

**LAND RESOURCE EVALUATION FOR LANDUSE PLANNING OF
MAWKYNREW C. & R.D.BLOCK, EAST KHASI HILLS,
MEGHALAYA**

ABSTRACT

BY

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Introduction

Land evaluation is the process of collating and interpreting basic inventories of soil, vegetation, climate and other aspects of land in order to identify and make a first comparison of promising land use alternatives in simple socio-economic terms. Land evaluation therefore, bridges the gap between the physical, biological and technological means of land use and its social and economic purposes. Increasing population has led to the scarcity and degradation of much of the land resources. In the last few decades scientists from various disciplines have realised the tremendous pressure on our land resources especially to that of soil, water and vegetation. In most cases, the land resources have not been utilised in a proper and efficient manner, mostly so because of the lack of availability of data and partly because of the ignorance of the people.

Therefore, land resource evaluation becomes the primary task of the geographers, so as to identify the problems, prospects and potentiality of the existing land-uses for future development

Statement of the Problem

Economic development of a region depends on the degree of resource use. To maintain and accelerate the momentum of economic development, a rational and optimal use along with conservation of resources is essential. Land resources needs to be evaluated in order to find out its potentiality for an optimal use so as to achieve the desired socio-economic development and this requires up-to-date and reliable information on natural resources in spatial format at the desired scale. Arriving at alternative planning scenarios requires integration of various spatial data. This involves the study of the spatial distribution and analysis of three basic factors which together form the resources, viz., natural, human and cultural resources.

Much of the problem of land evaluation, utilization, land use and land cover mapping is primarily due to the lack of sufficient database. The conventional method of collecting data is a costly and time taking affair and is characterized by gaps and unreliability, leading to inappropriate and unrealistic evaluation of land resources resulting in distorted developmental plans. The study area which falls within the East Khasi Hills district of Meghalaya, exhibits distinct agro-ecological condition followed by diverse agricultural practices and other economic activities. The difficult terrain, existing land utilization, inefficient planning and management techniques in the absence of detailed data base makes it more difficult to undertake such studies. Lack of development and poor socio-economic condition of the people in these areas demand a proper land resource evaluation to generate proper planning and management strategies.

The main characteristic of the area is that it is hilly in nature inhabited by the tribal people. The region is still underdeveloped due to the environmental and socio-economic constraints. So far, not much research has been done on mapping and evaluation of land resource corresponding to socio-economic development. The conventional method of data acquisition through ground survey is a tedious task, and in most cases it becomes unreliable and outdated. Therefore, remote sensing data which is more scientific and modern provides up-to-date and reliable information of the ground reality. It has an edge over the other data in the form of its repetitive coverage and quick survey. The present satellite data with high spatial and spectral resolution and its availability in false colour composite and panchromatic data gives a better picture for resource identification and interpretation. Using this technique an attempt has been made to evaluate the land resources for sustainable and optimal use.

It is in this context that the present study attempts to generate the overall picture of land resources in the Mawkynrew C & R D Block, (91° 55' to 90° 10' East longitude and 25° 15' to 25° 33' North Latitude and is covered by Survey of India topo-sheet No. 78 0/14 and 83 C/3) and to evaluate these resources in

order to assess the quality and quantity of the present land resources and to formulate a land use plan for a sustainable development of the area.

Objectives

The broad objective is to evaluate the existing land resources for a sustainable and integrated land use planning specifically for the following purposes:

1. to review the progress that has been made in the utilization of land resources, in view of the critical role of land resources as a major element in the development of the area;
2. to identify the various land capability classes in the study area that can support the best possible use and the sustainable management of land resources;
3. to draw attention to the existing problems and the need to improve the management of land resources,
4. to apply remote sensing and GIS techniques for data generation and evaluation of land resources.

Research Questions

1. Given the peculiarity of the geographical and socio-economic realities of the study area, what is the potential of the resource base?
2. Whether or not the standard methods of land evaluation is applicable to the area of study?
3. What are the capability status of the land in the study area?
4. Whether the existing land-use is sustainable or not?

Justification of the present study

The dependence of more than 80 percent of the population of the study area directly or indirectly on land resources in itself is an indicator of the importance that land resources play in supporting the basic needs of the people.

In the past the pressure on land was not as much as it is today. The jhum cycle which was 8 to 10 years a few decades ago has now reached 2 – 3 years. This is an indicator of scarcity of land due to increasing population, which has ultimately resulted in large scale degradation and deterioration of land resources. Unfortunately, the land resources which supports such a large chunk of population of this area is the least managed along scientific principles; rather it is subjected to fast ecological degradation due to the age old practice of 'bun' cultivation coupled with rising population. The location, physiography, and other physical factors together with the existing socio economic conditions, typical agricultural practices, occupational structure relating to forest resources inspires the researcher to evaluate the land resources of the study area and correlate the physical and socio-economic conditions to understand the overall land resource potentials of the area.

Summary & Conclusion

No matter what level of advancement nations have reached due to the industrial revolution and scientific innovations, 'Land' remains one of the single most important resource base for mankind.

The diverse physical conditions of the study area is revealed by the vast differences in the slope conditions between the central uplands and the southern steep lands. The elevation ranges from as low as 100 meters to more than 1600 meters above mean sea level and has been divided into six categories according to its excessiveness. The slopes in the lower elevations are more rugged than in the higher elevations and the vast differences in the relief cause variations in the intensity of rainfall and sunlight, which affect the soil conditions and landuse practices.

The study area has a well knit drainage network with a very high occurrence of 1st order streams comprising about 60 percent of the total length, and 2nd order streams covering 19.24 percent of the total length of all the

streams. The 3rd order and 4th order streams constitutes less than 10 percent of the total length, but offers much of the fertile river valleys where settled agriculture is practiced.

The drainage density ranges from less than 1 km/sq.m to above 3, and the drainage frequency ranges less than 2 to above 6 per sq.km. The overall drainage density and drainage frequency of the study area indicates that there is no scarcity of water as such, but the problem lies in its distribution and utility which is made inaccessible by rugged topographic conditions.

The climatic condition of the study area is governed by semi-temperate to temperate climate with an annual average rainfall of about 2400 mm in the central uplands, and the sub-tropical climate with cold to very cold winter conditions in the southern steep slopes. The mean annual air temperate in lower elevated lands is 23° C to 24° C while in the higher elevated lands it is 16° C to 17° C. The average humidity in this region varies from 67 to 79 per cent.

The study area also portrays a discouraging scenario in terms of literacy level (36.65 percent according to 1991 census), which is the lowest amongst the other entire C.D.Blocks of East Khasi Hills district. This coupled with the absence of higher secondary schools and vocational training centers made it worst due to poor distribution of available educational institutions even at the primary school level.

The poor transport and communication system, market facilities, post & telegraph services, etc. have acted as a hindrance to the interconnectivity between rural and urban centers, movement of goods and services, and the transfer of technology, which are essential components of economic development. Even the basic amenities like medical facilities. Potable drinking water and electricity is yet to reach a vast majority of people of the study area.

The economy is primarily backward and rural in character, with much of the population depending on primary economic activities which includes subsistence level of farming. The occupational structure reveals that main workers constitute only 47 percent of the total population and the rest belong to the non working class. A village level analysis further indicates a very high discrepancy with almost 50 percent of the villages having less than half of its population in the category of main workers. This together with 23 percent of the population in the age group of less than 6 years has led to high dependency ratio – a burden for the working population most of who are engaged in the subsistence level of primary economic activities.

Agriculture which is the mainstay for much of the rural communities of the state, have been able to engage only a meager amount of population of the study area. Paucity of land actually available for cultivation, pre-dominance of small and marginal farmers, and traditional agricultural practices have acted as a major obstacles in raising agricultural production. This has led almost 70 percent of the working population to rely on primary activities like livestock rearing, forestry, fishing, hunting and plantation. As high as 80 percent of the populations in 41 villages are engaged in these activities, this together with bun cultivation can be said to be the root cause of land degradation and forest degeneration in the study area.

According to the general degree of goodness in the sense of possible intensity of use the study area is divided into six land capability classes, i.e. Class II, III, IV, VI, VII and VIII. These six classes of land are further divided into two broad groups, namely, land suitable for cultivation and other uses which includes Class II, III and IV lands, and land not suitable for cultivation i.e. Class VI, VII and VIII lands. The absence of plane areas or leveled lands and other limitations deprives the area of Class I and Class V lands. It was observed that there is very limited area for agricultural purposes, as only 1.63 percent of the

land area falls in Class II, and 4.64 percent in Class III, while 21.06 percent comes under land capability Class IV, which has severe limitations for agricultural use. Thus, more than 70 percent of the land in the study area is not suitable for agricultural land use. This proves the fact as to why there is such a high dependency on forestry, livestock rearing, hunting, fishing and other non-agricultural primary occupations. The land capability classes are consistent with the composition of scale dependent mapping units, and meant to give only a broad idea of limitations. Considering the scale and the abstraction level of the mapping units, the management needs suggested here are broad and indicative in nature. Precise recommendations could follow only from farm level detailed soil surveys and investigations. However, the suggestions made above relate to the sustainable use with available technologies so as to prevent further degradation of the land.

The description of landuse/landcover pattern of the area reveals some alarming facts related to the land degradation in the study area. The majority of the population who are dependent on forest related primary activities are left with only 15.16 percent of dense forested area and 27.28 percent of open forest, most of which are secondary forest cover that provide very little biodiversity to cater to their needs. The area under permanent cultivation occupies only 5.38 percent of the geographical area, and bun cultivation occupies 4.19 percent. This together with plantations (1.41%) covers a little more than 10 percent of the total geographical area.

In order to find out the land resources of the past a forest cover map pertaining to the year 1965/66 was generated from the SOI toposheet and analysed in the Arc GIS environment to detect the changes occurring in the spatial and temporal dimension. A drastic change in the aerial extent of dense forest cover has occurred in the study area. Not only has the area occupied by dense forest cover, i.e. 41.51 percent in 1965/66, been reduced to a dismal 15.16 percent, but the quality and rich bio-diversity of the previous forest

resources is now overtaken by secondary forest cover, and only 8.86 percent remains in its original form.

Further analysis of the existing landuse/landcover pattern, the changes it has undergone, and its distribution over different physiographic and slope conditions leads to the understanding of the situation which compels the people to take up the present form of primary occupation that is dependent on forest related activities including bun cultivation. This also highlights the complexities of the study area in terms of its resource use and its management.

The importance of watershed as a planning unit is highlighted in Chapter-VI. The study area is divided into eight micro watersheds, and a diagnostic survey of land resources and land capability classes for each watershed is analysed. The environmental appraisal of the landuse potentials in the study area reveals some interesting facts about the utilisation of the lands under different capability classes: i) areas which are capable of agriculture use are presently left unutilised, and ii) areas which are not suitable for agriculture are being used for bun cultivation.

According to the stability of the resources and the capability of the land, the potential areas have been divided into two categories of use, namely i) potential areas for agricultural use, and ii) potential areas for non-agricultural use. It is observed that only 52.17 sq. km. or 14.49 percent of the study area offers the possibilities for agricultural use with varying degree of limitations, and in the absence of large areas under Class II and Class III lands, it becomes necessary to make the best possible use of Class IV lands.

The potential areas for non-agricultural use like forestry, animal husbandry, horticulture etc. offers a considerable scope for the development of these activities. Keeping in view the large section of the population who are dependent on primary activities other than agriculture, and directly or indirectly

dependent on achieving much of their daily requirements from the forest, the utilization of the lands belonging to Class VI and VII can be viewed as potential sites for forestry, animal husbandry and horticulture. As of the present socio-economic condition and technological dissemination, these activities together with agro-forestry are the best possible avenues for the people living in this area.

The identification and analysis of the potential areas for agricultural and non-agricultural land uses also led to an important finding related to land use activities in some of the vulnerable areas. These areas are highly susceptible to erosion and land degradation, and presently occupy 30.90 sq.km. or 5.98 percent of the total geographical area.

With the above background in mind, a land use plan for the study area has been formulated. Scientific management of land resources to ensure optimal utilization, vis-à-vis conservation and environmental protection has been the guiding principal for land use planning. The proposed land use plan focuses on the appropriate utilization of the potential areas, and the urgency to regenerate and conserve the vulnerable areas. The land use plan is meant to fit the physical, social and economic condition of the study area, and is not a rigid model, but a base on which micro level land use plans can be worked out after further investigation of the ground realities.

The areas falling under land capability Class II, which are unutilised offers high potentiality for agricultural use, provided some of the limitations imposed mainly by lack of irrigation and poor soil conditions are removed. This can be done with minimum input in the form of irrigation, fertilizers, and appropriate cropping pattern.

Class III and Class IV lands can be utilised after adopting special conservation practices, and land modifications such as contour bunding and terracing, providing irrigation, and by growing crops that provide good soil cover.

Terrace cultivation, and contour bunding are some of the methods which has been successfully adopted and can be expanded further to other areas.

It was found that the spatial distributions of most of the existing forest resources are concentrated on areas that fall in the category of Class VI and above. These areas are highly vulnerable to erosion and other environmental hazards; therefore, special attention must be given to these areas during its use. Conservation and management of the forest in these areas are important for preserving water, avoiding excessive run-off and enhancing biodiversity.

It was found that most of the households still practice the tradition of rearing livestock and poultry. This can be an alternative as well as a subsidiary occupation and further encouragement and improvement can be initiated by providing necessary support in the form of high breed stocks, quality feed and fodder, and other extension services.

Plantation is another important activity of the people especially of those living in the southern slopes. The lower elevations (less than 700 meters) have proved to be potential areas for various plantation crops. This together with agro-forestry and animal husbandry can become a lucrative activity for people and at the same time reduce the high dependency and degradation of the existing forest resources.

Degradation of forest resources is a major concern that threatens the very sustenance of the people depending on it. The root cause of forest degradation are: i) high dependency of the people in primary activities, which include lumbering till the recent past, and is now replaced by livestock rearing, forestry, hunting, etc which still sustains about 33 percent of the total population of the study area, and ii) the traditional agricultural practices, which reveals that shifting cultivation was one of the main activity till recent years, and is now replaced by

bun cultivation. This has not only resulted in deforestation but has also caused large scale degradation of the soils.

Some of the suggestions to tackle the problem of forest degradation include, low cost alternative and efficient energy sources, such as smokeless chullahs, bio-gas, solar energy, hydroelectricity, etc, to reduce the fuel wood crisis and rampant exploitation of already dwindling forest resources; launching of community based afforestation programmes; strengthening of local institutions to oversee the management of land resources; introduction of agro-forestry are essential steps. Modification of the processes involved in bun cultivation is seen as an important step to control both forest and soil degradation. This can be done by restricting in burning of debris, minimising tillage, and introducing mixed cropping practices. Soil conservation measures includes, contour drains, planting patterns perpendicular to slope, permanent tree cover to protect soil erosion, which are low cost and easily affordable by farmers.

The other areas which needs to be improved in the study area includes:- the introduction of low cost and effective technology, storage facility, transport and communication, credit and banking facilities; encourage cooperative and integrated farming; promoting income and employment generating activities. Investments in infrastructure like roads, market, capital and credit facilities; training, demonstration, and linkages to development packages; and the improvement of medical, health and educational facilities are some of the important areas.

The physical characteristics of the study area viz., relief, climate, soil, and slope has been the guiding factor that is responsible in shaping the occupational structure and farming system adopted by the people living in these areas. In the given geographical condition, the people obtain their basic minimum requirements from the forest, and adopting bun cultivation – a modified form of shifting cultivation. These activities which have been sustaining the people living

in these areas are now posing a serious threat to the land resources and their very survival.

Population growth and the quality of the people mainly in terms of age structure, literacy level, occupation and employment is the main factor that is imposing an increasing pressure on land resources leading to depletion of natural resources and the degradation of land. The disparity in the socio-economic condition can be attributed to the quality of land resources and the nature of land utilization and vice versa.

Though the area is very close to the capital city Shillong, the dissemination of technology and the level of education have been very low. With 36.64 percent of literate population in the study area is the lowest in the East Khasi Hills district. A teeming 23 percent of children in the age group of 0 to 6 years add to the overwhelming 52 percent of non-working population resulting in a very high dependency ratio.

A severe imbalance is foreseen in the carrying capacity of the land if drastic steps are not taken to change or modify the existing land utilization practices. The present area under various landuse/landcover, is dominated by 34.33 percent of grass/shrubs, 15.16 percent of dense forest cover, and 27.28 percent of open forest cover. The change detection study reveals that out of the 41.19 percent of dense forest cover in 1965/66 only 8.86 percent remains in its natural form, while 31.23 percent has been affected by one or the other type of Landuse/Landcover. Unless immediate conservation and management practices are implemented the existing forest resources offer very little hope for sustaining the future requirements.

It is alarming to note that forest cover changes in recent years is more dominant in the southern slopes and these areas having steep slopes often

experiencing the problems of erosion and land degradation, affecting its immediate areas and adjoining areas as well.

The shortage of good agricultural land in the study area is revealed by the low percentage of area under land capability Class II (1.63%), Class III (4.64%) and Class IV (21.06). Most of these areas have not been appropriately used mainly due to the inability of the farmers to overcome the limitations imposed by soil and slope. Strategies to tackle these problems have been suggested after examining some of the successful land use practices carried out in and outside the study area.

The presence of large areas under Class VI and Class VIII with favourable geographical conditions offers a vast scope for the development of forestry, animal husbandry and horticulture. This, apart from giving them their requirement for food, fodder, fuel wood, firewood and shelter will also make it possible to safeguard the existing natural forest from further degradation. The study also reveals that bun cultivation is practiced in some of these areas and it has been one of the major causes for large scale degradation of the land noticed in this area.

Analysis carried out at the watershed level provides a comprehensive background of the existing land resources of the study area. Further analysis of the existing land use/land cover in combination with the land capability classes gives a clear understanding of the variations in the distribution, utilization, potentials and vulnerability of land resources at the watershed level.

The proposed land use plan is formulated after closely examining all the findings related to the physical, social, economic, and technological aspects of the study area. It is aimed to be environmentally sound, socially acceptable, economically viable, and technically appropriate in achieving a sustainable development.

Various methods, guidelines and techniques prepared by FAO and other organisations have been consulted in preparing the land capability classification and land use plans of the study area. The tendency to utilise some of the automated land evaluation techniques had to be grounded because of the realisation that quantitative data alone does not provide a strong basis for land evaluation, but qualitative aspects like knowledge, experience, tradition, belief, skill, social background, and a variety of other factors that cannot be quantified have a strong influence on land utilization.

Remote sensing has proved to be an efficient technique for obtaining land resource data, especially as the source for landuse/landcover mapping. Without the satellite data, it would be almost impossible to generate accurate landuse/landcover map with such details. A combination of IRS IC FCC in 1:50,000 scale and IRS IC PAN data in 1:25,000 scale was found suitable to undertake land resource studies. Integration of other collateral spatial and non-spatial data provided as an added advantage for micro level planning. ArcGIS GIS 8.1 software provided the platform for digitization, data storage, manipulation, interpretation and generation of different thematic maps and linking of tables and other attributes, including collateral information to carry out land resource evaluation of the study area. It also provided a complete tool to analyse data both in raster and vector format for a comprehensive evaluation and planning processes.

In conclusion it can be said that the present study has brought about a realisation of the existing condition of land resources in the study area, and also created awareness about the future consequences that are likely to arise if the present land use practices continues. The linkages and interdependence of the physical and human resources in the study area is so intrinsic that without a mutual relationship and coexistence, the possibilities of achieving a sustainable development look very bleak. Ignorance, greed and poverty often result in unscrupulous use of resources and caused colossal damage to the land

resources. Researchers play an important role in using their knowledge and the available technology to identify the problems and finding the answers and recommendations to it. Coordination between governmental agencies and non-governmental organizations and the participation of the village based community and self help group is necessary to diffuse the knowledge and technology, which will ultimately rely on the acceptance and implementation of the people at the grass root level. Remote sensing, GIS, digital image processing (DIP) and simulation models provides new possibilities for better analysis techniques, monitoring, and forecasting. With the present advancement in RS & GIS it is possible to illustrate its application at grass root level and to integrate other spatial and non-spatial data in understanding and solving the problems related to land resources. These techniques need to be an integral part of decision support system in land resource evaluation and landuse planning.

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OCTOBER, 2004

I, Mr. Pankaj Thapa, do hereby declare that the subject matter of the thesis is the record of work done by me, that the content of this thesis did not form basis of the award of any previous degree to me or to the best of my knowledge to anybody else, and that the thesis has not been submitted by me for any research degree in any other University/Institute.

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CHAPTER- I
INTRODUCTION

CHAPTER-I

INTRODUCTION

1.1. The Concept of Land resource

Land can be considered as one of the most important free gift of nature. Land, being the carrier of those ecosystems, which provide the most benefits to mankind, is the over-all natural resource. The primitive man directly utilised the over-ground resources of the land through hunting and gathering, but the art of crop cultivation nearly 10,000 years ago brought about a remarkable change in man's utilization of land resources and provided much scope to meet his immediate needs like food, water, shelter and clothing.

History speaks eloquently of the high regard with which man has viewed land in times past. The ancient Minoans and Greeks prayed to an earth goddess, a reverence that has come down to us in the respect we show for Mother Earth. For long centuries, most war were fought for the possession of land, and the average man every where lived in close association with the soil, fields, forests, and fishing grounds that provided him with sustenance. Rights in land were often the key factor that determined an individual's economic, social and political status.

Land can be defined as the sum total of the natural and man-made resources over which possession of the earth's surface gives control.¹ This broad concept of land includes all the earth's surface, water and ice as well as ground. In addition to building sites, farm soil, growing forests, mineral deposits, and water resources, it also involves such natural phenomena as access to sunlight, rain, wind, and changing temperatures and location with respect to markets and other areas. Moreover, it includes all these man-made improvements that are attached to the surface of the earth and cannot be easily separated from it.

Much can be said about the basic importance of land resources in the modern world. They provide people with living space, with raw materials necessary for filling material needs, and with opportunities for satisfactions dear to the heart of man. People look to land for their physical environment, for the food they eat, for fibers and other materials needed to clothe their bodies and to provide housing and manufactured goods, for building sites, for recreation opportunities, and for scenery and open space.

This makes it clear that 'land' is much more than soil, topography, climate, political divisions, etc. The most appropriate definition of land, therefore, is one which involves the geographical aspects of "a tract of land" and reads; "a tract of land is defined geographically as a specific area of the earth surface; its characteristics embrace all reasonably stable, or predictably cyclic attributes of the biosphere vertically above and below this area including those of the atmosphere, the soil and underlying rocks, the topography, the water, the plant and animal populations and the results of past and present human activity, to the extent that this attributes exert a significant influence on present and future uses of land by man."²

According to the definition given by Food & Agricultural Organisation of the United Nations- "Land is defined as 'an area of the earth's surface, the characteristics of which embrace all reasonably stable, or predictably cyclic, attributes of the biosphere vertically above and below this area including those of the atmosphere, the soil and underlying geology, the hydrology, the plant and animal populations, and the results of past and present human activity, to the extent that these attributes exert a significant influence on present and future uses of the lands by humans'.³

This definition includes all the land resources; both natural and man-made features which are clearly permanent or cyclic in nature. Vegetation, animal population both natural and man-induced, are definitely included. Permanent

artificial structures such as dikes, canals, metalled roads or stable terraces are also considered a part of the land.

Land is a finite resource, while the natural resources it supports can vary over time and according to management conditions and uses.⁴ "Land Resources are the environmental resources of climate, water, soils, landforms, forests, pastures, and wildlife, on which agriculture, forestry and other kinds of rural land-use depend."⁵ "Land includes any ground, soil or earth, such as meadows, pastures, woods, waters, marshes and health, houses and other buildings upon it; the air, space above it and all mines and minerals beneath it. It includes anything fixed to the land; and growing trees and crops, except those which broadly speaking, are produced by the labour of the year"⁶

The Meghalaya Transfer of Land (Regulation), Act 1971 under section 2(a) states that unless otherwise required, "Land includes immovable property of every description and any right in or over such property". The Meghalaya Land Survey and Records Preparation Act, 1980, on the other hand give a more comprehensive picture and definition of land under section 2 (d) states that: "Land includes land covered or under any of the established or constituted under any law, custom or practice, agricultural or non-agricultural land, waste or arable land under any cultivation or otherwise and shall also include fisheries".⁷

The Land as we see it today is in many areas the result of a combination of both its natural genesis and the human influences which have been brought to bear on it in the past and of those which are still active in the present. Thus, the fundamental problem that faces the world today is the rapidly increasing pressure of population on physical resources, particularly on resources of land.

Expanding human requirements and economic activities are placing ever increasing pressures on land resources, creating competition and conflicts and resulting in sub-optimal use of both land and land resources. If, in the future,

human requirements are to be met in a sustainable manner, it is now essential to resolve these conflicts and move towards more resources. Integrated physical and land-use planning and management is an eminently practical way to achieve this. By examining all used land in an integrated manner, it makes it possible to minimize conflicts, to make the most efficient trade-offs and to link social and economic development with environmental protection and enhancement, thus helping to achieve the objectives of sustainable development. The essence of the integrated approach find expression in the coordination of the sectoral planning and management activities concerned with the various aspects of land-use and land resources.

Increasing population has led to the scarcity and degradation of much of the land resources. In the last few decades scientists from various disciplines have realised the tremendous pressure on our land resources especially to that of soil, water and vegetation. In most cases, the land resources have not been utilised in a proper and efficient manner, mostly so because of the lack of availability of data and partly because of the ignorance of the people.

Therefore, land resource evaluation becomes the primary task of the geographers, so as to identify the problems, prospects and potentiality of the existing land-uses for future development.

1.2. Statement of the Problem.

Land resources play an important role in the developmental processes of a country, especially in the developing countries like India, where more than 70 percent of the population is directly or indirectly dependent on agriculture. The growth of population is further aggravating the problem of managing the existing land resources. Scarcity of agricultural land has not only been caused by the growth of urban and industrial centres or changes in land-use, but degradation of existing agricultural land due to lack of proper management strategies has caused serious consequences.

India with 2.4 percent of the total land area of the world shares 25 percent of the world's population. The present rate of population increase may lead to an absolute scarcity of land. More so because of the serious regional scarcity of land, and in particular of productive land. Such scarcity of land has led to either migration of the people for greener pastures or to intensification of the existing type of land-use.

Out of the total land area of 323 million hectares (m.ha.), degraded lands of different types are officially reported to be about 130 m.ha.⁸ though some estimates put the figure at 163 m.ha.⁹ and even 175 m.ha.¹⁰ These degraded lands include revenue land meant for agriculture and other purposes, as well as forested lands.

The utilisation of land resources in the North Eastern States of India, when compared to most of the other states of the country depicts a vast contrast. The physical factors, like topography, climate, soil, location, etc. together with the complex socio-economic and cultural setup of this region has not only led to economic backwardness, but at the same time has led to the depletion of land resources as a result of the traditional practice of shifting cultivation, deforestation, and un-scientific method of agricultural land use is causing a serious damage to the fragile environment.

Economic development of a region depends on the degree of resource use. To maintain and accelerate the momentum of economic development, a rational and optimal use along with conservation of resources is essential. Land resources need to be evaluated in order to find out its potentiality for an optimal use so as to achieve the desired socio-economic development and this requires up-to-date and reliable information on natural resources in spatial format at the desired scale. Arriving at alternative planning scenarios requires integration of various spatial data. This involves the study of the spatial distribution and

analysis of three basic factors, which together form the resources, viz., natural, human and cultural resources.

Though a lot of work on land use, land cover mapping has been done by researchers and scientists at various levels in India, very little attempt is made to evaluate the existing land resources in order to assess its capability and suitability. Much of the problem of land evaluation, utilization, land use and land cover mapping is primarily due to the lack of sufficient database. The conventional method of collecting data is a costly and time taking affair and is characterized by gaps and unreliability, leading to inappropriate and unrealistic evaluation of land resources resulting in distorted developmental plans. This is more obvious in the difficult and hilly terrain of N.E. India. The study area falls within the East Khasi Hills district of Meghalaya, and exhibits distinct agro-ecological condition followed by diverse agricultural practices. The difficult terrain, existing land utilization, inefficient planning and management techniques in the absence of detailed data base makes it more difficult to undertake such studies. Lack of development and poor socio-economic condition of the people in these areas demand a proper land resource evaluation to generate proper planning and management strategies.

Since land resources are used for a variety of purposes which interact and may compete with one another; it is desirable to plan and manage all uses in an integrated manner. Integration should take place at two levels, considering, on the one hand all environmental, social and economic factors (including, for example, impacts of the various economic and social sectors on the environment and natural resources) and, on the other, all environmental and resource components together (i.e., air, water, biota, land, geological and natural resources). Integrated consideration facilitates appropriate choices and trade-offs, thus maximizing sustainable productivity and use. Opportunities to allocate land to different uses arise in the course of major settlement or development projects or in a sequential fashion, as lands become available on the market.

This in turn provides opportunities to support traditional patterns of sustainable land management or to assign protected status for conservation of biological diversity or critical ecological services.

The large scale degradation and depletion of land resources in the study area indicates inappropriate and uncontrolled land utilization. Most of the time the existing land use land cover is not assessed in terms of its actual potentiality, carrying capacity, and the limitations set by land resources.

The main characteristic of the area is that it is hilly in nature inhabited by the tribal people. The region is still under developed due to the environmental and socio-economic constraints. So far, not much research has been done on mapping and evaluation of land resource corresponding to socio-economic development. Due to the unavailability of resource maps and lack of accurate and reliable data it becomes difficult to propose a suitable land utilization and land management strategies and suggest developmental measures. The conventional method of data acquisition through ground survey is a tedious task, and in most cases it becomes unreliable and outdated. Therefore, remote sensing data which is more scientific and modern provides up-to-date and reliable information of the ground reality. It has an edge over the other data in the form of its repetitive coverage and quick survey. The present satellite data with high spatial and spectral resolution and its availability in false colour composite and panchromatic data gives a better picture for resource identification and interpretation. Using this technique an attempt has been made to evaluate the land resources for sustainable and optimal use.

The present study is an attempt to generate the overall picture of land resources in the Mawkynew C & R D Block, and to evaluate these resources in order to assess the quality and quantity of the present land resources and to predict its suitability for the purpose of sustainable development and environmental regeneration.

1.3. Reasons for Land Resource Evaluation.

Every land area has comparative strengths and weaknesses. Evaluation of these characteristics are necessary for proper planning and development. The importance of land evaluation received greater impetus of late because it has been increasingly clear that an efficient land use that does not degrade the land resources can only be obtained when the land condition or eco-system are well known.¹¹

“A basic characteristics of the Malthusian equation is that the numerator (Land or Resources) remains relatively fixed while the denominator (Population) continues to expand at a rate that some observers find alarming. Hence the ratio of land to man becomes ever smaller, and it becomes possible to write persuasive description of impending catastrophe”¹². The world’s population which was estimated at 6.25 billion by the turn of the century, has already crossed the 7 billion mark. Therefore, the need to increase food production, to meet the expanding needs of population is putting enormous pressure on all natural land resources, including land.

Land resources provide the basis for more than 95 percent of human food supplies; the greater part of clothing and all needs for wood both for fuel and construction. The development of the industrial age have substituted coal, oil and minerals for some of the fuel, construction and fiber needs, but in no way removed the basic dependency of society upon the renewable resources of land. Formerly, there was a solution to local problems of shortage of food and other basic necessities: to take more land into cultivation. Usually this was through clearance of forests, for forested lands are also the most fertile. The early taxation surveys of India recorded ‘culturable wasteland’, which today would be called land that is cultivable but not cultivated. Almost all such land has now been taken up¹³. Therefore, there is an ever increasing need to bridges the gap between the physical, biological and technological means of land use and its social and economic purposes.

The loss of land resources have tremendous impact on the socio economic condition of the country. Loss of forest cover, loss of top fertile soils, sedimentation of reservoirs, canals, loss of water resources and their quality result in the non-availability of land for cultivation or other land-use practices leading to unemployment and poverty. It also has impact on the people of rural base who are migrating to the urban area in search of job due to non-availability of cultivable land.

Thus, the challenges being faced by the country are to control the menace of deforestation, soil erosion, regeneration of the wasted potential development of land and water resources, protection of environment and above all to bring about awareness among the people so as to ensure the food security to the nation besides maintenance of the soil and land resources.¹⁴

Land evaluation is the process of collating and interpreting basic inventories of soil, vegetation, climate and other aspects of land in order to identify and make a first comparison of promising land use alternatives in simple socio-economic terms. Whereas, 'land suitability' is the fitness of a given tract of land for a defined use; differences in the degree of suitability are determined by the relationship, actual or anticipated, between benefits and required inputs associated with the use on the tract in question.¹⁵ A systematic land evaluation is necessary for the purpose of judging 'land suitability'; both for land use and for land improvement. Improvements in land resource management can only come about if preceded by awareness of the problems, and recognition of the need for action.

1.4. Assumptions & Research Questions

Land evaluation can be interpreted from land resource maps using two main sets of assumptions:

1. Actual land suitability, i.e. the stability of land units for the use in question in their present condition without major land improvement, and

2. Potential land suitability, i.e. the stability of land units for use in question at some future date after major land improvements have been effected where necessary.

With the above two assumptions in mind, the following research questions needs to be answered. They are:

1. Given the peculiarity of the geographical socio-economic realities of the study area, what is the potential of the resource base?
2. Whether or not the standard methods of land evaluation is applicable to the area of study?
3. What are the capability status of the land in the study area?
4. Whether the existing land-use is sustainable or not?

1.5. Objectives.

The broad objective is to evaluate the existing land resources for a sustainable and integrated land use planning specifically for the following purposes:

1. to support the best possible use of land and the sustainable management of land resources;
2. to improve awareness of the critical role of land resources as a major element in the development of agriculture and the rural sector;
3. to review the progress that has been made in different aspects of land resources, and to point to priorities for the future;
4. to draw attention to the urgent need for action to improve the management of land resources, if they are to be considered for the benefit of future generation;
5. to imply remote sensing and GIS techniques for data generation and evaluation of land resources.

1.6. Survey of Literature

The study related to land resources for specific purposes, like agriculture, settlement, transportation, etc. has important issue for all developmental activities in different parts of the world, since the 19th century. The "Land utilization Survey" conducted by Sir Dudley Stamp¹⁶ was one of its first kind to be done in Great Britain. His work resulted in a simple classification of land according to its inherent qualities. Other scholars like Parry et al¹⁷, and Siderius¹⁸ have conducted land evaluation related studies for specific purposes. Dent & Young¹⁹ provides a concise and practical introduction to the techniques and procedures of soil survey and land evaluation which play an essential part in the planning and management of land resources.

The study of land evaluation have been important programmes in FAO since its foundation in 1945. By 1970 many countries had developed their own systems of land capability classification and land evaluation, making international exchange and comparison of information difficult. Some form of standardization was obviously required. The International Institute for Land Reclamation and Improvement (ILRI) in Wageningen, which had traditionally concentrated on water issues, now wanted to pay more attention to "land" issues and sought contact with FAO for that purpose. This resulted in a joint project to develop a *Framework for Land Evaluation*, published in 1976²⁰.

The Framework drew substantially from earlier concepts and methodologies developed, e.g., in Brazil and Iran. It was subsequently applied in many countries in which FAO was active through UNDP-financed projects, and also in several bilaterally financed projects on natural resources inventories and evaluation.

In the years following publication of the Framework, detailed guidelines for its application on specific land resources were published; Land Evaluation for rain-fed agriculture²¹, Land Evaluation for forestry²², Land evaluation for

extensive grazing²³ were the three consecutive guidelines published since 1985. After three successive year of implementation of guidelines, especially in the field of agriculture and forestry, the FAO came up with the guidelines for soil description²⁴, after which the guidelines for land-use Planning were published as FAO Development Series.²⁵

During these years the concepts, principles and definitions of *land, land utilization types, land qualities, land suitability classification and land evaluation procedures* were already specified but in some circles the notion of a single, overall "land quality" in the sense of health-of-land has come to the fore.

The importance of land resources, came to the forefront with the establishment of the Global Assessment of Soil Degradation (GLASOD). The initiative was launched by UNEP, in 1987, in cooperation with the International Society of Soil Science (ISSS) and FAO. It resulted in the International Soil Reference and Information Centre (ISRIC) in Wageningen producing, at short notice and on the basis of admittedly incomplete knowledge, a credible global assessment of human-induced soil degradation. With the support of about 250 correspondents from all regions of the world this resulted in a world map showing causative factors, type, degree, rate and geographic extent of soil and land degradation. It was meant to be a quick and rough first attempt and did not deal with off-site effects, but it successfully raised public awareness of the problem of land degradation. The results were amply used, if not over-used, in the discussions related to the UN Conference on Environment and Sustainable Development in Rio de Janeiro, 1992; in the World Resources Institute's publications; in UNEP's World Atlas of Desertification. It also illustrated the need for better, quantitative information and an assessment of the social and economic consequences of land degradation, and prompted the International Soil Conservation Organization (ISCO) to start with a World Overview of Conservation Approaches and Technologies (WOCAT).

The United Nations Conference on Environment and Development (UNCED) meeting in Rio resulted in a series of new initiatives on assessment of sustainability and resilience of land resources. Supported by various institutions like the Commonwealth Agricultural Bureaux International (CABI), the International Board of Soil Research and Management (IBSRAM), World Bank, etc. resulted in concrete proposals for action. Agenda 21, meaning an agenda for the twenty-first century marked a big step forward in bringing the role of land resources to wider attention. Agenda 21 includes 6 chapters devoted to Land resources a basis for production. Chapter 10, of Agenda 21, called "An integrated approach to land resources planning and management," is meant to provide the over-arching approach to the more sectoral land-use issues (on mountains, forests, deserts, rainfed agriculture, etc.).

Haans et, al²⁶, presents an overall view of the current situation of land evaluation and its application in the European community. He illustrates the progress which has been made, since the European Community Land Resource Evaluation Symposium of Wexford in 1978. It also includes a review of established methods and more detailed account of how to put into practice the more recent approach of land suitability evaluation.

A good number of articles dealing with concepts, theories and models of land use, land classification, land capability, dynamics of land use and cropping pattern in different regions of India are discussed comprehensively by Mohammed²⁷ in his edited work.

Chakravarty²⁸ argues that of all the life support system in India Land resources is the most important one for we derive the bulk of our food and other requirements from plants growing on soil. But, utilization of these resources abounds with multiple problems. He makes a comparison of land utilization of Assam with that of India and describes the problems associated with land use and its suitability.

V.K Sharma²⁹ has used remote sensing techniques to generate different land resource maps for some parts of southern Haryana and Delhi. The preparation of land resource maps has been carried out using black and white aerial photographs of 1:25,000 scale, and other village based agricultural land use data and co-lateral data. The main purpose of generating land resource maps is for land use planning of these selected areas.

Data on land resources is one of the most important requirement for land resource evaluation purposes. Preparation of resource maps at a global level in 1:1million and 1:10 million scale for general planning of land resources was carried by FAO as far back as 1969³⁰. At Regional level it was done for large continents, regions or very large countries like USA, USSR, Brazil, China and India in map scale of 1:500,000 and 1:5 million. Maps in a scale of 1:2000 and 1:100,000 depending on the stage of planning or execution and on size and nature of the region involved were prepared for large regions within countries and some small countries. Each of these maps were prepared with the help of appropriate details as determined by field observation, air photo interpretation and laboratory analysis.

The integrative surveys carried out by the land Research Division of the Australian Commonwealth Scientific and Industrial Research Organisation (C.S.I.R.O) also provide an effective means for an initial land resource inventory of developing regions³¹.

The use of Remote Sensing techniques and GIS have been widely used for different land resource related studies and its application in the field of agriculture, forestry, urban planning, flood mapping and monitoring etc. have been well established. Krishnayya et.al³² gives examples of the case study of the Northern Talukas of Raigad District, where IRS IC satellite data has been integrated with other spatial data to illustrate its application in grass roots. They were able to identify forest encroachments (through hutment, farmhouses and

quarrying) and a landuse/landcover analysis that is contextually relevant was done. This paper also discusses how integration of remote sensing data with other spatial and non-spatial data to demonstrate the micro-level application of present and near-future satellite data in development, planning and management.

Bhan³³ describes the role of Remote sensing and GIS in natural resource mapping and inventory and highlights the role of remote sensing in Agriculture, Soil resources, land degradation, landuse/landcover, forest, water resources, ocean application, wasteland mapping, landuse mapping, urban sprawl mapping, nationwide vegetation mapping, flood mapping and monitoring etc.

Mohammad³⁴ uses remote sensing and GIS techniques to address the problem of land use planning for sustainable agriculture land management and establish the fact that Geo-informatics (the science and technology for collection, management, analysis and presentation of geographic and other spatially defined data) can help in providing a scientific basis for sustainable use of land resource which can lead to sustainable agricultural land management.

Chakrabarti³⁵ discloses that present state-of-art technology of remote sensing and GIS has added new dimension to the land evaluation procedure through integration and analysis of the up-to-date non spatial data and related non-spatial data to generate application specific new data set-the Geo-information. He points out that land evaluation data-set constitute the prime layer of the geo-information which in turn strengthens scientific base for sustainable use of land and water resources, improve the efficiency in utilization of renewable resources through long term scientific assessment, specifies the domain of social adaptation and technical adjustment with the physical environment because man acts as main factor and also a dependent.

Martin & Saha³⁶ has carried out land evaluation using Remote Sensing and GIS for suggesting suitable cropping pattern for a watershed in parts of Dehradun district of Uttar Pradesh. This was done with an objective to avoid over and under exploitation of natural resources for agricultural production. Deterministic land qualities like soil texture, soil depth, drainage, slope, erosion, coarse fragments and flooding hazards were taken into consideration to undertake suitability analysis for agricultural land utilization types using remote sensing and GIS techniques.

The application driven approach adopted by the Indian Remote Sensing Programme has enabled the optimum utilization of remote sensing technology to address national priorities. To achieve this, the concept of a National Natural Resources Management system (NNRMS)- an integrated resource management system aimed at optimal utilization of the country's natural resource through a proper and systematic inventory of the resource availability using remote sensing data in conjunction with the conventional techniques has been evolved.

Any achievement in land use study in India is probably due to pioneer work done by the late L.D .Stamp in Great Britain. While attending the 'Science Congress Association at Calcutta in 1938 he highlighted special impetus on mapping of land utilization and suggested to follow the model of land utilization survey of England in India. Indian Geographers too have been long attracted to studying the problems of land use in the country with a view to finding out ways and means for scientific utilization of land. The 1940 session of the Indian Science Congress held at Madras witnessed the importance of land use related studies and the necessity to undertake land use survey in India which, was pointed out by Chatterjee.³⁷ In his series of articles from 1953³⁸ to 1962³⁹, he pleaded for rapid survey and mapping of only marginal areas of different categories of land utilization with the help of a general map

Information on Land use planning and methodology in India was first contributed by Shafi⁴⁰. In his paper he “A Plea for Land Utilization Survey” he made a strong plea to carry out a land utilization survey with land capability survey to determine the measures for using land to the best advantage in relation to its intrinsic qualities. Systematic purposive sampling approach to land utilization survey used by him in 1952 while conducting land utilization survey in eastern Uttar Pradesh was one of the pioneering work of its kind undertaken in India⁴¹. After detailed study of structure and relief, drainage and climate, and soils of the entire area, he divided the whole area into four homogenous strata and selected the representative villages from each spectrum. Shafi⁴² also discussed in detail about the methods and techniques of Land use planning, land classification and land capability. He has elaborated on the various methods and techniques used in USA, USSR, Poland and Britain in case of land classification and land capability classification. After a brief review of various techniques adopted in different countries, he recommended that any technique adopted for land use survey in India should aim at recording existing use of land in the first instance, followed by mapping of land capability or land potentiality at the next stage⁴³

1.7. Justification of the present study

Land degradation lowers the productive potential of land resources, affecting soils, water, and forests. If unchecked, it can lead to irreversible loss of the natural resources on which production depends. The direct causes of degradation are a combination of natural hazards with unsuitable management practices. Underlying these are economic and social reasons, fundamentally arising from poverty and land shortage. There is a causal link between population increase, land shortage, poverty and land degradation which in turn effects the people through reduced food supplies, lower incomes, greater risk, and increased landlessness.

The study undertaken for research work is on 'land resources evaluation', definition of which is illustrated in the introductory chapter. The word 'land resources' has been selected instead of 'natural resources' because the former term is both broader and narrower than the later. It is broader because it includes all man-made improvements that are attached to land. 'Natural resources' can involve a broader concept in that it includes all nature-given resources from the center of the earth to the highest heaven, while the term 'land resources' is limited to surface resources together with the thin layer of subsurface and supra-surface resources that man uses in his daily life.

Concern over the intimate relationship between man, land, and food supplies has influenced the writings and teaching of many of the world's great thinkers, including the early economists who viewed land as a key factor in production. This concern over man's ties to land and his natural environment is somewhat less evident now in many parts of the world, but land resources still play a role of elemental significance. Without them, man's civilization and very existence would speedily end.⁴⁴

The fact that the supply of land resources is fixed while population numbers and new technology are increasing and creating new capital developments and products has prompted some decline in the proportionate importance of the role land resources play in the whole society. This does not mean, however, that land resources are expendable or unimportant. Their significance in absolute terms grows steadily with each passing year.

The dependence of more than 80 percent of the population of North East directly or indirectly on land resources in itself is an indicator of the importance that Land resources play in supporting the basic needs of the people. In the past the pressure on land was not as much as it is today. The jhum cycle which was 8 to 10 years a few decades ago has now reached 2 – 3 years. This is an indicator of scarcity of land due to increasing population, which has ultimately resulted in

large scale degradation and deterioration of land resources. The problem is more acute in the study area which is inhabited by 100 percent tribal population, out of which almost 80 percent is dependent on agriculture, livestock, forestry, fishing, hunting and plantations. Unfortunately, the land resources which supports such a large chunk of population of this area is the least managed along scientific principles; rather it is subjected to fast ecological degradation due to the age old practice of 'bun' cultivation coupled with rising population.

In India, most of the studies related to land resources has been done with special emphasis on soil quality or the production capacity of soil. Land use related study has been carried out for specific implication mostly for agricultural land utilization. Recognising the need for optimal land use planning, a National Land Use and Conservation Board (NLCB) was established in 1983, and restructured in 1985 with the main objective of formulation of National Land Use Policies, preparation of Perspective Plan (PP) for optimum utilisation of land resources and to coordinate similar activities in States through State Land Use Boards, It accords high priority to land resource conservation and has adopted perspective plan approach to reconcile the growing demand of land for satisfying various needs of the society. Besides, the evaluation studies carried out under the auspicious of NLCB, status of implementation of these 19-points by the State Govt. is being obtained and compiled by NLCB for a review of the situation on land use and framing future action plans.

Though data for general land use and land cover is available at the national and state level, data related to micro unit at a district or block level does not suffice to make an assessment of the existing resources. Moreover, the absence of cadastral maps makes it difficult to obtain accurate thematic maps of the area. Therefore, remote sensing data is the only source from which accurate and up-to-date information on the over ground land resources can be obtained.

