CHAPTER-1

Degradation and Development of Environment

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Introduction

This introductory selection has especially been written to present a theoretical background to the main theme and a framework in which the papers have been compiled, edited and arranged in the book. Salient features of the environment of the Northeastern part of India have also been mentioned in the end.

I

First of all definition and meaning of environment, ecology and ecosystem are dealt with for the sake of clarity of ideas and concept appearing in the volume. 'Environment' encompasses a wide range of aspects or entire conditions in which an organic or inorganic matter is placed in. Truly, it is a multi-faceted and poly-dimensional term, to comprehend and explain it will require another volume. However, in brief the term environment means whole sum of the surrounding external conditions within which an organism, a community or an object exists. All the components of environment are interrelated and mutually interdependent. The whole biophysical (including geochemical and gaseous) conditions at a given time and place constitute the environment which can be called 'physical/natural environment'. Another division is known an 'human environment' which includes conditions and situations formed by man.

The physical environment comprises the biophysical, chemical and gaseous elements of nature including animate and inanimate

components of the lithosphere, hydrosphere and atmosphere. In other words, this environment includes components of land (topography, relief, rocks etc.), water, air, climate, forests, soil and fauna, and all biogeochemical and gaseous cycles.

With the increasing concern for environment, quite oftenly, 'ecology' term is wrongly used as syncnym for 'environment'. Actually the former strictly means interrelationship of an organism with the latter. Thus, ecology is basically study of interrelationships between organism and its biophysical environment, and more vital is ascertaining of ecological equilibrium/balance lying in this interrelationship. Ernst Haeckel (1866) defined ecology "as the body of knowledge concerning the economy of nature the investigation of the total relations of animal to its inorganic and organic environment". In course of time meaning and scope of ecology have broadened to include 'the study of energy flow, . . . material cycle in biosphere, . . . and structure and function of nature' (Odum, 1975 : 1). Now it is viewed as the study of totality of man and environment, and a link between natural and human sciences. Castri (1981) opined that it is a science of converging disciplines to form a common trunk of ecology. The natural laws which influence survival and abundance of organism in the form of ecological balance are studied in its totality and all possible details. It simply shows that a single discipline cannot deal with all the ecological relationships, intricacy, complexities and varieties. Instead, a trans and multi-disciplinary team/study is essential to comprehend this all encompassing subject — ecology. This approach has been followed to some extent in the present small attempt. Interconnectedness among the various components of environment in which nature always strikes a balance to maintain its harmonious functioning is essence of ecology. Ecological study systematically explores and discerns the intricacy involved in interactions in a working — whole or set of environment on which depend survival of an organism.

All the above are perfectly manifested in the concept of 'ecosystem'. It can be considered as most significant development in the field of ecology, which has structured, ordered, systematised and synthesized study of interrelationships among organisms themselves and between organism and their environment by giving it a functional ecological-systems analytical approach of explanation. Ecosystem term (coined by Tansley in 1935) stands for both biome (biotic community) and its habitat (niches) of an ecological system — a working totality. It is the basic functional — a real — environmental

system consisting of self-regulating comlex-whole of mutually interacting, interdependent and integrated organisms (community) and their non-living environment, each influencing the properties and functions of one another and both necessary for maintenance of life (Odum, 1975). In German and Russian literature *'biogeoecoenosis'* is the equivalent term for natural ecosystem; while *'anthropogeocoenosis'* is analogous to man-modified ecosystem; *noosphere* is equal to technosphere, and *'ecosphere'* for whole global ecosystem. Kinds and size of ecosystem vary from a drop of water to entire planet earth as an ecosystem. However, there are no clear cut boundaries separating various kinds and size of ecosystems, for all are interrelated to one or other at many levels, and even togetherly influenced by celestial bodies. In fact, the entire universe is a complete working system with a set design and purpose. Therefore, any demarcation of a lake or pond or forest ecosystem is for the sake of convenience only, but undoubtedly each is a clearly discernible ecosystem unit of study.

It is worth mentioning here that division of ecology into plant, animal and man ecologies kills the very spirit of it. There is one ecology and that is of the planet earth. Of course, for the sake of detailed studies it is bifurcated into ecology of plant or animal or man. The ecosystem concept brings all these together, as it has synthesized various interrelationships to a single ecology of the planet earth where man is a dominant factor influencing fate of other ecologies. Thus welfare of all ecologies is culminating into Human Ecology, but neglect of anyone will be at the cost of the whole ecosystem. This ethical and rational view now guides the ways and means by which natural resources have to be utilised/harnessed without jeopardising potential of other resources and ecosystem as a whole.

A crucial and basic aspect of ecosystem in its capacity or potential to support its community and their environment. Ecosystem potentiality can be defined as 'an aggregate of resource potentials assessed by evaluating total productivity/utility of all resources of any ecosystem'. This is dynamic in nature and varies with time, technology, strategy, place and people. It is base of existence and functioning of animate and inanimate matters and flow of energy in the ecosystem, that means it is life line of ecosystem. For the community of an ecosystem it means net food production for their survival. Health of ecosystem and ecological balance depend on its constant and adequate supply. It is analogous to 'land capability or 'carrying capacity of land'. This involves measurement of strength of an ecosystem in respect of

its capability to sustain its living, non-living, dynamic and static ingredients. While doing this, all possible and perceptible uses/utility of all resources is taken into account.

II

Environmental Degradation

Utilization of natural resources is interaction between two systems — the natural and human. In course of the utilization, sometimes the very resource base is eroded leading to devaluation or diminution of environment, or some sort of disturbance is triggered in the ecosystem functioning and structure causing ecological imbalance. Over all, this is environmental degradation which in plain words is qualitative and quantitative decline/impoverishment/decrease/devaluation/degeneration/diminishment in the ecosystem potentiality/productivity affecting habitat of man, plant and animal. It can be due to both natural and human reasons. The degradation can be qualitative and quantitative both. The latter is evaluated through various tools and methods. Environment Impact Assessment (EIA) is recent method to evaluate adverse impact of human developmental activities on environment. On the other hand, some examples of qualitative degradation are loss of aesthetic values of the environment, decline in soil fertility, and pollution, congestion and poor use of space as a resource.

