to Trewartha 'climate represents a composite of day to day weather conditions and atmospheric elements, within a specified area over a long period of time.'[79] Critchfield states that, 'climate is more than statistical average; it is the aggregate of the atmospheric conditions involving heat, moisture, and air movement.'[80] In the opinion of Koeppen and De Long, 'climate is a summary, composite of weather conditions over a long period of time, truly portrayed, it includes details of variations, extremes, frequencies, sequences of weather elements which occur from year to year, particularly

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[79]Trewartha, G. T., 1954. *An introduction to climate*, McGraw Hill Series in Geagraphy.p. 402.
[80]Critchfield, H. J., 2002. *General Climatology*, Printice Hall of India, New Delhi.p. 453.

in temperature and precipitation. Climate is thus aggregate of the weather.'[81] Climate is now more and more frequently defined in a wider sense as the statistical description of the climate system. This includes the analysis of the behavior of its five major components: the atmosphere (the gaseous envelope surrounding the Earth), the hydrosphere (liquid water, i.e. ocean, lakes, underground water, etc.), the cryosphere (solid water, i.e. sea ice, glaciers, ice sheets, etc.), the land surface and the biosphere (all the living organisms), and of the interactions between them (IPCC 2007).[82]

Nagaland at macro level experiences monsoon type of climate with variants ranging from tropical to temperate conditions largely influenced by altitude, latitude and location. Here, the climate is governed by both the Arabian Sea and Bay of Bengal branch of Indian monsoon wind. It has a wet and warm summer and dry and cold winter. The summer climate is mainly governed by the development of depression over the monsoonal branch of Bay of Bengal which brings rain and storm in rhythmic form seasonally. The retreating monsoon wind blows in winter which brings little shower with cold wind from Siberian region. This wind touches mainly the place having higher altitude and in these places hailstorms are experienced which brings temperature further below freezing point especially during night time.

The southern Nagaland which constitutes the area of present interest, owing to its elevation, has a temperate type salubrious climate. It falls under one Agro-climatic zone of Mild Tropical Hill Zone and receives South West monsoon rain in summer and North East monsoon rain in winter.[83] According to Köppen and Geiger climatic classification,

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[81] Sing, S., 2005. *Climatology*, Prayak Pustak Bhavwan, Allahabad.p. 2.
[82]IPCC, 2007.*Climate Change 2007: The Physical Science Basis*, Contribution of Working Group I to the Fourth Assessment Report of the Inter-governmental Panel on Climate Change, Solomon, S., *et. al.,* (eds.). Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA.
[83]http://atmakohima.nic.in/DistrictProfile.html, extracted on 5/4/15.

the area is classified as Cwa.[84] The Kohima district being sheltered by the lofty mountain summits of the Barail ranges with Japfü peak at its centre remains usually snow-capped during the winter. Winter is very cold with minimum temperature falling down to 1°C. December and January are the coldest months of the year and are characterized by incidence of frost in some of the pockets. The spring season is warm and humid. The heat decreases during the autumn, October and November being the finest part of the year. Most of the rainfall is received in the month of July to August which is also the hottest part of the year with occasional rain from September to October. Summer and autumn skies are frequently over-clouded. The average annual rainfall which Kohima receives is 2000mm and the average temperature in Kohima is 17.8 °C. During the hottest part of the year (July or August) the temperature in Kohima is only on the average 80^0F or 90^0F (Fig 2.3).

For the study of the characteristics of weather and climate in and around the study area, daily meteorological data of five years (2009-2013) such as temperature, rainfall, and humidity have been collected at the meteorological observatory in Kohima town operated by the Soil and Water Conservation Department, Government of Nagaland (Appendix 2, 3, 4, 5 and 6).The principal elements of climate include radiation from sun and sky, temperature, precipitation and atmospheric pressure.[85] The average maximum and minimum temperature (2009-2013) is 22.79^0C and 12.20^0C (Fig. 2.3) respectively not too warm or cold during the whole season. Average annual rainfall is 1658.5mm with an average of 144.2 rainy days during 7 to 8 months of rainy days in a year (Fig 2.3). Because of the continuous rainfall during this season the temperature remains low.

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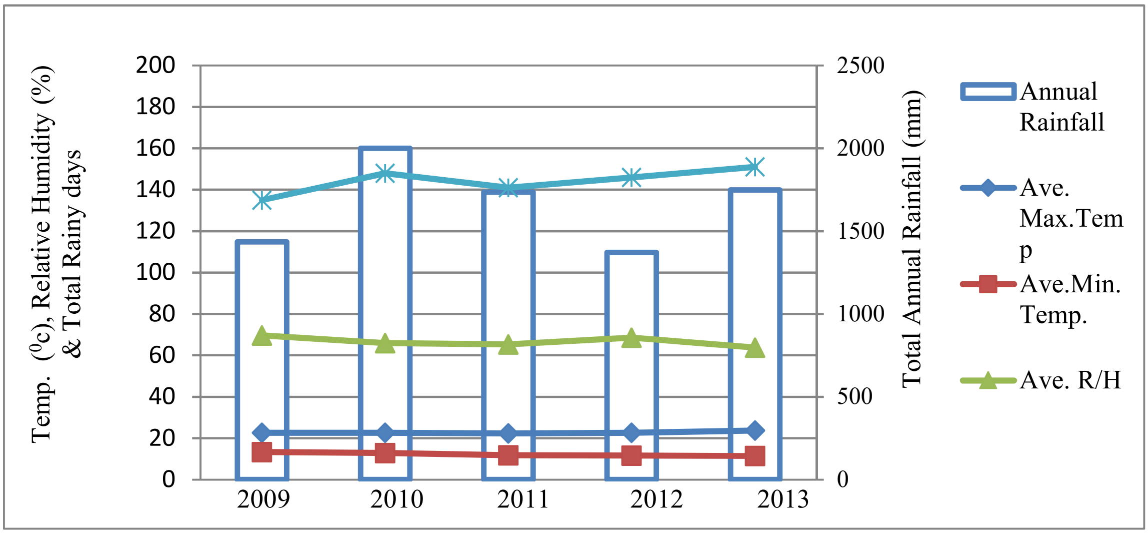
[84]http://en.climate-data.org/location/24623/, (C-temperate, w-dry winter and a-hot summer), accessed on 8/7/15.
[85]http://www.ieslamadraza.com/elena/websociales/geography3eso/Assistant%20Language/elements_of_climate.pdf., accessed on 25/7/15.

Soil tends to show a strong geographical correlation with climate. Temperature and precipitation which are the prime factors of climate strongly influence physical and chemical reaction on parent materials of soil. Due to human activities and change in climatic condition, soil formation and soil loss balance have been disturbed during the recent years. Climate determines vegetation cover which in turn influences the soil development and also soil loss. For a region whose main occupation depends mainly on agriculture and natural resources, it is important to study the responses of soil to the climatic condition of a region as erosional problems, desertification, and wasteland are increasing at the global scale because of the change in climate on the one hand and also due to the human activities on the other hand. There exist a relation between precipitation, temperature, runoff, erosion and vegetation and is thus, important to study the hydrological response to meteorological behavior for the assessment of land and water.

Fig. 2.3

Average Rainfall, Temperature and Relative Humidity(2009-2013): Kohima District



2.6 Drainage System

The drainage system of Nagaland is controlled by the presence of deep cut narrow gorges landscape, and has numerous numbers of seasonal and perennial rivers and streams. The rivers flow into Brahmaputra in the west in Assam or into Chindwin in the west in Myanmar (Fig 2.4). These rivers are generally not navigable as these are mostly of upper course river with high water current. The drainage system in Nagaland can be divided into 3 system viz., Bramaputra drainage system, Chindwin drainage system and Meghna drainage system. Dhansiri and its tributaries, Doyang and its tributaries, Milak and its tributaries and Dikhu and its tributaries are the important rivers which drain into Brahmaputra River in Assam. Tizu River and Zungki River form the important drainage system of Chindwin. Meghna drainage system is formed by Barak River and its tributaries which flow in the South-west tip of Nagaland mostly in Kohima district and run toward Manipur.

Kohima district falls under the Brahmaputra drainage system. The district has number of rivers which are the tributaries of Dhansiri River and Doyang River. The Dhansiri River rises between Nsong and NC hills below Laiseong peak and is joined by Intangki, Monglumok, theAmaluma, the Diphu of Dimapur district and Dzuda or Dzuna Rivers of Kohima district. This river flows towards west-north west direction and transverses through Dimapur District. Dzuda or Dzuna is another river that starts from south western part of the district of Khonoma and Mezoma village and crosses Zubza which later flows to Dhansiri River in Dimapur District. Khu, Khe, Die, Yhona, Miya Cha drainage are some of the tributaries of Doyang River. The Doyang River is the biggest river of Nagaland and found its point of origin at Mao Thana (Manipur district). Dzuu and Sidzu River alone with their tributaries which runs parallel in the south eastern part of Kohima district form the river system of Doyang. Kerhol nala, Keho nala, Zachar nala, Zilu drainage, Mezi nala, Tso nala, Theyi nala, Kerieu nala, Ukra nala, Ga nala, Ghegu nal, Thagu nala, Jagu nala, etc. are some of the tributaries of Dzuu River. These two rivers confluence to form a larger river as it flows in northerly direction. Sidzu River flows between Kohima and Phek district traverse through Pughoboto as Yeti River and later enters to Doyang River in Wokha district.

Fig. 2.4
Drainage Map: Kohima District

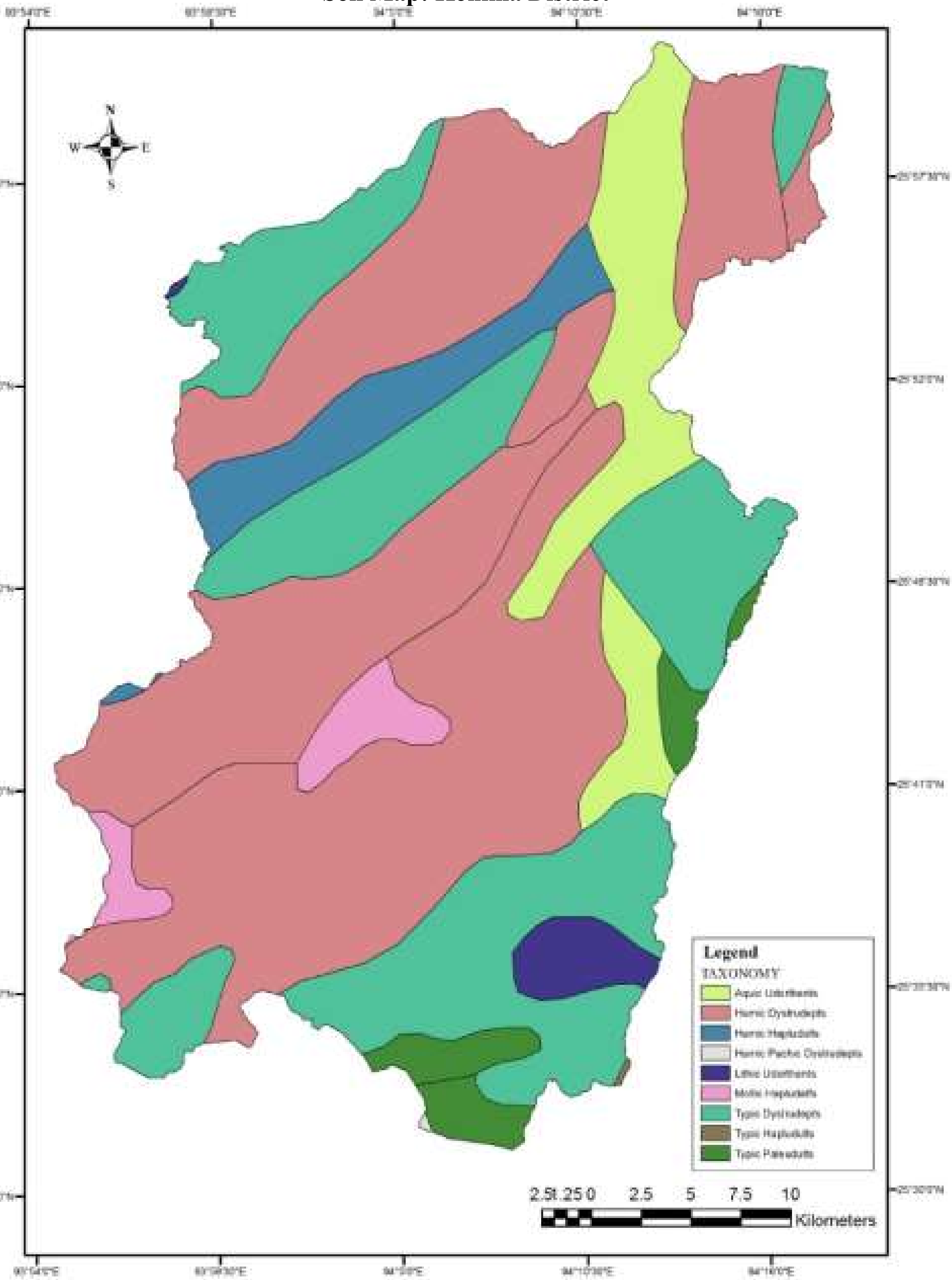
Source: GIS Centre, Nagaland.

2.7 Soil Genesis and Characters

Soils of Kohima district are of tertiary rocks belonging to Barail and Disang series. The Barail consist of alternating layers of sandstones and shales of Miocene age with Carboniferous intrusions or even coal seams. Ultra-basic intrusions are also observed in the east and south-eastern parts of the district. The underlying Disang series represents unfossiliferous shales, slates and phyllites.

Fig 2.5

Soil Map: Kohima District



Source: NRSC, Hyderabad

Although the total geographical area of the district is small, a great variation in soil types has occurred due to the variation in topography and climate (Fig 2.5). The foothill areas of the district bordering Assam with hot and monsoon rain climate are characterized by occurrence of lateritic soils, whereas the hilly areas having cool and temperate climate with coniferous vegetation have given rise to podzolic soils. Soils of the hilly areas having cool, mountain climate and with broad –leaved deciduous vegetation are termed as 'brown earth'. The transported soils occurring in the foothills and valley usually known as alluvial soil comprises the most fertile and productive soil of the district.

Soils which are developed on sandstone are usually co-textured deep and permeable and those derived from shales are medium to heavy textures, moderately deep or shallow, and slowly permeable, non-calcareous, generally fertile and response to application of fertilizers. Soils of the district are acidic, very rich in organic carbon but poor in available Phosphate and potash content. The pH value ranges between 4.80-6.0 while the organic carbons content may be as high as 2.943%. The average available phosphate and potash contents are 20 kg/ha and 120 kg/ha respectively.[86]

Soil of Kohima district may be classified into the following broad groups (Agricultural guide book, 1983) basing on their areas of their occurrences.

Cool and Temperate Zone with Coniferous Vegetation

The soil in this part of the zone, mostly on the hill slopes and terraces is Podzolic derived from non-calcareous shales. These soils are shallow to medium in depth, clay loam, acidic, rich in organic matters, but poor in phosphate and potash content.

[86]Government of Nagaland, 1978.Misc. Publication, The Directorate of Geology and Mining, Kohima.

Another type of soil, obtained at hill slopes and terraces is of shales. They are grayish brown to yellowish brown (brown earth) soil derived from shales. These soils are shallow to medium in depth, clay loam to silky clay loam, acidic and rich in organic matters. Available potash and phosphate contents are medium to poor.

Hot, Monsoon Climate with Mixed Vegetation

In and around undulating and rolling topography where the climate is marked by hot monsoon type, the soils found are reddish brown to yellow brown in colour. Red earth lateritic soils derived from sandstone soils are very deep, course to medium in texture, strongly acidic, rich in organic matters, but poor in available phosphate and potash content.

Old Alluvial Soils

These soils occur in the foothills and are reddish brown to yellowish brown in colour, but are characterized by a layer of boulders underlying the sub-soil. These are usually medium in texture moderately acidic and rich in organic carbon. The contents of available phosphate and potash vary from medium to low.

Recent Alluvial Soils

These are of transported ones found mostly in the valley. These soils are very deep, slightly acidic, and rich in organic carbon. Available phosphate and potash content varies from medium to low. Surface drainage may be moderately well drained or impededly drained. This type of soils is most fertile and productive in the district (Nagaland Agricultural Guide Book, 1983).

2.8 LandResources and the People

Land is the most important natural resources and in a comprehensive sense may include the physical, biological, mineral, hydrological and climatic characteristics of the land.

Though the quantity of land is fixed, yet it can be put to alternative uses and productivity and the returns can be increased by better uses and management and use of science and technology. Society has an abiding interest in land as it is indispensable and if properly managed could remain productive for years.

Situated in the south of Nagaland, the land of the region is filled with rich and fertile soil. Soil has been the fundamental resource base for agricultural production system. The soils of the region are generally acidic, very rich in organic, high in potassium and medium in phosphorus content (overall contain study).[87] Except in the valleys, with comparatively level and gentle gradients, the soil is thin because of torrential rain, rapid erosion of top soil layer which occurs on the hill slope. But a proper management of the land will be very productive. The major problems of land resources on the one hand are landslide, soil erosion and improper practices of agriculture and its people. And on the other hand are the lack of proper knowledge and awareness of the resources. The people of the region are the owners of the land and are the final decision makers for theutilisation of the land resources and thus, with proper inputs and knowledge to the people the land can be a huge source of income to the region.

The Angamis and Rengmas are the indigenous inhabitants of Kohima district and thereby, form the dominant tribes of the district. Nonetheless, the district wears cosmopolitan outlook because of the presence of a large number of people belonging to other communities. The Angami tribe spreads out north towards Tseminyu, west towards Dimapur district and south towards the border of Manipur state. The traditional habitats of Angamis are divided into four regions: (i) the Southern Angami's at the foothills of Japfu, (ii) Western Angami's in the west of the Kohima, (iii) the Northern Angami's in the north of Kohima and (iv) Chakhro Angami representing mostly small

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[87]Soil nutrient mapping of Nagaland, 2014.*Dept. of Agriculture, Govt. of Nagaland & ICAR-National Bureau of Soil Survey & Land Use Planning Nagpur.*p. 37-46.

village around Dimapur District. The reason foremergence of the Angamis as a dominant tribe of Nagaland from the early days is due to the geographical character of the territory they occupied, and the advanced kind of cultivation which has been in practice amongst them. Angami settlements with access to the plains of Assam on the one side and Manipur on the other have accentuated their adaptation to improved model of cultivation, the use of technology in agriculture, craftsmanship, trade and other livelihood techniques including a highly advanced form of wet terrace rice cultivation. Rengma tribes mostly in the Tseminyu sub-division live in a rectangular strip of land, surrounded by the homelands of Angami on the south, the Semas on the east and the Lothas on the north. The Rengmas are also of patriarchal society, therefore, the line of descent is traced through the male side and property rights goes to the male line. The Rengma tribes are also agriculturists and grow paddy through jhum cultivation and patches of wet terrace rice cultivation.

Like the case of other tribes under the umbrella of the connotation ‘Naga’, the indigenous people of Kohima district do have the same pattern of settlement though the structural design of their houses shows variation from those of other tribes. The settlement area is endowed with rich forests, pastures, flora, fauna as well as numerous springs and streams which irrigate their lands and enable cultivation. Most of the villages were generally situated at the most commanding position protecting themselves from the attack of the invading enemies which were very frequent when head hunting and disputes over land, etc. were rampant in the past. People are generally simple, hardworking and had a self-sufficient village economy. They could make useful and artistic object, were efficient in agricultural works and skillful in making baskets and other bamboo product. Their villages vary in size and observe the purest form of democracy like the other tribes in Nagaland. Though there is a village headman, decisions are made with the consent of elders and important persons of the village.

There are no specific rules or constitution which the people follow but it is their ethical and moral values which guided them to live in peaceful co-existence within and outside their village. Their traditional knowledge is another important characteristic which give more to the environment than what they have taken from it. The traditional knowledge and skills are based on their ethical values of environment which are not only accurate but also very scientific.[88]

2.9 Demographic Characteristics

The study of any region cannot be meaningful unless the demographic characteristics of the region are taken into account. The social and economic entities are essentially linked with the demographic profile of any region.

Table 2.2
Density of Population (2011)

Total population	Male	Female	Sex Ratio	Decadal Population Growth 2001-2011	Density per sq.km	Density position to State	Literacy Rate
267988	123966	129022	928	21.72	183	2nd	85.23

Source: Statistical Handbook of Nagaland: Directorate of Economics and Statistics.

The population of Kohima district as per 2001 census is over 3 lakhs out of which rural population is over 2 lakhs (75.16 per cent) and the urban pollution is 77, 000 person (24.83 per cent) against total population. The growth rate of population is 47.3 per cent that is less than the urban growth rate (49.8 per cent) of the district. The population density is 183 persons per sq. km which is very thin (Table 2.2). After the carving out of Peren and Dimapur districts from Kohima district, the population of Kohima district as per 2011 census is 267,988 persons out of which rural population is 1,46,900 persons

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[88]Yano, K., and Lanusosang, T., 2015.*A Threat to Environmental Ethics: a case study of the Angami tribe of Kohima District, Nagaland,*Elixir Environ. & Forestry 85 (2015). p. 34430-34433.

(54.82 per cent) and the urban population is 121088 persons (45.18 per cent) against the total population (Fig 2.7 and Fig 2.8).

Table 2.3
Population (1901-2011): Kohima District

Year	Total/ Rural/ Urban	Persons	Males	Females	Decadal Population Variation	
					Absolute	Percentage
1901	T	28074	14230	13844	-	-
	R	24981	12056	12925	-	-
	U	3093	2174	919	-	-
1911	T	41854	21733	20121	13780	49.1
	R	39431	20042	19389	14450	57.8
	U	2423	1691	732	-670	-21.7
1921	T	43193	22311	20881	1338	3.2
	R	40302	20619	19783	971	2.5
	U	2790	1692	1098	367	15.1
1931	T	48287	24609	23678	5095	11.8
	R	45528	22912	22616	5126	12.7
	U	2759	1697	1062	-31	-1.1
1941	T	48052	24134	23918	-235	-.05
	R	44545	22005	22540	-983	-2.2
	U	3507	2129	1378	748	27.1
1951	T	47717	24400	23317	-335	-0.7
	R	43592	22028	21564	-953	-2.1
	U	4125	2372	1753	618	17.6
1961	T	53004	27969	25035	5287	11.1
	R	45758	23538	22220	2166	5.0
	U	7246	4431	2815	3121	75.7
1971	T	79565	43581	35984	26561	50.1
	R	58020	29379	28641	12262	26.8
	U	21545	14202	7343	14299	197.3
1981	T	126832	68304	58528	47267	59.4
	R	92492	48532	43960	34472	59.4
	U	34340	19772	14568	12795	59.4
1991	T	209630	111548	98082	82798	65.3
	R	158212	81627	76540	65720	71.1
	U	51418	29876	21542	17078	49.7
2001	T	310084	162251	147833	100454	47.9
	R	233054	120590	112464	74842	47.3
	U	77030	41661	35369	25612	49.8
2011	T	267988	138966	129022	47820	21.72
	R	146900	76369	70531		
	U	121088	62597	58491		

Source: District Census Handbook, 2001, Series-14; Part XII-A & B; Nagaland.

Fig 2.6
Decadal Population Variation: Kohima District

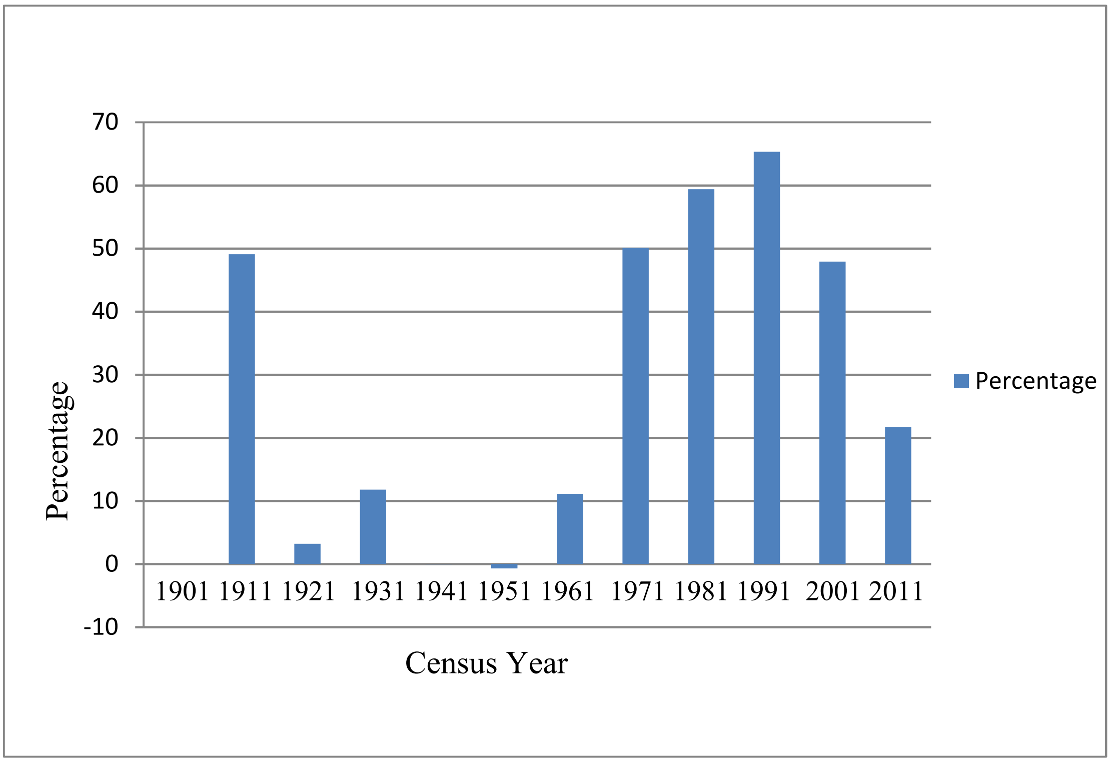


Fig 2.7
Population (1901-2011): Kohima District

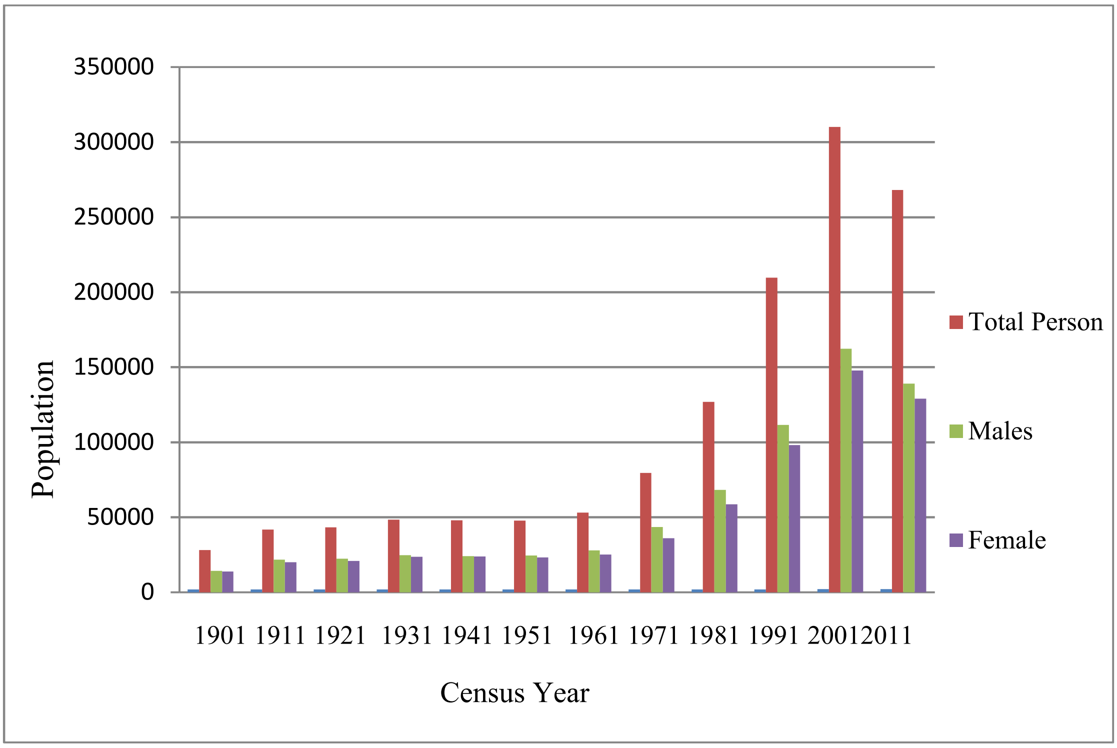
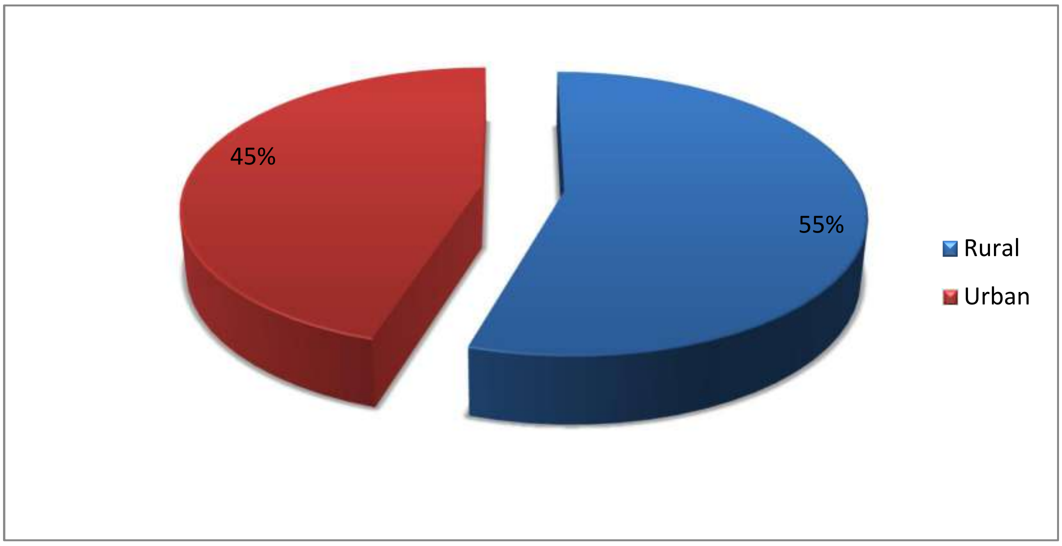


Fig 2.8
Rural and Urban population (2011): Kohima District



2.10 Forest Resources

Since time immemorial man and his activities for survival and leisure have circled around forest and its resources. Forest is a complex ecosystem composed of communities of plants, animals and micro-organisms interacting with each other and their environment which consists of abiotic components such as, soil, water, air, etc. Due to its diverse properties for utility, forest is considered a dynamic resource, and as a result over the years the forest cover has been changing depending on the intensity of utilization. It is the main source of fuel for cooking and also for all types of constructional activities. Forest also plays an important role in the biological cycle of life. Rejuvenation of soil is the product of forest. The people of the region consider forest as their provider of life. In fact, most of their culture and traditional knowledge is also the product of forest like many of the tribal peoples in the world.

The north eastern States of the India account for one-fourth of the country's forest cover.[89] Nagaland which is one among the north eastern states is a land of lush green forests, rolling mountains, enchanting valleys, swift flowing streams and beautiful

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[89]Report of Forest Survey of India in Forest Cover:http://pib.nic.in/newsite/PrintRelease.aspx?relid=86980, accessed on 10/10/15.

landscapes. The altitude of the State varies from 200meters in the plains to 3800 meters in the hills. It is one of the 25 hotspots of the world known for its biological diversity. Forests in Nagaland are endowed with rich fauna and flora. The National Forest Policy1988 emphasizes environmental stability and maintenance of ecological balance. According to the report given by the Government of Nagaland, the district has an area of 2923 km^2 against the total of 13318 km^2 in 2011 census and 2897$km^2$to the totalof13044km^2 in 2013 census of the state.[90] There is a total change of -26 km^2in the forest cover as per the 2011 and 2013 report (Table 2.4).

Table 2.4
Area under Forest, 2012-13 (Area in Km^2)

Sl.No	Particulars	2011 Assessment		2013 Assessment	
		Kohima	Nagaland	Kohima	Nagaland
1	Geographical area	3283	16579	3283	16579
2	Very dense forest	288	1293	289	1298
3	Mod. dense forest	1146	4931	1136	4736
4	Open forest	1489	7094	1472	7010
5	Total (2+3=4)	2923	13318	2897	13044
6	Percentage of Geographical Area	89.03	80.33	88.24	78.68
7	Change	58	-146	-26	-274
8	Scrub	0	3	0	2

Source: Statistical Handbook of Nagaland, 2013.

In the vast area of forest spread in the region, there are many wild animals and birds, some of which are facing extinction. There are two important birds' areas; namely, IN-NL-04 of Khonoma Nature conservation and Tragopan Santuary and IN-NL-08 Puliebadze Wildlife Sanctuary. Some vulnerable and endemic bird species that were found in these sites are:

[90] Statistical handbook of Nagaland, 2013.

N-NL-03 of Khonoma Nature Conservation and Tragopan Sanctuary

Vulnerable

i. Blythe's Tragopan
ii. Dark-rumped Swift

Endemic Bird Area

i. Blythe's Tragopan
ii. Dark-rumped Swift
iii. Grey Sibia
iv. White-naped Yuhina

IN-NL-08 Puliebadze Wildlife Sanctuary

Vulnerable

i. Blythe's Tragopan
ii. Mrs. Hume's Pheasant

Endemic Bird Area

i. Blythe's Tragopan
ii. Grey Sibia
iii. Beautiful Sibia
iv. White-naped Yuhina

Some of the prominent mammals among others are monkey, deer, stag, bear, wild buffalo, wild mithun, jungle cat and porcupines. Other wildlife including tigers is still known to be roaming in these forests as reported by the villagers. Even though further study of their existences in forest area has not undertaken, foot prints of these animals and tales of their encounter suggest their existence. According to them, there are several leopards and tigers roaming in this forest. For the last few decades, forest area in the region is slowly decreasing. The main reasons for decrease in forest cover are due to increase in population, expansion of both urban and rural settlement and excess extraction of timber for fuel and constructional purpose. Studies reveal that every year more than 500 truckload (one truckload consist of 5-6 thaks) of firewood are extracted from the forest for domestic purpose especially from the southern region of the district.[91]

2.11 Agriculture Resources

Agricultural sector is the key contributor to the overall progress of the economy in Kohima district as this sector engages the highest proportion of the working population and contributes significantly to State Domestic Product (SDP). Agriculture is the main source of livelihood of the rural population that constitutes more than 75 percent of the district's total population. Its performance has both direct and indirect impact on human welfare. Increased crop and livestock production positively impacts the consumption and hence, nutrition level of the producers and vice versa. Like the rest of the district, paddy is the principal crop of Kohima. The other major cereal is maize. Besides these, other crops cultivated in Kohima are jowar, small millets and barley. Kohima produces more than 10 percent of all commercial crops of Nagaland. There are some pulses production like ahar, moong and peas though their contribution to the agricultural output is insignificant. Hence, while being largely urbanized, Kohima still has a significant sector under agriculture.

The dominant agricultural system in the district is "terrace rice cultivation", which is traditionally practiced on the hill slopes with terrace benches using irrigated water from streams. The major crop is paddy, cultivated mainly during kharif season. This farming system is a form of settled cultivation which seems to be more sustainable, productive and ecologically less deleterious than jhum cultivation. "Zabou" system is another method of settled cultivation based on integrated watershed system generally practiced in Kohima and Phek districts. Under the system, runoff water from the upper catchments is harvested in ponds and used for growing paddy along with fishes and

[91]Primary data through interview.

snails in the kharif season and for cultivating vegetables in rabi season. Another prevailing traditional farming system is "jhum cultivation", commonly known as shifting cultivation, practiced alongside terrace cultivation on the hilly areas where mixed cropping pattern is followed during kharif season. Rice is the dominant crop, followed by maize, yam, pulses and varieties of vegetable crops. In recent years, cultivation of horticultural crops and cash crops has gained ground.

2.12 Water Resources

The predominant sources of water in Nagaland are surface water of rivers, streams, ponds and natural springs and subsurface water occurring as ground water. The rivers are mainly sustained by the heavy rainfall received in the state which is of the order of 2000-2500 mm, one of the highest amongst all states in India. Nagaland has 4 main rivers, namely, Doyang, Dhansiri, Dhiku and Tizu. These rivers are tributaries of Brahmaputra. Of these, Doyang flows towards the west through the Assam plains to join the mighty Brahmaputra, while Tizu River system flows towards the east and southeast and pours into the Irrawadi in Myanmar. The Barak River also drains into Nagaland, but in a negligible area when compared to Brahmaputra. Physiographically, the state consists of narrow strip of hills running from east to south west and facing the Assam plains to its north and north east. The ground water resources are under developed and underused and are mostly developed in the southern plain region of the state. On the whole, the ground water potential in the district is low as compared to that in the plains.

Though Nagaland is one of the wettest areas in the country, yet it is unable to meet its current water demand. Additionally, frequent river meandering and river bank erosion are caused due to high runoff during monsoons leading to loss of fertile land and damages to infrastructure and agriculture along the river banks. The natural springs and even the traditional wells which earlier were water enough to quench the thirst and to drench the farmer's fields are now gradually drying up due to human errors. In order to ameliorate the living conditions of the community, many departments under Government of Nagaland have taken many comprehensive plans, to protect such existing wetlands and also construct/create water bodies where ever feasible to streamline water resources of the state that include renovation of traditional/ancestral wells in the vicinity of the villages and other human habitation covering all the districts of Nagaland.