The present study is an attempt to generate a detailed thematic maps related to different land resources of the area from remotely sensed data and to combine these maps with other primary and secondary data and to analyse and evaluate the land resources in a GIS environment, so that a proper planning and management strategies of the area can be generated.

1.8. Methodology

Land resources data and land resource maps are the only reliable basis for predictions and interpretations of Land qualities⁴⁵. Basic land resource maps can always be reinterpreted for practical use with new assumptions or under new conditions. The methodology that has been applied for land resource survey is done in a multidisciplinary and integrated manner by collecting all possibly relevant data on the natural resources as well as the human resources. This has been done with the help of personal interviews, questionnaires, collection of data from different offices. Remote sensing data has been one of the most important sources for different thematic maps, substantiated by toposheets, ground truthing and other relevant methods.

Satellite images utilized for the present study indicate the spatial aspects of land use, landforms i.e. relief, drainage etc and other land cover, which are indicative of some aspects of other components. A thorough reconnaissance survey and familiarization with the area has given more additional land components i.e. permanent cultivation, bun cultivation, plantations etc. which has been eventually incorporated in the map.

Land cover and landforms generally constitute the primary sources of information for image interpretation supplemented by field data like soils, climate, etc. Land cover and land use classification system is an important aspect for image interpretation. There are various standard land use classification i.e. the world land use survey 'master key' (LUS-1)-prepared by a special world land use commission of the international Geographical Union (IGU) in 1952⁴⁶, LUS-2,

prepared in 1976⁴⁷ which was a refined version of LUS-1, but the basic conceptual drawbacks in differentiating land use and land cover and its inapplicability at micro level does not suit the purpose of land use, land cover classification for the present study. The land use / land cover (LUCC)⁴⁸ which has been formulated by the ITC is a much preferred classification as it provides consistent differentiation between land use and land cover; it is applicable at any scale for both satellite imageries and aerial photograph and exclusively designed for rural application. Therefore, the present land use/ land cover classification is primarily based on the ITC, LUCC, with slight modification, keeping in view the interpretability of the classes on satellite images.

In the present study, the physical aspects of land are first studied and mapped to provide a geographical framework into which the socio-economic dimensions are inserted later. Two basic stages to the assessment of land resources as applied in the present context is:

1. natural resource survey and land evaluation. Natural resource survey refers to the description, classification, and mapping of the physical environment viz. climate, water, landforms, soils, vegetation, etc.
2. land evaluation, the potential of the mapped areas for different kinds of land-use are assessed.

The land evaluation process described in figure 1.1. adopted from Young⁴⁹ and Rossiter⁵⁰ depicts a powerful interaction that occurs between all the stages in the land evaluation, which means that the planning process must be approached as a whole. The requirements of the different kinds of use that are to be evaluated largely determine the range of basic data that must be collected before evaluation can begin. Later, the identification of suitable forms of land use provides the building blocks for land-use planning.

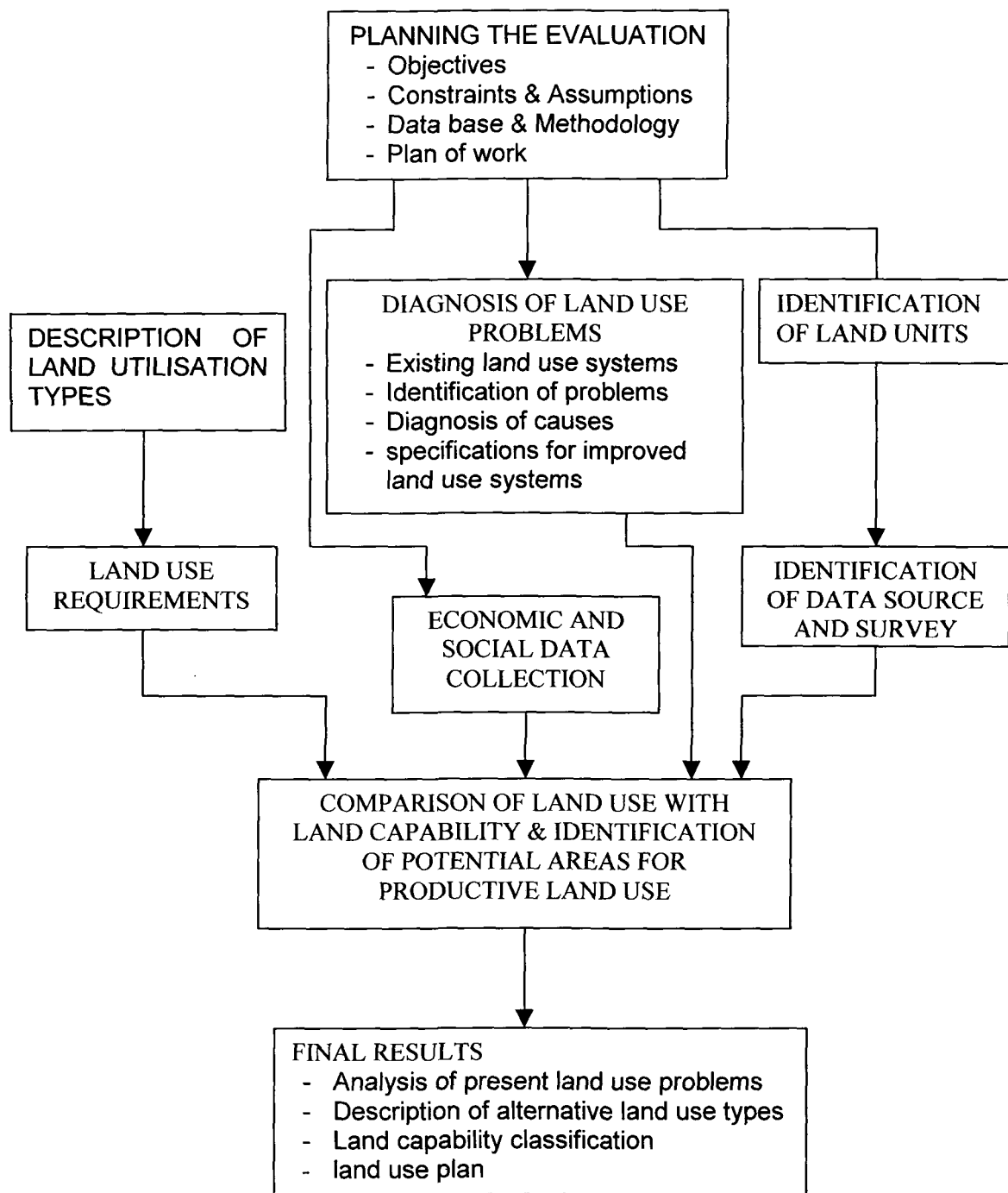


Fig.1.1. The land evaluation process.

1.9. Data Source and Data Collection

Remotely sensed satellite data is an important source of information on land characteristics. The principal use of remote sensing in the present study is to:

1. Produce land use and land cover maps;
2. Identify land mapping units such as geomorphic forms and ecological zones;
3. Update base maps
4. Locate specific points of interest to the evaluation, e.g. settlements;
5. Provide time series for temporary or seasonal phenomena, e.g. crop growth, vegetation intensity.

Table-1.1. Details of data source and range of data.

Data source	Details	Range of data
Toposheet	Survey of India toposheet No. 78 O/15, 83 C/3, 1:50,000 scale.	vegetation, water resources, land use, infrastructure, landforms
Satellite imageries	FCC, LISS III, IRS IC, 1:50,000 scale. & IRS IC PAN data in 1:25,000 scale	vegetation, land use, water resources, landforms, soils.
Ground survey	collection of soil samples, questionnaires, personal interviews, observation and field verification	soil, types of vegetation, agriculture, social and economic data
Secondary survey	Collection of relevant materials through the Block Development Offices, and other State Govt. and Central offices, including web sites.	Qualitative and quantitative information on soil, climate, landform, vegetation, land use, population, social and economic data.

The range of data that could be relevant to land resource evaluation is huge, but for the present purpose of study three basic sources have been widely used to collect maximum information.

1. Survey of India, Toposheet & Satellite Imageries have been used to generate the different thematic maps, viz. Land-use/Land cover. This has been further verified through ground truthing.
2. Data relating to socio-economic, climatic data, agricultural production etc. is collected from secondary sources, viz. District Census Office, Directorate of Agriculture, Block Development Office, National Informatic Centre, North Eastern Council etc.
3. Data which were not available from the above two sources, pertaining mainly to house-hold and village level information on farm size, agricultural input and output, etc were collected from the field investigation through personal interviews and questionnaires.

The application of space remote sensing has made remote sensing a very powerful tool for continuous monitoring of environment both in space and time domains, because of its unique capability in providing timely, repetitive and synoptic coverage over large areas across various spatial scales. In the present study, most of the thematic maps has been generated from satellite data. The collection of natural resource data through Remotely sensed satellite imageries has been carried out by visually interpreting the IRS IC PAN, 1:25,000 and IRS IC FCC 1:50,000 satellite data obtained from National Remote Sensing Agency, Hyderabad. It was possible to generate areas under rural settlement, roads, agricultural land etc. from the PAN images, whereas, vegetation cover, water bodies, degraded lands etc. could be more precisely mapped using the False Colour Composite imageries. The scale difference between the two maps was brought to an uniformed scale of 1:50,000 through reduction of the 1:25,000

scale. A Base Map (Map.1.1) depicting some prominent features rivers, roads, villages, etc, created from Survey of India (SOI) toposheet was used to record the field data, and also to rectify the displacements of objects and other errors in the satellite imageries. Contour maps, out of which relief and slope maps were generated is also extracted from SOI toposheet. The analysis is carried out at 1:50,000 scale.

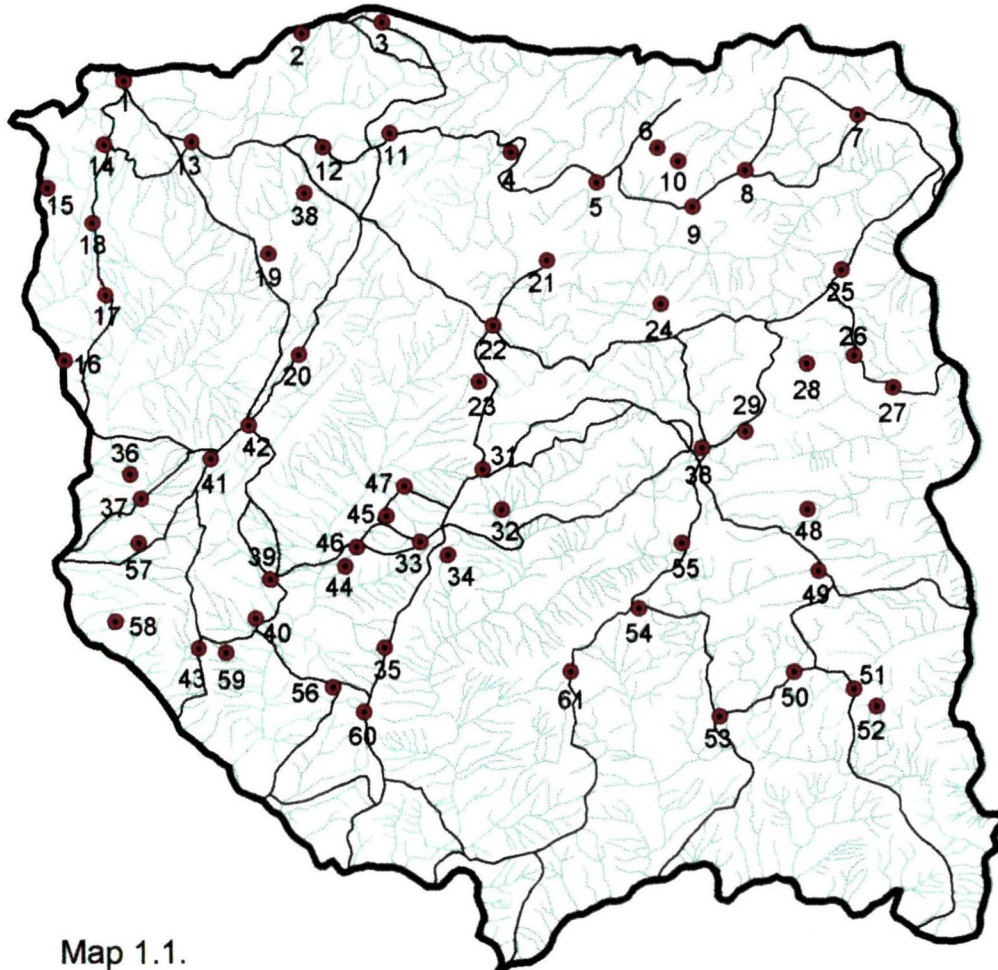
1.10. Use of Remote Sensing & GIS Techniques.

Recent development in the field of remote sensing has enhanced its application in various studies related to the environment and natural resources both in space and time domain. Remote Sensing has an advantage over the conventional method of mapping and data collection because it has unique capability in providing timely, repetitive and synoptic coverage over large areas over various spatial scales. In land resource related studies, remote sensing technology provide vital inputs for tackling some of the urgent environmental problems related to deforestation, land degradation and other anthropogenic problems at a local or micro level.

Remote sensing technologies for resource mapping have gone a long way ahead ever since it came in existence in the late 1960s. The advancement in the area of sensor system and availability of different platforms has made it possible to operationalise its utility in many areas of land resource mapping at the global, regional and local level. For effective harnessing of the natural resources, remote sensing technique has been used world-wide as a tool for resource mapping, monitoring and inventorisation have been achieved upto a reasonable level of accuracy in time and space domain, and also in a cost & time effective manner.

Remote sensing has been the subject of continuous research internationally for the last many decades and the most significant contributions include its wide use in inventory preparation for land, soil, vegetation, crop, water and mineral resources. The advantages of adopting the new and evolving spatio-

Mawkyntew C & R. D. Block BASE MAP



Code	Village Name		Village Name
1	Thangning	31	Ladryngngi
2	Mawiali	32	Umsham
3	Thynroit	33	Lyngshing
4	Kharang	34	Mynriah
5	Piengweit	35	Langsiew
6	Dinglieng	36	Umpdem
7	Nongjriong	37	Wahumsim
8	Syniasya	38	Madan Demkhieng
9	Umsning	39	Rngibah
10	Tanglei	40	Rangbuli
11	Jongksha	41	Mawlyngngot
12	Mawiapbang	42	Iewrynghep
13	Rableng	43	Ryngkya
14	Laitdiengsai	44	Kiang
15	Laitkyrhong	45	Siltham
16	Rangphiang	46	Khwad
17	Rasong	47	Nongpyrdi
18	Laitlum	48	Paskang
19	Mawbiang	49	Umsaw
20	Umkhoi	50	mawlang
21	Mawlein	51	Mawjatah
22	MAWKYNREW	52	Siangkhnai
23	Umtong	53	Syngtung
24	Laitmynsong	54	Khlieh U Sem
25	Mynsang	55	Mawsna
26	Mawdulop	56	Mawkhia
27	Ksanngi	57	Khapmaw
28	Mawsir	58	Iapdkhoh
29	Jatah Nonglyer	59	Thangbnai
30	Jatah Lakadong	60	Mawliat
		61	Mawrasai

1000 Mts 0 1 2 3 4 5 Kms

Map 1.1.

temporal analysis tools such as remote sensing, geographic information system and computerized data management in monitoring and managing land resources and the environment has been successfully demonstrated during the last three decades.

One of the most important application of remote sensing has been in the field of land use planning where 49 percent of the data generated from satellites is used for this purpose; 25 percent for military intelligence; 20 percent in agriculture, forestry and fishing; 5 percent in crisis management; and 1 percent in education, media and entertainment.⁵¹

Satellite remote sensing data at various spatial and temporal scales offer some of the following advantages:

1. most economic means of assessing the environmental parameters and impact of development processes.
2. excellent capability to monitor ecosystem composition, impact of management and degradation processes due to its repetitive nature of spatial data.
3. integrated information derived from the satellite data assists in evolution of appropriate action plans for initiating sustainable development.

In India, remote sensing programme took its root in 1970. The launching of the first Indian remote sensing satellite, IRS-IA in March 1988 provided a unique opportunity to use remote sensing data for various natural resource related studies i.e. forestry, wasteland, vegetation, crop, surface and ground water, marine resources, urban planning, assessment of land use etc.. This techniques have been successfully applied for many specific study i.e. crop acreage estimation (one month in advance) with more than 95 percent accuracy; detection and delineation of water logged area and salinity affected areas; identification and delineation of small size waste lands and preparation of

developmental plans on scales larger than 1:12,500; ground water prospects; erosion prone areas; location, extent and types of land and water pollution; jhum fires and impact of jhum cultivation; infrastructure development; urban planning; habitat management; drought warning; floods, etc. has been some of the specific studies where remote sensing techniques has been widely utilised to obtain vital information and necessary data.

The study area owing to its specific features of certain topography and difficult accessibility of some areas, has go a special relevance for the use of remote sensing technique in land resource management. The practical use of remote sensing is mainly to oversee conditions or solve problems dealing with the physical and cultural environment, mainly emphasising on the status of land resources in so far as these affect human activities.

GIS as a tool for mapping, analysing and storing data provides the best possible means for undertaking land resource evaluation. It has certain advantage over the conventional or manual method of drawing and analysing quantitative and qualitative data, they are:

1. easy, quick and permanent storage & retrieval of data.
2. accurate analysing and calculation of areas under different land use & land cover
3. Automatic procedures and data Integration Techniques
4. three dimensional view, Simulation and Modeling.

1.11. Organisation of the Manuscript

The contents of the research work are organised and classified in the following seven major chapters:

The first chapter elucidates the research design, and begins with an introduction on the concept of land resources, which is followed by the statement of the problem and the reasons why land evaluation is necessary. Some of the

assumptions and research questions, objectives and justification is included in this chapter, and an overview of the literature on the topic of research and the methodology that has been adopted to achieve the desired result have been discussed.

The identity of the study area in terms of its location, aerial extent and various other physical aspects like geology, geomorphology, physiography, relief and stream morphometry is discussed at length in the second chapter. In the absence of weather stations, the climatic conditions prevailing in the study area has been vividly described by analysing the data obtained from adjoining weather stations. A general description of the soil and agro-climatic zones of the study area is also accounted in this chapter.

The third chapter deals with the socio-economic condition of the people residing in the study area. The demographic characteristics and the availability and distribution of educational, medicine and health, drinking water, post and telegraph, market, transport and communication facilities are discussed. The economic activities of the people living in the study area is analysed under the various categories of occupational structure at the village level have been discussed with relation to its effect on the land resources.

The fourth chapter enunciates the taxonomy of land capability classification and the factors affecting it. It also describes the soil and slope condition of the study area according to which a land capability classification map is prepared and its suitability for agricultural and non-agricultural land use is accounted in this chapter.

The spatial distribution of the existing landuse/landcover pattern, the changes that has taken place in the landuse/landcover from 1965/66 to 1997/98, and the influence of physiography and slope in the utilisation and of land resources are the major highlights of the fifth chapter.

A diagnostic survey of land resources for landuse planning is covered in the sixth chapter. It further elaborates the importance of watershed as a planning unit, and describes the land resources and land capability classification of each watersheds separately. An environmental appraisal of landuse potential, major concerns in landuse planning and alternatives for better land utilisation and conservation is also discussed at length in this chapter.

The entire research work is finally summarised and concluded in the seventh chapter.

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CHAPTER-II
PHYSICAL SET- UP

CHAPTER II

PHYSICAL SET-UP

2.1. Identity of the Study Area.

Mawkynrew is one of the seven C.D.Block of East Khasi Hills district of Meghalaya (Map.2.1). It was created on 3rd March 1980 with its headquarter at Mawkynrew¹. It is located about 46 Kms away from the State Capital Shillong, and has a total geographical area of 355 Sq.Kms comprising of 65 villages. The geographical extend of the area is 91° 55' to 90° 10' East longitude and 25° 15' to 25° 33' North Latitude and is covered by Survey of India topo-sheet No. 78 0/14 and 83 C/3. The area is bounded by Mawryngkheng C.D.Block in the North, Pynursla C.D.Block in the West, and by Thadlaskein and Amlarem C.D.Block of Jaintia Hills in the East and South respectively.

2.2. Geology

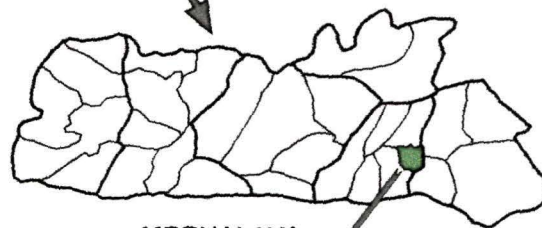
The geological formation of study area can be best understood by first examining the geological characteristic of the entire state of Meghalaya. The rock formation of this region which is part of the peninsular plateau ranges in age from the Precambrian to the Quarternary period. Genetically the rocks cover a wide spectrum of unlithified sediments and sedimentary rocks, formed by exogenic processes, and metamorphic and magmatic rocks formed by deep-seated endogenic processes.

The general stratigraphic sequence of the geological formations in Meghalaya is illustrated table-2.1.

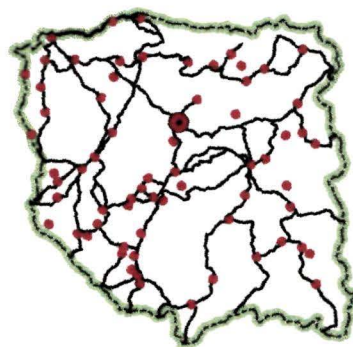
LOCATION MAP OF MAWKYNREW C&R.D.BLOCK
EAST KHASI HILLS, MEGHALAYA, INDIA



INDIA



MEGHALAYA



STUDY AREA

Legend

- VILLAGE LOCATIONS
- MAWKYNREW
- ROADS
- BLOCK BOUNDARY

Map 2.1

Table-2.1: Stratigraphic sequence of geological formations in Meghalaya

Geological Age	Group	Formation	Rock type
Recent	New Alluvium (thickness not known) Older Alluvium (thickness not known)	Unclassified	Sand, silt and clays
Pleistocene		Unclassified	Sand, clay, pebble, gravel and boulder deposits.
Mio-Pliocene	Dupi Tila Group (1050 m)	Unconformity	Mottled clays, feldspathic sandstone and conglomerate
		Unclassified	
Oligo-Miocene	Garo Group	Chengapara formation (700 m)	Sand, siltstone, clay, marl.
		Baghmara formation (530 m)	Feldspathic sandstone, pebble conglomerate, clay, silty clay.
		Kopili Formation (500 m)	Shale, sandstone, marl
Eocene	Jaintia Group	Simsang Formation (1150 m)	Siltstone-sandstone alternations, sand.
		Shella Formation (600 m)	Alternation of sandstone and Limestone
		Langpar Formation (100 m)	Calcareous shale, sandstone, limestone
Upper Cretaceous	Khasi Group	Mahadek Formation (150 m)	Arkose (glauconite)
		Bottom conglomerate Fm. (25m)	Conglomerate arkose
		Jaudkata Formation (140 m)	Sandstone conglomerate alternations.
Jurassic	Sylhet Trap (600 m)	Unconformity	Basalt, alkali basalt, rhyolite acid tuff.
		Unconformity	
Pre-Cambrian		Intrusives (Acid & basic)	Porphyritic and coarse granites, pegmatite, aplite, quartz vein epidiorite dolerite, basalt
		Shillong Group	Quartzite, phyllite, conglomerate
Archaean		Unconformity	Biotite-gneiss, biotite-hornblende gneiss, granitic gneiss, migmatite, mica-schist, sillimanite quartz schist, biotite granulite-amphibolite, pyroxene-granulite etc.
		Gneissic Complex	

Source: Geological Survey of India, North Eastern Region, Shillong.

The Archean basement of Meghalaya is a remnant of the northeasterly extension of the Indian Peninsula. It remained a land-mass experiencing earth movements leading to complete flooding and fracturing of the ancient rocks till Precambrian times when the central part now covering the eastern Khasi (includes the study area) and Central Jaintia hills, developed into a trough over which the sediments of Shillong Group of rocks is laid down. The sediments, later uplifted and folded, experienced low grade metamorphism as a result of granitic (Mylliem granites) and basic, ultra basic (Khasi green stone) intrusions². The study area falls under the Shillong series of perametamorphites and comprises of quartzite, usually friable, with sub-ordinate phyllite, quartz-sericite schist, conglomerate etc. It is exposed in the central and eastern parts of the Meghalaya plateau in districts of E. Khasi Hills and parts of Ri-Bhoi. The Shillong group of rocks are weakly metamorphosed marked by conglomerate containing cobbles and boulders of earlier rocks, i.e. archean crystallines, which formed the basement over which the Shillong series of rocks were originally laid down as sedimentary deposits in pre-cambrian times probably under shallow marine conditions. The direction of strike is NE - SW.

2.3. Geomorphology

On the basis of landform association, lithology, micro and macro climatic conditions and the prevalent fluvial processes the Meghalaya Plateau is divided into three main geomorphic provinces, namely the Northern Hill region, the central plateau and the southern dissected plateau³. Excepting the Northern Hill region, the study area distinctly indicate two of the later geomorphic characteristics:

2.3.1. The Central plateau region

The central pleateau region extends from the North western boundary of the study area and covers much part of the northern and central region. Its outer limit can be defined roughly by the contour line of above 1300 metres. These

areas contain the highest peneplain surface over which the tributaries of the rivers indicate adjustment to local structure and lineaments.

2.3.2. The Southern dissected plateau.

The southern dissected plateau covers most of the southern and south western region of the study area. The elevation is lower than that of the central plateau region with steeply dissecting hills affected by folding and faulting. The field evidences such as presence of deep gorges, V shaped valleys, water falls, support the presense of erosion and upliftment and are good evidence of rejuvenation of the region.

In order to bring out a comprehensive picture of the relationship between man and land resources and to evaluate the overall environmental aspects, the study area can be classified into the following landform units:

2.3.3. Plateau remnant.

The study area reveals a platform/table land like topography with high level of dissection, especially in the southern part of the study area, which much more dissected by deep valleys in comparison to the rest of the areas.

2.3.4. Deeply dissected Uplands

The deeply dissected uplands also reveal a similar topography of Plateau remnant, but it has a more intricate level of dissection. This is more prominent in the south western part of the state, where the influence of geological structure on the geomorphology is prominent. These areas have more or less dense vegetative cover.

2.3.5. Denudational Hills

This type of topography is characterised by sharp crested or low rounded hills with narrow or open valleys. They are formed due to the stripping up of loose, weathered material from the landscape by various processes of erosion.

Such features can be seen mainly in the Northern part of the study area which is mostly devoid of vegetation, but dominated by agriculture.

2.4. Physiography.

The study area is characteristic of the Meghalaya plateau representing a remnant of ancient plateau of Pre-cambrian Indian peninsular shield uplifted to its present height of about 600-1800m above Mean Sea Level. Based on detailed investigation of the landforms, agro-climatic and geological setup, the degree of undulations and slope angle, the study area can be divided into two distinct physiographic divisions (Map.2.2). They are:

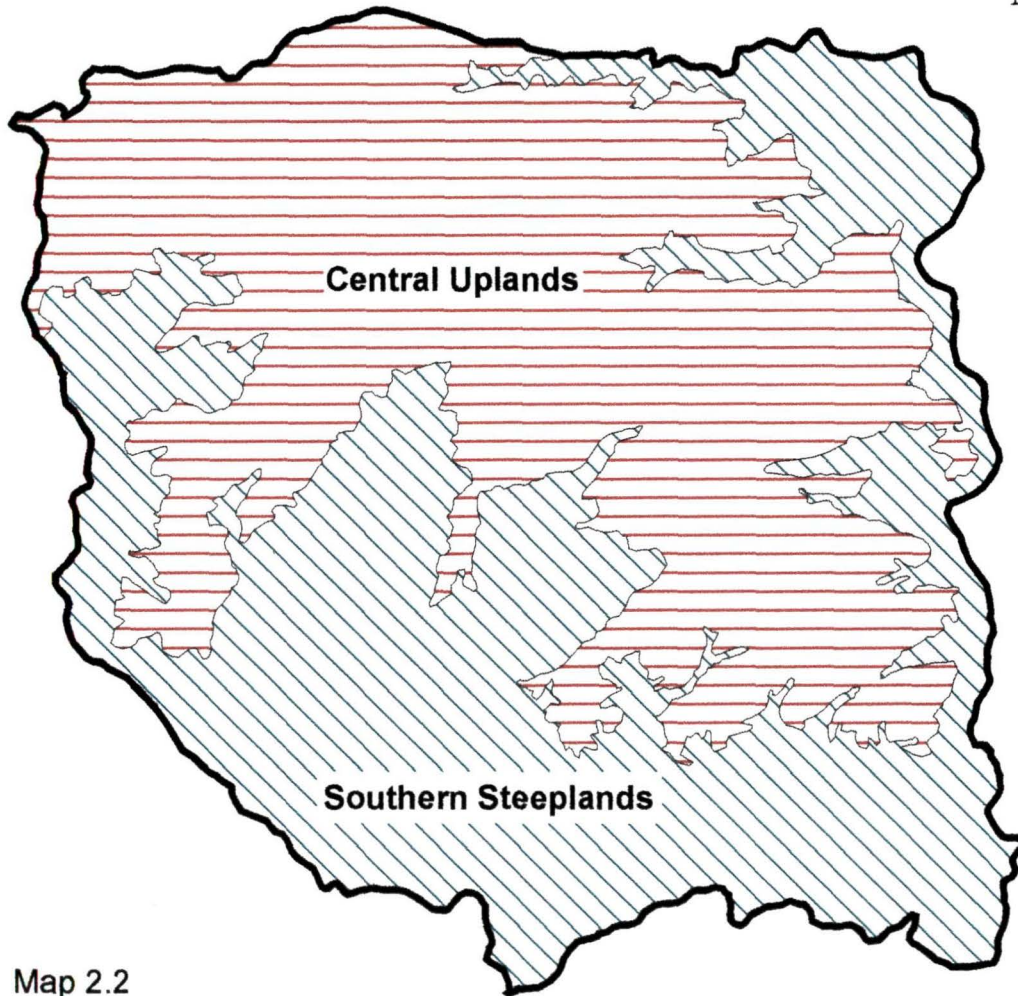
2.4.1. The Central Plateau Region.

This region comprises of 181.95 sq.kms (50.54%) of the study area stretching from the northern boundary and extending towards the eastern and south eastern portion of the study area. Its main characteristics are - folded undulating uplands with rolling hills, and comparatively shorter slopes, comprising of the Shillong groups of rocks. These areas can be grouped in the per-humid thermic sub eco-region having semi temperate to temperate climate with a mean annual temperature ranging from 15° to 22°C. The elevation in this physiographic division ranges from 1000 to 1600 meters.

2.4.2. The Southern Steep Lands.




These are areas which are characterized by steep to very steep slopes and long escarpments, and steeply dipping faults stretches southwards abruptly from the central pleateau within the Shillong group of rocks, with per-humid hyperthermic sub-eco region having subtropical climate with annual temperature of above 22°C. It occupies 49.46 percent of the study area with elevation of below 1000 meters above mean sea level falling to as low as 100 meters in a few places.

Mawkynrew C & R. D. Block PHYSIOGRAPHY



Legend

PHYSIOGRAPY

-  Central Uplands
-  Southern Steeplands
-  Block boundary

Map 2.2

1000 Mts 0 1 2 3 4 5 Kms

Table-2.2: Description of Physiographic units

Physiographic Unit	Elevation (in meters above M.S.L)	Average Slope (in Degrees)	Area (in Sq.Kms)
Central Uplands	1000 to 1600 (1848)	Less than 18 (2° minimum)	181.95 (50.54%)
Southern Steeplands	Less than 1000 (100 minimum)	More than 18 (45° maximum)	178.05 (49.46%)

Table-2.2. gives the detail of the physiographic characteristics of the study area. It is clear from this Table that the total geographical area is almost equally divided between the central uplands and the southern steplands. However, the average slope is more uniform in the Upper and Mid Central Uplands, while the southern steplands have very short slopes and elevation falls abruptly from place to place.

2.5. Relief

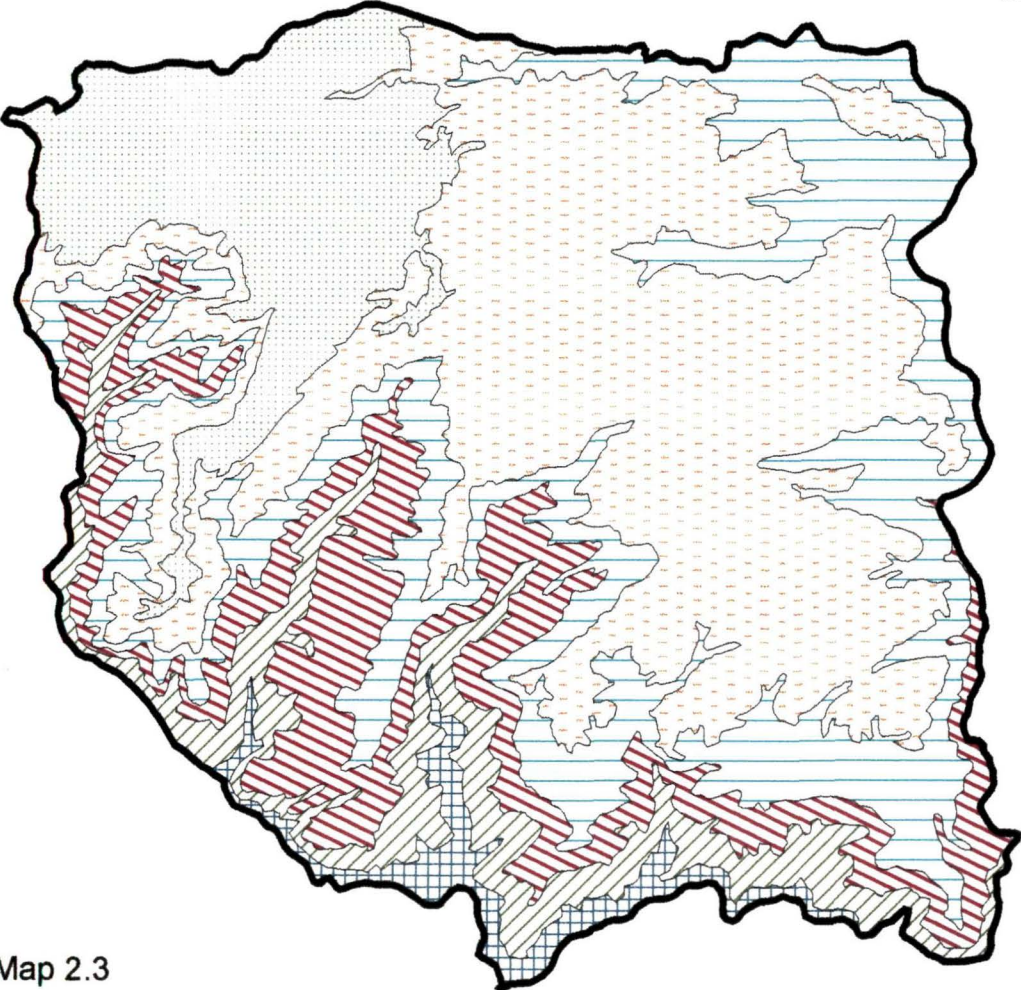
The term 'relief' here implies relative elevation and irregularities of the terrain or land surface considered collectively. The general relief of the study area is excessive, except in few pocketed narrow valleys and lands adjoining rivers and streams. The altitude varies from 200 to 1900 meters above mean sea level with general aspect towards the south. The central plateau region are areas which have elevation of more than 1400 metres, but are less to moderately excessive, whereas, the southern steep slopes are lower regions having altitude of 300 to 600 metres, occupying lesser area with narrow and steep slopes. The relief of the study area is divided into six units by taking a contour interval of 300 meters (Table 2.3 & Map. 2.3).

Table-2.3: Area under different relief conditions

Above MSL (in meters)	Excessiveness	Total Area	Area in Percentage
More than 1600	Less excessive	49.74	13.82
1300 – 1600	Moderately less excessive	134.29	37.30
1000 – 1300	Moderately excessive	83.64	23.23
700 – 1000	Excessive	50.57	14.05
400 – 700	Strongly excessive	31.27	8.69
Less than 400	Very strongly excessive	10.49	2.91
		360	100


Mawkynrew C & R. D. Block

RELIEF



Legend

Relief

-  Excessive
-  Less excessive
-  Moderately excessive
-  Moderately less excessive
-  Strongly excessive
-  Very strongly excessive
-  Block boundary

Map 2.3



i. Less excessive

The less excessive regions constitute the North Western part of the study area and is located at an elevation of above 1600 meters above MSL almost uniformly distributed and reaching to 1848 meters, which is the maximum spot height of the study area. It constitutes of only 13.82 percent of the geographical area. The rolling hills, gentle slopes and scattered river valleys are some of the characteristics of this region.

ii. Moderately less excessive

This region is an extension of the Upper Central Uplands, but having a difference of about 300 meters i.e. 1300 to 1600 meters above MSL. The moderately less excessive region is the most widely distributed region covering a geographical area of 37.30 percent of the study area.

iii. Moderately excessive

Covering an area of 23.23 percent, the moderately excessive regions lying at an elevation of 1000 to 1300 meters stretches from the Northwestern part of the study area in a narrow strip towards the Southern and Northeastern direction. Some of the areas especially in the northwestern portion of this region have highly rugged and steep slopes while the southeastern part is predominated by gentler slopes and river valleys.

IV. Excessive

With an altitudinal variation of 700 to 1000 meters, and a geographical area of 14.05 percent, this region forms a distinct physiographic unit, which divides the central uplands and the southern steplands. The region is characterized by steep slopes and highly rugged terrain conditions beyond which sudden and abrupt fall of elevation, can be noticed.

V. Strongly excessive

The strongly excessive region forms a continuous area along the Southern Steepland, but falls rapidly to an altitude of 400 to 700 meters above MSL. Much of the erosional and depositional activities is carried out in this region, leading to the formation of deep gorges and narrow river valleys. The total geographical area covered by the strongly excessive relief is 8.69 percent.

VI. Very strongly excessive

This region is the southernmost stretch and the lowest elevated areas (Less than 400 meters) of the study area. It comprises of 2.91 percent of the total geographical area with highly rugged and steep slopes.

One of the important physiographic and relief characteristics of the study area is the nature of gentler slopes and higher elevation of the central uplands, and the lesser relief but more rugged terrain of the southern steeplands. This divides the study area into two distinct physiographic and watershed divisions, which makes each other very unique.

2.6. Lineament

Murthy⁴ et al is of the view that lineaments are manifestation of deep seated fracture systems having repeated reactivation. Mapping of lineaments is done on the basis of linear features, such as streams, escarpments and mountain ranges, and zonal features that in many areas are the surface expression of fractures or fault zones.

Based on the satellite imageries of the study area the following lineament categories have been derived:

North – South 340° to 20°

North East to South West 25° to 65°

East –West 70° to 110°
North West to South East 295° to 335°

The direction of most of the lineament features of the study area is North-east to South-West and East-west facing (Map.2.4). This is characteristic of current bedding and intrusion by ultramafic sills and dykes. The East-West strip overlies the eroded Precambrian basement and themselves are non-conformably overlain by the upper Cretaceous sediments which is characteristic of the Sylhet traps comprising predominantly along the southern border of the Shillong Plateau⁵

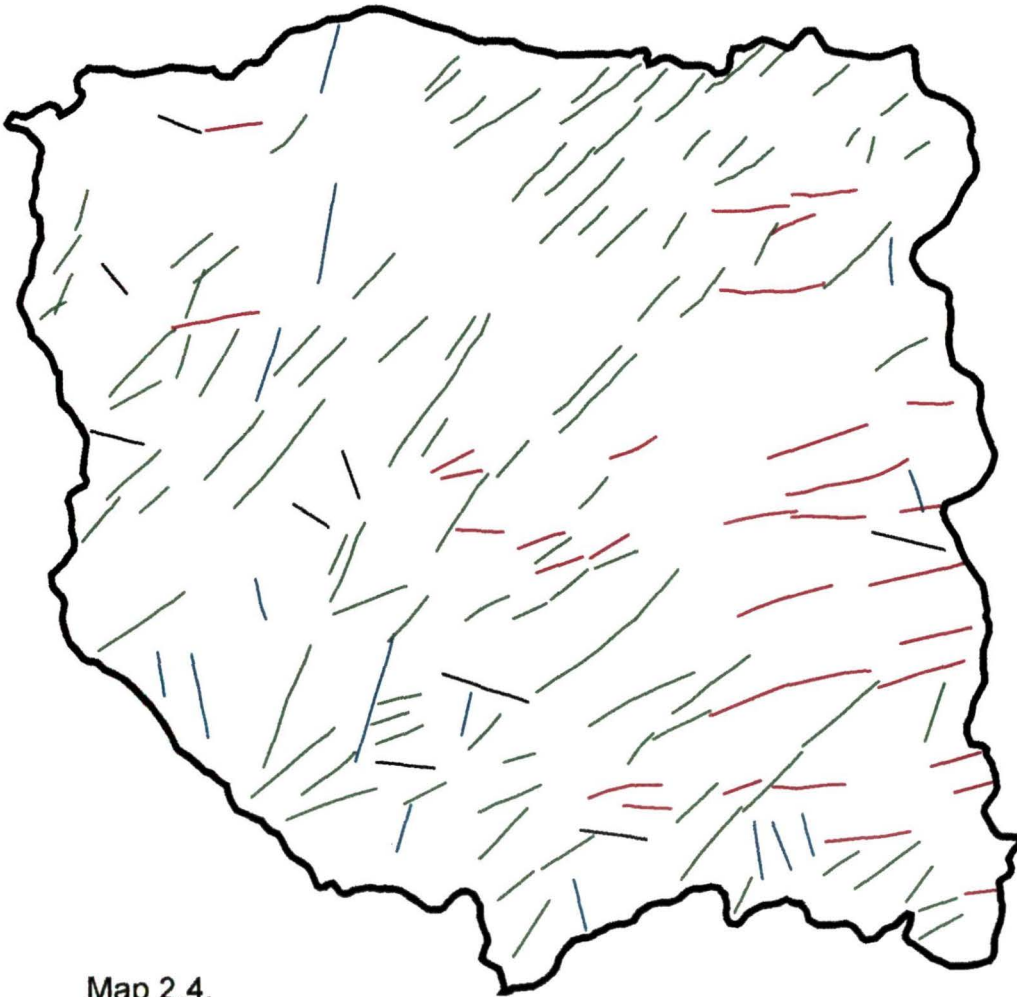
2.7. Stream Morphometry

Morphometric studies (defined as the measurement of the shape) in the field of hydrology were first initiated by R.E. Horton⁶ and A.E. Strahler⁷. Stream orders, drainage density and drainage frequency are considered to be an important exercise mainly because drainage system directly or indirectly influences the quality of other land resources like vegetation, soils, land use etc. Its understanding also helps to discover the holistic drainage properties for proper land use planning and management.

2.7.1. Stream order






In this system, channel segments were ordered numerically from a stream's headwaters to a point somewhere down stream. Numerical ordering begins with the tributaries at the stream's headwaters being assigned the value 1. A stream segment that resulted from the joining of two 1st order segments was given an order of 2. Two 2nd order streams formed a 3rd order stream, and so on (Fig.2.1).

Mawkyntew C & R. D. Block LINEAMENT

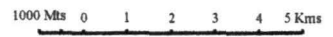


Legend

Alignment

-  E - W
-  N - S
-  NE - SW
-  NW - SE
-  Block boundary

Map 2.4.



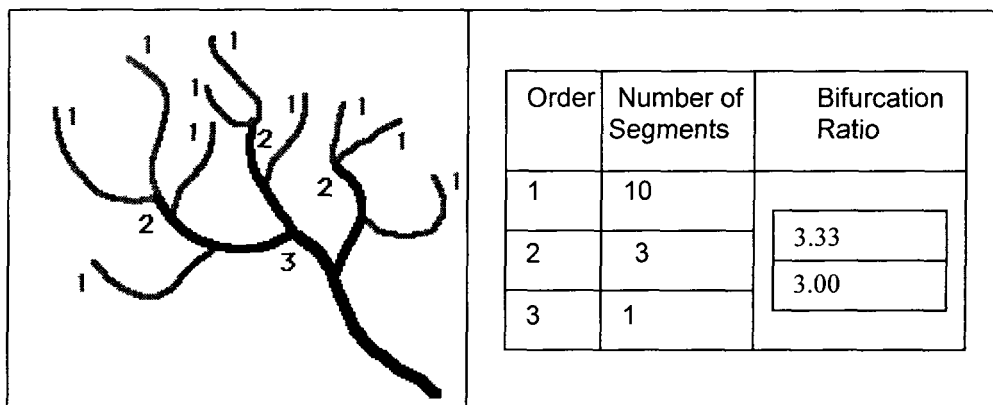


Fig. 2.1. Stream Ordering & bifurcation ratio

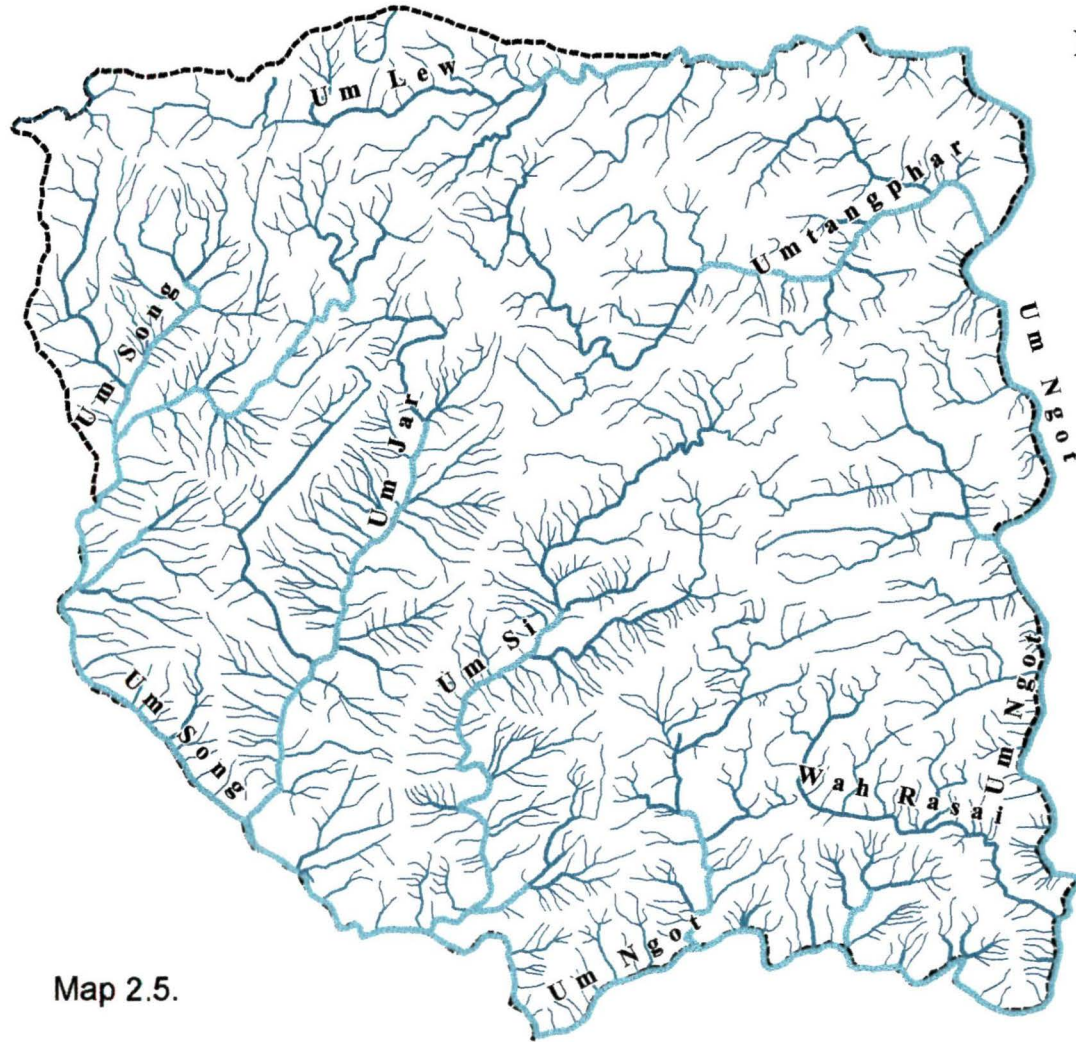
The analysis of stream orders (Table-2.4.) reveals that the 1st order streams occurs 1095 times over an area of 360 sq.kms, and comprises of 60.48 percent of the total length. Its density is much higher in the southern steep lands where it forms the origin and source all the streams and rivers. The 2nd order streams occur 330 times and covers 19.24 percent of the total lengths of all the streams. Though this two stream orders constitute a very high proportion of the total length of streams in the study area, its utility for irrigation purposes is not very significant. The 3rd order and 4th order streams constitutes most of the major rivers of the study area (Map 2.5). Although the number of occurrence and length of the streams are relatively less than the first two order streams, it provides much of the fertile river valleys where settled agriculture is widely practiced, especially in the central upland region.