The following are types of environmental degradation:

(1) Decrease in potentiality, productivity and biodiversity of ecosystem, and loss of genetic resources,

(2) Destruction of stability and climax vegetation of ecosystem,

(3) Destroying structure and functioning of an ecosystem,

(4) Depletion of bio, geo, chemical and gaseous resources and disruption in these cycles,

(5) Pollution of environment affecting its quality and quantity (most of the papers of the book cover this point),

(6) Damage to aesthetic and pragmatic values of environment,

(7) Replacement of virgin/primaeval invaluable vegetation with secondary growth and weeds, and wanton deforestation,

(8) Endangering plant and animal species to the stage of extinction,

areas, such as reclamation of flat valleys and construction of terraces for wet rice cultivation (particularly in the hilly regions), cultivation in *'beel'* and *'char'* areas (wet land) and irrigated agriculture in deserts to mention a few. Of course, the wet land are ecologically significant ecosystems from glabal biodiversity point of view.

Environmental Development

Development has generally been mistakenly put opposite to environment. How one can be against the very foundation on which it stands? Can there be development without environment/resource base? Definitely not. Then, where lies the mistake in which development is alleged for environmental degradation. The fault lies not in the development but in the way it is brought or planned or implemented. It means, if means and ways are wrong then results are also wrong, thus environment is also affected. For example, why to go for super dams whose reservoirs submerge invaluable fertile lands and forests. Energy and irrigation requirements can be met with small dams constructed in barren lands. Secondly, whatever destruction of environment is bound to occur in construction works, efforts should be made to minimise it to such a level where nature can replenish it in its own healing process. Timber needs can be met by cultivating trees, as it has already started in some places to stop cutting of natural forests for it. Many such examples can be given, but for space.

In recent decades, use of the term 'ecodevelopment' has gained popularity to describe – (i) eco-friendly development, (ii) development and/or rehabilitation or restoration of ecosystem, and (iii) ecosystem and development. In the similar sense 'ecorestoration' word is used. But no clear definition has come forth and here lies the flaw. Actually 'ecodevelopment' has altogether a different meaning in 'ecology'. The phrase 'ecosystem development' explains process of ecological succession in which a biological community regulates or attains climax stage and stability in an ecosystem. It is an orderly and progressive replacement of one community by another until a relatively stable climax community indwells the ecosystem, which is called 'ecosystem development' (Odum, 1975) or 'ecological succession' (Smith, 1972). "Strong physical forces or surges, as well as large harvests or pollution input from man's fuel-powered systems, will modify, halt, or abort this developmental course" (Odum, 1975 : 152). It is very clear now that the popular meaning of development and/or restoration of ecosystem is far from its textual meaning. Rather, it is unbelievably destruction of the very processes which are naturally

functioning for development of ecosystem. Ecodevelopment is a natural function of stabilization in the ecosystem. Whereas development based on ecosystem concept is a different process in itself. Hence both are not same, the former is natural, contrary to it the latter is man controlled. Writing 'eco-development' or 'eco-restoration' (i.e., with a dash) can be alright to show it as a human effort since 'eco' is prefixed here to mean 'concerned with habitat and environment', but that does not place it at par with the ecological 'ecosystem developement'.

As a matter of fact, man's fuel-powered systems and activities change, destruct or repulse the nature's automatic processes involved in development of ecosystem. Explicitly, development of ecosystem is beyond man's sphere. Even the highly modified systems of man altogether depend on the natural processes. Rather, understanding these processes and tuning his developmental works accordingly is in the the interest of man (for details please see *Odum*, 1975 : 163-164, 205-207). Through the fair and detailed studies of the resources ('goods' on which all depends), pollution ('bads' creating disorder which requires attention in terms of energy and human efforts if net benefit in resource utilization is sought), concept of 'bionomics' as a kind of expanded economics that includes cost-accounting of the works of nature as well as works of man, and finally 'ecosystem management' (i.e., management of man and his biophysical environment as a whole rather than as separate entities) something really can be done intelligently in the development of man and environment. "Underlying all of this is the need for a better understanding of the population-production complex on a large scale -- that is how population growth and economic growth are related and how control of one affects the other" (*Odum*, 1975 : 206-207).

'Sustainable Development' has been in currency for a considerable period in academic and non-academic circles. Prior to it came "integrated development'. What is the end result of such phrases in the background of the ground realities today where precisely the state of man and environment has further deteriorated and the strength more weakened than the time when such 'slogans' were coined. It is because of applying short-term solutions to long-standing, accumulated, and overriding problems. Today a plan/project is scrutinized at various levels to assess its environment worthiness, but tragically tomorrow after completion or mid-way itself the same becomes environment unworthy/unfriendly, thus further complicating the already declining health of environment. In this way the money, time, resources, labour

and a chance of a forward step are being simply wasted, and the idea of 'sustainable development' becomes a farce. When and who will assess that the development has been sustainable in terms of time, money, resources, human labour, socio-cultural cost, quality of life by holding up progress for maximum number of people and entire ecosystem as a whole? Only future time and generations hold the key to evaluate sustainability. But by that time many changes occure and priorities are reset or rearranged according to needs of the hour; and in the changed situation or by its own ills the development may appear unsustainable. In such circumstances doubts are raised that how far sustainable is 'sustainable development'. With some exceptions the development has, in recent times, invariably been unsustainable (reasons mentioned earlier) and that makes untenable the use of adjective sustainable to development.

Before concluding the debate one more interesting point has to be discussed here, and that is about wrongly equating 'regional development' with 'eco-development'. 'Regional development' is considered "as the articulation of qualitative changes in the geo-bio-techno-social complex of interdependent phenomena in such a manner that quality of human life improves within the framework of the integrity of the ecosystem. Regional development in this vital and fundamental sense is eco-development" (Raza, 1988 : 1). This sort of parity seems to be incompatible, since meanings of the both have different history and perspective, and have been streched beyond limit. Therefore, regional development cannot be eco-development. There is a basic defference of nature and approach of work done in the two, viz., in the first development of a multi-faceted complex is sought in integration with the ecosystem, while in the second ecologically sound development is desired where 'eco' is prefixed. Of course, the former can follow the principles of the latter. In this way, the former says 'what is to be done', and the latter tells 'how it has to be done'. Any way, apart from the incorrect parity between the two, both carry different sense than the meaning of 'ecosystem development' in the text books on ecology.