Power is a key input to economic development in the State. However, the district lacks the capability for power generation and most of its requirements are met from power transmission from other parts of the State and the adjoining states. According to the Statistical Handbook of Nagaland 2014, the total number of consumer in the district is 40,277 which include domestic light power, commercial, industrial, public lighting, public water works, bulk, etc. where the unit of consumption is 72.41 MU. Almost all the house in the district is connected with electricity but load shedding, power shortage and electrical theft are some of the problem faced in the district. Kohima located in a hilly region and also due to heavy rainfall which falls almost throughout the year can harness the streams for irrigational purpose and also for generating micro hydro-electricity power. But irrigation is still very weak in the region. Being an agricultural region, proper harnesses of this potential streams can boast the agricultural development.

2.13 Health Care Facilities

A look at Nagaland's demographic, mortality and morbidity profile reveals that the mortality status, including maternal and infant mortality rates, is better than the national average, but the morbidity profile is fast changing and causes concern.[92] The prevalence of infectious diseases is not only high but the increasing incidence of lifestyle-related systemic diseases contributes to creation of double burden of disease. The State has had great success in expanding the health care infrastructure in the four decades since statehood. The quality of health care has, however, been a cause of concern because of inadequate number of trained health care providers. About 500 doctors, including specialists, along with nursing support and paramedical staff, serve a population of 20 lakh. This gap is further accentuated by the concentration of specialists in the towns of Dimapur, Kohima and the other doctors in the district headquarters. Increase in the number of trained health personnel will be crucial in ensuring quality of health care at the nearly 500 health centres functioning at different levels across the State. Nagaland currently experience low levels of assisted deliveries, poor immunisation coverage, substance abuse, alcoholism and HIV/AIDS—needs to be reversed. The correlates of health (including social environment, physical infrastructure in sanitation and water supply, etc.) have to be addressed to create a conducive environment. The Communitisation of health services gives Naga society a unique opportunity, today, to improve its health status through preventive and curative primary health care, better management of the health infrastructure and efficient use of resources.

Kohima district has 3 Community Health Centres (CHC) out of the total of 21, 14 Primary Health Centre (PHC) out of 86 and 40 Sub-Centres (SC) out of 397, 1 Mental Hospital and 1 Tuberculosis (TB) Hospital (Table. 2.5). It also has 4 private nursing homes and a number of private clinics. The district has 369 anganwadi centers and 96 Accredited Social Health Activists (ASHAs). Many of the health centers have not been located as per Government of India norms. These units have very small population

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[92]Nagaland State Human Development Report, 2004.*Healthier Horizons*.p. 91:http://planningcommission.nic.in/plans/stateplan/sdr_pdf/shdr_Naga04.pdf, accessed on 27/6/2015

coverage as against the prescribed coverage of 20,000 per PHC and 3000 per SC. However, it is difficult to strictly follow the Government of India norms due to the topography and terrain of the State. In Nagaland, achieving the expected outcome as per Government of India norms is a challenge because of the small catchment areas of many of the health units.

Access to health services has been very imbalanced in terms of location, facilities, infrastructure, medical personnel and vulnerable sections of the population. Due to poor transportation facilities in the State, access to health care units is not easy in the rural areas except for areas located near or along the highways.

Table 2.5
Availability of Health Care Facilities: Kohima District

Health	Kohima
District Hospital	1
Community Health Centre	3
Primary Health Centre	14
T.B. Hospital	1
Mental Hospital	1
Sub-Centre	40
S.T.D. Clinic	1
D.T.C	1
Post Mortum Centre	1
Para Medical Training Institute	1
School of Nursing	1
State Health Food Laboratory	1

Source: Statistical Handbook of Nagaland 2014.

In Kohima district the villages in and around Botsa circle and Tseminyu circle are the areas of concern in terms of access to health services. The upgrading or shifting of location to increase accessibility is a challenge since the villages do not qualify for a health center due to the size of their population. Health services have however improved through the 'Village Health and Nutrition Day' held once a month since 2006. The PHCs and CHCs extend these services through mobile vans and ambulances provided to the CHCs at Viswema, Tseminyu, Chiephobozou and for the PHC at Botsa. In relation to other districts, the delivery of health care facilities is far better due to better communication, connectivity and proximity to other facilities. The health consciousness, however, needs to be improved with more education and awareness through Information Education Communication programmes. Health care is directly linked to the citizens. Hence, developing a system for evaluating the delivery of health care services at the grass root level is crucial.

2.14 Transport and Connectivity

A well-developed transport and communication system plays a vital role in ensuring sustained economic growth. The road length and density per unit area for Kohima district is 13.91 percent of the total road length of the State and Kohima district alone has a total of 1674.25 km as of 2012-2013 under PWD report which consist both surfaced and un-surfaced road. Majority of the roads in the district are surfaced as compared to the other district of the State. Almost all the villages in the district are approachable by either metaled or non-metaled roads and are, thus, connected to the urban areas of the district. With the increase in activities associated with urbanization and the corresponding increase of vehicular traffic, the existing road infrastructure in the major urban centres has become inadequate particularly in the capital town, Kohima. Kohima town is 'facing acute traffic management problems leading to air pollution, congestion and resultant loss of productivity. Moreover, the region having a high rainfall annually, improper drainage or lack of proper drainage along with it susceptibility to soil erosion are the main reasons which make the road condition pathetic as the water flows along the road making the road as their path of flow. Moreover, due to improper engineering plan, most of the metaled road is not lasting long which further leads to several problems. With the gradient of the soil of Kohima unsuitable for flyovers, the solution for easing the vehicular congestion in Kohima town would be construction of new road networks, better traffic management and improvement of the public transportation system.

In many ways the process of development in Nagaland and in the districts is unfolding only now and this is best reflected by how Kohima has been growing and changing. Barely a century and a half ago, the district was majorly in habitat by tribal people in their isolated hill top villages, amidst the pristine and dense forest. Within a short span of human history, Kohima transitioned under British colonial rule that included a World War, followed by the changes under independent India. Along with the political and administrative changes, development has also taken place at a very fast pace. The issue now is how Kohima districts progress from here and in what direction. While the district is well placed in the HDI ranking, attention is called for revamping the primary and secondary education in the government sector in rural areas to ensure equitable and inclusive human development. On the issue of employment, the workforce needs to be reoriented to the opportunities in the entrepreneurial sector and tothe job market requirements in the service sector. As the seat of the Government, the onus for development of the district cannot be left to the Government alone. Public private partnerships and participation of the community would be crucial in shaping and maintaining its development process. Here the rich social capital has to be capitalized. In conclusion, it will depend on the sagacity and the tenacity of the people of the district to realise and appreciate its potentials, recognise the pitfalls, optimize its strengths and opportunities to develop it into a model district.

CHAPTER 3
AGRICULTURE AND LAND USE PATTERN

Early man depended on hunting, fishing and food gathering. To this day, some groups still pursue this simple way of life and others have continued as roving herdsmen. However, as various groups of men undertook deliberate cultivation of wild plants and domestication of wild animals, agriculture came into being. Cultivation of crops, notably grains such as wheat, rice, barley and millets, encouraged settlement of stable farm communities, some of which grew into a town or city in various parts of the world. Early agricultural implements such as digging stick, hoe, scythe and plough developed slowly over the centuries and each innovation caused profound changes in human life. From early times too, men created indigenous systems of irrigation especially in semi-arid areas and regions of periodic rainfall.

Agriculture is derived from Latin words '*Ager*' and '*Cultura*'. Ager means land or field and Cultura means cultivation. Therefore, the term agriculture means cultivation of land where it is the science and art of producing crops and livestock for economic purposes. The primary aim of agriculture is to cause the land to produce more abundantly, and at the same time, to protect it from deterioration and misuse. It is synonymous with farming–the production of food, fodder and other industrial materials. The basic factor of agriculture is land. Knowledge about the area under the cultivation, as also the various crops grown, is vital to an understanding of the most important elements of agriculture.

3.1 Occupational Structure in Agriculture

Agriculture forms the backbone of the Indian economy and despite concerted industrialization in the last 40 years, agriculture still occupies a place of pride. Major allocation has been done in each five-year plan to agriculture. In 8th five-year plan, nearly 23 per cent of the national budget allocation goes to agriculture and allied agro-based cottage industries run on small scales. More than 60 per cent of the Indian population (60 million/1.05 billion) depends or involved in agriculture and allied activities. Nearly 40 per cent of the net national product is from agricultural sector. Approximately 35 per cent employment is generated from agriculture, out of which 75 per cent is found in rural areas either directly or indirectly. It provides the food grains to feed the large population of 85 crores.[93] It is also the supplier of raw material to many industries. Thus, the very economic structure of the country rests upon agriculture.

Nagaland has tropical rain forest (Am) which is characterized by a monsoon climate with one short dry season but sufficient annual precipitation. Temperature remains low (below 100 metres remain high i.e. about 27^0 c throughout the year). The summer monsoon is strong which generally lasts from June to October. In such climate condition, the cultivators follow a time schedule for the various operation of agriculture. Besides agriculture, people are also engaged in rearing of livestock, weaving, black smithy and handicraft. In the absence of any major industry almost the entire urban population depends upon government services for employment and livelihood.

Like any other districts in Nagaland, agriculture is the main occupation of the inhabitants of Kohima district where the bulks of the rural population depends on agriculture and even those in government services engage themselves in agricultural activities directly or indirectly. The occupational structure represents the economic activities of the people. The census of India has categorized the main workers into four groups such as cultivators, agricultural labourers, workers in household industry and other workers. The marginal workers refer to those who have worked less than 18 days in a year (Census of India).

The total population of the study area is 2,67,988 according to 2011 census (Table 3.1), out of 42.847 per cent (1,14,825 persons) are the total workers available and 57.153 per

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[93]Country Report: India, 2009. *Indian Agricult*ure – *An Introduction*,Submitted to Fourth Session of the Technical Committee of APCAEM 10-12 February 2009, Chiang Rai, Thailand.p. 2: http://un-csam.org/Activities%20Files/A0902/in-p.pdf,accessed on 23/2/1016.

cent (1,53,163 persons) are the total non-workers and the total main workers is 86.574 per cent (99408 persons) and the marginal workers is 13.426 per cent (15,417 persons). From the total main workers, 38.244 per cent (38,017 persons) are cultivators by residence, 0.917 per cent (911 persons) are agricultural labourers, 1.137 per cent are workers in household industries (1,131 person) and 59.702 per cents (59,349 persons) are other workers and according to 2001 census the total population is 2,19,318 out of which 42.605 per cent (93,441 persons) are the total workers and 57.394 per cent (1,25,877 persons) are the total non-workers, 44.657 per cent (41782 persons) are cultivators, agricultural labourers constitute 3.954 per cent (3694 persons), 3.476 per cent workers are in household industries (2745 persons) and other workers is 48.452 per cent (45274 persons).

Table 3.1
Distribution of Workers: Kohima District

Distribution	2011		2001	
	In persons	In per cent (%)	In persons	In per cent (%)
Total Population	2,67,988	13.531	219318	11.021
Total workers	114825	42.847	93441	42.605
Non-workers	153163	57.153	125877	57.394
Main workers	99408	86.574	78961	84.504
Marginal workers	15417	13.426	14480	15.496
Cultivators	38017	38.244	41782	44.657
Agriculture Labourers	911	0.917	3694	3.954
Workers in household industries	1131	1.137	2745	3.476
Other workers	59349	59.702	45274	48.452

Sources: Statistical Handbook of Nagaland (2001 & 2011).

It clearly reveals (Table 3.1) that bulk of the working population is engaged in agriculture. But interestingly the working population of cultivators, agriculture labourers and workers in household industries has been decreasing since 2011 but has increased in other workers. The decreasing of working population in agricultural sector and rising up of population in non-agricultural sector is mainly because of the availability of other working sources. Kohima being the second commercial hub centre and capital of Nagaland, its urban sector is expanding and is attracting the agriculture workers towards the secondary and tertiary occupation.

3.2 Agricultural System

The most striking difference between the people of Kohima especially the Angamis and their neighbors on the north is their **wet rice terrace cultivation**. The Angamis have an elaborate system of terracing and irrigation by which they turn the steepest hill sides into the flooded rice fields called the terrace cultivation. All the Angamis, however, do not practice this wet cultivation, as some of the villages prefer jhuming more than terrace practices. The reason for this is the availability of land and also the multiple crops which can be produced from the jhum field. Wet rice terrace cultivation is also done by the Rengma tribe sparsely spreading out in the suitable areas and mostly in the western Rengma areas. The method of cultivation is identical to that of the Angamis and it plays an insignificant role in the economics of the tribe. Majority of the tribe, however, depends more on Jhuming for their livelihood.

The method of preparing land for wet cultivation is a lengthy process (Plate 3.3). They dig and build the side of the hill into terraces of from 2 to 20 feet broad-200 feet broad if the ground is level enough. The stone taken out of the soil are used to bank up the walls of the terraces. The terraces are irrigated by channels which carry water from some streams for a distance that may sometimes be measured in miles. Many fields are even fed rivulets on their way. Each terrace, of course, cannot have its own channel, but usually obtains water either from the next terrace above it or from one of the terraces in the same row. The terraces are so carefully graduated that the water flows from terrace to terrace round a whole spur and back again to a point little below that from which it started. Water is also often carried from one terrace to another terrace in a hallow bamboo or channels are constructed in between. The terrace fields are the most valuable lands to them since it is prepared through their hard work without the help of any machinery. The rainfall in the Angami country is usually heavy and the terrace fields can be flooded all throughout the years if there is timely rainfall. But even when there is no timely rainfall, the dry terrace field which is almost similar to the wet terrace field is flooded with the arrival of the monsoon. Ownership of terraced fields is not communistic but strictly individual, and sales and divisions between heirs depend upon the owner of the field.

The traditional system of practicing **terrace cultivation** along the hill slope in steps formation is another valuable account of scientific knowledge of the people since early times and the method of preparation is almost similar to those of the wet terrace fields where the farmers maintain a carefully designed irrigation system (Plate 3.2). In this system, each stream is tapped soon after it emerges from the forest and reaches a gully wide enough to accommodate a series of terraces. While the stream continues on its course, diversions are made at angles leading water alongside the series of terraces so that by blocking or opening the connecting duct any field can be flooded or drained as required. The soil fertility remains almost constant without being deteriorated despite the fact that a particular plot of land is constantly under cultivation for years/ decades together. For, people traditionally use the manure of the droppings of their domestic animals such as, cows, pigs, etc. Cattle are often led into the terraces during cold season and let them graze there. This rejuvenates the soil condition. In addition to manuring, leaves of tree and hays which are the leftover of the harvest are used to increase the soil fertility. The digging of the terraces with spade in the later winter season and letting them to be flooded with water in rainy season is another stage of preparation. The flooding of the fields drowns the weeds already overturned in the surface soil, and when they have sufficiently decomposed and the mud is well puddled the field is ready for transplantation. Meanwhile, the seed paddy is sown thickly on a patch of dry ground late in March or early April. The seedlings become ready for transplantation about the end of the May or the early part of June. While transplantation the seedlings are planted separately in one or two. After plantation cleaning of the fields is done for two or three times.

The harvest is done in the month of October. Generally, the field nearby the village produces continuous supply of food and green vegetables throughout the season, thereby increasing the sustainability of agricultural products. The terrace cultivation can be best highlighted in the words of L.W. Shakespear (1914):

> "To a stranger suddenly arriving in the Angami country nothing strikes him with greater surprise and admiration than the beautiful terraced cultivation which meets the eye everywhere, on gentle hill-slopes, sides and bottoms of valleys, in fact, wherever the land can be utilized in this way. In preparation, upkeep, and irrigation, the greatest care is taken, far in excess of anything seen in the north-west Himalayas. The appearance of the countryside for miles south of Kohima, for instance, is such as to suggest the handiwork and labour of a far higher order of people then this wild Nagas. These terraced fields are often bordered with dwarf alder bushes, are carefully irrigated by an elaborate system of channels bringing water down from mountain streams, and luxuriant crops of rice are grown on them. To pass through the valley where stand the two powerful villages of Khonoma and Mezoma during late October when the crops are ripe is indeed a delight for the eye a veritable golden valley."[94]

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[94]Souza, A. D. 2001.*Traditional Systems of Forest Conservation in North East India- The Angami Tribe of India,* North Eastern Social Resarch Centre, Guwahati, Assam.p.8-11.

Jhum cultivation, in many ways, is interwoven into the culture and traditions of the people. In jhum cultivation the vegetation is slashed, burned, tilled and sown. After a year or two of culturing, the land is left fallow for seven to eight years so as to regain its fertility and during this period they continue to practice the jhum in different plot of land before they return to the same plot of land. Bundling along the contours of the fields is built with the fallen branches of trees during the slashing time or with stones and mud to check the soil erosion along the slope of the cultivated field. Another important system of this cultivation is **Alder based shifting cultivation**(Plate 3.6), an indigenous innovation of soil fertility management and is commonly followed among the Angamis. The farmers are specialized and have perfected it to an excellent cultivation system in which they incorporate nitrogen fixing plant *Alnus nepalensis*. The system allows the soil to regenerate faster and jhum cycle is managed every four years. It is identified as one of the most promising bio-physically workable and socially acceptable indigenously innovated adoption towards fallow management (Chankija,*et. al.,* 1998). The naturally grown Alder trees are cut or pollarded at a height of about two metres from the ground to obtain a head of shoots. The branches so cut are used or sold as fuel wood.

Zabo is a kind of mixed farming system which envisages the proper utilization of run-off rainwater from the upper catchments areas by diverting them through channels into a reservoir for storage and maintenance of soil fertility using organic sources of crop nutrition and biomass accumulation. This system enables the growers to efficiently utilize the total available water and helps manage the soil fertility indigenously which sustains their farming for centuries. This type of farming system is traditionally practiced in few and can be found among the southern Angami region where terrace practices are in abundance.

Kichen-gardening is another important method widely practiced by the people and the product is generally considered 'home crops'. It can be a small piece of land which is located near the resident or a few blocks from their house. Varieties of vegetables and crops are grown in that particular plot of land which supplies continuous source of food to the particular owner. Thus, this type of farming not only produces fresh crops and vegetables for consumption but is also agro-ecologically sustainable.

Agro-forestry which is the deliberate growth and management of trees along with agricultural crops and livestock is an important livelihood pattern vastly practiced among the Nagas. It is ecologically, socially and economically sustainable. This system is well suited to the local agro-ecological condition, the specific subsistence and cash needs of farmers, their social and cultural context and the environmental conservation.

Animal husbandryis important economic activity in the area. Milk and milk products (Butter, Ghee,etc.), meat, eggs, and silk are raw materials for small industries. Varieties of animals and poultry are reared in almost every household. Buffaloes, Mithun, local and non-local chicken, hens, ducks, rabbit, pigs, dogs, etc. are reared in abundance and goat, sheep, etc. in small scale. The most important reason of animal rearing among the people is mainly for consumption purpose. Apart from this, their dung is used for making manure. Mithun and buffaloes are used as draught animals. They are used in agricultural activities like ploughing of fields and for carrying loads. It is to be noted here that with rise in mechanized farming, the use of animal power for farm operations is on gradual decline.

Horticulture plays an important role in the rural economy. Planting of plantation crops such as coffee, cardamom, fruits like plum, peach, orange, banana, pine apple, passion fruits, papaya, etc. and vegetables such as cabbage, brinjal, chili, peas, bean, ginger, potato, tomato, garlic, and other leafy vegetables are important horticultural crops in the area. The products are sold and thus, supplement the farmer's income. Fishery is yet another occupation which is being taken up by the people of the region not only for own consumption but also for commercial purposes. In the district Paddy-cum- Fish culture is popularly practice.

3.3 Agriculture and Productivity

Agriculture remains the mainstay of the economy of the region. The tradition type of agriculture carried out in the primitive manners still determines the way of life of the majority of the people and agriculture produces most food requirement of the area. The activities of the agriculture are mostly done on the sloping slope of the hill which generally affects the land. Although the area receives high annual rainfall, almost six month of the year remains dry or with little precipitation and this leads to no substantial crops during the dry season especially in the winter.

The main crops of the region includes rice, maize, small millet, wheat, pulses, vegetables, etc. Main cash crops are oil seeds, sugarcane, potato, etc. Double cropping is done on a small portion of the permanently cultivated area. The lack of intensive cultivation is partly due to the nature of terrain and climatic condition and partly due to ignorance of the farmers. The major agriculture and horticulture statistics are presented in the Table 3.2 and 3.3 respectively. Figure 3.1, 3.2, 3.3, and3.4give the major agriculture and horticulture production in terms of the area under cultivation and production of Kohima district for the past 5 years (2008-2013). Cereal crops occupy the largest area of crop land followed by oil seeds, commercial crops and pulses. In 2010-2011, area for cereal crops cultivation was in the peak which later sharply decreased in 2011-2012 and later becomes constant. Oil seeds and commercial crops show its highest point for area under its cultivation in 2009-2010 and it decreased in 2010-2011 and later

Table 3.2

Major Crops (Agriculture)

Sl.no	Year	2008-2009		2009-2010		2010-2011		2011-2012		2012-2013	
	Items	Area	Production	Area	Production	Area	Production	Area	Production	Area	Production
1	Cereal Crops	16340 (K) 244940 (N)	41630 (K) 475520 (N)	23000 (K) 252310 (N)	28930 (K) 322440 (N)	24980 (K) 264400 (N)	49120 (K) 531860 (N)	20640 (K) 264750 (N)	41400 (K) 533270 (N)	20800 (K) 267050 (N)	43420 (K) 558510 (N)
2	Pulses	2730 (K) 33960 (N)	3030 (K) 39590 (N)	1800 (K) 24610 (N)	1540 (K) 29680 (N)	2850 (K) 34430 (N)	2840 (K) 36460 (N)	2910 (K) 34940 (N)	2930 (K) 37170 (N)	3020 (K) 36200 (N)	3270 (K) 40450 (N)
3	Oils Seeds	5310 (K) 63620 (N)	5600 (K) 72130 (N)	8680 (K) 104210	6870 (K) 86020 (N)	5340 (K) 65840 (N)	5540 (K) 67530 (N)	5380 (K) 6628 (N)	5580 (K) 68120 (N)	5410 (K) 66820 (N)	5580 (K) 68900 (N)
4	Commercial crops	4170 (K) 35140 (N)	41870 (K) 258956 (N)	5640 (K) 39560 (N)	24970 (K) 277700 (N)	3440 (K) 29400 (N)	39290 (K) 392170 (N)	3660 (K) 31240 (N)	35880 (K) 385800 (N)	4160 (K) 34900 (N)	41950 (K) 443750 (N)

Table 3.3

Other Crops (Horticulture)

5	Major fruits	2445 (K) 18646 (N)	18875 (K) 167705 (N)	4287 (K) 32310 (N)	25930 (K) 234037 (N)	4392 (K) 33276 (N)	24330 (K) 209548 (N)	4447 (K) 33651 (N)	25040 (K) 225081 (N)	4770 (K) 37479 (N)	34938 (K) 286920 (N)
6	Major vegetables	3480 (K) 30795 (N)	27270 (K) 233410 (N)	3695 (K) 34136 (N)	28408 (K) 250256 (N)	4045 (K) 31825 (N)	31825 (K) 284216 (N)	4910 (K) 44090 (N)	34855 (K) 312890 (N)	4710 (K) 43077 (N)	44355 (K) 430785 (N)
7	Major plantations	420 (K) 2950 (N)	25 (K) 972 (N)	420 (K) 3025 (N)	26 (K) 974 (N)	425 (K) 3280 (N)	30 (K) 7725 (N)	305 (K) 3390 (N)	70 (K) 7830 (N)	305 (K) 3750 (N)	175 (K) 12120 (N)
8	Major spices	1180 (K) 7585 (N)	3862 (K) 27077 (N)	1180 (K) 7605 (N)	3262 (K) 25852 (N)	730 (K) 4040 (N)	712 (K) 4032 (N)	615 (K) 3258 (N)	572 (K) 3373 (N)	645 (K) 882 (N)	882 (K) 9676 (N)

Source: Statistical Handbook of Nagaland (2008- 2013)

Area in Hectare and Production in Matric Tons. **(K)= Kohima(N)= Nagaland** shows constant area of cultivation. Area under pulses cultivation decreased in 2009-2010 but raises slightly in 2010-2011.

Paddy is the most prominent crop among the cereal crops which is produced both in Jhum and terrace cultivation (Under Jhum, area = 5,450 ha & production = 10,470 M.T, and under terrace, area =8,210 ha & production = 20,850 M.T according to 2012-2013 census). Maize is the second leading cereal crop production (Area = 4,610 ha & Production = 9,040 M.T, according to 2012-2013 census). Among the pulses naga dal (rice bean) ranked the highest in both area and production (Area = 798 ha & Production = 870 M.T according to 2012-2013 census). Under the oil seeds soya bean occupies the leading crop both in area and production (Area = 2,020 ha & Production = 2,560 M.T according to 2012-2013 census) followed by rape seed/mustard while potato (Area = 1,510 ha & Production = 15,250 M.T according to 2012-2013 census) is the most significant crops within the commercial crops followed by sugarcane and ginger according to their production.

Though cereal crops have the highest area under cultivation it is interesting to note that commercial crops are the most productive crops (area under cultivation is low but the production is very high, Fig 3.1 and Fig 3.2). Though the area is nestled in the hilly terrain, most of the rural areas have a connectivity road making the commercial crop easily accessible to the town as well as to those small markets available in different areas in the region. The government has initiated many schemes for the development of horticulture and the District Horticulture has extended such schemes to the farmers for growing more and more crops under horticulture pattern. Moreover, the agro-climatic condition of the region is favorable to the backyard and kitchen garden where most of the commercial crops are produced. Market access has hugely influenced farmers' production systems in the area on the one hand and on the other hand, the income on the production inputs, consumer goods, immediate cash and also the spread of awareness are attracting the farmers in the region to cultivate those commercial crops.

Fig 3.1
Major Crops: Kohima District (Hectare)

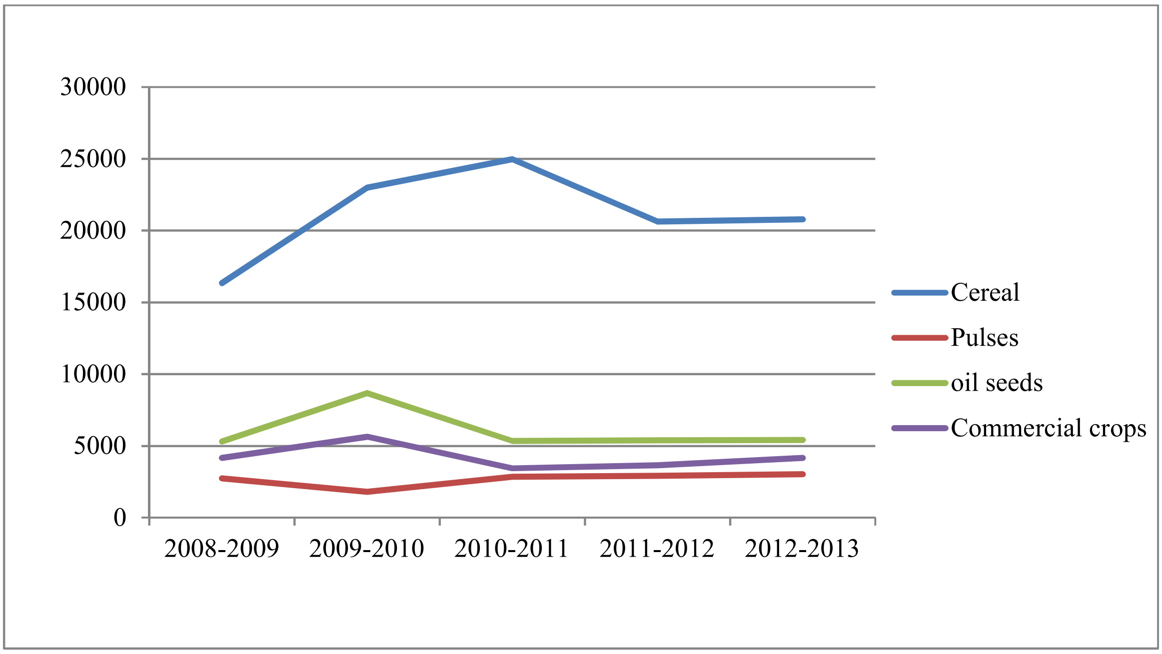


Fig 3.2
Major Crops: Kohima District (Matric tons)

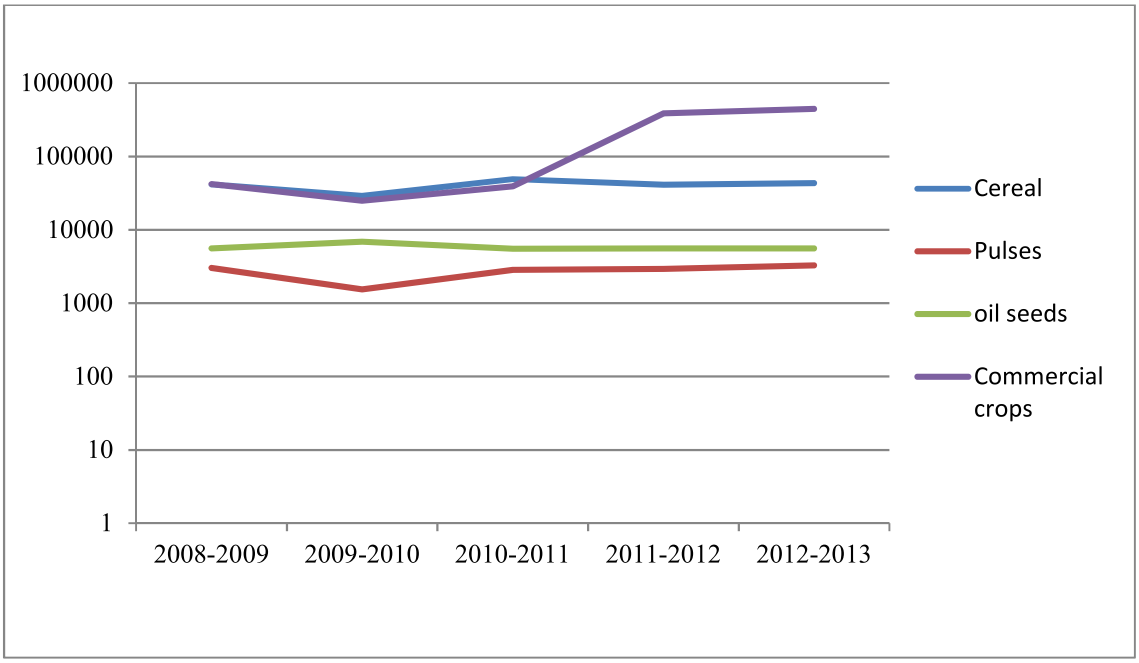


Fig3.3
Major other items: Kohima District (Hectare)

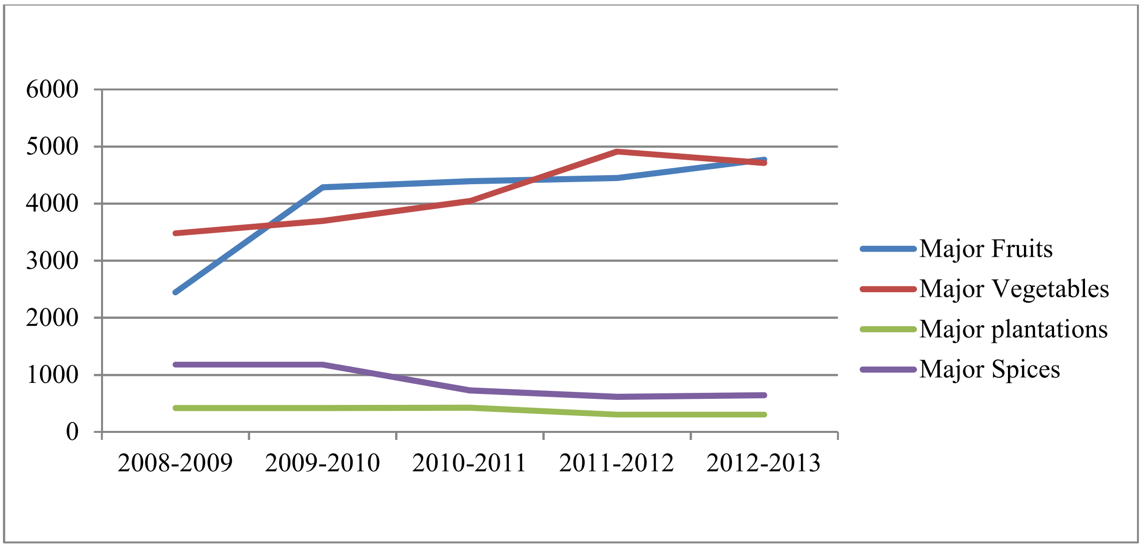
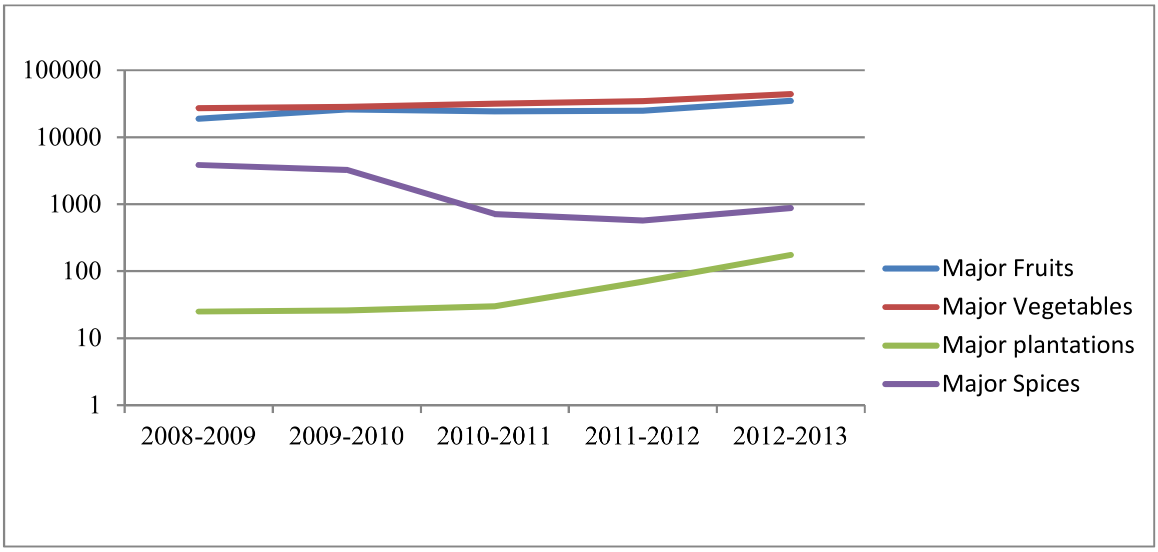


Fig3.4
Major other items: Kohima District (Tons)



3.4 Land Use and Land Cover

Land use refers to men's activities and various uses of land for domestic as well as economic purposes. Whereas, land cover refers to natural vegetation, water bodies, rocks/ soil, etc. Although land use is generally inferred based on the cover, yet both are related and interchangeable.

Nagas are a distinct group of the indigenous peoples of the state of Nagaland and of the surrounding states and country, namely; Myanmar. For centuries they have been directly or indirectly dependent on the natural environment for sustenance. Even today Nagas are known for their intimate link with nature and land which form an inalienable part of their life. For them, the dynamics of human-land relationship is crucial because the land plays a pivotal role in their societal structure.

Among the people of the Angami and Rengma tribes, there is a strong sense of human-land relationship. Like any other tribal society in Nagaland land forms the centrality of their lives and activities. Their entire socio-economic life is attached to land. Land further determines their citizenship to a particular village as no original member of the village would be found without land. Therefore, it is vital for a person to have land which is either inherited or acquired. Cultivable land is generally considered the most valuable form of property among the people due to its economic, political and symbolic significance. Not only is land a livelihood sustaining and productive asset, but land provides a sense of identity and rootedness because it has a durability and performance which no other possesses.

Traditionally, the people understand land as the main source of life. It is not simply commodity or property but indeed land is sacred to them. For them the existence of their God is manifested through the land itself. It is a gift of God and the spirit of God dwells in it. For this reason, most of the festivals and ceremonies are centered on their land as an indicator for the protection of their crops and thanks giving for the good harvest. Land is considered much more than just property and in fact, it forms part of their identity and life. Moreover, it is through the sweat of their ancestor, the land has been protected and passed to them.

For every plot/piece of land, boundary is marked or identify by a stream, contours, tree, rocks and pond. Even stones and pebbles are put by the owners to mark the boundary. The land ownership and management systems of land among the people are unique and are very different from the rest of the country where local customary law governs the land. The land ownership and management system can be categorized as follows:

3.4.1 Village Land

Every Naga village has a certain portion of the village land which is owned by the entire village and under the control of the village authority and similarly, every village of the Angami tribe and the Rengma tribe has also a village land. Around 50 per cent of a particular village land may come under it but it varies from tribe and even villages within a particular tribe. Initially, in an Angami village most of the land was under the village control but slowly later the division of land to different ownership began to take place. Residential site, Morung, village community platform, roads, church, monuments, reserved forest, woodland, etc. comes under the village land. People can use the forest resources for their personal consumption like construction provided they obtain permission from the village authority.

3.4.2 Clan Land

All clans in a village have a specific plot of land and forest within the village and outside the residential village area over which they have absolute right and ownership within the village such as sites for construction of houses, cultivation, and extraction of timber and also can do quarrying. Every member of the clan is entitled to get a share either for construction of residential house or for cultivation as per the availability of land. About 30 per cent of the land is owned by different clan within a village.

In some cases, lands are owned only by some families of a particular clan. The other members from that particular clan have no authority over those lands. This generally is found among the Angami tribe.