Table-2.4: Stream order, occurrence, bifurcation ratio & stream length

Stream Order	Number of Occurrence	Bifurcation Ratio	Length in Kms	Length in %
1 st	1095		678.14	60.48
2 nd	330	3.3	215.70	19.24
3 rd	104	3.2	111.13	9.91
4 th	34	3.1	116.23	10.37
	1563		1121.2	100

Analysis of this data also reveals some interesting relationships. For example, the ratio between the number of stream segments in one order and the

Mawkynrew C. & R. D. Block STREAM ORDER



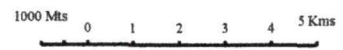
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Rivers/Streams

- 1st Order
- 2nd Order
- 3rd Order
- 4th Order

Block Boundary

Map 2.5.



next, called the birurcation ratio is consistently around three. R.E. Horton called this association the law of stream numbers⁸.

2.7.2. Drainage Density

Drainage density is a measure of the length of stream channel per unit area of drainage basin. Mathematically it is expressed as:

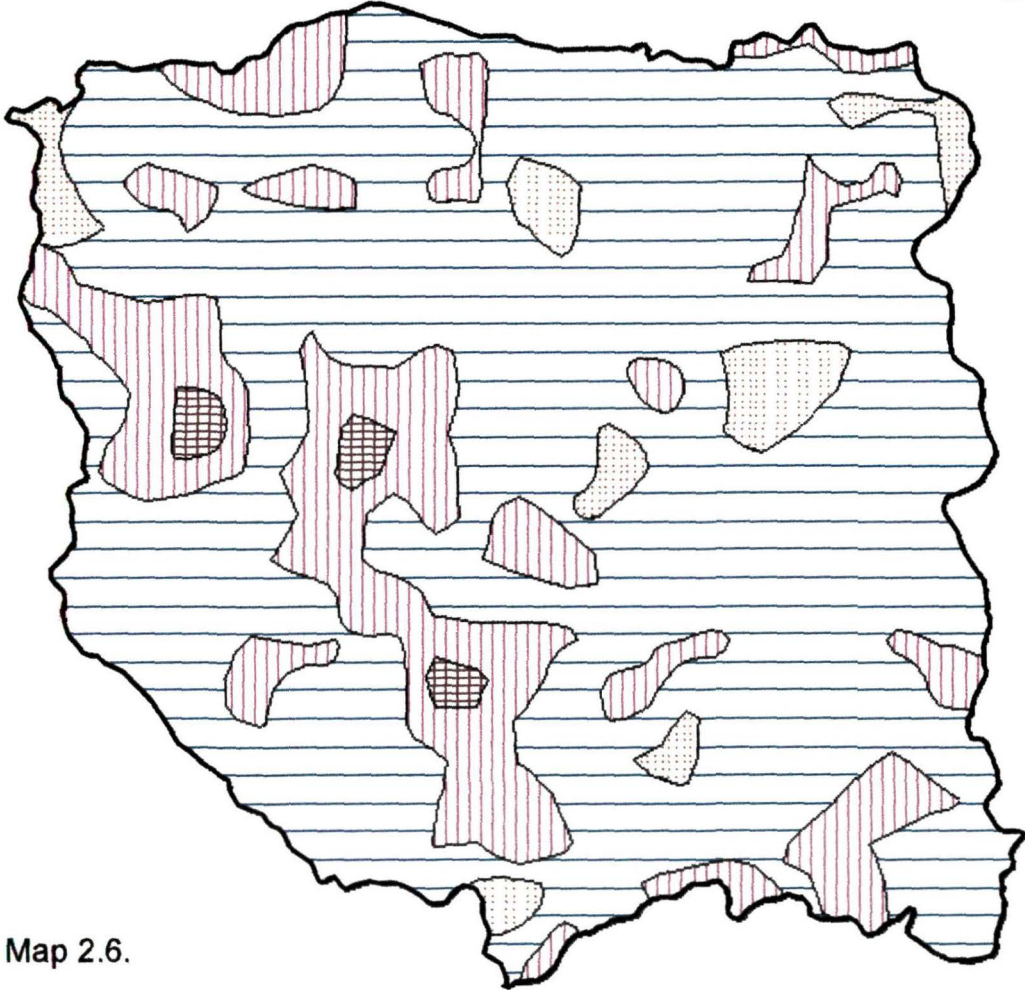
$$\text{Drainage Density} = \text{Stream Length} / \text{Unit Area (1 sq.Km)}$$

The measurement of drainage density and drainage frequency provides a useful numerical measurement of landscape dissection and runoff potential. Closer investigations of the processes responsible for drainage density variation reveals that a number of factors collectively influence stream density. These factors include climate, topography, soil infiltration capacity, vegetation, and geology. The total length of streams/rivers in the study area is 1121.2 kms, with an overall density of about 3 kms per sq. kms area. But, the distribution of area under different drainage categories shown in Table-2.5 indicates that the drainage density of 1 to 2 km/sq.km occupies the largest area (68.98%), whereas density of above 3 km/sq.km occupies only 1.14 percent of the geographical area. Medium and fine drainage density occurs mostly in the Southern steep slope experiencing sub tropical climate and well vegetated areas. The Central upland region having temperate to semi-temperate conditions have coarse to very coarse drainage density. (Map 2.6)

Table-2.5: Drainage density

Drainage density In Km/Km ²	Area in Sq.Kms	Area in Percentage	Density Category
Below 1	16.59	4.60	Very coarse
1 – 2	248.32	68.98	Coarse
2 – 3	90.98	25.28	Medium
Above 3	4.11	1.14	Fine
	360	100	

Mawkynrew C & R. D. Block DRAINAGE DENSITY

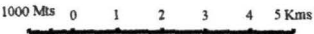


Legend

Drainage density (per sq.km)

- Below 1, Low
- 1-2, Moderate
- 2-3, Medium
- 3-4, High
- Block boundary

Map 2.6.



2.7.3. Drainage Frequency

Drainage frequency is the number of stream occurrence per unit area and mathematically denoted as,

$$\text{Drainage Frequency} = \text{Number of stream crossing} / \text{unit area}$$

The frequency of streams gives an idea about whether the streams are well knitted or the area is properly drained or not. Such analysis is helpful in finding out the availability of water and carrying out feasibility studies for irrigation purposes. Much of the study area falls under the category of coarse to medium drainage frequency, which constitutes 40.98 percent and 37.84 percent respectively. Only 17.07 percent of the total geographical areas has a drainage frequency of more than 6 per sq.km, while 4.11 percent of the area falls under the very coarse category (Table-2.6). The distribution of medium to fine drainage frequency is more common in the southern steep slopes, and coarse to very coarse frequency dominates the central upland region (Map 2.7). However, because of the rugged terrain and steep slope conditions very little advantage have been taken of these streams in relation to irrigation.

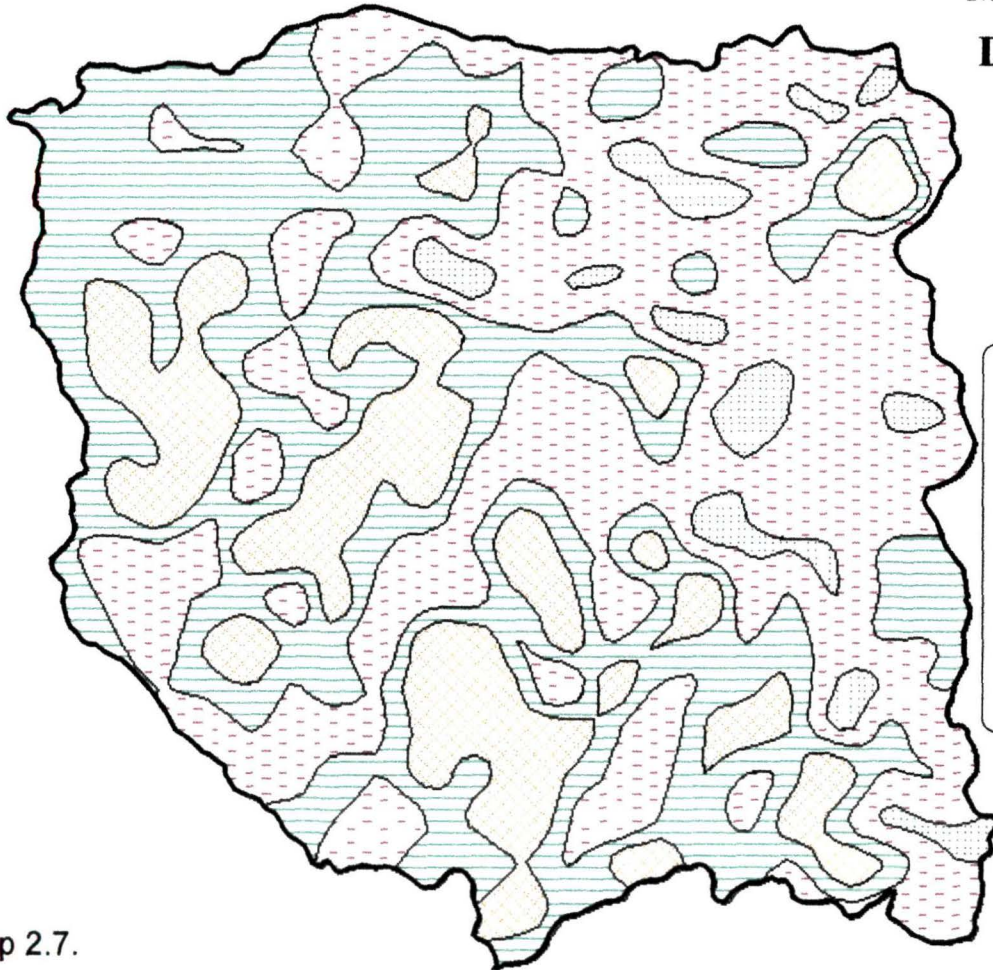
Table-2.6: Drainage frequency

Drainage frequency Per sq.Km	Area in Sq.Kms	Area in Percentage	Frequency Category
Below 2	14.80	4.11	Very coarse
2 – 4	147.53	40.98	Coarse
4 – 6	136.22	37.84	Medium
Above 6	61.45	17.07	Fine
	360	100	

2.8. Irrigation






Irrigation has so far played only a minimal role in the agricultural development and prosperity of the area. One obvious reason is the topography which makes alignment and construction of channels difficult and comparatively costly. Farmers in this area have traditionally depended upon rainfall which has seldom failed to meet their expectations, although in recent years the pattern

Mawkynrew C & R. D. Block DRAINAGE FREQUENCY



Legend

Drainage frequency (per sq.km)

-  Below 2, Low
-  2-4, Moderate
-  4-6, Medium
-  Above 6, High
-  Block boundary

Map 2.7.

1000 Mts 0 1 2 3 4 5 Kms

may have been occasionally erratic. The average annual rain fall which is quite high in the region during the cultivation season reduces the dependence on artificial alternatives. The advantages of the mighty river and the many tributaries of Umngot and Umsong may not be directly applicable in the agricultural sector, but with further feasibility studies, it can be assessed for hydel projects and fisheries.

2.9. Climate

In general, the entire state of Meghalaya comes under the humid tropical climatic conditions with nearly 3,000 mm average annual monsoon rain with its significant areal variation of about 10,000 mm ranging from 11,000mm on the southern slopes, especially in Cherrapunjee and Mawsynram, to only 1,200mm in the north-eastern parts of the plateau, especially in the tributary areas of Kopili river.

The rate of potential evapo-transpiration varies throughout the year. The southern slope of Shillong massif due to its shallow soils and poor vegetal cover, share more than 90 percent of annual precipitation run off.

Overall, water budget as calculated by the Central Ground Water Board for Cherrapunjee (situated on the south-central slopes), and Shillong (representing central parts of the table land of the plateau) show that summer season is a maximum run off period (May to October) when the moisture availability in the atmosphere and on surface is maximum (i.e. the case of per humid climatic conditions) with the moderate temperature (15° to 28° C). In the areas of southern slopes, the run off period is slightly longer than the central parts of Shillong massif because of 'rain shadow' and the influence of topographic features.

The central plateau region (uplands) is characterized by semi-temperate to temperate climate with an annual average rainfall of about 2400 mm, while the

southern steep slopes experiences sub-tropical climate with cold to very cold winter conditions. The mean annual air temperature in lower elevated lands is 23° C to 24° C while in the higher elevated lands it is 16° C to 17° C. The average humidity in this region varies from 67 to 79 per cent.

The climatic conditions of the study area plays an important role in the land use and crop adoption practices. The area is often under cloudy and foggy conditions which is more pronounced along the upland region. This has accounted for very less incident sunlight. In the absence of weather stations in the study area, it is not possible to derive climatic data of the area. However, since the area is characterized by two distinct physiographic units it is evident that the climatic conditions within the Central Plateau region and the Southern steeps will vary due to variation in altitude and exposure. The former experiences temperate to semi temperate climate and the later sub-tropical conditions.

In the absence of weather station in the study area, the rainfall data obtained from two stations closest to the area has been taken, namely Vegetable Research Centre, Upper Shillong (Appendix 2a,) representative of the Central plateau region and Amlarem, Jaintia Hills (Appendix 2b,) which borders the southern part of the study area and closely represents the physiography of the Southern steep region.

Taking the two average of the two stations and its average, the normal weather pattern of the study area can be described as follows:

January and February months are characterized by heavy morning dew and hoar frost, but generally rainless. Short spell of rain may occur in the middle of February.

The beginning of March and April is generally dry with southerly winds which might continue for several weeks, but subsequently early rains may start about the end of April generally in the daytime.

The month of May is initially warm and dry, with rains becoming more frequent as the month advances.

The period of heavy rainfall starts from the beginning of June and lasts upto August and often continue till September.

Rainy period draws to an end by October, and the cold season sets in from November onwards and advances with widespread frosts especially at higher altitude during December.

The Central Upland region of the study area have a temperate climate which is moderate in summer though severe in winter; places at lower elevations falling under the southern steep zones are comparatively warm and humid. In general, places south of the central uplands facing the on-coming south-west monsoons receive higher rainfall than those in the north which lie within the rain-shadow area. Rainfall becomes progressively heavy as one approaches the southern escarpment.

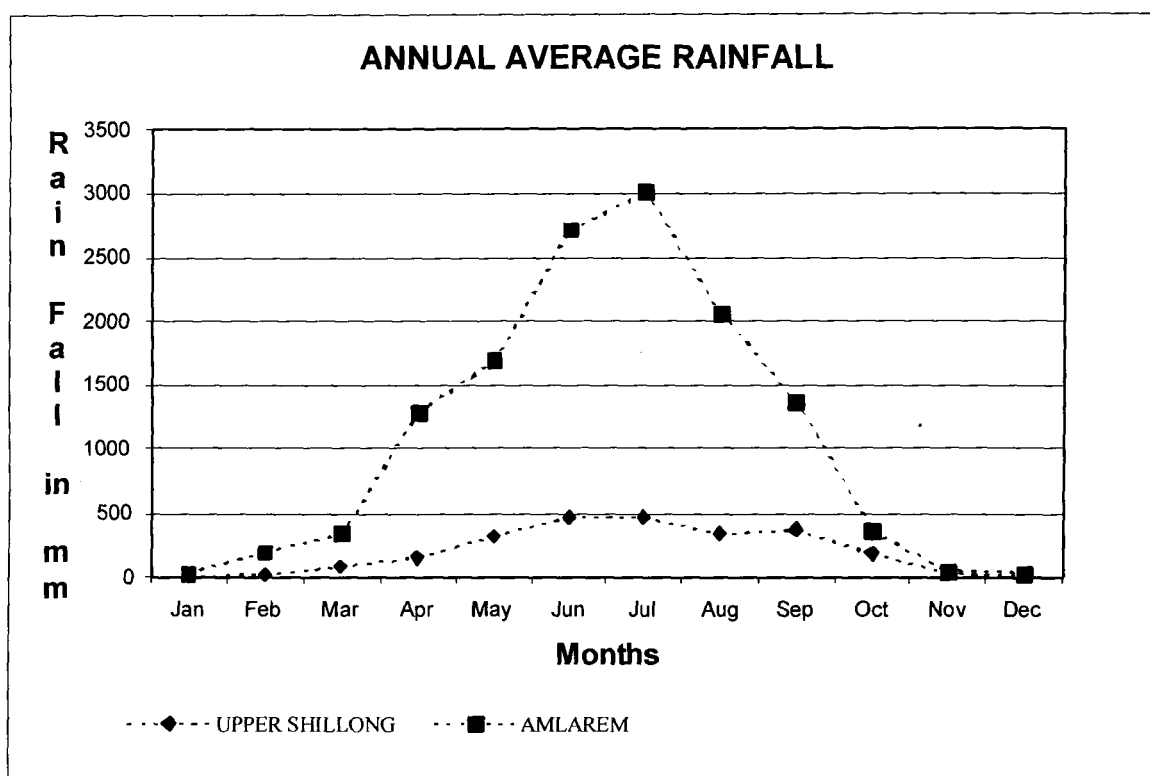


Fig. 2.2: Rainfall Graph

2.10. Soils

Soil is the collection of natural bodies occupying portions of the earth's surface that support plants and that have properties due to the integrated effect of climate and living matter, acting upon parent material, as conditioned by relief, over periods of time⁹. Basic and reliable data on soil resources have become the imperative need of the day for the scientific utilization of the natural resources in augmenting production of food, fibre, fuel, fodder and other vital necessities of the increasing population for sustenance. Infact, land evaluation originated with soil surveyors' desire to make their surveys useful to land users. The present study will look more into '*soil resource inventory*' (SRI) rather than '*soil survey*' so as to avoid the confusion with '*survey*' which would mean cadastral survey. Soil is viewed here as one of the land resources which has the most direct and continuous impact on agricultural land use. The basic objective for SRI is to

evaluate the existing physical and chemical properties of soil & its utilization so as to enable more numerous, accurate and useful prediction for specific purposes. This will be done through a general-purpose survey, which will provide the basis for a variety of interpretations for various kinds of uses, present and future. Soil makes a significant contribution to natural resource management. Information on soils with regard to their extent, nature and physico-chemical characteristics form one of the pre-requisite to achieve this task.

The National Bureau of Soil Survey and Land Use Planning¹⁰ has classified the soils of Meghalaya according to two distinct sub eco-region(zone):

i) Soils of warm per humid agro-eco sub region (zone) with thermic temperature regimes:

The perhumid thermic sub eco-region comprising of the central plateau region of the East Khasi Hills, West Khasi Hills and the Jaintia Hills district covering 30.1 percent of the geographical area, characterised temperate climate having warm summer and cold winter conditions. Soils developed on hill side and/or escarpments in this region are moderately shallow to deep, loamy skeletal to fine and excessively drained subject to moderate to very severe erosion hazards. Soils have structural/coloured to well developed textural B horizon and comprise Typic/Umbric Dystrochrepts, Typic Kandihumults/Haplohumults and Typic Kandiudults. Soils of hill top/upper hill slopes are shallow to deep, loamy skeletal to fine loamy and excessively drained with severe to very severe erosion hazards. Mostly soils having structural or coloured B horizon belong to Typic/Umbric Cystrochrepts while the Typic/Lithic Udorthents show either eroded soils or the soils at initiation of development with A/C horizon.

Soils of valleys are deep, fine loamy, poorly drained with very slight erosion. They have structural B horizon and comprise Humic Haplauquepts. All these soils are strongly acidic, humus rich and have low base saturation.

The areas falling in this regions are dominated by grass and pine forest, and the agricultural crop comprises paddy, potato, maize, vegetables and fruits mainly citrus and pineapples. Some of the problems associated with the soils of this region are soil erosion, soil acidity, excessive leaching, resulting in depletion of nutrients and soils of low base status, shallow soil depth in upper hill slopes and hill tops, and landslides in some of the areas.

ii) Soils of warm per-humid agro-eco sub-region (zone) with hyper thermic temperature regime:

The per humid hyperthermic sub-ecoregion constitutes middle and lower plateau region falling in continuation with the Central Plateau and covers East and West Garo Hills and part of East and West Khasi Hills and Jaintia hills. This region occupies 69.9 percent of the geographical area of the state, and is characterised by hot and moist summers and cool winters belonging to sub-tropical climate. Soils of the hill side slopes are moderately deep to deep, loamy skeletal to fine and well to excessively drained subject to slight to very severe erosion hazards. Most of these soils have structural/coloured and textural B horizon whereas some soils show initiation of profile development (A/C horizon). Taxonomically, these are Typic, Dystrachrepts. Soils of hill tops and upper hill slopes are moderately deep to deep, fine loamy to fine, excessively drained, subject to very severe erosion hazards and strong stoniness. They have structural/coloured B horizon and comprise Typic/Umbric Dystrachrepts.

Soils of undulating uplands with hillock are deep, fine and well to moderately well drained with slight erosion hazards. The soils of gently sloping plains are deep, fine, well drained and subject to slight erosion and flood hazards while soils of valleys are deep, fine loamy to fine and very poor to well drained with very slight to moderate erosion and slight flooding hazards. Mostly they have structural B horizon comprising of Umbric Dystrachrepts, Typic/Aeric Haplaquepts and Cumulic Humaquepts sub groups in Taxonomy. The soils of the

sub eco-region are very strongly to slightly acid. They have low to high base saturation.

The natural vegetation in this region comprise of wet evergreen, tropical moist deciduous and mixed pine-tropical moist deciduous forest. Shifting cultivation is the traditional farming system which has led to deforestation and severe soil erosion. Excessive leaching resulting in depletion of nutrients and low-base status soils, landslides in the steep slopes and flooding in valleys and plains are some of the problems associated with this region.

Survey conducted by the NBSS & LUB revealed that about 70 percent of the total area of the state is suffering from various kinds of problems of which steeply sloping areas, soil acidity, soil erosion, low P.K and base status are most significant¹¹.

2.11. Agro-Climatic Zones of Meghalaya.

Meghalaya falls under Zone II of the fifteen Agro-Climatic Zones of the Indian Peninsula. On the basis of topography, rainfall and temperature, soil type, cropping systems and geographical continuity or proximity the Agro-climate zone II of Meghalaya can be further sub-divided into five Agro-Climatic sub-zones (Table-2.7). The study area is akin to the sub region iii. Central Thermic Plateau and IV. Southern Slopes and Valleys (East).

- i) Hills and Northern Slope** comprising of the lower plateau in the north and western part of West Garo Hills, northern part of East and West Khasi Hills and the north eastern part of Jaintia Hills.
- ii) Central Hyperthermic Plateau** comprising of the central plateau of the Garo Hills and a portion of the central plateau of West Khasi Hills District.

iii) **Central Thermic Plateau** comprising of the central plateau of East Khasi Hills, West Khasi Hills and Jaintia Hills District .

iv) **Southern Slopes and Valleys (East)** comprising of the east and northern part of Jaintia Hills, southern part of East Khasi Hills and a portion of the southern fringe of West Khasi Hills.

v) **Southern Slopes and Valleys (West)** comprising of the southern part of West Garo Hills and a small segment of the southern part of West Khasi Hills.

Table-2.7: Agro-climatic sub-regions of Meghalaya

Sub-region	Agro-climatic features	Soils	Dominant geographic unit
I	Humid and warm with average rainfall between 1270-2332mm	Light to medium texture, depth varying between deep to very deep	Hills and rolling and undulating piedmont
II	Humid and hyper-thermic, moderately cold in winter and warm in summer rainfall varying between 2800-4000	Light to medium texture, depth varying from deep to very deep	Upper and middle plateau
III	Humid and moderately warm summer and severe winter, rainfall between 2800-6000mm	Light to medium texture, depth varying from deep to very deep	Upper and middle plateau
IV	Humid and warm, high rainfall ranging from 4000-10,000mm	Light to medium texture, depth varying from deep to very deep	Severely dissected and undulating low hills gentle to steep slope and rolling piedmont
V	Humid and hot, rainfall varying from 2800mm to as high as 4000mm	Light to heavy, depth varying from moderately deep to very deep	Rolling and undulating piedmont and valley land having depressions

Source: A Profile of Agriculture in Meghalaya, 1995, Directorate of Agriculture, Shillong.

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CHAPTER III
SOCIO-ECONOMIC BASE

CHAPTER III

Socio-Economic Base

3.1. Introductory Statement

Man's over-all demand for land resources finds its role in the need and aspirations of the many individuals who make up society. These people have different wants and desires. Upto a certain point they are all primarily concerned with the physical need to secure sufficient food and other materials to sustain life. Beyond this point their demand for land and its products is influenced largely by technological developments, custom and traditions, their educational and cultural backgrounds, their incomes and spending power, individual tastes and personal goals, and by the changing attitude that come with advancing age. Each of these factors helps to condition the over-all demand picture. But the basic factors affecting the demand for land is that of population numbers¹. However, it is not only the quantity of population, but the quality that determine the characteristics of land resource and its utilization.

Physical factors like location, relief, slope, climate etc. and the socio-economic conditions such as the size of the population, age and sex ratio, literacy, market, capital etc. are intrinsically linked with each other. Therefore, and understanding of the various physical and socio-economic characteristics of the study area is considered as an important aspect for land resource evaluation and land use planning purposes. In order to understand the socio-economic condition and its impact on the land utilization, various secondary data as well as primary data with the help of interviews and questionnaires were collected. Particular emphasis is stressed upon the general population characteristics, livelihood pattern, existing land resources, agriculture and allied activities.

3.2. The People

The study area is predominantly inhabited by the Khasis who live mostly in the permanent villages in houses perched on the hills or built on elevated flat space by using the locally available materials like wood, bamboo, thatch and reed. They have their own dialect and distinctive cultural identity and follow the matriarchal system of social structure. The entire population of the Mawkyntrew C.D.Block is rural based. According to the 1991 Census² the total population comprised of 30,170 persons as against 20415 in 1981 – a addition of nearly 1000 people per year. With a population density of 85 persons per sq.km, the study area shares 6.5 percent of the total population of East Khasi Hills district (Table 3.1).

Table: 3.1. Total Population of C&R..D.Blocks of East Khasi Hills District

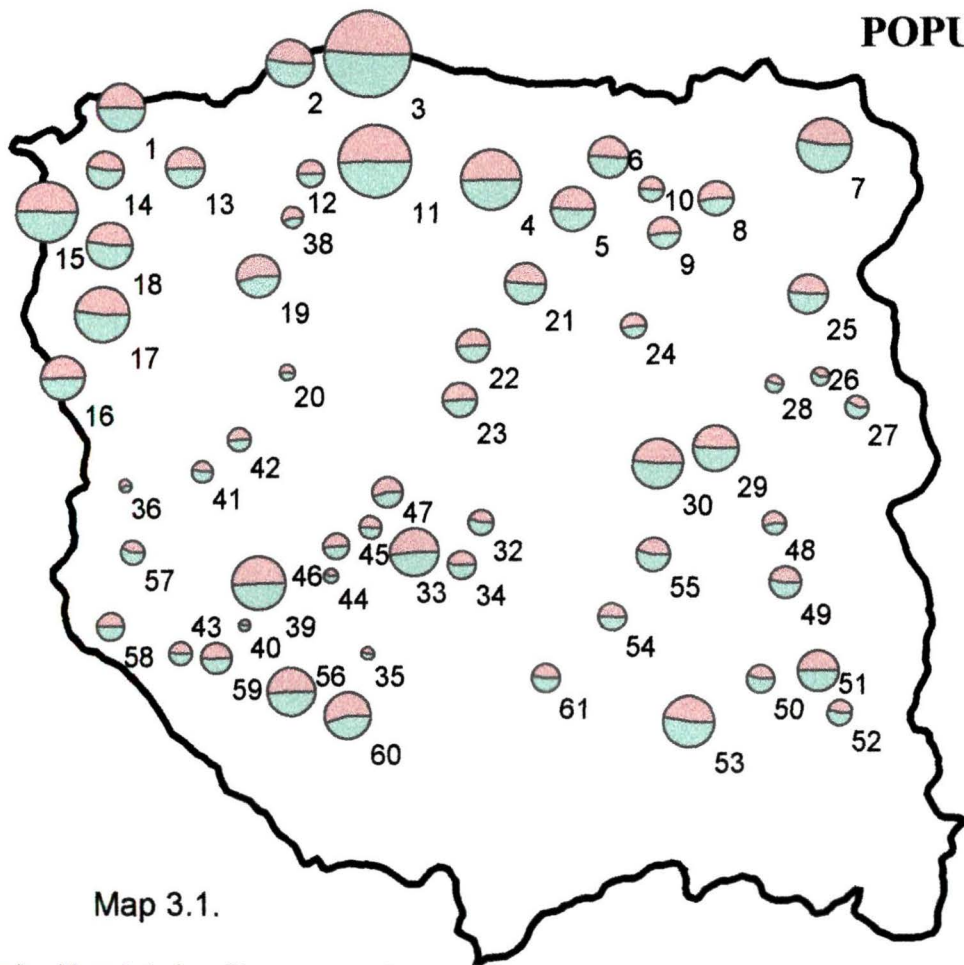
Name of C.D.Block	Total Population	% of Total Popn.	Male	% of Male Popn.	Female	% of Female Popn.
Nongpoh	50561	10.90	26221	51.86	24340	48.14
Bhoi Area	76751	16.54	39355	51.28	37396	48.72
Mawryngkneng	35914	7.74	17973	50.04	17941	49.96
myllem	70607	15.21	35897	50.84	34710	49.16
Mawphlang	46685	10.06	23363	50.04	23322	49.96
mawkyntrew	30170	6.50	15187	50.34	14983	49.66
Shella (Bholaganj)	38022	8.19	19461	51.18	18561	48.82
Pynursla	47171	10.16	23480	49.78	23691	50.22
Mawsynram	38194	8.23	19445	50.91	18749	49.09
	434075		220382		213693	

Source: Census of India 1991

The village level distribution of household ranges from as low as 8 in Langsiew, Umpdem and Rangbuli to 331 in Thynroit which records the highest no of household, and also records the highest population of 2270 persons. Some of the villages like Rangbuli, Langsiew and Umpdem have a total population size of 40 to 50 persons. (Map 3.1)

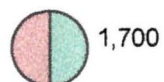
(Village wise distribution population and no. of households is given in Appendix 3a)

Mawkynrew C & R. D. Block POPULATION DISTRIBUTION & SIZE



Legend

Total_Popn



Male

Female

Block boundary

Map 3.1.

(Refer Map 1.1. for village names)

1000 Mts 0 1 2 3 4 5 Kms

3.3. Land Tennure & Land holdings

By and large, land is the common property of the community and elders of the clan recognized by written customary laws and usage. The distribution of land is controlled by the 'Durbar' or the village council. Traditionally, the Durbar has an organisational structure in which at least one adult male from every family is represented as a member and the Headman/Sardar is the Chairman. The land tennure system of the area can be classified into three groups of ownership; i) Private land (Rikynti) which belongs to private parties/individuals ii) Raj Land (Ri-Raid) where the land is controlled by a village or a group of villages, and iii) clan land (Rikur) which belongs to a particular clan. In the absense of land holding records, it is not possible to obtain quantitative data on the distribution of land holdings. However, studies conducted by NERDA³ reveals it generally varies according to the type of landuse (Table – 3.2). During the allotment of land for agricultural purposes, it is ensured that any person who does not cultivate the land allotted to him for three consecutive years will forfeit his right to cultivate this land any longer.

Table: 3.2. Average Land holding size

Landuse	Average Land holding size (in Hectares)
Bun Cultivation	Less than 1
Permanent Cultivation	(+ -) 1
Horticulture and other Plantations	1 to 2

Source: NERDA 1998.

The absence of maps/records is a drawback not only in the matter of development but also unnecessary litigations. Though the government introduced the scheme of Cadastral Survey and preparation of preliminary records (Meghalaya Land survey and Record Preparation Act, 1980, amended and passed in the Meghalaya Legislative Assembly in August, 1991) with a view to identify the owner/user to implement the Land Reforms, the programme has not been successful as the people had doubts and fears and apprehensions about its operation.

3.4. Literacy

Education widens the mental horizon of a person and thereby prepares him/her to be receptive to new ideas.⁴ The levels of literacy which is considered as one of the important indicators of development, to a large extent also affect the way land resources are utilized and managed, and plays a vital role in the socio-economic development. According to the 1991 census the area had a literacy rate of only 36.65 percent which is the lowest amongst all the other C.D.Blocks of East Khasi Hills district. This excluding children in the age group of 0 – 6 years which comprises an overwhelming 23.20 percent of the total population of the study area (Map 3.2). The study area records only 36.64 percent (1991Census) of its population as literates. Though the Provisional District Census of 2001, reveals that the literate population as 53.16 percent, it is still the lowest amongst all the districts of East Khasi Hills. Female literacy is higher than the male literacy i.e. 35.33% and 37.95% respectively. Lack of educational institution in most of the villages coupled with poor road and transportation facilities are some of the hindrances, which is responsible for low literacy level in the study area.

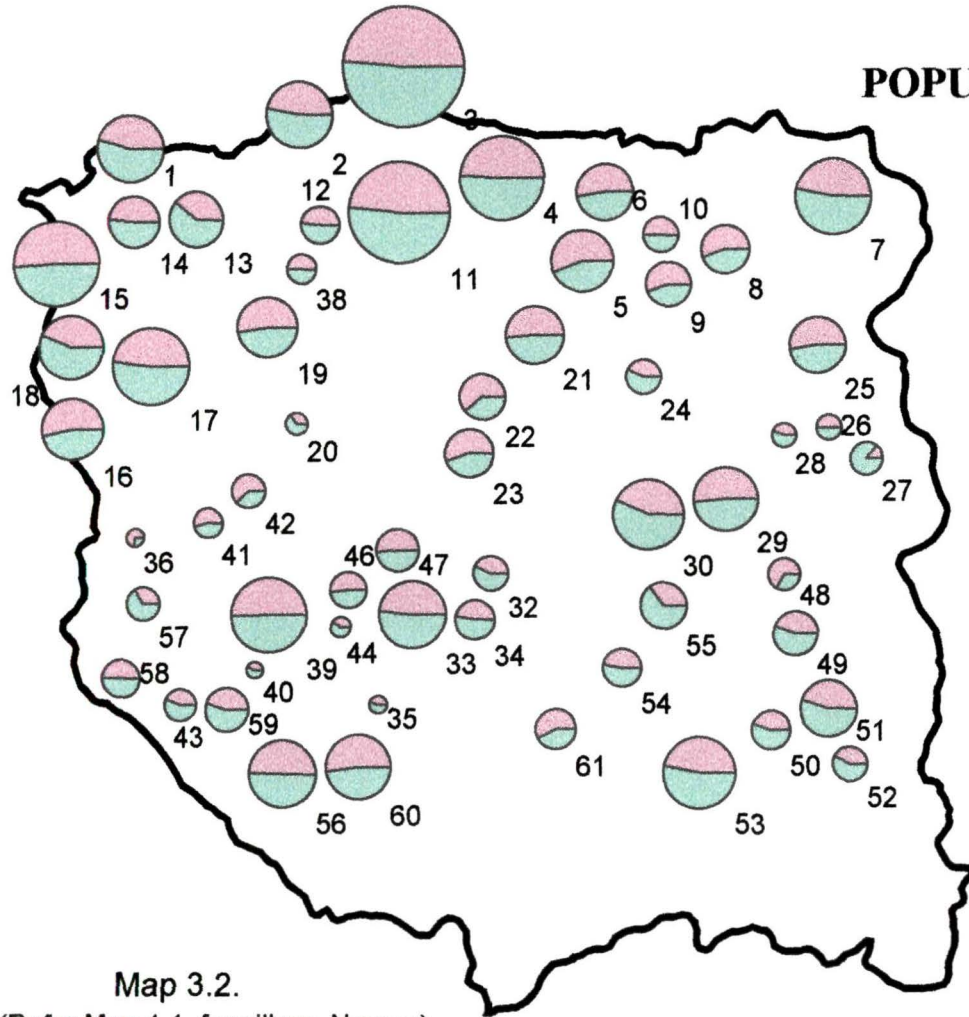
Table: 3.3. Literacy rates for Rural Population of C.D.Blocks (excluding children in the age group 0-6)

Name of C.D.Blocks	Percentage of Literates		
	Total	Male	Female
Nongpoh	38.36	44.34	31.81
Bhoi Area	40.99	43.57	28.3
Mawryngkneng	44.71	41.21	48.19
myllem	61.98	64.39	41.62
Mawphlang	41.00	40.39	41.62
mawkynew	36.64	35.33	37.95
Shella (Bholaganj)	49.61	51.56	47.54
Pynursla	47.77	50.58	48.97
Mawsynram	45.91	48.92	45.77

Source: Census of India 1991

The level of literacy at the village level varies from more than 50 percent in only ten villages, Mawjatah recording the highest of 64%, otherwise all the other

Mawkynrew C & R. D. Block POPULATION IN THE AGE GROUP OF 0 - 6 YEARS



Legend

Total_Popn

880

0_6YrsMale

0_6YrsFem

Block boundary

Map 3.2.
(Refer Map 1.1. for village Names)

1000 Mts 0 1 2 3 4 5 Kms

villages have literacy rate of less than 50 percent. In some villages like Mawsir, Umsning and Nongronj it is as low as 2 percent. (Map 3.3)

Village wise literacy level and population in the age group of 0 to 6 is given in Appendix 3b.

3.5. Educational Institution

Education of the rural farmers is believed to contribute to farm productivity and differential rate of diffusion of technological change i.e. a transition from a traditional to modern agriculture.⁵ Amongst the various social factors, low literacy level coupled with the lack of educational institutions, has been a hindrance for development of the region. Out of the 65 villages only two villages namely Jongkhsha and Umtong have school up to class X, and 14 villages have primary and Junior secondary or middle school (includes class IV to VI). About 65 percent of the villages have primary schools, while 11 percent of the villages do not have any schools located within their village. This means that majority of the students need to move away from their village to attend middle school, and secondary school level.

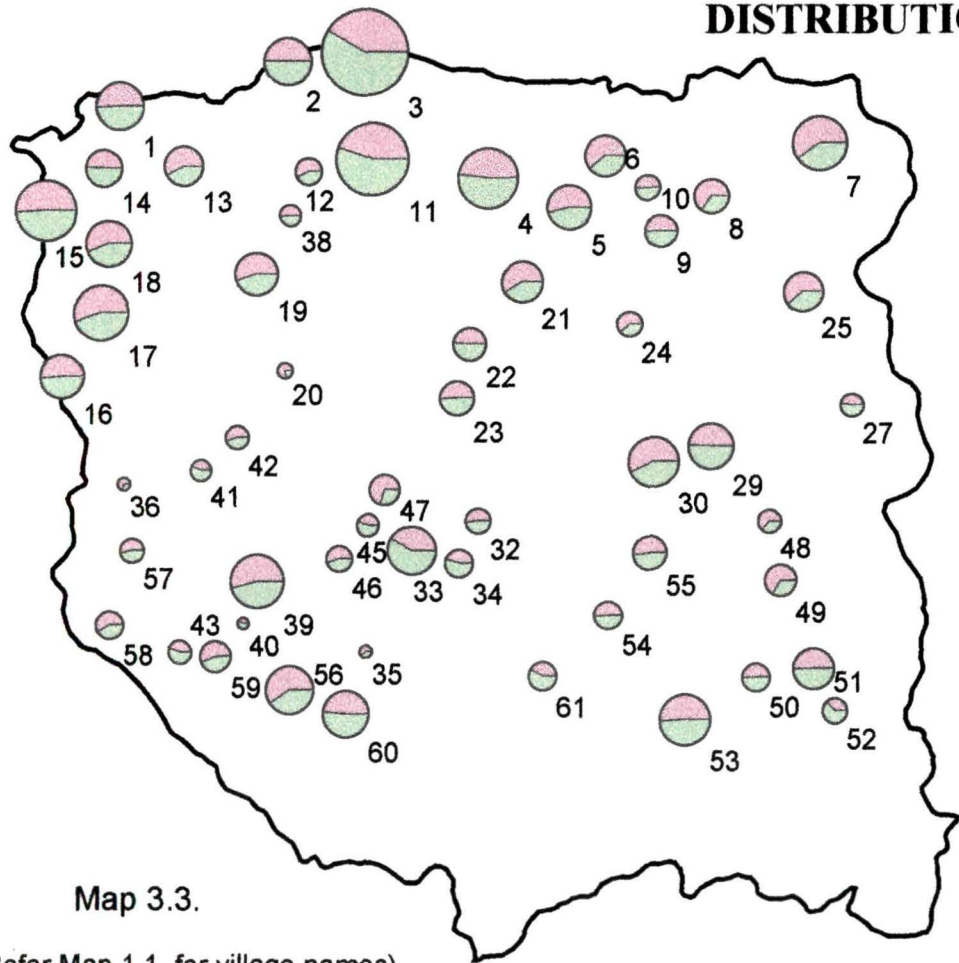
Considering the fact that nearly 23 percent of the population belong to the age group of less than 6 years and the literacy rate excluding the population of this age group is only 36.64 percent, the study area needs special attention for the improvement of educational facilities, and also encourage adult literacy which is prevalent only in two villages. (Table 3.4)

Table: 3.4. Village wise Educational Institutions

Educational Institution	No of villages
Located -5 Km away from the village	7
Primary School (including Nursery, Kindergarten upto Class III)	42
Primary School and Junior Secondary or Middle school (includes class IV to VI)	14
Primary School, Junior Secondary & Secondary (includes class VII to X)	2
Adult Literacy Class/Centre	2

Mawkynrew C & R. D. Block

DISTRIBUTION OF LITERATE POPULATION



Legend

Total_Popn

1,700

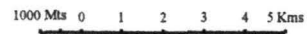
MaleLit

FemaleLit

Block boundary

Map 3.3.

(Refer Map 1.1. for village names)



3.6. Medical Facilities

Though the State has made substantial investment in health sector, mainly in the primary health care throughout the 8th Plan and the 9th Plan period, the primary health care institutions are functioning sub-optimally because of lack of some critical personnel and also organized referral services.

The performance of the State in terms of achievement in family welfare programme, malaria eradication, iodine deficiency disorders etc has been sub-optimal⁶. The facilities at the block level is far more discouraging. There are only two primary health centre and three dispensary for the entire study area, and the distance that needs to be covered by the villagers to avail these facilities 5 to 10 Kms. The population of 30 Villages or 46 percent of the villages have to travel more than 10 kms to reach either of the two centers. 15 percent of the villages have it within 5 to 10 kms, and 31 percent of the villages villages have it within 5 kms. (Table 3.5)

Table: 3.5. Village wise Medical facilities

Medical Facilities	No of villages
Located 5 Kms away from the village	21
Located in between 5 to 10 Kms away from the village	10
Located 10 Kms away from the village	30
Dispensary	3
Primary health Centre	2

3.7. Portable Drinking Water

Most of the villages in the study area are having some or the other sources for drinking water located within the villages. Tap water is the main source of portable drinking water for nearly 41 percent of the villages. About 28 percent of the villages obtain drinking water from more than one source, while 18 percent of the villages obtain it from the well. Other sources for drinking water are hand pump (6 villages) river and spring water. (Table 3.6)

Table: 3.6. Village wise availability of drinking water

Drinking water (Portable)	No of villages
Located Less than 5 Kms away.	2
Tap Water	28
Well Water	12
Hand Pump	4
River Water	1
Spring Water	1
More than one source	18

3.8. Post & Telegraph

There are only 4 post office located in the entire C.&R.D.Block which means that nearly 94 percent of the villages have no post and telegraph facilities located within the village. About 54 percent of the villages have post office located more than 10 kms away, 8 percent of the villages have it within 5 to 10 Kms and 32 percent have a post office within 5 Kms away from their village (Table 3.7).

Table: 3.7. Village wise Post & Telegraph services

Post & Telegraph	No of villages
Located less than 5 Kms away	21
Located between 5 -10 Kms away	5
Located more than 10 Kms away	35
Post Office	4

3.9. Market

Nearly 90 percent of the villages have no market/hat facilities within their village. Only five villages have weekly markets and four villages have bi-weekly markets. 50 percent of the villages have markets located more than 10 kms away, 20 percent have it within 5 to 10 kms, and an equal percentage of villages have markets located less than 5 kms away from their village. (Table 3.8).

Table: 3.8. Village wise market facilities

Market	No of villages
Located less than 5 Kms away	13
Located in between 5 to 10 Kms	13
Located more than 10 Kms away	33
Bi-weekly	1
Weekly	5

3.10. Transport / Communication

Public transport facilities mainly bus services as indicated in Table 3.9. is available to only 31 percent of the villages, and 40 percent of the villages have accessibility to a bus stop less than 5 kms away from the village. 21 percent of the villages have a bus stop within 5 to 10 Kms, while 8 percent have it located more than 10 Kms away.

Table: 3.9. Village wise location of Bus stop

Communication (Nearest Bus Stop)	No of villages
Located less than 5 Kms away	26
Located in between 5 to 10 Kms away	14
Located more than 10 Kms away	5
Bus Stop	21

The poor public transport system is severely affected by the dismal road conditions as about 42 percent of the villages have only foot paths as approach road, and another 42 percent of the villages is connected by katcha or un-metalled roads. Only 13 percent of the villages in the entire study area have metalled roads (Table 3.10).