The above shows clearly that in the discourses and studies on environment, ecology and ecosystem a number of terms, phrases and slogans are used to mean things which are somtimes beyond their textual and dictionary meanings. This action can be out of growing concern for encironment also. A plethora of such words, mostly prefixing 'eco', have come up, which have certainly enriched

terminology in ecology, but these should be used in right perspective and with precise understanding. However, intention of the user is clear and the scope of the terms include the same components and aspects which are common in the subject. All want a development harmless to environment. But there has to be a caution for using and increasing a jargon of terms. This academic dialogue is concerned with the worrying trend, hence not against any scientists including the contributors to the volume.

In the background of the above, a generic phrase 'environmental development' is proposed to have guiding principle, ideology, practical approach and an all encompassing policy of improving environment. Environmental development is opposite to environmental degradation because the former brings positive changes while the latter causes negative changes in the environment. Environmental development envisages, first development of environment; and secondly a development without impoverishing the values, strength and potentiality of environment, which is achieved by following the principles and laws of environment, and structure and functioning of ecosystem. Even if some portion of environment is damaged in course of certain developmental works/activities; efforts should be made to repair, restore, rehabilitate, regenerate and rebuild it. But even this kind of damage should be avoided as far as possible, because any sort of reconstruction can not be identical to an ecosystem with its all biodiversity, dynamism and well-knit complexities. For example, in forestation (afforestation and reforestation both) trees can be grown but forest ecosystem can not be created which wholly lies in nature's domain. Moreover, checking of damage to environment should be preferred to heavy and costly restoration work of the damaged environment as 'prevention is better than cure'. However, such conservational efforts are necessary to gauge human intention and attitude towards environment, hence must continue for ever. The prevailing indifferent attitude has to be given up for the benefit of man himself because conservation and development of environment are ultimately in his own interest, not only today but in future as well. Development has to embrace environment in its fold and take it as an accompanion in the progress of the entire mankind and global ecosystem.

How to Develop Environment ? : The ideal of 'development of environment' is not difficult to achieve, rather it must be accomplished otherwise the *Dooms Day* is not far off. It is because environment forms the very base of other types of development. The ongoing

developmental activities cannot afford to be detrimental to an ignorant of the environment, ecology and ecosystem. The secret of real progress lies in looking at development and environment as a single entity in which the former moves on the shoulders of the latter, or both are considered two wheels of a cart of progress driven by man. Hence, they are not rival to each other. Significant to note here that environment can survive without man, but man cannot survive without environment and its resources.

'Conservation' of environment is indispensable component of the above proposition. It is a key word of success today and a better survival tomorrow. Success of conservational endeavours can only ensure a bright future. Simmons (1973) defined conservation as practical management of resources. Conservation is of three types: (i) Conservation as preservation, (ii) Conservation as wise use, and (iii) Conservation as environment management in which are included (a) protection of physical and mental health of the people, (b) enhancement of economic gains, and (c) preservation of sensory and participatory pleasures. The overall idea behind conservation is maintenance of continuity of ecosystem potentiality by the present generation for the future generations by (i) preserving the invaluable and precious gems of environment, (ii) judicious, rational and wise utilization of the resources, and (iii) maintenance of ecological balance.

Keeping the theme of the book in mind, following points are enumerated for preventing degradation of environment, which ultimately leads to development of environment. (1) Adoption of ethical approach to environment which would not consider human being and their welfare alone as the overriding factor but take the entire ecosystem into consideration. (2) Conservation of forests as they play vital role in the ecosystem and ecological balance. (3) Implementation of Wildlife Protection Act strictly and taking stringent actions against law evaders. (4) Strict observance of pollution control measures and laws. (5) Application of polluter's pay principle. (6) Search and use of substitute materials, especially for non-renewable resources and generally for resources whose natural regeneration takes longer time. (7) Practice of 'No waste' has to be encouraged, and recycling of waste to lessen burden on natural resources on one hand, and checking pollution of environment on the other. (8) Solution of environmental problems basically lies in change in attitude, perspective, thinking, Angle, bearing, understanding and mentality with which environment is perceived and harnessed, e.g. from infinite to finite, greed to

generous, plundering to prudence, destruction to conservation, apart to a part, and selfish to rational. (9) Holistic and balanced view in favour of all man, plants, animals and enviroment. (10) There is no single solution to all problems, instead alternative/various solutions are required, even for one problem to enable selection of the most suitable and beneficial one. (11) Trans-inter and multi-disciplinary approach is practical for it. (12) Coordination among different developmental agencies, departments and projects, and a fair scrutiny and evaluation of a project by 'environmental cell' at all levels from formulation to implementation and further in its operation by giving due place and importance to each viz., planner, financier, implementor, user, beneficiary, and people and environment of the area where it is to be established. (13) Active, coordinated and constructive role of the NGOs, socio-cultural, educational and religious institutions, teachers, students, leaders, women, youth and common man in conservation of environment. (14) There are no permanent political solutions to any environmental problems/challenges, but political will and positive role of the politicians are necessary in facing the challenges as they run governments where decisions are taken and executed.

III

Some Cases and Issues Related with Degradation and Development of Environment in Northeast India

Though these topics are dealt with in the book, even a few relevant points are discussed below. This is an attempt to complete the issues left in the Preface and present more data on specific cases.