3.4.3 Individual Land

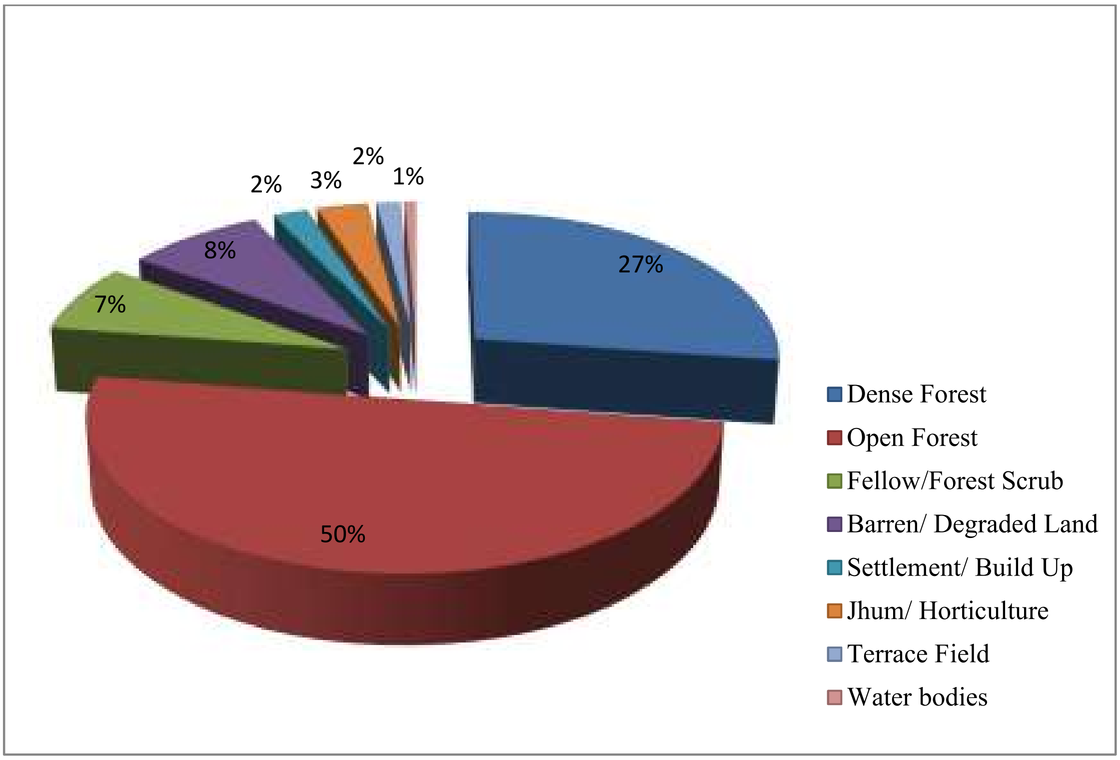
Terrace cultivation, farmlands, tree plantation, residential sites, some forest land, etc. come under the individual land. It is observed that individual land is more among the Angami tribe since the common village land and clan land are slowly being divided due to certain reasons. Individual land otherwise can be either inherited or acquired.

In recent years, many of the clan land and lineage lands are now in the hands of individuals. Increase in privatization and individual ownership especially of land under permanent cultivation such as wet rice cultivation, terraced lands, orchards, gardens, tree farming, bamboo grooves, etc. are recent noticeable trends. Another reason for this is increase in population which further alienated the land into smaller pieces and which later comes under individual lands. However, as mention above the practices and trends of land ownership differs from one tribe to another and also within different village within a tribe. They are largely depending on the existing traditions, availability of land and interpersonal relationship with the traditional institutions.

The land use system, thus, provides the indigenous tribes of the region to enjoy certain rights, privileges, and concessions on matters of land ownership, use of forests, and shifting cultivation *(Jhum)*. Many of the rights, privileges, and concessions enjoyed by the people of the region are traditional and unwritten but have constitutional sanction. Indeed, these rights, privileges, and concessions are unique to the conditions of the people. Except reserved forests, protected forests and purchased land, such rights and privileges had been ensured through adoption of the *Naga Hills Jhumland Act, 1946* and *Nagaland Jhumland Act, 1970.*

The distribution of land use and land cover is indicated in percentage in Figure 3.5. 77 per cent of the district land comes under dense forest and open forest and 5 per cent of the land is used as jhum cultivation, horticulture, and terrace cultivation. Settlement and build up area occupies 2 per cent of land. Fellow and forest scrub constitute 7 per cent of the total area and 8 per cent comes under barren and degraded forest. Water bodies such as streams or rivulets constitute only 1 per cent of the total area.

Fig 3.5
Land use and Land cover:Kohima District



Sources: From LULC classification of satellite image (IRS-R2, L3 Data).

3.5 Agriculture and Environment

Agriculture is a principal platform for human development and social welfare. It is the foundation upon which diverse economies have been built and it provides a pathway to improve the social status of any nation. Increase in agricultural production in an economy can come about basically in two ways, viz a) through an increase in the land area under cultivation and b) through more productive utilization of land already under cultivation. The former source of agricultural growth is important for a country where population is sparse and cultivable land is available in abundance. But with the ever increasing population in the world the agricultural scientist, researchers and policy makers opted for the later source where agricultural production must come primarily from more productive utilization of the existing cultivated land area. And in the process of technological modernization in agriculture, environment is sometimes compromised due to the greed of man and also in the absence of proper management. The improvement upon agriculture production, its efficiency and effectiveness are closely interlinked with environmental consideration.

Moreover, despite impressive achievement in agricultural sector the level of adoption of modern agricultural technology varies from state to state and within state from region to region and even within a region from crop to crop. The main reason for this is not lack of technological and scientific discoveries needed for agricultural development but converting them into production accomplishment and using the same as an instrument of agricultural growth and social change. This could depend to a great extent on the understanding of the totality of the situation on which the new technologies are created and also understanding the socio-economic activities at the local level.

Land cover change in agriculture has shown diverging trends during the last few decades in the intensification of agriculture and also at the same time farm land abandonment.[95] In Kohima district, it has been observed that the area under different crop cultivation is not constant i.e., when one crop area under cultivation is decreasing; it has been observed that there has been increase in another crop area under cultivation

[95]European Environment Agency, 2005.*The European Environment - State and outlook 2005*. Copenhagen.

(Table 3.1). Thus, farm land abandonment occurs due to the shifting practices of crops. And in the processes of the shift, new lands are converted into agricultural area causing land cover change in agriculture.

Sala, *et. al.,* stated that land use change is an important driver of biodiversity change as natural areas are converted to agriculture or urban areas.[96] One of the key factors causing the decline in biodiversity includes habitat disturbance and changes in the food chain. Patches of natural habitats in cultivated landscapes may increase assemblages of some species in the fields.[97]At the same time it may decrease some species. Deforestation is a serious problem of environmental degradation in the area under study. Conversion of forest land into agricultural land, shifting or jhum cultivation, horticulture, agri-link road construction, forest fire, timber extraction, etc. are the major causes of deforestation in the study area. Another problem is the degradation of soils and irreversible losses of soils due to soil sealing and erosion. The productive capacity of soils depends on the content of mineral nutrients, organic carbon, soil structure and texture. Erosion affects all these soil properties. Loss of organic matter, soil biodiversity and consequent deterioration of soil fertility are often driven by unsustainable agricultural practices, such as deep ploughing.[98]Soil erosion in the area is generally caused due to the agricultural on the steep slope and the area under study being a hilly terrain in physiography, it has been observed that there is immense loss of soil due to agricultural activities such as deforestation, ploughing, etc. Use of fertilizer, insecticides and weedicides is rare in the region, though its use might be in some pockets. It is only recently that some farmers have started using high yielding varieties of seeds for raising a part of their crops. Climate change poses new challenges to agriculture. The measures

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[96]Sala, O. E., *et.al*., 2000.*Global biodiversity scenarios for the year 2100*, Science 287.p. 1770- 1774.
[97] Jeanneret, P., *et. al.,* 2003.*Quantifying the Impact of Landscape and Habitat Features on Biodiversity in Cultivated Landscapes.Agriculture, Ecosystems and Environment 98*.p. 311-320.
[98]European Environment Agency, 2003.*Europe's Environment: The Third Assessment, State of Environment Report No 1/2003*. Copenhagen.

of adaptation to climatic change are likely to affect the relative profitability of different crops and production methods. Moreover, agriculture itself is also an important contributor to global emissions of greenhouse gases (GHG), in particular for methane (CH4) and nitrous oxide (N2O).

The new institutional innovations that globalization has brought about in the society are market, trade and finance, communication and media, technology and science, migration and inter-cultural transactions. Globalization has led to a new trend of homogenization in development process all over the globe. Since the onset of the current era of economic liberalization, privatization and globalization (LPG), the areas inhabited by indigenous peoples have been put under the mercy of globalization. Being mostly dependent on the nature for their living has made them sensitive and vulnerable to these changes. The sustainable subsistence livelihood of these people is now under threat with the free flow of global capital to these regions which is intent on exploring and exploiting their mineral resources.

Kohima district is well connected with Assam on the one side and Manipur on the other. Thus, the region is easily accessible to the changes occurring around. The changes do not remain external but enter the community itself through the internalization of the dominant culture. As it is a known fact that the rural and tribal knowledge is not created in distant laboratories and then brought to the users but it is the product of the environment itself. This experimental knowledge may be out of date when seen against the scientific knowledge of today, but it is benign without side effect and hence futuristic too. The traditional tribal systems are based on the concept of nature in general and land in particular as community sustenance that has come down from the ancestors and is preserved for posterity. The study reveals that globalization is one of the main reasons for deteriorating the traditional agriculture practices.[99] Oral transmission, without any written record, of that traditional knowledge is another main cause where the modern world is fast consuming it to the brink of extinction. Another vital factor that has led to the loosening of people's adherence to traditionally bound environmental is Christianity which emphasizes spiritual life than the temporal one.

Due to the open market system the agriculture commodities which flow into the market in a large quantity are available at much cheaper rate and are drowning the native commodities. Price of rice, vegetables and other food crops offered to the small producers remains very low. Instances are that when the price of potatoes and vegetables in this hilly region dropped so low farmers had to leave some of their crops unharnessed and those harvested crop also fail to reach the market. This brings losses to those poor farmers who solely depend on the agriculture income and thus, are forced to find alternative source of income giving birth to a new problem of waste land as the existing agricultural land are wasted.

In the late 90's the Government encouraged the people to grow cash crop such as coffee, ginger, turmeric, sugarcane but with no proper management and absence of industries to convert the raw materials into profitable product, the farmers who have invested into it have suffered a severe blow in their income. Moreover, the forests lost in account of the process also affect the environment. Thus, the impact of globalization on the agrarian sector of the region has worsened the plight of the farmers and also the environment at the same time.

According to the 2011 census Kohima district has a total population of 270,063. The total population of the district was 3,14,366 as per Census 2001. The sex ratio stands at

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[99]Yano, K and T. Lanusosang , 2003. *Globalisation and its Impact on Agriculture: a Case study of Kohima District, Nagaland,*International Journal of Bio-resource and stress management 2013, 4(4). p. 651-654.

944 females per 1000 male. Though the population growth rate over the decade 2001-2011 was 0%, it is expected to rise. Moreover, with the increasing demand of agriculture production, environmental lost will be inevitable.

Agriculture is largely a struggle against nature in terms of sustainability and the prospects for improving environmental performance. Moreover, income generated from agriculture when the land itself is not suitable for large scale agricultural activities is inherently limited. As a major user of natural resources, agriculture has a significant impact on the environment. Contrary to many other economic activities, agriculture has both harmful and beneficial effects on the environment, by changing the quality or quantity of soil, water, air, biodiversity and landscapes.

No doubt, the region is very rich in natural resources and is favorable to agricultural activities. But due to its hilly terrain physiography, sustainable agricultural practice is restricted. Further, Kohima being the capital of the state and the district as well, people from the neighboring district and outside the state are throng to it in search of better livelihood. This adversely affects the agricultural activities in the rural areas. Therefore, integrated agricultural, environmental and cultural policies to preserve the heritage of rural environments should be the core of agricultural development. Organic agriculture which is generally more environmentally friendly than conventional agriculture is expanding among the farmers to meet increasing consumer demand, although it still only accounts for a relatively small share of agricultural production and food consumption. Allied activities in agriculture such as horticulture, animal husbandry, poultry farming, apiculture, floriculture, mushroom farming, etc. and also aquaculture are important system of agriculture which can boasts agriculture in the region. These activities can prove a boon not only in generating income to the farmers but also agro-environmental friendly. Due credence should be given to these activities by both government and non-government organizations in the rural programmes. Despite the frequent environmental disasters, agriculture is still potentially a renewable enterprise. With the right technological solutions combined with the right policy directions effectively implemented, it can contribute to a sustainable and equitable food system.

CHAPTER 4
ESTIMATION OF SOIL LOSS

4.1 Universal Soil Loss Equation (USLE)

Soil loss by runoff is a severe ecological problem occupying 56 per cent of the world wide area and generally accelerated by human-induced soil degradation.[100] Despite the fact that soil erosion can be caused by geomorphologic process, accelerated soil erosion is principally favored by human activities. Rapid population growth, deforestation, unsuitable land cultivation, uncontrolled and overgrazing have resulted in accelerated soil erosion in the world. There are varieties of soil erosion, and rill and inter-rill erosion are the re-current types of water erosion, involving detachment, transport, and accumulation of soil particles to a new depositional area, deteriorating soil quality as well as diminishing the productivity of vulnerable lands.[101] Soil loss is also activated by an amalgamation of factors such as slope length-steepness, climate change, land cover patterns and the intrinsic properties of a soil, which makes the soil particles more prone to erosion.

Soil erosion is second only to population growth as the biggest environmental problem the world is facing. The United States is losing soil 10 times faster than the natural replenishment rate, while China and India are losing soil 30–40 times faster.[102] As a result of erosion over the past 40 years, 30 per cent of the world's arable land has become unproductive. Around 60 per cent of eroded soil ends up in rivers, streams and lakes, making waterways more prone to flooding and to contamination from fertilizers and pesticides. Erosion also reduces the ability of the soil to store water and support plant growth, thereby reducing its ability to support biodiversity.[103]

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[100] Bai, Z.G.,*et. al.*, 2008.*Proxyglobalassessment of land degradation*, Soil Use and Management, 24.p. 223–234.

[101] Fernandez, C.,*et. al.*, 2003.*Estimating water erosion and sediment yield with GIS, RUSLE, and SEDD*, Journal of Soil and Water Conservation, 58(3), 128 Community Perception, Royal Swedish Academy of Sciences.

[102] Pimentel, D., 2006. *Food and environmental threat of soil erosion,*Journal of the Environment, Development and Sustainability,8.p. 119–137.

[103]Op. cit., Pimentel, D., 2006.

Accelerated soil erosion has adverse economic and environmental impacts.[104] It creates on-site and off-site effects on productivity due to decline in land/soil quality.[105] Asia has the highest soil erosion rate of 74 ton/acre/yr[106] and Asian rivers contribute about 80 per cent of the total sediments delivered to the world oceans and amongst these Himalayan rivers are the major contributors.[107] Raymo and Ruddiman (1992) articulated that the Himalayan and Tibetan regions although covers only about 5per cent of the earth's land surface, but supply around 25per cent of the dissolved load to the world oceans.[108]

Soil erosion is a widespread problem in agriculture in the developing countries. Each year, 75 billion tons of soil is removed due to erosion, with most of it coming from agricultural land and as a result, around 20 Mha of land is lost. It is very high in Asia, Africa and South America averaging 30–40 t ha^{-1}1 $year^{-1}$.[109] In the humid tropics of Asia, farmers grow subsistence crops in sloping land using highly erosive practices. An average rate of soil loss for Asia is 138 t ha^{-1} $year^{-1}$.[110] An estimated 175 Mha of land in India, constituting about 53per cent of the total geographical area (329 Mha), suffers from deleterious effect of soil erosion and other forms of land degradation. Active erosion caused by water and wind alone accounts for 150 Mha of land, which amounts to a loss of about 5.3 Mt of sub-soil per year. In addition, remaining 25 Mha land has been degraded due to ravine, gullies, shifting cultivation, salinity, alkalinity, and water

[104] Lal, R., 1998. *Soil erosion impact on agronomic productivity and environment quality: Critical Review. Plant Science, 17.*p. 319-464.

[105] Lal, R., 2001. *Soil degradation by erosion, Land Degradation & Development, 12*.p. 519 –539.

[106]El-Seaify, S.A., 1994. *State of Art of Assessing Soil and Water Conservation Needs and Technologies*, in Adopting Conservation the Farm: An International Perspective on the Socio-economics of Soil and Water Conservation, Soiland Water Conservation Society, lowa, USA. p. 13-27.

[107] Stoddart, D. R., 1969. *World erosion and sedimentation in water*, in Chorley, R. J. (Ed.), Water, Earth and Man. Methuen, London.p. 43-64.

[108]Raymo, M. E. and Ruddiman, W. F., 1992.*Tectonic forcing of Late Cenozoic climate, Nature, 359*.p. 117-122.

[109]Barrow, C.J., 1991.*Land degradation,* Cambridge University Press, Cambridge.

[110]Sfeir-Younis, A., 1986.*Soil conservation in developing countries,* Western Africa Projects Department/TheWorld Bank, Washington, DC.

logging.[111] Dhruvanarayana and Rambabu (1983) have estimated that in India about 5,334 Mt (16.4 t ha^{-1}) of soil is detached annually; about 29per cent is carried away by river into the sea and 10per cent is deposited in reservoirs resulting in the considerable loss of the storage capacity.[112]

North Eastern Hill region of India comprises 8 states namely Assam, Arunachal Pradesh, Manipur, Meghalaya, Mizoram, Nagaland, Tripura and Sikkim. The area is dominated by three land forms that associated viz., a) The Greater Himalayas, b) Strong dissected high lands and c) Low lying riverine plains. The Annual rainfall of the region varies from 2,000 to 10,000 mm. The topography and climate of the region is conducive to accelerate soil erosion, which has been recognized as a serious threat to environment.[113] Nagaland, which was once submerged in the deep Tythyan Sea, presents complicated structural and physical features and the formation of land mass may be co-relatable with the young fold mountains of the Alpine Himalayan orogeny. Its topography is similar to that of any other young mountain terrain features with hills, sharp ridges, deep gorges and narrow valleys. Climate of Nagaland is typical of a tropical country with heavy rain fall. The average rainfall of the area is about 2000mm to 2500mm which is relatively high. Though rainfall is not uniform in the state, in some region continuous rainfall for days is observed during the months of June to August which is the peak of the rainy season. Based on the morphotectonic elements, the Naga Hills has been longitudinally divided, from west to east, into three distinct units, namely- the Schuppen Belt, the Inner Fold Belt/ the Patkai Synclinorium and the Ophiolite Belt.

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[111]Reddy, M. S., 1999.*Theme paper on "Water: Vision 2050"*, Indian Water Resources Society, Roorkee. p. 51-53.

[112] Dhruvanarayana, V. V., Babu, R., 1983. *Estimation of soil loss in India*, Journal of Irrigation Drainage Engineering, 109(4). p. 419-433.

[113] Solanki, R. C., Singh, A., 1996.*Soil erosion research on steep slopes in north-eastern hill region of India,* a review Indian Journal Soil Conservation, 24(3). p. 187-192.

4.2 Remote Sensing and GIS in Soil Erosion Assessment

Assessment of soil erosion rate is essential for the development of adequate erosion prevention measures for sustainable management of land and water resources. However, validating the results of erosion rates is difficult because accurate measurements are generally expensive and time consuming, and standard equipment is hardly available.[114] The use of remote sensing images has proved successful in monitoring soil erosion changes in time and space.[115]It has proved to be a straightforward and inexpensive tool in erosion risk assessment.[116] Geographic Information System (GIS) technologies are valuable tools in developing environmental models through their advance features of data storage, management, analysis, and display.[117]

In qualitative methods, the qualitative factors integration firstly classifies some major factors based on specific standard, and the classified factors are then integrated according to certain formula to create an erosion risk map.[118] This method is used widely because it is rarely influenced by personal subjective knowledge, and when combined with geographic information systems (GIS) can efficiently and quickly monitor erosion risk.[119] Based on remote sensing and GIS, the qualitative analysis of the dynamic changes of the spatial distribution and intensity of the soil erosion can provide an important basis for soil erosion assessment, control, and prediction. This analysis is significant in the sustainable utilisation ofland resources and water environment safety.

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[114] Stroosnijder, L., 2005.*Measurement of erosion: Is it possible?*Catena. p. 2-3, 162-173.

[115] King, C.,*et. al.,* 2005.*The application of remote-sensing data to monitoring and modelling of soil erosion*.Catena.p. 79-93.

[116] Lu, D.,*et. al.,*2004.*Mapping soil erosion risk in Rondônia, Brazilian Amazonia: using RUSLE, remote sensing and GIS*, Land Degrad.Dev. 2004, 15.p. 499-512.

[117]Burrough, P. A. and McDonnell, R.A., 1998.*Principles of Geographic Information Systems*; Oxford Science Publications: New York, USA.p. 356.

[118] Zhang, X.,*et. al*., 2010.*Identification of priority areas for controlling soil erosion,* Catena, 83.p. 76-86.

[119] Tian, Y.,*et. al.,* 2008.*Risk assessment of water soil erosion in upper basin of Miyun Reservoir, Beijing, China*, Environ.Geol.,4.p. 937-942.

It also provides derivations of the scientific basis for ecological construction and sustainable development of social economy.

4.3 Soil Erosion Model

Erosion models are used to predict soil erosion. Soil erosion modeling is able to consider many of the complex interactions that influence rates of erosion by simulating erosion processes in the watershed. Various parametric models such as empirical (statistical/metric), conceptual (semi-empirical) and physical process based (deterministic) models are available to compute soil loss. In general, these models are categorized depending on the physical processes simulated by the model, the model algorithms describing these processes and the data dependence of the model. Empirical models are generally the simplest of all three model types. They are statistical in nature and based primarily on the analysis of observations and seek to characterize response from these data (Wheater, *et. al.,* 1993). The data requirements for such models are usually less as compared to conceptual and physical based models. Conceptual models play an intermediary role between empirical and physics-based models. Physical process based models take into account the combination of the individual components that affect erosion, including the complex interactions between various factors and their spatial and temporal variability's. These models are comparatively over-parameterised.

Most of these models need information related with soil type, land-use, landform, climate and topography to estimate soil loss. They are designed for specific set of conditions of particular area. The Universal Soil Loss Equation (USLE) designed by Wischmer and Smith [120] was to predict soil loss from sheet and rill erosion in specific conditions from agriculture fields. Modified or Revised universal soil loss equation (MUSLE) (Williams and Berndt; Meyer, 1975) a modified version of USLE is

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[120]Wischmeier,W. H., Smith, D. D., 1978.*Predicting rainfall erosion losses,* USDA Agricultural Research Services handbook 537.USDA, Washington, DC.p. 57.

applicable to other conditions by introducing hydrological runoff factor for sediment yield estimation.

4.4 Revised Universal Soil Loss Equation (RUSLE) Calculation

The erosion causing factors such as climate, soil properties, vegetation cover and management practices are considered for estimating soil loss. The RUSLE equation is a multiplicative function of five factors controlling the rill and inter-rill erosion (Renard, *et. al.,* 1997) and can be expressed as:

A= R*K*LS*C*P (t ha^{-1} yr^{-1})-------------------(1)

Where:

A is the mean annual soil loss expressed in ton $ha^{-1}yr^{-1}$

R is rainfall and runoff erosivity index (in MJ mm$ha^{-1}yr^{-1}$)

K is soil erodibility factor (in ton ha h $ha^{-1}MJ^{-1}$mm)

LS is slope steepness and slope length factor (dimensionless)

C is the cover and management factor (dimensionless)

P is the conservation practice factor (dimensionless).

4.5 Erosivity Index of RUSLE

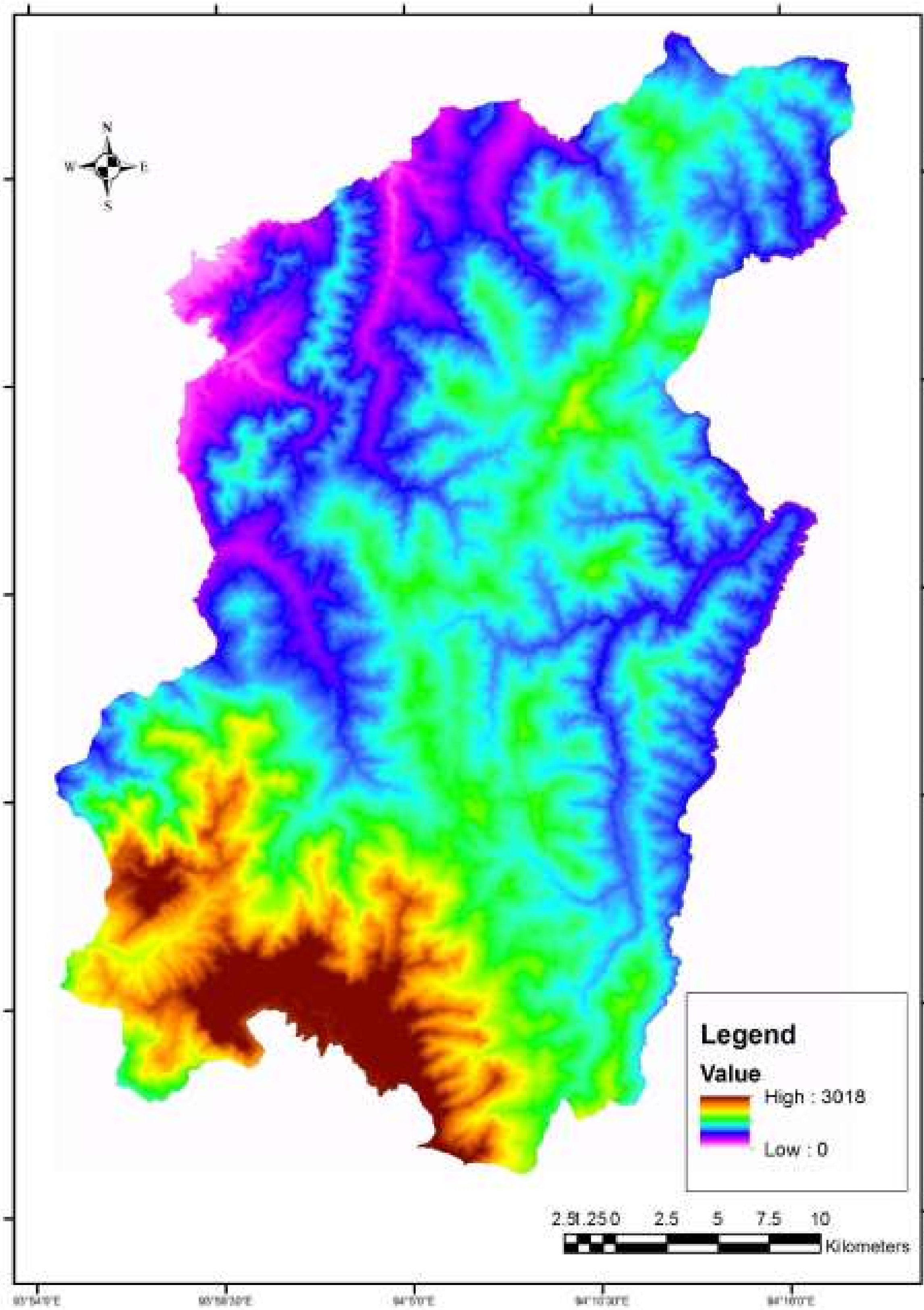
In the recent past sediment yield and soil erosion studies using GIS and Remote sensing technologies have been carried out by many investigators. The present study is an attempt to determine the average soil loss in Kohima district of Nagaland taking the average rainfall for the last six years from 2009-2014. Erdas Imagine 2014 and ArcGIS 10.2.2 have been used for generation of various thematic layers landuse/landcover map, slope map, flow direction map, aspect map, and other data sets of the study area. The satellite images, acquired from the National Remote Sensing Centre, Hyderabad (India) and Aster DEM (Fig. 4.1) form the primary base map to generate different thematic map for RUSLE calculation. The details of the satellite images are listed below.

ID	- IRS-R2
Sensor	- L3Data
Path	- 112 and 113
Row	- 53
Date of pass	- 21November 2011 and 26 Nov 2011 (respectively)
Season	- November
No. of Band	- 4
Resolution	- 23 m
Swath wide	- 142 km

The satellite images of the study area come under two paths and rows and the images are mosaic to finally provide the map in digital mode. The IRS-R2 LISS III and the Aster DEM have been geometrically corrected from a known geocoded map of the study area using ten ground control points such as the graticule intersections in terms of geometric projections into WGS 84, UTM Zone 46N as Datum. A second-degree polynomial transformation model was utilized for this purpose. The geometric precision was tested, by comparing the Root Mean Square Error (RMSE) of the corresponding graticule intersections with their theoretical coordinates kept within one pixel.

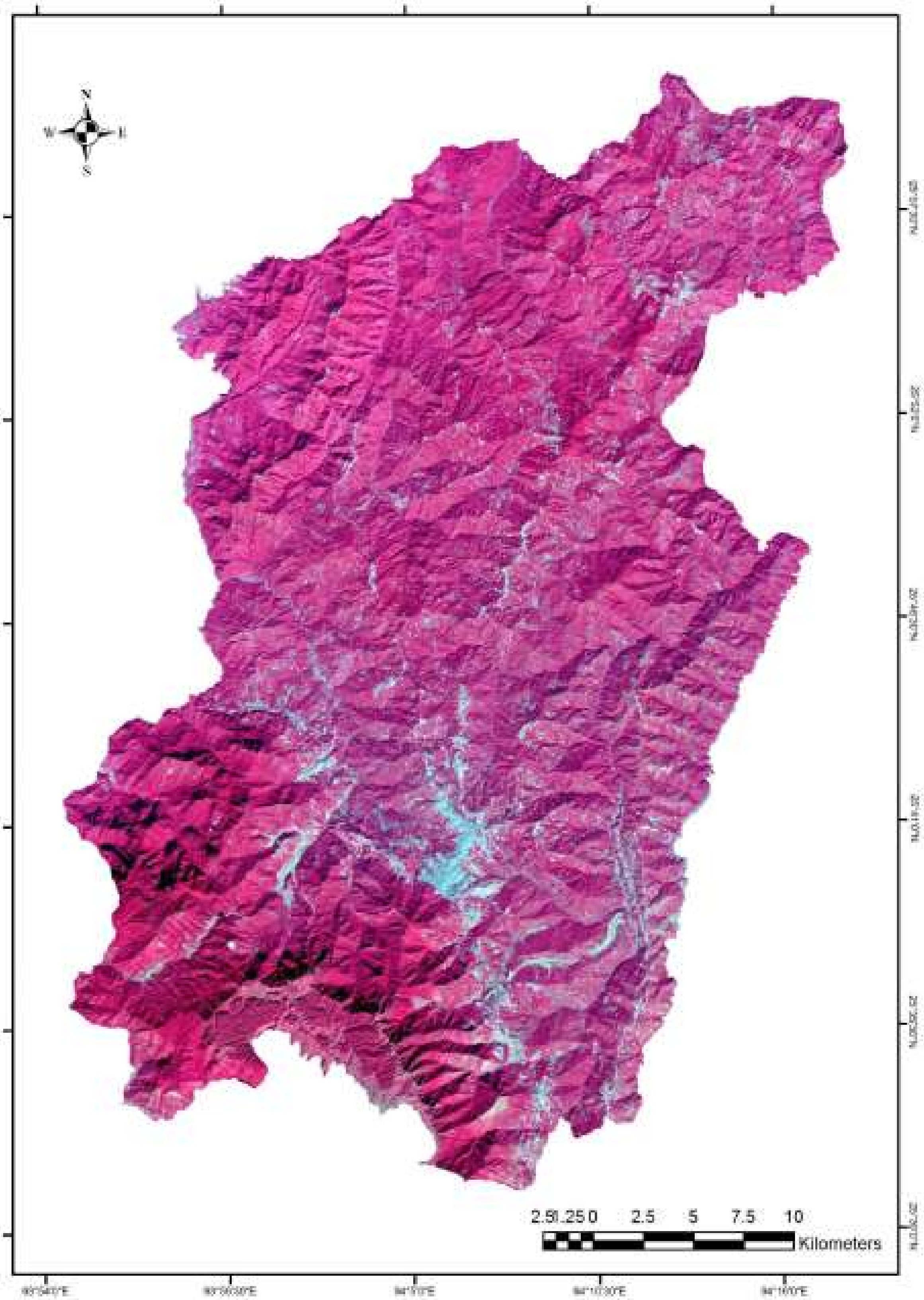
The IRS-R2 LISS III was used for preparing landuse/landcover through digital interpretation using ERDAS IMAGINE software. The False Colour Composite (FCC) of study area is presented in Fig. 4.2, and unsupervised classification was carried out and area statistics is presented in Fig.4.3 and Table4.1 respectively. Land use / land cover classification is done through the process of unsupervised classification in Erdas with 25 different classes and later through hybrid classification the classes are further minimized to 8different classes. With the classification done in the Erdas, ground truth-in was taken up to check the accuracy of the classification and recoding was done to those over-lapping classes.

Fig. 4.1
Digital Elevation Map: Kohima District



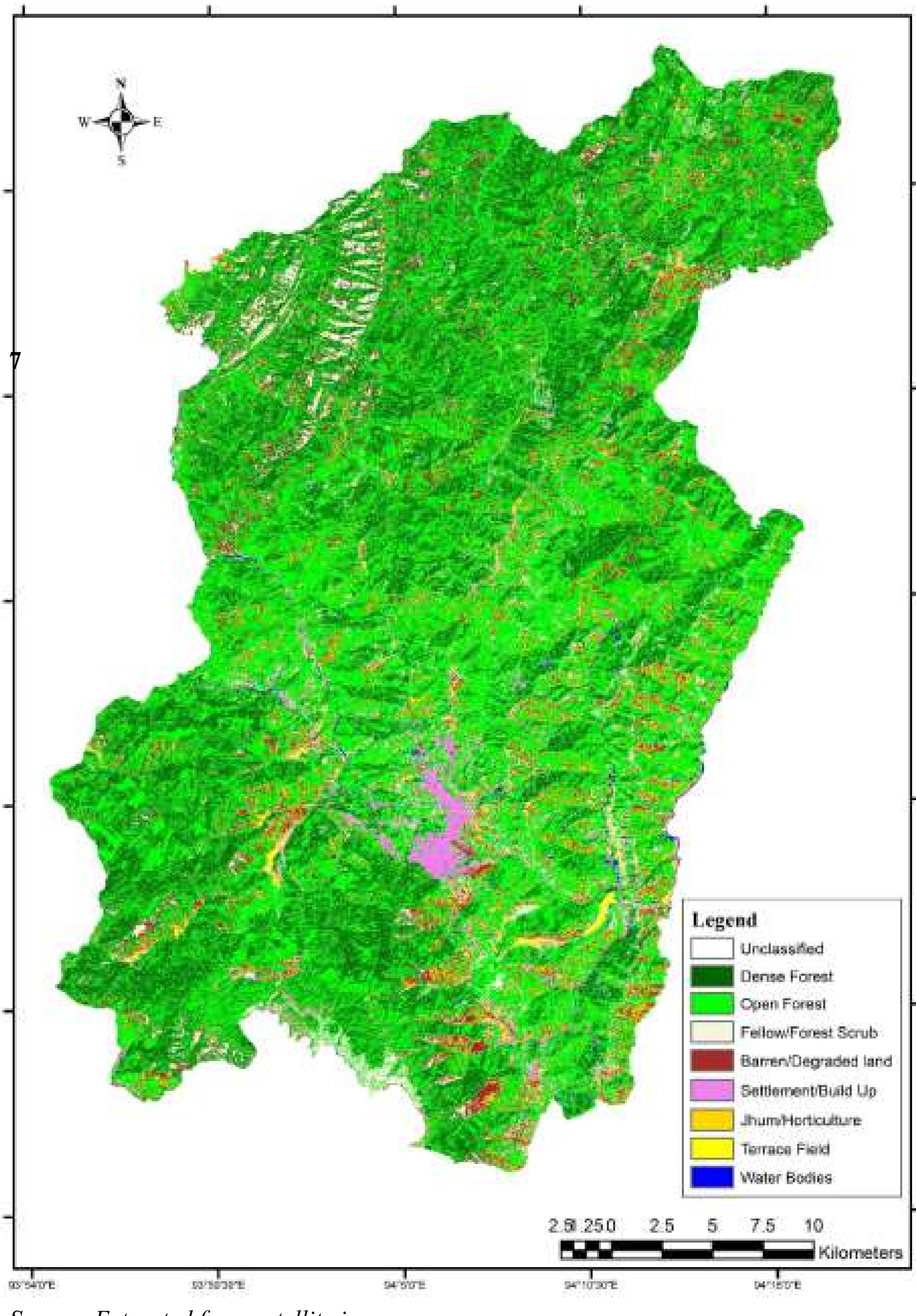
Source: Downloaded from Bhuvan.

Fig. 4.2
False Colour Composite: Kohima District



Source: National Remote Sensing Centre, Hyderabad.

Fig. 4.3
Landuse/Landcover Map: Kohima District



Source: Extracted from satellite images.

Table 4.1
Maximum likelihood report for landuse/land cover classification

Class Name	Histogram	Area (ha)	Area (%)
Dense Forest	6,27,783	36,160.3	27.318
Open Forest	11,51,821	66,344.9	50.123
Fellow/Forest Scrub	1,68,941	9,731	7.351
Barren/Degraded Forest	1,87,444	10,796.8	8.156
Settlement/Build Up	46,279	2,665.67	2.014
Jhum/ Horticulture	68,976	3,973.02	3.002
Terrace	32,198	1,854.6	1.404
Water Bodies	14,534	837.158	0.632
Total	22,97,976	1,32,363.448	100.000

Source: From LULC map.

The erosivity factor used in RUSLE is explained as follows:

R factor

Long-term average R-values are often correlated with more readily available rainfall values like annual rainfall or the modified Fournier's index (Sadeghi, *et. al.,* 2011). Due to the lack of data and instrument, a simple computation of R factor, data from single meteorological stations (as expressed in Equation 2) was applied for determining the precipitation.

$R=79+0.363X_a$ (Choudhury and Nayak, 2003)[121]-------------------------(2)

Where X_a is the average annual rainfall in mm over the study area.