Table: 3.10. Approaching roads to villages

Approaching road to village	No of villages
Pucca Road	9
Katcha Road	27
Foot-Path	28
Foot Path & Katcha Road	2

Though Shillong the capital of the state is the nearest town for all the villages falling under the Mawkyntew C.&R.D. Block, the poor transport and road network within the block and within the villages has acted as an hindrance for interconnectivity between the rural and urban centres and hindrance to mobility of goods and services. It can be noticed from Table-3.11 that about 15 percent of the villages, mainly located in the north western part of the study area are less than 30 Kms away from Shillong. 12 percent of the villages are located within 30 to 40 Kms, 23 percent within 40 to 50 Kms, and about 40 percent of the villages are located more than 50 Kms away from the states' capital.

Table: 3.11. Distance to nearest town

Distance to nearest town (Shillong)	No of villages
Less than 30 Kms	10
30 – 40	8
40 – 50	15
50 – 60	26
More than 60	6

Considering the fact that transport and communication plays a vital role in the interconnectivity between rural and urban centres, and facilitate the movement of goods and services, and the transfer of technology, it is an irony that the overall condition of the various amenities in the study area is not very encouraging. Even the basic amenities like provision of electricity for domestic purposes is met for only 40 percent of the villages, while 60 percent of the villages have no electricity (Table 3.12). Firewood is the main source of fuel for cooking purpose and this is one of the factors that has strained the forest resources.

Table: 3.12. Power supply

Power Supply	No of villages
Electricity for Domestic Purpose	26
Un-electrified	39

(Village wise availability of public amenities is given in Appendix 3c and 3d)

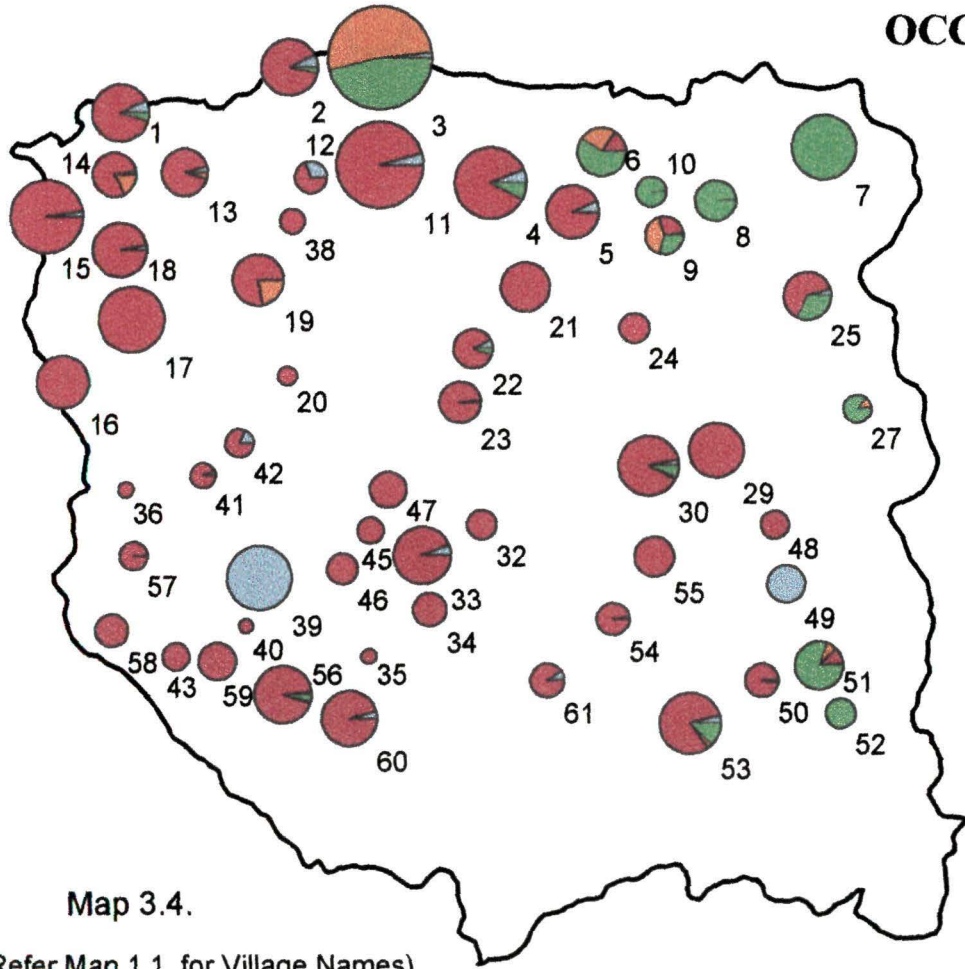
3.11. Economic Activities

The economy of the region is primarily backward and rural in character, with much of the population depending on primary economic activities which includes subsistence level of farming. Bun cultivation, which is a traditional form of agriculture, is extensively practiced in the hilly terrain of this region, apart from which other activities like animal husbandry and horticulture is also widely carried out.

3.11.1. Occupational Structure

The occupational structure of the study area reveals that only 47.12 percent of the total population constitute of main workers i.e. a regular worker who had worked for six months or more in various capacities in a year. More than half (52.10%) of the population of the study area belongs to the non working class. Livestock, forestry, fishing, hunting and plantation is the main activity of almost 70 percent of the total main workers. Apart from this, the study area offers very little opportunity for other primary activities. The physical factors, which has been discussed in Chapter II, act as a major constraint in the agricultural development of the region. Cultivators and agricultural labourers comprising of 15.40 percent and 7.46 percent respectively constitutes the common activity of main workers in the study area. (Table 3.13 & Map 3.4)

Mawkynrew C & R. D. Block OCCUPATIONAL STRUCTURE



Legend

Total_Popn

1,200

TotCults

TotAgLabs

Tot_LFFHPs

Tot_OthSer

Block boundary

LFFHPs - Livestock, Forestry,
Fishing Hunting & Plantations

Map 3.4.

(Refer Map 1.1. for Village Names)

1000 Mts 0 1 2 3 4 5 Kms

Table: 3.13. Occupational Structure of Mawkyntrew C&R.D.Block

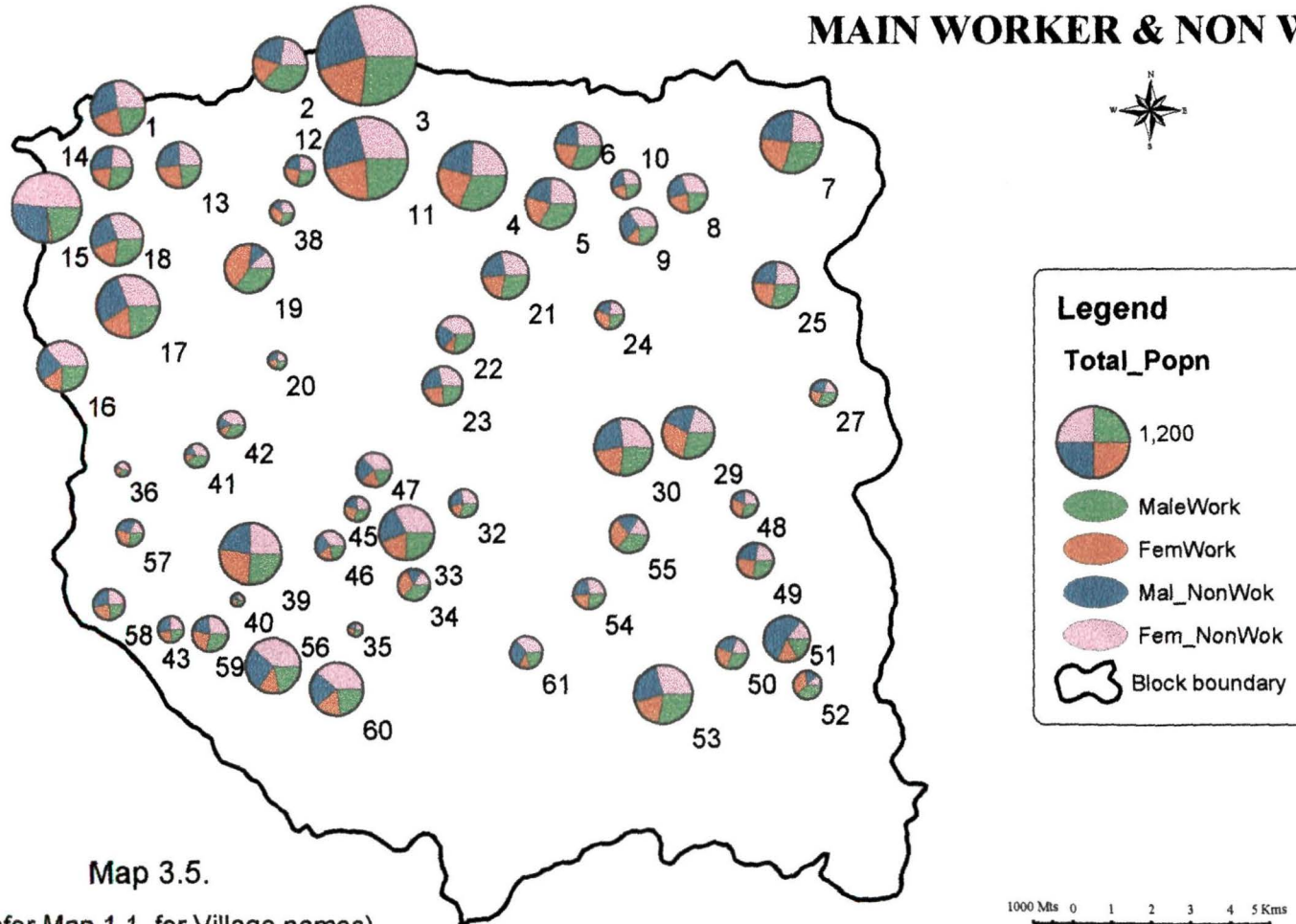
Occupational Structure	Total	% to total Popn.	% to total main workers	Male	% to total main workers	Female	% to total main workers
Total main workers	14217	47.12		8007	26.54	6210	20.58
Cultivators	2190	7.26	15.40	1218	8.57	972	6.84
Agricultural Labourers	1060	3.51	7.46	595	4.19	465	3.27
Livestock, Forestry, Fishing, Hunting and Plantation	9858	32.67	69.34	5586	39.29	4272	30.05
Mining and Quarrying	12	0.04	0.08	10	0.07	2	0.01
Manufacturing Processing, Servicing & Repairs	72	0.24	0.51	47	0.33	25	0.18
Constructions	64	0.21	0.45	63	0.44	1	0.01
Trade & Commerce	358	1.19	2.52	168	1.18	190	1.34
Transport, Storage & Communications	44	0.15	0.31	44	0.31		
Other Services	559	1.85	3.93	276	1.94	283	1.99
Marginal Workers	234	0.78	1.65	38	0.27	196	1.38
Non-Workers	15719	52.10		7142	50.24	8577	60.33
Total Population	30170			15187		14983	

Source: Census of India 1991.

3.11.2. Main Workers

A main worker is a regular worker who had worked for six months or more in different capacities. The village level distribution of the main workers indicates that almost half of the villages have less than 50 percent of its population in the category of main workers. 17 villages have 50 to 60 percent main workers, only 3 villages have 60 to 70 percent main workers and only 2 villages constitute more than 70 percent of its population in the main workers category. (Table 3.14) Since the study area provides very little opportunity in the other sectors like construction, manufacturing, processing, house hold industries, trade and commerce etc. most of the main works are directly related to primary economic activities. Map 3.5 shows the village wise distribution of main workers and non workers.

Mawkynrew C & R. D. Block MAIN WORKER & NON WORKERS



Map 3.5.

(Refer Map 1.1. for Village names)

Table: 3.14. Village wise distribution of total Main workers

Total Main Workers (Percentage to total Popn of the village)	No. of Villages
Less than 40	11
40 – 50	28
50 –60	17
60 – 70	3
More than 70	2

3.11.3. Non Workers

The fact that Meghalaya's rural unemployment rate is the lowest amongst the North-Eastern region, is also reflected in the study area where the non working population constitute an overwhelming 52.10 percent of the total population. The non working population (persons who is either not doing any work or who does some work from which he does not earn any income) in the study area is also the highest amongst all the C&R.D.Block of East Khasi Hills district. This is partly due to the fact that 23 percent of the total population constitute children in the age group of less than 6 years. The village wise distribution of the non working population (Table 3.15) indicates that only 2 villages have less than 30 percent non working population, 4 villages have 30 to 40 percent, 25 villages have 40 to 50 percent of its population in this category. About 52 percent of the villages records more than 50 percent of its population as non workers. This reveals a high dependency rates on the working population – a burden for the working population most of whom are engaged in the subsistence level of primary economic activities.

Table: 3.15. Village wise distribution of non workers

Non Workers (in Percentage)	No. of Villages
Less than 30	2
30 – 40	4
40 – 50	25
50 – 60	26
More than 60	8

(Refer to Appendix 3e for further details)

3.11.4. Dependency Ratio

The dependency ratio i.e. ratio of non workers to workers per thousand indicates the general nature of work participation of the population in a given situation and the apparent economic burden on the working population. It can be seen from table 3.16 that the dependency ratio in most of the villages is high i.e. 26 villages fall in the category of 1000 to 1500, 7 villages in 1500 – 2000 and 2 villages in more than 2000 category. This sums up to 35 villages in dependency ratio of above 1000, whereas, except 4 villages which fall in the dependency ratio of less than 500, the rest falls in between 1000 – 1500.

Table: 3.16. Dependency Ratio

Dependency Ratio	No of villages
Less than 500	4
500 - 1000	26
1000 - 1500	26
1500 - 2000	7
More than 2000	2

3.11.5. Cultivators

The rugged and hilly terrain of the study area makes much of its land unsuitable for cultivation. Moreover, the high incidence of bun cultivation, paucity of land actually available for cultivation, pre-dominance of small and marginal farmers besides small holdings, have imposed major obstacles in raising agricultural production in the region. According to 1991 census, about 75 percent of the State's population depended on agriculture for their livelihood. Compared to this the study area supports only about 10 percent of its population in the agricultural sector.

The Census of India 1991 defines cultivators as person(s) who is engaged by oneself or by supervision or direction in one's capacity as the owner or leases of land held from Government or as a tenant of land held from private person or institutions for payment of money, kind or share. It can be observed from table-3.13, that cultivators and agricultural labourers constitute 15.40 percent and 7.46

percent of the total main workers respectively. In both the cases the percentage of male cultivators/agricultural labourers is more than the female. At the village level the distribution of cultivators and agricultural labourers reflects a diverse pattern. 43 villages have less than 1 percent of its total population working as cultivators, and only 8 villages record for more than 50 percent of cultivators (Table-3.17). The rest of the villages signify very few people working as cultivators.

Table: 3.17. Village wise percentage of cultivators

Cultivators (in Percentage)	No. of Villages
Less than 1	43
1 – 10	9
11 - 20	1
21 – 30	1
31 – 40	1
41 – 50	2
Above 50	8

3.11.6. Agricultural Labourers

Agricultural labourers are people who work in another person's land for wages in money, kind or share and have no right of lease or contract on land on which he works.⁷ A total of 48 villages (74%) have less than 1 percent of its total main workers engaged as agricultural labourers, 14 percent of the villages record for less than 10 percent of agricultural labourers and only 3 percent have above 30 percent of its population working as agricultural labourers. Thus, agriculture which is the mainstay for much of the rural communities of the state, have been able to engage only a meager amount of population of the study area.

The distribution of cultivators and agricultural labourers at the village level is mostly concentrated in the central upland region of the study area, which provides some basis for permanent agriculture. Most of the villagers are engaged in bun cultivation, which is not a full time occupation and is not accounted in the census data.

Table: 3.18. Population engaged as agricultural Labourers (in percentage)

Agricultural Labourers	No. of Villages
Less than 1 Percent	48
1 – 10	9
10 – 20	2
21 – 30	4
Above 30	2

(Village wise distribution of cultivators and agricultural labourers is given in Appendix 3f)

3.11.7. Other Primary activities

Other primary activities includes people engaged in either of the primary occupation like livestock rearing, forestry, fishing, hunting, plantations etc. These activities constitute the largest occupation sustaining 32.67 percent of the total population of the study area (Table-3.13). Out of the 47.12 percent main workers, nearly 70 percent belongs to this category. The village wise distribution of people engaged in the other primary activities (Table-3.19) further reveals that more than 80 percent of the population of 41 (63 percent) villages are dependent on either of these activities. Only 8 villages have less than 1 percent of its population working in the other primary activities.(Table-3.19).

Table: 3.19. Population engaged in other primary activities (in percentage)

Livestock, Forestry, Fishing, Hunting & Plantation, orchard and allied activities	No. of Villages
Less than 1 Percent	8
1 – 20	3
21 – 40	2
41 – 60	2
61 – 80	9
More than 80	41

3.11.8. Other Services

People working in the tertiary sectors like banking, administration, defence, education, health, medical, research and other institutions which fall under this category comprises of only 1.5 percent of the total population of the study area. Since the area is purely rural in nature, there are very few tertiary sector establishments within the study area, and very few people of the study area have been found to be engaged in the other activities apart from agriculture and other primary activities. Only 4 villages record for more than 10 percent of its population engaged in other services, while 7 villages have 5 to 10 percent of its population engaged in other services, 31 villages (48%) have 1 to 5 percent, and 24 villages (35%) have less than 1 percent of its working population engaged in other services. (Table-3.20)

Table: 3.20. Population engaged in other services (in Percentage)

Other Services	No. of Villages
Less than 1	24
1 – 5	31
5 – 10	7
More than 10	4

(Refer Appendix 3g for village wise distribution of population engaged in other primary activities and other services)

Thus, the overall socio-economic conditions of the people reveal a chronic problem in the various sectors which are all indicators of development and an integral component of the human resources. Low literacy rate, lack of educational institutions, poor transport and communication system, health and medical facilities coupled with a high dependency on primary economic activities like livestock, forestry, fishing, hunting, etc, makes this region a deprived and backward region.

Development strategy for Meghalaya during the past few decades has primarily aimed at strengthening of the techno-economic infrastructure and

improving the delivery system for social services. Rapid development of road network from less than 2000 kms in 1970's to 7328 Kms as on 2001 had a positive impact on the State's economy and society. Besides, there is discernible shift in cropping pattern towards cash and plantation crops. Accessibility to modern health care facilities has improved substantially and the health indicator like Infant Mortality Rate which is better than the national average. About 95 percent of the existing villages are provided with potable drinking water. Apart from agricultural development, the State Government has also shown keen interest in the secondary and tertiary sectors. There has been a significant increase in the proposed allocation of outlays in these sectors. The prioritizations of sectoral allocation are transport (20.08%), Energy (12.55%), and social services (33.65%). The Government of Meghalaya is pursuing a policy of bringing about an industrial culture, developing local entrepreneurship and generating employment opportunities for the local people⁸. However, very little of this has penetrated to the grass root level in the study area. Considering the fact that the quality of human resources play a vital role in the utilization and management of land resources, it is imperative that the developmental activities of the state have to take serious measures to bring about socio-economic progress and holistic development in the study area.

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¹ *Raleigh Barlowe, 1972: Land Resource Economics – The Economics of Real Property, Prentice Hall International, INC London. p. 10.*

² Census of India (1991): **District Census Handbook**, East Khasi Hills, Series -16. Part XII-A & B.

³ NERDA (1998): *Assessing of Land Resource Degradation Affected Through Shifting Cultivation-‘Bun’ within the Mawkynrew C&R.D.Block, East Khasi Hills, Meghalaya. Pilot Project Report for NRSA, DOS, Govt. of India, Hyderabad.*

⁴ Rajagopalan, C. & Singh J (1971): **Adoption of Agricultural Innovations**, Delhi, p.19.

⁵ Saini, G.R. (1979): **Farm Size, Resource use Efficiency & Income Distribution**, Delhi, pp.33-34

⁶ Meghalaya Tenth Plan (2002-2007) and Annual Plan-2002-03, (Background Note for the Meeting between Deputy Chairman, Planning Commission and the Chief Minister, Meghalaya , 1st March 2002)

⁷ Census of India (1991): *opcit*, p.5.

⁸ *Ibid*

CHAPTER IV
TAXONOMY OF LAND CAPABILITIES.

CHAPTER IV

Taxonomy of Land Capabilities.

4.1. Introductory Statement

Sound utilization of land resources involves consideration of an environmental management dimension prior to decisions regarding what constitutes the best land uses. Land capability classification is an important aspect of this issue. Land Capability Classification (LCC) is one of the innumerable methods of land evaluation that can be based on broad interpretation of soil qualities and other factors of place¹. It can also be defined as a systematic arrangement of different kinds of land according to those properties that determine the ability of the land to produce on a virtually permanent basis.

LCC can be considered as a planning tool in laying out conservation measures and practices on farms so as to farm the land without serious deterioration from erosion or other causes. Two other uses of LCC include area land use planning and inventorying conservation needs.² Though there are physical, economic, and social factors involved in changes needed to maintain land in a permanently productive condition, the present land classification gives more emphasis on physical conditions, against which the economic and social factors have been correlated for formulating land use planning.

Physical land classification to a large extent depends on the nature of resources, which can be divided into three categories according to its stability and possibility for modification. They are:

i. Very Stable Resources:

Climate, physiography, geological formation and relief can be considered as very stable resources because it provides practically very little freedom to bring about drastic changes and is almost completely free of man's influence.

Local activities like burning of fossil fuel/forest fire/Shifting cultivation, or the leveling/terracing of land for permanent cultivation can bring about certain changes in the micro climatic and relief of the area. But, usually these resources are more or less free from man's influence and are generally stable in nature. The study area shares almost an equal area under two distinct physiographic and climatic condition, namely the central upland with temperate to semi temperate climate and the southern steeplands with sub-tropical climate. There is very little that can be done to modify these stable resources. Instead, people need to adjust their activities according to the opportunity it provides and adapt themselves to the given environmental conditions provided by these stable resources.

ii. Moderately Stable Resources:

Soils, water and some artificial elements, e.g. check dams, channels etc. of the land are flexible enough, within certain limits, to be improved or modified for land development. This also implies that these land resources are vulnerable to human pollution, degradation and destruction. Human activities may lead to building up of a particular soil through soil management/improvement or modification or destroy it through erosion and degradation. Soil degradation due to bun cultivation and inefficient management of the land in the study area has infact been one of the most crucial factor that have made much of potential agricultural land unproductive. Therefore, moderately stable resources such soil, water and the artificial features of the land needs special attention and demands proper conservation and management strategies.

iii. Relatively Unstable Resources:

Vegetation and related biological features are relatively unstable and vulnerable to both physical influence and human influences. Felling of trees for firewood, timber, charcoal, etc, clearing of land for shifting cultivation in the past has to a large extent already affected these unstable resources of the study area. Present activities like bun cultivation, clearing of land for plantation, over grazing

etc. is further aggravating the problems. In an area where majority of the people are dependent directly or indirectly on forest resources for their livelihood, has perhaps been one of the most exploited resources. This resource is not only unstable and vulnerable in itself but also have a great influence on the stable and moderately stable resources. Therefore, utmost importance and priority needs to be given to the conservation and management of these resources.

4.2. Factors affecting Land Capability

The physical, socio-economic and cultural factors play an important role in determining the capability of the land to produce. It is impossible to modify the physical factors like climate, physiography, relief, etc, but it is possible to adopt certain landuse practices to suit these conditions under favourable socio-economic conditions. Though there are physical, economic, and social factors involved to maintain land in a permanently productive condition, it is best to start with a classification based solely on physical conditions, against which the economic and social factors could be 'correlated to make a complete land classification. Amongst the physical factors soil and slope are the two most important factors considered by most experts for preparing land classification maps. Thus, slope and soils have been taken as the two important parameters to derive a suitable Land classification map of the study area, apart from which the physiography, climate, drainage, and other land facets have been referred as and when required.

4.2.1. Soil characteristics

Soil characteristics in any one place result from the combined influence of climate and living matter, acting upon the parent rock material, as conditioned by relief, over periods of time, including the effects of the cultural environment map and man's use of the soil³. In studying the characteristics of soil and in predicting its potentialities for use, one cannot work with the whole continuum at once. It is through classification, as a tool, that the relationships among soils and between

them and their environment is established. In the present study the following soil characteristics have been considered for land capability classification. They are:

i) Texture of top soil

Soil texture refers to the relative proportions of the various size groups of individual soil grains in a mass of soil. Specifically, it refers to the proportions of clay, silt, and sand below 2 millimeters in diameter. The determination of soil texture is done with the help of the “soil textural triangle” (Fig-4.1).⁴ As with each other soil characteristic, no direct relationship that can be applied generally to all soils exists between soil textural class and fertility, productivity, or other inferred qualities. To make such inferences it is necessary to know the other important soil characteristics. The study area in general has fine silty loam to silty clay soils with particle size ranging from .025 to 0.1 mm, with 18 to 34 percent clay content.

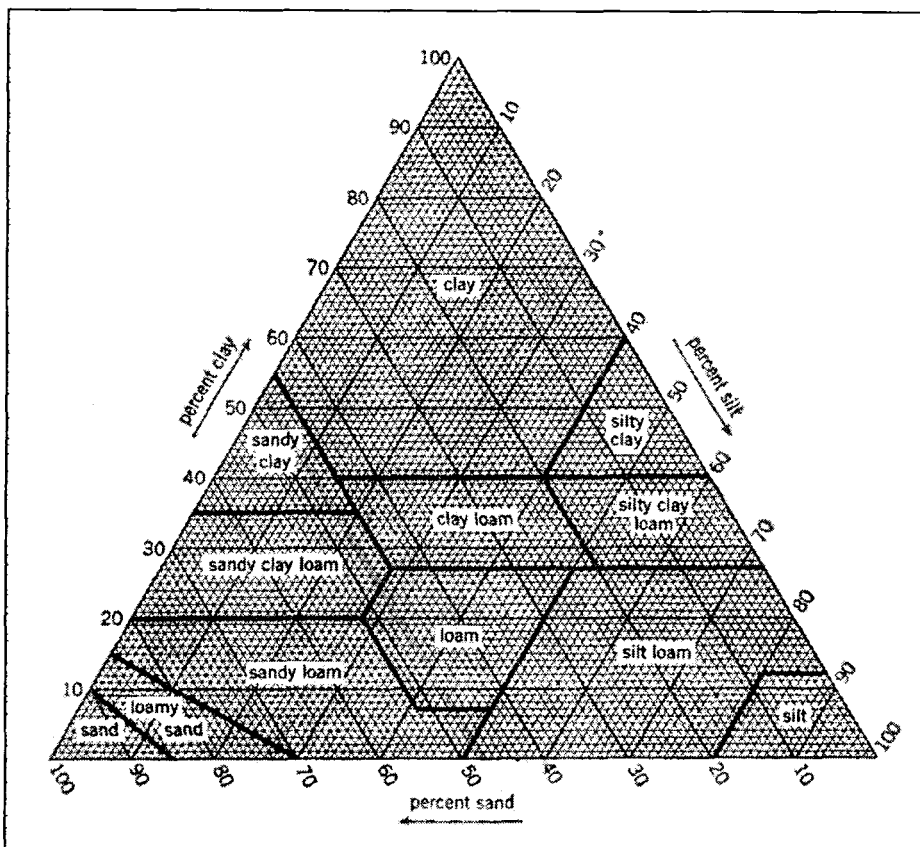


Fig-4.1: Basic soil textural classes

ii) Effective soil depth

Soil depth phases are distinguished for variations in the total depth of the soil profile, which are significant to soil use and management. Table 4.1. gives a outline of depth classes, applicable to all soils, and the ranges within which the upper and lower limits of depth classes may be set:

Table-4.1: Soil depth classification

Soil Category	Upper limits (inches)
1. Very shallow	0
2. Shallow	5 – 10
3. Moderately deep (or moderately shallow)	20 – 30
4. Deep	30 – 50
5. Very deep	50 – 60

Source: Soil Survey Manual

The soils of the study area is generally deep. The variation in the depth and other details of the soils at different locations of the study area is shown in Appendix 4a.

iii) Permeability of top soil and sub-soil

Soil permeability is that quality of the soil that enables it to transmit water or air. Although runoff is closely related to slope, internal drainage depends upon the permeability of the soil and of the material beneath it. Thus a permeable soil may be well drained on a gentle slope, whereas a slowly permeable soil may be imperfectly or even poorly drained on the same slope. The rate of infiltration and the permeability of the plow layer may fluctuate widely from time to time because of differences in soil management practices, kinds of crops, and similar factors. It can be observed that the soils of the study area is generally well drained with moderate to rapid permeability.

(Details of the soil characteristics analysed from some of the sample sites in the study area is given in appendix-4b)

4.2.2. Associated land features:

Apart from the above physical characteristics of soils, other important factors that has considered in classifying land capability are slope, extent of erosion and degree of wetness.

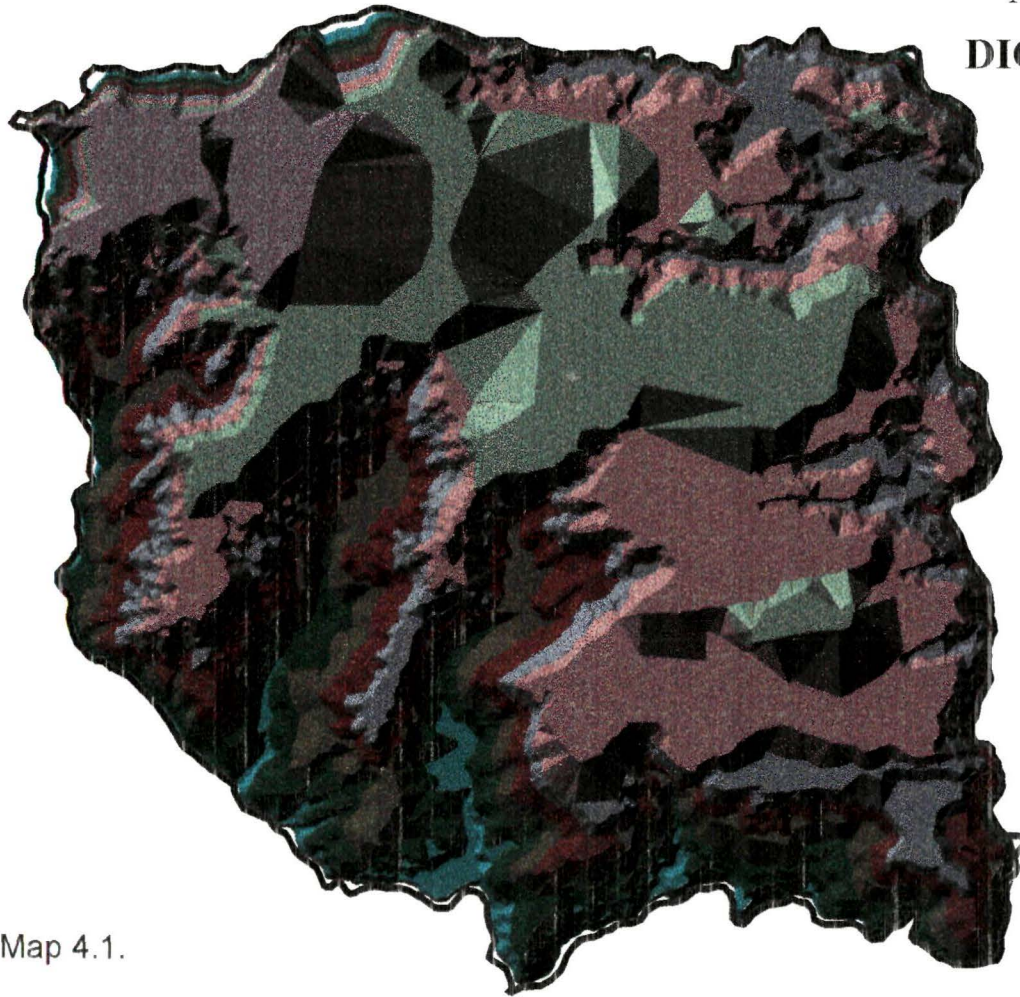
i) Slope of the land

In the present concept of soil as landscape, slope has been taken as major controlling characteristics of the soil and other land facets. Within the permissible slope ranges of soil types broad classes of soil slope are demarcated wherever significant changes occur. In the present concept slope may be defined as the maximum derivative in any direction of a plane tangent to the surface as modeled by the Digital elevation model (DEM).

Slope affects land qualities such as runoff, erosion hazard, moisture balance and landslide. The influence of slope on land resource utilization and its influence on the development of soil, soil erosion, agricultural practices and development of transportation is well established. Its relevance in the present study derives greater significance in relation to the existing land resources and for land classification.

The slope map was generated by transforming the vector contour data Triangular Irregular Network (TIN) a structure in which a surface is represented as a series of non-overlapping contiguous triangular facets, of irregular size and shape⁵. Aspect and Digital elevation model of the study area was created using TIN data through surface analysis model in the ARC/GIS package (Map 4.1). Based on the inclination of slopes in degrees as formulated by Anthony Young⁶, the study area is divided into five slope categories. Overlaying this on the satellite imageries, provided a synoptic view of terrain conditions and gave a balanced idea pertaining to other characteristics of the land.

Mawkynrew C & R. D. Block DIGITAL ELEVATION MODEL



Legend

Elevation



1000 Mts 0 1 2 3 4 5 Kms

Map 4.1.

The nature of slope in the study area is highlighted by the fact that 48.48 percent of its geographical area falls in the steep category. This combined with very steep slopes (2.04%) and moderately steep (27.66%) slopes together constitutes nearly almost 80 percent of the area (Table-4.2). Considering slopes as one of the important factor for landuse, the area would be left with only about 20 percent of gently sloping to moderately sloping land surface. Practically, only 1.44 percent falls under gentle slopes, while 20.39 percent falls in the category of moderate slopes. Such slopes predominate the central upland region where gently rolling concave slopes are widely prevalent (Map 4.2). Thus, the nature of slope is one of the conditions that gives very little scope for settled cultivation, and compels the people living in these areas to adopt the traditional form of bun cultivation.

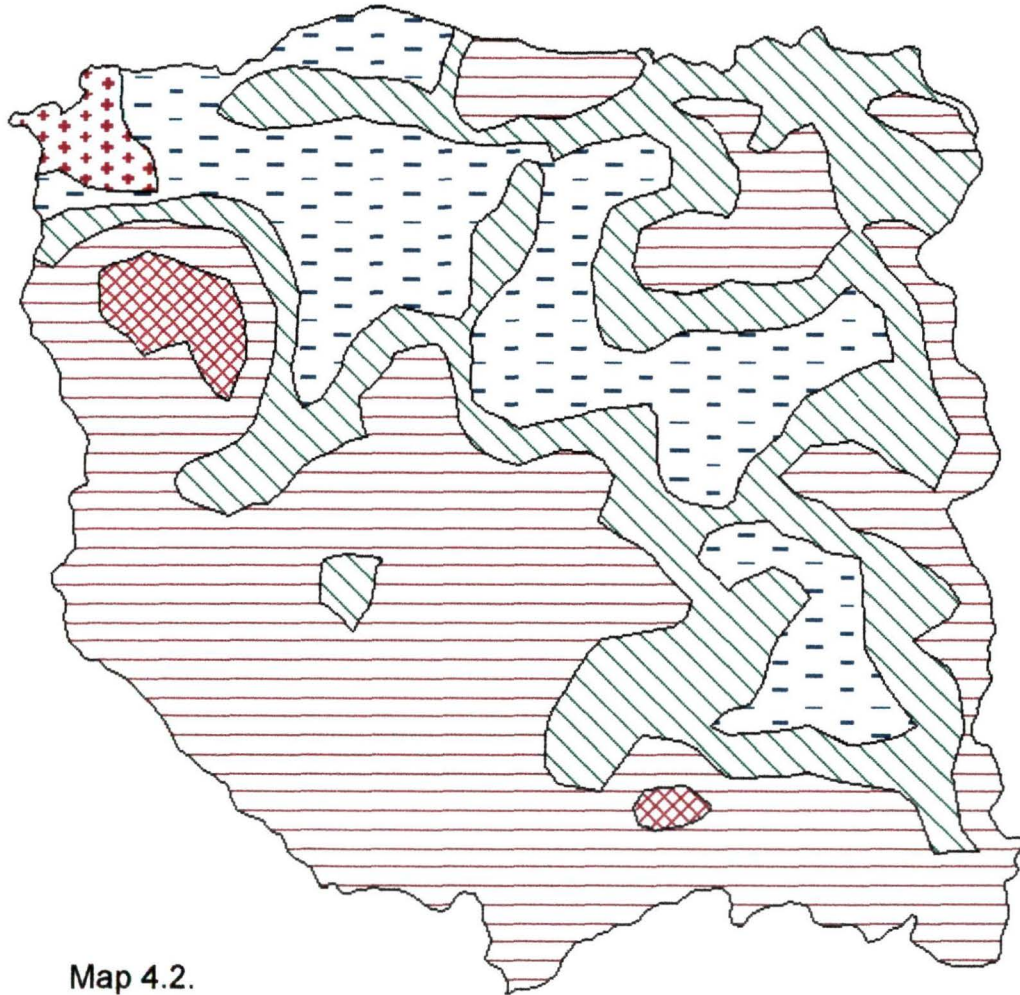
Table-4.2: Area under different slope categories.

Slope in Degrees	Slope Category	Area in Sq.Km	Area in Percentage
2-5	Gentle	5.17	1.44
5-10	Moderate	73.42	20.39
10-18	Moderately Steep	99.57	27.66
18-30	Steep	174.51	48.48
30-45	Very Steep	7.33	2.04
		360	100

ii) Extent of erosion






The present use of the word 'erosion' is in the sense of 'accelerated water erosion'. Through erosion and redeposition, unconsolidated mineral parent materials of soils are accumulated. Erosion is both constructive as well as destructive, and the type of landuse/landcover often influences the rate of erosion. Erosion induced by man is much more powerful than those caused by the natural processes,⁷ Ground observation indicates that the accelerated erosion of soil in the study area is aggravated mostly due to disturbance of the natural landscape, usually by man. The study area because of its inherent slope conditions, practice of bun cultivation, burning, grazing and forest cutting is prone

Mawkynew C & R. D. Block AVERAGE SLOPE MAP



Legend

Slope Category

-  Gentle
-  Moderate
-  Moderately Steep
-  Steep
-  Very Steep

Map 4.2.

1000 Mts 0 1 2 3 4 5 Kms

to severe erosion. Sheet erosion is common in the central upland regions of the study area, on uncovered soils, while rill erosion and gully erosion is more conspicuous in the southern steeplands.

iii) Degree of wetness

The major land quality of “availability of water” can be approximated by the measurement of precipitation, ground water and water retention capacity of the soil. The land quality is measured by determining the degree of wetness, which is often determined by soil depth and by the porosity and structure of the subsoil. Much of the soils if the study area is well drained from surface with moderately rapid permeability.

4.3. General description of the soils in the study area

In general, the soils of the study area can be associated with the Shillong group of landscape, falling under Ultisols, Inceptisols, Altisols and Entisols based on soil taxonomy classification. Being stable for long time the soils are medium to fine textured varying in depth.

The southern high plateau areas have deep coarse to fine textured and gravely/loamy skeletal to fine loamy soil. The surface soil texture varies amongst sandy loam, loam and clayey loam with dark brown and reddish brown and red in colour. The subsoil texture varies from sandy/silty loam to clay loam/silty clay loam, and are generally dark reddish brown to reddish brown in colour. Clay percentage varies from 10 - 40 per cent and are excessively drained with severe to very severe erosion hazards.

The soils developed on hill-side and escarpments with long steep slopes are moderately deep to deep, coarse to fine textured (loamy skeletal to fine and excessively drained). The surface soil texture varies amongst sandy loam, loam and clay loam, and the subsurface soil varies from sandy loam to clayey loam. The colour of the surface soil is dark brown and dark greyish brown and

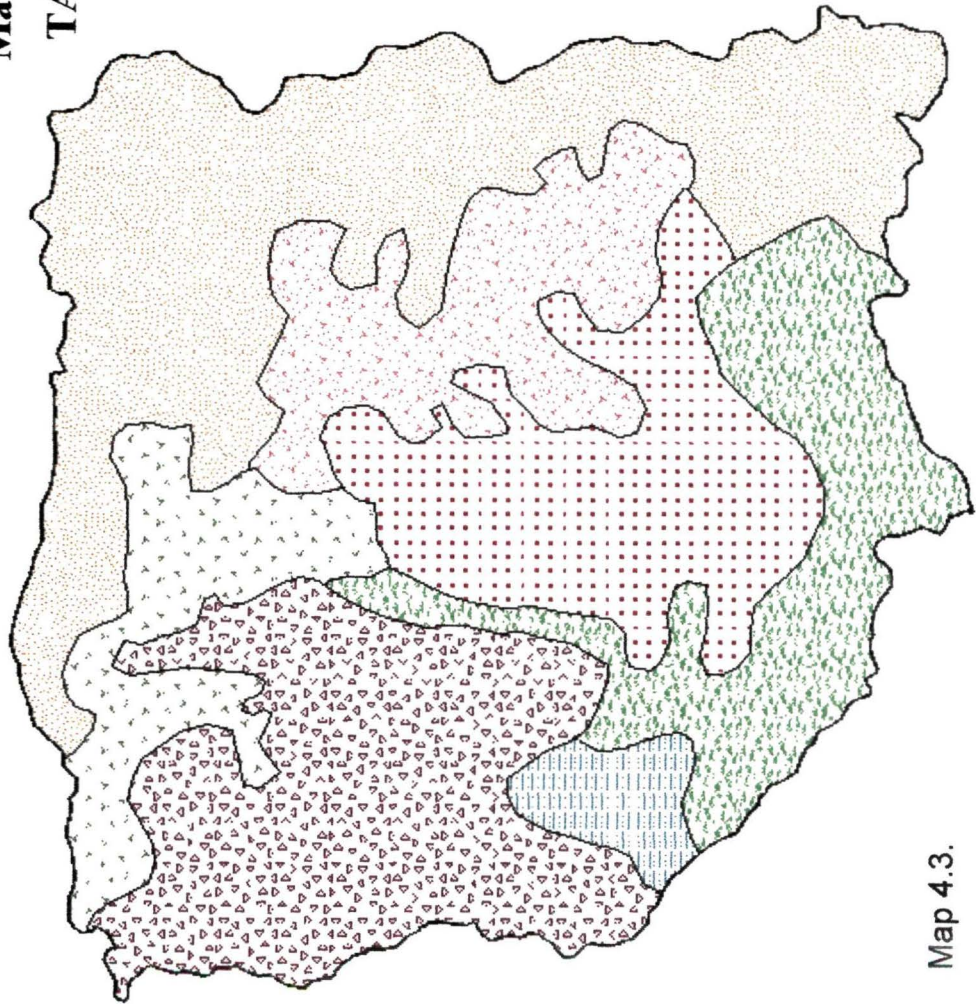
subsurface soil varies from dark reddish brown to reddish brown and red in colour.

Soils of the study area are also in general acidic. They are highly leached due to heavy precipitation, hilly topography and prevalence of bun cultivation, which also causes deficiency in micro nutrients. Soils derived from the gneisses is mostly medium to fine textured having thick profile, and dark tan to dark reddish brown in color, and loamy to clayey in texture. In areas predominated by the presence of lush vegetation cover or dense forest rich humus content of topsoil due to leaf litter can be noticed.

4.4. Soil Taxonomy

Generating the soil map of the study area has been the most difficult part of the exercise. Though an understanding of the various characteristics of the soil had been derived through the testing of soil samples from various sites, on one hand it was difficult to demarcate the exact boundaries and the extent to which the particular group of soils belonged. On the other hand, the land capability classification done which was done using GIS, demanded for a map with spatial distribution of soils. Therefore a soil taxonomic map was prepared with the help of experts from the Department of soil conservation, Meghalaya. The soil maps prepared by the National Bureau of Soil Survey & Land Use Planning⁸, Satellite Remote Sensing Survey of Meghalaya⁹ and the Report on soil and land use survey of Meghalaya¹⁰ formed the base for the taxonomic map of the study area. Moreover, samples collected from some of the sample sites and field survey were also taken into account to determine the physical, chemical and other characteristics of the soil, and accordingly the study area has been divided into five mapping units to derive a taxonomic soil map (Map 4.3) and its description is provided in table -4.3.

**Mawkynrew C & R. D. Block
TAXONOMIC SOIL MAP**



Legend

SOIL_TYPE	Symbol
1	Red triangles
2	Blue horizontal lines
3	White
4	Green vertical lines
5,A	Red dots
5,B	Green dots
5,C	Red triangles
boundary	Black outline

Map 4.3.

(Refer Table-4.3 for Soil Type details)



Table-4.3: Description of soil taxonomy of the study area.