Degradation of Environment : Deforestation, soil erosion and various types of pollution are mainly responsible for impoverishment of environment in Northeast India. Some of the grave examples are discussed here briefly. Sheet erosion, formation of rills and gullies and bank-cuts are main processes involved in degradation of land. The land in and around Cherrapunjee has been degraded due to deforestation and subsequent loss of top soil cover (for details, please see book edited by Tiwari and Singh, 1995). This has happened surprisingly in the highest rainfall zone of the world, where deforestation by man was followed by increased soil erosion due to high rainfall. Moreover, in limestone region regrowth of soil is slower than other geological formation (Husain, 1984), because here chemical weathering

predominates over physical weathering. Whatever regolith is produced by the latter, is easily washed away by excessive rain water in absence of protective vegetation cover. Thus, deforestation and high rainfall are jointly responsible for faster soil erosion. It takes thousands of years for their regrowth. This all express fragility of wet tropical hill ecosystem. The barren topography of Cherrapunjee region has led many scientists to call it a 'wet desert' or a process of 'desertification', in the wettest area of the world. Though both are inappropriate, but mentioned to show seriousness of the diminishing ecosystem potentiality. No doubt, the barren rocky surfaces may look like a scene in desert. In fact, 'desert' term is used for the areas where biotic productivity is very low due to aridity, particularly of plants, and 'desertification' means accentuation of desertic conditions in and around deserts. Luckily, both the situations are absent in Cherrapunjee area, hence better to use some other terms for indicating graveness of environmental degradation. Otherwise, it sends wrong signals in the academic/scientific circles. Decline in environment of Cherrapunjee area has been aggravated by another anthropogenic factor, i.e., Cherra-Muwalah Cement Factory. Cement and smoke emitted from the factory are cause of pollution. Alarmingly, cement deposition is found even in the honeybees of the area which causes neurological disorders and related disorientation in the bees (Gupta, 1994). The famous Cherra honey is also affected which finally reaches into food-chain of man. This is the state of environment now where the War Khasi people live, who used to practice traditionally conservation of environment (as reported by Das Gupta in this book). Abhik Gupta has also found presence of cadmium in fish and snails of Cachar area, which form part of the traditional diet of the Dimasa people.

In the granite areas of the Khasi Hills, particularly in Mylliem, Nongkrem and Laitdom-Nongspung region, gully erosion was wide spread even before the coming of the British. Iron smelting was responsible for it, because the local people used to extract iron ore by strip-mining, and that induced artificial erosion of the hills. Vast quantity of charcoal was burnt to smelt iron ore (magnetite nodules) to get iron for making implements. This destruction of land and forests came to an end with stoppage of trade and export of raw pig iron and implements to Sylhet and other places (Kharsati, 1984). More information on soil erosion is in the book where this work is published.

In the adjacent Jaintia Hills of the Eastern Meghalaya plateau, the environment is devalued by the effluents from coal mines. Pollution of soil and water by iron, sulphuric acid, dehydrogenases and esterases,

dumping of waste, rat hole minig, acid-mine-drainage from the mines affecting agricultural lands, subsidence of fertile land due to collapse of mines below, and drying up of surface drainage as streams now flow through rate hole mines have been observed by Tiwari and Das Gupta (1993), and Das Gupta and Tiwari (1994). According to them, paddy fields, streams and general health of the people and environment are affected by coal mining. Situation might not be different in the collieries of the Garo Hills and Upper Assam.

The fertile plains and flat valleys of the Northeast are subjected to degradation by deposition of new soil (sand and boulders) carried by streams and rivers coming from surrounding hills and mountains. In the Papu and other flat valleys of Kameng Himalaya this has been noticed by the editor (Husain, 1990). The plains between the Brahmaputra river and the surrounding hills and mountains, specifically the foothills of Bhutan Himalaya, receive new sediment from these hills where excessive soil erosion is caused by indiscriminate deforestation. For Assam it is a temporary loss of fertility as the soil will become fertile after some years under natural processes, but it is permanent loss to the hills (of her forests, soil and economy). Quarrying of hills and river beds for building stone, boulders, sand etc. is also responsible for increasing soil erosion in the hilly regions.

Potentiality of some of the aquatic ecosystems of the Northeastern India has also been reduced due to pollution and human interference and encroachment. While studying mineralogy and sediment chemistry of rivers in the Northeast, Mahanta and Subramaniam (1993) have found iron, manganese, zinc, copper, lead, chromium and cadmium as major elements in the suspended sediments of the Brahmaputra river. Pollution of water courses by heavy metals released from coal mines has already been covered. Similarly, pollution of water bodies due to release of industrial effluents and urban sewarage has been discussed in detail in the book by various authors. To monitor water quality of major streams in Shillong, both biological and physical studies have been conducted by Srinivas *et.al.* (1994). They observed that concentration of most trace metals is higher than the prescribed limits in the pre and post monsoon seasons. Numerous pathogenic organisms are also present in the water. Utmost attention has to be paid to conservation of water as in next century this is going to be the most scarce resource.

Ecology of the famous Loktak lake of Manipur has been threatended like any thing. In the book Thorose is worried but

optimistic about survival of the Keibul Lamjao National Park inhabited by the endangered *Sangai* (Brow-antlered deer). But Deb Krori (1992) is apprehensive about the continuation and functioning of the original 'aquatic ecology' in the wake of dredging in the lake. This rejuvenation work was done to restore the largest fresh water lake of the Northeastern India to its earlier natural state, as the area and capacity of the lake shrunk due to growth of weeds and vegetation, siltation and human interference which has affected the generation of hydroelectricity in lean months when depth of lake ranges from 1.5 to 3 metres only. About 0.89 M cubic metres suspended sediment is transported annually to the lake from denuded hills by 12 major rivers, and total 4 M cubic metres by all the streams which are active mainly during the monsoon for 4 - 6 months. Continuation of such heavy sedimentation in the lake will further reduce its storage capacity in near future. The oxygen-poor water is unhealthy for fish growth, and on 30 per cent surface of the lake *phumdi* (1.5 metre thick floating mats of weed and soil) is scattered. The problem of water hyacinth could be controlled with the introduction of weevil in the lake. On the other hand, economic interests of about 35,000 people of 16 - 18 villages were affected when their 7,000 hectares land was submerged due to construction of Ithai Barrage on the Manipur river. Regarding dredging Deb Krori has raised some pertinent points: (1) The dredged sediment (spoil) is likely to re-enter from dykes into the lake, (2) The increased turbidity and oxygen poor water may lead to decline in the growth of fishes, (3) Removal of sediment and *phumdi* will have adverse impact on animal ecology as the latter is habitat of the *Sangai* also, (4) Impact of dredging on status of nutrients in the lake for aquatic life is not known, (5) The ring bund will limit spread of lake water or it will allow submergence of agriculture land which earlier formed part of the lake itself, (6) Comprehensive holistic management approach on the line of diagnostic ecological research has to be followed, (7) Gravity of the problem lies in use of mechanical activities in such restoration works. (Is it restoration in real ecological sense?); and (8) Economy is before ecology or vice-verse. This is an example of real dilemma. If water level in the lake is increased as per needs of the power station then survival of *phumdi* is doubtful because the yearly cycle of its lowering to lake bed is broken; and if this cycle is allowed to continue then the power station will not get enough water to generate electricity to its full capacity. Of course, answer lies in restoration of the lake to its original state as it is nature's gift. Man can generate electricity from other

sources and rivers, but he cannot build another Loktak lake, certainly not the whole aquatic ecosystem.