Rainfall data of 6 years (2009-2014) from the Directorate of Soil and Water Conservation Department, Kohima was used for calculating the Rainfall erosivity (R factor). The study area has no record of rainfall intensity as a result the monthly rainfall data were used to calculate the R-factor annually using the equation 2 as mentioned

[121]Choudhury, M. K. and Nayak, T., 2003.*Estimation of Soil Erosion in Sagar Lake Catchment of Central India*, Proceeding of the International Conference of Water and Environment, December 15-18, 2003, Bhopal, India. p. 387-392.

above. The annual and average rainfall for a period of the six years is presented in Table 4. 2.

Table 4.2
Rainfall erosivity factor (MJ mm ha^{-1} h^{-1})

Year	Annual R (mm)
2009	1436.4
2010	2000.6
2011	1735.8
2012	1370.7
2013	1749
2014	1383.3
Average	1612.6

Source: Soil and Water Conservation Department, Kohima, Nagaland

Soil Erodibility - K factor

Soil erodibility is the manifestation of the inherent resistance of soil particles for the detaching and transporting power of rainfall (Wischmeier and Smith, 1978). It has been found that the erodibility of a soil increases proportionally with the amount of fine sand and silt content. In fact, finer textured soils, very rich in clay, are more resistant to particles detachment, because of their great cohesion, while coarser textured soils allow to a high infiltration of water, avoiding superficial runoff. Even the organic matter content is important for stating erodibility, as it contributes to increase particle aggregation (by the presence of chelating agents) and water infiltration.

The K-factor was calculated using the following relationship (Foster et.al.1991):

$K=2.8 * 10^{-7} * M^{1.14} * 12 – a+4.3*10^{-3}*b – 2+3.3*c-3$------------------(3)

Where,

M= particle size parameter i.e (per cent silt+ per cent very fine sand)*(100-per cent clay)

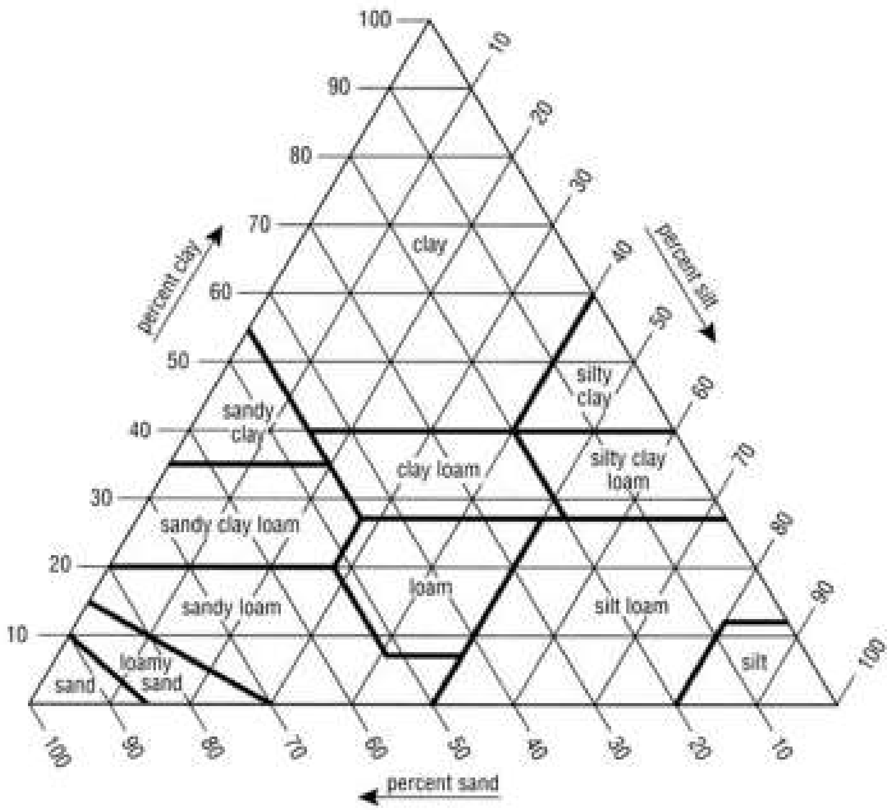
a= organic matter content (in per cent)

b= soil structure code and

c= soil permeability

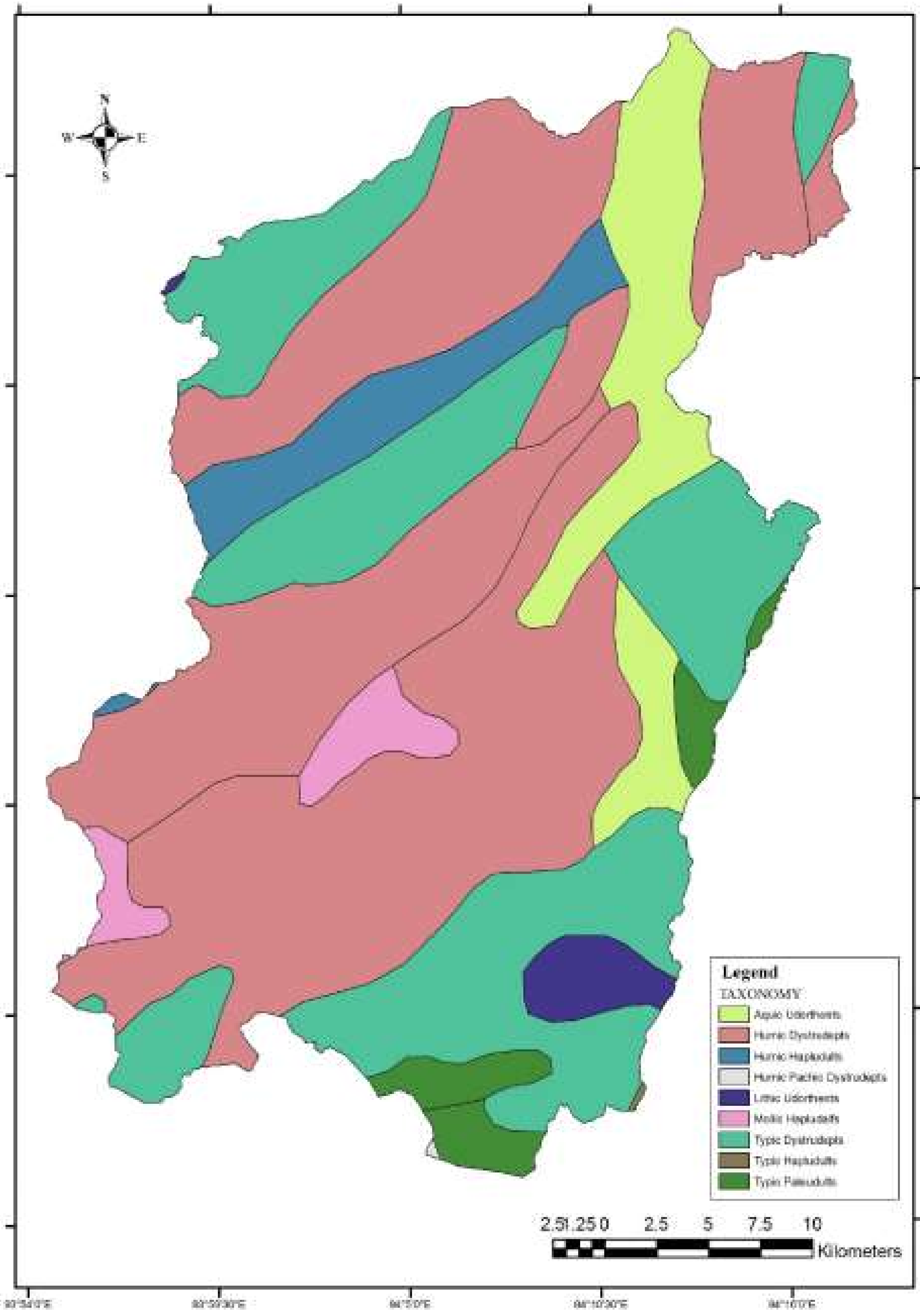
The value of K factor is based on the soil map given by The National Bureau of Soil Survey and Land Use Planning (Fig. 4.5). For the soil texture available on which the value assigned is used basing on NBSS code, the soil structure code value is assigned as 2 and soil permeability code ranges from 2-5 (Appendix1). The soil types present in the area are loam, clay and loamy skeletal. Sand per cent, clay per cent and Silt per cent are calculated using the soil texture triangle which is given in Fig 4.4.Organic matter contain per cent in the landuse/ landcover of the study area ranges from 0-3.1 (Fig.4.6). And the magnitude of the soil erodibility (K) and the spatial distribution (Fig 4.7) indicate wide variation ranging from 0.21 to 0.40.

Fig. 4.4
Soil Texture Triangle



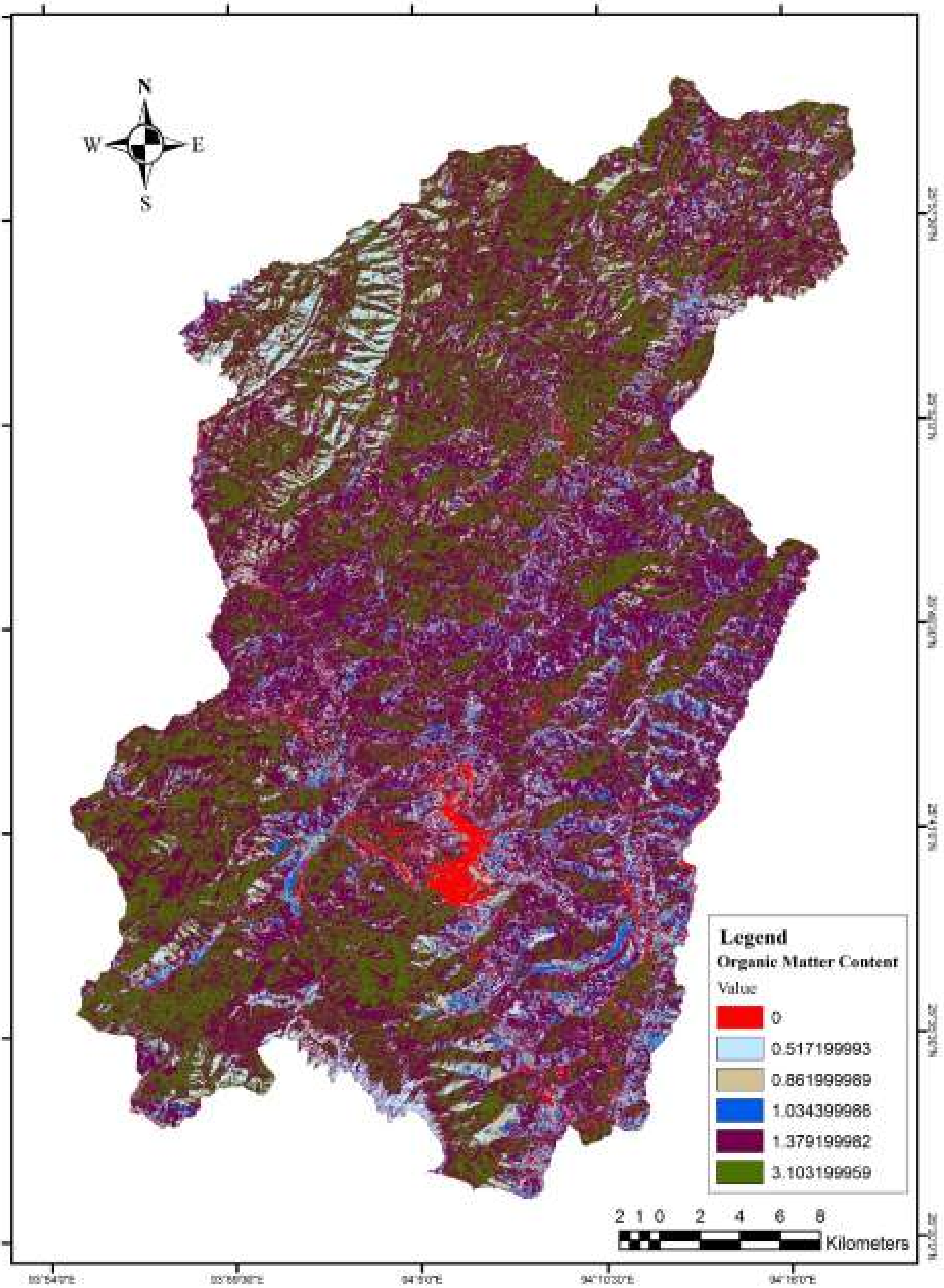
Sources: USDA Soil Texture Triangle.

Fig. 4.5
Soil Map: Kohima District



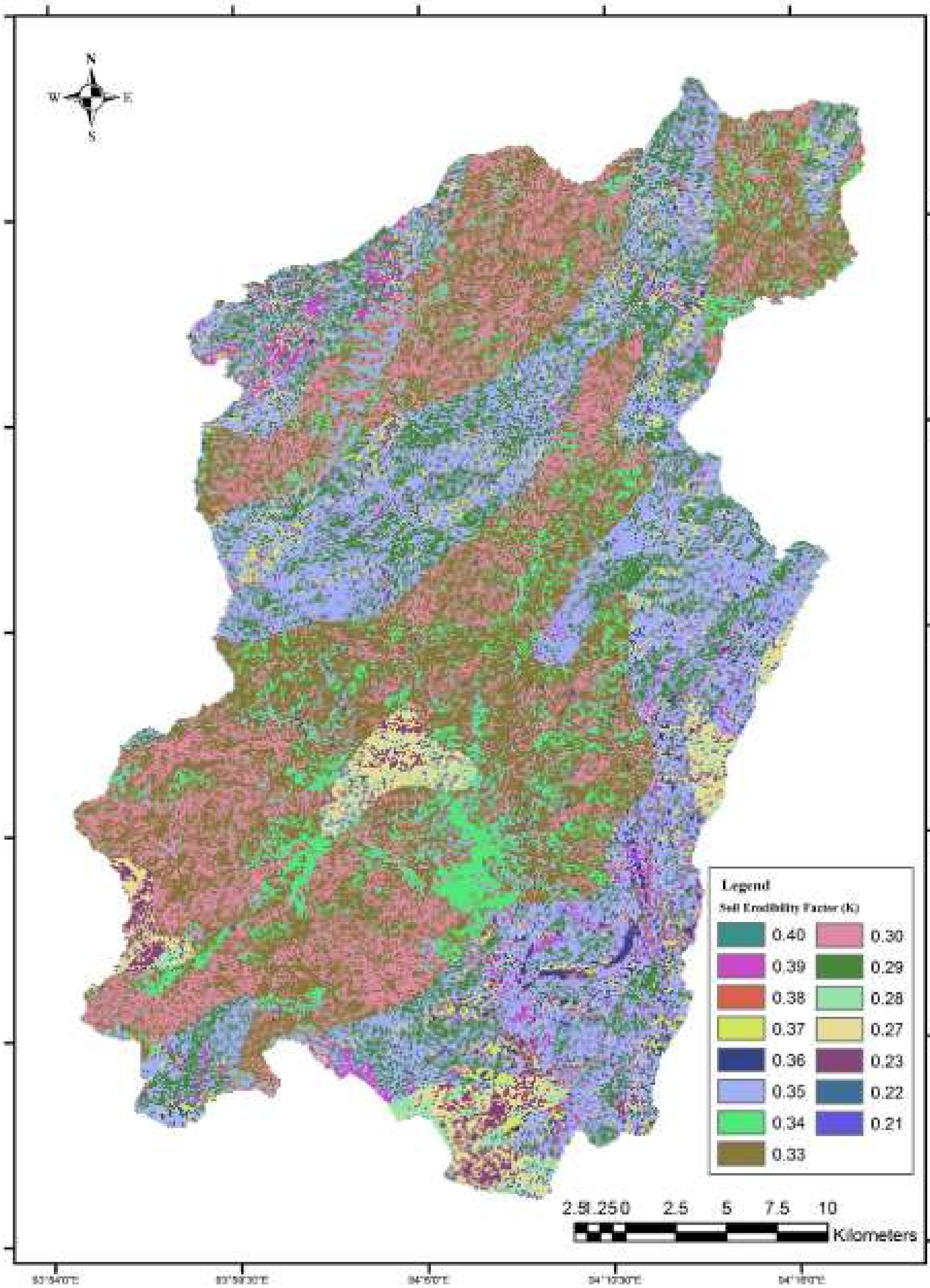
Source: National Bureau of Soil Survey and Land Use Planning.

Fig. 4.6
Organic Matter Contain (in per cent): Kohima District



Source: Extracted from LULC map.

Fig. 4.7
Spatial Distribution of Soil Erodibility Factor: Kohima District



Source: Extracted from LULC map.

Slope Steepness and Length: LS factor

The topographic factor is a very important parameter in water soil erosion, since the gravity force is playing a decisive role in surface runoff. LS factor takes into account of the steepness (S), which increases the velocity of runoff, and the length (L) of a slope, which contributes to enlarge the ground surface affected by runoff. In USLE and RUSLE, the method of slope length calculation is with the notion that the longer the slope, the higher the soil loss without considering the three dimensional complex nature of terrain.[122] However, other researchers claimed that soil loss does not depend on slope length for three dimensional complex terrains where there is flow convergence and divergence; instead it is influenced by upslope contributing area. Thus, it should be substituted by upslope contributing area.[123] Thus, it is helpful to consider the three dimensional complex terrain geometry as well as the upslope contributing area to better comprehend the spatial distribution of soil erosion and deposition process.

In this study, L and S were computed separately. The L-factor is calculated based on the relationship developed by McCool, *et. al*., (1987).[124] The equation follows as:

$L= (\lambda/22.13)^{m}$ -----------------(4)

where L=slope length factor; l=field slope length (m); m=dimensionless exponent that depends on slope steepness, being 0.5 for slopes exceeding 5 per cent, 0.4 for 4 per cent slopes and 0.3 for slopes less than 3 per cent. The percent slope has been determined from DEM, while a grid size of 200 m for field slope length (λ). Similar assumption of

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[122] Robert, P. S., Hilborn, D., 2000. *Factsheet: universal soil loss equation (USLE)*. Queen's printer for Ontario.

[123] * Desmet, P.J.J., Govers, G., 1996.*A GIS procedure for automatically calculating the USLE LS factor on topographically complex land scape units*.Journal of Soil and Water Conservation, 51.p. 427-433.

*Moore, I.D., Burch, G.J., 1986.*Physical basis of the length-slope factor in the universal soil loss equation*.Soil ScienceSocietyofAmerica Journal, 50(5).p. 1294-1298.

* Mitas, Z., Mitasova, H., 1996.*Modeling topographic potential for erosion and deposition using GIS*, International Journalof GIS, 10.p. 629-641.

[124]McCool, D. K., *et. al.,* 1987.*Revised slope steepness factor for the universal Soil Loss Equation*, Trans of ASAE 30(5). p. 1387-1396.

field slope length has been attempted by several researchers (Onyando,*et. al*., 2005; Fistikoglu and Harmancioglu, 2002;Jain,*et. al*., 2001).

Slope Steepness Factor (S)

The S-factor was calculated based on the relationship given by

McCool,*et. al.,* (1987) for slope longer than 4 m as:

$S = 10.8 \sin \theta + 0.03$ for slopes < 9% ------------------------- (5)

$S = 16.8 \sin \theta - 0.50$ for slopes ≥ 9% ------------------------- (6)

Where S=slope steepness factor and θ=slope angle in degree.

The slope steepness factoris dimensionless. LS factor was derived with the help of Arc Info GIS.The spatialdistribution of these factors so derived is shown in Fig. 4.8 and Fig.4.9.To establish the digital map of slope length, a Digital Elevation Model (DEM) was created in ERDAS. Slope in percentage was created from the DEM. Fill and flow direction was again processes from DEM where flow accumulation was extracted and LS-factor was computed in Arc GIS raster calculator using the map algebra expression in Eq. (4) suggested by Mitasova and Mitas[125] (1999) and Simms, *et. al*.(2003).[126]

LS= POW ([flow accumulation]*Cell size/22.13, 1.6)*POW(sin[slope]*

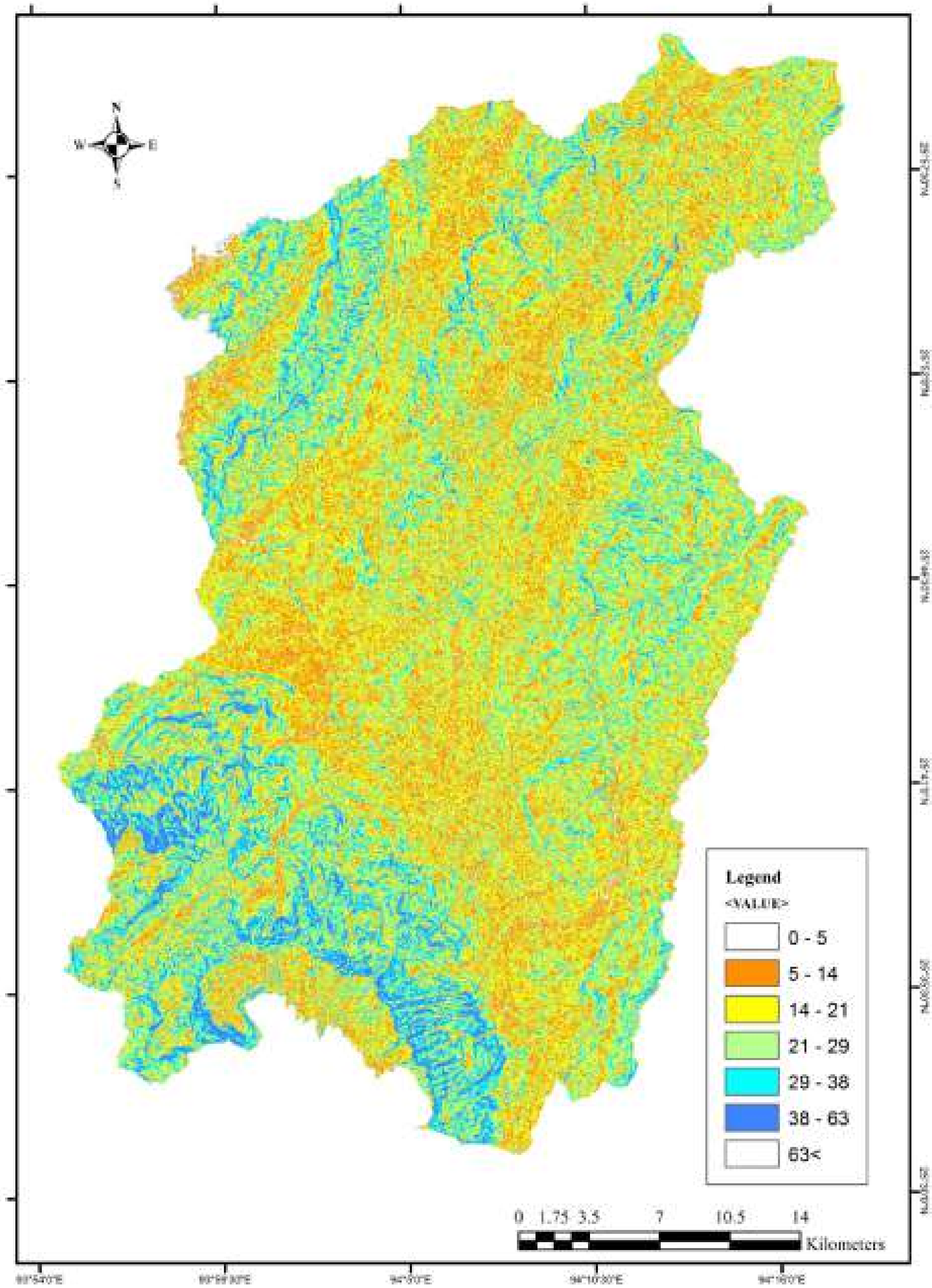
0.1745/0.0896, 1.3 ------------------(7)

LS factor was found tobe in the range of 0.1 to 42.5.

[125] Mitasova,H., Mitas,Z., 1999. *Modeling soil detachment with RUSLE 3D using GIS*, IL, USA: University of Illinois at Urbana –Champaign.

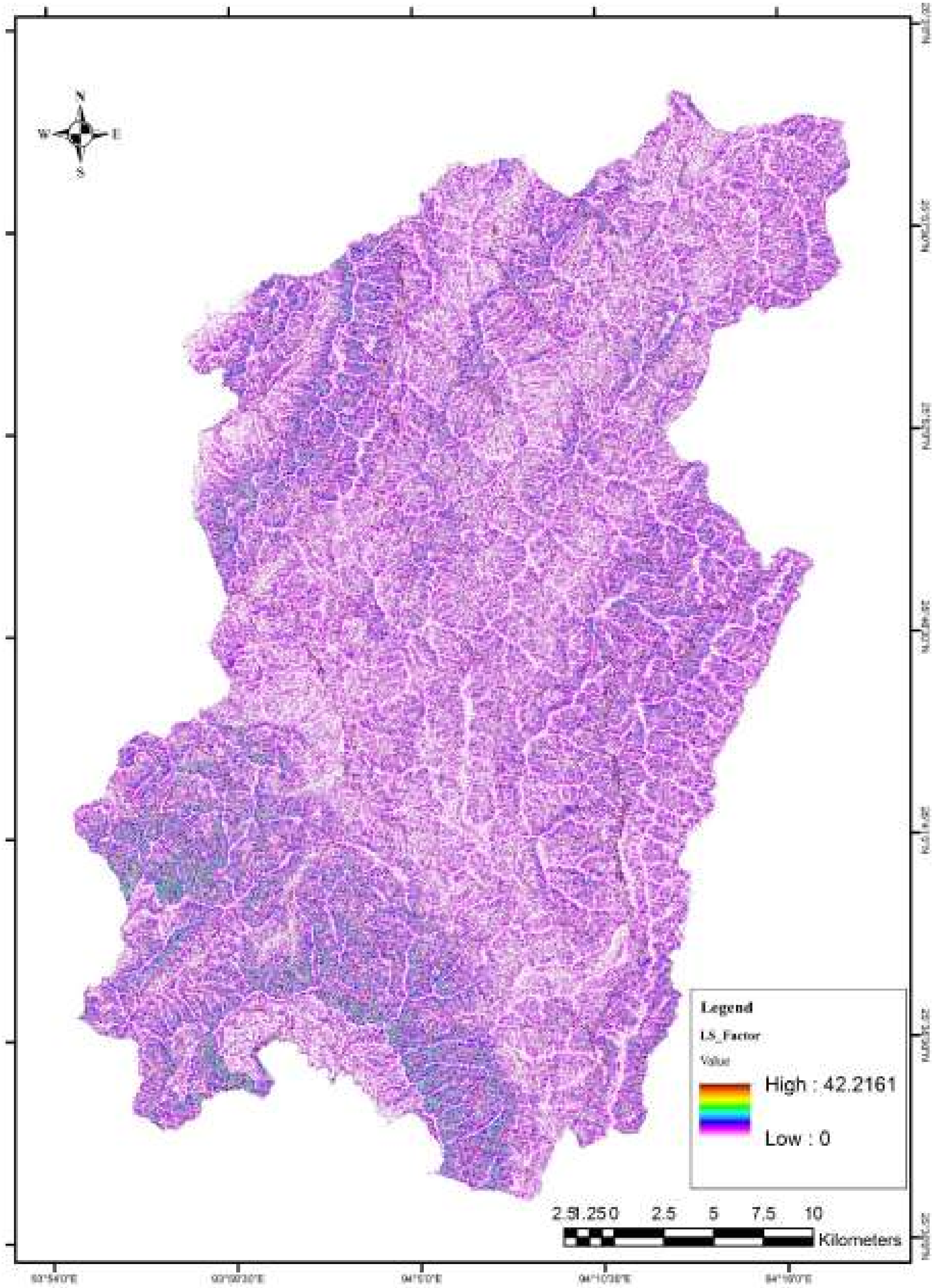
[126]Simms, A.D.,*et. al.,* 2003.*Application of RUSLE for erosion management in a coastal catchment ,Southern NSW*, in proceedings of the international congress on modeling and simulation: integrative modeling of bio-physical, social and economic systems for resource management solutions, July14–17. p. 678–683

Fig. 4.8
Slope Map (in per cent): Kohima District



Source: From DEM through GIS.

Fig. 4.9
Spatial Distribution of LS Factor: Kohima District



Source: From DEM through GIS.

Cover and Management: C Factor

The cover and management (C) factor represents the ratio of soil loss from land with specific vegetation to the corresponding soil loss from a continuous fallow.[127] It is the single factor most easily changed and is the factor most often considered in developing a conservation plan. The spatial distribution of the C factor is shown in Fig. 4.10.

Table 4.3
Crop Management Factor for Different Landuse/Landcover Classes

Land use/Land Cover	C-value
Agriculture	0.28
Degraded Forest	0.008
Dense Forest	0.004
Open Forest	0.008
Fellow agriculture	0.180
Jhum Cultivation	0.33
Settlement	1.0
Waterbody	0.28

Source: USDA-SCS, (1972),[128] Rao, (1981).[129]

Conservation Practice: P Factor

Erosion control practice factor (P-factor) is the ratio of soil loss with a specific support practice to the corresponding loss with up slope and down slope cultivation (Wischmeier &Smith,1978). Conservation factor (P) depends on land use/cover information of the study area. The values for P-factor are assigned to be 0.28 for area under paddy cultivation and 1.0 for other area. The values are based on the values suggested by Rao (1981). The conservation factor is found to be 0.28 and 1.00 (Fig. 4.11).

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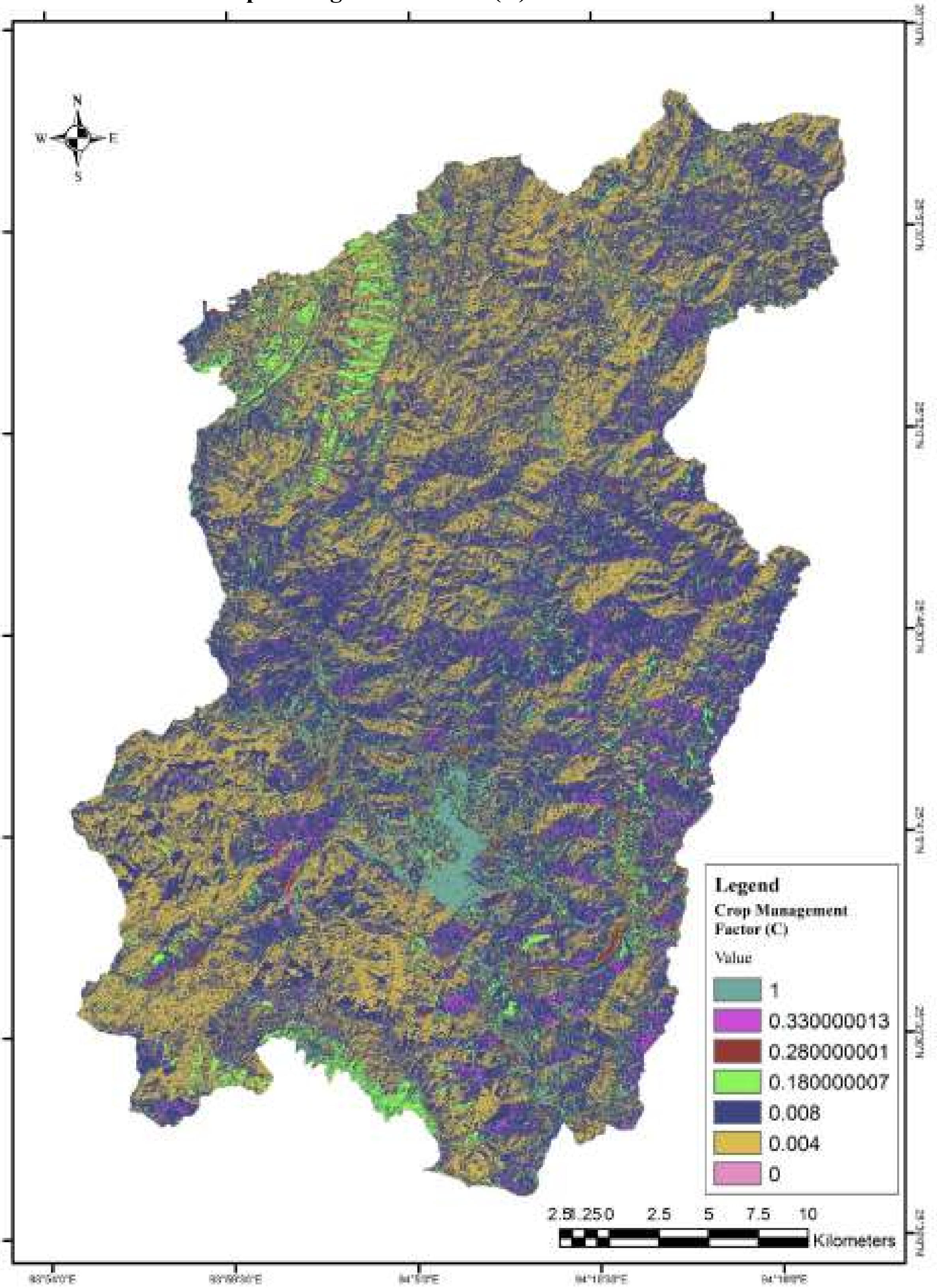
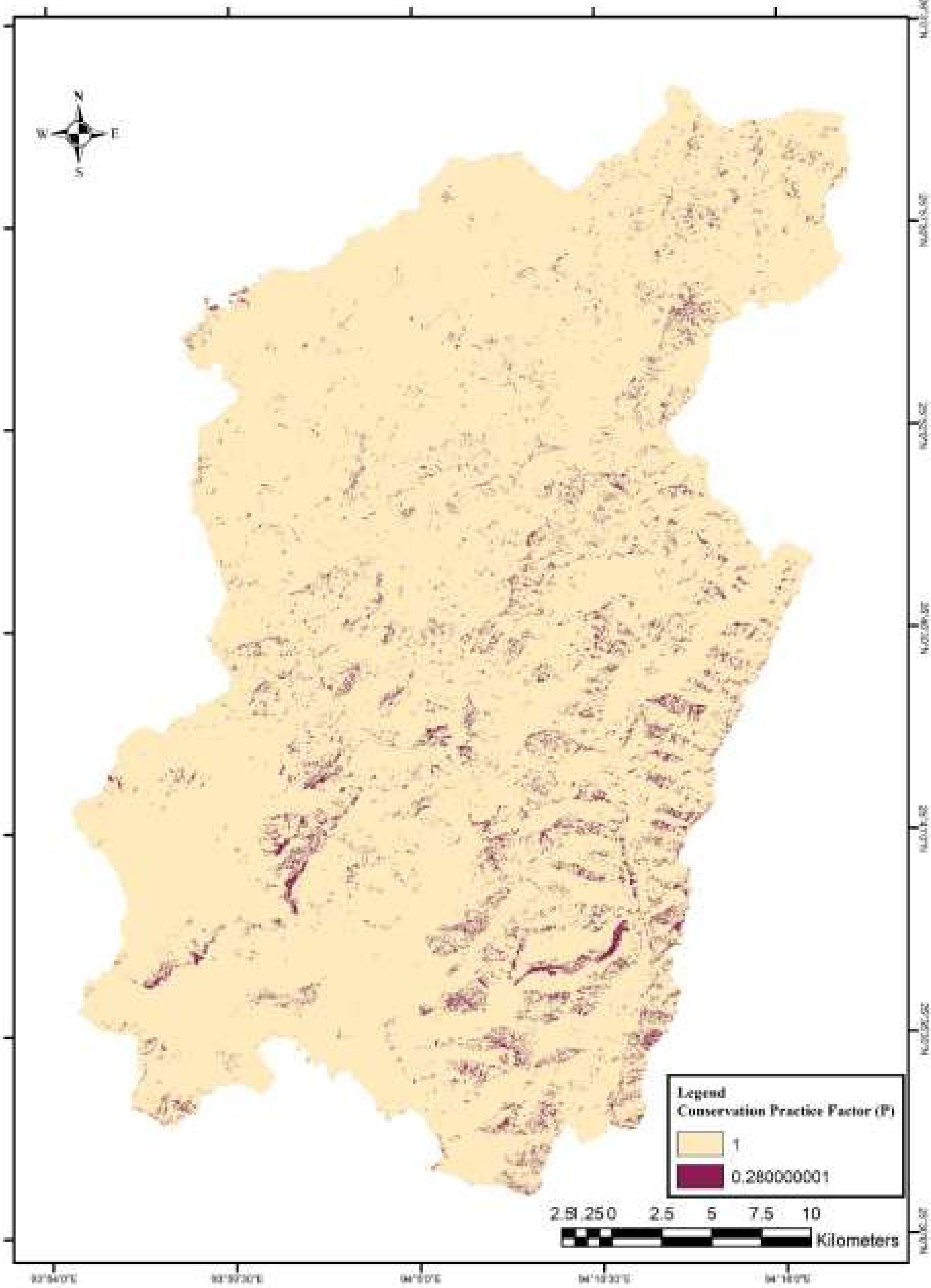
[127] Morgan, R.P.C., 2005. *Soil erosion and conservation* (3rd Edn), Oxford: Blackwell Publishing.
[128]USDA-SCS., 1972.*Hydrology,* in SCS national engineering handbook, section 4. US Department of Agriculture, Washington, DC.
[129] Rao, Y. P., 1981. *Evaluation of cropping management factor in universal soil loss equation under natural rainfall condition of Kharagpur, India,* proceedings of the Southeast Asian Regional Symposium on Problems of Soil Erosion and Sedimentation, Asian Institute of Technology, Bangkok. p. 241-254.

