Environmental Issues of North East India

Editor

Zahid Husain

Environment is the most discussed topic in the world today because of two reasons. First is the environmental degradation that has threatened the survival of all life forms on the surface of the earth. Second is the environmental management, which includes successful utilisation of the environmental resources and solution of the environmental problems. These points are the focus of the present book. It deals with the state of environment (particularly the geoenvironment), degradation of environment (land, water and forest), and environmental management in Northeastern part of India. Though Northeast India can boost of still having some pristine environment, but that very environment is subjected to degradation due to plundering attitude of man, and that is a point of great concern today. That is why scientists from different branches of knowledge have contributed to make this volume a multidisciplinary one where results are integrated to understand the complexities of environmental systems in a better way so that it can be managed successfully for ever. The book will be of interest for the geoenvironmentalists, social scientists, planners and technocrats.

Rs. 550/-

Zahid Husain Qureshi (b. 1952), M.A., Ph.D. Geography (Udaipur). After working in a UNESCO project during 1975 he joined the Geomorphology Section, Central Arid Zone Research Institute (ICAR), Jodhpur as a *Research Scholar* in 1976. In the CAZRI he received further training in Geomorphology and Remote Sensing while doing research on decertification and prior/buried courses of the Saraswati River in the Thar Desert. Then he was involved for one year (1978–79) in doing research, along with a team on palaeoenvironment and archaeology of the Thar Desert while working in a UGC project as a *Post-Doctoral Fellow* of the Poona University at Deccan College, Pune. From October 1979 to March 1997 he carried out research on human ecology of the Northeast India as a *Research Associate (Ecology)*, Anthropological Survey of India, Shillong. Since April 1997 he has been engaged in teaching and research in physical geography as a *Reader* at North-Eastern Hill University, Shillong. He specialises in geomorphology, environment, ecology and remote sensing. He is Life Member of a few academic societies and also associated with editing of some journals. Till now he was involved in completion of about 10 major research projects/topics, either jointly or individually, and has been able to publish 33 articles/papers in local, regional, national and international journals and books. He has edited a book—*Environmental Degradation and Conservation in North East India* (1996), and written a book on *Geoecology of Kameng Himalaya* (2002) to mark the occasion of UN 'International Year of Mountains 2002'.

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Dedicated to
World Environment Day
and
Earth Day

PREFACE

Our planet earth is unique. Its physical and biological components are parts of an interacting system known as ecosystem. Human activities depend mostly on the exploitation and consumption of resources (mostly biotic) and cause a wide range of environmental degradation.

The most important natural resource is land comprising soil, water and associated plant and animal life involving the total ecosystem. Our future depends on the preservation and improvement of the natural resources. But there has been extraction of bio-mass over large areas at the cost of land's natural capability of regeneration and re-enrichment, resulting in an irreversible land degradation causing socio-economic and environmental problems. In the field of mindless mining of coal and other natural resources the miners and the metallurgists to an extent are responsible for polluting the rivers, streams and atmosphere. They function as an agent to disturb the ecological balance by their unscientific works. The making of roads in the hill regions without proper slope stabilisation may induce landslides, excessive cutting of forest may increase soil erosion, depletion of wild life, worms and insects which sustain the ecosystem. In a planned development process all the issues of eco-balance have to be considered and then decision has to be taken scientifically on any development activity.

It is imperative that an awareness of this situation be created at all levels with decision makers, land use planners, farmers and the people. A sound technical basis for the preservation and improvement of the mother earth in

the context of North East India has to be found. We need to improve our soil capital as well. With this end in view the North-East India Council for Social Science Research held a seminar on 'the Mother Earth' in the context of North East India on 5 June 2002. The present volume has included 21 papers presented to it.

We take this opportunity to thank Mr. K.L. Tariang, Director, Dept. of Soil and Water Conservation, Govt. of Meghalaya for his initiative and support to hold this important seminar. We would like to thank Mr. Arun Kumar Verma of Regency Publications, New Delhi for undertaking expeditious publication of this volume.