Interference in the ecosystem and ecology of such wet lands is also found in the Brahmaputra valley, particularly near urban centres. For example, Bhattacharya (1984) alerted about threat to 'Dipar Bil' from expanding urban areas of Guwahati city. The 10 sq. km. large Bil or Beel has been traditional fishing ground of the Kaivarta fishermen (nearly 1 lakh) who supply fish to urban inhabitants of Pandu, University township and Jalukbari.

The biggest loss is of the 'green gold' in the Northeastern region which can not be measured by any means. The figures about area from where forest cover has been removed show only the physical or material or partial loss, but what about the destruction of habitats of wild life, rare vegetation, genetic resources, interrelation with the climatic factors and soil binding vegetation, which are associated with deforestation and that can not be assessed quantitatively. However, data of deforestation speak itself about the tragedy caused by man. While inaugurating the Seventh Regional Workshop on *'Paryavaran Vahini'* in Shillong (on 18.5.1995) Mr. P. Keswani, Regional Chief Conservator of Forests, Ministry of Environment & Forests, Shillong, gave following startling information. About 650 species of plants and 70 species of animals of this region have been listed as 'endangered'. In the Northeast India 18 'hot spot' of the world have been identified with reference to threats to biodiversity. This region has about 50 per cent montane plant species of India, of which many are endemic to the region. The Northeastern part is ecologically more fragile and sensitive than rest of India, due to typical geology, topography and high rainfall. Nearly 65 per cent area of this region is under forest cover, but health of these forest is not sound as about 68-79 per cent of it are 'degraded forests'. Around 75 per cent forests of Assam and Arunachal Pradesh belong to closed category of forest description. There are 630 woodbased industries in Assam alone which need 7.4 lakh cubic metres of wood per year, but that quantity is twice of the sustainable yield from the reserved forests. "Such situation makes illicit removals from forest more lucrative". Therefore, there is an urgent need to bring out innovative strategies to stop the region from falling into 'Brazilian Trap'. The situation is further worsened by rampant encroachment on forests, of late especially on inter-state borders in Assam. About 2200 sq. km. area is under encroachment in Assam itself. These factors have caused extensive damage to wild life

and its habitat, and man-animal conflict has become order of the day particularly in the 'Elephant Corridors' (Keswani, 1995). Encroachment on forest lands, game sanctuaries, national parks and forested inter-state and international borders by extremists, poachers, smugglers etc. has also come to notice. Impact of this on environment can be anybody's guess.

As per the Assessment Report 1991-93 the Forest Survey of India (FSI), there was decrease of 665 sq. km. forest area, against increase of mere 30 sq. km. forest area in the Northeast as a whole. Statewise break up of the loss in descending order was 243,156,106,96 and 64 sq.km. in Assam, Mizoram, Meghalaya, Arunachal Pradesh and Manipur respectively. Surprisingly, there was gain of forests only on 27 and 3 sq. km. area in Nagaland and Tripura, respectively. The deforestation is causing decline in rainfall and increase in droughts, heat waves, floods, soil erosion and many other negative changes.

Some more examples of environmental degradation include a general decline in annual rainfall, meagre increase in average annual temperature, and spread of weeds and harmful micro-organisms in new areas, drying up of water sources, (reference in the editor's revised paper on Shillong particularly), wastage of natural gas in Assam threat to world famous Kaziranga National Park (habitat of one horn rhino), loss of fertile land due to bank erosion by the floods in the mighty Brahmaputra and other major rivers, decreasing area of the largest river island — Majuli (in the Brahmaputra river), and unusual frequent floods in which valuable land and forests are destroyed.

Development of Environment : In Northeastern India thrust is on conservation of forests and wild life (as these are vital and prominent components of environment) to preserve the natural endowment and biodiversity/genetic resources. A number of national parks and game sanctuaries have been established here. The important ones are — Namdapha in Arunachal Pradesh (also meant for Tiger Projecct), Kaziranga and Manas in Assam, Balphakram and Tura Range Biosphere Reserve and Gene Sanctuary in Garo Hills and Keibul Lamjao in Loktak Lake of Manipur. There are some smaller but important ones also. For the development and protection of flora and fauna in Kameng Himalaya of Arunachal, the government has set up (i) Sona-Rupa Game Sanctuary near Rupa, (ii) High Altitude Trout Hatchery at Nuranang (near Tsela), (iii) Low Altitude Trout hatchery at Shergaon, (iv) Oak Tasar Composite Centre at Dirang Dzong, and (v) Orchid Centre at Tipi (Husain, 1990).

Number of reserved forest and sacred groves too are serving the purpose of conservation. The Chakrasila Hills Reserve in Dhuburi District of Assam is one of them which became famous in 1989 when a highly endangered Golden langur (*presbytis geei*) was again spotted there by the environmentalists' society — Nature's Beckon, Dhuburi. This beautiful monkey is considered exclusing to this part of Assam as it was first seen in 1953 by a naturalist E.P. Gee in the forest on Assam-Bhutan border between the Sonkosh and Manas rivers. Other important wild life in the reserve are tiger, gaur, hornbill etc. (The Sentinel, 1993).

As cultivation of trees and other plant species has to be taken up to meet timber and other needs, many projects are in offing in this field. Four fast growing species viz., *Cryptomaria Japanica, Pinus Radiata, Paulomia* and *Dandocalamus Asper* are proposed to be grown in Meghalaya under a pilot scheme by the Indian Council of Forest Research (ICFR). The first three are timber trees. The fourth is Chinese bamboo, which Dr. D.N. Tiwari, Director, ICFR, had successfully cultivated in China during 1980s and that revolutionised her forest economy. After growing the three timber species, today China has 25 million cubic feet of surplus timber (The Shillong Times, 1994). If such schemes become successful here with the support of the farmers and owners of the forest lands (in Meghalaya it is under State Forest Department, District Councils, Private and Community ownership), burden of forests will be reduced to great extent, and landscape will be more green as well. There is a welcome move by the Dutch Government to fund massive forestation project in Meghalaya, Assam and Arunachal Pradesh to improve ecosystems of Northeast India (The Shillong Times, 1995). More details about conservation of environment of the Northeast are available in published works by Sharatchandra *et.al.* (1980), Gupta and Dhar (1992), Medhi (1993), Tiwari and Singh (1995), Saikia and Borah (1994) and Jaswal (1984).