Mapping Unit	Area in Sq.Kms (area in %)	Soil Taxonomy (Soil Association)	Description
1	39.83 (11.06)	Typic Kandiuults Typic Dystrochrept	<p>Deep, freely drained, acidic in reaction, less organic matter, fine textured, fine loamy particle size class i.e. by weight 15% or more of the particles are fine sand with 25-0.1 mm in diameter or coarser; including fragments upto 7.5 cm in diameter; 18-34% clay in the fine earth fraction. Loamy surface with moderate soil erosion hazard.</p> <p>Associated with moderate deep, freely drained acid soil. Particle size class: coarse loamy i.e. by weight 15% or more of the particles are fine sand with diameter 0.25 – 0.1 mm or coarser; including fragments up to 0.25 – 0.1 mm or coarser; including fragments up to 7.5 cm in diameter; Less than 18% clay by fine earth fraction. On gentle sloping hill tops with very severe erosion hazards and stoniness.</p>
2	9.22 (2.56)	Typic Kandihumults Typic Dystrochrepts	<p>Deep, freely drained, acidic in reaction, relatively high in organic matter, loamy surface soil, on strong to moderately steep side-slopes of hills.</p> <p>Particle size class – fine loamy i.e. by weight, 15% or more of the particles are fine sand with 0.25 to 0.1 mm or coarser; including fragments upto 7.5 cm in diameter; 18 – 34% clay in the fine earth fraction, moderate soil erosion hazard and strong stoniness. Associated with moderately deep, freely drained, acidic in reaction, loamy skeletal in particle size class i.e. rock fragments make up to 35% or more by volume; enough fine earth to fill</p>

			interstices larger than 1 mm, the fraction is loamy as defined for the loamy particle size class; on very gentle sloping hill tops with severe erosion hazards and strong stoniness
3	30.18 (8.38)	Typic Kandihumults Typic Dystrochrepts Typic Hapludults	<p>Deep, freely drained, acidic in reaction, relatively high content of organic matter, loamy surface soil, on strong to moderately steep side slopes of hills, moderate soil erosion hazard and strong stoniness. Particle size class is fine loamy i.e. by weight 15% or more of the particles are fine sand; 0.25 – 0.1 mm in diameter or coarser; including fragments up to 7.5 cm in diameter; 18 – 34 % clay in fine earth fraction.</p> <p>Associated with this unit are:-</p> <p>Moderately deep, freely drained, on gentle sloping hill tops with very severe erosion hazard and strong stoniness. Particle size class; fine loamy i.e. by weight 15% or more of the particles are fine sand; 0.25 – 0.1 mm or coarser; including fragments up to 7.5 cm in diameter; 18 – 34% clay in the fine earth fraction.</p> <p>Deep, freely drained, acidic in reation, deep to moderately deep to hard rock, have an ochric epipedon, on moderately to steep side slopes with severe erosion and strong stoniness. Particle size class: fine loamy i.e. by weight, 15% or more of the particles are fine sand, 0.25 – 0.1 mm or coarser; including fragments upto 7.5 cm in diameter.</p>

4	49.7 (13.81)	Umbric Dystrochrepts Typic Dystrochrepts	<p>Moderately shallow, freely drained, darker surface soil on moderately to steep side slopes of hills having loamy surface with severe erosion hazard and strong stoniness. Particle size class is fine loamy i.e. by weight 15% or more of the particles are fine sand; diameter 0.25 – 0.1 mm or coarser; including fragments up to 7.5 cm in diameter.</p> <p>Associated with moderately shallow, freely drained, darker surface soil, on gently to moderately sloping hill tops with severe erosion hazard and strong stoniness. Particle size class is loamy skeletal i.e. rock fragments make upto 35% or more by volume; enough fine earth to fill interstices larger than 1 mm; the fraction is finer than 2 mm is loamy as defined for the loamy particle size class</p>
5		Umbric Dystrochrepts Typic Udorthents	<p>Moderately deep, freely drained, darker surface soil, acidic in reaction, on very steeply sloping hill escarpments having sandy surface with very severe erosion hazards and strong stoniness. Particle size class is coarse i.e. by weight 15% or more of the particles are fine sand, diameter 0.25 – 0.1 mm or coarser; including fragments up to 7.5 cm in diameter; less than 18% clay in the fine earth fraction.</p> <p>Soil association are: Deep to moderately deep, freely drained, organic matter decreases with depth, on steep hill tops with severe soil erosion hazards and strong stoniness. Particle size class is coarse loamy i.e. by weight 15% or more of particles are fine sand, diameter 0.25 – 0.1 mm or coarser; including fragments up to 7.5 cm fraction.</p>

5.A	52.96 (14.71)	Rhodie Paleudults	<p>Deep, freely drained, on very old stable land surfaces, with severe soil erosion hazard and strong stoniness; mostly darkened throughout the upper meter and the epipedon is normally dark coloured mainly due to large amount of free iron-oxides rather than the organic matter. Particle size class is loamy skeletal, i.e. rock fragments make up to 35% or more by volume; enough fine earth to fill interstices larger than 1 mm; the fractions finer than 2 mm is loamy as defined for the loamy particle size class.</p>
5.B	105.27 (29.24)	Typic Dystrochrepts	<p>Moderately deep, freely drained, acidic in reaction, on very gently sloping hill tops with severe erosion hazard and strong stoniness. Particle size class is fine loamy by weight 15% or more of the particles are fine sand; diameter 0.25 – 0.1mm or coarser, including fragments up to 7.5 cm in diameter. The fractions finer than 2 mm is loamy as defined for the loamy particle size class</p>
5.C	72.84 (20.23)	Typic Dystrochrepts	<p>Moderately deep, freely drained, with very severe erosion hazard and strong stoniness. Particle size class is loamy skeletal i.e. rock fragments make up to 35 % or more by volume; enough for the earth to fill interstices larger than 1 mm, the fractions finer than 2 mm is loamy as defined for the loamy particle size class.</p>

4.5. Land Capability Classification

LCC can be put under three main categories. Capability class forms the first category of land capability unit, and indicates the general degree of 'goodness' in the sense of 'possible intensity of use'. This is followed by the capability subclass, which indicates the major limitations like erosion hazard, excess water, soil limitation within the rooting zone, and climatic limitations. Capability unit forms the third category and corresponds to phases of soil series in the detailed soil survey and where each unit is numbered on the basis of management differences. However for the present study due to the limitation of the soil data, it is attempted to generate only a broad capability class, which can be further substantiated into a detailed subclass and unit level after a detailed soil survey analysis.

In the present context the Capability Class relates to the general degree of 'goodness' in the sense of 'possible intensity of use' i.e. I = best to VIII = worst adopted from Klingebiel & Montgomery¹¹. As discussed earlier, land classification involves a complex procedure of analysing the soil, slope, climate, existing landuse and landcover etc. Various options are available in the ARC GIS software to generating Land capability classification maps both in the raster and vector format. The accuracy of such maps depends to a large extent on the details and quality of data, weightage assigned to each land facets, and the methods applied.

The factors affecting land capability as discussed in the earlier part of this chapter has been considered to generate the land capability classification of the study areas. However, due to limitations of data, and difficulty in generating detailed maps, only relatively permanent land characteristics have been considered, e.g. physical characteristics of the soil which are more permanent are given more importance than chemical characteristics which are modifiable. The economic evaluation like cost of land improvement, profitability, etc is not considered. Some of the socio-economic factors such as distance to market,

kinds of roads, literacy, occupation etc has been dealt separately and given due importance in formulating land use plans for these capability classes.

Two important parameters taken for the present land classification is the soil and slope. Based on its characteristics these two parameters have been arranged in rows and columns on the basis of its degree of fitness in descending order and the capability class was assigned (Fig 4.2). After comparing the various land units and examining the other attributes like drainage, physiography, existing landuse/landcover etc. of each polygon a final land classification map was prepared (Map 4.4).

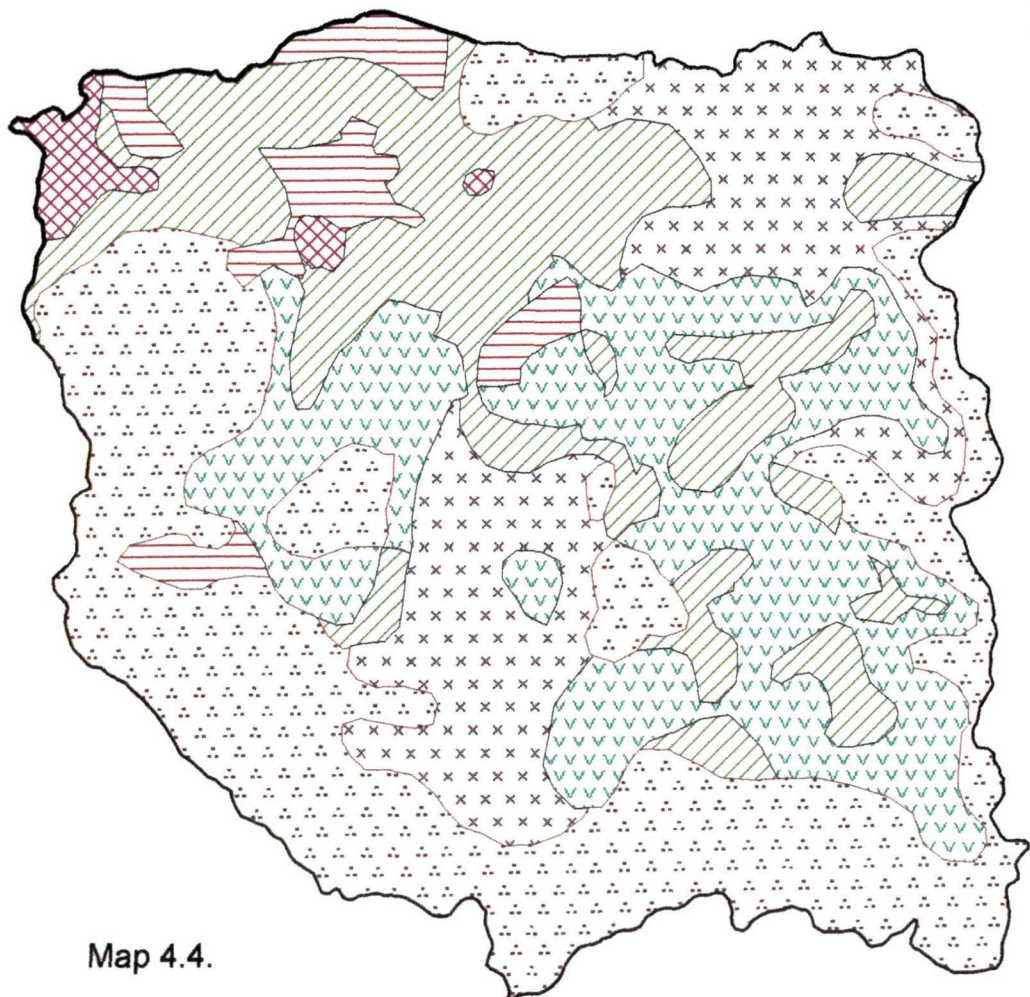
Slope →	Gentle	Moderate	Moderately Steep	Steep	Very Steep
soil ↓					
2	II	II	IV	VII	VIII
3A	II	II	IV	VII	VIII
1	II	III	IV	VII	VIII
5A	III	III	VI	VIII	VIII
4	III	III	VI	VIII	VIII
5C	III	IV	VI	VIII	VIII
5B	IV	IV	VII	VIII	VIII

Fig.4.2: Land capability class assigned to soil & slope combination.

Table-4.4. Area under different land capability class








Land Capability Class	Area in Sq.Km.	Area in Percentage
II	5.88	1.63
III	16.71	4.64
IV	75.82	21.06
VI	78.26	21.74
VII	60.73	16.87
VIII	122.60	34.06
	360.00	100

Mawkynew C & R. D. Block LAND CAPABILITY CLASSIFICATION



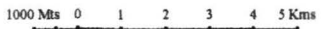
Legend

LCC_Code

-  II
-  III
-  IV
-  VI
-  VII
-  VIII
-  boundary

Map 4.4.

(Refer Chapter IV for LCC_Code description)



It can be observed from Fig- 4.2 and table-4.4. that the land capability class I and II are not indicated. This is because apart from good soil conditions, areas belonging to class I land needs to have nearly leveled slope with very little erosion hazards. Soils in class V too have little or no erosion hazards and the land is nearly leveled, but have other limitations, such as overflow, stoniness, wetness or severe climate. Therefore, these two classes of land does not occur in the study area because at the given unit and scale of analysis of slope no area fell in the category of below 2 degrees which is considered as nearly leveled to gentle slopes. Thus, the study area has been divided into six land capability classes, and has been described under different categories according to the intensity of hazards and limitations of use.

4.5.1. Land suitable for cultivation and other uses.

Three classes of land have been identified under this category. They are:

i. Class II

All Class II lands has been included under this category. Such areas have moderate limitations that reduce the choice of plants or require moderate conservation practices. The Limitations mainly result from the effects of one or more of the following:

- i) gentle slope
- ii) moderate susceptibility to erosion
- iii) less than ideal soil depth
- iv) occasional damaging overflow
- v) slight climatic limitation on soil use and management.

Only 1.63 percent (5.88 sq.kms) of the total geographical area falls under the category of land with moderate limitation and is mostly found in the northwestern part of the central plateau region.

ii. Class III

Lands under class III have severe limitations that reduce the choice of plants. This could be due to the restrictions in its use resulting either from soil condition or slope. Such areas can be considered as moderately good land, which can be used for cultivation after taking necessary conservation practices. Limitations of soils in class III may result from the effects of one or more of the following:

- i) moderately sloping land
- ii) high susceptibility to water or wind erosion
- iii) very slow permeability of the sub-soil
- iv) shallow soil depth to bed rock, which limits the rooting zone and the water storage
- v) moderate climatic limitations

The percentage of area occupied by Class III land is only 4.64 percent which is found in few pockets of the central upland region.

iii. Class IV

Lands falling under class IV have very severe limitations that reduce the choice of plants and require very careful management, or both. The restrictions in their use is greater than those in Class III, and the cultivation of crops are limited as a result of the effect of one or more permanent features such as:

- i) steep slopes
- ii) severe susceptibility to water and wind erosion
- iii) shallow soils
- iv) low moisture holding capacity
- v) excessive wetness with continuing hazard of water logging after drainage
- vi) moderately adverse climate.

The above three classes of lands which has been considered upto some extent to be suitable for agricultural practices although with various levels of

limitations, together comprise 27.33 percent of the geographical area. Out of this, 21.06 percent falls under class IV lands, which have very severe limitations. In such circumstances, the people of the study area is left with very few options for permanent agriculture, and have resorted mainly to bun cultivation.

4.5.2. Land not suitable for cultivation

i. Class VI

Lands falling under class VI category have severe limitations that make them generally unsuitable for cultivation and limit their use largely to pasture or range, woodland, or wildlife food or cover. 21.74 percent of the study area is falls in this category, and are characterised by continuing limitations, which are very difficult to correct such as:

- a) steep slopes
- b) severe erosion hazard
- c) stoniness
- d) shallow rooting zone
- e) excessive wetness or overflow
- f) low moisture capacity
- g) salinity or sodium

ii. Class VII

Lands in class VII have very severe limitations that make them unsuited to cultivation and limit their use largely to controlled grazing, woodland, or wildlife. Physical condition of soils is such that it is impractical to make improvements for agricultural use. Restrictions imposed by soil and slope are permanent and more severe than those in class VI. Much of these areas have moderately steep to steep slopes and occupy 16.87 percent of the geographical area, mostly along the southern steep slopes of the study area.

iii. Class VIII

Landforms in class VIII have limitations that preclude any form of cultivation, and restrict their use to recreation, wildlife, water supply, or to aesthetic purposes. Soils and landforms in class VIII cannot be expected to return significant onsite benefits although indirect benefits from wildlife use, watershed protection or recreation may be possible.

Limitations may result from the effects of one or more of the following:

- a) erosion hazards
- b) steep to very steep slopes
- c) severe climate
- d) wet soil
- e) stoniness

It can be observed from table-4.4. that class VIII lands occupy 34.04 percent of the study area, forming the single largest category of land capability classification. Soil and slope together with other geographical factors like physiography, climate, drainage, etc have played a major role in making much of the land in the study area unsuitable for agriculture. Thus, class VIII land combined with Class VI & VII, amount to 72.67 percent of the study area, which are practically unsuitable for any form of agriculture.

The approach followed in the present study provides the basic data for land capability classification. However, it may be mentioned that the land quality, or limitations indicated above are not static and the different parameters are not independent in their effects, but are interactive and involve processes which needs to be monitored at regular intervals. For example, poor management practices, or the destruction of vegetation cover in can cause land degradation and lead to worsening of its capability (negative change) or land with severe limitations such as class III, can be converted to class II after proper modification and management activities (positive change). These changes can be best

understood by analysing the land resources at a micro level, which needs to be fully supported by adequate field investigations. If sites and situations are well characterized, based on sound taxonomic principles, research knowledge can be transferred to other locations where similar conditions exists.

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CHAPTER-V

EXISTING LANDUSE/LANDCOVER PATTERN

CHAPTER-V

Existing Landuse/Landcover Pattern

5.1. Introductory Statement

The term 'land use' in the present context means "man's activities on land which are directly related to the land"¹ or "the expression of man's management of ecosystems in order to meet some of his needs"², and Land cover means "the vegetational and artificial constructions covering the land surface"³.

It is very useful to look at all land resources together from the viewpoint of landuse, which constitute the cultural ecosystem in which man tries to obtain his objectives by exercising human control on the key variables, within the ecosystem that mainly comprise of the landcover. Landuse is therefore, based on the available land resources and must be adapted to these resources as well as to human requirements by means of mechanical, chemical and biological tools combined into management systems. Because of the complex nature of landuse, which include ecological and technological as well as economic and social aspects, it is often difficult to find a good approach for studying it.⁴

Landuse/Landcover of an area especially that of a rural and agrarian base projects one of the most important criteria amongst all the various characteristics of land. The uncoordinated exploitation of land resources often lead to rapid environmental degradation resulting in the loss of biodiversity. Soil erosion, sedimentation and loss of soil fertility is a major environmental concern of modern times, which threaten the very productivity of the land in which people depend for their basic food requirements.

5.2. Existing Landuse/Landcover

The landuse/land cover of the study area has been divided into eleven categories which could be directly identified and delineated from the satellite

imageries and a clear distinction could be made between each landuse and landcover. The distribution of area under each type is given in Table 5.1., and Map 5.1

Table:5.1 Area under different Landuse/Landcover

Landuse / Landcover	Area in Sq.Km.	Area in Percentage
Built-up	17.08	4.74
Permanent Cultivation	19.36	5.38
Bun Cultivation	15.09	4.19
Plantation	5.06	1.41
Dense Forest Cover	54.58	15.16
Open Forest Cover	98.22	27.28
Grass/Shrubs	123.59	34.33
Fallow Land	11.45	3.18
Sandy/Rocky	5.49	1.52
Barren Land	5.63	1.56
Water Bodies	4.45	1.24
Total	360	100

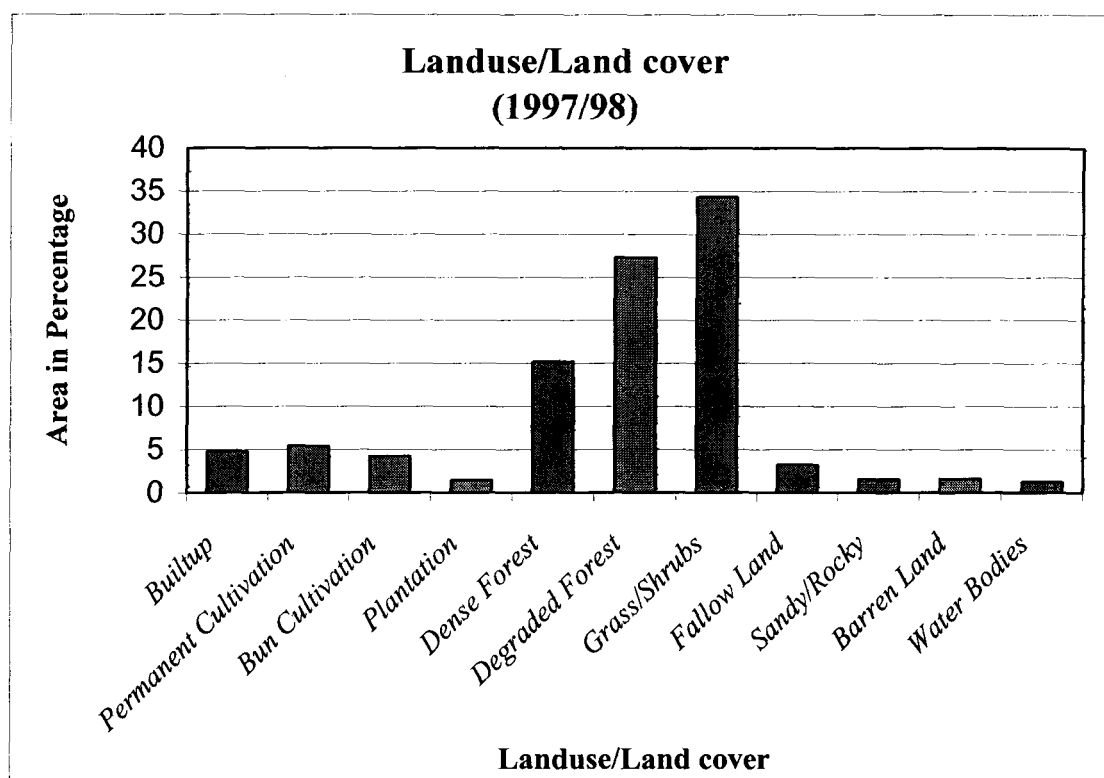
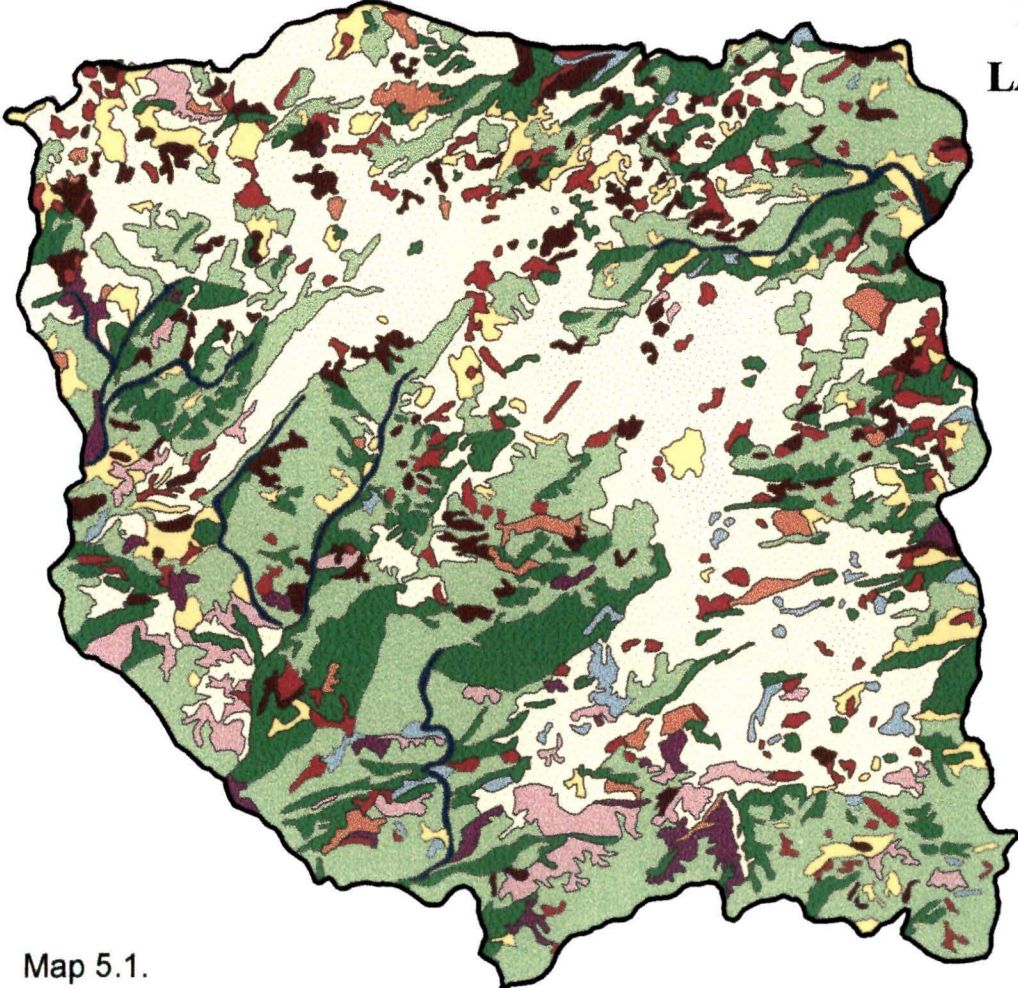


Fig.5.1. Landuse/Landcover 1997/98

**Mawkynew C & R. D. Block
LANDUSE/LANDCOVER MAP**

1997/98



Legend

Landuse/Landcover

-  Builtup
-  Permanent Cultivation
-  Bun Cultivation
-  Plantation
-  Dense Forest Cover
-  OpenForest Cover
-  Grass/Shrubs
-  Fallow Land
-  Sandy/Rocky
-  Barren Land
-  Water Bodies
-  boundary

Map 5.1.

1000 Mts 0 1 2 3 4 5 Kms

5.2.1. Builtup

The builtup areas demarcated in the study area mainly comprise of rural settlement. Apart from the village settlement some of the institutional areas could also be identified, therefore, all artifacts has been clubbed under 'builtup' rather than settlement. The area under this category cover 4.74 percent of the total geographical area of the region which mainly include the 65 inhabited villages, most of which is located in the Central upland region. The scattered distribution of the builtup areas with uneven shape and relatively very small sizes of the polygon in indicates the rural nature and dependence of the people on primary activities. Field verification of the builtup areas reflected scattered settlement in most of the areas, while linear settlement pattern was also found especially along the roads.

5.2.2. Permanent Cultivation

The area under permanent cultivation includes settled agriculture and terrace cultivation, which is widely prevalent in the Central Upland regions. These two landuse practices together occupy 5.38 percent of the total geographical areas. The identification and distinction of the permanent cultivation from that of plantation and bun cultivation is done through direct interpretation from 1:25,000 IRS ID PAN data, using the interpretation keys and substantiating it with ground truthing. It can be ascertained that much of the fertile river valleys close to human habitation has already been utilized for permanent cultivation, most of which is used for the cultivation of rice. Terrace farming which is also included under this category is a more recent practice, but serves as a better agricultural landuse especially in the Central Upland regions where bun cultivation has brought much area under severe land degradation. The Khasi Hills being predominantly a hilly region, valley lands and plain lands are very limited. Wherever such lands exist, they are generally narrow and are flanked on both sides by steep hills. The narrowness of valley lands and plain lands prevents the large-scale adoption of agricultural machinery. These are only a few of the factors that have stood in the way of rapid growth and development of agriculture in the districts⁵. Such

characteristics is widely prevalent in the study area, making permanent cultivation areas scarce, fragmented and un-mechanized.

Important cash crops grown in the study area are tapioca, ginger, pan-leaf and black pepper. Sweet potato and yam are grown for domestic consumption. Almost all kinds of vegetables suitable for varying climatic conditions are also cultivated. Vegetables that do well in high altitudes include cucumber, carrot, turnip, varieties of beans and peas, cauliflower and cabbage, tomato, mustard etc.

5.2.3. Bun Cultivation

Studies made by Gangwar and Ramakrishnan in the early part of 1970s, in Khasi Hills mentions about changes in the characteristics of shifting cultivation and its environmental consequences. – “the Khasis have adopted a fallow system of agriculture in which the burning operation of jhum is eliminated. This new system may cause even more rapid depletion, desertification and loss of soil fertility such that the fallow/sedentary agricultural system often becomes uneconomic⁶. Earlier records and written documents about this new modified form of shifting cultivation is unknown, but the transition from shifting cultivation to Bun cultivation can be mainly attributed to the use of fertilizers, mono cropping and the shortage of land. The project report – “Satellite Remote Sensing Survey, Meghalaya” carried out by the NRSA for NEC indicates that ‘bun’ cultivation at higher elevations of Meghalaya where the tops of the hills are used to grow potatoes on raised beds along slopes, has resulted in an annual soil loss of 40 to 50 tonnes per hectare. For every tonne of the potato grown in this way, two tonnes of soil are lost. Consequently these slopes become absolutely bare with no soil to hold the vegetation.⁷

At present the process involved in Bun cultivation includes:

- clearing of vegetation during the month of December/January.
- laying the debris in rows and allowing it to dry

- covering the debris with soil from adjacent areas and burning.
- Sowing (mainly potato) during the month of February (pre-monsoon) and September (post monsoon).

Among the different types of commercial crops in the study area, the most important is potato. The Central upland areas of high altitude is extensively under potato cultivation and a major portion of what is grown finds a ready market in the State. The main drawback in potato cultivation as practiced in these areas is the adoption of a peculiar method of soil-preparation (kh.thang bun) whereby woody stems of plants, commonly lantana, are cut and left to dry in separate heaps before being covered with turf and then set on fire. After combustion is complete, the whole residual material is intermixed before the seed potato is planted. This method is persisted in because of the belief that it prevents attacks of blight. By loosening the top soil, however, it leads to serious erosion particularly in fields situated on hill slopes. Government is trying to encourage the potato farmers to resort to the other methods by subsidizing contour-bunding and terrace cultivation. The introduction of blight resistant varieties of potato like the Kufri Jyoti by the Agricultural department may encourage farmers to give up the present unsatisfactory method of soil-preparation⁸.

Current practices of shifting cultivation in the hills of northeast India with shortage of land in the face of growing population, reducing periodicity of Jhum cycle are not ecologically healthy and it is a practice that has, among other factors, taken a toll on the vegetal cover in the hills.⁹ Unlike shifting cultivation, bun cultivation is coupled with high intensity tillage, indiscriminate application of chemical fertilizers, pesticides and insecticides. At present the reduction of Bun cycle to 2 to 3 years and the absence of vegetation in-situ, have forced the farmers to carry vegetation debris from adjoining forest lands to bun cultivation sites.¹⁰ As of today, in view of population rise and pressure on land including the ever increasing and manifold needs, this agricultural practice has become

unsustainable and further acute the problem and consequently render the environment more fragile.

5.2.4. Plantation

Covering an area of 1.41 percent, the areas under plantation is mostly found in scattered pockets along the southern slopes. Ground survey also revealed many areas in the central upland regions where plantation activities are carried out together with agro forestry, but being illegible in the satellite imagery it was not possible to demarcate plantation done at scale smaller than 0.1 sq.km. The Khasi Hills have for long been famous for the fruits that grow here. Both soil and climate are conducive to the growth of different types of fruits ranging from tropical to temperate varieties depending on altitude¹¹. The study area having highly favourable conditions for the plantation of fruits like oranges, pears, plums, peaches, passion fruit, pomegranate etc. in the central upland region, and banana, tapioca, betel leaf, Papaya, sugarcane etc. in the southern steep slopes, can be seen as an appropriate alternative to combat the practice of bun cultivation.

5.2.5. Dense Forest

Forest type is defined as a unit of vegetation, which possesses broad characteristics in physiognomy and structure sufficiently pronounced to permit its differentiation from other such units¹². Spatial distribution of forest types and their canopy crown cover are essential for understanding the total forest ecosystem and such information is indispensable for the purpose of forest management especially for decision making in planning forest land development and controlling measures.¹³

The different categories of forest cover is classified on the basis of crown cover density – i.e. more than 40 percent crown cover is clubbed under dense forest cover, 10 to 40 percent crown cover as open forest and less than 10 percent canopy cover as grass/shrubs. Though the third category is generally

classed as Open forest, the study area having a large stretch of land especially in the central upland region under grass and shrubs with very little continuation and homogeneity in open forest land, the category of 'grass/shrubs' was found to be more appropriate.

Forest has been one of the most important land resources, directly extractable and usable for meeting the requirements of food, fuel and fodder of the people residing in the study area. This is strongly supported by the fact that the occupational structure in the category of livestock rearing, forestry, hunting and plantation comprise of 69.34 percent of the total population of the study area.

The criteria for classifying areas under dense forest is the inclusion of all areas having crown cover of more than 40 percent. A combined interpretation of the PAN and FCC data provided a very accurate delineation of the areas under dense forest cover. Ground truthing and change detection analysis revealed that the existing dense forest cover is a combination of three main types:

1. the undisturbed mixed dense virgin forest cover,
2. natural growth of mixed dense forest cover, and
3. secondary dense forest cover, mainly pine.

The present area occupied by dense forest cover is only 15.16 percent, most of which is located in the deeply dissected southern slopes. The hurdle between conservation and management of forest resources and the existing pressure of nearly 70 percent of the population which are directly or indirectly dependent on this resource creates a strong base to go into a more detailed study of the forest cover and the changes taking place therein, which is discussed in more detail in the preceding section.

5.2.6. Open Forest

The area under this category includes forest areas having 10 to 40 percent crown cover. 27.28 percent of the total geographical area of the region is covered by open forest cover, predominantly pine, which is considered to be secondary forest. Most of the areas under this category has been influenced by forest fire, bun cultivation and then abandoned, lumbering activities at one time or the other. The geographical distribution of open forest cover is closely associated with that of the dense forest cover in the sense that these two land cover, most of the time shares a common boundary, and in proximity to builtup and bun cultivation areas. The open forest areas needs a serious consideration because of the fact that while the dense forest cover can be treated as conservation zone, the open forest cover can act as a forest produce zone requiring careful management, so as to provide the basic requirement of food, fodder and fuel to the inhabitants.

5.2.7. Grass/Shrubs

Areas having less than 10 percent forest cover has been clubbed together with grass and shrubs, the reason being that there was very less continuity and homogeneity in the forest cover under this category. A large area of the central plateau region, where the practice of bun cultivation is more intense is predominantly covered by grass/shrubs. The distribution of areas under this category shows continuity over space and shelters within it small areas of other landuses, mostly bun cultivation. For most farmers, the indicator of soil fertility is the type and density of vegetative cover that regenerates in the abandoned bun sites – they too are aware that the land is not being left fallow for long enough to regenerate its fertility. The shortage of cultivable land and the ever increasing demand for agricultural land often compels the farmers to cultivate on lands which they know may not necessary bear the desired output.

Gangwar and Ramakrishnan in the early part of 1970s revealed the fact that in many areas in the Khasi Hills of Meghalaya, where forest have almost

disappeared and the land is being desertified because of the reduction in Jhum cycle length to less than 5 years¹⁴. The impact of bun cultivation in the region can be seen from the fact that 34.33% of the geographical area is now under grass/shrubs, which constitute the largest area under land cover category. The rampant practice of bun cultivation and the reduction of bun cycle to 2 to 3 years¹⁵, could soon lead to the desertification of these areas. Therefore, these areas need special attention and management strategies as it occupies most of the central upland region, which are more favourable for agriculture and other activities than its southern counterparts.

5.2.8. Fallow Land

Fallow lands, which cover an area of 3.18% mostly, belong to the category of recently abandoned bun cultivation. Unlike the area under grass and shrubs, land belonging to this category indicates some pattern of the beds arranged in rows and columns, which are used for bun cultivation. Since the data pertains to the month of March, the existing and other fresh bun cultivation sites were already used for sowing potato, and hence abandoned bun cultivation sites of recent nature are clubbed under fallow lands. This also gives a meaningful interpretation about the intensity of land degradation due to bun cultivation as the existing area under bun cultivation almost equals to that of the fallow land.

5.2.9. Sandy/Rocky

These areas constitute degraded topsoils armoured by stony and sandy layers at their surface, which are in many cases the result of erosion and deposition. In some areas of the central uplands, large tract of lands with rocks and stones exposed to the surface can be noticed vis-à-vis bun cultivation practices. Sandy/Rocky areas in the Southern steplands are more common in the steep slopes deprived of vegetation cover, and along the rivers and streams. The deforestation activities and landuse changes taking place in the southern slopes, and the practice of bun cultivation in the central upland regions are the main factors that have led to the outcome of sandy/rocky land facets. Though the

area under this category is only 1.52% it can have far reaching consequences on the land and water resources especially in the southern slopes leading to expansion of wastelands, landslides, siltation, soil erosion and other associated problems.

5.2.10. Barren Lands

In the present context barren lands does not mean unproductive lands, but indicates areas which are deprived of any vegetation cover, and recently cleared for plantation, construction and other purposes. Comprising of 1.56% of the total geographical area the barren lands is more dominant in the southern steeplands where most of the land under this category is being prepared for plantation purposes. In the central uplands, barren lands are found in smaller patches along the roads and settlement sites, which are meant for the expansion of builtup areas.

5.2.11. Water bodies

The areas under water bodies mainly comprise of the areas falling under the two major rivers of Umsong and Umngot, and also form the district boundary. These two river systems occupy a broad area, which could be distinctly delineated from the panchromatic satellite imagery. Though some of the minor streams and rivers forming narrow linear feature has been clubbed under the category of adjoining landuse/landcover, the rivers occupying larger areas has been demarcated as a polygon under the category of water bodies. In the absense of data on the quality and volume of water, it becomes difficult to make an assessment on the availability of water for irrigation and other purposes, but 1.24% (4.45 Sq.Kms) of the total geographical area occupied by water bodies is a significant indicator of the breadth and length of the two mighty rivers of Umsong and Umngot which constitutes two distinct watershed boundary of the study area.

5.3. Changing Pattern of Landuse/landcover

Most of the time the existing landuse/landcover is not assessed in terms of its actual coverage, changes – both negative and positive, and its impact on the society, economy and environment is often ignored. In view of rapid changes in land utilization for various developmental activities from time to time, a completely updated knowledge of the land resources and its changes is obligatory pre-requisite for identifying environmentally fragile and high-risk zones where immediate steps to tackle the problems can be intensified and for better scientific land resource management. Change detection studies is perhaps one of the most important exercise which is largely carried out to understand the changes taking place in the spatial distribution of landuse/landcover. Such studies not only reveal the past and present landuse/landcover conditions and the changes therein, but also help in bringing about awareness of the fast depleting resources and predicting the future consequences. The amount, intensity and pattern of landuse/landcover changes can be best understood by way of comparing the existing landuse/Landcover with that of the past. However, due to the absence of accurate and reliable data, and the complexities involved in generating past data, the SOI toposheet was taken as the base year for deriving two main types of LULC i.e. forest cover, which was a predominant landcover of the study area in 1965/66 and 'other landuses' which mainly includes lands under grass/shrubs, barren lands, areas under permanent cultivation and builtup mainly rural settlement.

5.3.1. Landuse/Landcover 1965/66

The total area under forest cover mainly dominated by dense pines and mixed jungle in 1965/66 was almost 41.51 percent, whereas the area under other landuses comprised of 58.49 percent of the total geographical area. Their distribution over the two physiographic divisions reveals that the southern steep slopes constituted 58.67 percent of its area under dense forest cover and 41.33 percent was covered by other landuses. The Central Upland region, which is more accessible and suitable for Bun cultivation and other landuses, has come

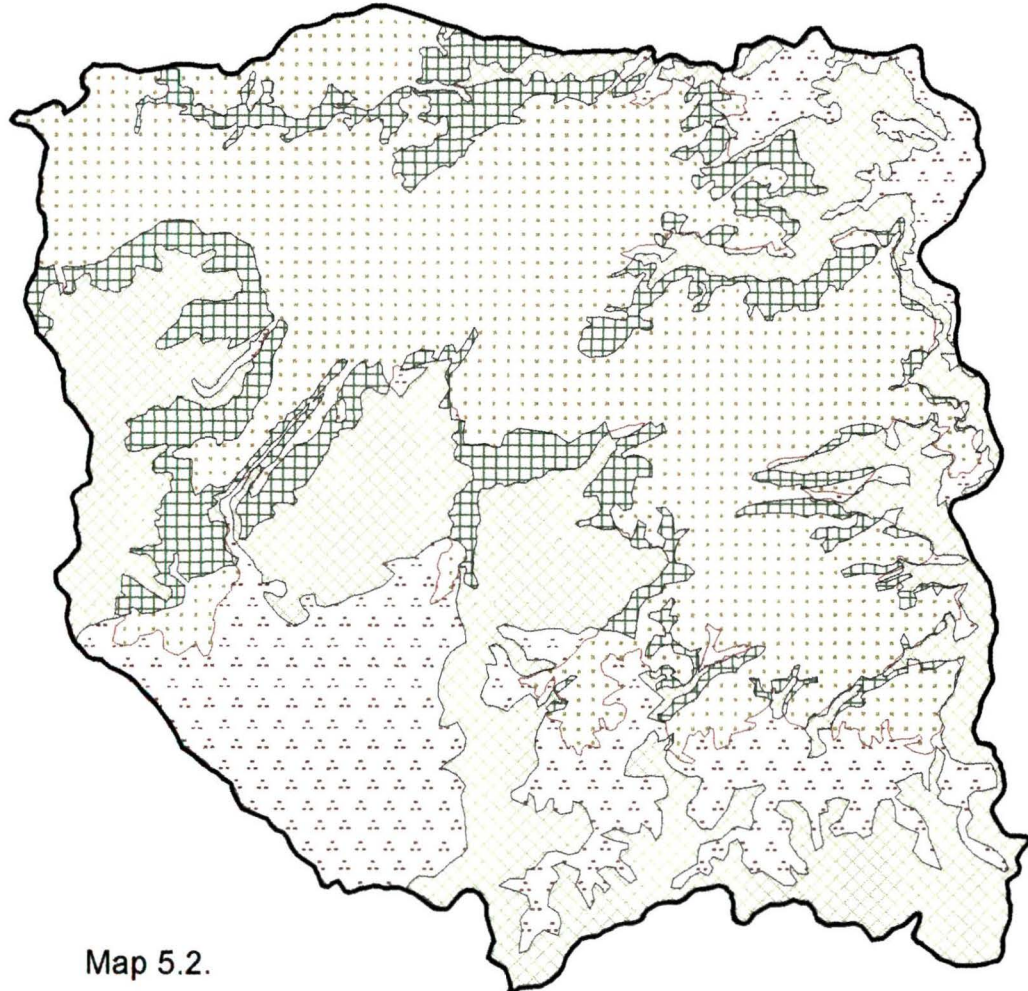
under severe forest depletion rendering 75.29 percent of its area to other landuses (Map 5.2)

The distribution of landuse/landcover in the two different physiographic zones of the study area (Table-5.2) reveal that the central uplands consisted only 24.71 percent of its area under dense forest cover and 75.29 percent in other landuses. The southern steeplands on the other hand, was dominated by dense forest cover, which covered 58.67 percent of the total geographical area during 1965/66, and 41.33 percent was covered by other landuses. The present condition that prevails in the central upland region which is dominated by extensive area under grass/shrubs can be said to have come under human influence even prior to 1965/66, while those prevailing in the southern steeplands are more recent in nature. Thus, the larger percentage of the distribution of forest cover clearly indicates inaccessibility as one of the important factor for the prevalence of dense forest cover in the southern steep slopes, while the more accessible and gentle sloping areas of the central uplands have been affected by other landuses.

Table-5.2: Forest Cover status under different Physiographic units (1965/66)
Area in Sq.Km

Physiography	Dense forest cover	Area in %	Other Landuse	Area in %	Total Area	Area in %
Central Uplands	44.95	24.71	136.99	75.29	181.94	50.54
Southern Steeplands	104.47	58.67	73.59	41.33	178.06	49.46
Total	149.42	41.51	210.58	58.49	360.00	100

Mawkynew C & R. D. Block
LANDUSE/LANDCOVER &
PHYSIOGRAPHY
(1965/66)



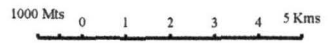
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 boundary

Landuse/Landcover & Physiography

-  Central Uplands, Dense Forest Cover
-  Central Uplands, Other Landuses
-  Southern Steeplands, Dense Forest Cover
-  Southern Steeplands, Other Landuses

Map 5.2.



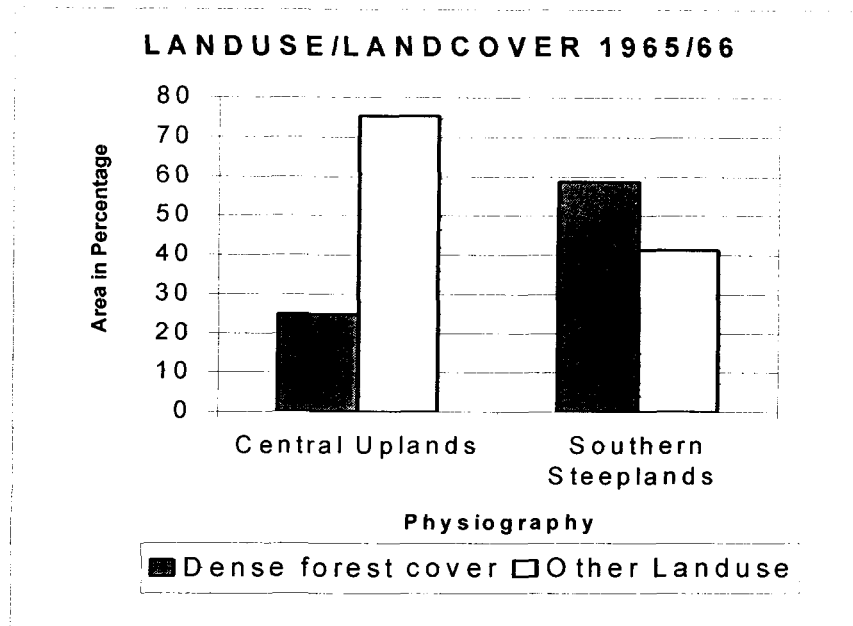


Fig. 5.2. Landuse/Landcover 1965/66

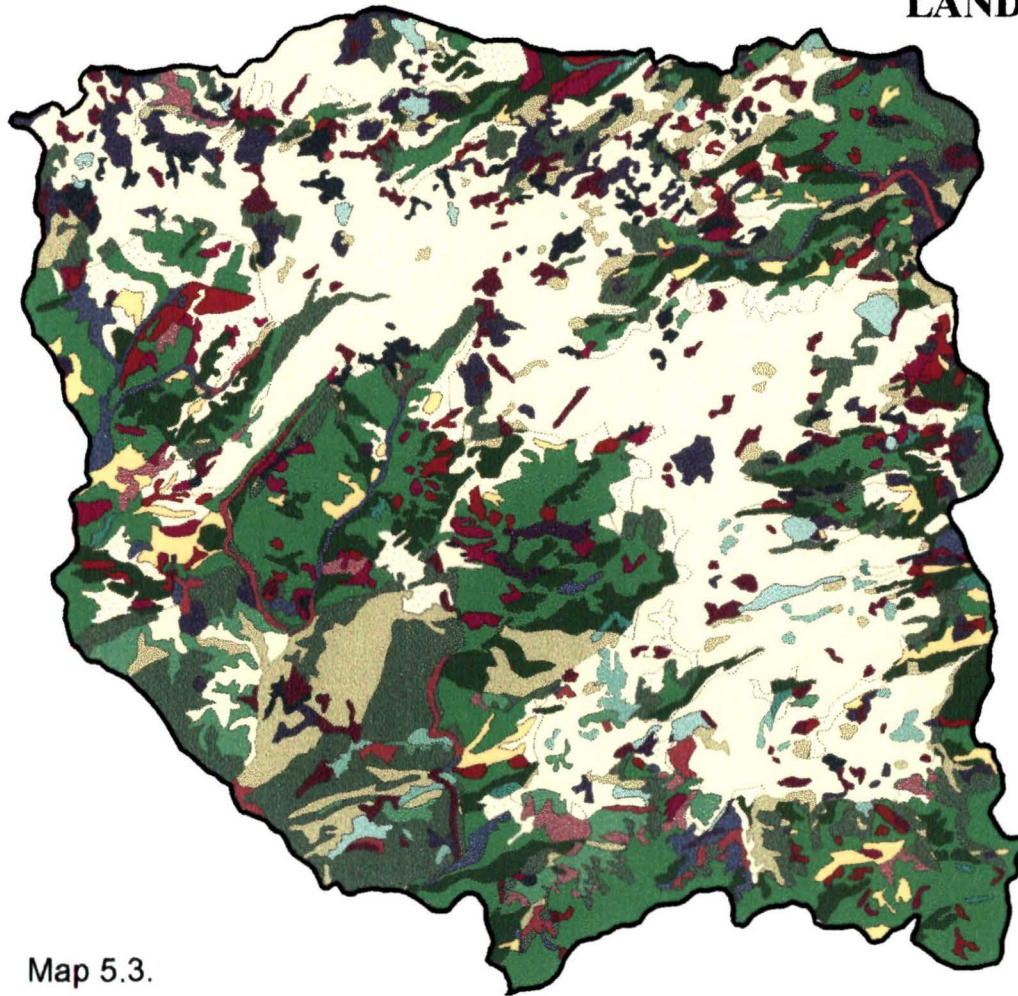
5.3.2. Changes in Landuse/Landcover (1965/66 to 1997/98)

A comparison of the Landuse/Landcover existing in 1997/98 which has already been discussed above and the landuse/land cover of 1965/66 (Map 5.3) reveals some drastic changes within a span of thirty-two years and indicates some alarming facts related to the loss of biodiversity and land degradation. Dense forest cover which occupied 41.51 percent of the study area is now reduced to a dismal 15.16 percent, much of which is not the original forest cover that existed during 1965/66, but secondary forest cover which has grown in areas where human interference is minimal. Most of the areas which was under dense forest cover in 1965/66 has either been converted to open forest cover mainly pine or to grass and shrubs.