5 February, 2003

B. Datta Ray
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EDITOR'S NOTE

Every year on the 5th June the North-East India Council for Social Science Research (NEICSSR), Shillong organises a seminar or a panel discussion or a lecture to mark the occasion of the *World Environment Day*. This is because of two main reasons. First and the foremost being that the NEICSSR is an affiliated body of the United Nations Environment Programme (UNEP), hence it is obligatory on the Council to join the efforts of the UNEP in propagating the cause of the world environment. Secondly, the Council is itself dedicated to facilitate research, discussion and publication on environment. This is evident from its various academic activities and number of publications related to the environment and management of natural resources, particularly of the Northeast India. Therefore, on the 5th June 2002 a Seminar was held on 'The Mother Earth' to celebrate the *World Environment Day* by focussing attention on the land and its resources in Northeast India. The theme was purposely selected to focus attention on the deteriorating state of the earth/land and the land based/governed environment, nowadays called *'geoenvironment'*. In fact, the rapid rate of depletion and degradation of the land and its resources has jeopardised the existence of the various life forms on the surface of the earth. It has not only disrupted the functioning of the global ecosystem/geoecosystem/geosystem/ecosphere but also reduced the carrying capacity of the earth. This is the most burning topic in any discussions on environment of the earth today. Hence, the present book is entitled as *'Environmental*

Issues of Northeast India' to actually understand and solve the environmental problems of the region.

The book is primarily an outcome of the papers presented in the Seminar. However, there are some invited papers as well to have a comprehensive picture of the state of the environment as far as possible. The environmental issues raised in this book are, in fact, a sequel to the topics discussed a few years back in the previous edited book- *'Environmental Degradation and Conservation in Northeast India'* (Husain, 1996). The only difference is that the present volume concentrates more on the geoenvironment or land based environment.

The degradation and conservation of environment are two complementary issues which are the most important ones also from the point of view of having a healthy environment capable to give sustainable supply of energy and matter for the better functioning of all types of ecosystem with their abiotic and biotic components (including man). Today, on one side, we are very much concerned about the nature, type, rate, intensity, magnitude and causes of the degradation taking place in land, water, air and organic components of environment and their impact on the living and non-living components of the global ecosystem. On the other side, we are very much worried and thus making every possible efforts to check further deterioration of the environment and restore the lost glory of the environment by conserving it on ecologically sound principles. That's why environmental conservation tops the agenda in any meetings on man and environment of the earth, right from the entire globe to a farmer's field levels. This is because to save the environment with all its potentialities we have to think globally but act locally. Otherwise, the environmental problems cannot be solved because they are not only complex but they transcend all boundaries, including the political ones. Moreover, in this age of globalisation the environment has also been globalised where people and environment of any part of the earth are subjected to the happenings the world over, and the

utilisation of environmental resources is no more locally governed only. Secondly, the local/regional environment is influenced by the global environmental change, *e.g.*, global warming and sea level rise.

The present book has three broad sections, each emphasising a particular issue of the environment, which is worth paying attention by the environmentalists. The First Part deals with the *state of the geoenvironment*, especially different aspects of the land and water—the two most vital components of the environment. It helps us not only to manage these resources properly but also to efficiently manage the hazards and disasters related with land and water. While the Second Part covers the most common environmental problem experienced the world over—the *environmental degradation*, particularly of the land, water and the organisms. *Environmental management* is the theme of the Third Part, for this is the basic approach and method which can help us to reduce the rate, intensity and extent of environmental degradation on one hand, and maintain the ecological balance on the other so that sustainable supply of environmental resources is maintained for the present and future generations.

The five papers included in the First Part deal with very critical issues of the land and water. Of course, here land is considered in its all-comprehensive sense, which includes geological and geomorphological points of view related with the geodynamics, structure, lithology, seismisity, and mass movement in the form of landslides, subsidence etc. It also focuses on the productivity of land for agriculture purpose, which actually determines fate of the people living in any part of the earth. Landslide is the most frequent and devastating geohazard in the hills affecting life and property of the hill dwellers and disrupting the communication system, particularly along the roads, railways and in and around human habitations. The entire hilly part of the Northeastern region suffers from this problem with varying magnitude, frequency and extent. Day by day the problem is getting more and more severe

and it has become chronic, and crores of rupees are spent every year for the management of this geohazard.

The first two papers by the geologists are related with the geodynamics and the landslides. R.K. Avasthy as a pioneering worker on the landslides has given a brief account of the researches carried out on occurrence and causes of landslides in different parts of Northeast India. He has attributed both natural (earthquakes, faults, discontinuities, etc.) and human (road cutting, wrong location of the settlements, etc.) causes for the occurrence of landslides. He has identified six types of landslides in the region. Keeping the seriousness of the problem in mind appropriate suggestions have been put forward to check the incidence of landslides and reduce the risk involved in it, particularly how to save and develop the hill towns (mostly the state capitals like Aizawl and Kohima). Landslide hazard zonation map of Northeast India has also been prepared to help in locating the vulnerable areas and for disaster management. In the similar paper Trilochan Singh describes the occurrence of the landslides as a geoenvironmental hazard in context of the restless Arunachal Himalaya. According to him the geodynamics plays an important role in making this part of India more prone to the landslides and earthquakes. The juxtaposition of the three litho-tectonic systems in Arunachal, the slow northward movement of the Indian shield and the presence of various faults and thrusts in the region are main causes of the geodynamic activities in the Northeast India. Landslide is an outward expression of these activities, which itself create dangerous geohazard.