A 74 million dollars project of the World Bank to save forests and lessen human dependence on them in India has also been going on, though it has come under criticism on the grounds of inadequate research and faulty approach. In recent days a number of projects and schemes have been launched in the country, which will cover this region as well. National river and lake cleaning projects are in offing. The government is going to give number of incentives for establishing urban waste treatment and recycling units to convert the waste into sourse of energy and other usuable products. Another novel project to

'Clean India' has been initiated throughout the country on 15 July, 1995 in the wake of the fear created by garbage on the streets and plague (?) of Surat. 'The Exnora-Intach Clean India Campaign' in its crusade will cover more than 100 cities, to emphasise on cleaning the surroundings, dumping waste in proper manner and place, and utilization of practical, cost-effective methods of solid waste management. The coordinator of the campaign is Capt. J.S. Velu (The Shillong Times, 1995). In the field of research and development for alternatives or substitutes to reduce load on the natural resources, 'rice husk boards' developed indigenously by the Indian Plywood Research Institute (IPRI) and given to National Resource Development Council (NRDC) to get it manufactured for commercial use by private firms, have come as light and durable material in place of wood (Dakshinamurthy, 1995). There is plenty of rice husk in the Northeast for it. Certainly such sincere efforts will bring fruits in the Northeast too by helping in preventing negative changes and promoting positive changes in its environment.

IV

Salient Features of Natural Environment of Northeast India

The Northeast part of India is endowed with rich and varied biophysical environment because of its unique geographical location in the extreme northeastern corner of Indian Sub-continent, and presence of hills and mountains on three sides except a narrow gap in the west. Being situated on the trijunction of India, China and Southeast Asia the region used to act as corridor in the movement and assimilation of different elements of man, culture, plants and animals from these regions. Different types, arrangement and association of landforms (archaic plateau, young folded mountains, perennial rivers, fertile alluvial plains and valleys), great altitudinal variation (from 50 to 7090 metres) alongwith latitudinal extent have given rise to almost all types of bioclimatic belts/life zones of the world. This include—tropical wet evergreen, tropical moist deciduous, sub-tropical pine, mountain wet and dry temperate, sub-Alpine and Alpine types of forests and climates. These zones have distinct flora and fauna with indigenous and exogenous elements and various types of soils (in situ and alluvial both) rich in humus contents. The following note is based on field work, studies of toposheets, remote sensing, and published

literature (largely GSI, 1974). Fig. 1 depicts a general picture of the environment of Northeast India.

Natural environment of an area consists of factors like — physiography (mainly relief, topography and drainage), geology, site, location, extent, space, climate, soil, flora and fauna.

A. Site, Location and Extent

The Northeastern part of India comprises of seven states — Assam, Arunachal Pradesh, Manipur Meghalaya, Mizoram, Nagaland and Tripura together known as 'seven sisters'. It is mini India in many respects, having 8.32 per cent (2,55,083 sq. km.) and 3.76 per cent (31,547,314 persons) area and population, respectively of India (excluding J & K, 1991). Density of population is 124 persons per sq. km. but there are great regional variations. Northeast India extends between 22° to 29°30'N latitude and 89°41' to 97°25' E longitude. The latitudes place the region in the tropical and sub-tropical belt of the world. Relatively greater distance from the main land, poor communication facilities, vast mountainous terrain, dense forests, heavy rainfall, wet lands, frequent floods and cold climate of high altitude region have created a geographical remoteness/isolation of this area. Its long international border with Bhutan, China (Tibet), Myanmar (Burma) and Bangladesh (Fig.1) has made this part of the country important and sensitive from geopolitical and strategic point of view. The southern most tip of Tripura is hardly 25 kms. away from sea. But Meghalaya plateau which receives full thrust of the southwest monsoon is about 350 kms. far from the northernmost apex of the triangular Bay of Bengal, which is the advantage Meghalaya has. This indicates relatively close proximity of the Northeastern region to the sea than other parts of the northern half of the Indian Peninsula. The almost east-west orientation of the plateau and the Himalaya mountains, the elbow shape spread of these landforms along with almost north-south running Indo-Burma ranges and proximity to sea have contributed to its being one of the wettest places on the earth influencing its climate, flora, fauna, economy and man.

B. Geology and Physiography

(Including rocks, minerals, seismicity, relief, topography, drainage, soils etc.)

The geological structure of the region varies in age. The pre-cambrian metamorphosed and crystalline rocks are in Meghalaya-

Mikir plateau and Rengma Hills (and also in the Greater Himalaya range). The tertiary, old sedimentary and granitic rocks are in the young folded mountains — the Himalaya and Indo-Burma ranges. The pleistocene and recent (holocene) unconsolidated sediment deposits (alluvium and gravels) in the river valleys of the Brahmaputra, Barak and Imphal particularly and along the courses of other rivers in general. The Dauki fault and Naga thrust are prominent lineaments. Important minerals found in the region are – coal, oil, gas, uranium, sillimanite, limestone, fire-clay, fuller's earth, feldspar, quartz, marble and base metals. Seismologically it is a weak zone. Thus, numerous earthquakes have rocked down this area during memorable history of man. The last major one was in the year 1950, which devastated the entire Northeast and surrounding regions. Many lesser tremors have been felt after that in entire region, particularly in the Barak valley, Indo-Burma ranges and Meghalaya.

The prominent physical features of Northeast India are ridges (hills and mountains) and furrows (valleys). Most imposing of these are almost east-west running three parallel landforms. Out of which two are ridges formed by the mighty Himalaya in the north and Meghalaya-Mikir plateau in the south, and the third is the rammed Brahmaputra valley. All three are lying as sandwich in which the Meghalaya-Mikir plateau has pressed the shape and orientation of the remaining two. The region can be divided into following four main physiographic units which are actually northeastern extension of the major physiographic divisions of the Indian sub-continent. Interesting to mention that all the hill ranges of the region are joined to one another, thus forming part of a vast chain of mountains of the world.