Fig. 4.10
Crop Management Factor (C): Kohima District



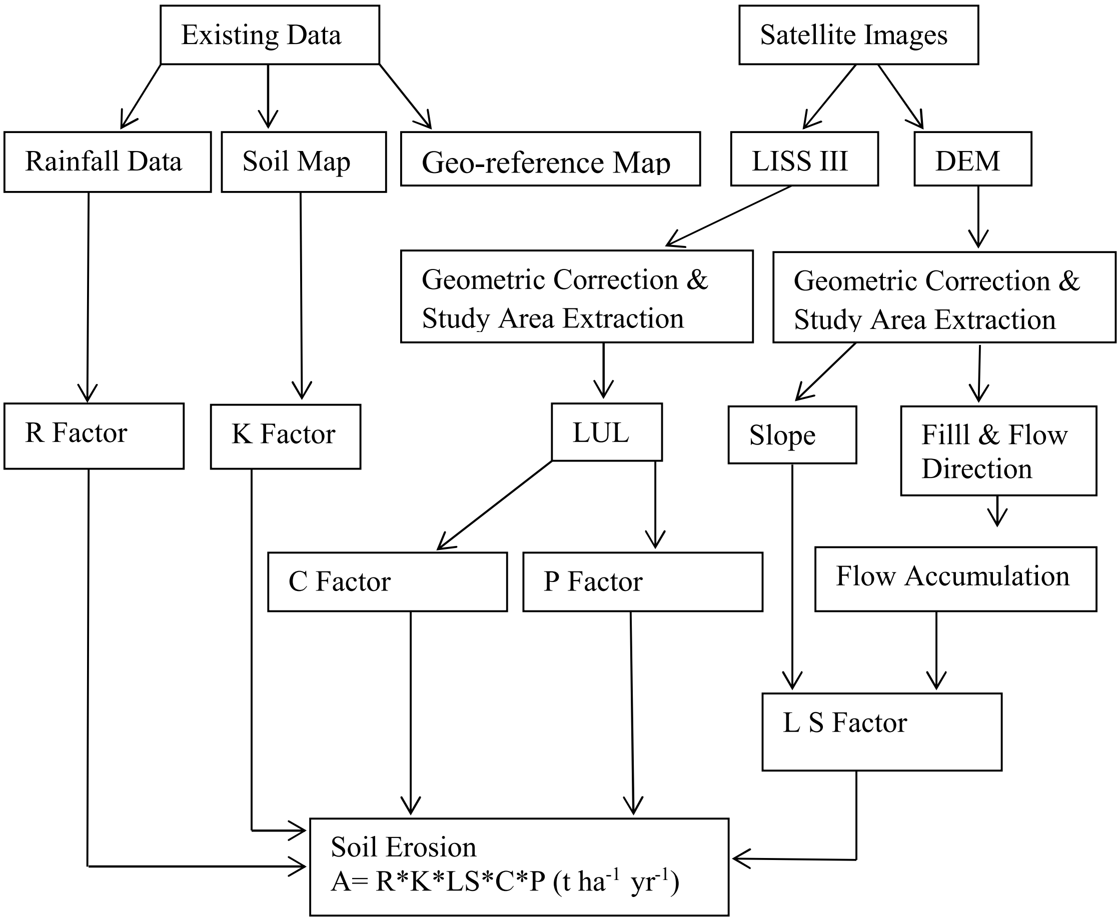
Source: Extracted from LULC.

Fig.4.11
Conservation Practice Factor (P): Kohima District



Source: Extracted from LULC.

4.6 FLOWCHART OF METHODOLOGY



4.7 Average Annual Soil Loss Estimation: Kohima District

The study provides an overall insight into causes of soil erosion resulting from interaction of the USLE factors spatially and quantitatively. The estimated average annual soil loss(year wise) and the spatial distribution of average soil loss of the entire area under study arepresented in Table 4.5 and Fig. 4.12 respectively. The wide variation in soil loss is mainly due to the variation in R factor. Minimum sediment yields (60.408t $ha^{-1}yr^{-1}$) is found in the year 2012, when therainfall was 1370.7 mm.Similarly, the highest value of sediment yield (103.042t $ha^{-1}yr^{-1}$) is found in the year 2010 when the rainfall was 2000.6 mm. It is found that there is a close correlation between the rainfall characteristics and soil loss. An increase in rainfallamount is generally accompanied by an increase in soil loss. In this study, on an average thepotential soil erosion inKohima district, is found to be 77.7536 t ha^{-1} yr^{-1} (Table 4.5 and Fig. 12) with high erosion level in the settlement, build up area and cultivation area (average soil loss is 53.846 t ha^{-1} yr^{-1}). It is noticed that anthropogenic activities is one of the main causes of soil erosion in the area. Moreover, highly erosive prone areas are mainly concentrated in higher altitudes of the study area. This area experiences high drainage density, low soil thickness and high slope, which may be the contributing factor for the high erosion proneness. Above all, the high intensity of rainfall is one of the main reasons which accelerate the soil erosion in the highly erosive prone areas. The soil loss of the entire region is categories into 6 classes as presented below.

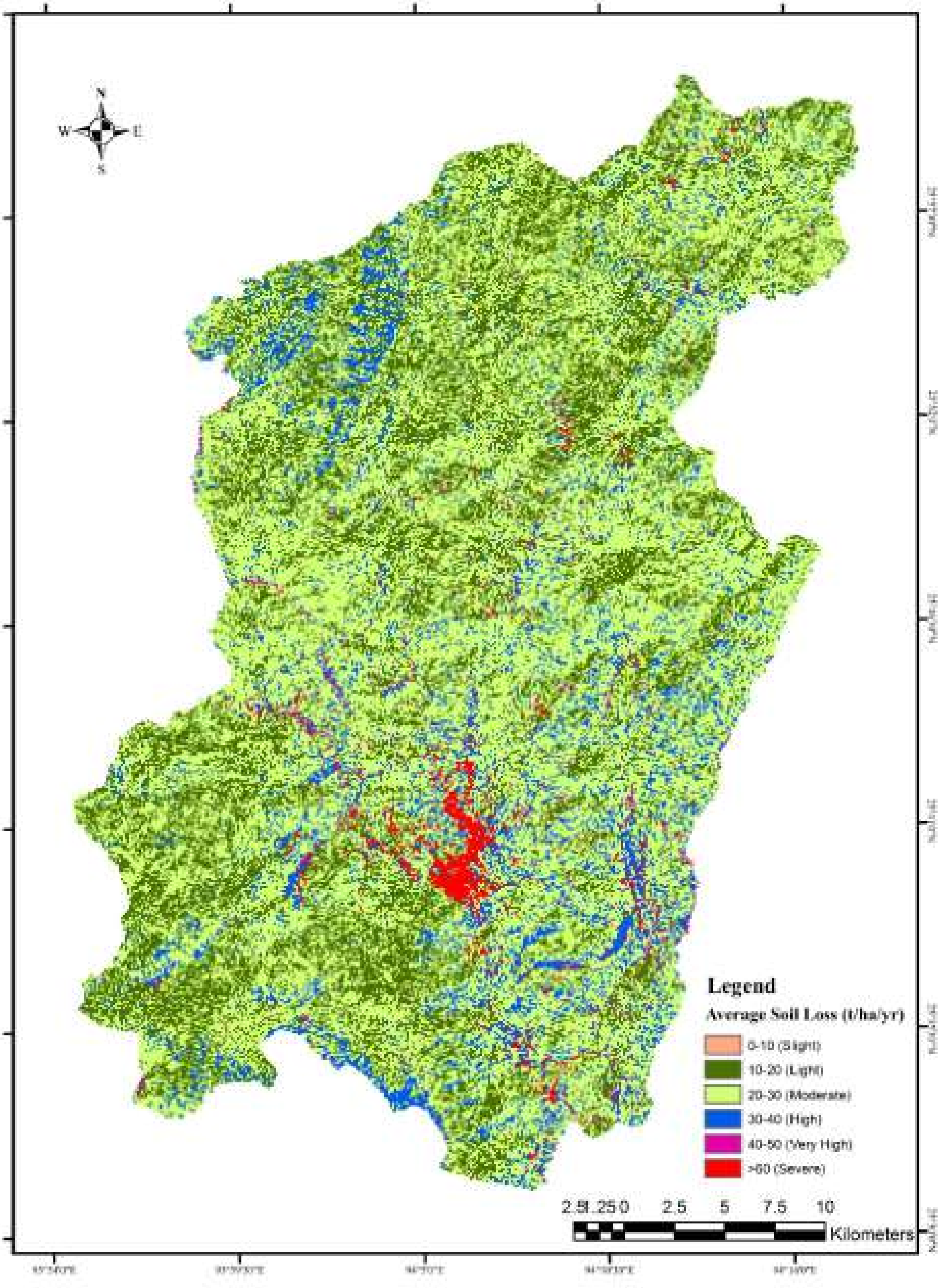
Table 4.4
Soil loss Class

Value	Class
0-10	Slight
10-20	Light
20-30	Moderate
30-40	High
40-50	Very High
>60	Severe

Table 4.5
Average annual soil loss of the study area (Year wise)

Year	Average annual soil loss (t ha^{-1} yr^{-1})
2009	72.807
2010	103.042
2011	83.938
2012	60.408
2013	84.275
2014	62.052
Average	77.7536

Fig. 4.12
Spatial Distribution of Average Annual Soil Loss: Kohima District



Source: Extracted from GIS basing on the erosivity factor.

Accelerated erosion due to misuse of resources of land, water and soil is today one of the most difficult and pressing problems before man. Both engineering and biological methods have been used to check the soil erosion but it is still without a plausible check. With the present rate of soil loss, it is felt that the conservationists and policy makers should take an immediate measure to conserve the top layer of soil meant for cultivation and environmental rehabilitation. The main reason behind the high erosion in the settlement area is due to the soil characteristics of Kohima district which contain fine particles of sand which encouraged the soil erosion. Another reason of high rate of soil erosion is due to the slope factor as the region mostly lies in hilly terrain. Due to the settlement purpose the vegetative covers are cleared and thus, the intensity of the flow of water increases which directly increases the flow of soil. Proper urban planning and soil survey in the settlement region is required at the earliest as the urban area is expanding rapidly. By-laws of different construction in the town should be properly implemented so as to avoid excessive soil degradation. Courtyard vegetative cover in the settlement area should be encouraged. Cover Cropping and Mulching should be encourage to the farmers as it is effective at reducing soil erosion by leaving a cover over the soil which reduces soil displacement associated with the impact of raindrops hitting soil particles. They also reduce the volume and velocity of runoff over the soil. Sloping agricultural land should be bench terraced using vegetative barriers. The existing forest cover must be carefully protected and augmented re-stocking the sparse open forests as vegetation increases the strength and competence of the soil in which it is growing and therefore, contributes to its stability. In the study area, adequate soil conservation measures may be provided. The area must be kept under meaningful vegetation by striking a balance between the demands for material need sand its biotic resources.

CHAPTER 5
STATUS OF SOIL EROSION

No part of the world is saved from the degradational forces of soil erosion. Indeed, the occurrence of landslide is a phenomenon experienced in most parts of the world though in different degrees. Some areas or regions are more subjected to both interior and exterior forces that lead to more frequencies of the landslides. Some areas, however, may appear to be more stable and are marked by tranquility. Nevertheless, in one way or the other the surface of the planet earth is susceptible to the forces that are acting in unison or otherwise resulting in the mass downward movement of the soil.

The down-slope movement of the masses, rocks debris or earth under the influence of gravity is termed as a landslide,[130]encompass a wide range of phenomena including slumps, rock falls, debris slides, and earth- debris and mud-flows. Landslides may be shallow or deep-seated and are caused by changes in slope stability resulting from undercutting, changes in water saturation or loss of woody vegetation. Activities that increase erosion and slope instability in uplands include logging, road and trail construction and forest conversion. Landslides as one of the major natural hazards, account every year for enormous damage to life and property. It is a very important type of mass movement which takes place over the earth surface on the down slope under the influence of gravity and consequently the broken rock materials get accumulated at the foothills.

Landslide occurrence is on the increase worldwide, the consequences of which can be loss of life, loss of livestock, damaging or destroying residential and industrial developments, villages or even entire towns, destroying agricultural and forest land and negatively influencing the quality of water in rivers and streams.[131]The worldwide increased population and economic pressures in mountainous areas have forced human

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[130]Cruden, D.M., Varnes, D. J., 1996.*Landslide types and processes*, in Turner A. K. and Shuster, R.L., (eds) Landslides: Investigation and Mitigation, Transp Res Board, Spec Rep 247. p. 36-75.
[131]UNESCO/UNEP, 1988.
http://mak.ac.ug/documents/Makfiles/theses/Kitutu_Kimone_Mary_Gorret.pdf,accessed on 03/07/2015.

activities to shift to practices such as deforestation, urban development and agriculture into potentially hazardous regions.[132]Landslide hazard stands as the second geological hazard following earthquake (Li, *et. al*., 1999; the U.S. Geological Survey, 2000).[133] FAO states that steep terrain, vulnerable soil, heavy rainfall and earthquake activities make large parts of Asia highly susceptible to landslides.

Fig 5.1
Landslide Map of India

Source:http://appscmaterial.blogspot.in/2012/02/disaster-managementlandslides.html.

[132] Guthrie, R. H., 2002. *The effects of logging on the frequency and distribution of landslides in three watersheds on Vancouver Island, British Columbia*, Geomorphology 43.p. 273-292

[133] Li,*et. al.,* 1999.*Real-time following prediction of the ladslide*. Changdu: Changdu University of technology press.

An area of about 0.49 million sq.km out of the total area of India is vulnerable to landslide and about 0.098 sq.km of an area in Northeast India is vulnerable to landslide. The other region vulnerable to landslide in India includes the Himalayas, Nilgiris, Ranchi Plateau and Eastern and Western Ghats of India. As many as 20 states of India are affected by different degrees of landslide hazard. Of these, the states of Sikkim and Mizoram have been assessed to be falling under very high to severe hazard classes. Most of the districts of the states of Jammu & Kashmir, Himachal Pradesh, Uttarakhand, Arunachal Pradesh, Nagaland and Manipur come under high to very high landslide hazard classes (Fig 5.1). In the Peninsular Region, the hilly tracts of states like Karnataka, Andhra Pradesh, Tamil Nadu, Maharashtra, Goa, Madhya Pradesh and Kerala constitute low to moderate hazard prone zones.[134]

5.1 Landslides Occurrences: Kohima District

Wedged between the collision boundaries of the Himalayan plate in the north and the Indo-Burmese plate in the east, the North Eastern region of India is one of the most seismically active regions in the world. The North East of India (latitude 22-29º N and longitude 90-98º E) is jawed between the two ranges (arcs), the Himalayan range to the North and the Indo-Burmese range (IBR) to the East. The Mishmi Hills occur at the junction between the Eastern Himalayas and the IBR. The northern part of the NS trending sigmoid IBR has been named as the Naga Hills. The Naga Hills link the EasternHimalayas (Arunachal Himalayas) to the North and the Andaman Nicobar Islands to the South. Belts of narrow tectonised but nearly continuous late Mesozoic-Eocene Ophiolite suite of rocks (igneous rocks) and associated sediments (cherts and lime stones) skirt along the northern margin of the Himalayan range and the Eastern

[134]http://www.portal.gsi.gov.in/portal/page?_pageid=127,671641&_dad=portal&_schema=PORTAL, accessed on 8-8-2015.

margin of the IBR (the Naga Ophiolite), owning their origin to the collision history of the Indian Plate with the Tibetan Plate (towards the north) and later with the Burmese Plate (towards the East) respectively, sometimes 30 million years ago, leading to the development of fold- thrust belts of the Himalayas and the IBR. It is the outcome of that plate convergence and collision which makes the NE Indian region one of the most seismically active areas of the world. With complex tectonic and geological set up of the region and intense continental convergence of the northward moving of Indian plate at the rate of 20+03mm/year mega earthquakes of magnitude 8 and above have occurred in the past.

Table 5.1
Recorded Earthquake in the Past Few Years

Year/Month	Magnitude in Richter scale	Epicentre
2010/February (24^{th})	4.0	Nagaon
2011/January (23th)	4.2	India-Bangladesh border
2011/November (21^{st})	5.9	Myanmar
2012/ May (11^{th})	5.4	Nagaon's Katiala and Puonigodam
2012/July (1^{th})	5.8	Phek
2013/January (9^{th})	5.8	Phek
2013/September (8)	3.5	Meghalaya (Shillong)
2013/November (6)	5.4	North-west of Barpathar, Karbi Anglong
2014/ January (29^{th})	5.1	Located 198km south of Kohima (Indo-Myanmar border)
2014/December	4.8	Indo-Myanmar border in Manipur
2015/ April (25^{th})	7.9	Nepal Earthquake
2015/May	4.8	Tuensang

Source: From Local Newspaper.

Nagaland, one of the states in the North Eastern region of India is a multi-hazard prone state. It comes under the seismic zone IV/V and hence, falls under a very high damage risk zone. The natural tectonic setting makes Nagaland prone to earthquakes resulting in loss of life and material. A large number of moderate to large magnitude earthquakes have occurred within the state boundaries as well as within a range of 100km around it (Table 5.1). Altogether twelve major earthquakes have occurred in the region in the last 100 years of which the epicenter of the 1950 Great Earthquake was located only 7km towards north of Mon, a district headquarters located about 200kmnorth of Kohima. It was the sixth largest earthquake of the 20th Century. The shock lasted 8 minutes causing 1,500 deaths, destruction of 2000 houses and other structures while rendering rail and road connectivity useless. The energy of the earthquake matched that of 100,000 atomic bombs and churned up nearly 10,000 sq. miles of earth.[135]The most other notable ones are the Great Shillong Earthquake on 12th June 1897 which measured 8.7 in the Richter scale and the Assam Tibet Earthquake on 15th August 1950 which measured 8.5 in the Richter scale. In addition to these, it has been experiencing many minor earthquakes ($M \leq 4$) from time to time though negligible the earthquakes have been an important factor in making the sensitive soil and rocks to move.[136]

For the major landslides in the district, the average depth of these mass movement ranges from 4 to 10 metres. In case of the selected landslide, most of them are of flow in nature. In other words, the common mass wasting type is 'mudflow' or 'creep'. Falls types are basically liberated fragments coming from vertical and over hanging outcrops or by bounding and rolling from slopes so steep that no slip plane is necessary. Slide, on

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[135]http://www.nagenvis.nic.in/ViewGeneralLatestNews.aspx?format=Print&Id=1024, accessed on 23/6/2013.

[136]An interview with 15 BRTF Commander, Tajpal Singh (dated 13th July, 2013) said that due to these many light seismic shocks occurrence in and around the state, those sensitive area becomes more versatile to landslides particularly towards late monsoon and during storms or cloudbursts, it trigger massive landslides in various parts of the district.

the other hand, occurs when bedding or cleavage planes, master joints, fault fractures dip towards a valley or other depression at a dangerous angles[137] which occupies only few sites of the selected areas. Landscapes developed out of this are either plane surface or spoon-shaped.[138] Less significant mass movements like solifluction which literally means "soil flow' come under the purview of flow type. Often the courses of the perennial rivers are blocked by depositional mass, and the ponds are formed (Themi Za landslide blocking Kayielo rii) and valley.

Selected landslides account for about 10 km^2 of the total area of the district. Four of the biggest landslides studied are Kohima Municipal Council dumping area landslide, Phasama landslide at NH 39, Themi Za landslide (Plates 5.4.1, 5.1.1, 5.1.3 respectively)and the Mission Compound landslide which accountfor about 5 km in radius (in term of affected areas). The variation in length is large, ranging from 0.36 to 1. 02 km. The two active ends of the slide include the forehead margin on top and the deposited debris at the bottom. The breadth varies from 0.75 to 0.234 km at the widest part of the cross-section. The frequency of the land slide occurrence is high during July and August, each month drainage about 35 per cent of the landslides. Landslides in the months of winterseason is minimum due to less rainfall.

The possible factors responsible for landslide occurrence may be singular or a combination of several factors. Landslide occurrence around settlement areas is mainly due to lack of proper drainage to convey runoff during the rainy days. This accounts for 40 per cent of the landslides while road construction in combination with other factors accounts 30 per cent is also quite significant. Other anthropogenic activities

[137] Holmes, A., 1965. *Principles of Physical Geology*, new and fully revised edn, London and Edinburgh: Thomas Nelson & Sons and Gilluly, *et al.*, 1968. *Principles of Geology*, Third 3rd Edition.
[138] Ahmed, E., 1973. *Soil erosion in India*, Asia Publishing, House, Bombay-1.p. 80-109

areresponsible for 20 percent landslide occurrence. Deforestation is no less significant a factor for landslide and the rest are due to natural factors. Landslides in and around the settlements and cultivated areas are inevitably followed by collateral damages in the proximity.

Table 5.2
Past Landslides Recorded: Kohima District

Year/Month	Place	Causes	Remarks
1978	Mission Compound at Bara Bosti Village, Kohima	Settlement pressure on land slide prone area	Great damaged to a large area including a sizeable part of Kohima village
1994/July	Kiruphema Village in NH-39, 21 kms away from Kohima.	The landslide was triggered by incessant rainfall.	Vehicular traffic was closed for a week which cause transportation problem along the NH-39
2003	New Market Colony, Kohima Town	Incessant downpour for weeks, improper drainage and settlement pressure on land over landslide prone area.	100 houses were damaged
2003 /August & 2011/ June	KMC Dumping area along NH-39	Accumulation of non-dissolvable material over large area which discourage vegetation growth and also the once sinking area when it was exposed to incessant rainfall caused heavy landslide in the area	Severely affected transportation system between Kohima and Dimapur. In 2011 the road was completely wash away.
2008/ August	New market colony, Kohima town	Incessant downpour for weeks, improper drainage and settlement pressure on land over landslide prone area.	Several houses affected by sinking phenomenon and large craters could be seen in many places
2010/ October	Lower Chandmari Colony, Kohima Town	Incessant downpour for weeks and settlement pressure on land over landslide prone area.	Destroyed 4 houses and Rs. 40-50 lakhs of estimated properties was damaged.
2010/ October	Pezielietsia Colony, Kohima town	Incessant downpour for weeks and settlement pressure on land over landslide prone area.	Destroyed 3 houses and displaced 5 families numbering around 25 people. Properties worth several lakhs of rupees were destroyed.
2011/June	Below Naga Hospital	Incessant downpour for week over the sinking Area.	Landslide stretched above and below the road causing more than 4 acres of soil loss.

2011/May	New traffic diversion constructed near War Cemetery at Kohima town.	Heavy rainfall over the earth cutting made by man which loosen the soil to cause landslide and moreover, the soil around the area is largely rocky clay.	Damaged an official quarter occupied above the area.
2011/August	Between Chiechama and Botsa, NH 61	Slope cutting done for the expansion of road over unstable soil and due to continuous rainfall for nearly 3 weeks caused the soil to fall.	Landslide stretched above the road and also below the road where around two hectares of land has completely failed to restrain the mud flow and traffic along the NH disturbed for weeks.
2012/ August	D Block near Gurudwar at Kohima (One way road in the town)	Incessant rainfall over sinking area	3 building destroyed and 21 families affected. Traffic congestion for weeks.
2012/June	Themi Za below Viswema village 22 kms from Kohima Town	Heavy rainfall over existing landslide area of sensitive clayey and shale which fails to uphold the soil causing a huge landslide.	Landslide stretched about 900 m in length and 60 m in wide causing destruction of more than 3 hactares vegetative covers along the landslide area
2013/ July	Phesama village along the NH 39 which is about 12 km from the Kohima town (Below the Naga Heritage village)	Continuous heavy downpour of rain over sinking area, improper drainage and moreover, poorly planned road construction which was constructed as an exit road from Heritage village alone the NH trigger heavy landslide above and below the road.	Traffic movement was disturbed for about a month which causes a huge turmoil to the public. Moreover, around 2 acres of terrace field below the NH were completely destroyed due to the mud flow from above.
2015/August	Secretariat Road Kohima	Incessant rainfall and blockage of water passage due to random dumping on garbage in Sanuorü stream. The hume pipes which allows the water to cross the road below was clogged with bottles, wastes and dirt and in allow the water level to rise up to 50-55 feet which compelled the authority to cut off the road for the water to pass out.	One house was completely submerged, traffic congestion, tons of soil loss.
2015/August	NH 39 at Phesama village which is 20 metres away from the 2013/ July landslide.	Incessant rainfall over sinking area, improper drainage and negligence from the authority in- charge at the initial stage of the mudslide above the road. Soil	5 km radius area affected by this landslide and was consider the biggest landslide in Nagaland. Traffic stranded for days along the NH, 33 houses including a commercial building were dismantle due to

		contained a mixture of sand, clay and sticky mud type, which absorbed excess water and reduced soil's grabbing capacity resulting in the continuous mudslide. Another caused was that spring water gushing out from the mountain top and it flow down directly to the road below. History reveal that the particular landslide have occurred in the area in 1962, 1990 and 2003.	the mudslide. Terrace field below were destroy due to the mud flow.

Source: Local Newspapers and field visits.

Landslide, a common phenomenon in Kohima district is one of the most important factors of soil erosion. Top soil and vegetative covers on large scale are considerably lost every year during the monsoon season. Landslides are mainly found below settlement areas, terrace fields, rolling Jhum land and road construction. Much of the district is very hilly comprising of steep slopes and high relief. The district is predominantly made up of shales and sandstones in various combinations. Most of the rocks, particularly the shales are sheared, fractured, crumpled, and weathered to various extents. They are normally saturated with water which leads to the building up of high pore-water pressure thereby causing the loss of shearing strength and collapse of the soil structure. Repeated thrusting and faulting have further weakened the rocks. Such sandstone areas are known for rock falls and debris slides.[139]

Kohima district is covered by semi-consolidated Tertiary group comprising Disang, Barail, Surma and Tipam formation. It may be observed in Kohima district that the Disang group is made up of weak consolidated rocks like splintery shale's, flaggy sandstones, etc. and in some area the shales are highly sheared, crumpled and weathered

[139]Home Department, Government of Nagaland, 2012.*Nagaland State Disaster Management with support from NDMA & UNDP.* p. 9-12.http://nidm.gov.in/PDF/DP/NAGA.PDF, accessed on 4/6/13.

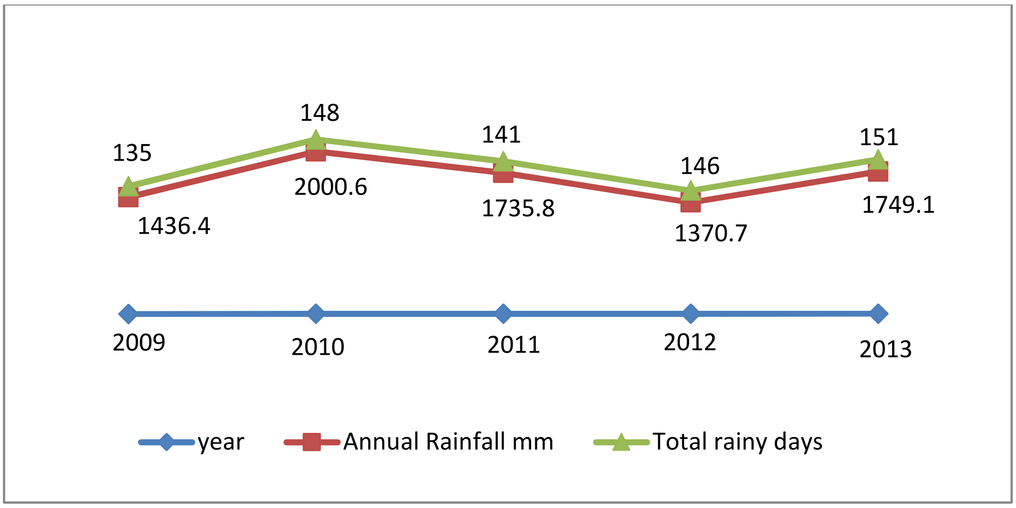
to high degree which are unstable and are prone to landslide (Merhiilietsa landslide in May 2007).Perhaps, this is one of the reasons that make the Disang formation more susceptible to landslide. Barail group is composed of uniformly hard ferruginous sandstones with minor shale's. Barail rocks become exposed as we move towards the capital from Mao gate. The young Barail rocks which are mainly composed of shale's and sandstone are highly vulnerable to landslide. The properties of the shale stone is such that it does not allow water to percolate much and instead absorb water and expand. In the process of its expanding the stability of the soil is disturbed which makes the soil to falls of slides (in the case of Themi Za at Viswema village). Moreover, clayey soils and shales have low hydraulic conductivity and can be difficult to drain. On the other hand, when the dip angle of the shale is along the slope, the soils over the shale are more susceptible to landslide. Most of the slides in the area are caused due to this reason. It is also observed that during rainy season the shallow soils lying above shale bed are prone to landslide. The cohesive force that exist between the soil and the shale bed becomes weak as the water loosen up the soil grip on the shale's bed and make the soil to slide away causing mudslide. The general area in low-lying hills which are prone to landslides is due to unstable rock materials, especially during the rainy season which lasts from May to September.

The soil formations of Kohima, in general, being loose sedimentary type have high porosity and therefore, highly permeable and highly susceptible to erosion resulting in the formation of ruts and gullies and leading to failure of soil mass. Erosion of supporting soil also leads to failure of perched rock blocks. Most of the buildings in the city area have sloping roofs and are constructed facing the uphill side. This necessitates construction of longer columns on the downhill side, i.e., on backyard of the buildings. Continuous erosion of this kind reduces the bearing capacity on slopping ground and in many places has even exposed the building foundation and caused the collapse of some buildings as well as the soil to move downward.

Increase in the runoff volume affects the regimes of the natural downhill drains and toe cutting has been observed in many cases. Such toe cutting leads to slope failure near these natural drains. Slope failure occurring near these drains adversely affects the stability of the slope in general and leads to repeated slope failure in that area. Such toe failure also leads to blockage of drains promoting infiltration of water into the ground causing saturation of the soil, which adversely affects the stability. During the summer season, more specifically from June to October, the rainfall is heavy and almost continuous, recording above 2500 mm during this period. So, permeable materials get saturated due to long continued heavy rains that, instead of the pelting rain driving individual particles in the form of 'rill' or 'rainwash' down the slope, the whole of the surficial materials becomes a mass of mud and debris that moves like lava flow.

According to the observations made by Scientists Kripalani, *et. al*., over the Eastern Himalayas in 1996, there is an increase in rainfall during the monsoon season. Nagaland, being a part of the Himalayan Range, is also experiencing the increase in rainfall. The increase is not in the average total rainfall annually, but in the average intensity and quantum of discharge during the monsoon. Nagaland in located geographically at the catchment level of the Eastern Himalayas, where the clouds from the Bay of Bengal condense and discharge their rain loads. And as opined by the scientists from NIDM, 'As a result of Global Warming, the clouds are heavier laden and resultantly contains heavier quantum of moisture to discharge'. Consequently, the heavier rains are apprehended to become a recurring phenomenon, on account of which, comprehensive salvage and preparedness strategies and policies, need be planned by the concerned authorities. The impacts of this Global Warming and Climate Change, has had effects all over Nagaland, in the form of widespread landslides. The highest casualty of the heavy rainfall is reportedly the roads landslide.

Fig. 5.2
Meteorological Data (2009-2013)



Source: Directorate of Soil and Water conservation Department, Kohima Nagaland.

Another important factor causing landslides in the district is faulty road construction methods. Road construction has aggravated the intensity of landslide. One of the main reasons for this is the slope cutting process while constructing the road as it disturbed the slope stability. Most of these slide areas remain weak with mud flow and sinking of highways occurs every monsoon season due to the composition of loose sand and dark-brown clays where water seepage are quite high. For instant, the NH-39 is snapped by a deep and wide landslide at the KMC dumping area. The once sinking zone has now become a valley stretching from above the road to the river below in a stretch of about a kilometer. The NH-39, afflicted with numerous other landslides, is only a sample. There are reports that almost all the roads connecting the different areas of the district are under peril. Most roads in Kohima is cut across the mountain ranges, without culverts and proper drainages (nullah), making the roads carry the entire water flow from above, to accumulate or flow to a concentrated outlet stream. This flow when accumulated in the sinking zone builds up the process of landslide. Landslides occur because road construction design and slope stabilization structures are very poor besides natural. Moreover, below most of the unstable highway, gabion walls have been constructed for support but due to the overlying pressure, weak bearing capacity of the soil and their own weight, gabion walls fail to hold the soil and instead lead to further landslide activities. Rebuilding roads in all possible scientific ways with utmost care in highly disturbed slopes on short term basis and fix the problems of the areas do not serve the purpose. Measures on long term basis are to be under-taken. Avoiding of sensitive areas through toposheet and satellite imaginary studies before the construction can minimize the landslide.

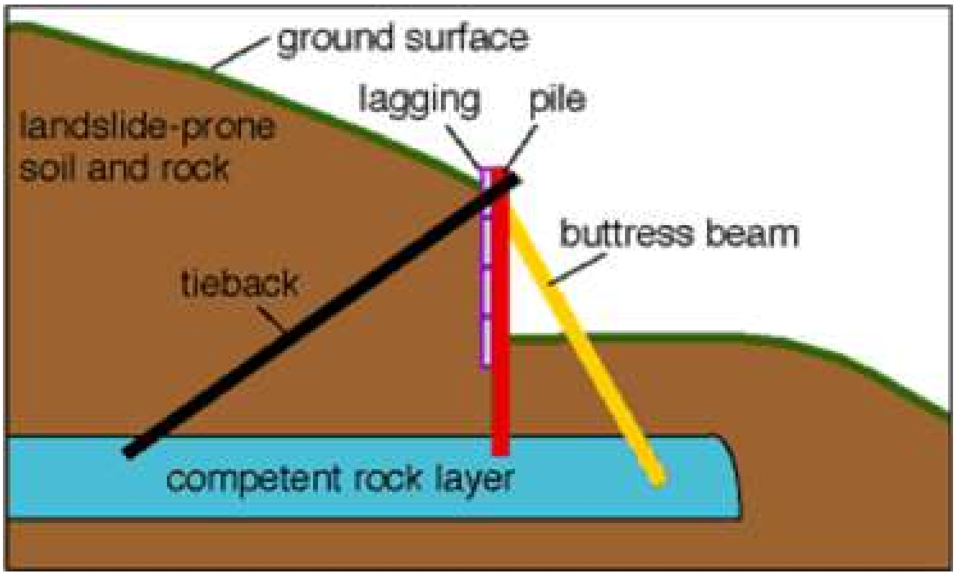
Due to increasing urbanization and demand for land in the city area, and lack of enforcement of development controls, people have started construction even on the valley lines, completely blocking the drainage path in some cases. These drains need to cross the road system in several stages through culverts. Eroded soils and garbage carried down by water during torrential rainy season block many a time cross drains and lead to over flowing of water onto the road (for instant the Secretariat road site at Kohima, Plate 5.2.1).Increasing urbanization has also increased the surface runoff because extension in the pucca ground cover or black topping through the construction of building, courtyards, roads, pavements, etc., reduces infiltration of rainwater significantly and increases surface runoff, thereby increasing the volume and discharge in the area and drain which in turn remove the top soil rapidly and also cause landslide in the areas. It may be noted that, high magnitude landslide occur around areas where economic activities are high especially in the settlement areas and along the construction of road. Massive landslides are, therefore, caused mainly due to human activities that break down the cohesiveness of the existing weak consolidated rocks.

Water is a main factor in causing landslides in the district like Kohima. Incessant rainfall for days or weeks occurs during the months of June to August and it even extents to September. Improving surface and subsurface drainage at the site can increase the stability of a landslide-prone slope. Surface water or hill stream should be diverted away from the landslide-prone region by channeling water in a lined drainage ditch or sewer pipe to the base of the slope. Landslide which occurs at the NH 39 at Phesama village can be an example of hill slope stream causes of landslide which originates from the mountain slope and flow down to the road directly. As a result, the areas in the vicinity are affected and there are incidences of heavy mudslides. The surface water flowing down from the hill towards any sensitive area should be diverted as to avoid the occurrence of landslide in the surrounding area. Surface water being allowed to pond on the landslide-prone slope is another factor that causes landslides.

Most of the constructional works in the district are located on the hill slope which is 25^0–30^0 slope angles especially the road construction and it is inevitable since the whole area of the study is hilly region. Heavy constructional works on the hilly area such as concrete building sometimes put pressure on the land and the soil falls and slides gradually. Thus, avoiding such types of constructional works in populated areas and towns can control erosional landslide. On the other hand, the removal of soil and rock at the head of the landslide, though arduous it may be, can inevitably puncture the pressure and slow down the process of land falling. Flattening of the slope angle at the top of the hill can also help in stabilizing the landslide prone slopes.

Constructing piles and retaining walls can also control landslide. Piles are metal beams that are either driven into the soil or placed in drill holes. Properly placed piles should extend into a competent rock layer below the landslide to prevent the loose soil oozing out through the gap between the piles. Further, retaining walls can be constructed by adding lagging (metal, concrete, or wooden beams) horizontally between the piles, which further can be strengthened by adding tiebacks and buttressing beams (Fig 5.3).[140]

Fig 5.3
Retaining Wall with Tiebacks and Buttress Beams.



Source: http://www.kgs.ku.edu/Publications/pic13/pic13_5.html.

Trees, grasses, and vegetation can minimize the amount of water infiltrating into the soil, slow the erosion caused by surface-water flow, and remove water from the soil. Although vegetation alone cannot prevent or stop a landslide, removal of vegetation from a landslide-prone slope may initiate a landslide. Some of the vegetation that can be introduced for binding the soil from soil erosion and landslide in the district are

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[140]Tiebacks are metal rods that extend from the piles to a competent rock layer below the ground surface. Buttress beams are metal beams that are inclined downslope from the piles that prevent the piles from toppling. Lagging consists of wooden, metal, or concrete beams placed upslope and between the piles to fill in the gaps. (Prevention and Remediation of Landslides- Kansas Geological Survey, Public Information Circular)

Exbucklandia populnea, *Alnus nepalensis,*[141] *Thysonolaena maxima* (broom), *Chimonocalamus graffithianus*, common bamboo, *Cynodon dactylon* (ground grass), *Sacccharum* spp., Salix spp.,[142] etc. It can help prevent the landslide as well as add in artificial landscape which when planted in arranged formation (Fig 5.4).