Out of the 41.51% of dense forested area in 1965/66 only 8.86% remains unaffected, whereas 16.89 % of the dense forest is converted to open forest, and 7% degraded to grass and shrubs. The other Landuse practices that has taken place in the dense forest, i.e. built-up, permanent cultivation and bun cultivation individually occupy nearly 2 % of the changes. The scarcity of good agricultural

LANDUSE/LANDCOVER CHANGES

1965/66 TO 1997/98



Legend

 boundary

Landuse/landcover Change

-  Dense forest to Barren Land
-  Dense forest to Builtup
-  Dense forest to Bun Cultivation
-  Dense forest to Open forest
-  Dense forest to Dense forest
-  Dense forest to Fallow land
-  Dense forest to Grass/Shrubs
-  Dense forest to Permanent Cultivation
-  Dense forest to Plantations
-  Dense forest to Sandy/Rocky
-  Other Landuses to Barren Land
-  Other Landuses to Builtup
-  Other Landuses to Bun Cultivation
-  Other Landuses to Open forest
-  Other Landuses to Dense forest
-  Other Landuses to Fallow Land
-  Other Landuses to Grass/Shrubs
-  Other Landuses to Permanent Cultivation
-  Other Landuses to Plantations
-  Other Landuses to Sandy/Rocky

1000 Mts 0 1 2 3 4 5 Kms

Map 5.3.

land and/or the ever increasing demand of the growing population for agricultural land is also reflected by the encroachment of much of the agricultural practices, i.e. permanent cultivation (2.31%) and bun cultivation (2.13%) in areas which were initially under dense forest cover (Table-5.3).

Table-5.3: Landuse/Landcover Changes (1965/66 to 1997/98)

LULC Changes (1965/66 to 1997/98)	Area in Sq.Km.	Area in %
Dense forest to Built-up	5.27	1.46
Dense forest to Permanent Cultivation	7.83	2.18
Dense forest to Bun Cultivation	7.15	1.99
Dense forest to Plantations	1.86	0.52
Dense forest to Dense forest	31.91	8.86
Dense forest to Open forest	60.82	16.89
Dense forest to Grass/Shrubs	25.19	7.00
Dense forest to Fallow land	3.77	1.05
Dense forest to Sandy/Rocky	3.62	1.01
Dense forest to Barren Land	1.99	0.55
Other Landuses to Built-up	11.81	3.28
Other Landuses to Permanent Cultivation	11.53	3.20
Other Landuses to Bun Cultivation	7.94	2.21
Other Landuses to Plantations	3.2	0.89
Other Landuses to Dense forest	22.67	6.30
Other Landuses to Open forest	37.4	10.39
Other Landuses to Grass/Shrubs	98.4	27.33
Other Landuses to Fallow Land	7.68	2.13
Other Landuses to Sandy/Rocky	1.87	0.52
Other Landuses to Barren Land	3.64	1.01
Water Bodies	4.45	1.24
Total	360	100

The interpretation of the changes that has taken place in the 'other landuse' categories may not be very appropriate because of the fact that it is difficult to find out the category of exact landuse that existed in 1965/66. But, an obvious and significant change that has taken place in the 'other landuse' is the 6.30 percent or nearly 23 sq.kms. of area which is now predominated by the presence of dense forest cover. This positive change in the landcover indicates the regenerating capacity of the land and the self-regulatory mechanism of nature that usually interplay its own role when human influence is minimal. A

geographical analysis of the areas where such changes has taken place also reflects its ruggedness and hilly nature, which has made these areas practically impossible to be used for agricultural purposes or any other secondary activities. Thus, the overall scenario of this area highlights a significant change of 16.46 percent area converted from dense to open forest cover, dense to grass, shrubs (7 %) and other landuses which together has brought about almost 35 percent of the dense forest cover to be influenced by one or the other type of landuse activities, leaving behind only 8.86 percent of the original forest cover intact.

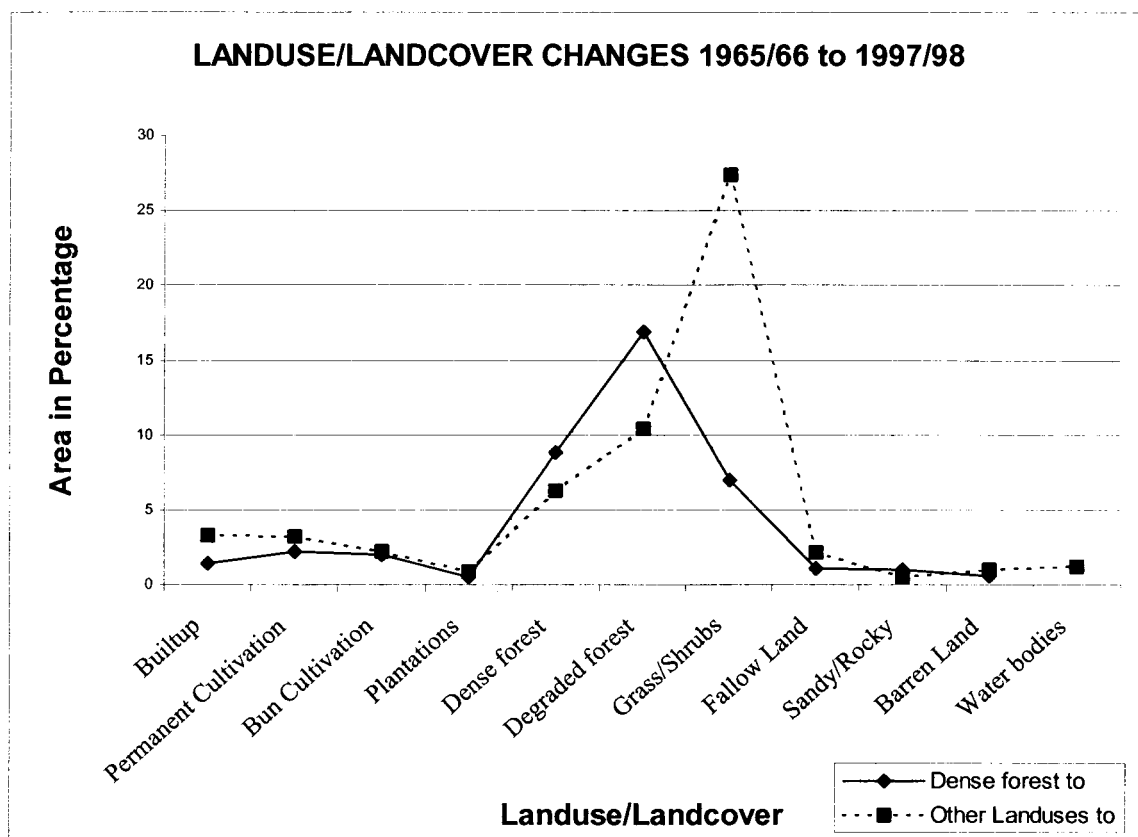


Fig. 5.3: Landuse/Landcover Changes – 1965/66 to 1997/98

5.4. Impact of Physiography on Landuse/Landcover

The effect of altitude and rainfall has already been noticed in vegetational changes. It is generally noted that for every 270 m increase in altitude a fall of 1°C temperature upto 1500 m takes place, above which the temperature fall is

more rapid. The temperature fall is also pronounced in the leeward side of the hill than on the windward side. The rainfall and duration have highest influence on the growth and development of various plants.¹⁶ With increase in altitude in mountainous terrains, the capacity to absorb ecological disturbances decreases. This aspect renders highland environments ecologically fragile in nature.¹⁷ The interrelationship with physiography, climate, soil and vegetation cover is often disturbed due to mans' economic activities. This is more rampant and serious especially in the hilly and mountainous terrain where the demand for land due to increasing population and poor land use activities creates an unwarranted exploitation and burden on the forest cover. This is characteristic of the present study area, where a physiographic approach is being adopted to understand the intensity of forest cover changes and loss.

Physiography to a large extent have a direct influence on the landuse/landcover, and it is often true that much of the influence of human activities has always been in the plain areas which are more accessible than those of the rugged and harsh physiographic conditions. As discussed earlier the altitudinal variation of the study area ranges from a minimum of 100 meters to 1800 meters above M.S.L. dividing the region into two distinct physiographic zones based on altitude, topography, climate, vegetation etc. They are the Central upland regions which is characterized by gentle sloping to moderately sloping lands and the southern steplands with steep to very steep slopes located at lower altitudes.

The landuses/landcover map superimposed on the physiographic map using overlay analyses in the GIS environment, helped in understanding the distribution and impact of landuse/landcover in the two physiographic zones and vice versa. The central uplands (50.54%) and Southern Steplands (49.46%) share almost an equal geographical area in terms of its size, but, the landuse/landcover characteristics within these two physiographic units is quite distinct.

5.4.1. Landuse/Landcover in the Central Upland

The influence of human activity and the pressure on the land resources in the Central Upland region is clearly indicated by the fact that landuses such as builtup (2.74%), permanent cultivation (2.86%) and bun cultivation (2.61%) occupies more area in this physiographic division than in the southern steplands. Grass/Shrubs, crossing a double figure of 27.99 % of area, is the single largest landcover in the central upland region, while all other landuse/landcover occupy less than 10% of the geographical area. The dependence of the people on the traditional bun cultivation has been a major factor for the depletion of forest resources, leaving only 4.59% of the area is under dense forest cover and 7.53% under open forest cover.

Out of the 181.95 sq.km. of area in the Central uplands, more than half i.e. 55.37% is under grass/shrubs, which in itself is an indicator of the large scale degradation of the forest and soil resources of this area. Almost an equal percentage of area is shared by three main landuse categories, namely builtup (5.42%), permanent cultivation (5.66%) and bun cultivation (5.16%). While the area under builtup and permanent cultivation is more or less static in nature in terms of its expansion and location, the practice of bun cultivation has either led to the utilization of newer areas which is predominantly covered by dense forest or open forest cover, or the use areas under grass/shrubs which are not left fallow for long enough to regenerate its soil fertility as bun cycle is now reduced to two to three years.

Table-5.5: Landuse / Landcover in Central Uplands (Area in Sq.Km)

Landuse/Landcover	Central Uplands	% to total area of the physiographic unit	% to total geographical area
Builtup	9.86	5.42	2.74
Permanent Cultivation	10.29	5.66	2.86
Bun Cultivation	9.39	5.16	2.61
Plantation	1.63	0.90	0.45
Dense Forest	16.53	9.08	4.59
Open forest	27.09	14.89	7.53
Grass/Shrubs	100.75	55.37	27.99
Fallow Land	2.12	1.17	0.59
Sandy/Rocky	0.71	0.39	0.20
Barren Land	3.35	1.84	0.93
Water Bodies	0.23	0.13	0.06
Total	181.95	100	50.54

5.4.2. Landuse/Landcover in the Southern Steeplands

The southern steeplands have lesser area under the four major landuses, i.e. builtup (2%), permanent cultivation (2.52%), bun cultivation (1.58%) and plantation (0.95%) as most of these areas having steep slopes and rugged topographic conditions are not largely favourable for different landuse activities. Most of the existing forest cover of the study is located in the southern steeplands, sharing 10.57% of area under dense forest cover and 19.76% under open forest cover. These two landcover together occupies almost 60% of the area of the southern steeplands and comprising the two most predominant landcover category of this region. This physiographic unit also shares a significant percentage of its area under builtup, permanent cultivation, bun cultivation and plantations, which can be found in scattered pockets of the river valleys and in areas having gentle to moderate slopes. Large tracts of lands are also being cleared for plantation activities, which are more recent in nature, rendering 5.24% of the area under fallow land. Further analysis revealed that much of the dense forest cover which existed in the past is now converted into open forest, grass/shrubs-fallow-barren-sandy/rocky etc. The southern steeplands because of its rugged and steep physiographic conditions is highly susceptible to landslides, erosion and rapid land degradation and needs special consideration in the landuse/landcover planning and management strategies.

Table-5.6: Landuse / Landcover in the Southern Steeplands (Area in Sq.Km)

Landuse/Landcover	Southern Steeplands	% to total area of the physiographic unit	% to total geographical area
Builtup	7.22	4.06	2.01
Permanent Cultivation	9.07	5.09	2.52
Bun Cultivation	5.70	3.20	1.58
Plantation	3.43	1.93	0.95
Dense Forest	38.05	21.37	10.57
Open forest	71.13	39.95	19.76
Grass/Shrubs	22.84	12.83	6.34
Fallow Land	9.33	5.24	2.59
Sandy/Rocky	4.78	2.68	1.33
Barren Land	2.28	1.28	0.63
Water Bodies	4.22	2.37	1.17
Total	178.05	100	49.46

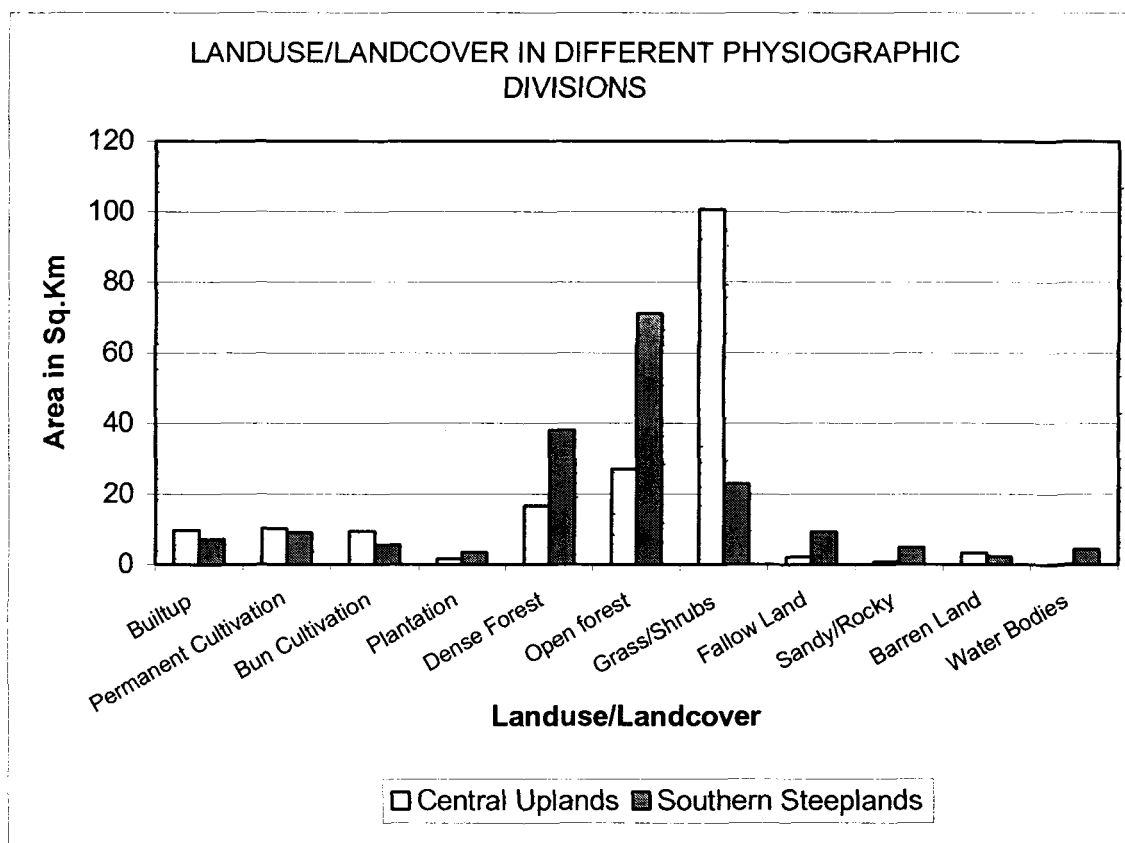


Fig.5.4: Distribution of Landuse/Landcover in different Physiographic zones

5.5. Landuse/Landcover under different slope categories

Slope is one of the most important elements of a site. It directly affects many of the other features like vegetation, runoff, soil erosion etc. Slope also causes certain limitations regarding construction and accessibility, as well as slope stability and erodibility. Specifically, with respect to potential land uses, certain gradients are preferred for certain types of uses. The nature of terrain and slope conditions of the study area has already been mentioned in chapter II. In this chapter an analysis of the distribution of landuse/landcover in various slope categories is attempted.

5.5.1. Landuse/Landcover under Gentle Slope (2° - 5°)

Only 5.17 Sq.Km. that is 1.44 percent of the geographical area falls under the slope category of 2°-5° considered as gentle slope, which under favourable climatic and soil conditions would be deemed suitable for agricultural purpose. Though the percentage of landuse/landcover to that of the total study area is quite negligible, the area under different landuse/landcover to that of the total area under gentle slope reveals that only 23.79 percent of its area is utilized for permanent cultivation. A large proportion of the area is under Grass/Shrubs (53.19%) the main reason being poor soil and lack of irrigation facilities. This has also led the people to resort to bun cultivation which occupies 7.35 percent of the total area under this slope category. As a result of which much of these areas are devoid of any forest cover (Table-5.7)

Table-5.7: Distribution of Landuse/landcover in gentle slopes

Landuse/Landcover	Area in Sq.Km.	Area in % to total study area	Area in % to total area of Slope
Builtup	0.45	0.13	8.70
Permanent Cultivation	1.23	0.34	23.79
Bun Cultivation	0.38	0.11	7.35
Plantation	0.25	0.07	4.84
Grass/Shrubs	2.75	0.76	53.19
Barren Land	0.11	0.03	2.13
Total	5.17	1.44	100

5.5.2. Landuse/Landcover under Moderate Slopes (5° - 10°)

Moderate slope constitutes 20.39% of the geographical area, and is spread mainly in the central upland region. It can be ascertained from table-5.8 that as much as 68.09 percent of the total area under this category is under grass/shrubs, which is the single highest landcover, amongst all the slope category. Permanent cultivation (7.12%), Open forest (8.05%), bun cultivation (5.41%) and dense forest cover (3.26%) are the major landuse/landcover in this area.

Table-5.8: Distribution of Landuse/landcover in moderate slopes

Landuse/Landcover	Area in Sq.Km.	Area in % to total study area	Area in % to total area of Slope
Builtup	3.97	1.10	5.41
Permanent Cultivation	5.23	1.45	7.12
Bun Cultivation	3.03	0.84	4.13
Plantation	0.79	0.22	1.08
Dense Forest Cover	2.39	0.66	3.26
Open Forest Cover	5.91	1.64	8.05
Grass/Shrubs	49.99	13.89	68.09
Fallow Land	0.89	0.25	1.21
Sandy/Rocky	0.07	0.02	0.10
Barren Land	1.14	0.32	1.55
Water Bodies	0.01	0.00	0.01
Total	73.42	20.39	100

5.5.3. Landuse/Landcover under Moderately steep slopes (10° - 18°)

The Moderately steep slopes forms a sort of buffer between the lower and higher slope categories and covers 27.66% of the total geographical area. The major landcover in the moderately steep slopes comprises of grass/shrubs (45.43%), open forest cover (20.01%), and dense forest cover (13.21%). Builtup (5.84), permanent cultivation (4.05) and bun cultivation (5.47%) constitutes the main landuses (Table-5.9)

Table-5.9: Distribution of Landuse/landcover in Moderately steep slopes

Landuse/Landcover	Area in Sq.Km.	Area in % to total study area	Area in % to total area of Slope
Builtup	5.81	1.61	5.84
Permanent Cultivation	4.03	1.12	4.05
Bun Cultivation	5.45	1.51	5.47
Plantation	1.66	0.46	1.67
Dense Forest Cover	13.15	3.65	13.21
Open Forest Cover	19.92	5.53	20.01
Grass/Shrubs	45.23	12.56	45.43
Fallow Land	1.14	0.32	1.14
Sandy/Rocky	0.11	0.03	0.11
Barren Land	2.22	0.62	2.23
Water Bodies	0.85	0.24	0.85
Total	99.57	27.66	100

5.5.4. Landuse/Landcover under Steep slopes (18° - 30°)

The hilly and rugged nature of the study area is revealed by the fact that almost half of the geographical area in this region falls under the steep and very steep slopes category. The percentage share of area under dense forest (21.47%) and open forest (40.32%) as indicated in Table-5.9 is the highest amongst all the other slope categories, and the area under grass/shrubs (13.22%) is the lowest. Though the landuse activities in this slope category is relatively lower than in the other slope categories, the percentage area of fallow land and sandy/rocky land tends to increase with the increase in slope. The distribution of permanent cultivation (5.07%) shared by the steep slopes is mostly found along small pockets of river valleys. Since almost half of the geographical area of the Mawkynew C&R.D.Block falls under the category of steep and very steep slopes, the people are left with not other alternative, but to utilize even those areas which may not necessarily be very favourable for various landuse activities. In the absence of good agricultural land in the lesser slopes, and also due to the mounting pressure of population on land the areas under steep slopes has become one of the most vulnerable areas.

Table-5.10: Distribution of Landuse/landcover in steep slopes

Landuse/Landcover	Area in Sq.Km.	Area in % to total study area	Steep Area in % to total area of Slope
Builtup	6.53	1.81	3.73
Permanent Cultivation	8.87	2.46	5.07
Bun Cultivation	6.23	1.73	3.56
Plantation	2.36	0.66	1.35
Dense Forest Cover	37.58	10.44	21.47
Open Forest Cover	70.56	19.60	40.32
Grass/Shrubs	23.13	6.43	13.22
Fallow Land	8.79	2.44	5.02
Sandy/Rocky	5.11	1.42	2.92
Barren Land	2.06	0.57	1.18
Water Bodies	3.29	0.91	1.88
Total	174.51	48.48	100

5.5.5. Landuse/Landcover under very steep slopes (30° - 45°)

Only 2.04% of the total geographical area falls under the category of steep slopes and is largely predominated by grass/shrubs (33.97%), open forest (24.97%) and dense forest cover (19.92%). Apart from 4.37 % builtup areas, there is virtually no other landuses practiced at a large scale in this region. Attempts to cultivate some of these areas, deforestation and recent clearing for plantation purposes, have rendered some of these areas into fallow land (8.59%), sandy/rocky (2.73%) and barren land (1.36%).

Table-5.11: Distribution of Landuse/landcover in very steep slopes

Landuse/Landcover	Area in Sq.Km.	Area in % to total study area	Area in % to total area of Slope
Builtup	0.32	0.09	4.37
Dense Forest Cover	1.46	0.41	19.92
Open Forest Cover	1.83	0.51	24.97
Grass/Shrubs	2.49	0.69	33.97
Fallow Land	0.63	0.18	8.59
Sandy/Rocky	0.2	0.06	2.73
Barren Land	0.1	0.03	1.36
Water Bodies	0.3	0.08	4.09
Total	7.33	2.04	100

The analysis of existing landuse/landcover pattern, the changes it has undergone, and its distribution on different physiographic and slope categories leads to the understanding of the complexities of the study area in terms of its resource use and management. However, It is apparent from this study that land degradation is one of the major problems in the study area. Deforestation and forest degradation, which is an important indicator of the state and change of land resources, associated with traditional farming practices, has been the major factor than is responsible for land degradation. Increase in population, taking place on a base of limited land resource is the driving force that often leads to land degradation. Young is of the view that land shortage and poverty together lead to non-sustainable land management practices, the direct causes of degradation. He further elaborates that poor or landless farmers, with insecure land tennure, are led to clear forest, cultivate steep slopes, or make short-term, unbalanced fertilizer applications, which lead to land degradation, causing lower productivity and lower responses to inputs.¹⁸ The nature of land degradation is highlighted by the fact that 34.33 percent of the study area is now under grass/shrubs, and the conversion of as much as 32.23 percent of the dense forest cover to other landuses.

The ever increasing population pressure and rising demand for food, fodder and fuel is responsible for the spatio-temporal changes occurring not only in the central upland regions, but also in certain areas in the southern slopes which are relatively less accessible. Thus the natural factors like climate, soil, topography, etc. which limited agricultural practices in the southern slopes, have been overcome by adopting new techniques like contour bunding, terracing, and horticulture. It has also been observed from the change detection studies that forest cover changes in recent years is more dominant in the Southern slopes and these areas having steep slopes often experiencing the problems of erosion and land degradation, affecting its immediate areas and adjoining areas as well.

In India, Singh¹⁹ et.al reported a soil erosion rate of 1885 t/km² /yr from 40 to 50 percent (22° to 26°) slopes under natural mixed forests typically of north eastern hilly conditions. Applying this to the study area, would mean that the rate of soil erosion especially in the hilly areas deprived of any vegetation cover is much higher. Considering this fact, the land utilization in the study area on the southern steep slopes warrants some immediate attentions. If left unchecked, this environmentally fragile ecosystem will have far reaching consequences in the near future. The shortage and scarcity of lands under moderate to gentle slopes, erratic rainfall and low irrigational facilities associated with poor land management, have acted as a major hindrance for the people in proper utilization of the land resources. Against this background, an attempt is being made in chapter VI for a sound landuse planning for the study area.

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CHAPTER VI
DIAGNOSTIC SURVEY OF LAND RESOURCES
& LAND USE PLANNING

CHAPTER VI

Diagnostic Survey of Land Resources & Land use Planning

6.1. Introductory Statement

The concept of land resource evaluation brings together two principal aspects of land use planning and management- i) making the best use of resources, and ii) conserving them for the future. In short it can be described as “sustainable use of land resources”, Land use today in any region of the world is very much the result of past developments, it is never fully adjusted to the present situation and even less to developments which will occur in the future¹. Therefore, land resources needs to be judiciously used in a manner that will permit future generation to retain as many ‘degrees of freedom’ for their land use as will be possible. In other words, land use and concurrent land improvement have to leave room for future developments, combined with minimization of land degradation and maximization of its attempts to meet human demands.

The preceding chapters have dealt with the various aspects of land resources, like landuse/landcover, land capability, physical and socio-economic settings, etc. It has also led to an understanding that the utilization of resources, competition for land, methods of land management and the limitations imposed by the physical environment affect and condition the land resources to a great extent. The physical limitations of the study area discussed in Chapter II, the socio economic issues discussed in Chapter III, the taxonomy of land capabilities and the existing landuse/landcover patterns discussed in Chapter IV and V respectively, describes some of the complexities of the study area. The hilly and rugged terrain, predominance of areas under steep slopes and excessive relief conditions, practice of unsustainable bun cultivation, presence of large areas under grass and shrubs, and the distribution of most of the area under Class VI, VII, and VIII lands imposes certain difficulties in the process of land use planning and management. In this chapter an attempt has been made to make a

diagnostic survey of the existing land resources in order to achieve a meaningful land use planing of the study area.

6.2. Watershed as a Planning Unit

The selection of the entire Mawkynrew Community and Rural Development Block in relation to its administrative boundary which have so far been considered as the unit of study, had its own advantages in terms of collection and integration of both spatial and non spatial data, cross referencing etc. But, it is realised that the administrative boundary was too large and vague to form a planning unit. Taking watersheds as a planning unit is considered appropriate because it forms a fundamental geomorphic unit not only for basic morphological studies but also for other environmental studies related to proper exploitation and utilization of available land and water resources. Complex natural landscapes and their environmental functions are often best understood when thought of in terms of watersheds, rather than in the traditional context of political boundaries.

The study area has been divided into eight micro watersheds (Map 6.1) namely, Umsong, Umjar, Umsi, Umngot, Wah Rasin, Wah Pamskew, Umtangphar and Umlew watersheds. The distribution of area under each watershed is given below:




Table-6.1. Area under different watersheds

Watershed	Area in km ²	Percentage to total area
Umsong	55.78	15.49
Umjar	56.74	15.76
Umsi	57.38	15.94
Umngot	44.08	12.24
Wahrasin	25.00	6.94
Wah Pamskew	31.09	8.64
Umtangphar	46.36	12.88
Umlew	43.57	12.10

Mawkynrew C & R. D. Block WATERSHED MAP



Legend

-  watershed
-  drainage
-  boundary

Map 6.1.



A diagnostic survey of the distribution of land resources and capability classes is carried out by superimposing and overlaying the various thematic maps with the watershed map. Data on physiography, relief, slope, drainage density, drainage frequency, land capability classification, landuse/landcover etc. is given separately for each watershed in appendix 6.

6.2.1. Land resources in Umsong Watershed.

The Umsong watershed forms much of the western boundary of the study area and constitutes 15.49 percent of the total geographical area. As much as 60.09 percent of its area falls under the central upland region with relief of above 1000 to 1600 meters, while 39.91 percent of its area falls in the southern steep slopes having an altitudinal variation of 400 to 1000 meters. The Umsong watershed is characterised by a well knit dendritic drainage system. More than 50 percent of its area is covered by medium drainage density and drainage frequency. A high percentage of its area fall under the steep slopes (55.41%) and very steep slopes (11.03%). This along with the limitations imposed by soil and other factors makes much of the area in this watershed to fall within the Class VIII (60.16 %) and Class VI (4.70%) capability classes. In such a given slope conditions and land capability classes, it is imperative that an equal amount of its area should have been under forest cover. But, the distribution of different landuse/landcover in this watershed reveals that only 12.87 percent of its area is under dense forest cover, and 25.53 percent under open forest cover. Grass/shrubs (35.05%) constitutes the largest land cover of the Umsong watershed. The amount of bun cultivation (6.29%) is higher than the total of the study area and is the second highest amongst all the other watersheds.

However, the Umsong watershed also provides some scope for permanent agriculture which presently occupies 7.26 percent of the geographical area. The distribution of land capability classes which can be put to agricultural uses (though with certain limitations), i.e. Class II (7.14%), Class III (9.97%) and Class IV (18.04%), can be further harnessed through proper utilization and

management practices of the land resources. Presently, grass/shrubs covers as much as 60.80 percent of Class II land, 46.22 percent of Class III, and 63.42 percent of Class IV land.

Table-6.2: Area of Landuse/landuse under each LCC in the Umsong watershed

Landuse/Landcover	II	III	IV	VI	VIII	Total	% to total area of watershed
Builtup	0.25	0.23	0.57	0.12	0.55	1.72	3.08
Permanent Cultivation	0.44	0.85	0.68	-	2.08	4.05	7.26
Bun Cultivation	0.5	0.74	0.65	0.09	1.53	3.51	6.29
Plantation	-	-	-	-	0.17	0.17	0.30
Dense Forest Cover	0.17	0.18	0.51	0.06	6.26	7.18	12.87
OpenForest Cover	0.38	0.66	1.27	0.87	11.06	14.24	25.53
Grass/Shrubs	2.09	2.57	6.38	1.32	7.19	19.55	35.05
Fallow Land	-	-	-	0.16	2.12	2.28	4.09
Sandy/Rocky		0.2	-	-	1.2	1.40	2.51
Barren Land	0.15	0.13	-	-	0.16	0.44	0.79
Water Bodies	-	-	-	-	1.24	1.24	2.22
Total	3.98	5.56	10.06	2.62	33.56	55.78	100
% to total watershed area	7.14	9.97	18.04	4.70	60.16	100	

N.B. Area in sq.kms/Roman Numerical indicates Land Capability Class.

6.2.2. Land resources in Umjar Watershed.

The Umjar watershed shares its entire western boundary with the Umsong watershed, and occupies 15.76 of the total geographical area. It also shares the largest number of villages amongst all the watersheds of the study area. Compared to the other watersheds, the land utilization indicates that the area under dense forest cover (20.23%) and open forest cover (35.78%) forms about 56 percent of the total geographical area, which is the highest, and grass/shrubs (22.58%) is the lowest area under these three land cover amongst all the watershed, However, considering the fact that as much as 70.46 percent of its area under steep slopes and almost 80 percent falling under Class VIII (42.25%), Class VII (11.16%), and Class VI land (29.26%), the present landuse practices will have to comply with only 2.22 percent of the area under Class III and 15.12 percent under Class IV land, which can be put to agricultural uses to some extent. Nearly 70 percent of Class III land is under open forest cover, and 62.59

percent of Class IV land is under grass/shrubs. The distribution of dense forest cover is mainly in Class VII and Class VIII land. While it may be necessary to conserve and maintain the areas under forest cover, especially in the higher slopes, the areas under Class III and Class IV category can be harnessed for agricultural and other landuses.

Table-6.3: Area of Landuse/landuse under each LCC in the Umjar watershed

Landuse/Landcover	III	IV	VI	VII	VIII	Total	% to total of the watershed
Builtup	0.02	0.1	0.42	0.71	1.22	2.47	4.35
Permanent Cultivation	0.09	0.29	0.3		1.3	1.98	3.49
Bun Cultivation	0.03	0.02	1.73	0.17	0.34	2.29	4.04
Plantation	0	0	0.01	0.08	0.25	0.34	0.60
Dense Forest Cover	0.06	1.16	1.64	1.93	6.69	11.48	20.23
OpenForest Cover	0.87	1.64	7.43	1.82	9.11	20.87	36.78
Grass/Shrubs	0.05	5.37	4.15	1.51	1.73	12.81	22.58
Fallow Land	0	0	0.26	0	1.68	1.94	3.42
Sandy/Rocky	0.02	0	0	0.11	0.47	0.6	1.06
Barren Land	0	0	0	0	0.58	0.58	1.02
Water Bodies	0.12	0	0.66	0	0.6	1.38	2.43
Total	1.26	8.58	16.6	6.33	23.97	56.74	100
% to watershed area	2.22	15.12	29.26	11.16	42.25	100	

6.2.3. Land resources in Umsi Watershed.

The Umsi watershed covering the central and southern portion of the study area shares a common boundary with all the other watersheds, except Umlew and Umsong. It occupies 15.94 percent of the geographical area and is the largest watershed of the region. However, this area offers very little space for different landuse practices as much of its area falls under steep slopes (66.24%), most of which is in the southern steplands (60.72%). Apart from dense forest cover (18.21%), open forest cover (31.94%) and grass/shrubs (32.94%), there are very little areas under any of the major land uses. The limitations for major land utilization in this area, existing landuse/landcover and the vulnerability to land degradation of this area can be seen from the fact that much of its area falls under Class VI (22.15%), Class VII (42.26%) and Class VIII (20.18%) land. Only

15.41 percent of its area is under the Class IV land, where very limited agriculture can be practiced. As a result of which people have resorted to bun cultivation and plantation activities in the Class VII and Class VIII lands. The distribution of landuse/landcover under different land capability class reveals that 69.80 percent of the Class IV land, and 74.19 percent of Class VI land is under grass/shrubs.

Table-6.4: Area of Landuse/landuse under each LCC in the Umsi watershed

Landuse/Landcover	IV	VI	VII	VIII	Total	% to total area of watershed
Builtup	0.47	0.26	0.68	0.09	1.50	2.61
Permanent Cultivation	0.77	0.06	0.08	0.17	1.08	1.88
Bun Cultivation	0.03	0.32	0.92	0.16	1.43	2.49
Plantation	0.01	0.07	0.5	0.45	1.03	1.80
Dense Forest Cover	0.63	0.82	6.3	2.7	10.45	18.21
OpenForest Cover	0.76	1.32	10.47	5.78	18.33	31.94
Grass/Shrubs	6.17	9.43	2.56	0.35	18.51	32.26
Fallow Land		0.15	1.14	1.12	2.41	4.20
Sandy/Rocky		0.06	0.43	0.38	0.87	1.52
Barren Land		0.22	0.61	0.09	0.92	1.60
Water Bodies			0.56	0.29	0.85	1.48
Total	8.84	12.71	24.25	11.58	57.38	100
% to watershed area	15.41	22.15	42.26	20.18	100	

6.2.4. Land resources in Umngot Watershed.

The Umngot watershed constitutes 12.24 percent of the geographical area, and forms the northern half of the river Umngot, encompasses the southern and southeastern boundary of the study area. Excessive relief, short and rugged terrain with steep slopes cover as much as 66.52 percent of the area. Much of its area is therefore unsuitable for any of the land use activities as 68.40 percent of the area in this watershed falls in Class VIII category, and 21.12 percent falls in Class VI category. Pockets of river valleys and moderate to moderately steep slopes, has provides some scope for permanent cultivation which presently occupies 3.06 percent of the total area. The introduction of horticulture in some of

these areas, have brought 2.18 of its area under plantations. A major concern of this watershed is the presence of large area under sandy/rocky (5.20%), fallow land (7.74), and barren land (3.02%), grass/shrubs (26.68%). Only 10.10 percent of the area is under dense forest cover, while 37.34 percent is under the open forest cover. More than 60 percent of the Class VIII land in this watershed is under forest cover, but the Class IV and Class VI lands are mainly dominated by grass shrubs. Though this watershed is sparsely populated, there has been much degradation of the land mainly due to clearing of land for plantation purposes. It is true that the southern steeplands of the study area has a congenial environment for plantations of horticultural crops, but, the choice of area and crops for plantations will need further research at the farm level, so as to check the negative impact on the land and water resources.

Table-6.5: Area of Landuse/landuse under each LCC in the Umngot watershed

Landuse/Landcover	IV	VI	VIII	Total	% to total area of watershed
Builtup	0.11	0.58	0.92	1.61	3.65
Permanent Cultivation	0.04	0.12	1.19	1.35	3.06
Bun Cultivation			0.46	0.46	1.04
Plantation		0.73	0.23	0.96	2.18
Dense Forest Cover	0.47	0.59	3.39	4.45	10.10
OpenForest Cover	0.03	0.94	15.49	16.46	37.34
Grass/Shrubs	3.49	5.49	2.78	11.76	26.68
Fallow Land	0.09	0.18	3.14	3.41	7.74
Sandy/Rocky	0.12	0.04	2.13	2.29	5.20
Barren Land	0.27	0.64	0.42	1.33	3.02
Total	4.62	9.31	30.15	44.08	100
% to watershed area	10.48	21.12	68.40	100	

6.2.5. Land resources in Wah Rasin Watershed.

Wah Rasin is the smallest watershed, constituting only 6.94 percent of the total geographical area. 45.76 percent of its area is falls under the central uplands physiographic unit, which is mainly characterised by moderate to moderately steep slopes, and 54.24 percent falls within the southern steeplands, which is predominated by moderately steep to steep slopes. Permanent

cultivation (6.92%) and plantation (3.96%) is the dominant land use activities of this area, which is mainly concentrated in the Class IV land. As much as 59.16 percent of the area in this watershed falls under Class VI category, making it relatively accessible and potential for forestry and animal husbandary. But, the fact that 51.96 percent of the land is presently under grass/shrubs indicates that this area too has come under severe land degradation. The distribution of landuse/landcover in the different land capability class indicates that the share of builtup, permanent cultivation, bun cultivation and plantation is generally high in Class VI, VII and VIII land. And at the same time these classes also maintain a high percentage of area under forest cover in almost all the different watersheds. This is mainly because of the fact that very insignificant amount of land fall in the Class II to Class IV category, and also because of the occupational structure of the inhabitants (as discussed in chapter III), who depend on primary activities, like forestry, hunting, plantation, fishing and livestock rearing. Thus, the Class VI and higher order lands provide the best opportunity for these activities, apart from providing pockets of river valleys for permanent cultivation. But, how far it will be able to sustain the population is an issue, which needs to be seriously considered.

Table-6.6: Area of Landuse/landuse under each LCC in the Wahrasin watershed

Landuse/Landcover	IV	VI	VIII	Total	% to total area of watershed
Builtup	0.23	0.45	0.27	0.95	3.80
Permanent Cultivation	0.22	0.46	1.05	1.73	6.92
Bun Cultivation		0.12		0.12	0.48
Plantation	0.15	0.8	0.04	0.99	3.96
Dense Forest Cover	0.15	1.97	1.35	3.47	13.88
OpenForest Cover	0.04	2.05	2.16	4.25	17.00
Grass/Shrubs	3.78	8.53	0.68	12.99	51.96
Fallow Land		0.41	0.09	0.5	2.00
Total	4.57	14.79	5.64	25	100
% to watershed area	18.28	59.16	22.56	100	

6.2.6. Land resources in Wah Pamskew Watershed.

Wah Pamskew constitutes only 8.63 percent of the total geographical area, and it is the second smallest watershed of the study area. 63.91 percent of its area falls under the central uplands, with relief ranging from 1300 to 1600 meters above m.s.l, making much of its area moderately less excessive. The distribution of area under different land capability classes, reveals that only 14.99 percent falls under Class IV land, while Class VI (40.88%), Class VII (15.70%) and Class VIII (28.23%) lands share the major portion of the geographical area. This watershed comparatively shares a larger proportion of area under different landuses. Barren land (3.28%), builtup (8.62%), bun cultivation (4.66%), permanent cultivation (5.24%) and plantation (2.51%) constitute about 25 percent of the total area in this watershed. As with other watersheds, a common phenomenon is the predominance of area under grass/shrubs (38.44%), and relatively less area under vegetation cover, i.e. dense forest cover (16.63%) and open forest cover (19.68%). The distribution of dense forest cover and open forest cover is mostly in Class VII and Class VIII lands, while grass/shrubs dominate more than 50 percent of Class IV and Class VI lands.

Table-6.7: Area of Landuse/landuse under each LCC in the Wah Pamksew watershed

Landuse/Landcover	IV	VI	VII	VIII	Total	% to total area of watershed
Builtup	0.29	0.96	0.76	0.67	2.68	8.62
Permanent Cultivation	0.05	0.27	0.36	0.95	1.63	5.24
Bun Cultivation	0.24	0.34	0.54	0.33	1.45	4.66
Plantation	0.03	0.28	0.09	0.38	0.78	2.51
Dense Forest Cover	0.67	1.24	1.08	2.18	5.17	16.63
OpenForest Cover	0.59	2.13	0.61	2.79	6.12	19.68
Grass/Shrubs	2.62	6.75	1.33	1.25	11.95	38.44
Sandy/Rocky				0.29	0.29	0.93
Barren Land	0.17	0.74	0.11		1.02	3.28
Total	4.66	12.71	4.88	8.84	31.09	100
% to watershed area	14.99	40.88	15.70	28.43	100	

6.2.7. Land resources in Umtangphar Watershed.

The Umtangphar watershed comprises of 12.88 percent of the geographical areas of the Mawkynrew C.&R.D.Block, and is predominantly under the influence of the central upland physiographic division as 70.38 percent of its area falls under the central upland region. Conducive geographical factors have led to nearly 40 percent of its area to be clubbed under land capability Class II, III and IV. Permanent cultivation (6.45%) and bun cultivation (5.52%) are the two dominant land use practices in this watershed. Open forest cover (22.76%) and dense forest (13.61%) and grass/shrubs (42.6%) are the major land cover of this area. In the absence of good agricultural lands in all the watersheds, and the utilization of steep slopes for bun cultivation, areas falling in the capability Class III and Class IV lands can be considered as potential sites for crop cultivation vis-à-vis animal husbandry, after further identification and examination of the suitable areas.

Table-6.8: Area of Landuse/landuse under each LCC in the Umtangphar watershed

Landuse/Landcover	II	III	IV	VI	VII	VIII	Total	% to total area of watershed
Builtup	0.04	0.14	1.11	0.41	1.13		2.83	6.10
Permanent Cultivation		0.26	1.37	0.13	1.04	0.19	2.99	6.45
Bun Cultivation	0.03	0	1.23	0.31	0.87	0.12	2.56	5.52
Plantation			0.01		0.15		0.16	0.35
Dense Forest Cover		0.15	1.44	0.75	3.62	0.35	6.31	13.61
OpenForest Cover	0.01	0.3	2.2	1.54	6.07	0.43	10.55	22.76
Grass/Shrubs	0.2	1.79	8	6.26	3.52	0.01	19.78	42.67
Fallow Land				0.12			0.12	0.26
Barren Land			0.08				0.08	0.17
Water Bodies			0.39		0.57	0.02	0.98	2.11
Total	0.28	2.64	15.83	9.52	16.97	1.12	46.36	100
% to watershed area	0.60	5.69	34.15	20.53	36.60	2.42	100	

6.2.8. Land resources in Umlew Watershed.

The Umlew watershed forms the entire southernmost boundary, and covers 12.13 percent of the total geographical area. Excepting the eastern portion, which constitutes of steep and moderately steep slopes, much of the area is dominated by moderate slopes (36.47%) and gentle slopes (6.72%) forming part of the central upland region, which covers 75.97 percent of this watershed. The Umlew watershed is the only watershed of the study area which has large area under the capability classes suitable for agriculture, i.e. Class II (3.72%), Class III (16.64%) and Class IV (42.85%). Therefore, it also shares the largest area under permanent cultivation (10.10%) and also bun cultivation (7.51%). Areas under grass/shrubs occupy 37.27 percent of the geographical area in this watershed, and its distribution is predominant in Class II, Class III & Class IV lands, which has been mostly abandoned bun cultivation sites as it can no longer productive. This is also the reason why people have resorted to bun cultivation and plantation in Class VII and Class VIII lands. The distribution of dense forest cover, open forest cover and grass/shrubs is almost equally divided at 22 to 25 percent in Class VII and Class VIII lands of the Umsi watershed.

Table-6.9: Area of Landuse/landuse under each LCC in the Umlew watershed

Landuse/Landcover	II	III	IV	VII	VIII	Total	% to total area of watershed
Builtup	0.39	0.5	1.12	0.81	0.5	3.32	7.62
Permanent Cultivation	0.22	1.38	2.37	0.38	0.2	4.55	10.44
Bun Cultivation	0.02	0.43	0.86	0.86	1.1	3.27	7.51
Plantation				0.31	0.32	0.63	1.45
Dense Forest Cover		0.33	1.8	2.11	1.83	6.07	13.93
OpenForest Cover		0.71	2.99	1.83	1.87	7.40	16.98
Grass/Shrubs	0.99	3.53	7.83	2	1.89	16.24	37.27
Fallow Land		0	0.79			0.79	1.81
Sandy/Rocky		0.04				0.04	0.09
Barren Land		0.33	0.92		0.01	1.26	2.89
Water Bodies						0.00	0.00
Total	1.62	7.25	18.68	8.3	7.72	43.57	100
% to watershed area	3.72	16.64	42.87	19.05	17.72	100	

Thus, the nature of distribution of the landuse/landcover over various land capability classes, clearly indicates high discrepancies in the land resources and possibilities it offers for various land utilisation. While a few watersheds enjoy a sizeable amount of land under Class II, III and IV, most of the watersheds are predominated by the large presence of lands belonging to capability Class VI and above, each imposing a certain level of limitation, advantages and disadvantages for its use.

6.3. Environmental Appraisal of Land use Potential.

The vital need for wisely managing our valuable land resources is now increasingly appreciated. The uncontrolled exploitation of land areas often leads to disastrous results that have an adverse effect not only on the environment, but also on the overall economic welfare of communities within and outside the affected area. As a consequence, increasing emphasis is now being laid on scientific management of land resources in a manner that ensures optimal utilization, keeping in view conservation and environmental protection needs. Therefore, environmental appraisal of the landuse potentials becomes an important component for land resource evaluation, which needs to be oriented to both land resource conditions as of present and optimal land utilization practices for the future.