Very crucial property of the land is its productivity on which depends the food production in a region; hence its assessment is essential for food security on one hand and to take stock of the land degradation on the other. Undoubtedly, land productivity is unevenly distributed over time and space, due to both natural and human factors. The paper by Bimal Sharma and Zahid Husain explains the districtwise spatial variation in land productivity in

the state of Assam. The state has two basic land units—the *valleys* of the Brahmaputra and Barak, and the *hills* of Karbi Anglong and North Cachar Hills, mainly responsible for variation in land productivity, but within each land unit there are some variations also. Land productivity of each district has been evaluated with the help of simple statistical formula. Then districts have been grouped into three categories of high, medium and low land productivity by giving suitable reasons for the difference in the land productivity in Assam. This vital property of land is under serious threat from the pollution, degradation and soil erosion, and over exploitation of the land to produce more food to feed the rapidly increasing population. Actually, for the better survival of man and environment not only the land productivity has to be maintained but it has to be enhanced/improved also with appropriate methods, technology and strategy, especially in agrarian country like ours.

After the land, water is the most vital natural resource on the surface of the earth. Therefore, its proper appraisal, assessment, utilisation, conservation and management are as essential as water itself is for the all life forms. Within the Northeast India the valleys of the rivers like the Brahmaputra, Barak, Imphal etc. have an excess of water by virtue of having a good number of water bodies and wetlands in their fold. In contrast to it, the Himalaya Mountains, Meghalaya Plateau and some parts of the Indo—Burma Ranges though receive a substantial amount of annual precipitation but surprisingly suffer from scarcity of water resources, *e.g.*, the Cherrapunjee area which shares the record of receiving the highest orographic rainfall in the world with Mawsynram. In reality, the mountains are the sources/storehouses of water for the plains, for whatever is the rainfall in the hills it flows down the slope towards the plains, more rapidly in case the rainfall intercepting vegetation cover has been removed and water-absorbing/holding soil has also been eroded, mainly due to the human activities. Hence, the rainfall has to be

properly harvested in the hills itself to have water round the year, and here the forest and soil cover plays a vital role in naturally storing the rainfall. Recently, the Union Government has launched a rupees 1000 crore project—*Hariyali* (greenery) for rainwater harvesting in India with the dual objective of tackling water scarcity problems and augmenting the resources of the panchayats/village councils.

K.L. Tariang while taking stock of the rich water resources of Meghalaya has pointed out that these resources are at risk due to degradation of land and forest in the catchments/watersheds. Because of it the sources of water have depleted from a happy state of plenty to a miserable state of scarcity. Moreover, one has to pay a heavy price now for small quantity of water that too not available at right time and in good quality. Therefore, he has suggested innovations and strategies for harvesting rainwater in the area where it falls to solve water scarcity problem and change the paradoxical situation occurring in the place of 'the abode of clouds', *i.e.*, Meghalaya in general and the rainiest area of the Cherra-Mawsynram particularly.

The pattern and trend of rainfall over an area greatly control the availability of water in time and space. Its yearly variation, rise and fall affect the sources of water. It is a common belief that rainfall has been decreasing in many parts of the earth, including the Northeast India. However, the paper by Prasenjit Das and H.J. Syiemlieh tells a different story. While analysing the trend of annual rainfall in the Brahmaputra valley they have clearly negated the common belief. Their study shows that over the last 25 years the annual rainfall has increased, instead of decrease, in the seven stations out of the nine stations in the Brahmaputra valley. Coupled with deforestation in the surrounding hills and resultant increased surface flow and shorter concentration time of rainwater in the rivers could the increasing annual rainfall be attributed to occurrence of more frequent and severe floods in the recent years in the valleys.