Many methods are used to remedy the landslide problems. The best solution, of course, is to avoid landslide-prone areas altogether. Before utilizing land for any purpose it is best to consult an engineering geologist or a geotechnical engineer to evaluate the potential for landslides and other geology-related problems.

Fig 5.4
Binding of Soil through Artificial Vegetation

5.2 Socio-Economic Factors and Its Impact on Soil

Humanities are closely and inextricably linked to the natural environment in which they are embedded. The productive social activities, social structures and relations of the societies are shaped to a significant degree by the natural resource mix available such as the physical geography, weather patterns, the amenability of natural conditions to

[141]An indigenous tree in the area.
[142]A tree that is planted on the bundling wall of the dry/wet terrace field.

transformation, and variety of other characteristics of the environment. But during the process of human activities for survival and development environmental degradation including depletion of renewable and non-renewable resources and pollution of air, water and soils, can be a significant source of stress upon societies. The interrelationships between society and nature, and the importance of environmental health to social health, have recently become important topics at the global level. Sustainable development has become a broadly accepted goal, and is seen as an essential element of social development.

Soil erosion remains the world's biggest environmental problem, threatening sustainability of both plant and animal in the world. Over 65 percent of the soil on earth is said to have displayed degradation phenomena as a result of soil erosion, salinity and desertification.[143]Soil is the most vital of earth's natural resources. It hosts more than three quarters of the world's man-made developments. It is the home of both animate and inanimate beings. Most of the earth's natural resources are directly linked to or found in the soil. Threat to soil istherefore, threat to life.The process ofsoil erosion could be slow and imperceptible, or it may occur at an alarming ratecausing serious loss of top soil. Generally, the natural process of soil erosion is slow but is accelerated when the anthropogenic activities are supplemented to the process.

5.2.1 Socio–Economic Effects of Soil Erosion: Global Scenario

Erosion, as it affects man and its environment, is natural and as old as the earth itself.[144] It is seen as the gradual washing away of soil through the agents ofdenudation which

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[143]Okin, G. S., 2002.*Toward a Unified View of Biophysical Land Degradation Processess in Arid and Semi-arid Lands*, in Global Desertification: Do Humans Cause Deserts? Reynolds,J.F., and Stafford SmithD.M., (eds), Dahlem University Press. p. 95-97.

[144]OMAFRA Staff, 2003.*Soil Erosion, Causes and Effects*, Ridge Town and College of Agricultural Technology, Ontario Institute of Pedelogy.http://www.search.gov.on.ca.8002/compass?view-template=simplr, accessed on 5/8/2015.

include, wind, water and man.[145] These denudating agents loose, wear away, dislodge, transport and deposit wear off soil particles and nutrients in another location.

Soil erosion (by water) has been observed to degrade the global land resource base. Its impacts are felt on soil quality, agricultural productivity, movement of pollutants, ecological diversity in streams and wetlands, river channel change, infrastructure and building uses, and effects of flooding.[146] History revealed that the rise and fall in civilization is linked to the quality and management of soil and land.[147]

As quantities of soil particles are carried away on daily basis unnoticeably, soil quality gets depreciated significantly. The soil that erosion carries off now totals 22 billion tons a year worldwide.[148] In Europe, 12 per cent of soil is threatened by water erosion alone. Similarly, 95 million and 500 million of land are badly affected by soil erosion in North America and Africa respectively and moreover, economic losses from soil erosion in South Asia is said to have currently accumulated to 6.9 billion dollars.[149]

In South-Asia, 140 million hectares, or 43 per cent of the region's total agricultural land, suffered from one form of degradation or more where soil erosion impacting many areas than other form of degradation.[150] In South Africa, annual soil loss is estimated at 300-400 million tones.[151] Study revealed that not less than 43 per cent of the country's populations were confined to 13 per cent of the land; this has resulted into pressure on and over-utilization of the land, exposing it to soil erosion and causing poverty to the

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[145] Abegunde, A.A. *et. al.,* 2003.*The impact of Erosion on Rural Economy: The Case of Nanka in Anambra State of Nigeria, in Urban Finance and Infrastructure Development in Nigeria*, Fawehinmi, Y., (ed.) Atlantis Books. p. 227-243.
[146]http://www.sntc.org.sz/eearticles/soildeg.html,accessed on 27/6/2014.
[147] Burke, G.,1979. *Towns in the Making*, Edward Arnold (Publishers) Limited, London.
[148]Hanyona, S., 2001.*Soil Erosion Threatens Farm Land of Saharan Africa*, in The Earth Times, January 10, 2001, http://forests.org/archieve/african/so erthre htm,accessed on 5/8/2015.
[149]Beijing Time (Peoples daily), 2002. *Soil Erosion, Biggest Global Environmental Problem*, Tuesday,May 28,2002, http://english.people daily.com.cn,accessed on 5/8/2015.
[150] Owens, David W.*et. al.,* 2000.*Soil Erosion from Two Small Construction Sites in County, Wiscomsin*, in Third World Network (TWN ONLINE), http://www.twnside.org.sg/title/land-ch.htm U.S. Geological Survey, USGS Fact sheet FS-109-00 August 2000, http://wi.water.usgs.gov , accessed on 5/8/2015.
[151]*Food and Agriculture Organisation*, http://www.batany.uwc.ac.za, accessed on 5/8/2015.

people. Moreover, soil erosion automatically results in reduction or loss of the biological and economic productivity and complexity of terrestrial ecosystems, including soil nutrients, vegetation, other biota, and the ecological processes that operate therein as such that its impact is myriad. It requires 1000 million each year to replace soil nutrients carried out to the sea by run-offs annually in the area. Erosion also affects crop productivity. Dlamini[152] opines that there has been a 17 per cent cumulative productivity loss over 45 years (1945-1990) as a result of soil degradation. In addition, they observed that yield reduction due to past erosion could have been as high as 40 per cent, with a mean of 6.2 per cent for sub-Saharan Africa (Siherr and Yadav, 2000). Construction of roads and building also impact soil erosion in human society. This is clearly seen in South-eastern Nigeria and Wisconsin, United States of America among others.[153]

Physical processes offer only a partial explanation of the causes of soil degradation. It will recognise the role played by crop cover or vegetation density in initiating or controlling erosion and it is quite clear that this factor is strongly influenced by farmers who are responding to socio-economic factors. Therefore, the socio-economic and physical factors which drive soil erosion need to be addressed in tandem. Perhaps, socio-economic factors are equally important for disciplinary protections of soil and it is rare that a study attempts to do this. Evans made an attempt with his assessment of the socio-economic and physical drivers, impacts and costs of erosion for UK and Wales.[154] This covered both the present and the past, and outlined how the present-day impacts

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[152]http//www.sntc.org.sz/eeartides/soiloleg.html,accessed on 5/8/2015.

[153] Ofomata,G.E.K., 1984. *Erosion in the forest zone of Nigeria*, A Paper Presented at the 27th Annual Conference of Geographical Association of Nigeria, University of Nigeria,Nssuka.p. 7.

[154]Broardman, J.*,et. al.,* 2003.Socio-economic factors in soil erosion and conservation, Environmental science and policy 6 (2003).p. 1 http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.486.4956&rep=rep1&type=pdf, accessed on 4/7/2014.

could be alleviated. Besides Evans, Stocking and Murnaghan also discuss the factors affecting land users and land degradation.[155]

5.2.2 Relationship of Forest and Soil

For the study of the present topic, relations between forest and soil are highlighted as they are inter-dependent. Forests have important protective as well as productive functions. They not only supply timber, fuel, fodder and a variety of other products but also have a moderating influence against floods and erosion and help maintain soil fertility. Forests and soils play a broad, complex and interactive role within the environment. Soils have provided the foundation for trees and entire forests over millions of years. Soil is an important component of forest and woodland ecosystems as it helps regulate important ecosystem processes, such as nutrient uptake, decomposition, and water availability. In turn, trees as well as other plants and vegetation, are an important factor in the creation of new soil as leaves and other vegetation rot and decompose.

However, the relationship between soils and forests is much more complex and far-ranging. Soils and forests are intrinsically linked, with huge impacts on each other and on the wider environment. Tree roots stabilize ridge, hill and mountain slopes and provide the soil with the necessary mechanical structural support to prevent shallow movements of land mass: landslides rarely occur in areas with high forest cover.Sound forest management practices, including measures to introduce or maintain forest cover on erosion-prone soils and run-off pathways, will help control or reduce the risk of soil erosion and shallow landslides. Forest restoration in dry land areas is vital for soil protection.

[155]Op. cit., Broardman, J.,*et. al.,* 2003.

The importance of these effects has often been ignored in the past, with the clearance of tree vegetation and the subsequent loss of millions of hectares of productive land. Furthermore, as forests continue to be cleared-exposing the land to direct attack from wind and rain-soil erosion and land degradation are still undermining agriculture's resource base. In order to protect our soils, we need to protect our trees and forests. Both of these vital resources play pivotal roles in food security and a healthy environment.

5.2.3 Land Use System

The most direct socio-economic influence on the soil is via landuse system. Landuse is defined as the arrangements, activities and inputs people undertake in a certain land cover type to produce, change or maintain it.[156]According to Celik[157] and Liu *et. al.,*[158] land use and soil management practices influence the soil nutrients and related soil processes, such as erosion, oxidation, mineralization, and leaching, etc. As a result, it can modify the processes of transport and redistribution of nutrients. In non-cultivated land, the type of vegetative cover is a factor influencing the soil organic carbon content (Liu *et al.,* 2010). Moreover, soils through landuse changes also produce considerable alterations,[159] and usually soil quality diminishes after the cultivation of previously untilled soils.[160]The human activities on land have transformed the characteristics of the Earth's surface, leading to changes in soil physic-chemical properties, soil fertility, soil erosion sensitivity and content of soil moisture. Changes of forests to rangeland and

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[156] Gregorio, A. D., Jansen, L. J. M., 1998. *Land Cover Classification System (LCCS): Classification Concepts and User Manual*,For software version 1.0. GCP/RAF/287/ITA Africover - East Africa Project in cooperation with AGLS and SDRN Nairobi, Rome.p. 3.

[157] Celik, I., 2005. *Land-use Effects on Organic Matter and Physical Properties of Soil in a Southern Mediterranean Highland of Turkey*, Soil Tillage Res. 83. p. 270–277.

[158] Liu XL, *et. al.,*2010.*Impact of Land use and Soil Fertility on Distributions of Soil Aggregate Fractions and some Nutrients*.Pedosphere 20(5). p. 666–673.

[159] Fu B, *et. al.,* 2000.*The Relationships between Land use and Soil conditions in the Hilly area of the Loess Plateau in Northern Shaanxi, China*, Catena 39. p. 69-78.

[160] Neris. J, *et. al*.,2012.*Vegetation and Land-use Effects on Soil Properties and Water Infiltration of Andisols in Tenerife (Canary Islands, Spain)*,Catena 98. p. 55–62.

agriculture lands are one of the most concerns in environmental degradation and world climate change.[161]

The majority of landuse changes in Kohima district are related to agricultural use of the land where more than half of the total population is directly or indirectly dependent on it as a source of income and also for food. Due to the increasing population growth, forest lands are degraded and converted to agricultural lands. Agricultural activities change the soil chemical, physical or biological properties. Such activities include cultivation (mechanized by hand), tillage, weeding, terracing, sub-soiling, deep ploughing, manure, compost and fertilizer applications, liming, draining, irrigation and empoldering.[162] The main agricultural systems in the study area are jhum cultivation and terrace cultivation. Besides, plantations and horticulture are sparsely distributed. It is a well-known fact that jhum practices are the most destructive force of deforestation where vast vegetation is cleared in preparing the soil suitable for the seeds. Thus, the bare soil becomes vulnerable for surface runoff. The physiography of the district is rather hilly and jhum site are prepared along the slope of the hills and mountains. The process of removing the top soil is further surge in the absence of vegetative cover along the hill slope. Rejuvenation of the jhum fields is mostly absents among the practitioners after the abandon the jhum field. It has been found that negligence of rejuvenation in the abundant jhum fields are more common where the land belongs to the community land or clan land than to a private land. Moreover, most of the jhum fields fall under the community land or clan land and has been found that most farmer who practices jhum in the community forest neglect regeneration of the land after they abandoned the land. Thus, the fallow land is exposed to further soil loss until it rejuvenates itself again.

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[161] Wali, M. K.,*et. al.*, 1999.*Assessing Terrestrial Ecosystem Sustainability: Usefulness of Regional Carbon and Nitrogen Models*, Natural Resources 35. p. 20-33.

[162] Bridges, E.M., de Bakker, H., 1997. *Soils as an Artefact: Human Impacts on the Soil Resource*, The Land 1.p.197- 215.

Farming practices associated with some crops encourage runoff and erosion. Horticulture crops such as potatoes are cultivated in abundance along the foot hills of the Barail range. The cultivation of potatoes in rows and ridges which channel runoff and the de-stoning of soils for potato cultivation also encourage soil erosion.[163]

Another important agriculture practice is terrace cultivation and it is one of the oldest types of land and water resource management in the region where the farmers have perfected the art of step cultivation. The principal advantage of terrace cultivation is that it can protect the terraced areas soil by reducing the velocity of the runoff and thereby soil erosion by breaking the length of the slope that runoff has available. It cannot only reduce the rate of soil erosion but can also trap and hold rainwater. This allows the cultivation of water-intensive crops, such as rice, in these areas. Some authors explain that one major disadvantage of terraces is that it retain too much water leading to saturation and consequently storm runoff.[164]The problem with ground saturation is that it can lead to water overflow during periods of heavy rains. This can end up causing more damaging runoff than in un-terraced areas. Lasanta, *et. al*. (2001),[165] further describe that the foot of a terrace wall is often affected by erosion, because of the steepness and the sparse vegetation cover. He also observed that erosion on the foot of the terrace slope could lead to deterioration of the terrace as a whole as well as gully formation, which eventually leads to increased erosion. The author further observed that heavy soil loss occurred during the preparation of plantation in most of the terrace field. Most of the fields will be overflowing with water during the rainy season. And for the paddy to be planted in the field the soil are disturbed for leveling and so during this

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[163] Boardman, J. *et al.,* 2013. *Socio-economic Factors in Soil Erosion and Conservation*,Elsevier Environmental Science & Policy 6.p. 1–6.http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.486.4956&rep=rep1&type=pdf, accessed on 9/7/2015.

[164] Gallart, F*., et. al.,* 1994.*Studying the Role of Old Agricultural Terraces on Runoff Generation in a Small Mediterranean Mountainous Basin*. Journal of Hydrology 159(1-4).p. 291-303.

[165] Lasanta, T., *et. al*., 2001.*Marginal Lands and Erosion in Terraced Fields in the Mediterranean Mountains*.Mountain Research and Development 21(1).p. 69-76.

process most of the soil run away along with the overflowing water. Additionally, if not properly maintained, terraces can lead to greater soil erosion, often down slope from the terracing, than in non-terraced areas. Unmaintained terraces usually lead to mudslides, the creation of deep gulley's and increased soil erosion, particularly in sandy soils or on extremely steep terrains.

5.2.4 Deforestation

As mentioned above, jhum practice is considered the main driving force of deforestation in the area but there are also other forces that are also responsible for deforestation such as wood for fuel, timber, forest fire, development (such as settlement, road construction), etc. Fuel wood extraction is done largely for subsistence.[166] Indigenous people and small farmers harvest fuel wood for cooking and heat. In some areas, large-scale harvesting is used to produce charcoal for subsistence and markets. For fuel wood extraction, tree species are largely irrelevant. Thus, there is complete clearing, which can lower the prospect for forest regeneration. In the study area most of the villages are dependent on firewood for kitchen chores. Though there is availability of the domestic LPG gas for cooking, most of the people are still attached to the traditional usage of the firewood for different purposes. As a result of this, thousands of trees are cut down annually only for the purpose of firewood.

Road construction increases access to forested land and is the first step towards developing forested region, often for agriculture[167] and expansion of settlement. Thus roads often initiate the deforestation process.[168] People in the region have constructed agri-link road for the last few decades. With the introduction of MGNREGS, funds were utilize for the construction of road and in the process large forest were cut down. These

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[166] Geist, J., *et. al.,* 2001.*What drives Tropical Deforestation?*p. 29.http://www.pik-potsdam.de/~luedeke/lucc4.pdf,access on. 23/2/16.

[167] Tomich, T. (ed.), 2003.*Forces Driving Tropical Deforestation,* ASB (Alternatives to Slash-and-Burn) PolicyBriefs 06, Nairobi, Kenya, November.

[168] Eliasch, J., 2008. *Climate Change: Financing Global Forests,* the Eliasch Review, London: Earthscan. p.47-48.

agri-link roads were also one of the factors that have encouraged the people for further timber extraction and also for fuel extraction from the forest as the road cut through most of the dense forest of the region. Man-made forest fire is also another problem for the vegetation losses in the area(Plate 3.8). In some villages forest fire is considered as traditional practices as the old vegetation are burned down to paveway for the growth of new siblings to grow again. During the last few decades accidental forest fire made by anthropogenic activities has become common where large hectares of forest area were burned down to ashes (burning of Japfu Mountain and Dzukou valley). As explained earlier, construction of agri-link road and forest fire are some of the problems which are responsible for the loss of vast forest in the region and these in turn leads to most of the soil problems due to vegetation losses.

5.2.5 Stone Quarry

The general objective of stone quarrying is to produce large rectangular blocks suitable for cutting into smaller, regularly-shaped products. In considering the importance of quarry product, domestic uses like building stones, sand, pebble, slabs, etc., are products of immense value. Conclusively, the whole activity including marketing and distribution provides various job opportunities and economic aids. Environmental degradation due to indiscriminate quarrying and mining activities in an agro-environmentally fragile and sensitive is a serious issue of concern. The ever increasing human aspiration and requirements are the major causative factor disturbing the environmental equilibrium. A section of poor village people are involved in these activities for their livelihood. In the trade-off between the socioeconomic needs and environment conservation, generally the former takes the upper hand. Focusing on it on soil, it can cause different calamities such as landslides and flashfloods.

Quarries on hills generally have a large geomorphic impact. A study conducted by Danilo Israel revealed that quarrying has potentially significant negative environmental impacts. Mountain quarrying results in the scraping of the upland topsoil and vegetation and the destruction of the aesthetic value of the quarried area. For river quarrying, the noted effect was the uneven deepening of the riverbeds, and the destruction of the river banks.[169] In the Southern Angami villages such as, Kigwema, Jakhama, Viswema, etc., quarrying along the stream and small river beds are noticeable. In one of the stream quarry sites in Kigwema village (*Dziidieke,* Plates 5.5 and 5.7), the streambed is extensively deepened and large areas are been effected due to erosion such as mud slide, landslide, etc. Another important factor which is enhancing the rate of erosion due to quarrying is the use of modern technological tools. The traditional method of quarrying was just the use of hand on tools where stone are dug out with tools such as spades, pick, shovel, etc, which in a way dug the required area only but now excavator are used to dig the stone (Kigwema and Jostoma village) which dig out the soil haphazardly which further disturb the stable soil. Another effect of quarrying on soil loss is the use of running water to wash the top soil to extract the stone.

The soil infertility results in two ways. It is true that tons of dust is deposited on the paddy field and reduces the fertile soil. The other way is the improper drainage system. The contaminated water, during the monsoon season flows in all the directions and especially so in the direction of paddy field and plantation because of gradient.

The process of extraction of minerals and environmental problem go side by side as for development is concerned. Mining cannot be altogether stopped in the context of environmental awareness. Agreeable remedies for both sides have to be found and that

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[169]http://www.pids.gov.ph, accessed on 24/2/2016.

favor both sides. Provision must be made for green belt of plantation that will check further erosion and soil loss. Environmental awareness should be developed with people undertaking quarry works.

Study reveals that most of the jhum cultivations are practiced in the community land and there are no policies to rejuvenate the abandoned fields once they are used. Another main reason of socio-economic factors on soil problems is the increased privatization and individual ownership, especially of land under permanent cultivation such as wet rice cultivation, terraced lands, orchards, gardens, forest, bamboo grooves, etc., in the region. Access to forest product becomes recognized to the owner and he can get as much timber or firewood or employ others to do so. In some villages like Mima and Mitelephe, it is open that the owner can sell firewood to other village besides his personal use if the forest is his and this practice extend to some other village of the study area even though restriction are there by their respective village council. Thus, as they have the right to do anything with the land that belongs to them, those policies and laws which are not pleasing to them becomes impractical and resulting in the decrease of the vegetation covers in the area.

From the foregoing, it is possible to identify that the socio-economic factors have directly and indirectly contributed to the soil losses and soil problems in the area. Souza (2001) states that in the southern Angami area, people have admitted that the extent and quality of the forest cover has decreased in the recent times because of two reasons: the extension of jhum cultivation and the harvesting of forests for firewood and timber.[170] While the area of the terrace cultivation remains unchanged, the forest cover has decrease. In addition, extensive expansion of settlement along the National Highways (NH 39 and NH 61) is also some of the problems which are decreasing the vegetative

[170]Op. cit., Souza, A.D., 2001. p. 59

covers in the area. At present scenario, due to the destruction of the vegetative cover through various anthropogenic activities, soil loses are occurring at a greater pace through means of gulley erosion, rill erosion, mud slide, landslide, etc. (Plates 5.3.1). In the past, the traditional and social values of the region have been playing a great role in maintaining the balance in the environment.[171] They have their religious belief and practices ensuring environmental conservation on the one hand and on the other hand they serve the same purpose in the sense that they combine with social control mechanisms to ensure the sustainable use and management of forest resources. But the entry of globalization has brought about in the society a new trend of homogenization in the developmental process. With the pressure from the commercial forces increasing and the need for cash income growing, the fertile soil in the area is feeling the impact due to the vegetation loss.

Education, which includes gaining knowledge on consequences of soil erosion and on soil conservation measures, is an important variable process in soil conservation. Awareness programme on sustainable agriculture practice, knowledge upon the importance of forest on soil, relationship between men and environment, alternative means of employment for the farmers and people to discourage those unsustainable mean of occupation such as excessive quarrying and timber extraction, are some of the key factors that the government can initiate. The village council can make rules and regulation to check excess deforestation and also forest fire as the respective village council has the highest authority in a particular village. Students and youth bodies can issue notices and hold awareness programme to discourage wasteful practices and promote tree plantation. It would be in the best interest of the people to support and participate in such initiative. Christianity which once emphasis spiritual life than the temporal one and is responsible for the loss of some of the most valuable traditional

[171]Op. cit., Yano, K., & Lanusosang.T., 2015. p. 34430-34433

practice which are friendly with the environment can take the responsibility to revive those value again.

5.3 Land Use Policy and Its Impact on Soil

The North-east region has the highest number of indigenous peoples (220communities according to the Anthropological Survey of India) in the sub-continent. ABritish colonial legacy of post-independent India is that the territories of these nationalities and communities, besides having been broken and fragmented by the division of the region by India, China, Burma (Mynmar) and Bangladesh, are further divided into seven states viz., Arunachal Pradesh, Assam, Manipur, Mizoram, Nagaland, Tripura and Sikkim, the more recent one in the name of reorganization. Most of the North-East region is governed by the Fifth and Sixth Schedules of the Constitution of India. The Panchayats (Extension to the Schedule areas) Act, 1996 extends 73rd Amendment, to the Fifth Schedule areas. Three states Mizoram, Nagaland and Meghalaya including the hill areas of Manipur are excluded from 73rd Amendment as Nagaland and hill areas of Manipur are under the provisions of Articles 371A and 371C of the Constitution while Assam, Arunachal Pradesh, Mizoram, Meghalaya, Tripura, are covered by the Sixth Schedule.

In the study area the problem of fragmentation of land holdings is not an issue on account of the peculiar pattern of land-ownership, tenure and use, prevalent in the state. The land belongs either to the village community, clan or individual. The only legal framework is the Jhum Land Regulation Act. 1970. The ownership of land and the individual rights are governed by customary laws of the community. There is little or no alienation of people from their land due to the unique ownership and management system of the people. Indeed even the farmers despite their poor economic condition can be considered resource rich. The cultivable land is the most valued form of property for its economic, political and symbolic significance. It is a productive, wealth-creating and livelihood sustaining asset. It also provides a sense of identity and rootedness because it has durability and permanence, which no other asset possesses. Over and above this, ancestral land has a symbolic meaning, which purchased land does not. Moreover, there are different rules for devolution of ancestral and self-acquired land. Naga society is based on patrilineal descent and hence children take their social identity from their father and are placed in his agnatic group and familial unit.

5.3.1 Administrative Policy

Nagaland remains outside the purview of the 73rd Constitutional Amendment[172] and enjoys a special provision under Article 371A of the Constitution of Indiagiving them the opportunity to continue their own practices of local self-governance. The provision bars the application of all Acts of the Indian parliament dealing with "religious or social practices of the Nagas; Naga customary law and procedure; administration of civil and criminal justice involving decisions according to Naga customary law; ownership and transfer of land and its resources unless approved by the state legislature to the entire state of Nagaland."[173] This is activated through Village Councils and Village Development Boards. Under this special provision are:

1. The customary laws of the Nagas will have precedence over the Indian Penal Code (IPC);

2. Land and its resources will belong to the Nagas and not to the Government of India; and

3. Naga customary laws will have full control over Naga affairs.[174]

Also, various customary laws regulate the forests and *Jhumlands* in Nagaland despite the presence of Nagaland Forest Act, 1968. Here, it needs to be highlighted that the

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[172]Siddiqui, S., Chohan.S., 2015.*Legal Response to Institutionalizing Participatory Land Use Planning in Nagaland,* United Nations Development Programme, New Delhi, India. p.5.

[173]http:/!indiacode.nic.in/coiweb/fullactl.asp?tfnm=00%2048, accessed on 27/2/2016.

[174]Iralu, K.D., 2000.*Nagaland and India, The Blood and The Tears: A Historical Account of the 52 Years lndo-Naga War and the Story of those who were never allowed to tell it,* Private Publications, FirstPublished in September. p. 451-452.

state government has also protected the rights of customary laws through the enactment of the Nagaland *Jhumland* Act. 1970. These regulatory bodies have acquired enhanced capacity to influence the decision-making process of the state government. Some of the provision which guided their practice of jhum cultivation and their forest are mentioned below (Table 5.3).

Table 5.3

Special Provision of Nagaland

Sl.No	Provision
1	Nagaland Forest Act, 1968.
2	The Nagaland Village Area and Regional Council Act, 1970.
3	The Naga Hills Tuensang Area (Administration) Regulation, 1957.
4	The Nagaland Tribal Area, Range and Village Council Act, 1966.
5	The Naga Hills Jhumland Regulation, 1946.
6	Nagaland Jhumland Act, 1970.
7	Joint Forest management Resolution, Nagaland, 1997.

Source: Darlong (2004)

A major strength that contemporary Naga society has inherited is the 'social capital' that has stemmed out of traditional institutions and practices.[175] There is strong social bonding and community spirit, and absence of caste and social discrimination. There is no landless household although the major proportion of land is held as common village land which is regulated by the village councils. The people have a strong bonding with the social institutions and resources which occupies the centre-stage of their daily life. The community resources and institutions such as forests, woodlots, ponds/tanks, community halls, churches, community grounds, schools, healthcare units, power, etc., are maintained in each and every unit village. The resources and institutions are managed by separate representative committees empowered to lay down rules and regulations for effective management and development. The resources and institutions

[175]State Human Development Report 2004 : Nagaland. p. 51.

are for common use and every individual has the liberty to use it freely but with prior consent of the village council, tribal chief or headman within the ambit of traditional laws and regulations of the respective village/tribe. The land ownership and management systems amongst the Angami's and the Rengma's are unique as mentioned above and different from the rest of the country like the other groups in Nagaland, where local customary laws govern the land. These customary laws are usually not codified but have the legitimate sanction. The enforcement of these traditional laws and regulations rests on traditional village institutions such as village councils, tribal chiefs or headmen.

5.3.2 Village Administration

Village level institutions have been strong in all the Naga areas including thestate of Nagaland. Since time immemorial Naga villages have been independent under two major forms of village governments; viz, democratic and autocratic. For instance, the Angamis, the Aos, the Chakhesangs etc. have democratic forms of government whereas the Sema's and the Konyak's have autocratic form of government. The governments are run as per the customary laws, the guiding principles of life in society. Traditionally, life in every village in Nagaland is managed by the council of elders. Village organisation in the Naga society is primarily based on institution of clan which is constituted by a group of families amongst whom inter-marriage is strictly prohibited. It is the basic unit of the village administration. Two or more such clans forma village.

Geographically, like every other villages in Nagaland, the Angamis and the Rengmas villages too are divided into khels (wards or sectors) which are made up of a cluster of families. In a village there are normally two or more khels. A khel has its respective council body to look into different matters within the khel and from here the representative are sent to the village level for different administrative posts. As a matter of fact, the specific issues would be passed down to the khels, clans and families before the village council could come to a decision. However, there was no uniform legal system of village government till 1970 which led the state of Nagaland to pass an act known as Nagaland Village, Area and Regional Act, 1970. It was amended in 1973 and1978 as Nagaland Village and Area Council Act with a view to bringing uniformity in Village Council structure all over Nagaland. For further understanding of the administrative set up in a particular village of the study area, the establishment of the village council and the village development boards are highlighted below.

Village Council

A Village Council consists of members chosen by villagers in accordance with the prevailing customary practices and usages and is later approved by the state government. Representatives are sent from different khels for various posts which consists of Chairman, secretary, treasurer and members from each khel. Besides these posts Chairman and secretary have their vice or assistant. The powers and duties entrusted upon them are: a) to formulate village development schemes, b) to supervise proper maintenance of water supply, roads, forest, education, c) to constitute Village Development Boards, administer justice in accordance with the customary laws and d) usages, to maintain law and order.

Village Development Boards (VDBs)

In accordance with the Nagaland Village, Area and Regional Council Act, 1970,VDBs came into existence in 1980, as a subsidiary to Village Council. As envisaged in the Act, the constitution of Village Development Boards (VDBs) to take upon the responsibilities of the Village Council was formalized through the Village Development Boards Rules and notified in 1980. The Village Development Board formulates development priorities for the village, prepares action plans and executes them, using the village community or other funds. A VDB is managed by a committee chosen by the Village Council and includes traditional leaders and twenty-five percent of the membership is reserved for women. Government assistance to the VDBs includes grants-in-aid, matching cash grants, Jawahar Rozgar Yojana, MGNREGA, and other development and welfare programmes. The VDBs have become the cornerstone of de-centralised planning and development in Nagaland. They have played a pivotal role in creation and maintenance of infrastructure in the villages– community halls, village roads, schools, water tanks, toilets, granaries, rice mills, community fishery ponds, community wells/tanks, culverts and suspension bridges, etc. The State Government has been encouraging internal resource mobilisation by the VDBs through different schemes. Building on the rich social capital of the village communities and benefiting from this structural linkage, the VDBs continue to pioneer micro-level development in imaginative, culturally appropriate and resource-efficient ways.

No other Indian states enjoy the special status given to the state. However, in the same year when Article 371A was granted to Nagaland, another regulation called the Nagaland Security Regulation 1962 having 21 pages document was promulgated by the President of India for the maintenance of law and order in the state of Nagaland.[176] Though, there are other regulations relating to law and order in Nagaland, the relevant part for which the study is concerned lies in Section 5 A (I) of the Nagaland Security Regulation Act, 1962 under the title, "Access to certain places and areas and shifting from inhabited areas" which says "If the Governor considers it necessary or expedient so to do in the public interest or in the interest of the safety and security of Nagaland, he

[176]Op. cit., Iralu, K. D., 2000.p. 452.

may, by order direct, in respect of any inhabited area to be specified in that order, that subject to any exemption made by him by general or special order:

(a) all residents or any class of residents shall remove themselves or be moved from the said area to any other specified area by the Governor and remain in that other area for such period as may be specified by him;

(c) any animals or property or any specified class of animals or property shall be removed from the said area to any other area specified by the Governor; and may do any other act involving interference with private rights of property which is necessary for any of the aforesaid."

According to lralu, absolute power is given to the Governor of Nagaland by the Constitution of India to do whatever he likes with the people of Nagaland.[177] Though Article 371A protects the customary laws and practices of the people which are activated through the Village Councils, Village Development Boards, Tribal Councils, Communitisation, etc. all working for the improvement of the societies, the above discussion points out that, more power and weightage has been invested to the governor of the state.

Development and environmental degradation are interlinked. Though development of the region is good on the one hand, the destruction of the environment is pregnant with all the negative effects on the other hand. For instance, the famous Hornbill Festival site at Kisama has been developed by the order of the State government with the purpose of enhancing the celebration of the festival. But while doing so, converting large chunk of land into a tourism place, surrounding area has become more vulnerable to heavy landslides. In fact, the frequent landslides have become a major problem for the area. In many places within the study area, huge fund is utilized mainly for road construction.

[177]Op. cit., Iralu, K. D, 2000.p. 455.

Most of the forested area is now found to be criss-crossed by agri-link roads. The use of modern technology for this purpose has additionally made the soil unstable. Further, the villagers extract forest wood for material purposes such as for construction and cooking. In some areas, large areas of forest are cut down to produce charcoal for subsistence and markets. Indeed, the construction of road has further encouraged huge deforestation which adds to the further loss of vegetation and biodiversity. Thus, landslide, rock and mud fall, rill and gully erosion, etc. have become a common problem in the region. Consequently, dealing with the land problems caused by the short sighted development policies on the part of the state government has become a major issue in the region.

Nevertheless, the bottom-up system of decision making which decentralized the region from the rest of the country favors the decision making of the people with proper studies and policies. Also the highest democratic platform which still exist in the societies among the people of the study area have the right to protect and reject any forms of regulatory act which does not favors the region. Khel which consist the smallest Council Body and Board in a village can play a major role in the decision making and setting up of new rules and regulation at the village level. Therefore, the Village council, VDBs, Tribal Councils as well as the smaller unit of the council that starts at the khel level can protect their customary laws and land. Awareness needs to be created with regards to the protection, preservation and management of the forested area. Effort has to be made at all levels right from the stage of primary school to the stage of the secondary level. For, any devastating activity on the given environment definitely leads to the degradation and impairment that becomes if unchecked, irreparable. Since, all are intricately linked there is every likelihood that the area under study, marked by hilly terrain may turn unsuitable even for habitation, unless precaution measures are adopted by creating awareness at the top as well as at the grass root levels.

CHAPTER 6
SUMMARY AND CONCLUSION

6.1 Summary and Conclusion

Soil erosion, a major environmental problem has become a burning topic in all over the world especially in the agricultural world. Billions of dollars are cost due to the problem of soil erosion not only in the developing and under developing countries but even in the developed countries. The mountainous regions, such as the Himalayas and the Andes, suffer from the world's highest erosion rates.[178] NEH region which is an extension of the Himalayan ranges is dominated by three land forms such as the Greater Himalayas, Strong dissected highlands and Low lying riverine plains. The topography and climate of the region is thus, conducive to accelerated soil erosion which is a serious threat to environment.

The entire study has been organized into six chapters. The foremost chapter consists of the introduction of the thesis and the conceptual study of soil erosion and the process of soil erosion at the global context, the study area i.e., Kohima district, the objectives, statement of the problems, methodology, and related literatures has been reviewed to get the insight of the theoretical and practical works of the present study.

The second chapter covers the physical frameworks of the study area. It deals with the historical background of the district which highlighted the formation of Kohima district. Through the study of the geomorphology and the geological settings, an attempt has been made to interpret the origin and development of landforms of the study area. The chapter also explains the climatic conditions, drainage system, soil characteristics, land resources and the people, the demographic characteristics, forest resources, agriculture resources, the water resources, health care facilities and transport connectivity which provides a clear picture of the district.

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[178]Op. cit.,Ismail and Ravichandran, 2008.

The third chapter is titled as ‘Agriculture and Landuse Pattern’. The chapter is partially divided into two parts of study which is directly highlighted in the tittle. In the study of agriculture, the occupational structure which represents the economic activities of the people is emphasized by categorizing the people of the region into total main workers, non-workers and marginal workers where the total main workers is further classified into four groups such as cultivators, agricultural labourers, workers in household industry and other workers. It also covers the different agricultural system where the different methods of cultivation and the productivity of the agriculture of the study area have been studied. Effort have been made further in the chapter to study the different landuse pattern of the region under land ownership and management system and also classifying the total area through satellite image using Erdas software to study the land use and land cover. In brief the whole chapter is an attempt to study the agriculture system and landuse pattern of the study area so as to acquire the information to the changes arising due to globalization and modernization which affect our environment and to develop agriculture through integration of agricultural, environmental and cultural policies.

The thesis also evaluates the soil loss in Kohima district, Nagaland using the application of recent technologies; remote sensing and the application of Geographical Information System (GIS) in the fourth chapter.To have an understanding of the various researches carried out in the field of remote sensing and GIS applications in soil erosion, a number of research articles, journals, conference proceedings and websites were referred. Such a review helped in developing the methodology to be adopted for this study and also in identifying the limitations of such a study. Various parametric models such as empirical (statistical/metric), conceptual (semi-empirical) and physical process based (deterministic) models are available to compute soil loss. An honest attempt has been done in this chapter to estimate the soil loss using the RUSLE equation which is a multiplicative function of five factors controlling the rill and inter-rill erosion. The factors causing erosion such as climate, soil properties, slope, vegetation cover and management practices are considered for estimating soil loss.

The fifth chapter is dedicated to the soil erosion status in the region. It begins with the study of landslide which deals with the causes and factors responsible for triggering the fall of slope in the region. The physical factors such as geomorphological characteristics, geological settings, the frequent occurrence of tectonic movement and the high intensity of rainfall in the region and the anthropogenic factors are investigated in different sites of landslide occurrences so as to acquire awareness to the loss of soil through landslide. The chapter further deals with the socio-economic factor leading to soil erosion. Socio-economic factor such as agricultural practices, deforestation and quarrying which in one way or the other way are connected to the process of soil loss are emphasized. It also takes into account of the landuse policies of the region through the study of the village administrative system so as to investigate the policies affecting the environment and also to create an approachable development from the top as well as at the grass root level. The last chapter constitutes the summary and conclusion. It includes a summary of the whole thesis, the research findings and recommendations.