Most of the value ascribed to land resources is directly related to the ability to use them. In this sense, the economic supply of land resources always reflects the current level of technological development. The present land use is the result of different causes, which are directly related to the nature and quantity of land resources, others of which have their origin in cultural, social and economic conditions of the past and their developments within the context of history. A continuous field of tension is created between available resources and human needs resulting in land use, which is a human effort to meet his needs and aspirations. Present land use, therefore, must always be, if not continually, at

least periodically, tested against other possible methods of land use or potential land use.

It has been observed that there are many areas that fall in the Class II, III & IV category, which are presently covered by grass/shrubs or are left unutilized. At the given scale and quality of data, it will not be possible to indicate the exact reason why each of these individual classes and parcels of lands are not being utilized. Reasons could be many, i.e. lack of irrigation, poor soil condition, erosion, land ownership etc. and will need further research at a micro level, preferably at the farm level. There are also areas falling under Class VI and above, which have either been put to agricultural and other land uses or are left fallow, barren and largely under grass/shrubs. Though these areas are classed under lands not suitable for any agricultural activities, the abundance of water, favourable climate, narrow scattered river valleys and small pockets of gentle slopes within these areas have provided opportunities for agriculture. However, in the given geographical condition, the level of technology, and shortage of good land, it is the areas which fall under Class II, III and IV, that needs to be fully tapped for agricultural extensions, and restrict the use of land falling under Class VI and above classes.

In finding out the potential sites for different land uses, all areas falling under forest cover, built up, plantation, sandy/rocky and permanent cultivation, are masked, while lands falling under grass/shrubs, bun cultivation, fallow and barren land have been considered to be potential areas for various land uses. It may also be mentioned that this is only a physical assessment of potential sites and does not include economic feasibility.

Keeping in view the stability of the resources and the land capability, the potential areas has been divided into two classes: They are:

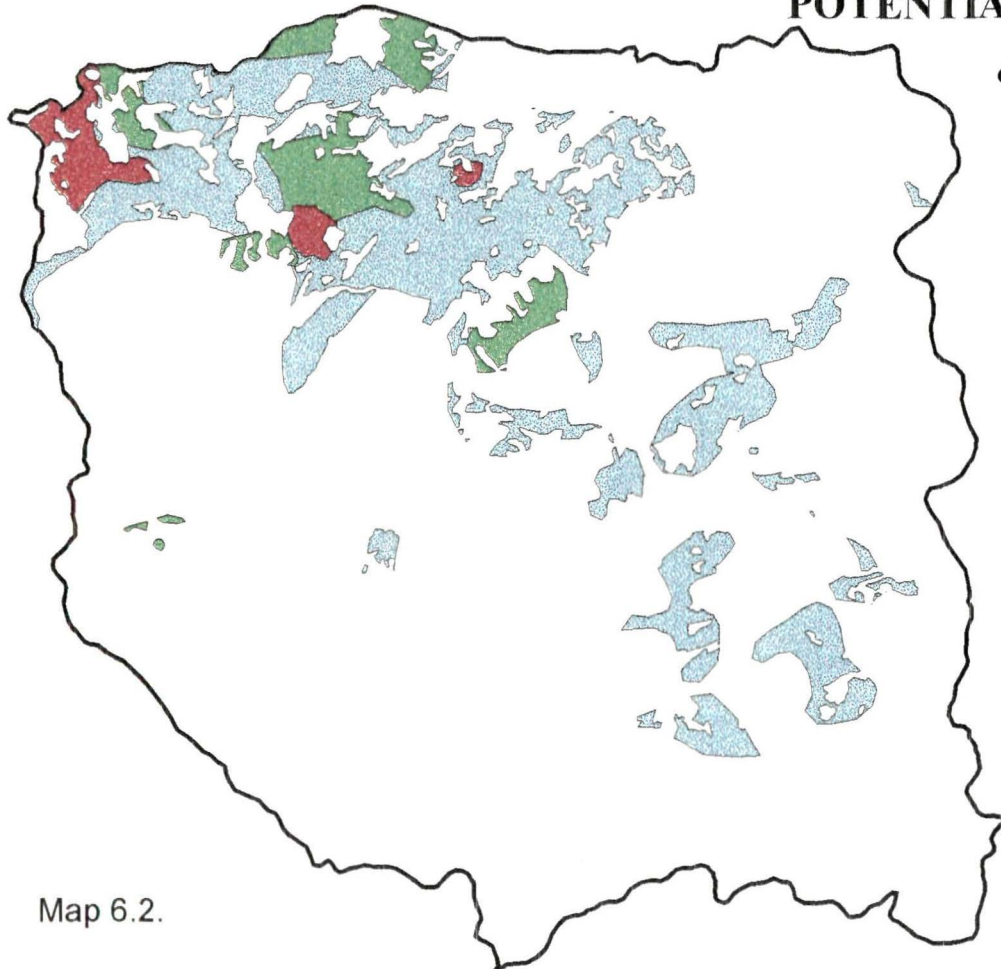
i. Potential sites available for agriculture and other uses.

The potential sites available for agricultural and other land uses can also be considered as relatively safe areas for land use. These areas are mostly plains and valley areas where the slope and soil conditions are at the permissible limit for the land to be used for cultivation. After superimposing the land capability map with the existing landuse/landcover map, it has been observed that some of the areas which belong to Class II, III and IV are presently under grass/shrubs, barren, fallow conditions or is being utilized for bun cultivation. 52.17 sq. km. or 14.49 percent of the total area falls under this category. Though the potentiality of the land decreases, as the limitation increases from lower to higher capability classes, in the absence of large areas under Class II and Class III, suitable methods needs to be innovated to make best use of the land under Class IV. It can be observed from Table-6.10 that only 2.97 or less than 1 percent of the Class II land, and 1.76 percent of the Class III land most of which is located in the Umsong watershed is presently left unutilised. Apart from this, there is practically very little or no land in this category in the other watersheds. However, unutilised Class IV lands which occupy 11.91 percent of the geographical area is the most dominant category, which can be put to some extent of agricultural land use, and are present in all the watersheds. (Map 6.2)

Table-6.10: Potential areas for agriculture and other uses (Area in km²)





Watershed	(II)	Area in %	(III)	Area in %	(IV)	Area in %	Total	Area in %
Umsong	2.74	4.91	3.44	6.17	7.03	12.60	13.21	23.68
Umjar	-	-	0.08	0.14	5.39	9.50	5.47	9.64
Umsi	-	-	-	-	6.2	10.81	6.20	10.81
Umngot	-	-	-	-	3.85	8.73	3.85	8.73
Wahrasin	-	-	-	-	3.78	15.12	3.78	15.12
Wah Pamksew	-	-	-	-	3.03	9.75	3.03	9.75
Umtangphar	0.23	0.50	1.79	3.86	9.31	20.08	11.33	24.44
Umlew	-	-	1.01	2.32	4.29	9.85	5.3	12.16
Total	2.97	0.83	6.32	1.76	42.9	11.91	52.17	14.49

Mawkynrew C & R. D. Block
POTENTIAL SITES FOR AGRICULTURAL
& OTHER LANDUSES



Legend

Land Capability Class

-  II
-  III
-  IV
-  boundary

Map 6.2.



ii. Potential areas for non agricultural uses.

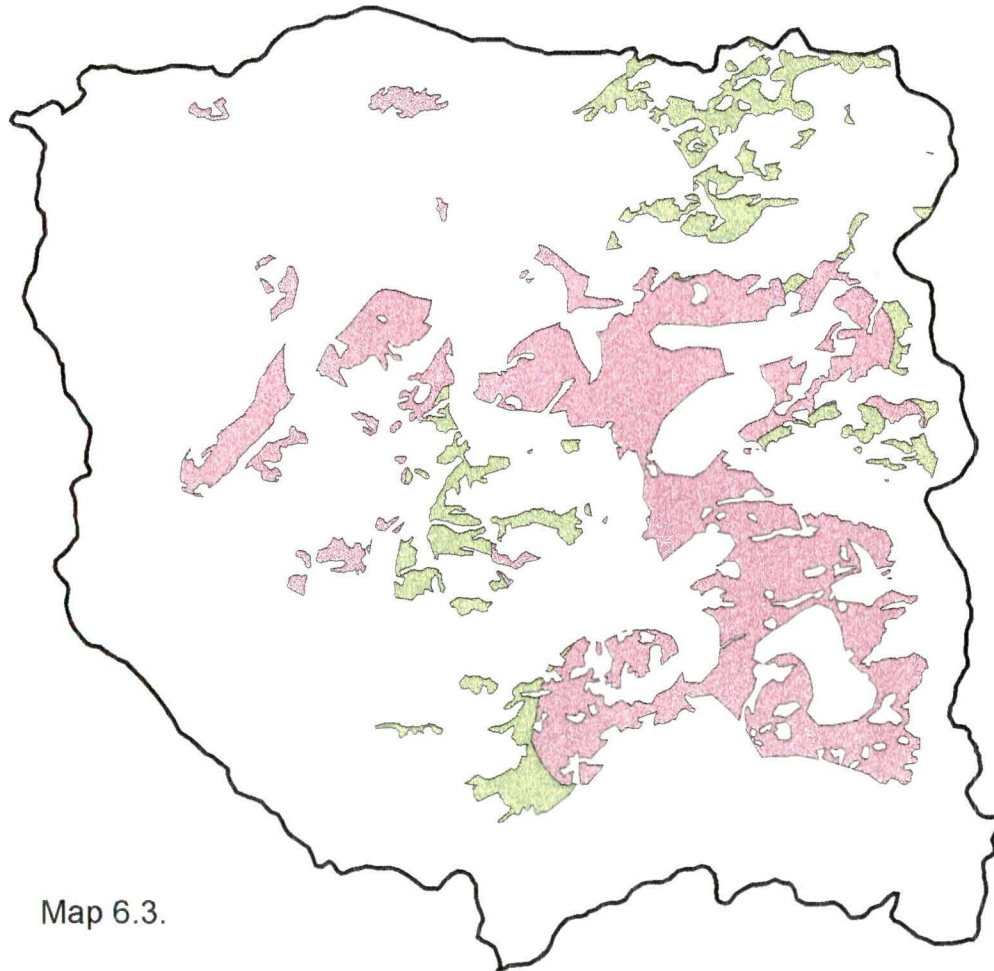
The potential areas for non agricultural uses embrace all lands which are not safe for agricultural uses i.e. Class VI, Class VII and Class VIII lands, but can be used for other non agricultural uses, which includes forestry, animal husbandry, horticulture, etc. Over exploitation, inappropriate utilisation and improper land management make these areas susceptible to degradation. Keeping in view the large section of the population who are dependent on primary activities other than agriculture, and directly or indirectly dependent on achieving much of their daily requirements from the forest, the utilization of the lands belonging to Class VI and VII can be viewed as potential sites for forestry, animal husbandry and horticulture. This, apart from giving them their requirement for food, fodder, fuel wood, firewood and shelter will also make it possible to safeguard the existing natural forest from further degradation. (Map 6.3)

Table-6.11: Potential areas for non-agricultural use (Area in km²)

Watershed	Area	(VI)	Area in %	(VII)	Area in %	Total	Area in %
Umsong	55.78	1.57	2.81	-	-	1.57	2.81
Umjar	56.74	6.14	10.82	1.68	2.96	7.82	13.78
Umsi	57.38	10.12	17.64	5.23	9.11	15.35	26.75
Umngot	44.08	6.31	14.31	-	-	6.31	14.31
Wahrasin	25.00	8.94	35.76	-	-	8.94	35.76
Wah Pamksew	31.09	7.83	25.18	1.98	6.37	9.81	31.55
Umtangphar	46.36	6.69	14.43	4.39	9.47	11.08	23.90
Umlaw	43.57	15.70	36.03	2.86	6.56	18.56	42.60
Total	360	63.30	17.58	27.14	7.54	90.44	25.12

It is evident from Table-6.11 that the distribution of areas under Class VI occupies 63.30 sq.km. or 17.58 percent and Class VII occupies 27.14 sq.km. or 7.54 percent of the total geographical area. Areas presently under bun cultivation, grass/shrubs, barren, and fallow conditions are included in these classes. The existing landuse/landcover does not provide enough biomass or soil cover and because of the slope conditions these areas are highly susceptible to soil erosion and land degradation. However, these areas have favourable

**Mawkynrew C & R. D. Block
POTENTIAL SITES FOR
NON AGRICULTURAL USES**



Legend

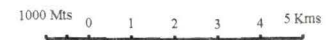
Land Capability Class

 VI

 VII

 boundary

Map 6.3.



conditions for agro-forestry, horticulture, animal husbandry etc. Animal husbandry will have to be done in appropriate manner either through controlled grazing or using these lands for deriving fodder for the animals. The study area can be seen as potential site for such activities, as almost all the watersheds except Umsong have more than 10 percent of their area, under this category.

iii. The Vulnerable areas

The land capability classification and its analysis with the existing landuse/landcover of the study area, apart from providing the potential sites for agricultural and other landuses, also revealed some alarming facts related to the utilization of Class VIII lands. It can be observed from Table-6.12 that 30.90 sq.km. or 5.98 percent of the total geographical areas under this category is under grass/shrubs, bun cultivation, permanent cultivation, or fallow condition. Such areas have been classified as 'vulnerable areas' as these areas because of steep slopes and heavy rainfall are highly prone to erosion, and even though it may be productive in the short run, it has high possibilities of soon getting degraded and unproductive. (Map 6.4)

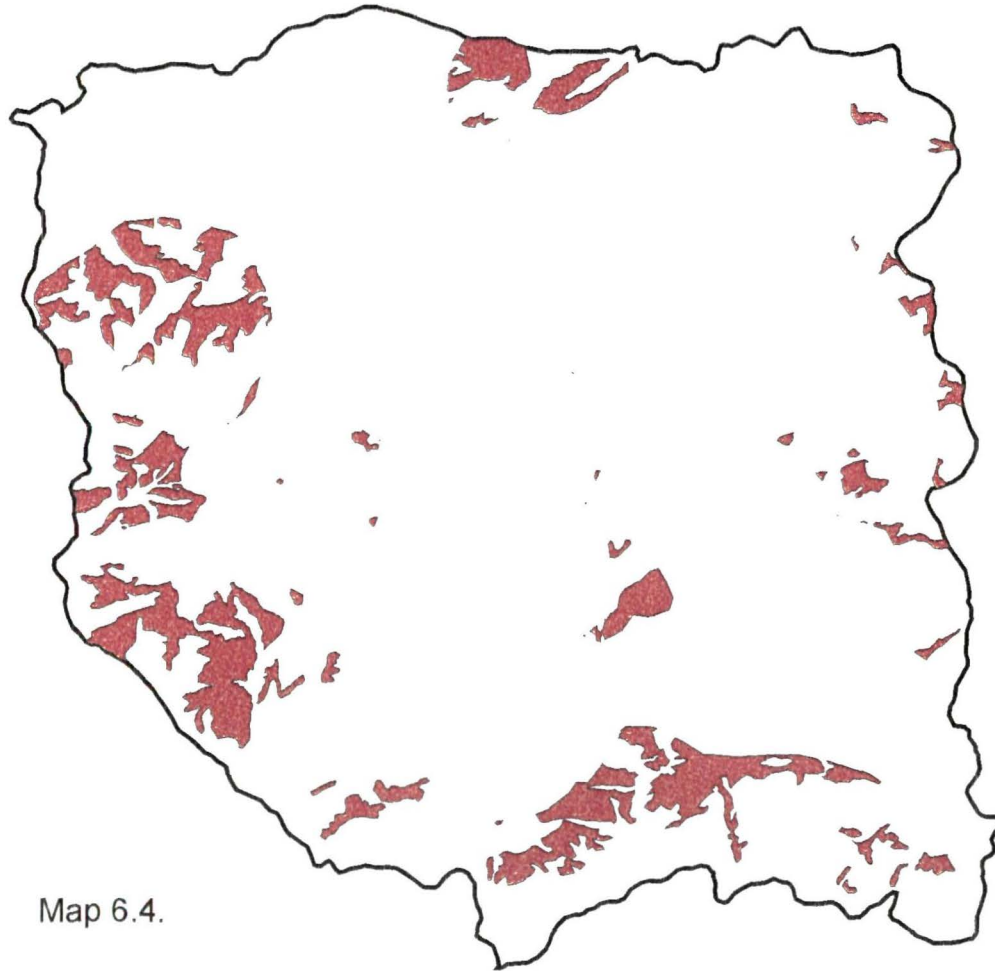
Table-6.12: Distribution of Vulnerable areas

Watershed	(VIII) Area in km ²	Area in %
Umsong	11.00	19.72
Umjar	4.33	7.63
Umsi	1.72	3.00
Umngot	6.80	15.43
Wahrasin	0.77	3.08
Wah Pamksew	1.58	5.08
Umtangphar	0.13	0.28
Umlew	3.00	6.89
	30.90	8.58

At the watershed level, the percentage of vulnerable areas are comparatively very high in the Umsong (19.72%) and Umngot (15.43%) watersheds, Umjar, Wah Pamskew and Umlew have in between 5 to 10 percent of its area under this category. The mounting population pressure on the fixed

Mawkynrew C & R. D. Block

VULNERABLE AREAS



Legend

Land Capability Class

-  VIII
-  boundary

Map 6.4.



land resources, especially in the central upland regions is one of the reason that is pushing the people to the vulnerable areas. Therefore, controlling/restricting the present landuses, and promoting afforestation on agro forestry basis will be the desirable steps which needs immediate focus in these areas.

The uncontrolled exploitation of land areas often leads to disastrous results that have an adverse effect not only on the environment, but also on the overall economic welfare of communities within and outside the affected area. As a consequence, increasing emphasis needs to be laid on scientific management of land resources in a manner that ensures optimal utilization, keeping in view conservation and environmental protection needs. The environmental appraisal of the landuse potentials serves as an important component for land resource evaluation and land use planning. After identifying these potential areas, and assessing the land resource conditions as of present, it becomes imperative to evolve appropriate and optimal land utilization practices for the future, keeping both the demands and aspirations of the people and the conservation and protection of the environment.

6.4. Land use Planning

Land use planning is the systematic assessment of land potential, social and economic conditions, and alternative patterns of land use, for the purpose of adopting land-use options which are most beneficial to land users, without degrading natural resources; together with the selection of measures most likely to encourage such uses of land.²

Land resources and land use, as well as land evaluation and land use, are complicated matters which can never be fully calculated from available data. Experience always plays an important role and, seen in this light traditions are extremely useful means of transferring knowledge and experience through successive generation. It is a simple matter of social ethics that the people whose entire life is tied to the land and who are completely dependant upon its

production, should be considered with the highest priority. Economic viability and ecological sustainability are important factors which needs to be considered in land use planning, but the success ultimately depend on social acceptability and implementation of these plans at the grass root level.

With the rise in population placing ever-increasing pressures on scarce land, governments of developing countries should give high priority to rational land use (using different types of land in ways best suited to their potential), improve land management (in agriculture and forestry, so as to secure higher productivity), avoidance of land degradation (temporary or permanent lowering of the productive capacity of land as a result of human action) so as to conserve resources for the future).³

The nature of the study area in terms of its landscape, distribution of various resources- both natural and man-made, social and occupational structure etc. makes the task of landuse planning a very complex and difficult exercise. The diagnostic survey of the land resources in different watersheds and its distribution over the different land capability classes has made it clear that the absence of land for permanent agriculture and degradation of existing land resources is a major problem in all the watersheds. This has been more pronounced in areas where builtup, permanent cultivation, bun cultivation and plantation is more significant. It has been observed that watersheds having larger proportion of area under these activities, support very little area under vegetation cover and as such make it highly susceptible to land degradation.

It is often said that the stakeholders and people at the grass root level are the best judges regarding the utilization of their lands. It may be argued that the adaptation of a unique form of agricultural practice, viz. bun cultivation and other primary economic activities have sustained them so far, but the real issue is the question of future sustainability. Its negative impact can already be noticed in the central upland regions, where most of the area have suffered the impact of bun

cultivation, and can no longer support any form of agriculture, unless soil conditions are improved. Growing population, expanding grass/shrub lands, dwindling forest resources and present occupational structure largely absorbed in activities related to direct or indirect utilization of forest resources pose a serious concern for the future of the people living in this area. Low literacy rate, lack of educational, health and medical facilities, and poor infrastructure further highlights a grim picture. Environmental protection, ceasing land degradation and better management forms an important component of land use planning. It would have been much easier, had this been the only purpose of land use planning. Complexities arise when sustainability and improvement in the standard of living condition of the people, which is an integral component, is amalgamated to it. It is a established fact that deforestation is the primary cause of land degradation, soil erosion and other environmental related problems, but at the same time it is not possible to conserve all the forest. People especially the tribals living in the hilly regions rely almost entirely on forest resources for their livelihood. As long as size of population was small, their land use activities even tradition ones like shifting cultivation was sustainable and not much of a threat to the environment. But, rapidly increasing population in recent years have resulted in the ever increasing demand for food, fodder, fuel wood and land for agriculture. On one hand there is urgent need to halt further land degradation, and on the other hand, there is the immediate requirement to meet the growing demands of the people. This can only be tackled through a proper land use planning. "A good land use is probably the best conservation practice"⁴

6.4.1. Proposed Land use Plans

Appropriate land use planning is not only essential for the potential and vulnerable areas, which are presently under one or the other kind of land utilization, but must also include areas which are not directly utilized. After considering all the various physical, social and economic factors of the study area an attempt is being made to formulate a comprehensive land-use plan. This is not a rigid model, but can be subjected to further modification depending on

the ground realities at the grass root level. The proposed land use plan in Table-6.13 can serve as a base for identifying the potential areas for various activities under different land capability classes. However, the intensity of land use depends on the land capability class, and limitations of the safe use of land increases as one moves from Class I to Class VIII. Fig. 6.1. gives a clearer understanding of the intensity with which each land capability class can be used with safety.

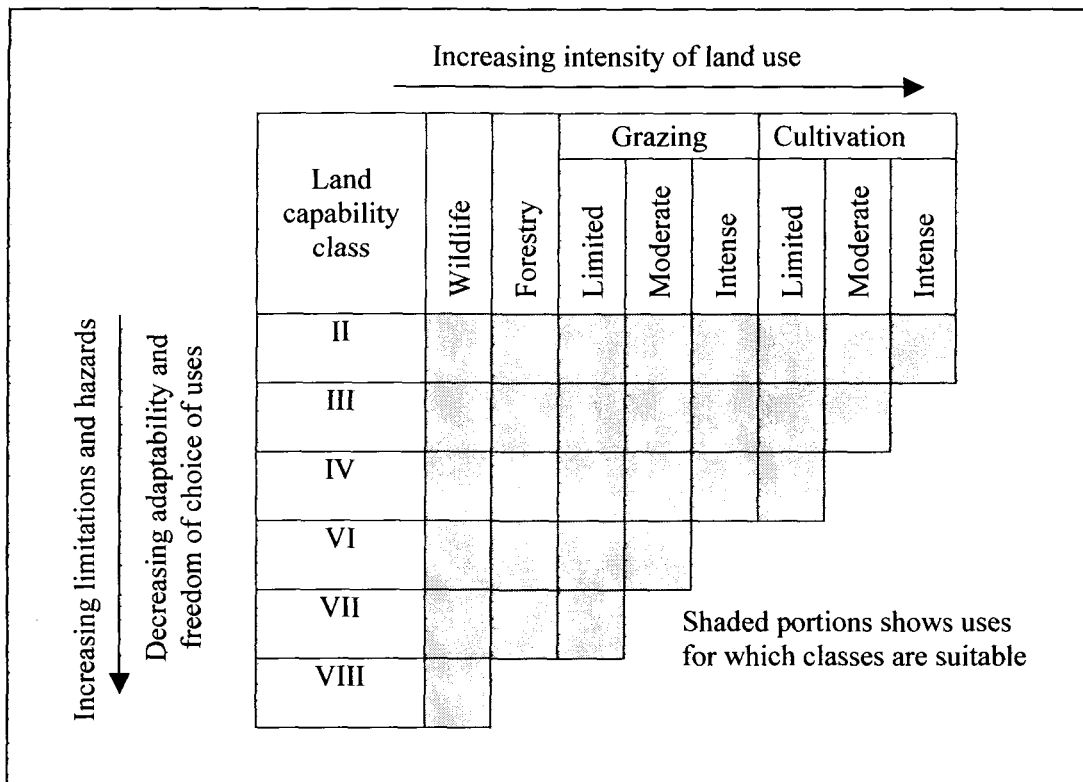


Fig.6.1: Intensity with which each land capability class can be used with safety. (Modified from Hockensmith and Steele)

Fig-6.13: Proposed Landuse Plans

LCC Type	Existing Landuse/ Landcover	Proposed Land use Plans
II	Permanent Cultivation	Areas belonging to Land Capability Class II which are presently under permanent cultivation/plantation/builtup landuse types mostly occurring in the Central Upland region having leveled to gentle slopes. These lands as such have very few limitations and areas under permanent cultivation is mainly used for mono cropping. Double cropping and other options to increasing yield can be explored.
II	Barren/Bun/ Grass/Shrubs/ Fallow lands	These areas can be considered highly potential areas for agricultural landuse, which can be possible with minimum input in the form of irrigation, fertilizers, appropriate crop combinations and land modification. Bun cultivation in Class II, III and IV lands need to be replaced with other alternatives form of agriculture.
III	Permanent Cultivation	Though the Class III lands have severe limitations that reduce the choice of plants and require special conservation practices, some of these areas have been successfully utilized for permanent cultivation with land modifications such contour bunding and terracing. Crop rotation & mixed cropping practices can further enhance agriculture in these areas.
III	Barren/Bun/ Grass/Shrubs/ Fallow lands	The limitations imposed by the Class III lands can be overcome to some extent by land and soil modification, provide irrigation, and by growing crops that provide soil cover such as legumes. Such areas also have the potentiality for Agro forestry, horticulture, and dairy farming.
IV	Plantation	Plantation mainly include fruits like oranges, pears, plums, peaches, passion fruit, pomegranate etc. in the central upland region, and banana, tapioca, betel leaf, Papaya, sugarcane etc. in the southern steep slopes. It has been observed that this activity has received very little acceptance by the people, mainly due to the long gestation period and lack of marketing and storage facilities. Therefore in order to make successful it will need a proper coordination between the farmers, communities and the government, along side

		improvement of infrastructure- marketing, storage, processing & packaging.
IV	Barren/Bun/ Grass/Shrubs/ Fallow lands	Class IV lands have severe limitations on the choice of crops and management practices. In the absence of good agricultural land in the study area, more and more areas falling under Class IV and above are being utilized for bun cultivation. This is also because the adjoining areas have enough vegetation and biomass required for burning in bun plots. It is imperative to control bun cultivation in these areas, and to seek for alternative landuse practices and explore the possibilities for terracing, contour bunding, strip cropping, agro-forestry, horticulture and afforestation and other special conservation practices.
VI, VII, VIII	Permanent Cultivation	It has been explained above that though the Class VI, VII and VIII lands are not suitable for permanent cultivation, pockets of plain areas along river valleys and hills or terracing have provided space for permanent cultivation. There is a high risk involved in utilizing these areas for permanent cultivation mainly because of the surrounding conditions. But, it would be impractical to suggest the farmers to abandon these lands, because it is these areas from which they obtain vegetables, legumes and other cereals for daily consumption. Contour bunding, retention walls, strip cropping, and at the same time maintaining the vegetation cover in the surrounding areas will help reduce the risk of erosion in these areas.
VI, VII, VIII	Barren/Bun/ Grass/Shrubs/ Fallow lands	Bun cultivation needs to be restricted in these areas. Such areas especially in the southern slopes have been widely used for plantation purposes, and vegetation cover of large tracts of lands have been cleared at once, leaving it exposed to rain and erosion. The physiography, slope and climatic conditions make these areas highly vulnerable to erosion and other environmental hazards, therefore, it would be necessary to abandon bun cultivation as far as possible. However, the areas under Class VI, and VII can be utilized for forestry, horticulture, animal husbandry, fodder grasses, etc. But, lands under Class VIII needs immediate restoration of forest cover.

All	Water Bodies	<p>The study area on the whole has a good drainage network. Water bodies (includes areas covered by rivers/streams/lakes etc), are present in almost all the land capability classes. No other natural resources probably suffer more than water from the utilization of land. Apart from this, the availability of water also has a direct bearing on landuse. Construction of dams for irrigation and mini hydel projects, embankments on flood prone areas, afforestation of catchment areas, are some of the case specific requirements of the study area.</p>
All	Sandy/Rocky	<p>There is very little that can be done to with the sandy/rocky areas, except use it for quarrying of sand and stones for construction purposes. Though it occupies only 5.49 sq.km. (1.52%) of the total area, the distribution is very high in the southern steplands, especially in areas where vegetation cover is sparse. Erosion and deposition are the main agents that produce such landscapes. Therefore, further degradation of land can only be controlled through forest conservation, afforestation, and landuse practices than will arrest erosion, runoff and flooding.</p>
All	Dense forest/ Open Forest Cover	<p>In view of the dependence of the people on forest for fuel wood, fodder, food, shelter, etc, it would be essential to maintain this resource in a way that will be able to supply the requirement of the people on a continual basis. Conservation (wise use) and Management of the existing forest cover, mainly by controlling open grazing, forest fire, extraction of medicinal plants and herbs for commercial purpose. Some of the areas presently under open forest cover, which are mainly dominated by pine trees can be replaced with other fast growing varieties including fruit trees. Joint Forest Management through community based afforestation and other forest related programmes especially in the degraded lands can play an important role in enhancing the forest resources.</p> <p>All landuse in the areas under Class VIII land needs to be restricted, except for indirect benefits like wildlife protection, parks, watershed protection, recreation, and promotion of eco-tourism.</p>

It is clear from Table-6.10 and Table-6.11 that there are still areas which offer suitable conditions for agricultural and other landuses, but have not been fully exploited. Though all these lands may have certain limitations, it can be corrected by slight to moderate land modification and soil improvements, depending on its capability class. Terrace cultivation has been one way of land improvement, which has been successfully carried out in some parts of the Central Uplands. It is often beneficial to forgo the economic cost of improvement of land, because in the long run, as under the present unproductive and exposed conditions, the environmental problems that could arise in the future if left unattended can take an irreversible turn.

The areas falling under land capability Class II, which are presently under the barren/bun/Grass/Shrubs/Fallow conditions can be considered as areas with high potentiality for agriculture. However, few limitations like irrigation, poor soil condition due to lack of proper soil conservation, and inappropriate land management and cropping practices in general, have left these areas fully unexploited. Therefore, minimum input in the form of irrigation, fertilizers, and appropriate crop combinations can help in utilization of these areas for agricultural purposes.

Though the Class III lands have severe limitations that reduce the choice of plants and require special conservation practices, some of these areas have been utilized for permanent cultivation with land modifications such contour bunding and terracing. The limitations imposed by the Class III lands can to be overcome to some extent by land and soil modification, providing irrigation, and by growing crops that provide soil cover such as legumes. These areas also have potential for Agro forestry and horticulture.

Class IV Lands can be used for cultivation, but there are severe limitations on the choice of crops and management practices. Terracing, contour strips, or other special conservation practices are required. In the absence of good

agricultural land in the study area, there is a tremendous pressure on lands which are not suitable for cultivation, and this often compels the farmers to resort to bun cultivation. It is imperative to control the practice of bun cultivation in these areas, provide alternative land use practices and also carry out afforestation activities.

The threat to the forest cover has been highlighted in chapter V where a results of the change detection studies in the land use/land cover has been discussed. Dense forest cover, be it in any of the land capability classes needs to be protected from further exploitation. More so because the existing dense forest cover and open forest cover mainly occupies the lands under Class VI and above, which are highly vulnerable to erosion and other environmental hazards. Conservation and management of these forest resources needs to be given special priority. Protection of existing forests is important not only to preserve the water of the catchment areas of the watersheds but also to avoid excessive water run-off that may damage agricultural lands downstream.

The tradition of rearing up livestock and poultry which include cattle, pigs, goats, hens and ducks for domestic consumption has a good scope to be enhanced for commercial purposes. Animal husbandry can be an alternative as well as a subsidiary occupation provided elaborate arrangements for effective control of animal diseases, breeding, quality feed and fodder, extension services, etc are met. Enhancement of production, productivity and profitability of livestock enterprise must be given greater attention. Areas falling under land capability Class VI and Class VII can be successfully utilised for horticultural and animal husbandry. The lower elevations (less than 700 meters) of the Southern slopes have proved to be potential areas for banana, betel leaves, black pepper and other plantation crops. This can become a lucrative activity for people residing in these areas and also help maintain the existing forest resources

The ICAR⁵ model of land use, which suggests forestry, horticulture and agriculture at different levels of slope, can be effective for the management and

utilization of land in the study area. This model specifies that the lower portion of the slopes can be used for agriculture, the middle portion for horticulture and pasture, and the top portions for agro-forestry, each sharing about $\frac{1}{3}$ rd of the area.

Most of the areas falling under Class VIII lands, are largely occupied by dense forest cover. However, of late the scarcity of land, have resulted in the utilization of some of these areas for agricultural purposes, and the consequences arising out of human interference on these areas is beginning to surface out. These areas, therefore needs immediate attention so that necessary steps are taken to conserve and preserve these areas. It has been observed that the area under water bodies are more prominent in the densely forested areas under land capability Class VIII. These are the areas which act as a source of water for all the streams and rivers of the watershed, and serve the irrigation and domestic requirements of the villages. Apart from its preservation and maintenance, these areas can be judiciously utilized for recreation, wild life, eco-tourism and source of water supply.

6.4.2. Major concerns for landuse planning

A major issue that pose a serious concern for the communities living in the study area is the degradation of forest resources. Almost all their activities and means to their livelihood are directly or indirectly dependent on this resource, which no longer provides all the diverse requirement of food, fodder, fuel wood, timber, medicinal herbs and plants, etc. Two major issues highlight while attempting to analyse the root cause for the degradation of forest resources:

i. High dependency of the people in primary activities.

Prior to the Supreme Court ban on timber felling, lumbering used to be the major activity of the people living in the study area. Present data on the occupational structure (discussed in Chapter III) reveals that livestock rearing, forestry, hunting, plantations etc. still constitutes the largest economic activity

sustaining about 33 percent of the total population of the study area. Out of the 47 percent main workers, nearly 70 percent of the population belongs to this category. At the village level, more than 80 percent of the population of 41 (63 percent) of the villages are preoccupied in such activities, which is a major factor for the depletion of forest resources. The chains of cause and effect due to forest clearance can be perceived from Fig.6.2.

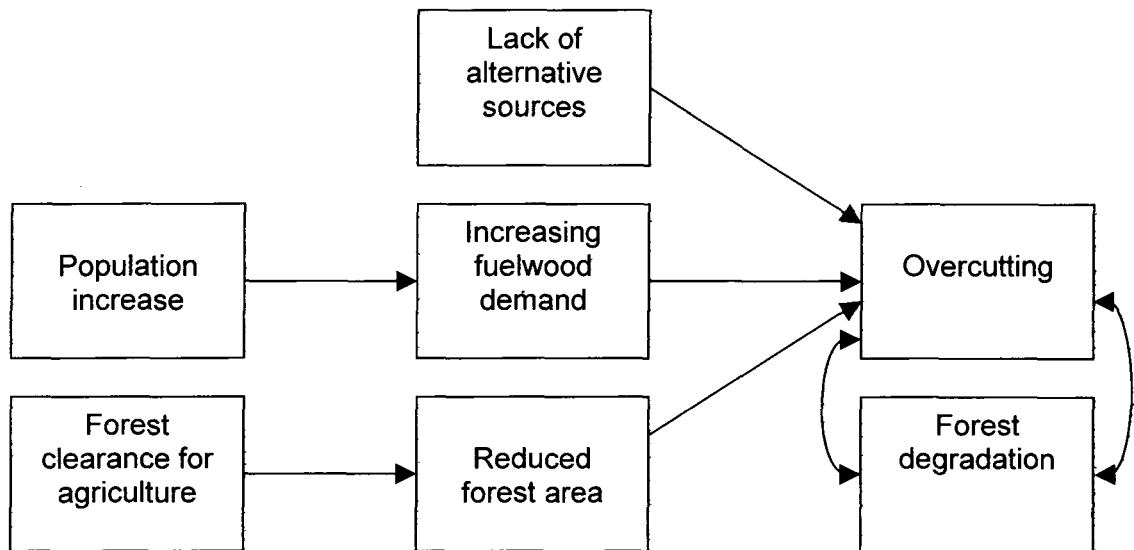


Fig.6.2. Chains of cause and effect in forest clearance (adopted from Young:2000)

Researchers have shown that a gradual reduction in forest cover in tropical environments is associated with decreased rainfall infiltration, increased runoff, accelerated water erosion and soil loss, reduced nutrient uptake, reduced nitrogen fixation, reduced replenishment of soil organic matter, increased wind erosion, and other harmful influences that contribute to a decline in soil fertility and crop yields⁶.

Therefore given the relationship between forests and soils, water conservation, and watershed stabilization, forest degradation is one of the most important concern of the study area.

ii. Traditional agricultural practices.

Past records and interactions with the villagers reveal that shifting cultivation was one of the main activity of the people till recent years. The scarcity of the land, introduction of commercial crops, and permanent settlements made the farmers to adopt to bun cultivation, which is now practiced extensively in the central upland regions. Thus the degradation of forest resources due to the initial practice of shifting cultivation is only made worst by the existing bun cultivation. Young⁷ is of the view that the diagnostic analysis, which means finding the causes, or chains of cause and effect (Fig. 6.3), leads to the identification of the problems of a farming system. This can be explained from the following diagram:

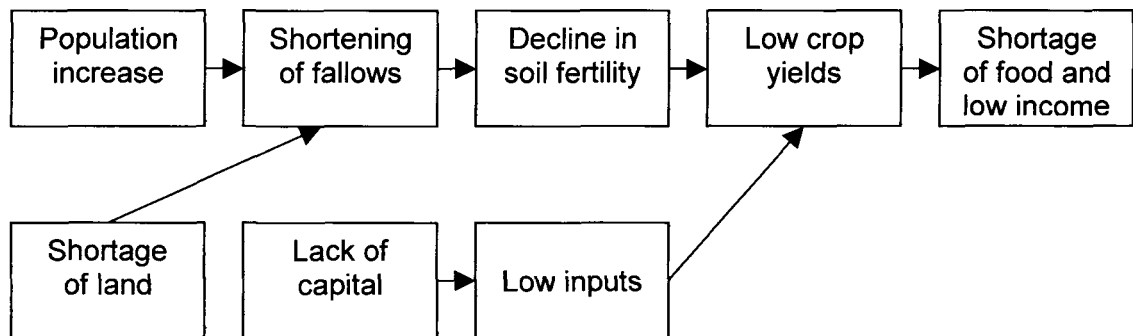


Fig. 6.3: Chains of cause and effect in agricultural land use. (adopted from Young:2000)

It has been affirmed that the process of burning involved in bun cultivation (explained in detail in chapter V) has far more serious impact on soils, than that of shifting cultivation. Research conducted by the ICAR reveals that the soil pH, and available K, P, is much higher in the bun cultivation sites than on Jhum areas⁸ (Table-6.14)

Table-6.14: Effect of burning on soil characteristics

Soil Properties	Pre-Burning	Post Burning	
		Jhum sites	Bun sites
Soil pH	4.6	5.3	6.6
Available K (ppm)	120.0	420.0	620.0
Available P (ppm)	0.65	19.1	61.1
LR (t/ha)	8.3	5.8	0.8

N.B. Burning of Biomass @ 80 t/ha.

Source: Lecture Notes Off-Campus Training on Farming System, ICAR.

The above table indicating the effects of burning on soil characteristics proves that the burning process involved in bun cultivation is more harmful than that involved in jhum cultivation.

Table-6.15: Landuse/Landcover falling within a radius of 500 Metres from Bun sties.

Landuse/Landcover	Total area in Sq.Km.	Area within 500 metres radius	Area in Percentage to total
Built-up	17.08	8.70	50.95
Permanent Cultivation	19.36	9.08	46.89
Plantation	5.06	1.00	19.68
Dense Forest Cover	54.58	21.65	39.68
Open Forest Cover	98.22	36.25	36.91
Grass/Shrubs	123.59	43.36	35.08
Fallow Land	11.45	2.87	25.06
Sandy/Rocky	5.49	1.44	26.28
Barren Land	5.63	1.86	32.95
Water Bodies	4.45	2.05	46.08
Total	360	128.26	

In order to get a clearer understanding about the impact of bun cultivation on the immediate surroundings a 500 meter radius from the bun cultivation sites was constructed (Map 6.5). This revealed that almost an equal amount of area i.e. 35 to 37 percent, under dense forest, open forest and grass/shrubs falls within the radius of bun cultivation sites. It is also noticed from Table-6.15. that builtup and permanent cultivation occupy as high as 50.95 percent and 46.89 percent of the area within the bun cultivation sites. Areas under other landcover

Mawkynew C & R. D. Block BUFFER BUN CULTIVATION

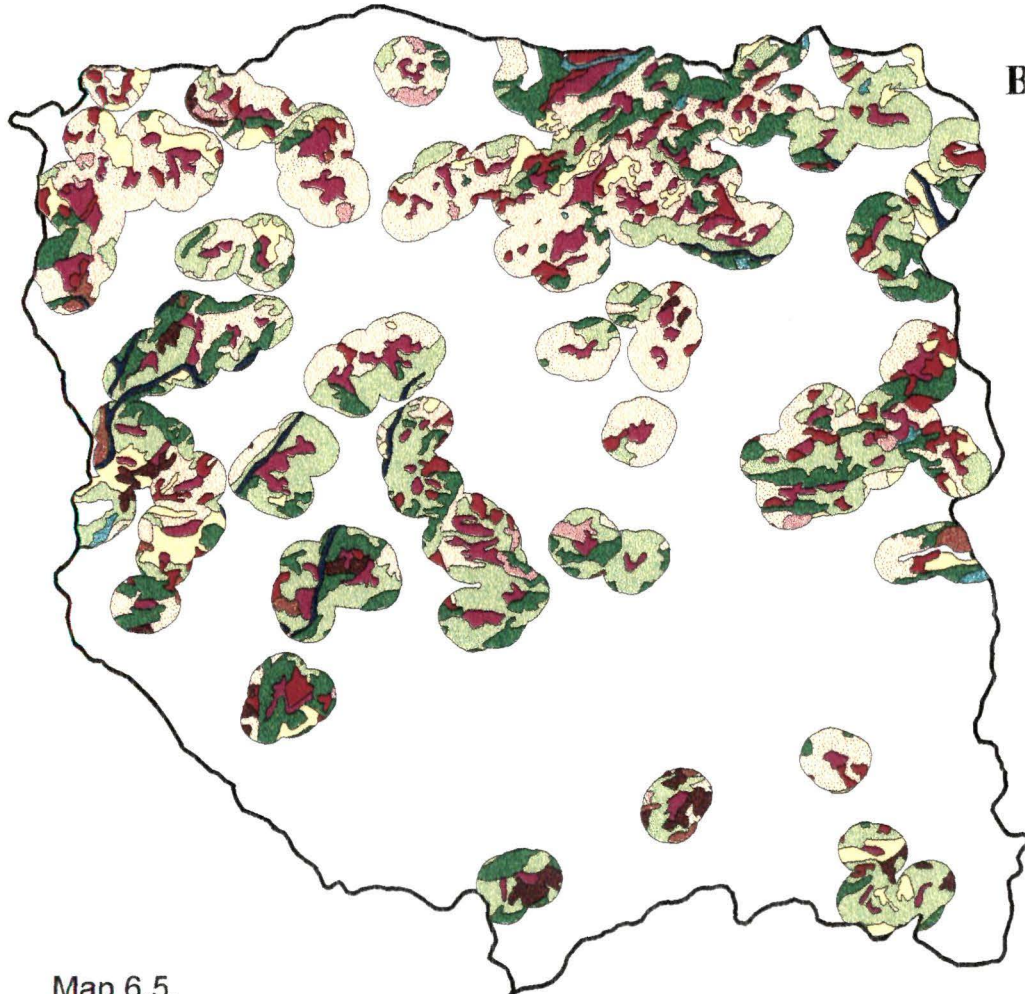
500 Meter Radius



Legend

LANDUSE

- Bun Cultivation
- Barren Land
- Builtup
- Dense Forest Cover
- Fallow Land
- Grass/Shrubs
- OpenForest Cover
- Permanent Cultivation
- Plantation
- Sandy/Rocky
- Water Bodies
- boundary



Map 6.5.

1000 Mts 0 1 2 3 4 5 Kms

i.e. fallow land, sandy/rocky, barren land, cover about 25 to 33 percent of the adjoining areas. Thus, the overall coverage of landuse/landcover within 500 metres from the bun cultivation sites is indicative of the impact on the land resources in its immediate surroundings.

6.4.3. Alternatives for better land utilization and resource conservation.

The alternative option for meeting the daily requirements from forest resources depends more on maintaining and enhancing forest resources rather than barring the people from utilizing them. Introducing low cost alternative and efficient energy sources, such as smokeless chullahs, bio-gas, solar energy, hydroelectricity, etc, will help not only to reduce the fuel wood crisis, but at the same time reduce the exploitation of the already dwindling forest resources. Fragmentation of forest cover due to clear cutting for plantations, bun cultivation and forest fire can be observed in large patches of forested land. Mitigation of forest fragmentation is critical for halting bio-diversity loss. Site investigation also reveal that the cultivation of broomstick is becoming a lucrative activity which is now being grown in the abandoned bun cultivation sites. However, people are of the view that this plant is further worsening the soil condition and adjoining vegetation cover. Therefore, it is advisable that new species of crops and plants be tried only after proper assessment of its harmful effect on soil and water condition. Tea is an alternative crop, which can be tried in the study area. This crop has produced successful results in the Mawryngkneng Block, which is close to the study area and have similar geographical and climatic conditions.

Community based afforestation programmes, joint forest management schemes and assistance from governmental, non-governmental and research organisations can play an active role to restore the deforested areas with suitable species of trees and plants. Further strengthening of local institutions is essential to oversee the management of land resources especially in combating uncontrolled grazing, forest fire, illegal felling and ensuring people's participation in developmental programmes.

Agroforestry systems - a multiple purpose, highly productive and ecologically stable farming system which combines agriculture and forestry (including animal husbandry) can be an important form a new landuse pattern in the study areas. Agroforestry systems have a high potential to conserve soil and water compared with the pure plantation and bun cultivation. The feasibility of regenerative projects is dependent on acceptance by the villagers to commit to long term transition from a solely agricultural cropping system to one of agroforestry. The ultimate goal being conservation of the forest ecosystem while satisfying the needs of local farmers for goods and income. Apart from slowing deforestation, agroforestry practices can also improve water infiltration, create hedgerows against winds, in-crop legumes, mulch use of grasses, increased tree crops of high forage value, tree stands for fuel and timber, reclaim eroded land, and the preservation of natural stands of trees. Mushroom cultivation, sericulture, and bee-keeping can also be an associated with agroforestry.