Papers in the Second Part discuss the most serious issue of environment—the degradation that is responsible for

reducing the value of environment both qualitatively and quantitatively. Degradation of environment has been going on from centuries in many types, rates, ways and extent due to a number of factors and processes. Even people of the early civilisations experienced and contributed to this problem. The ultimate result is decline in the suitability and comfortability of environment for different living beings, including man whose survival has definitely been threatened. Because of it, environmental degradation has gained attention of the scientists from various disciplines. A.K. Bhagawati has presented a very gloomy picture of the riverine tracts of the Brahmaputra. He has given an account of the environmental degradation in this very sensitive landscape due to pressure of over population even on the marginal lands like the *chars* (sand bars) and islands lying in the course of the mighty Brahmaputra River. Utilisation of the marginal land units for various purposes has led to their degradation. Floods and bank erosion are severe hazards in these tracts, especially after the occurrence of the great earthquakes of 1897 and 1950. Faulty construction of the houses, roads, embankments etc. are equally responsible for the environmental degradation of the area.

Very rarely man has been able to practice the principle of *'development without destruction'*. Thus, many a times there have been deleterious impacts of the development projects on the benign environment. This is happening even today despite implementation of the rule of submitting an *'Environmental Impact Assessment'* (EIA) report with every developmental plan as a part of the planning process. Now the report about the probable impact of a development project on environment submitted with the plan is called *'Environmental Impact Statement'* (EIS). Whereas EIA is now actually applicable to the study of the impact(s) of a development project after its completion, and A.K. Bora's paper is an attempt in that direction. He has made an empirical assessment of the adverse effects of an irrigation project on the environment and economy. No doubt the

irrigation facilities have improved the agriculture performance in the command area, but the benefits compared to the losses are very less. The irrigation system has degraded the forest, land and water due to its improper maintenance and operation. Moreover, high sediment yield from the catchment has even threatened the life span of the barrage itself. Is it a real development/sustainable development?

Land is the most degraded component of the environment, only next to the forest. Though all types of land/landscape are subjected to degradation (*e.g.*, hills, plateaux, plains, coasts, etc.) but the highly degraded seems to be the wetlands, especially those that are located in and around urban and industrial centres. Of course, there are examples in the world where the wetlands of countryside have also been degraded due to draining off the water to prepare agricultural fields. That's why great concern is being shown nowadays to the wetlands through out the world, and in the Northeast India as well which can boost of having a great variety and number of fresh water wetlands. Serious efforts are afoot the world over to save and conserve the wetlands as they are very valuable ecosystems formed at the interface of the land and water. Wetlands are indeed a typical geoecosystem characterised by water saturated or submerged piece of land having unique geomorphology, hydrology, soil, flora and fauna. These are an essential (vital as well) segment of the landscape ecology, for they play a crucial geomorphological, hydrological and biological role in the complex of the geoecosystem. Therefore, degradation and depletion of such a valuable unit of land is definitely a matter of great concern for the scientists of different disciplines in general and the geoenvironmentalists in particular. That's why there is a paper by N. Memma Singha and Zahid Husain to show concern about the dying wetlands of Assam, particularly of Guwahati City. Decline in total wetland area and total water spread area of the Silsako and Numalijalah wetlands has been calculated by them from the sequential

toposheets and satellite imagery. This pitiful situation has arose due to encroachment of the wetlands for construction of houses (colonies), roads, railways, industries etc. as the City requires space for horizontal expansion with the increase of population and development. Blockage of incoming streams has also caused decline in the total water spread area. Almost 80 per cent of the original area of the wetlands is lost to the encroachment—a wasteful use of the wetlands indeed. Pollution of the wetlands is another reason of their degradation.

Environmental pollution as a result of the contamination of the land, water, air and biome by toxic substances and gases has not only reduced the quality and quantity of environment but the biodiversity too. Biodiversity is certainly lost the world over, but the rate and intenstiy varies in time and space. O.P. Singh has tried to explain the lethal effects of the contamination of environment on various life forms and also on the inorganic elements. Such papers remind us of our erroneous acts which are costing too much to the plants and animals, and even man himself is not free from its detrimental effects.

The land is so much so important resource that it could easily be called the mother of all resources, that's why we address it as *'mother earth'*. Every society has its own perception about the earth/land and its usefulness for various purposes and P.R. Mawthoh has presented the perception of the Khasi people. He has also described abuse of the land in Northeast India through soil erosion and land degradation. Shifting cultivation has been considered responsible for the land degradation. The Second Part on environmental degradation ends with another paper on abuse of land/environment by Bibhash Dhar. He has not only tried to create public awareness about it but also suggested measures to check it and maintain our surroundings in much better and beautiful manner.