6.2 Major Findings

This Ph.D programme has been conducted in order to fulfill the aim and objective of the research work undertaken. It is a sincere attempt to identify the problematic issues of soil erosion in the district of Kohima. It is also to strengthen the knowledge of the real conditions prevailing in the district and of the hurdles that retard the balanced growth of the region.

Geomorphologically, about 70% of the area under study is hilly coupled and the terrain is rugged and slopes are generally steep. It is interesting to note that water in all the rivers rises up rapidly during the rainy days but abruptly falls when the rainfall subsides. Therefore, most of the streams remain dry or almost dry during the dry season. This is due to the steep slope and high degree of porosity of rock in the area. The porous nature of rocks gives rise to a large number of temporal seepages which cause gully erosion and massive landslides here and there. Because of the folds, faults, dissected plateaus, interlocked ridges, domes, and steep hilly sides, occurrence of landslides and soil erosion are frequent. Folds, faults, dissected plateaus, interlocked ridges, domes, steep hilly sides and landslides are among the geomorphic features of the hilly area.

Geological formation of rocks in Kohima district mainly consist ofDisang and Barail where the rocks are characterize with splintery shale in nature with inter-bedded sandstone. Disang shale is very fine grained, finely laminated and commonly exhibit curved or concentric surfaces which are weak rocks.

Kohima district which is located at 94^{0}5’11” to 94^{0}7’12”E longitude and 25^{0}28’20” to 25^{0}31’ 51”N latitude form part of the most severe seismic zone in the country and thus, highly prone to earthquake and landslide. Due to subduction of the Indian plates into Myanmar plates along the Naga hills range in the east and the continued intense collision of the Indian plate with the Eurasian plate in the Himalayan range in the north the region is seismically very active. Moreover, it may be noted that, high magnitude landslide occur around areas where economic activities are high especially in the settlement areas and along the construction of road in the region. Massive landslides are, therefore, caused mainly due to human activities that break down the cohesiveness of the existing weak consolidated rocks.

The Annual average rainfall lies between1300-2000 mm or more. Water as it is a main factor in landslides in the district like Kohima. Incessant rainfall for days or weeks occurs during the months of June to August and it even extent to September. Moreover, the intensity of the rainfall and number of rainy days in a year is also very high and occasionally the region experience cloud bursting which give result to numerous mud slide and soil losses. Study reveals the area is most susceptible to landslide during the rainy season, which is June to October. Extensive earth cutting on hill slopes, deforestation, haphazard construction activities on hill slopes leads to increased instances of landslides in this portion.

Kohima district which is an extension of the Himalayan ranges is highly affected by soil erosion due to the hilly terrain region. The physical factors along with the anthropogenic factors remain the main causative forces for the high loss of soil. Moreover, most of the settlement and the agricultural practices are located between the slope angle ranging from 20^0-30^0 or even higher which is another main reason of soil loss.

The soil formations of Kohima, in general, being of loose sedimentary type have high porosity and therefore, highly permeable and highly susceptible to erosion resulting in the formation of ruts and gullies and leading to failure of soil mass. Erosion of supporting soil also leads to failure of perched rock blocks.

The region is very rich in natural resources and is favorable to agricultural activities. Agriculture is the main occupation of the region and cereal crops occupies the largest area of crop land and production where paddy is the leading cereal crops. Terrace is more dominant than jhum in the study area. No doubt, Jhum produce more varieties.

Commercial crops are among the crops which are rising in production. There is a huge scope in wet-terrace cum fisheries in the district. But due to its hilly terrain physiography, sustainable agricultural practice is restricted. Being the capital district of the state, every work of people from the neighboring district and outside the state are attracted to its urban life which results in increasing the population and demand of food. Thus, the people opted for the source where agricultural production must come primarily from more productive utilization of the existing cultivated land area.

The thesis is concerned with the application of recent technologies; remote sensing and the application of Geographical Information System GIS in the assessment of soil erosion in Kohima district of Nagaland. The study demonstrates the importance of remote sensing and GIS in spatial data collection and analysis.In generation of degradation status map GIS (overlay) analysis was found to be a simple and straightforward method for a combined analysis of multi thematic layers.

Under LULC classification of 2011 satellite image in the ERDAS software, more than 75% of the area comes under forest and the rest of the land are distributed as settlement, barren, fellow, agricultural and water bodies.Soil erosion assessment was estimated using RUSLE under 5 erosivity factor (R K L S C P) with RS and GIS application. The average soil loss for the period of 6 years (2009-14) was found to be 77. 75 t ha^{-1} yr^{-1}. The annual soil loss recorded was highest in the year 2010 (103.042 t ha^{-1} yr^{-1}) where the annual rainfall was 2000.6 mm. It is interesting to note that, even though more than 75% of the area is covered with forest and the rest been shared with the other LULC, the rate of erosion is very high. This is due to the physical factor (geomorphology, geology, soil, slope, climate, etc.) of the area on the one hand and the anthropogenic factors (socio-economic activities, developmental activities, expansion of urban and rural areas due to increase in population, land use changes created by the people) on the other hand.

Jhum and wet terrace/ terrace practices have advantages and disadvantages. No doubt, the occurrence of soil erosion is less in the terrace cultivation than in the jhum cultivation. Deforestation and forest fire on the hilly terrain results in rapid soil losses.

Water logging causes salinization, soil compaction and excess water logging in the terrace leading to landslide or slope failure leading to terrace soil losses.

The study reveals that most of the jhum fields which falls under the community land or clan land, regenerating of the land are often neglected by the farmer when the abandoned the land which further encourage soil erosion.

The region is easily accessible to the changes occurring around. The changes do not remain external but enter the community itself through the internalization of the dominant culture. As it is a known fact that the rural and tribal knowledge is not created in distant laboratories and then brought to the users but it is the product of the environment itself. This experimental knowledge may be out of date when seen against the scientific knowledge of today, but it is benign without side effect and hence futuristic too. The traditional tribal systems are based on the concept of nature in general and land in particular as community sustenance that has come down from the ancestors and is preserved for posterity. The study reveals that globalization is one of the main reasons for the deteriorating the traditional agriculture practices.

Oral transmission, without any written record, of that traditional knowledge is another main cause where the modern world is fast consuming it to the brink of extinction. Another vital factor that has led to the loosening of people’s adherence to traditionally bound environmental is Christianity which emphasizes spiritual life than the temporal one. It also appears that the new acts and laws adopted by the government and which are being encouraged through various governmental programmes seem to be not so fitting to the environmental of the region.

Another finding in the study area is that, land tenure system has considerably changed. Most of the land which belongs to the community land and clan land once are now transfer or owned by the individual or under the private land. These private lands are rented for agricultural practice to other farmers and it was found in many cases that there is a negligent among the farmers to follow recreational system in the land after they have used the land since it does not belongs to them.

Stone Quarry on hills is another socio-economic activity in the region which has a large geomorphic impact. Mountain quarrying has resulted in the scraping of the upland topsoil and vegetation and the destruction of the aesthetic value of the quarried area. River/streams quarrying in the region have noted effect in the uneven deepening of the riverbeds, and the destruction of the river banks.

The study has tried to put up the administrative system of the study area so as to help in the future policy making and establishment of any development.

6.3 Recommendation

- ❖ Top soil should be saved, then spread over refilled areas and seeded with fast growing grasses.
- ❖ Well documentation on the geomorphology, geology and zonation of landslide map of the region is required.
- ❖ Priorities should be given on soil protection, sustainable management of water and land cover restoration.
- ❖ Proper irrigational network should be constructed so as to sustain the most scientific practice of agriculture in the region that is terrace cultivation which is more stable and friendly to environment than jhum cultivation. Crops like fruits and vegetables and spices should be increased as it provide more income and opportunity to the farmers' to sale the products.

- Land is the source of life for all the biotic being. Thus, care should be taken by the people of the region to protect the land from any developmental experiment.
- Training programmes and seminars in the villages to sensitize the problems of soil erosion and also its management should be carry out by the government agencies.
- The rural and tribal knowledge is not created in distant laboratories and then brought to the users but it is the product of the environment itself. Hence, the application of the traditional knowledge, guarded by constitutional and legal support, policy and law of the Government, developmental processes, etc. should be encouraged with a view to preserving the healthy, traditional and environmental ethical values.
- In today's world the traditional knowledge of the people is very negligible due to the modernization and lavishing lifestyle. But this is the need of time that we have to live in harmony with the nature like tradition knowledge. There must be an awareness and capacity building programmes for the local community by the local government/administration or disaster management authorities to disseminate the knowledge on the landslide triggering factors and creation of early warning signals before the occurrence of any mishap.
- It is a known fact that still the constructional works are mostly done through conventional methods without proper engineering plan and study. Any contract work given to the contractors should be carried out as per the technical specification. In the state, however nepotism and favouritism are given a free ride, most of the times. People with lack of technical knowledge and expertise when given the assignment cannot execute the works effectively and fully.

When such as this happens with no control over the system, any construction either road or building is doom to fail, causing rather huge damage only to the environment. So, proper environmental assessment must be made mandatory by the government before any constructional project is approved. Silt fencing, erosion controls blankets, sediments trap, plastic covering and proper drains inlets and outlet are essential to check the soil fall.

- ❖ Good ground drainage essential to prevent is saturation and consequent weakening. Adequate drainage is also needed when any kind of civil work, like retaining walls, has been constructed.Proper surface water runoff must be ensured, especially where houses androads have disrupted the natural flow of water. It can be achieved by providing a proper canalization network.

- ❖ Conservation practice like deep rooted tress and trees with broad canopy that intercept rainfall have to be planted and in addition to that another conservation practices like complete stripping or terracing of soil to a bedrock slope has to be practice as terraces reduce the slope length and sometimes the slope steepness. Root systems bound materials together and plants prevent water percolation and take water up out of the slope.

- ❖ Some of the vegetation that can keep the soil from getting eroded and degraded in the district are *Exbucklandia populnea*, *Alnus nepalensis* (Alder tree), *Thysonolaena maxima* (broom), *Chimonocalamus graffithianus*, common bamboo, *Cynodon dactylon* (ground grass), *Sacccharum* spp., *Salix* spp., Vetiver spp. etc.

- ❖ Micro-watershed and macro watershed management should be understood and should form the basis for soil conservation measures in the region. The watershed planning should be a co-operative endeavor of various disciplines such as Engineering, Agronomy, Forestry, Irrigation, and Soil Science and also not neglecting the knowledge of the local people who are the owner of the lands and well verse with the environment.

❖ The diversity of a landscape system in terms of field parcel, land use, vegetation, soil, slopes and geomorphology creates complexity and heterogeneity in natural landscapes. Therefore, a hierarchical approach of spatial risk modeling may provide better evaluation of soil loss for different level of landscape i.e. plot, watershed and landscape scale. Hierarchical approach already highlighted needs to be adopted in the study of various landscape levels to understand erosion factors and erosion assessment.

❖ Further investigation is recommended to study the extent of soil erosion in greater detail and depth so as to understand problems prevailing in the prone and affected areas better.

❖ Lastly, we should keep in mind that “Environment is what we have inherited from tomorrow rather than from yesterday”.

BIBLIOGRAPHY

Books and Journals

Abegunde, A.A. *et. al.,*2003. *The impact of Erosion on Rural Economy: The Case of Nanka in Anambra State of Nigeria,* in Urban Finance and Infrastructure Development in Nigeria, Fawehinmi, Y., (ed.) Atlantis Books.

Abrol, I.P. and Sehgal, J., 1992. *Degraded Lands and their Rehabilitation in India*, in Greenland, D.J. and Szaboles, I. (eds.), Soil Resilience and Sustainable Land Use, Presented Intern. Conf. on Soil Resilience and Sustainable Land Use, held at Bucharest (Hungary).

Acharya, B. C., 1958. *Nature and Extent of Soil erosion in Parts of Kalahandi District, Orrissa,* Geographical Review of India. 41(4).

Acharyya, S.K., 1991. *Late Mesozoic to Early Tertiary basin evolution of the Northern and Eastern Collision margins of the Indian Plate*, Journal of Himalayan Geology, 1.

Ahmed, E., 1973. *Soil erosion in India*, Asia Publishing, House, Bombay.

Angima, *et. al.*, 2003. *Soil Erosion Prediction using RUSLE for Central Kenya Highland Conditions*, Agric. Ecosys. Environ.

Anon, 1975. *Food Statistics, Twenty-fifth Bulletin*, Directorate of Economics and Statistics, Ministry of Agriculture and Irrigation, New Delhi.

Anonymous, 1975. *Report of National Commission of Agriculture, part IX chapter 42*, Ministry of Agriculture and Flood (c.f soil erosion and its control,ed., Morgan R.P, Van Nostrand Reinhold Company, New York).

Asres, Y., *et. al*., 2014. *Application of Neutron Activation Analysis Technique for the Analysis of Soil Samples from Farmlands of Yebrage Hawariat, East Gojjam, Ethiopia*, J. Agricultural Science and Technology.

Asthana, D.K and Asthana, M., 1992. *Environment; Problems and Solutions,* Jaipur and New Delhi; Rawat Publications, ISBN 81-7033-257-4.Bai, Z.G., *et. al.,* 2008.*Proxy global assessment of land degradation*, Soil Use and Management, 24.

Barrow, C.J., 1991. *Land degradation*, Cambridge University Press, Cambridge.

Bhagabati, *et. al.,*1990.*Survey of Research in Geography on North-East India (1970-1990),* New Delhi;Regency Publications; ISBN- 81-86030-89-1.

Bharadwaj, O. P., 1961. *Soils Bist-Jullandur Doab,* National Geographer. 15(4).

Bhattacharya, R., 1956. *Soil Erosion in Santhal pargans, Calcutta,* Geographical Review.24 (9).

Beijing Time (Peoples daily), 2002. *Soil Erosion, Biggest Global Environmental Problem*, Tuesday,May 28,2002, http://english.people daily.com.cn, accessed on 5/8/2015.

Bellinfate, N. Jordan, A .Martinenz-zavala.,1999.*Mapping of Erosive Status in Campo de Gibralttar (Spain),* in Bech, J. (ed), extended abstracts 6th International Meeting on Soils with Meditarrenean type of climate. Universsidad de Barcelona, Barcelona (Spain).

Bennett, H. H., Chapline, W. R., 1928. *Soil Erosion - a National Menace*, U.S. Department of Agriculture, Circular.

Bio-economic Modelling in Natural Resources Management, *Global Theme on SAT Futures ICRISAT, Pantancheru,* http://www.icrisat.org/what-we-do/impi/research-briefs/rb-strategic-assessment/impi-rb1-nrm.pdf, accessed on 4/3/2008.

Boardman, J., *et. al*., 2003.*Development of Badlands and Gullies in the Sneeuberg*, Great Karoo, South Africa, Catena 50.

Broadman, J., 2006. *Soil erosion Science: 'Reflections on the limitations of current approaches'***.** Catena, Vol. 68, Issues 2-3, 31 December 2006.

Boardman, J. *et al.,* 2013. *Socio-economic Factors in Soil Erosion and Conservation*, Elsevier Environmental Science & Policy 6 1–6,http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.486.4956&rep=rep1&type=pdf, accessed on 9/7/2015.

Bongonoviae, M. *et. al.,* 1999.*Mapping of erosive status in Campo de Gibralter (Spain)*, in Bech, J. (ed), extended abstracts 6th International Meeting on Soils with Mediterranean type of climate, Universidad de Barcelona Barcelona (Spian).

Bridges, E.M., de Bakker, H., 1997. *Soils as an Artifact: Human Impacts on the Soil Resource*, The Land 1.

Briggs, *et. al.,* 2009.*Fundamentals of Physical Geography, (2nd Canadian Edition)*, Copp Clark Pilman Ltd., A Longman Company Toranto; ISB 0-7730-5173-2.

Broardman, J*., et. al.,* 2003.*Socio-Economic Factors in Soil Erosion and Conservation, Environmental Science and Policy* 6 (2003). http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.486.4956&rep=rep1&type=pdf, accessed on 4/7/2014.

Bruce-Okine, E and Lal, R., 1975.*Soil erodibility as determined by raindrop technique*, Soil Sci. 119(2).

Burke, G., 1979. *Towns in the Making*, Edward Arnold (Publishers) Limited, London.

Burrough, P.A; McDonnell, R.A., 1998.*Principles of Geographic Information Systems*; Oxford Science Publications: New York, USA.

Buyinza, M. and Mugagga.F., 2010. E*conomic Impacts of Land Degradation in Mid-Hills of Mt. Elgon Watershed, Eastern Uganda',J. Soil Nature 4(1):1-6 (August 2010), ISSN-1994-1978 (Online) & ISSN-2075-1672 (Optical) Medwall Journals,* http://ggfjournals.com/assets/uploads/JSN-V4_I1_(1-6)_Buyinza(FINAL_F_PRINT).pdf, accessed on 23/4/2011.

Byers, A., 1986.*Landscape Changes and Man Accelerated Soil Loss: the case Sagarmatha, Nation Park Khunbu, Nepal,* Mountain research and development. 7(3).

Celik, I., 2005. *Land-use Effects on Organic Matter and Physical Properties of Soil in a Southern Mediterranean Highland of Turkey*, Soil Tillage Res. 83.

Census of India (2001), *Nagaland State: District Profile*, Census Publications New Delhi.

Chakrabarti, D.K. and Banerjee, R.M., 1988.*Evolution of Kohima Synclinorium Are appraisal*, Records of the Geological Survey of India.

Chary, S. N. and Vyasulu, V., 2000.*Environmental Management, an Indian perspective,* Publisher: MacMillan.

Choudhury, M.K. and Nayak, T., 2003.*Estimation of Soil Erosion in Sagar Lake Catchment of Central India*, proceeding of the International Conference of

Water and Environment, December 15-18, 2003, Bhopal, IndiaChorley, R.J., 1957. *Illustrating the Laws of Morphometry*, Geological Magazine, v. 94.

Chaudhary, R. S. and Sharma, P.D., 1988.*Erosion Hazard Assessment and treatment prioritization of Giri River catchment, North Western Himalayas,* Indian, J. Soil.Cons. 26 (1).

Country Report: India, 2009. *Indian Agriculture – An Introduction*, Submitted to Fourth Session of the Technical Committee of APCAEM 10-12 February 2009, Chiang Rai, Thailand, http://un-csam.org/Activities%20Files/A0902/in-p.pdf, accessed on 23/2/1016.

Critchfield, H.J., 2002. *General Climatology*, Printice Hall of India, New Delhi.

Cruden, D.M., Varnes, D. J., 1996.*Landslide types and processes*, in Turner A.K.; Shuster R.L. (eds) Landslides: Investigation and Mitigation. Transp Res Board, Spec Rep 247.

Dasmann, R.F., 1984. *Environmental Conservation (Fifth Edition).*

Davis, W.M., 1922. *Peneplains and the Geographical Cycle*, Bull. Geol. Soc. Soc. Am., 33.

Davis. W. M., 1898. *Physical Geography, Boston, (1902),* Elementary Physical Geography, Boston.

Demontzey.P., 1878.*Treaty Practice Reforestation and Sodding Mountain,* J. Rothschild, Paris.

Deori, P., 2005. *Environmental History of Naga Hills 1881-1947,* Publisher: Shipra Publications.

Desmet, P.J. J. and Govers, G., 1996. *A GIS procedure for automatically calculating the USLE LS factor on topographically complex land scape units*, Journal of Soil and Water Conservation, 51.

Department of land resources Government of Nagaland Integrated watershed management programme (IWMP), *State perspective and strategic plan (SPSP) of Nagaland.*

Dhruvanarayana, V. V., Babu, R. 1983. *Estimation of soil loss in India*, Journal of Irrigation Drainage Engineering, 109(4).

Dhuruva Narayan, V. V. and Sastri G. S., 1985.*Soil Conservation in India*, in Soil Erosion and Conservation, Swaify, S.A., Holerhaner, S.A.,(eds.) Soil conservation. Soc, Am. Ankey , La.

Dhruvanarayana, V.V., 1987. *Downstream impacts of Soil Conservation in the Himalayan Region*, Mountain Research and Development, Vol. 7, No. 3, 1987.

District Census Handbook Kohima, 2011.*Series-14 PART XII-B.*

Dokuchaev. V. V., 1877. *Ravines and their importance and in Cartography of Russian Soils (1879).*

Douglas, I., 1967. *Man, Vegetation and the Sediment Yields of Rivers*, Nature. 215.

Dregn, H.E., 1992. *Erosion and Soil Productivity in Asia*, J. Soil Water Conservation.

Drury, S. A. (1987). *Image interpretation in Geology*, Allen and Unwin. London.

Duley, F.K., 1939.*Surface Factors affecting the Rate of intake of Water by Soils*, Soil Sci. 50c.am proc. 4.

Eliasch, J., 2008. *Climate Change: Financing Global Forests,* the Eliasch Review, London: Earthscan.

Ellison Ellison, W.D., 1944.Two devices for Measuring Soil Erosion, Agricultural Engineering.

El Swaify, S.A., 1977. *Succeptibilities of Certain Tropical Soil to Erosion by Water,* in Greenland, D.J and Lal, R. E. (eds) Soil conservation and management in the humid tropics, Wiley, Chichester.

El-Swaify, S.A., *et. al.,* 1982.*Soil Erosion by Water in the Tropics,* Research and Extension Series 024, Hawaii Institute of Tropical Agriculture, University of Hawaii Press, Honolulu.

El-Seaify, S.A.,1994. *State of Art of Assessing Soil and Water Conservation Needs and Technologies*, in Adopting Conservation the Farm: An International Perspective on the Socio-economics of Soil and Water Conservation, Soil and Water Conservation Society, lowa, USA.

England and Lessene, 1962.*Effects of Simple Crop Covers on Runoff*, Journal of Soil and Water Conservation.17(1).

Environment and Development,2007.*Sustainable Development in Thailand,* Lessons for implementing Local Agenda 21 in three cities; Aki Tonami, Akihasa, Mori in a review of international Policy Journal; Vol. 16.Nov.3 Sep. 2007.

European Environment Agency, 1998.*European Environment: The Second Assessment*, office for official publications of the European communities; Luxemburg.

European Environment Agency, 2003.*Europe's Environment: The Third Assessment*, State of Environment Report No 1/2003. Copenhagen.

European Environment Agency, 2005.*The European Environment - State and outlook 2005*, Copenhagen.

Evans, R., 1980. *Characteristics of Water Eroded Fields in Lowland England,* in; Proceedings of Symposium on Assessment of Erosion in USA and Europe, Ghent, Belgium, Feb. 27-March 3, 1978. (Wiley Press).

Evans, B., 1995. *Soil Erosion and Landuse: Towards a Sustainable Policy*, The Moller centre, Cambridge white house press.

Evans, R., 1996. *Soil Erosion and its Impacts in England and Wales*, Friends of the Earth, London.

FAO., 1981. *Soil and Water Conservation COAG/81/8*, Presented to the 6th session of the Committee of Agriculture, Rome, Italy.

FAO/UNEP, 1995.*Methodology for Assessing Soil Degradation*, New York.

Fernandez, C., *et. al.,* 2003.*Estimating Water Erosion and Sediment Yield with GIS, RUSLE, and SEDD,* Journal of Soil and Water Conservation, 58(3), 128 Community Perception, Royal Swedish Academy of Sciences.

Food and Agriculture Organisation, http://www.batany.uwc.ac.za, accessed on 5/8/2015.

Fournier, F., 1960.*Climate et erosion,* La relation centre I, erosion du Sol Par 1, eau et les precipitation atmospheriques presses Universitaire, Paris, 210.

Funnell, Don and Parish, Ramola, 2001. *Mountain Environments and Communities,* Printed and Bond in Britain by Beddles Ltd, Guildford and King's Lynn, ISBN 0-415-18101-1(hbk), ISBN -0-415-18102-x(pbk).

Fu, B., *et. al*., 2000.*The Relationships between Land use and Soil conditions in the Hilly area of the Loess Plateau in Northern Shaanxi, China*, Catena 39.

Gallart, F., Llorens, P. and Latron, J., 1994.*Studying the Role of Old Agricultural Terraces on Runoff Generation in a Small Mediterranean Mountainous Basin*, journal of Hydrology 159(1-4).

Ganguly, J.B., 1996. *Sustainable Human Development in the North-East,*Published by Regency Publications, ISBN 81-86030-29-8.

GBPIHED, 2001.*Himalayan Ecology & Development*, G.B. Pant Institute of Himalayan Environment and Development in ENVIS Bulletin; Volume 9,No. 2, 2001.Geist, J., *et. al.,* 2001.*What drives Tropical Deforestation?*(http://www.pik-potsdam.de/~luedeke/lucc4.pdf, accessed on. 23/2/16).

Getis, A., *et. al.,*2004.*Introduction to Geography (Ninth edition),* Published by Mc Graw-Hil, ISBN -07-252183-x.

Ghosh, B.B., 1982. *History of Nagaland*, S, Chand and Co. Ltd. New Delhi.

Giordano, A. and Marchisio, C., 1989. *Analysis and Correlation of the Existing Soil Erosion Maps in the Mediterrenean Coastal Zones,*PAPMalaga (spain).

Gosh, B. B. (1986), *Pattern of Use and Ownership of Land in Nagaland*, *in Land Reform and Peasant Movement: A Study of North-East India,* Goswami. A., (ed.), Omsons Publications, New Delhi. p. 183-187.

Ghosh, K*., et. al.,*2013.*Assessment of Soil Loss of the Dhalai River Basin, Tripura, India Using USLE*, International Journal of Geosciences, 2013, 4, 11-23 http://file.scirp.org/pdf/IJG_2013011115152357.pdf, accessed on 25/2/2015.

Goswami, D.C.,1985. *Brahmaputra River, Assam, India: Physiography, Basin Denudation and Channel Aggradation*, Water Resource Research, 21.

Goudie, A., 2006. *The Human Impact on the Natural Environment; sixth edition* (The Human Impact on the Soil),Blackwill Publishing.

Government of Nagaland, 1978. Misc. Publication, The Directorate of Geology and Mining, Kohima.

Greenland, D.J., 1977. *Soil Damage by Intensive Arable Cultivation: Temporary or Permanent?* Phil. Trans.Soc. London B281.

Gregorio, A. D., Jansen, L. J. M., 1998. *Land Cover Classification System (LCCS): Classification Concepts and User Manual*, For software version 1.0. GCP/RAF/287/ITA Africover - East Africa Project in cooperation with AGLS and SDRN Nairobi, Rome.

Guthrie, R. H., 2002. *The Effects of Logging on the Frequency and Distribution of Landslides in Three Watersheds on Vancouver Island, British Columbia*.Geomorphology 43.

Gupta, D., 1993. *Study of Erodible and Non Erodible Soils of Kandi Belt of Jammu,*M.Sc. Theisis, SKUAST, Shalimar, Kashmir.

Hanyona, S., 2001.*Soil Erosion Threatens Farm Land of Saharan Africa*, in The Earth Times, January 10, 2001, http://forests.org/archieve/african/so erthre htm, accessed on 5/8/2015.

Hitzhusen, F.J., 1993. *Land Degradation and Sustainability of Agricultural Growth*, Some Economic Concepts and Evidence from selected Developing Countries, Agric Ecosystem Environment. 46.

Home Department, Government of Nagaland, 2012.*Nagaland State Disaster Management with support from NDMA & UNDP.* p. 9-12. http://nidm.gov.in/PDF/DP/NAGA.PDF, accessed on 4/6/13.

Holmes, A., 1965. *Principles of Physical Geology*, new and fully revised edn, London and Edinburgh: Thomas Nelson & Sons and Gilluly, *et al.*, 1968. *Principles of Geology*, Third 3rd Edition.

Horton, R.E., 1945. *Erosional Development of Streams and their Drainage Basin: Hydrophysical Approach to Quantitative Morphology*, Geol. Soc. America Bull., v. 56.

Hudson, N.W., 1961. *An Introduction to the Mechanics of Soil Erosion under Conditions of Sub-Trophical Rainfall*, Rhod, Sci Ass proc. 49(1).

Hudson, N.W., 1975. *Basic aspects of Soil Erosion Research Required to Develop a Soil and Water Conservation Programme for the Humid Tropics,* International Conference on soil conservation and management in the humid tropics.IITA Ibdan (Nigeria).

Hudson, N., 1995. *Soil Conservation*. Iowa State University Press,Ames, Iowa http://edocs.fu-berlin.de/diss/servlets/MCRFileNodeServlet/FUDISS_derivate_000000002786/03_Definitions.pdf;jsessionid=7D4217C86F58F3DC5336F55951555BDF?hosts=, access on 3/2/2015.

Hutton, J.H., 1921. *The Angami Nagas, London*: Macmillan.

IPCC, 2007. *Climate Change 2007: The Physical Science Basis*, Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change.

Iralu, K.D., 2000. *Nagaland and India, The Blood and The Tears: A Historical Account of the 52 Years lndo-Naga War and the Story of those who were never allowed to tell it,* Private Publications, FirstPublished in September.

Ismail, Jasmin and Ravichandran, S., 2008. *RUSLE2 Model Application for Soil Erosion Assessment Using Remote Sensing and GIS*, Water Resource Management 22.

Jain, S. K., *et. al.,* 2001.*Estimation of Soil Erosion for Himalayan Watershed Using GIS Technique,* Water Resources Management 15.

Jiang, Q. I. and Tan, 1974. *Soil Erosion and Conservation in the Wuding River valley, China.*

Jeanneret, P., *et. al*., 2003.*Quantifying the Impact of Landscape and Habitat Features on Biodiversity in Cultivated Landscapes*, Agriculture, Ecosystems and Environment 98.

Jones, M. J and Wild, A., 1975.*Soil of the West African Savanna*, the maintenance and improvement of their fertility, Tech. Comm. 55, Common wealth Bureau of Soils, Harpenden, England.

Jones, R.J.A., *et. al*., 2006.*Identifying Risk Areas for Soil Erosion in Europe,* in W. Eckelmann et. al. (eds.), Common Criteria for Risk Identification according to Soil Threats, European Soil Bureau Research Report 20, EUR 22185 EN, 23-

33, Office for Official Publications of the European Communities, Luxembourg.

Jordan, A. Bellinfante, N. and Paneque, J., 2002. *Valoraci on de paisajes erosivos en el Campo de Gibraltar (Cadiz-Espana) Almoraima (Revista de Estudios Campogils Raltarenos). 23*.

Joseph, G. (2005), *Fundamental of Remote sensing* (Second edition).

Joshi, H. (2001), *Nagaland Past and Present*, Akansas Publishing House, Uttam Nagar, New Delhi.

Judson, S., 1965.*Physical Geology*, Prentice Hall, USA, 1965, 3rd edu.

Kayastha, S. L., 1965. *Some Aspects of Soil Erosion Conservation,* National Geographical Journal of India. 15(6).

King, C., *et. al.,* 2005.*The application of remote-sensing data to monitoring and modelling of soil erosion.*Catena.

Khan M. N., 1955. *Threat of Soil Erosion to Yammuna Khadar,* Geographical Review of India.12(6).

Kozmenko, A. S., 1954. *Principles of Soil Control (in Russian)*, Sekhozgiz, Moscow.

Kozmenko, A. S., 1909 & 1910. *Sunken Down, Landslide and Erosion Formations in the Northeastern part of the Novosilsk Rayon of the Tula Province (in Russian),* Zemlevedenie 111, IV, Moscow.

Kumar, B.B., 2005. *Naga Identity (1st edition)*, Concept publishing company, New Delhi-110059, ISBN 8180691926.

Kumar, M., 2010.*Soil Responds to Climate Change: Is Soil Science in India responding to?*Curr.Sci., 99.

Kumar, S., (2011), *Indigenous Communities' Knowledge of Local Ecological Services*, Journal of the Economic and Political Weekly, Vol. 36, No. 30, pp. 2859-2869.

Kumar, P., 2004. *Economic of Soil Erosion, issues and perspective of India,* Publisher: Concept Publishing Company.

Kunte, S.V., 1988. *Geomorphic Analysis of Upper Assam Plains and Adjoining areas for Hydrocarbon Exploration*, Journal of Indian Society of Remote Sensing 16.

Kurien, J. K. (1998), *Traditional Ecological Knowledge and Ecosystem Sustainability: New Meaning to Asian Coastal Proverbs*, Journal of the Ecological Applications, Vol. 8, No. 1.

Laften J. M., *et. al., A.,* 1997.*WEPPPredicting water erosion using a process based model,* J. of Soil and Water Cons. 52.

Lal, R., 1988. *Soil Erosion by Wind and Water: Problems and Prospects*, in R. Lal (ed.), Soil Erosion Research Methods., Soil Water Conserv. Soc. Amer., Ankeny. IA, USA. Lal, R. and Stewart, B.A., 1990. Soil Degradation: A Global Threat, Advances in Soil Sci., 11: XIII-XVII.

Lal, R. (eds.).1994. *Soil Erosion Research (Second edition),* St. Lucie Press, Inc., 100 E. Linton Blvd., Suite 403B, Delray Beach, Fl 33483.

Lal, R., 1995. *Global Soil Erosion by Water and Carbon Dynamics*, in Lal, R., et. al., (eds), Soils and Global Change, CRC/Lewis, Boca Raton, FL.

Lal, R., 1998. *Soil Erosion Impact on Agronomic Productivity and Environment Quality: Critical Review,* Plant Science, 17.

Lal, R., 2001. *Soil Degradation by Erosion,* Land Degradation & Development, 12.Lazarervvić, R., 1973.*Erosion in the SFR of Yugoslavia.*

Landbein, W. B and Schumm, S. A., 1958.*Yield of sediment in relation to mean annual precipitation,* American geophysical Union, Transac. 39.

Lasanta, T., *et. al*., 2001.*Marginal Lands and Erosion in Terraced Fields in the Mediterranean Mountains*.Mountain Research and Development 21(1).

Lazarevic, R., 1975. *Geomorphology,*Institute of Forestry and Wood Industry, Belgrade

Leopold, L. B and Dunne, T., 1971.*Field method for Hillslope Description*, Tech. Bull.7, British Geomorphological Research Group. 24.

Li., *et al*., 1999.*Real-time following Prediction of the Landslide*. Changdu: Changdu University of technology press.

Liu XL, *et. al.,* 2010.*Impact of Land use and Soil Fertility on Distributions of Soil Aggregate Fractions and some Nutrients*, Pedosphere 20(5).

Lowdermilk, W.C., 1953. *Conquest of the Land through 7,000 years, Agric*. Inform. Bull No. 99: U.S. Dept. of Agric. Washington D.C.

Lu, D*., et. al.,* 2004.*Mapping soil erosion risk in Rondônia, Brazilian Amazonia: using RUSLE, remote sensing and GIS*, Land Degrad.Dev. 2004, 15.

Lutz, J. F., 1934. *The Physical-Chemical Properties of Soil Effecting Soil Erosion,*Research Bulletin, No. 212.Agri-Expt. Station Univ. of Missouri, Columbia.

Madebwe, V. and Madebwe, C., 2005.*An Exploratory Analysis of the social, Economic and Environmental Impacts on Wetland.The case of Shurugwi District,* *Midlands Proviunce, Zimbabwe.J. App. Sci Res. I (2): 2005,* http://www.google.co.in/interstitial?url=http://www.insinet.net/jasr/228-233.pdf.,accessed on 29/7/2009.

Magrath,W.B. and Arens, P., 1989. *The Cost of Soil Erosion on Java: a Natural Resource Accounting Approach*, Environment Department Working Paper 18, World Bank Policy Planning and Research Staff,World Bank,Washington, DC.

Maji, A. K., 2004. *Indian Council of Agricultural Research, Nagaland- Soil series of Nagaland,* prepared and published by National Bureau of SoilSurvey and Land Use Planning (ICAR).

Martinenz - Zavala, L. *et.al.*, 2000. *Evaluation of the erosion risk in Andevalo (Sw Spain),* Rubio, J.L., *ed.al*,. (eds.) ESSC III International Congress, Man and Soil at the Third Millenium. Valina (Spain).

Malhotra, G., *2009.Man and Development* in Journal on tradeoff between Economic Development and Environmental degradation (cross country analysis) volume XXXI No. 2 June 2009.

Marcus, Colchester,2003. *'Salvaging Nature, Indigenous Peoples, Protected areas and biodiversity,* Publisher Springer original York.

McCool, D.K., *et. al.,* 1987.*Revised Slope Steepness Factor for the Universal Soil Loss Equation*, Trans of ASAE 30(5).

Medhi, Dilip K.2005. *Man and Evironment in North East India*, New Delhi-110027; Omsons Publications, T-7 Rajouri Garden; ISBN 81-7117-111-7.

Meester, T. D., *et. al.,* 1977.*Some Problems in Assessing Soil Loss from Small Scale Field-Measurements,* International Conference on role of soil physical properties in maintaining productivity of tropical soils IITA. Ibadan.

Meyer, L. D., 1965. *Symposium of Simulation of Rainfall for Soil Erosion Research,* Transactions, Am. Soc. Agr.Engnr.8(1).

Mishra, A.,. *Sustainable Development as Principle of Environmental Protection: Some Reflection,*http://www.ignou.ac.in/schools/soss/FINAL_SOSS_CONFERENCE/full_%20papers/e1/abhishek%20misra-1.pdf,accessed on 4/7/2009.

Mitas, Z., Mitasova, H., 1996. *Modeling Topographic Potential for Erosion and Deposition using GIS*, International Journal of GIS, 10.

Mitasova,H., and Mitas,Z., 1999. *Modeling Soil Detachment with RUSLE 3D using GIS*, IL, USA: University of Illinois at Urbana –Champaign Mitra, B., *et. al*., 1998.*Application of Fuzzy Logic to the Prediction of Soil Erosion in a Large Watershed*, Geoderma 86.

Moldenhauer, W. C., 1965. *Procedure for studying Soil Characteristics by using Disturbed Samples and Simulated Rainfall,* Transactions, Am Soc Agr Engnrs. 8(1).

Moore, I.D., Burch, G.J., 1986. *Physical Basis of the Length-Slope Factor in the Universal Soil Loss Equation*.Soil Science Society of America Journal, 50(5).