(1) Young Folded Mountains and Hills

(a) ***The Himalaya Mountains*** : This predominant geomorphic feature is spread in the north (Arunachal Pradesh) as a part of the Eastern Himalaya. The highest peak is Kangto (7090 m) followed by Gorichen (6023 m). Areas above 4000 m altitude are confined to the Himalayan region. General height increases from south to north. However, the highest point of the Eastern Himalaya is at Namcha Barwa peak (7755 m) which lies beyond international boundary in Tibet. Major divisions of the Himalaya from Bhutan in the west to Myanmar in the east are – Kameng, Subansiri, Siang, Dibang and Lohit. The last two are also called Mishni Hills. The easternmost portion of the Central Himalayan arc ends around the Northeastern

syntaxial bend or orographic swerve. Beyond which lies Lohit Himalaya, whose maximum elevation is 4578 m at Daphabum, and its Chaukan chicken's beak protrudes southeastwards. There are many passes to cross these mountain ranges viz. Bum La (4647 m), Tse La (4740 m, the highest in the Northeast), Bomdi La (2938 m) Diphuk (4353 m) and Chaukan (2432 m). Glaciers, snow peaks, gorges, lakes, springs, waterfalls and terraces are found here.

(b) ***Indo-Burma Hill Ranges*** : There is a continuous chain of almost north-south extending young folded mountains starting from the south of Lohit hills on Indo-Myanmar border following the Patkai Bum, Naga, Manipur and Mizo (Lusai) hills, reaching upto Arkanyoma in Myanmar. The highest point of these ranges is at Saramati peak (3826 m) followed by Mol Len peak (3018 m) on Indo-Myanmar border in Naga Hills. Mt. Japvo (2995 m) and Laikot (2833 m) are other higher points on this chain of hills. The general height decreases in the northeast, west, southwest and south of this triangle located around the junction of Naga-Manipur Hills. For example, 2568 m and 1763 m in East Manipur hills, 1780 m and 1721 m in Patkai Bum, and 2157 m at Blue mountain in Mizo hills. Parallelism is peculiar characteristic of these ranges, thus a serrated topography of ridges and furrows is conspicuous. Whenever the gap is wider between two ridges, flat valleys are found, like the large Imphal valley lying between the widely separated eastern and western Manipur hills.

One of the western offshoots of this chain is the Barail range starting from the junction of Naga and Manipur hills (i.e. southwest of Kohima town), trending in NEE to SWW direction and merging with the North Cachar hills in the west. Its maximum elevation is 2062 m. Another offshoot is Tripura hills in the west of Mizo hills, which have similar characteristics but lower in height (below 1000 m) and sparsely located, therefore, a number of flat valleys lie in-between.

(2) Old Plateau and Hills

The oldest landform as an outlier of the peninsular block is the Meghalaya-Mikir (including Rengma hills) plateau. Isolated hillocks of this block even appear as near as 30-40 kms. to the Himalayan sediments, e.g. hillocks near Tezpur and Vishawnath Charali on the northern back of the Brahmaputra valley. These all are not parts of the Himalayan mountains.

(a) ***The Meghalaya Plateau :*** The Garo, Khasi and Jaintia Hills form the Meghalaya plateau. This table land rises abruptly in the south.

It is an imposing landmass lying in eastwest direction across the path of the southwest monsoonal winds which strike on its southern escarpment or precipitous face causing the heaviest orographic rainfall of the world (i.e. about 1300 cms. annually) in Mawsynram-Cherrapunjee belt. The highest part of the plateau is in the Khasi Hills reaching to 1961 m at Shillong peak. Height decreases in all directions from this point. In Garo Hills Nokrek peak is at 1412 m altitude. The slope gradually declines towards north and west. The plateau bears marks of four erosional surfaces. Significant to mention presence of 'mini-canyon' in Mahadeo valley of Balphakram plateau area in the southeastern Garo Hills. Similar deep gorges are found in adjacent southwestern Khasi Hills. The flat surfaces and rounded hills of the plateau are areas of natural savanna grasslands, and at many such places agriculture is practised successfully.

(b) ***Mikir-Rengma Hills :*** Part of the plateau but highly dissected and isolated. The Kopili river flows between the Meghalaya plateau and these hills. Its northern portion reaches almost to the bank of the Brahmaputra river. Maximum height is 1359 m above m.s.l. in Rengma Hills and 886 m in Mikir Hills.

(c) ***North Cachar Hills :*** These are just continuation of the plateau region. The Barail range connects it to the Indo-Burma ranges, while low hills join it to the Rengma Hills in the north through a gap near Diphu and Jamuna river. It is highly dissected rugged country. The world famous Jatinga–an intense biogeomagnetic field lies in these hills where number of birds commit suicide every year. The highest point is near the Haflong pass (1736 m). The metre-gauge railway line between Lumding and Silchar was laid across this beautiful hill-section by constructing numerous bridges and tunnels.

(3) Alluvial Plains and Valleys

(a) ***The Brahmaputra and Barak Plains :*** The plains formed by the Brahmaputra river system are the largest in the Northeast. Exclusively they are in Assam state. The plains lie below 200 m altitude and slope from Sadiya (130 m) in NEE to Dhuburi (34 m) in SWW with a length of 720 km. and maximum width of 80 km. and it merge into the mingled delta of the Ganga and Brahmaputra rivers in the southwest of the Garo Hills. The fertile alluvial soil is used for growing rice, tea, jute, vegetables and many other crops. It is a thickly populated area in Northeast India.

Though smaller in size than the Brahmaputra plains, the Cachar

plains formed by the Barak river system also have high density of population due to their suitability for agriculture. Such plains are also found in Tripura, and further downstream they are called as the Surma or Sylhet plains in Bangladesh, which finally merge into the mingled delta of the two mighty rivers of the Indian sub-continent.