The Third Part of the book is devoted to the management of environment (land, water and forest). It is because the proper management of environmental resources can

only save man and environment both. Therefore, appropriate technology and strategy has to be developed and employed to achieve efficient management of environment and its resources. This would not only ensure optimum utilisation of resources but also the ecological balance and sustainable development, all of which are equally important. The starting paper on this theme is by K.K. Satapathy, which deals with the methods and techniques of management of land in the mountains where shifting cultivation (now detrimental) is still practised by thousands of hill dwellers. In place of it he has suggested agri-horti-silvi-pastoral system for the hilly region in which toposequence based crop cultivation has to be developed. He has also suggested methods of soil and water conservation in the hills. It is worth mentioning here that no developmental plan can afford to ignore the indigenous knowledge about the husbandry of land and animal. Hence, the indigenous methods, techniques and strategies have to be incorporated in the developmental plan for the future.

N.N. Sarmah has discussed land and water management problems in the region. Being two vital resources of the environment the management of land and water has to be integrated by adopting the watershed management approach. In fact, watershed management is a practical answer to the eco-friendly development and environmental conservation where all the resources of a river basin are managed in such a manner that development of one does not harm the development of the other, and in this way an over all development of man and environment both takes place. On the other hand, Sujit Deka and A.K. Bora advocate that environmental conservation is also possible through the wasteland management. If wastelands could be developed properly it will certainly help in enhancing the potential of an area and thus in saving the environment as well. This is because increasing population pressure on land and demand for food has led to subsequent expansion of agriculture and that is not possible now without utilisation of the wastelands. They have

suggested ways and means for the wasteland management. The only point that has been bothering the mind for a long time is a correct definition of the wastelands. Of course, for the wastelands in terms of agriculture Dudley Stamps' definition of the wastelands can be taken as authentic one. This is because a piece of land considered waste for a particular use (here for example for agriculture) might not be waste for any other use (say industry or settlement). Therefore, wasteland concept is land use specific. Moreover, a land lying unused now but has the potential for the development of agriculture can also be considered a wasteland. Dealing with the land management the last paper is by Niranjan Das, where he has suggested application of the organic manure to replenish the soil on one hand and check the land degradation on the other, because the chemicals used in the agricultural fields are harmful to the land and water resources.

After careful and sustainable management of land, it is time now to turn to the management of the forests, and in this regard U.K. De's paper is a welcome contribution, first exhaustively covering different aspects/issues of forest management theoretically, and then giving an example of Joint Forest Management (JFM) in Tripura. He is of the opinion that economic incentive should be given to the people to make JFM more attractive and fruitful. Actually, JFM has emerged as a practical approach towards management of forests, especially the degraded forests or regenerated forests where the community or communities living in and around the forest area participate actively in its management to get benefits from the forest. Sometimes, such efforts are not as successful as desired due to lack of interest shown by the people. Hence, De has proposed economic incentive for JFM programme in Tripura whose case study has been cited. Effectiveness and success of the policies and campaigns of environmental conservation depend on the nature and ownership pattern of resources (commonness, exclusion and non-exclusion possibility), socio-economic conditions of the people and the possibility of

enforcement of different policies. He has pointed out drawbacks of common property resources (CPRs), thus the principle of anticommons could be an effective way of preserving the critical environmental resources. In fact, the greed, selfishness, lack of responsibility towards the community and the environment, and declining role of the traditional institutions in the management of environment and resources are some of the main causes for the over exploitation of the CPRs. Otherwise, CRPs have been bank of resources for the society in the past, and it can still play the same role, provided peoples' attitude towards it changes.

Over all environmental management is in focus even if a single resource is being developed. That's why D.C. Goswami has suggested social forestry for the environmental management in the Himalayan region. While R.P. Bhattacharya has discussed forest conservation in Arunachal Pradesh as forests are declining rapidly. One of the primary reasons of the depletion of forest is collection of fuel wood from it. Hence, to save the forests alternate sources of energy have to be discovered. In this regard D.R. Das has suggested bioenergy as a renewable source of energy not only to save the forests but also to meet the growing energy needs. Technological know how and financial support are required by the people to develop such schemes. Therefore, for the establishment of a bioenergy plant the Ministry of Non-Conventional Energy Sources gives 90 per cent subsidy in the Northeast India.

For an efficient and successful management of environment it is necessary to understand the processes of resource formation, recognition, utilisation and conservation. S. Aravamudhan has theoretically tried to explain it through various definitions, concepts and diagrams, along with examples from the Northeast India. According to him it is important to know what is available as resources in the region, and how far they are being utilised for the benefit of the people of the region. A. Henia in her paper has discussed that how environmental awareness could be

raised in the region through the literacy campaigns to successfully manage the environment.