Morgan, R. P. C., 1978. *Soil Erosion Measurement and Soil Conservation Research in cultivated areas of the U.K.* Geog. Jour.

Morgan.1996. *Erosion and Soil Conservation*, Oxford University Press. Madrid.

Morgan, R.P.C., *et al*., 1998. *The European Soil Erosion Model (EUROSEM): a Dynamic Approach for Predicting Sediment Transport from Fields and Small Catchments*, Earth Surface Processes and Landforms.

Morgan, R.P.C., 2005. *Soil Erosion and Conservation* (3rd Edn), Oxford: Blackwell Publishing.

Mukherjee, K. L. and Mukherjee, B., 1957. *Reclamation of Usar Soils in Vernasi",* National Geographical Journal of India.

Nagaland Basic Facts, 2007.

Nagaland State Human Development Report, 2004.*Healthier Horizons*.http://planningcommission.nic.in/plans/stateplan/sdr_pdf/shdr_Naga04.pdf, accessed on 27/6/2015.

Nagaland post, *Dimapur Monday*, November 30, 2009.

Nagaland post, *Dimapur- Reference of Landslide.*

Nandy, D.R*., et. al.,* 1975.*Geology of the NEFA Himalaya*, G.S.I., Misc. Pub.24(1).

Napier, T. L., 1986. *Socio-Economic Factors Influencing the Adaptation of Soil Erosion Control Practices in USA*, Workshop on Erosion Assessment for EEC-Methods and Models, Brussels, Belgium, Dec., 1986

NEC (1995), *Basic Statistics of the North Eastern Region*, North Eastern Council, Shillong, India.

Negi, S.S., 1996. *Forests for Socio-Economic and Rural Development in India,* New Delhi;MD Publications.

NEPED (1999), *Building Upon Traditional Agriculture in Nagaland, India*, NEPED and IIRR, International Development Research Centre, New Delhi, India.

NEPED (2006), *Adding Value to shifting Cultivation in Nagaland, India*, NEPED, International Development Research Centre, New Delhi, India.

Neris. J, *et. al*., 2012.*Vegetation and Land-use Effects on Soil Properties and Water Infiltration of Andisols in Tenerife (Canary Islands, Spain)*, Catena 98.

Ngai, E.W.T., Chan, E.W.C., 2005. *Evaluation of Knowledge Management Tools using AHP*, Expert Systems with Applications, 29.

Nigam, M. N., 1968. *Soil Erosion in Kashmir Himalayas,* abstracts of the International, Geographical Union Congress.

NRSC, 2010.Remote sensing application.

Nuh, 2002.*My Native Country: The Land of the Nagas*, Delhi & Guwahati: Spectrum Publications for Research Department, Council of Naga Baptist Churches.

Ofomata,G.E.K., 1984. *Erosion in the Forest Zone of Nigeria*, a Paper Presented at the 27th Annual Conference of Geographical Association of Nigeria, University of Nigeria, Nssuka.

Oldeman. L,R., 1994. *The Global Extent of Soil Degradation, in Greenland*, D.J., Szabolcs I, editors. Soil resilience and sustainable land use, Wallingford: CAB International.

Olson, G.W., 1981. *Archaeology: Lesson on Future Soil Use*, J. Soil water Conserv. 36.

Oluodo, A.,2009. *An Assessment of Socio-Economic Impacts of Housing Construction Activities on Water Resources in Malaysia,* European;Journal of scientific research ISSN 1450-216X Vol.33 No. 3.

Okin, G.S., 2002. *Toward a Unified View of Biophysical Land Degradation Processess in Arid and Semi-arid Lands,* in Global Desertification: Do Humans Cause Deserts? Reynolds, J.F., and Stafford Smith D.M., (eds), Dahlem University Press.

OMAFRA Staff, 2003.*Soil Erosion, Causes and Effects,* Ridge Town and College of Agricultural Technology, Ontario Institute of Pedelogy.http://www.search.gov.on.ca.8002/compass?view-template=simplr, Access on 5/8/2015.

Onweremadu, E.U., et. al., 2008.*Deterioration of Soil Organic Components and Adoptability of Green fallows for Soil Fertility Replenishment* in the Journal of American Science, 4(2), , ISSN 1545-1003, http://www.jofamericanscience.org/journals/am-sci/0402/10_0383_Deterioration_am.pdf, accessed on 2/6/2009.

Owens, D. W., *et. al.,* 2000.*Soil Erosion from Two Small Construction Sites in County, Wiscomsin*, in Third World Network (TWN ONLINE), http://www.twnside.org.sg/title/land-ch.htm U.S. Geological Survey, USGS Fact sheet FS-109-00 August 2000, http://wi.water.usgs.gov , accessed on 5/8/2015.

Parr, J.F., *et. al.,* 1990.*Global Assessment of Soil Degradation (GLASOD), World Map of the Status of Human- induced Soil Degradation*- An Explanatoty Note. ISRIC, Wageninggen.

Panabokke, C. R. (1977). *Erosion Hazard and farming systems in the humid tropics of South Asia,* in Greenland, D. J. and Lal, R (eds), Soil conservation and management in the humid tropics, Wiley, Chichester.

Pareira, H. C., 1956. *A Rainfall Test for Structure of Tropical Soils,* J. Soil.Sci. 7(1).

Partha, J. D., 2003.*Water and Climate Induced Vulnerability in Northeast India*; *Concerns for Environmental Security and Sustainability,* http://www.indiaenvironmentportal.org.in/files/WATCH_Research_Report_on_climate_and_disasters.pdf, accessed on 4/10/2011.

Pathak, M. and Verma, R., 1958.*Soils- Its Erosion and Conservation in the District of Ranchi,* National Geographical Journal of India.

Penek, A., 1894. *Morphology of the Surface of the Earth,* Published by Verlag von J. Engelhorn Nachf., Stuttgart.

Peel T. C., 1937. *World Soil Erosion and Conservation*, Cambridge University press; Cambridge.

Pillai, M. S.,2003. *Eco-friendly practices/ remedial measures for environmental sustainability,*4th International R&D Conference on water and energy for 21st century, 2003 Aurangabad, Maharashtra, India, http://www.ccriindia.org/portal/cict/articles/ecofriendly.pdf.,accessed on 5/8/2009.

Pimental,D., *et al*., 1993. *Soil Erosion and Agricultural Productivity*, in Pimental, D. (ed.), World soil erosion and conservation. Cambridge University Press, Cambridge.

Pigmental, D. (eds). 1993. *World Soil Erosion and Conservation,* Great Britain at the University Press, Cambridge.

Pimental, D. C., 1995.*Environmental and economic cost of soil erosion and conservation benefit,* Science. 267.

Pimentel, D., 2006. *Food and environmental threat of soil erosion*, Journal of the Environment, Development and Sustainability, 8. Rahim Hamood, R., 2009. *In Cycle of Erosion propounded by Davis and Penk Computerative Study*, AL-Fatih Journal .No.38, http://www.iasj.net/iasj?func=fulltext&aId=16936, access on 8/2 /15.

Pirazizy, A.A., 1992. *Environmental Geography and Natural Hazards. (Section iv, Soil Erosion),* New Delhi- 110059;Concept Publishing Company.

Poreba,G. j., and Prokop,P., 2010. *Estimation of Soil Erosion on Cultivated Fields on the Hilly Meghalaya Plateau, North-East India,*http://www.academia.edu/1006576/Estimation_of_soil_erosion_on_cultivated_fields_on_the_hilly_Meghalaya_Plateau_North-East_India.

Puri, G. S., 1956.*Soil and Water Conservation Problems of Bashaha Himalayas,* National Geographical Journal of India.22(2).

Quansah, C., 1982. *Laboratory Experimentation for the Statistical Derivation of Equation for Soil Erosion Modelling and Soil Conservation Design*, Ph.D Theisis, National College of Agricultural Engineering, Cramfield Institute of Technology.

Rao, A., 1983. *Geology and Hydrocarbon Potential of a part of Assam-Arakan Basin and Adjacent Regions*, Petroleum Asia Journal.

Rao, P.K., 2001. *Sustainable Development*, Economics Policy, Publisher: Wiley-blackwell Concept, ISBN 8170225701.

Rao, Y. P., 1981. *Evaluation of Cropping Management Factor in Universal Soil Loss Equation under Natural Rainfall Condition of Kharagpur, India,* proceedings of the Southeast Asian Regional Symposium on Problems of Soil Erosion and Sedimentation. Asian Institute of Technology, Bangkok.

Rathore, S.S.,2000.*Paradigm Shift for Enhancing Rice Productivity in Nagaland: Existing Practices and their Refinement,*http://gbpihed.gov.in/envis/HTML/vol16_2/S.S.%20Rathore.pdf, accessed on 4/7/2009.

Rawat, J. S., et.el., 2013. Estimation of Erosivity Index and Soil Loss under different Land Uses in the Tropical Foothills of Eastern Himalaya (India), International Society for Tropical Ecology. 54(1): 47-58, ISSN 0564-3295.

Ray, B.D., 2002. *Agenda for North East India,* New Delhi-110059Concept Publishing Company; ISBN 81-7022-938-3.

Raymo, M. E. and Ruddiman, W. F., 1992.*Tectonic Forcing of Late Cenozoic Climate*, Nature, 359.

Reddy, M.S., 1999.*Theme paper on "Water: Vision 2050*", Indian Water Resources Society, Roorkee.

Richter, G., 1998. *Soil Erosion and Cultural Landscape*, in Richter , G. (eds.). Soil erosion - Analysis and the Balance Sheet of an Environmental Problem.Darmstadt .

Robert, P. S., Hilborn, D., 2000. *Factsheet: Universal Soil Loss Equation (USLE)*. Queen's printer for Ontario.

Robinson, D.A. and Blackman, J.D., 1990.*Some Costs and Consequences of Soil Erosion and Flooding around Brighton and Hove, autumn 1987*, in Boardman, J., et. al. (eds), Soil Erosion on Agricultural Land. Wiley, Chichester.

Roose, E., 1972. *Comparison des causes de I" erosion et des principes de lulte antierosive en region tropicale humide, tropicale seche et mediterraneene,* Alti journees d' Etude du genie Rural a Florence.

Rose, C. W., 1660. *Soil Detachment caused by Rainfall,* Soil Sci. 9(1).

Rose, C. W., 1961. *Rainfall and Soil Structure,* Soil Sci. 9(1).

Rose, C. W., 1962. *Some Effects of Rainfall, Radiant Drying, and Soil Factors on Infiltration under Rainfall into Soils,* J. Soil.Sci. 13(2).

Roy, J. H., 1942. *Flood Water Erosion in the Upper Brahamputra Valley Calcutta,* Geographical Review. 5(5).

Sala, O.E., *et.al*., 2000. *Biodiversity – Global Biodiversity Scenarios for the Year 2100*. Science 287 (5459): 1770-1774.

Saleh, S. I., 1989.*Nagaland' Economy in Transition since 1964,* New Delhi; Omsons Publications.

Sambi, R. and Jayasree, 2008.*Rural Development Levels of Living in North East India,* Reform Era Journal, Rural development, Vol. 27 No. 1, Jan-March 2008.

Scherr, S., 1999.*Soil Degradation: A Threat to Developing Country Food Security by 2020*, IFRI Food, Agric. and Environment Discussion Paper 27, Washington, DC.

Schumm, S. A., 1956. *Evolution of Drainage Systems and Slopes in Badlands at Perth Amboy*, New Jersey: Geol. Soc. America Bull. V. 67.

Section II 14. 35**.** *'UN Economic and Social Development Division of Sustainable Development. Conservation and Management of resources for Development,* *chapter-14; Promoting Sustainable Agriculture and Rural Development,* http://www.un.org/esa/sustdev/documents/agenda21/english/agenda21toc.htm, accessed on 6/8/2010.

Segal, J., and Abrol.I.P., 1994.*Soil Degradation in India: Status and Impact,* Oxford & IBH publishing Co. Pvt. Ltd., New Delhi 110001, India.

Sfeir-Younis, A., 1986.*Soil Conservation in Developing Countries*, Western Africa Projects Department/The World Bank, Washington, DC.

Sharda, V.N., *et. al.,* 2012.*Identification of Soil Erosion Risk Areas for Conservation Planning in different States of India*, Journal of Environmental Biology, March 2013.

Sharma, A. K.,2002. *Biofertilizers for Sustainable Agriculture,* Published By Agrobios (India), Printed at Vinay Offset Printers, Jodhpur, ISBN 81-7754-118-8.

Sharma, J. P and Shyampura, R. L. and Sehgal, J., 1994. *Soils of Gujrat for optimizing Landuse,* Pub.29, National Bureau of Soil Survey and Landuse Planning, Nagpur.

Siddiqui, S., Chohan.S., 2015.*Legal Response to Institutionalizing Participatory Land Use Planning in Nagaland,* United Nations Development Programme, New Delhi, India.

Siddiqui, S., Chohan.S., 2015.*Legal Response to Institutionalizing Participatory Land Use Planning in Nagaland,* United Nations Development Programme, New Delhi, India.

Simms, A.D., *et. al*., 2003.*Application of RUSLE for Erosion Management in a Coastal Catchment ,Southern NSW*, in proceedings of the international congress on modeling and simulation: integrative modeling of bio-physical, social and economic systems for resource management solutions, July14–17.

Singh, D. R. and Gupta, P. N., 1982.*Assessment of Siltation in Tehri reservoir,* Proc. International Symposium on Hydrological Aspect of Mountainous Watershed, University of Roorkee, Roorkee (Nov. 4-6, 1982) Mangalik Prakashan, Saharanpur. Garde, R. J. and Kothyari, U. C., 1987. Sediment Yield Estimation, Journal Irrigation and Power (India) 44(3).

Singh, S., 2008.*Environmental Geography; Soil system,* Publisher:Prayag Pustak Bhavan.

Singh, R. B., 1995. *Natural constitute the real wealth, Intrinsic & Extrinsic value and environmental ethics,* in Misra, R.P., Environmental Ethics, a dialogue of culture, Publisher Singh, G. Rambabu R. Narain, P. Bhushan, L. S and Abrol, I. P., 1992. *Soil erosion rates in India,* J.Soil. Cons. 18(3).

Singh, S., 1999.*A resource Atlas of Arunachal Pradesh*, Government Publication.Government of Arunachal Pradesh, Itanagar.

Singh, S., 2005.*Climatology*, Prayak Pustak Bhavwan, Allahabad.

Smutylo, T., 2001.*Crouching Impact, Hidden Attribution: Overcoming Threats to Learning in Development Programs,* Evaluation Unit, International Development Research Centre Ottawa, Canada - 22-24 May 2001 page 17- NEPED,website-http://www.idrc.ca/uploads/user-S/10899909431CROUCHING_IMPACT.pdf, accessed on 11/6/2010.

Soil Science Society of America. 2001. *Glossary of Soil Science Terms*, Soil Science Society of America, Inc., Madison WI.

Statistical handbook of Nagaland,2009, 2010, 2011, 2012, 2013, 2014 and 2015.*Directorate of Economics & Statistics, Government of Nagaland.*

Stocking, M.A., 1986.*The Cost of Soil Erosion in Zimbabwe in terms of Loss of Three Major Nutrients,* FAO Consultants Working Paper 3, AGLS, Rome.

Strahler, R.L., 1957. *Quantitative Analysis of Watershed Geomorphology,* Am. Geophys. Un Trans., 38.

Strahler & Strahler, 2002.*Physical Geography; Science and system of the human geography(*3rd Edition*)*,Publishers- John Wiley & Sons, Inc.

Soil nutrient mapping of Nagaland, 2014.*Dept. of Agriculture, Govt. of Nagaland & ICAR-National Bureau of Soil Survey & Land Use Planning Nagpur*.

Solanki, R. C., Singh, A., 1996. *Soil erosion research on steep slopes in north-eastern hill region of India*, a review Indian Journal Soil Conservation, 24(3).

Solomon, S., *et. al.,* (eds.). Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA.

Souza, A.D. (2001), *Traditional Systems of Forest Conservation in North East India-The Angami Tribe of India*, North Eastern Social Resarch Centre, Guwahati, Assam.

State Human Development Report 2004.*Nagaland.p. 51.*

Stocking, M.A., Murnaghan, N., 2001.*Handbook for the Field Assessment of Land Degradation*, Earthscan, London.

Stoddart, D. R., 1969. *World Erosion and Sedimentation in Water*, in Chorley, R. J. (ed.), Water, Earth and Man. Methuen, London.

Stroosnijder, L., 2005. *Measurement of erosion: Is it possible?*Catena.

Subramanian, V., Sitasaward, R. and Joshi, L.U., 1985.*Rate of Sedimentation in the Yamuna river Around Delhi using the 2 2 6 Ra 2 10 PB method*, Journal of Radio analytical and Nuclear Chemistry, 90{2).

Surell, A., 1942. *Study on the Torrents of the Hautes-Alpes,* 2nd ed. 1870, Paris.

Theodora, C. F., & Pun, H., 2006.*Section II, UN Economic and social Development Division for Sustainable Development. Economical and social Development Conservation and management of Resources for Development*, Chapter 13; Managing fragile ecosystems, sustainable development inEnvironmental science and policy; Journal vol. 6 issue 1 Feb 2006.www.managing fragile ecosystems, sustainable development.environmental science and policy, accessed on 24/5/2010.

Thirunaranan, B. M., 1936. *The Study of Soils*, Journal of the Madras Geographical Association. 46(13).

Tian, Y., *et. al.,* 2008.*Risk Assessment of Water Soil Erosion in Upper Basin of Miyun Reservoir, Beijing, China*, Environ. Geol., 4

Tomich, T. (ed.), 2003.*Forces Driving Tropical Deforestation,* ASB (Alternatives to Slash-and-Burn) PolicyBriefs 06, Nairobi, Kenya, November.

Tisdell, C., Kartik, R., 1997. *Sustainability of Land Use in North-east India: Issues Involving Economic, the Environment And Biodiversity,* in International Journal of social economics Vol-24 Issue 1/2/3, ISSN: 0306-8293 DOI:10. 1108/03068299710161188 Publisher: MCB UP Ltd.

Toy, T. J. and Renard, K. G., 1998.*Introduction*, in Toy, . T. J. & Foster, G. R. (eds.). Guidelines for the Use of the Revised Universal Soil Loss Equation (RUSLE) Version 1.06 on Mined Lands, Construction Sites and R.

Toy, T. J., *et. al*., 2002.*Soil Erosion: Processes, Prediction, Measurement, and Control*, New York: John Wiley and Sons.

Trewartha, G.T., 1954. *An Introduction to Climate*, McGraw Hill Series in Geography

Uri, N.D. and Lewis, J.A., 1998.*The Dynamics of Soil Erosion in US Agriculture*, Science of the Total Environment 218.

USDA-SCS., 1972.*Hydrology,* in SCS National Engineering Handbook, Section 4. US Department of Agriculture, Washington, DC

Verma, P., 1966. *Formation and Conservation of Soil in an around Pathari Hills*, Indian geographical Journal.

Verstraeten, G. and Poesen, J., 1999. *The Nature of Small Scale Flooding, Muddy Floods and Retention Pond Sedimentation in Central Belgium*, Geomorphology 29.

Vogel, H., 1990. *Deterioration of a Mountainous Agro-Ecosystem in the Third World due to Emigration of rural ,Labour*, in Messerli, B. and Hurni, H. (eds), African mountains and highlands: problems and perspectives. African Mountains Association, Bern.

Vohra, B. B., 1975. *Land water management problems in India. Training Div. Dept. of Personal and Admn*, Reforms, Cab. Sect, New Delhi.

Wali, M. K., *et. al*., 1999.*Assessing Terrestrial Ecosystem Sustainability: Usefulness of Regional Carbon and Nitrogen Models*, Natural Resources 35.

Wangshimenla (2002), *Environmental Ethics, Social Norms and Land Use Practices in Ao Region, Nagaland*, Ph.D. Thesis, Department of Geography, Nagaland University, Lumami.

WCED (World Commission on Environmnet and Development), 1987.*Our Common Future*, Oxford University Press, Oxford and New York.

Wen, D., 1993.*Soil Erosion and Conservation in China*, in Pimental, D. (ed.), World Soil Erosion and Conservation, Cambridge University Press, Cambridge.

Whitehead, A. (2002), *Tracking Livelihood Change: Theoretical, Methodological and Empirical Perspectives from North-East Ghana*, Journal of Southern African Studies, Vol. 28, No. 3, Taylor & Francis, Ltd. URL - http://www.jstor.org/stable/823432, accessed on 26/5/2015.

Whitlow J. R., 1984. *Environment, Land Utilization and Development Prospects in Zimbabwe*, 77(1).

Wilson, L., 1973. *Variation in Mean Annual Sediment Yield as a Function of Mean Annual Precipitation,* American Journal of Science. 273.

Wischmeier,W. H., Smith, D. D., 1978. *Predicting Rainfall Erosion Losses,* USDA Agricultural Research Services handbook 537, USDA, Washington, DC.

Wollny, E., 1895.*Studies of the Behavior of the Atmospheric Precipitation to Plant and to the Ground,* Research from the field of Agriculturphysik 18.

Wu, W., 1999.*Environmental Change Monitoring - A Case Study in the Region of Yinchuan, Ningxia, China*, accessed on 29/5/2010-n http://www.gisdevelopment.net/application/environment/conservation/ma04031.htm.

Yano, K and T. Lanusosang , 2003. *Globalisation and its Impact on Agriculture: a Case study of Kohima District, Nagaland*, International Journal of Bio-resource and stress management 2013, 4(4).

Yano, K., and Lanusosang, T., 2015.*A Threat to Environmental Ethics: a case study of the Angami tribe of Kohima District, Nagaland*, Elixir Environ. & Forestry 85 (2015).

Zhang, X., *et. al.,* 2010.*Identification of Priority Areas for Controlling Soil Erosion,* Catena, 83.

Ziemnieki, 1968.*Amelioration for the Erosion Control.*

Website

http://atmakohima.nic.in/DistrictProfile.html, accessed on 5/4/15

http://en.climate-data.org/location/24623/, (C-temperate, w-dry winter and a-hot summer), accessed on 8-7-15

http://education.nic. in/stats/StateProfile0506.pdf , accessed on 29/3/2015

http:/!indiacode.nic.in/coiweb/fullactl.asp?tfnm=00%2048, accessed on 27/2/2016.

http://mak.ac.ug/documents/Makfiles/theses/Kitutu_Kimone_Mary_Gorret.pdf, accessed on 03/07/2015

http://pib.nic.in/newsite/PrintRelease.aspx?relid=86980. *Report of Forest Survey of India in Forest Cover*: accessed on 10/10/15

http://www.ieslamadraza.com/elena/websociales/geography3eso/Assistant%20Language/elements_of_climate.pdf. Extracted on 25/7/15 http://www.nagenvis.nic.in/ViewGeneralLatestNews.aspx?format=Print&Id=1024, accessed on 23/6/2013.

http://www.portal.gsi.gov.in/portal/page?_pageid=127,671641&_dad=portal&_schema=PORTAL, accessed on 8-8-2015.

http://www.undp.org/content/dam/india/docs/hdr_kohima_2009_full_report.pdf, accessed on 29/3/2015

http://www.undp.org/content/dam/india/docs/hdr_kohima_2009_full_report.pdf,accessed on 29/3/2015

http://www.sntc.org.sz/eearticles/soildeg.html,accessed on 27/6/2014

http//www.sntc.org.sz/eeartides/soiloleg.html, accessed on 5/8/2015

http://www.pids.gov.ph, accessed on 24/2/2016

PHOTO PLATES

Plate3.1 Jhum fieldin hilly slope at Tseminyu

Plate 3.2 Rolling terrace field at Kigwema village

Plate 3.3 Tree planted along the bund of Wet terrace field to check mud slide in Southern Angami

Plate 3.4Bamboo plantation along the bund to checkmud slide in Southern Angami

Plate 3.5 Traditional practice of improving the soil

Plate 3.6 Alder based cultivation at Khonoma

Plate 3.7 Wet terrace cultivation in steep slope

Plate 3.8 Forest fire destroying the vegetation at Chiechama village

Plates 5.1

Landslide at Southern Angami region

Plate 5.1.1 Landslide at Phesama Village along NH 39 which was triggered due to spring water gushing from the hill slope

Plates 5.1.2 Landslide below Kisama Haritage alongNH 39 triggered by the construction of an exit road at a sinking area

Plate 5.1.3 Land slide at Themi Za below Viswema village

Plate 5.1.4 Landslide below Viswema village due to road construction at sensitive area

Plate 5.1.5 Landslide and rill erosion along the approch road of Kidima village due to road construction and step cutting on the top of the flow to minimize erosion

Plate 5.1.6 Construction at unstable site along the road

Plate 5.1.7 Cracks along a new constructed road (Viswema and Kedima approach road)

Plate 5.1.8 A natural landslide at *Lemvii rii* (a range) at Kigwema village due the steep slope

Plate 5.1.9 Retaining wall constructed at different location along the NH 39 to minimize landslide

Photo Plates 5.2
Landslide at Kohima town

Plate 5.2.1 Arial view at Sanuorü stream erosion due to blocked of drainage along the Secretariat road

Plates 5.2.2 Landslide below Naga Hospital

Plate 5.2.3 Mud Flow due to dumping garbage below Naga Hospital

Photo Plates 5.3
Landslide at Northern Angami region

Plate 5.3.1 Landslide between Chiechama and Bosta, NH 61

Plate 5.3.2 Landslide between Chiechama and Bosta due to improper drainage at NH 61

Plate 5.3.3 Cutting the top of the slide to stabilize landslide at NH 61

Plate 5.3.4 Mud fall and cracks at Bosta due to unscientific construction of diversion road

Plate 5.3.5 Rock fall along with soil along the NH 61

Plate 5.3.6 Drainage mud flow due loss of vegetation and settlement in the hill slope

Plate 5.3.7 Mudslide along the NH 61

Photo Plates 5.4
Landslide in Western Angami region

Plate 5.4.1 Landslide at KMC dumping area creating a valley

Plates 5.4.1 Landslide at NH 39 and retaining wall constructed on both side of the road to control landslide

Plates 5.4.2 Rock and mud fall due to quarrying

Plate 5.5 Jhum preparation (burning of vegetation)

Plate 5.6 Soil loss at the foot of the jhum field

Plate 5.5 Land cover changes and soil erosion caused by stone quarry (more than 20 acres of land affected)

Plates 5.6
Mountain quarry

Plate 5.7 River quarry

Plate 5.8 Stone quarry in southern Angami area

Plate 5.9 Step cutting to minimize the slope failure

APPENDIX 1

Soil Parametersand theirCodes

Surface Form

inaris code	nbss code	class
1	D	Dissected
2	H	Hummocky
3	L	Level
4	G	Gently sloping
5	U	Undulating
6	O	Rolling
7	S	Steep
8	R	Ridges
9	V	Valleys
10	T	Terraces
11	P	Plateau
12	I	Island
13	M	Marshes
14	H1	Hill
-1		No data

Parent Material

inaris code	nbss code	class
1	A	Alluvium
2	C	Colluvium
3	E	Aeolian
4	G	Granite
5	N	Gneiss
6	S	Schist
7	D	Sandstone
8	B	Basalt
9	L	Limestone
10	T	Glacial
11	M	Marine sediments
12	U	Undifferentiated
13	GN	Granite Gneiss
14	-	Weathered Basalt
15	-	Kaolinite
16	-	Laterite
17	-	Gneisses/schist
18	-	Shale/slate
19	-	Weathered charnakytes
20	-	Weathered sandstone
21	-	Weathered gneiss
22	-	Weathered shale
23	-	Phyllite
24	-	Rock outcrops
25	-	Quarzite
26	-	Khandoloites
27	-	Diorite
28	-	Sedimentary
-1	-	No data

Soil Depth

inaris code	nbss code	class
1	0	Ext.shallow
2	1	Very shallow
3	2	Shallow
4	3	Mod. shallow
5	4	Mod. deep
6	5	Deep
7	6	Very deep
-1	-	No data

Particle Size Class

inaris code	nbss code	class
1	G	Fragmental
2	Z	Sandy-skeletal
3	K	Loamy-skeletal
4	P	Clayey-skeletal
5	S	Sandy
6	L	Loamy
7	R	Coarse-loamy
8	M	Fine-loamy
9	T	Coarse-silty
10	Y	Fine-silty
11	C	Clayey
12	F	Fine
13	V	Very fine
14	D	None
-1	-	No data

Soil Temperature Regime

inaris code	nbss code	class
1	F	Frigid
2	M	Mesic
3	T	Thermic
4	H	Hyperthermic
5	I	Isothermic
6	P	Isohyperthermic
7	C	
-1	-	No data

Soil Reaction (pH)

inaris code	nbss code	class
1	1	Strongly acidic (<4.5)
2	2	Mod. Acidic (4.5-5.5)
3	3	Slightly acidic (5.5-6.5)
4	4	Neutral (6.5-7.5)
5	5	Slightly alkaline (7.5-8.5)
6	6	Mod. Alkaline (8.5-9.5)
7	7	Strongly alkaline (>9.5)
-1	-	No data

Soil Drainage

inaris code	nbss code	class
1	0	Extremely poor
2	1	Very poor
3	2	Poor
4	3	Imperfect
5	4	Moderately well
6	5	Well
7	6	Somewhat excessive
8	7	Excessive
-1	-	No data

Surface Texture

inaris code	nbss code	class
1	s	Sandy
2	l	Loamy
3	c	Clayey
4	cl	Course loamy
5	-	Clay loam
6	-	Sandy clay loam
7	-	Silt
8	-	Silty loam
9	-	Silty clay
10	-	Silty clay loam
11	-	Sandy clay
12	-	Clay skeletal
13	-	Gravelly sand
14	-	G. loamy sand
15	-	G. sandy loam
16	-	G. loam
17	-	G. clay loam
18	-	G. sandy clay loam
19	-	G. silt
20	-	G. silt loam
21	-	G. silty clay loam
22	-	G. sandy clay
23	-	G. clay
24	-	Loamy skeletal
-1	-	No data

Slope

inaris code	nbss code	class
1	a	Level to nearly level (0-1%)
2	b	Very gentle (1-3 %)
3	c	Gentle (3-8 %)
4	d	Moderate (8-15 %)
5	e	Moderately steep (15-30 %)
6	f	Steep (30-50 %)
7	g	Very steep (>50 %)
-1	-	No data

Salinity

inaris code	nbss code	class (Ece (dS/m))
1	-	NA
2	S0	Negligible (1-2)
3	S1	Slight (2-4)
4	S2	Moderate (4-8)
5	S3	Mod.strong (8-15)
6	S4	Strong (15-25)
7	S5	Severe (25-50)
8	S6	Very severe (>50)
-1	-	No data

SODICITY

inaris code	nbss code	class (ESP)
1	-	NA
2	N0	Negligible (<5)
3	N1	Slight (5-15)
4	N2	Moderate (15-25)
5	N3	Strong (25-40)
6	N4	Severe (>40)
-1	-	No data

Surface Stoniness

inaris code	nbss code	class
1	-	Nil
2	t1	Slight (<15%)
3	t2	Moderate (15-40%)
4	t3	Strong (>40%)
-1	-	No data

Flooding

inaris code	nbss code	class
1	0	Nil (-)
2	1	Slight
3	2	Moderate
4	3	Severe
5	4	Very severe
6	5	Occasional flooding
-1	-	No data

Organic Carban (OC)

inaris code	nbss code	class
1	-	0.5%
2	-	0.5 – 0.75%
3	-	0.75 - -1.0%
4	-	1.0 – 2.0%
5	-	2.0 – 5.0%
6	-	>5.0%
-1	-	No data

Cation Exchange Capacity (CEC)

inaris code	nbss code	class (cmol/kg)
1	-	<10
2	-	10 – 20
3	-	20 – 30
4	-	>30
-1	-	No data

APPENDIX 2
Meteorological Report of Kohima 2009

Particular	Jan	Feb	Mar	Apr	May	June	July	Aug	Sep	Oct	Nov	Dec
Ave. Bar. Temp. ^{0}C	12.8	14.6	17.8	20	21.7	22.1	22.6	21.9	22	20.4	16.9	12.6
Ave. Max. Temp. ^{0}C	16.8	20.3	22.2	24.6	25	25.9	25.7	25	25.3	23.9	20.8	16.7
Ave. Min. Temp. ^{0}C	6.7	9.2	11.7	15.1	15.7	17.1	18.3	17.7	17	14.6	10	6.4
Ave. Mean. Temp. ^{0}C	12.1	14.7	17.2	19.9	20.8	21.7	22.2	21.5	21.4	19.6	15.9	11.9
Ave. Dew Point. ^{0}C	7.7	8.9	10.7	16.4	18.6	20.4	21.8	21.4	20.1	16.4	10.8	6.2
Ave. R/H %	61	54.8	53.8	64.5	75.7	81.4	86.7	88.9	79.7	71.7	60.3	57.6
Rainfall in mm	0	10.6	24.6	32.1	138.4	205.7	277.2	388.2	216.8	129.4	13.4	0
No. of Rainy Days	0	2	4	10	19	20	25	24	18	12	1	0

APPENDIX 3
Meteorological Report of Kohima 2010

Particular	Jan	Feb	Mar	Apr	May	June	July	Aug	Sep	Oct	Nov	Dec
Ave. Bar. Temp. ^{0}C	12.8	13.8	18.7	21	21.1	20.7	22	22.4	21.6	20	16.6	13.3
Ave. Max. Temp. ^{0}C	17.8	19.3	24.3	26	24.8	24.4	24.5	25	24.7	23.6	20.6	16.2
Ave. Min. Temp. ^{0}C	6.2	6.8	12	15	15.5	16.6	17.4	17.5	16.6	14.4	9.7	6.5
Ave. Mean. Temp. ^{0}C	12	13.1	18.2	20.5	20.2	20.5	21	21.3	20.7	19	15.2	11.4
Ave. Dew Point. ^{0}C	3.1	5.1	6.2	12.9	16.7	19.3	20.1	20.3	20.3	17.4	11.6	7.3
Ave. R/H %	41.8	46.5	38.2	56	68.1	82.4	87.8	83.8	83.8	75.5	66.6	61.7
Rainfall in mm	1.4	8.2	56.9	60.8	119.5	347.1	530.6	464.3	226.5	162	2.1	21.2
No. of Rainy Days	1	2	6	9	17	27	26	25	19	14	1	1

APPENDIX 4

Meteorological Report of Kohima 2011

Particular	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec
Ave. Bar. Temp. ^{0}C	10.3	13.3	17.6	18.5	20.5	21.9	21.8	21.9	22	20	15.6	12.7
Ave. Max. Temp. ^{0}C	14.9	19.1	23.4	24	24.6	25	24.5	25.8	25.6	24	20.9	15.6
Ave. Min. Temp. ^{0}C	4.1	6.7	9.7	12.7	14.6	16.9	17	16.4	16.4	13.5	8	5.2
Ave. Mean. Temp. ^{0}C	9.5	12.9	16.6	18.4	19.6	21	20.8	21.1	21	18.8	14.5	10.4
Ave. Dew Point. ^{0}C	4.1	4.9	7.9	11.5	17.3	20.5	20.3	20.3	19.6	16.5	8.8	6.6
Ave. R/H %	55.7	43.8	45.6	54.8	74.7	85.9	87.4	81	78	69.6	52.4	55.8
Rainfall in mm	9.8	5.2	56.8	34.9	265.6	308.2	437.7	239.9	336.3	31.7	9.7	0
No. of Rainy Days	2	1	5	5	19	27	28	21	23	7	3	0

APPENDIX 5

Meteorological Report of Kohima 2012

Particular	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec
Ave. Bar. Temp. ^{0}C	10.8	13.8	17	20.2	22.3	22.2	22.8	22.8	21.9	19.4	17	13.2
Ave. Max. Temp. ^{0}C	14.7	18.8	21.9	24.6	25.9	25.4	25.7	26.2	25.3	23.4	21.3	18.5
Ave. Min. Temp. ^{0}C	3.9	6.3	10	13	14.8	16	17.3	16.8	16.1	12.4	8	5.7
Ave. Mean. Temp. ^{0}C	9.3	12.6	16	18.8	20.4	20.7	21.5	21.5	20.7	17.9	14.7	12.1
Ave. Dew Point. ^{0}C	6.4	6	8	14.8	17.4	19.4	20.4	20	19.7	15.8	11.2	7.2
Ave. R/H %	66.4	50.8	47.7	64.1	67.3	80.2	81.6	78.6	83.3	74.5	64.9	63.6
Rainfall in mm	32.7	15.2	49.2	81.5	130.8	218.8	295	258.7	123.6	124.3	40.2	0
No. of Rainy Days	9	3	10	11	9	22	24	21	23	11	3	0

APPENDIX 6

Meteorological Report of Kohima 2013

Particular	Jan	Feb	Mar	Apr	May	June	July	Aug	Sep	Oct	Nov	Dec
Ave. Bar. Temp. ^{0}C	11.8	14.9	17	20.2	20.8	22.3	22.7	22.6	22.1	20	16.6	13.2
Ave. Max. Temp. ^{0}C	16.7	21.8	24.3	25.4	24.8	27.2	26.4	27	26	25.1	22.4	17.7
Ave. Min. Temp. ^{0}C	4.2	7.2	9.8	12.5	14.3	16.1	16.6	16.6	15.7	12.6	7.4	4.1
Ave. Mean. Temp. ^{0}C	10.5	14.5	17.1	19	19.6	21.7	21.5	21.8	20.9	18.9	14.9	10.9
Ave. Dew Point. ^{0}C	4.5	5.6	7.2	10.4	16.9	19	20.6	20	19.1	16.9	12.2	6.3
Ave. R/H %	54.8	43.5	38.9	48.2	74.4	73.5	84.6	80.5	76.9	71.7	61.5	57.5
Rainfall in mm	0	0	45.2	115.4	332.5	298.2	350.9	268.5	226.3	112.1	0	0
No. of Rainy Days	0	0	6	11	23	24	29	21	22	15	0	0