(b) ***Higher Flat Intermountain Valleys :*** Occurrence of small flat structural intermountain valleys in the hilly areas is very significant from agriculture development point of view. Special mention is made of the Imphal valley (500-1000 m), Apatani or Kale valley (2000 m), Mechuka, Siyom (above 1500 m), Papu, Pakke, Kaya, Yangse (400 - 600 m), Sangti, Chhug (1600-1800 m), Simsang (near Williamnagar, 300 m) and many smaller ones. Other than these valleys, narrow belt of flat lands along the courses of the major and minor hilly rivers and their relatively wide valleys on the periphery of the hills and plateaus when they debounch into the plains have also provided quite favourable lands for agriculture.

(4) Drainage

(a) ***The Brahmaputra Drainage System :*** The Brahmaputra is an antecedent river and alongwith its main tributaries like the Manas, Subansiri and Lohit (all antecedent), Dibang, Kameng, Noa Dihing, Tirap (Namchik), Dhansiri, Kopili, Umkhri, Umiam, Dudhnai, Krishnai, Didram, Jinjiram, Ringgi and Ganol forms one of the largest drainage systems in the world. Numerous small and big tributaries join this system from all the surrounding mountains and hills of the Northeast. That's why incessant rainfall in any part of the region results into inundating plain areas of the valleys. Though *beels* (low lands or depressions with water) are scattered all over the Brahmaputra valley, but the area near the confluence of the Siang, Dibang and Lohit rivers is most moist, to which the vicinity of the 400 cms. isohyet adds more dampness.

(b) ***The Barak River System :*** This system drains the Barak or Cachar plains and its surrounding hills. Rivers from the Meghalaya plateau and Tripura hills also join this network.

(c) ***Other Drainage Systems :*** Some rivers originating in the Indian territory enter into Myanmar. These are upper reaches and tributaries of the Chindwin in the Patkai, Naga and Manipur hills, of which Manipur river flowing through the Imphal valley is important one because the Loktak lake is connected with it. The Kaladan river rising from the southern Mizo hills also flows towards south into

Myanmar. Some rivers of Tripura also flow southwards to independently reach the sea.

C. Climate

The Northeastern India has different types of climate ranging from hot and moist tropical in plains and foot-hills to cold and dry alpine of higher mountains due to influence of location, topography and altitude.

Humid and warm tropical and sub-tropical climate occur in the Brahmaputra and Barak plains; Mizo, Manipur, Naga, Patkai, Mikir, Rengma, North Cachar, Garo, Khasi, Jaintia and Tripura hills, Barail range and lower slopes (below 1800 m) of the Himalaya mountains. Sometime the Mizo and Manipur hills experience drought in this belt. Temperate climatic conditions prevail in the entire hilly region between 1800-3500 m altitude. Alpine type of climate is experienced above 3500 m in the Himalaya.

As metioned earlier the highest annual rainfall of about 1300 cms. is received in Mawsynram-Chrrapunjee area. The next heavy rainfall zone of 300-400 cms. is on the lower slopes of the Himalaya in the hairpin bend at the head of the Brahmaputra valley, and also on windward slopes of Mizo hills and Cachar plains. In Manipur, southwestern Naga and Mishmi hills, Barail range and Tripura plains annual rainfall is below 200 cms. Rest of the area including the Brahmaputra plains, western and northern slopes of Meghalaya and Mizo hills receive precipitation between 200-300 cms. In higher areas of the Himalaya rainfall decreases to 100 cms., but it is compensated by snowfall during winter. Though southwest monsoon is the main source of rainfall in summer, but in rest of the year rains are also received from cyclones and depressions formed in the Bay of Bengal, western disturbances, nor'westers and local convectional thunderstorms. Due to extension of the Meghalaya plateau across the southwest monsoonal winds, the windward and leeward impact on rainfall is quite obvious here. That's why rainfall decreases from south to north.

In the plains, temperature is high between 35° to 40°C during summer months. In the lower valleys of hilly areas summer temperature also reaches near to this. Whereas in higher altitude temperature seldom rises above 25°C in short summers. Winter temperature in plains is 12° to 15°C while in hills it goes below zero. As a whole winter is relatively severe in the Northeast.

An important characteristic of climate of this region is flow of

strong southwestern winds in summer (March-April-May) causing damage to houses and standing crops. Chilly northern winds sometimes set in during winters. Movement of katabatic and anabatic winds (i.e. down and up valley winds, respectively) is common in the mountains, particularly in the ridges and valleys of the Himalaya.

D. Flora and Fauna

Northeastern India has one of the richest and varied flora and fauna of the world. Tropical and subtropical evergreen, semi-evergreen and deciduous types of vegetation occur in the plains and lower altitude (below 1200 m) slopes of hills and mountains. The main species are sal, *hallok, hathipolia*, bamboos, cane etc. Temperate vegetation is generally found above 1200 m in the Himalayan mountains, but its species occur even at 1000 m in Meghalaya plateau and in Indo-Burma ranges with trees like–pine, oak, birch, magnolia etc. The actual altitudinal boundary between the tropical and temperate bioclimatic belt is 1800 m. Real temperate forests and grasslands occur between 1800 m to 3500 m in the Himalayan mountains. Above 3500 m the Alpine type of vegetaion is found with predominance of grasslands, rhododendron and bushes. The overall climatic conditions (particularly high moisture and moderate temperature), relief, topography and soil are conducive for faster and luxuriant vegetation growth and, therefore, the Northeast is one of the most green parts of the world.

Variety of fauna inhabit in these forests. Most valuable are one horn rhino, yak, dancing deer, *mithun*, elephants, gaur, tiger, panther, leopard, bear, gibbon, langur, hornbill, fishes, butterflies and reptiles.

E. Soils

Owing to influence of the biophysical factors mentioned above, the soils of the region are of different types. Alluvium is spread over the plains of the Brahmaputra, Barak, Imphal valley, and narrow ribbon of flat lands of hill rivers and streams.

In the in situ soils, brown to reddish sandy loam soils are commonly found on the hill slopes of the entire region. Lateritic soils occur in Meghalaya plateau, Mikkir-Rengma hills and Manipur hills. Some pockets of greyish sandy loam are also scattered on the hill slopes. In the flat valleys of the hills and in the plains where water remains stagnant or drainage is poor, clayey loam soils are found. Due to heavy rainfall the hill soils are acidic and rich in phosphate, potash and calcium. Soils under the densely forested areas have thick layer

of humus, thus very fertile in the beginning, but exhaust rapidly after two to three years of cultivation.

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