Some points emerge from the book. First is about having fundamental knowledge of the state of environment that helps in understanding the factors and processes involved in the occurrence and solution of the environmental problems on one hand and in finding appropriate technology and strategy for environmental management and solution of the problems. This also helps in disaster management. In this case the nature and characteristics of land have been touched upon in the book, mainly those related with the geoenvironment. Second point tells about the application of the 'systems approach' in the environmental studies. It is because the various components (land, water, forest, animals, etc.) of environment are interrelated, interdependent and interconnected, hence should be taken as parts of a system. Though studied separately, but as a part of the larger system they play crucial role in the functioning and maintenance of the system, which is called as *ecosystem* by the ecologists, *geosystem* by the earth scientists and *geoecosystem* by the geoenvironmentalists. The integrated approach of watershed management comes nearer to the systems approach; of course, a watershed can be a part of a larger river basin. Therefore, a comprehensive understanding of the entire environment as a system is necessary to deal effectively and efficiently with its management and problems, and this is possible only through multi/inter-disciplinary works. That's why this book comprises of contributions on various aspects of environment from the scientists of different disciplines. It has been tried to integrate their contributions, conclusions and results for understanding the environment from holistic point of view, manage the environment without destroying its potentials and attack the environmental problems from all directions to get the best results.

Thirdly, it emphasises on adoption of appropriate technology and strategy of environmental management, and to have the right attitude towards the environment. The

days of plundering attitude have gone. Man will be benefited if he harmonises and tunes his activities with the nature and functioning of the environment. Utilisation of environment has to be in such a way that sustainable supply of its resources could be maintained. In fact, man does need both—the environment and development for the sustenance and progress of not only the present generation but of future generations as well. That's why man cannot afford to destroy the very base of his survival.

In the end it can be said that the environmental issues discussed in the book are only tip of the iceberg. Still much more has to be done to really understand the intricacies and complexities of the environment and its management. It is because every day the environmental problems are increasing in number, extent, frequency, intensity and complexity, which further complicate the situation. Even then sincere efforts have to be made in this direction to have a better environment on which the present and future generations can flourish. Though the time is passing out of our hands, but still we can make a fresh beginning where utilisation of environment goes on without damaging and degrading its potentiality. With the fast growing concern about the environment the task seems not to be very difficult one. Moreover, man has got now better picture of the problems and the science and technology to solve them too. We only need little efforts at our own level that can become part of the global efforts. Destiny of man is dependent on a healthy, resourceful, unpolluted and equally distributed environment.

6.2.2003

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SPATIAL VARIATION OF LAND PRODUCTIVITY IN ASSAM

Bimal Sharma and Zahid Husain

Introduction

Owing to different environmental and human factors the land productivity in the world has great areal and temporal variations. There are numerous studies on the spatial variations of land productivity in the world. Land productivity or soil productivity is the capacity of land or soil, in its natural environment, to produce crop under a specified system of management, and is expressed in terms of yield (Sehgal, 1996: 6). A group of agricultural scientists explains the variations of land productivity in relation to the physiographic factors, especially soil and meteorological conditions, which generate land potential for cultivation and determine the agricultural yield (Stamp, 1958, 1960; Vink, 1975; Prasad *et al.*, 1987; Smit *et al.*, 1991, and others),

The agricultural production per hectare of land in India is low relative to the world average because of several reasons. However, the shift from traditional means of agricultural production to modern ones may be seen especially after green revolution effects. An un-impressed change in land productivity in India is due to unequal diffusion of the new agricultural technology from one area and crop to the others (Singh, 1994). Though Assam is endowed with ideal conditions of agricultural prosperity but there are many impediments in the way of its achievement.

Agricultural production has not been able to keep pace with the growing demand in the state. Even until the early years of planning, Assam was a food surplus state, but due to excessive growth of population, the usual slow growth rate in production turned it gradually into a deficit state (Lekhi and Choudhury, 1993). Oschwald (1996) interpreted the process of change in landuse scientifically considering the productive capacity of soil according to its natural potentials and imposed limitations for different types of landuses. Though Assam has good physiographic conditions but it does not show a good response in the productivity level. These facts should be studied for the under developed agricultural economy prevailing in the Assam plains where the agricultural landuse pattern seems to be stagnant in nature and unchangeable over time inspite of fertile soil and favourable meteorological conditions with significantly increasing population pressure as well as the urban growth (Taher, 1975; Das, 1984; and Bhagabati, 1993). Therefore, the spatial variations in land productivity may be result of both human and physiographic conditions in the state. The present research examines the districtwise spatial variation of land productivity in Assam. A simple cartographic technique of showing the areal variation of land productivity in Assam has been adopted by collecting districtwise agricultural statistics for the year 2000–2001, simple statistical formula is used to derive land productivity of each district.

A number of studies have been done and models developed by economists and geographers on land productivity. There are several reasons behind the changes in productivity patterns over time and space. They may systematically be described in order to understand the major attributes of land productivity. Of course, land productivity (that is defined as Y=O/A) is directly proportional to the total quantity of agricultural output and inversely proportional to total cultivated land (Rahman and Singh, 1995). The spatial patterns of agricultural growth and productivity relationship are infact the result

of the intensification of output augmenting practices (especially the increasing use of modern technology and irrigation). The application of these input factors increases level of land productivity and the rate of agricultural output (Binswanger and Ryan, 1977; Binswanger, 1978).

Generation of Indices

In order to test the validity of the facts as described above, the districtwise quantitative strength of land productivity is indexed in the following manner:

Land productivity refers to the agricultural output per unit of cultivated land as:

$$Y = (O/A)$$

where, Y = Yield production per unit of land

O = Production
A = Area

The Agricultural output (o), which can be measured as:

$$O = AiYi$$

where, I = 1, 2...n as number of crops

Ai and Yi are the Area and Yield of a particular crop of a region.

Results and Discussion

Land Productivity Variations

After compiling data on the land productivity of each and every district of Assam with the help of above mentioned equations for the year 2000–2001 (Table 1), the districts are arranged in four major categories of land productivity (Table 2 and Figure 1) namely, areas of Very High

Productivity (>18 quintals/hectare), High Productivity (15–18 quintals/hectare), Low Productivity (12–15 quintals/hectare) and Very Low Productivity (<12 quintals/hectare). It is found from Table 2 that 17.17 percentage of total area falls under Very High category where as 16.85 percentage falls under High category, 44.44 percentage falls under Low category and 21.54 percentage falls under Very Low category. It means maximum area is under Low category, followed by the Very Low category, together covering about 60 per cent land of Assam.

From the Table 1 and Figure 1 it is quite evident that land productivity in Assam has great spatial variations. Of course the temporal variation is also there but it is out of the purview of the present paper. The highly uneven areal differentiation in the land productivity of Assam is due to various agro-climatic factors.

Table 1: Districtwise Land Productivity in Assam (2000–2001)

Sl.No.	Name of Districts	Land Productivity (quintals/hectare)
1.	Dhubri	14.08
2.	Goalpara	16.49
3.	Kokrajhar	10.58
4.	Bongaigaon	10.28
5.	Kamrup	13.85
6.	Nalbari	10.94
7.	Barpeta	11.77
8.	Darrang	11.83
9.	Sonitpur	12.76
10.	Nagaon	16.51
11.	Morigaon	18.95
12.	Jorhat	15.54
13.	Golaghat	18.91
14.	Sibsagar	19.36
15.	N. Lakhimpur	9.81
16.	Dhemaji	13.26
17.	Dibrugarh	16.12
18.	Tinsukia	13.38
19.	Karbianglong	13.40
20.	N.C. Hills	12.88
21.	Cachar	21.13
22.	Hailakandi	17.38
23.	Karimganj	21.28

Source: Directorate of Statistics and Economics, Govt. of Assam, Guwahati.

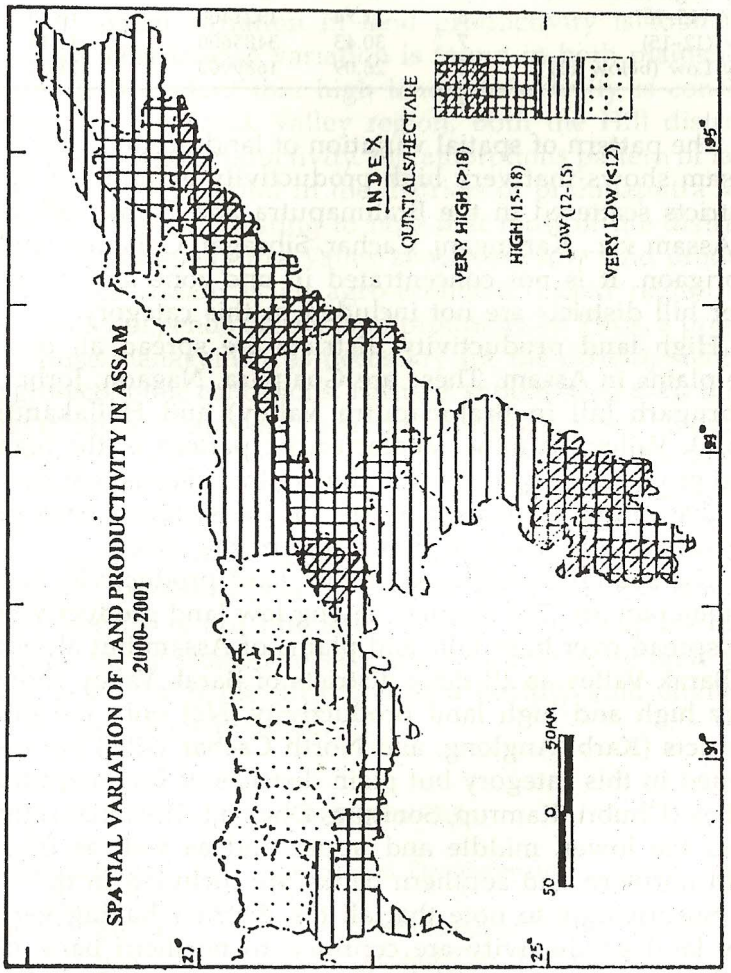
SPATIAL VARIATION OF LAND PRODUCTIVITY IN ASSAM
2000-2001
INDEX
QUINTALS/HECTARE
VERY HIGH (>18)
HIGH (15-18)
LOW (12-15)
VERY LOW (<12)
50 0 50KM
27°
25°
91°
93°
95°

Figure 1

Table 2: Areas under different land productivity classes

Categories (quintals/hectare)	No. of District	% of District Area	% of the Area of the State	
			Total (ha)	Percentage
Very High (above 18)	5	21.74	1346900	17.17
High (15–18)	5	21.74	1321400	16.85
Low (12–15)	7	30.43	3485600	44.44
Very Low (below 12)	6	26.09	1689900	21.54

The pattern of spatial variation of land productivity in Assam shows that very high productivity is found in the districts scattered in the Brahmaputra and Barak valleys of Assam viz., Karimganj, Cachar, Sibsagar, Golaghat, and Morigaon. It is not concentrated in one zone and moreover hill districts are not included in this category.

High land productivity districts are spread all over the plains in Assam. These are Goalpara, Nagaon, Jorhat, Dibrugarh (all in Brahmaputra Valley) and Hailakandi (Barak Valley). Another characteristic pattern of the high land productivity districts of Brahmaputra valley is that they are distributed from west to east on the southern bank of the valley from lower to upper part of the valley.

The spatial distribution of low land productivity has unique pattern. The districts having low land productivity are spread over both hills and plains of Assam but absent in Barak Valley as all three districts of Barak Valley show very high and high land productivity. Not only the hill districts (Karbi Anglong, and North Cachar Hills) are included in this category but plain districts of Brahmaputra Valley (Dhubri, Kamrup, Sonitpur, Dhemaji, Tinsukia) right from the lower, middle and upper and as well as from both northern and southern banks are included in it.

Surprisingly to note that all the districts having very low land productivity are confined to northern bank of Brahmaputra valley (Kokrajhar, Bongaigaon, Nalbari, Barpeta, Darrang, North Lakhimpur) right from west to east. It is also interesting to note that very high cropping intensity is found in the very low land productivity zone. This appears to be quite contrasting keeping the very

low land productivity in mind but this is basically due to increasing human pressure on cultivated land.

Conclusion

Great spatial variation in land productivity is found in Assam. Districtwise variation is found in both plains and hills. It is evident that high land productivity is concentrated in the Barak Valley region. Both the Hill districts show low land productivity. But amorphous pattern of land productivity is found in the districts of Brahmaputra Valley. It is also interesting to note that most of the districts of lower Brahmaputra Valley show very low land productivity. As Assam is an agro-economic based region, its economy depends on the land productivity. Thus, a proper landuse management is necessary for the development of agro-economic conditions. Farmers should keep their mind on increasing land productivity by using organic manures, irrigation, etc. Intensive cultivation has to be practiced instead of extensive one, but in that case also every possible care should be taken to prevent land degradation, due either to over taxing of the soil fertility or to soil erosion. It should also be kept in mind that the land or soil fertility is not infinite, it has its own limit and that could not be crossed to save the productivity of land and make it sustainable. In this way a healthy land environment can be maintained.

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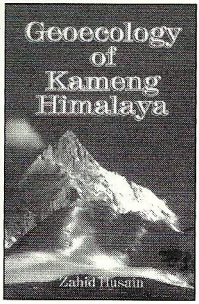

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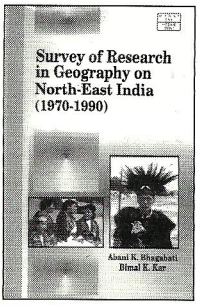

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