The problem associated with bun cultivation can mainly arises due to the process involved in burning the debris and intensive tillage even on steep slopes (discussed in detail in Chapter V). Traditional practices be it bun cultivation or shifting cultivation has always remained a source of livelihood and often the only option available for the tribal people living in the harsh geographical conditions. In a subsistence economy, the food requirement has to be derived locally and agricultural practices such as these offer the only possibility to do so. Moreover, the scarcity of good agricultural land in the study area allows very little scope for permanent cultivation. Under these circumstances, unless an alternative source is provided, there is very little chance that the people will abandon bun cultivation, and all attempts to eradicate it will remain futile. Apart from the land use plans suggested above, the impact of bun cultivation on the environment including soil and vegetation cover can be reduced to a great extent if some of the process involved is modified or controlled:

i. Restrict burning of debris.

The idea behind burning of debris is mainly to control the pest/blights and avail nutrients from ashes of burnt plant residues. Therefore, provision of blight resistant varieties of seeds, pest control measures, and addition of organic fertilizers to enhancing soil quality can be an important strategy to stop burning of debris. Instead, these bio-mass can be converted to organic compost.

ii. Minimize tillage

Unlike shifting cultivation where there is little or no tillage, bun cultivation involves maximum tillage of the land and also scraping of the adjoining areas to raise the bed and allow smooth flow of water. This is quite detrimental even in moderate slope conditions. Therefore, minimizing tillage, mulching and strip cropping can be effective in reducing erosion as well as enhance the water holding capacity and soil fertility.

iii. Mixed cropping

Most of the areas under bun cultivation is utilized for growing potato which is finds a ready market and is also easily storable. In doing so, there has not only been indiscriminate application of chemical fertilizers, insecticides and pesticides to boost the yield, but have also replaced the indigenous varieties of crops, such as local millets, sweet potato, sesamum, maize, and vegetables. Bringing about variations in the crops through mixed cropping practices is therefore necessary to improve soil quality and also supplementing the nutrient requirements of the people.

Among the soil conservation measures, those involving low capital investment such as contour drains, planting patterns perpendicular to slope, permanent tree cover to provide protection to the soil can be easily afforded by the farmers. Capital intensive conservation practices such as bench terracing and orchard benches can be undertaken on a small scale.

The study areas has a moderate to medium drainage density and drainage frequency which can be better utilized by constructing minor irrigation projects to meet the water requirements for the agricultural lands. Options to tap the water resources for generating hydro electricity, drinking water and irrigation to meet domestic demands can be further assessed.

Apart from the environmental factors, the social and economic factors too have an adverse impact on mans activities, and vice-versa. Therefore the mitigation of these adverse effects cannot be done by tackling the environmental factors alone. It requires change in all the interacting factors. They are:

- i. Low cost and effective technology, storage facilities, transport and communication, credit and banking facilities.
- ii. Promotion of income and employment generating activities and diversification of economic activities.
- iii. Investment in the required infrastructure i.e. roads, market, capital and credit facilities,
- iv. Training, demonstration, and linkages to development packages.
- v. Improvement in medical, health and educational facilities.
- vi. Population control

The land tenure system and land ownership system plays an important role in the management of resources in the Khasi society. Traditional institutions, beliefs and values needs to be revived, and the stake holders must be inculcated in the planning process. Redistribution of underutilized lands to reduce pressures on lands unsuitable for cultivation are structural changes that are necessary to foster a sound pattern of natural resource utilization in the agricultural sector and to reduce the risks of soil erosion.

Cooperative farming can be started in villages where a specific kind of food item is produced, so that the locals can bring their produce to an area where the storage and distribution facilities are located. Not only will this help them get a good price for their produce, but will also create jobs for more people.

Alternatives which has been tried by the Govt. of Meghalaya and the Indian Council for Agricultural Research units to control jhumming, can be demonstrated in these areas. The most acceptable among them is silvicultural and horticultural use of the land in hilly areas with least disturbance to soil system. However, alternative source of livelihood will have to be provided atleast till such systems become profitable and viable, as such programmes will affect the source of income of the farmers.

In conclusion it may be mentioned that the thrust area of land use planning lies on sustainable use of basic resources such as land, water, and vegetation, in such a way that it serves the objectives of accelerated growth, employment and alleviation of poverty on a sustainable basis. It is observed that rural poverty largely exists among the landless and marginal farmers. Access to land/common property resources, therefore, must form a key element of the anti-poverty strategy in rural areas.

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CHAPTER VII
SUMMARY AND CONCLUSION

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SUMMARY AND CONCLUSION

No matter what level of advancement nations have reached due to the industrial revolution and scientific innovations, 'Land' remains one of the single most important resource base for mankind. Land not only holds all the natural resources, like soil, water, vegetation, mineral, wildlife, etc. but is in itself a resource upon which all human occupation related to agriculture, industries, and all other activities are based. Population explosion vis-à-vis mans' desire for a better quality of life have continuously created a field of tension between man, resources and the environment. The success or failure of societies has not only depended on the resources offered by land, but to a large extend depends on how the obstacles imposed by the environment is tackled and how land is being used. Amongst all, the art of agriculture has probably remained to be one of the most important occupations that caters to the food requirement of the world's population and still sustains a large section of the people living in the underdeveloped regions of the world. But, the ever-increasing demand for food and the scarcity of land arising out of rapid population growth has not only strained existing agricultural land, but has pushed people to unfavourable areas where the risk of land degradation and environmental degeneration is very high. These two factors are often ignored to such an extent that it ultimately becomes too late to rectify the land for productive use. Under these circumstances, the importance of land evaluation becomes increasingly relevant, mainly due to the realisation that an efficient land use that does not degrade the land resources can only be obtained when the land condition or eco-system are well known.

The present research is an attempt to evaluate the existing land resources and its utilization and propagate a sound land use planning for the Mawkynrew C.&R.D.Block, East Khasi Hills District of Meghalaya. The location, physiography, climate, together with its distinct social and economic milieu gives

a unique identity to the study area and offers a plethora of research and learning of the intricate relationship between man and land resources and vice versa.

The broad objective of the present study is to evaluate the existing land resources for a sustainable and integrated land use planning, to support the best possible use, and sustainable management of land resources.

The study is based on the assumption that the land has an actual suitability, i.e. the stability of land units for the use in question in their present condition without major land improvement, and potential suitability, i.e. the stability of land units for use in question at some future date after major land improvements have been effected where necessary. These assumptions raises certain questions related to the potential of the resource base; applicability of the standard methods of land evaluation; the capability status of the land; and sustainability of the existing land-use. An attempt has been made to answer these questions in relation to the study area.

Data base generation at the required extent is made possible with the help of remote sensing techniques and toposheets. Ground truth verifications, thorough investigation of sample sites, collection of primary and secondary data, further supplemented the database. ARC GIS software provided a strong tool to process, generate and analyse multiple data and to derive the desired output.

Investigation of various works done in relation to land resource evaluation is carried out by surveying available literatures in the library, Internet and other media. Literature survey reveals that studies related to land evaluation was carried out as early as 1945 under the aegis of FAO, and various guidelines have been formulated. But, inspite of its importance, especially in the agricultural regions, very few extensive research materials are available in context of India.

An analysis of the physical base of the study is attempted in Chapter II. The central uplands with folded undulating rolling hills and the southern steep lands with long escarpments, and steeply dipping faults are the two main physiographic divisions. The Shillong series of weakly metamorphosed rocks with archaic crystalline basement forms the geological composition of the study area. The direction of most of the lineament features of the study area is north-east to south-west and east-west facing. Current bedding and intrusion by ultramafic sills and dykes have resulted in most of the lineaments to face the north-east, and south-west direction.

The diverse physical conditions of the study area are revealed by the vast differences in the slope conditions between the central uplands and the southern steep lands. The elevation ranges from as low as 100 meters to more than 1600 meters above mean sea level and has been divided into six categories according to its excessiveness. The slopes in the lower elevations are more rugged than in the higher elevations and the vast differences in the relief cause variations in the intensity of rainfall and sunlight, which affect the soil conditions and landuse practices.

The study area has a well knit drainage network with a very high occurrence of 1st order streams comprising about 60 percent of the total length, and 2nd order streams covering 19.24 percent of the total length of all the streams. The 3rd order and 4th order streams constitutes less than 10 percent of the total length, but offers much of the fertile river valleys where settled agriculture is practiced.

The drainage density ranges from less than 1 km/sq.m to above 3, and the drainage frequency ranges less than 2 to above 6 per sq.km. The overall drainage density and drainage frequency of the study area indicates that there is no scarcity of water as such, but the problem lies in its distribution and utility which is made inaccessible by rugged topographic conditions.

The study area falls under Agro-Climatic Zone II of the Indian Peninsula, and represents two out of five agro-climatic sub zones of Meghalaya, i.e. the central thermic plateau region having semi temperate to temperate climate, and the southern slopes and valleys having subtropical climate.

The climatic condition of the study area is governed by semi-temperate to temperate climate with an annual average rainfall of about 2400 mm in the central uplands, and the sub-tropical climate with cold to very cold winter conditions in the southern steep slopes. The mean annual air temperate in lower elevated lands is 23° C to 24° C while in the higher elevated lands it is 16° C to 17° C. The average humidity in this region varies from 67 to 79 per cent.

A detailed socio-economic status and its influence on the land utilization and impact on the development of the study area is carried out in Chapter III. The study area is fully dominated by the indigenous tribal population who follow the matriarchal system of social structure. The total population of 30,170 persons scattered in hamlet or village settlement with a population density of 85 persons, constitutes 6.5 percent of the population of East Khasi Hills.

The land is either owned by individuals/private land (Ri kynti) or belongs to the village community/Durbar (Ri-Raid). Both the systems of ownership have its own advantages and disadvantages, and have largely influenced the utilization and management of land resources in the study area.

The study area also portrays a discouraging scenario in terms of literacy level (36.65 percent according to 1991 census), which is the lowest amongst the other entire C.D.Blocks of East Khasi Hills district. This coupled with the absence of higher secondary schools and vocational training centers made it worst due to poor distribution of available educational institutions even at the primary school level.

The poor transport and communication system, market facilities, post & telegraph services, etc. have acted as a hindrance to the interconnectivity between rural and urban centers, movement of goods and services, and the transfer of technology, which are essential components of economic development. Even the basic amenities like medical facilities. Potable drinking water and electricity is yet to reach a vast majority of people of the study area.

The economy is primarily backward and rural in character, with much of the population depending on primary economic activities which includes subsistence level of farming. The occupational structure reveals that main workers constitute only 47 percent of the total population and the rest belong to the non working class. A village level analysis further indicates a very high discrepancy with almost 50 percent of the villages having less than half of its population in the category of main workers. This together with 23 percent of the population in the age group of less than 6 years has led to high dependency ratio – a burden for the working population most of who are engaged in the subsistence level of primary economic activities.

Agriculture which is the mainstay for much of the rural communities of the state, have been able to engage only a meager amount of population of the study area. Paucity of land actually available for cultivation, pre-dominance of small and marginal farmers, and traditional agricultural practices have acted as a major obstacles in raising agricultural production. This has led almost 70 percent of the working population to rely on primary activities like livestock rearing, forestry, fishing, hunting and plantation. As high as 80 percent of the populations in 41 villages are engaged in these activities, this together with bun cultivation can be said to be the root cause of land degradation and forest degeneration in the study area.

It has been easy to blame the economic activities for the loss and deterioration of land resources, but it is realised that unless the literacy level is

improved, and avenues created in the tertiary sectors there can be no solution to it. At present only 2 percent of the total population of the study area are engaged in the tertiary sector.

It is realised that the problems related to land resources are multidimensional in nature resulting due to the several complex series of factors, mainly, physical, socio-economic and technological. The analysis of all these factors as discussed in Chapter II and Chapter III respectively, forms a base and provides a clear understanding of the limitations and hurdles that needs to be overcome by exploring the actual capability of land through a proper land use and land management plans.

The taxonomy of land capability classification, and the various factors affecting it has been evaluated in Chapter IV. The resources have been divided into three classes according to its stability and possibility for modification, viz.

i) very stable resources, e.g. climate, physiography, geology, and relief, which provides practically very little freedom to bring about drastic changes and is almost completely free of man's influence, ii) moderately stable resources like soil, water and some artificial elements that are flexible enough, within certain limits, to be improved or modified for land development, and iii) relatively unstable resources, such as vegetation and related biological features which are unstable and vulnerable to both physical influence and human influences. It is realised that these three conditions have a major influence on land utilization and are decisive factors that govern the taxonomy of land capability classification. All these parameters are taken in to consideration for preparing the land capability classification map of the study area. Soil and slope have been taken as the two important parameters for land classification. Though soil is one of the important factors which decide the capability of land to produce, it is slope that has acted as a major hindrance in adopting settled agriculture in the study area. This is authenticated by the fact that only 1.44 percent of the study area has less than 5° slope which can be considered to be suitable for permanent cultivation provided

other factors are favourable. Almost 50 percent of the study area is characterised by steep to very steep slope, which provide little or no scope for any form of agriculture.

According to the general degree of goodness in the sense of possible intensity of use the study area is divided into six land capability classes, i.e. Class II, III, IV, VI, VII and VIII. These six classes of land are further divided into two broad groups, namely, land suitable for cultivation and other uses which includes Class II, III and IV lands, and land not suitable for cultivation i.e. Class VI, VII and VIII lands. The absence of plane areas or leveled lands and other limitations deprives the area of Class I and Class V lands. It was observed that there is very limited area for agricultural purposes, as only 1.63 percent of the land area falls in Class II, and 4.64 percent in Class III, while 21.06 percent comes under land capability Class IV, which has severe limitations for agricultural use. Thus, more than 70 percent of the land in the study area is not suitable for agricultural land use. This proves the fact as to why there is such a high dependency on forestry, livestock rearing, hunting, fishing and other non-agricultural primary occupations. The land capability classes are consistent with the composition of scale dependent mapping units, and meant to give only a broad idea of limitations. Considering the scale and the abstraction level of the mapping units, the management needs suggested here are broad and indicative in nature. Precise recommendations could follow only from farm level detailed soil surveys and investigations. However, the suggestions made above relate to the sustainable use with available technologies so as to prevent further degradation of the land.

The description of landuse/landcover pattern of the area discussed in Chapter V has provided an insight on the existing land utilization, and revealed some alarming facts related to the land degradation in the study area. The majority of the population who are dependent on forest related primary activities are left with only 15.16 percent of dense forested area and 27.28 percent of open

forest, most of which are secondary forest cover that provide very little biodiversity to cater to their needs. The area under permanent cultivation occupies only 5.38 percent of the geographical area, and bun cultivation occupies 4.19 percent. This together with plantations (1.41%) covers a little more than 10 percent of the total geographical area.

In order to find out the land resources of the past a forest cover map pertaining to the year 1965/66 was generated from the SOI toposheet. This was then superimposed with the existing landuse/landcover map and analysed in the Arc GIS environment to detect the changes occurring in the spatial and temporal dimension. A drastic change in the aerial extent of dense forest cover has occurred in the study area. Not only has the area occupied by dense forest cover, i.e. 41.51 percent in 1965/66, been reduced to a dismal 15.16 percent, but the quality and rich bio-diversity of the previous forest resources is now overtaken by secondary forest cover, and only 8.86 percent remains in its original form.

Further analysis of the existing landuse/landcover pattern, the changes it has undergone, and its distribution over different physiographic and slope conditions leads to the understanding of the situation which compels the people to take up the present form of primary occupation that is dependent on forest related activities including bun cultivation. This also highlights the complexities of the study area in terms of its resource use and its management.

The importance of watershed as a planning unit is highlighted in Chapter-VI. The study area is divided into eight micro watersheds, and a diagnostic survey of land resources and land capability classes for each watershed is analysed. The environmental appraisal of the landuse potentials in the study area reveals some interesting facts about the utilisation of the lands under different capability classes: i) areas which are capable of agriculture use are presently left

unutilised, and ii) areas which are not suitable for agriculture are being used for bun cultivation.

According to the stability of the resources and the capability of the land, the potential areas have been divided into two categories of use, namely i) potential areas for agricultural use, and ii) potential areas for non-agricultural use. It is observed that only 52.17 sq. km. or 14.49 percent of the study area offers the possibilities for agricultural use with varying degree of limitations, and in the absence of large areas under Class II and Class III lands, it becomes necessary to make the best possible use of Class IV lands.

The potential areas for non-agricultural use like forestry, animal husbandry, horticulture etc. offers a considerable scope for the development of these activities. Keeping in view the large section of the population who are dependent on primary activities other than agriculture, and directly or indirectly dependent on achieving much of their daily requirements from the forest, the utilization of the lands belonging to Class VI and VII can be viewed as potential sites for forestry, animal husbandry and horticulture. As of the present socio-economic condition and technological dissemination, these activities together with agro-forestry are the best possible avenues for the people living in this area.

The identification and analysis of the potential areas for agricultural and non-agricultural land uses also led to an important finding related to land use activities in some of the vulnerable areas. These areas are highly susceptible to erosion and land degradation, and presently occupy 30.90 sq.km. or 5.98 percent of the total geographical area.

With the above background in mind, a land use plan for the study area has been formulated. Scientific management of land resources to ensure optimal utilization, vis-à-vis conservation and environmental protection has been the guiding principal for land use planning. The proposed land use plan focuses on

the appropriate utilization of the potential areas, and the urgency to regenerate and conserve the vulnerable areas. The land use plan is meant to fit the physical, social and economic condition of the study area, and is not a rigid model, but a base on which micro level land use plans can be worked out after further investigation of the ground realities.

The areas falling under land capability Class II, which are unutilised offers high potentiality for agricultural use, provided some of the limitations imposed mainly by lack of irrigation and poor soil conditions are removed. This can be done with minimum input in the form of irrigation, fertilizers, and appropriate cropping pattern.

Class III and Class IV lands can be utilised after adopting special conservation practices, and land modifications such as contour bunding and terracing, providing irrigation, and by growing crops that provide good soil cover. Terrace cultivation, and contour bunding are some of the methods which has been successfully adopted and can be expanded further to other areas.

It was found that the spatial distributions of most of the existing forest resources are concentrated on areas that fall in the category of Class VI and above. These areas are highly vulnerable to erosion and other environmental hazards; therefore, special attention must be given to these areas during its use. Conservation and management of the forest in these areas are important for preserving water, avoiding excessive run-off and enhancing biodiversity.

It was found that most of the households still practice the tradition of rearing livestock and poultry. This can be an alternative as well as a subsidiary occupation and further encouragement and improvement can be initiated by providing necessary support in the form of high breed stocks, quality feed and fodder, and other extension services.

Plantation is another important activity of the people especially of those living in the southern slopes. The lower elevations (less than 700 meters) have proved to be potential areas for various plantation crops. This together with agro-forestry and animal husbandry can become a lucrative activity for people and at the same time reduce the high dependency and degradation of the existing forest resources.

Degradation of forest resources is a major concern that threatens the very sustenance of the people depending on it. The root cause of forest degradation are: i) high dependency of the people in primary activities, which include lumbering till the recent past, and is now replaced by livestock rearing, forestry, hunting, etc which still sustains about 33 percent of the total population of the study area, and ii) the traditional agricultural practices, which reveals that shifting cultivation was one of the main activity till recent years, and is now replaced by bun cultivation. This has not only resulted in deforestation but has also caused large scale degradation of the soils.

Some of the suggestions to tackle the problem of forest degradation include, low cost alternative and efficient energy sources, such as smokeless chullahs, bio-gas, solar energy, hydroelectricity, etc, to reduce the fuel wood crisis and rampant exploitation of already dwindling forest resources; launching of community based afforestation programmes; strengthening of local institutions to oversee the management of land resources; introduction of agro-forestry are essential steps. Modification of the processes involved in bun cultivation is seen as an important step to control both forest and soil degradation. This can be done by restricting in burning of debris, minimising tillage, and introducing mixed cropping practices. Soil conservation measures includes, contour drains, planting patterns perpendicular to slope, permanent tree cover to protect soil erosion, which are low cost and easily affordable by farmers.

The other areas which needs to be improved in the study area includes:- the introduction of low cost and effective technology, storage facility, transport and communication, credit and banking facilities; encourage cooperative and integrated farming; promoting income and employment generating activities. Investments in infrastructure like roads, market, capital and credit facilities; training, demonstration, and linkages to development packages; and the improvement of medical, health and educational facilities are some of the important areas.

The physical characteristics of the study area viz., relief, climate, soil, and slope has been the guiding factor that is responsible in shaping the occupational structure and farming system adopted by the people living in these areas. In the given geographical condition, the people obtain their basic minimum requirements from the forest, and adopting bun cultivation – a modified form of shifting cultivation. These activities which have been sustaining the people living in these areas are now posing a serious threat to the land resources and their very survival.

Population growth and the quality of the people mainly in terms of age structure, literacy level, occupation and employment is the main factor that is imposing an increasing pressure on land resources leading to depletion of natural resources and the degradation of land. The disparity in the socio-economic condition can be attributed to the quality of land resources and the nature of land utilization and vice versa.

Though the area is very close to the capital city Shillong, the dissemination of technology and the level of education have been very low. With 36.64 percent of literate population in the study area is the lowest in the East Khasi Hills district. A teeming 23 percent of children in the age group of 0 to 6 years add to the overwhelming 52 percent of non-working population resulting in a very high dependency ratio.

A severe imbalance is foreseen in the carrying capacity of the land if drastic steps are not taken to change or modify the existing land utilization practices. The present area under various landuse/landcover, is dominated by 34.33 percent of grass/shrubs, 15.16 percent of dense forest cover, and 27.28 percent of open forest cover. The change detection study reveals that out of the 41.19 percent of dense forest cover in 1965/66 only 8.86 percent remains in its natural form, while 31.23 percent has been affected by one or the other type of Landuse/Landcover. Unless immediate conservation and management practices are implemented the existing forest resources offer very little hope for sustaining the future requirements.

It is alarming to note that forest cover changes in recent years is more dominant in the southern slopes and these areas having steep slopes often experiencing the problems of erosion and land degradation, affecting its immediate areas and adjoining areas as well.

The shortage of good agricultural land in the study area is revealed by the low percentage of area under land capability Class II (1.63%), Class III (4.64%) and Class IV (21.06). Most of these areas have not been appropriately used mainly due the inability of the farmers to overcome the limitations imposed by soil and slope. Strategies to tackle these problems have been suggested after examining some of the successful land use practices carried out in and outside the study area.

The presence of large areas under Class VI and Class VIII with favourable geographical conditions offers a vast scope for the development of forestry, animal husbandry and horticulture. This, apart from giving them their requirement for food, fodder, fuel wood, firewood and shelter will also make it possible to safeguard the existing natural forest from further degradation. The study also reveals that bun cultivation is practiced in some of these areas and it has been

one of the major causes for large scale degradation of the land noticed in this area.

Analysis carried out at the watershed level provides a comprehensive background of the existing land resources of the study area. Further analysis of the existing landuse/landcover in combination with the land capability classes gives a clear understanding of the variations in the distribution, utilization, potentials and vulnerability of land resources at the watershed level.

The proposed land use plan is formulated after closely examining all the findings related to the physical, social, economic, and technological aspects of the study area. It is aimed to be environmentally sound, socially acceptable, economically viable, and technically appropriate in achieving a sustainable development.

Various methods, guidelines and techniques prepared by FAO and other organisations have been consulted in preparing the land capability classification and land use plans of the study area. The tendency to utilise some of the automated land evaluation techniques had to be grounded because of the realisation that quantitative data alone does not provide a strong basis for land evaluation, but qualitative aspects like knowledge, experience, tradition, belief, skill, social background, and a variety of other factors that cannot be quantified have a strong influence on land utilization.

Remote sensing has proved to be an efficient technique for obtaining land resource data, especially as the source for landuse/landcover mapping. Without the satellite data, it would be almost impossible to generate accurate landuse/landcover map with such details. A combination of IRS IC FCC in 1:50,000 scale and IRS IC PAN data in 1:25,000 scale was found suitable to undertake land resource studies. Integration of other collateral spatial and non-spatial data provided as an added advantage for micro level planning.

ArcGIS GIS 8.1 software provided the platform for digitization, data storage, manipulation, interpretation and generation of different thematic maps and linking of tables and other attributes, including collateral information to carry out land resource evaluation of the study area. It also provided a complete tool to analyse data both in raster and vector format for a comprehensive evaluation and planning processes.

In conclusion it can be said that the present study has brought about a realisation of the existing condition of land resources in the study area, and also created awareness about the future consequences that are likely to arise if the present land use practices continues. The linkages and interdependence of the physical and human resources in the study area is so intrinsic that without a mutual relationship and coexistence, the possibilities of achieving a sustainable development look very bleak. Ignorance, greed and poverty often result in unscrupulous use of resources and caused colossal damage to the land resources. Researchers play an important role in using their knowledge and the available technology to identify the problems and finding the answers and recommendations to it. Coordination between governmental agencies and non-governmental organizations and the participation of the village based community and self help group is necessary to diffuse the knowledge and technology, which will ultimately rely on the acceptance and implementation of the people at the grass root level. Remote sensing, GIS, digital image processing (DIP) and simulation models provides new possibilities for better analysis techniques, monitoring, and forecasting. With the present advancement in RS & GIS it is possible to illustrate its application at grass root level and to integrate other spatial and non-spatial data in understanding and solving the problems related to land resources. These techniques need to be an integral part of decision support system in land resource evaluation and landuse planning.

Gross national product per capita is widely employed as an index for the wealth of nations, and human development index has been developed with combined indicators of health and education. A corresponding land resource index combining sub-indices of the status of soils, water, forest, and bio-diversity is possible in principle, and represents a target for the future.

The present research has led to the discovery of new facts and also a fresh interpretation of facts already known. The topic of research is not a unique subject matter, but is being viewed from a unique perspective. A look at the reality from perspective of space has given a new dimension to this research.

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APPENDICES

APPENDIX 2a

Rainfall in mm (Station: Vegetable Research Centre, Upper Shillong)

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
1981	19.3	10.1	56.5	177.2	367.8	152.1	818.7	291.8	248.4	3.2	Nil	36.8	2181.9
1982	Nil	Nil	50.4	151	161.7	706.6	271.3	350.8	403	Nil	46.2	Nil	2141
1983	Nil	24.8	68.8	109.3	205.1	249.3	1220.9	393.7	572.4	206.8	Nil	18.3	3069.4
1984	9.3	Nil	46.4	47.2	146.1	394	998.2	97.9	700.3	32.9	Nil	Nil	2472.3
1985	Nil	Nil	Nil	102.4	185.6	136.7	74.1	90.6	54.5	16.3	3.4	2.3	665.9
1986	9.2	Nil	31.8	88.5	178.4	142.6	102.7	98	225.9	277	23.3	NA	1177.4
1987	Nil	32.1	36.4	262	324.8	621	726.8	730.3	198.7	239.4	60.3	Nil	3231.8
1988	26.3	103.8	279.7	367.7	658.8	789.4	86.6	682.7	325.7	170.4	189	63.3	3743.4
1989	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
1990	Nil	26.6	306.7	308.7	1074.1	802.5	120.2	91.5	95.5	237.7	Nil	Nil	3063.5
1991	6.3	3.1	148.4	93.4	208.6	482	718.7	368.6	449.1	NA	Nil	37.8	2516
1992	N.A	28.3	86.8	130.6	777.3	546.1	581.2	491.9	781.8	405.8	87.4	NA	3917.2
1993	Nil	Nil	36.4	237.4	113	632	672	743.9	818	842.2	32.5	Nil	4127.4
1994	Nil	Nil	NA	NA	NA	487.9	63.9	79.6	22.4	77	NA	NA	730.8
1985	1.4	8.3	Nil	16.9	86.4	316.8	65.2	267.6	276.9	63.1	5.5	Nil	1108.1
Average	5.13	16.94	82.02	149.45	320.55	461.36	465.75	341.35	369.47	183.70	31.97	11.32	2439.01

APPENDIX 2b

Table-8: Rainfall in MM (Station: Amlarem)

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
1981	39.0	34.2	114.4	323.3	761.6	1039.4	2744.5	1209.1	1291.8	128.9	8.3	104.8	7799.3
1982	Nil	16.1	41.7	958.7	364.0	1998.0	2762.8	1141.6	1332.0	70.6	54.9	13.7	8754.1
1983	13.42	57.3	310.7	416.8	375.32	1512.79	2477.1	1601.3	1336.3	261.7	Nil	38.3	8401.03
1984	20.3	2.1	84.3	1235.5	2712.5	1341.3	3600.3	1252.7	2453.1	460.8	Nil	Nil	13162.9
1985	8.0	62.7	589.2	1129.1	1247.6	2652.5	2768.1	1370.6	481.6	81.1	9.2	Nil	10399.7
1986	18.1	Nil	84.4	879.8	194.8	1002.6	1838.6	1404.2	982.5	655.2	166.3	Nil	7226.5
1987	2.0	Nil	260.8	547.1	223.4	1511.1	2407.8	2252.4	1781.5	150.4	45.1	147.2	9328.8
1988	Nil	80.1	72.5	452.2	3510.81	4092.10	4129.66	9088.77	54.47	547.5	276.0	10.0	22314.11
1989	4.0	168.5	3.0	810.6	779.9	NA	NA	NA	NA	NA	NA	NA	1766
1990	180.0	332.8	656.0	9002.1	3366.2	10689.6	10217.6	1212.8	2177.8	708.9	72.8	Nil	38616.6
1991	28.3	37.3	57.4	283.8	3654.4	3080.8	2138.4	2863.8	2938.5	636.4	Nil	31.4	15750.5
1992	Nil	190.2	1404.3	533.1	1424.0	1407.2	2413.1	1485.2	1789.1	324.3	Nil	Nil	10970.5
1993	158.30	1611.10	453.60	270.7	2314.0	4009.4	2600.8	2653.7	1143.9	276.7	76.3	Nil	15548.50
1994	16.3	94.7	554.2	1214.7	2830.8	3716.25	1882.4	1331.5	1372.2	788.8	25.5	Nil	13827.35
Average	34.84	191.94	333.32	1289.82	1697.10	2718.07	2998.65	2061.98	1366.77	363.66	52.46	24.67	13133.28
Average of Two Stations	19.99	104.44	207.67	719.64	1008.83	1589.72	1732.20	1201.67	868.12	273.68	42.22	18.00	7786.15

APPENDIX 3a

Village Level Household, Population & Sex Ratio

Code	Name of Village	No. of Households		Total Population				
		Total	% to total	Total	% to total	Male	Female	Sex Ratio
1	Thangsning	109	2.13	694	2.30	352	342	97
2	Mawlali	107	2.09	677	2.24	357	320	90
3	Thynroit	331	6.48	2270	7.52	1165	1105	95
4	Kharang	177	3.46	1082	3.59	533	549	103
5	Pingwait	99	1.94	593	1.97	300	293	98
6	Dienglieng	81	1.59	490	1.62	252	238	94
7	Nongjrong	153	2.99	879	2.91	472	407	86
8	Syniasia	126	2.47	357	1.18	169	188	111
9	Umsning	57	1.12	312	1.03	148	164	111
10	Tanglei	53	1.04	193	0.64	98	95	97
11	Jongkhsha	274	5.36	1582	5.24	778	804	103
12	Mawiabpang	33	0.65	219	0.73	108	111	103
13	Rableng	87	1.70	473	1.57	231	242	105
14	Laitdiengsai	69	1.35	407	1.35	218	189	87
15	Laitkyrhong	194	3.80	1127	3.74	565	562	99
16	Rangphlang	101	1.98	584	1.94	285	299	105
17	Rasong	141	2.76	918	3.04	478	440	92
18	Laitlum	96	1.88	638	2.11	336	302	90
19	Mawblang	103	2.02	554	1.84	253	301	119
20	Umkhoi	12	0.23	74	0.25	36	38	106
21	Mawlein	92	1.80	514	1.70	266	248	93
22	Mawkynew	54	1.06	328	1.09	160	168	105
23	Umtong	62	1.21	361	1.20	173	188	109
24	Laitmysang	37	0.72	186	0.62	86	100	116
25	Mysang	82	1.60	480	1.59	249	231	93
26	Mawdulop	14	0.27	98	0.32	58	40	69
27	Ksanrangi	24	0.47	162	0.54	95	67	71
28	Mawsir	16	0.31	91	0.30	51	40	78
29	Jatah Nonglyer	62	1.21	628	2.08	320	308	96
30	Jatah Lakadong	127	2.49	763	2.53	397	366	92
31	Ladryngngi							
32	Umsham	36	0.70	191	0.63	105	86	82
33	Lynshing	129	2.52	690	2.29	333	357	107
34	Mynriah	56	1.10	236	0.78	121	115	95
35	Langsiew	8	0.16	48	0.16	25	23	92

Contt..

36	Umpdem	8	0.16	50	0.17	21	29	138
37	Wahumsim							
38	Madan Demkhlieng	32	0.63	135	0.45	58	77	133
39	Ryngkya	33	0.65	160	0.53	83	77	93
40	Rangbuli	8	0.16	42	0.14	23	19	83
41	Mawlyngngot	28	0.55	136	0.45	73	63	86
42	Iewrynghep	34	0.67	169	0.56	81	88	109
43	Rngibah	87	1.70	474	1.57	230	244	106
44	Klang	11	0.22	60	0.20	33	27	82
45	Siltham	23	0.45	147	0.49	73	74	101
46	Khwad	33	0.65	201	0.67	98	103	105
47	Nongpyrdi	52	1.02	281	0.93	127	154	121
48	Pashang	22	0.43	165	0.55	75	90	120
49	Umsaw	49	0.96	298	0.99	157	141	90
50	Mawlang	31	0.61	233	0.77	127	106	83
51	Mawjatah	65	1.27	491	1.63	249	242	97
52	Siangkhnai	34	0.67	185	0.61	99	86	87
53	Sytung	138	2.70	792	2.63	418	374	89
54	Khlieh A Sem	42	0.82	224	0.74	113	111	98
55	Mawsna	42	0.82	335	1.11	183	152	83
56	Mawkhia	114	2.23	693	2.30	336	357	106
57	Khapman	36	0.70	173	0.57	96	77	80
58	Iapdkhoh	45	0.88	228	0.76	115	113	98
59	Thangbnai	69	1.35	293	0.97	144	149	103
60	Mawlat	105	2.05	644	2.13	291	353	121
61	Mawrasai	39	0.76	247	0.82	131	116	89
62	Wah Lyngdoh	95	1.86	562	1.86	282	280	99
63	Umblai	17	0.33	94	0.31	49	45	92
64	Wahlakhiat	147	2.88	827	2.74	403	424	105
65	Nongryngkoh	192	3.76	1109	3.68	531	578	109
66	Nohron	184	3.60	1018	3.37	512	506	99
67	Nonghulo	93	1.82	805	2.67	403	402	100
	Total	5110	100	30170	100	15187	14983	

APPENDIX 3b

Village wise population in 0 to 6 age group and Literates

	Name of Village	Total Popn. of the Village	Population (0-6 age group)				Literates			
			Total	% to village Popn.	M	F	Total	% to village Popn.	M	F
1	Thangsning	694	158	22.77	86	72	211	30.40	104	107
2	Mawlali	677	184	27.18	98	86	376	55.54	188	188
3	Thynroit	2270	551	24.27	283	268	475	20.93	277	198
4	Kharang	1082	270	24.95	137	133	205	18.95	106	99
5	Pingwait	593	171	28.84	74	97	186	31.37	85	101
6	Dienglieng	490	109	22.24	52	57	108	22.04	42	66
7	Nongjrong	879	199	22.64	106	93	20	2.28	8	12
8	Syniasia	357	108	30.25	48	60	98	27.45	34	64
9	Umsning	312	111	35.58	49	62	8	2.56	4	4
10	Tanglei	193	42	21.76	21	21	102	52.85	50	52
11	Jongkhsha	1582	337	21.30	174	163	310	19.60	171	139
12	Mawiapbang	219	52	23.74	27	25	90	41.10	38	52
13	Rableng	473	100	21.14	61	39	152	32.14	64	88
14	Laitdiengsai	407	76	18.67	39	37	142	34.89	72	70
15	Laitkyrhong	1127	283	25.11	137	146	141	12.51	69	72
16	Rangphlang	584	133	22.77	62	71	346	59.25	167	179
17	Rasong	918	289	31.48	150	139	261	28.43	117	144
18	Laitlum	638	174	27.27	98	76	144	22.57	63	81
19	Mawblang	554	122	22.02	58	64	56	10.11	25	31
20	Umkhoi	74	20	27.03	13	7	14	18.92	3	11
21	Mawlein	514	134	26.07	65	69	116	22.57	48	68
22	Mawkynrew	328	72	21.95	28	44	176	53.66	89	87
23	Umtong	361	88	24.38	39	49	174	48.20	85	89
24	Laitmysang	186	44	23.66	25	19	60	32.26	23	37
25	Mysang	480	97	20.21	46	51	128	26.67	50	78
26	Mawdulop	98	12	12.24	6	6	0	0.00	-	-
27	Ksanrngi	162	26	16.05	22	4	21	12.96	11	10
28	Mawsir	91	9	9.89	5	4	2	2.20	2	-
29	Jatah Nonglyer	628	103	16.40	50	53	67	10.67	34	33
30	Jatah Lakadong	763	204	26.74	116	88	216	28.31	94	122

31	Ladryngngi									
32	Umsham	191	46	24.08	26	20	61	31.94	29	32
33	Lynshing	690	187	27.10	96	91	263	38.12	152	111
34	Mynriah	236	36	15.25	19	17	151	63.98	83	68
35	Langsiew	48	9	18.75	5	4	27	56.25	11	16
36	Umpdem	50	11	22.00	3	8	11	22.00	3	8
37	Wahumsim									
38	Madan Demkhlieng	135	28	20.74	14	14	27	20.00	13	14
39	Ryngkya	160	41	25.63	23	18	56	35.00	31	25
40	Rangbuli	42	14	33.33	8	6	9	21.43	5	4
41	Mawlyngngot	136	26	19.12	12	14	74	54.41	41	33
42	Iewrynghep	169	50	29.59	19	31	55	32.54	24	31
43	Rngibah	474	127	26.79	63	64	260	54.85	119	141
44	Klang	60	12	20.00	7	5				
45	Siltham	147	-			-	32	21.77	18	14
46	Khwad	201	48	23.88	23	25	76	37.81	34	42
47	Nongpyrdi	281	70	24.91	34	36	54	19.22	16	38
48	Pashang	165	45	27.27	15	30	44	26.67	16	28
49	Umsaw	298	89	29.87	49	40	55	18.46	18	37
50	Mawlang	233	27	11.59	15	12	108	46.35	53	55
51	Mawjatah	491	110	22.40	61	49	317	64.56	158	159
52	Siangkhnai	185	21	11.35	12	9	95	51.35	59	36
53	Syntung	792	141	17.80	75	66	455	57.45	222	233
54	Khlieh A Sem	224	60	26.79	32	28	95	42.41	46	49
55	Mawsna	335	43	12.84	28	15	60	17.91	29	31
56	Mawkhia	693	160	23.09	81	79	114	16.45	46	68
57	Khapmaw	173	39	22.54	26	13	57	32.95	26	31
58	Iapdkhoh	228	56	24.56	28	28	84	36.84	35	49
59	Thangbnai	293	44	15.02	24	20	41	13.99	18	23
60	Mawlat	644	169	26.24	81	88	68	10.56	35	33
61	Mawrasai	247	68	27.53	29	39	116	46.96	67	49
62	Wah Lyngdoh	562	90	16.01	45	45	110	19.57	46	64
63	Umblai	94	26	27.66	15	11	34	36.17	21	13
64	Wahlakhiat	827	204	24.67	98	106	171	20.68	74	97
65	Nongryngkoh	1109	268	24.17	136	132	400	36.07	192	208
66	Nohron	1018	172	16.90	90	82	64	6.29	22	42
67	Nonghulo	805	183	22.73	88	95	441	54.78	225	216
		30170	6998	23.20	3555	3443	8490	36.64	4110	4380

APPENDIX 3c

Village wise education, Medical and other facilities

Co de	Name of Village	Education	Medical	Drinking water (Portable)	Post & Telegraph
1	Thangsning	P (3) M, AC	-(5)	TK	-(5)
2	Mawlali	P,M	-(10+)	W, TK,R	-(10+)
3	Thynroit	P,M	D	W,TK,R	-(5)
4	Kharang	P (2) M	D	HP	PO
5	Pingwait	P (2)	D	T	-(5)
6	Dienglieng	P (3)	-(5)	T	-(5)
7	Nongjriong	P	-(5-10)	T	-(5-10)
8	Syniasia	P (2)	-(5-10)	T	-(5-10)
9	Umsning	P	-(5)	T	-(5)
10	Tanglei	P	-(5)	T	-(5)
11	Jongkhsha	P,M,H	-(10+)	W,TK,T	-(5)
12	Mawiapbang	P	-(10+)	W,TK	-(5)
13	Rableng	P	-(10+)	T	-(10+)
14	Laitdiengsai	P,M	-(5)	HP,T	-(5)
15	Laitkyrhong	P,M (2)	-(5)	T,HP	-(5)
16	Rangphlang	P (2)	-(10+)	T,TW	-(10+)
17	Rasong	P (2)	-(10+)	T,TW	-(10+)
18	Laitlum	AC, P (2)	-(10+)	HP	-(10+)
19	Mawblang	P	-(5)	W	PO
20	Umkhoi	P (2) M	-(5-10)	W,HP	-(5-10)
21	Mawlein	P (2)	-(5)	W,O	-(5)
22	Mawkynew	P (2) M	P,H,C	T,W	PO
23	Umtong	P,H	-(5)	T,O	-(5)
24	Laitmysang	P	-(5-10)	W	-(5-10)
25	Mysang	P	-(5-10)	W,O	-(10+)
26	Mawdulop	P	-(5-10)	W,O	-(10+)
27	Ksanrangi	P	-(10+)	T	-(10+)
28	Mawsir	P	-(5)	W	-(10+)
29	Jatah Nonglyer	P	-(5)	HP	-(10+)
30	Jatah Lakadong	P	P,H,C	HP	-(10+)
31	Ladryngngi				

32	Umsham	P	-(-5-10)	W	-(-5)
33	Lynshing	P (2) M	-(-5-10)	T,W	PO
34	Mynriah	P	-(-10+)	T	-(-5)
35	Langsiew	-(-5)	-(-10+)	T	-(-10+)
36	Umpdem	- (-5)	-(-10+)	T	-(-10+)
37	Wahumsim				
38	Madan Demkhlieng	-(-5)	-(-10+)	T	-(-10+)
39	Ryngkya	P (2)	-(-10+)	T	-(-10+)
40	Rangbuli	P,M	-(-10+)	T	-(-10+)
41	Mawlyngngot	P (2)	-(-10+)	W	-(-10+)
42	Iewrynghep	-(-5)	-(-10+)	W	-(-10+)
43	Rngibah	P,M	-(-10+)	W,S	-(-10+)
44	Klang	-(-5)	-(-10+)	W	-(-5)
45	Siltham	P	-(-5)	-(-5)	-(-10+)
46	Khwad	P	-(-10+)	T	-(-5)
47	Nongpyrdi	P	-(-10+)	S,W	-(-5)
48	Pashang	P	-(-5)	-(-5)	-(-10+)
49	Umsaw	P	-(-5)	R	-(-10+)
50	Mawlang	P	-(-5)	W	-(-5)
51	Mawjatah	P (2)	-(-5)	W	-(-5-10)
52	Siangkhnai	P	-(-5)	T	-(-5)
53	Syntung	P,M	-(-5)	T	-(-5)
54	Khlieh A Sem	P (2)	-(-5-10)	T	-(-10+)
55	Mawsna	P	-(-5)	W	-(-10+)
56	Mawkhia	P	-(-10+)	T	-(-10+)
57	Khapmaw	P	-(-10+)	T	-(-10+)
58	Iapdkhoh	P	-(-10+)	T	-(-10+)
59	Thangbnai	P (2)	-(-10+)	T	-(-10+)
60	Mawlat	-(-5)	-(-10+)	W	-(-10+)
61	Mawrasai	P,M	-(-10+)	T	-(-10+)
62	Wah Lyngdoh	P	-(-10+)	T	-(-10+)
63	Umblai	-(-5)	-(-10+)	W	-(-10+)
64	Wahlakhiat	P(2)	-(-10+)	S	-(-10+)
65	Nongryngkoh	P (2) M	-(-10+)	T	-(-10+)
66	Nohron	P	-(-10+)	T	-(-10+)
67	Nonghulo	P(2)	-(-5)	T	-(-5)

APPENDIX 3d

Village wise market, communication and other facilities

Co de	Name of Village	Day or days of Market/hat if any	Communications(Bus stop)	Approach to village	Distance to nearest town (Shillong)	Power Supply
1	Thangsning	-(-5)	-(-5)	PR	18	ED
2	Mawlali	-(-10+)	BS	KR	25	ED
3	Thynroit	-(-10+)	BS	KR	30	ED
4	Kharang	-(-10+)	-(-5-10)	KR	42	ED
5	Pingwait	-(-10+)	-(-5-10)	KR	44	ED
6	Dienglieng	-(-10+)	-(-5-10)	KR	43	ED
7	Nongjriong	-(-10+)	-(-10+)	KR	49	ED
8	Syniasia	-(-10+)	-(-10+)	KR	47	ED
9	Umsning	-(-10+)	-(-10+)	KR	45	ED
10	Tanglei	-(-5)	-(-5)	PR	33	ED
11	Jongkhsha	-(-10+)	-(-5)	KR	40	ED
12	Mawiapbang	-(-10+)	BS	PR	35	ED
13	Rableng	-(-10+)	BS	PR	30	ED
14	Laitdiengsai	-(-5)	-(-5)	PR	29	ED
15	Laitkyrhong	-(-5)	-(-5)	KR	18	ED
16	Rangphlang	-(-10+)	-(-5-10)	FP	86	-
17	Rasong	-(-10+)	-(-5)	PR	20	ED
18	Laitlum	-(-10+)	BS	KR	22	ED
19	Mawblang	-(-5)	-(-5)	KR	30	ED
20	Umkhoi	Weekly	BS	KR	40	-
21	Mawlein	-(-10+)	-(-5)	KR	52	ED
22	Mawkynew	-(-10)	BS	PR	50	ED
23	Umtong	-(-10+)	BS	PR	51	ED
24	Laitmysang	-(-10+)	BS	PR	56	ED
25	Mysang	-(-5-10)	-(-5)	KR	64	-
26	Mawdulop	-(-5-10)	-(-5)	KR	68	-
27	Ksanrangi	-(-5-10)	-(-5)	KR	68	-
28	Mawsir	-(-5)	-(-5)	FP	50	-
29	Jatah Nonglyer	Weekly	BS	KR	42	ED
30	Jatah Lakadong	-(-5)	BS	KR	44	ED
31	Ladryngngi					

32	Umsham	-(5)	BS	FP,KR	32	-
33	Lynshing	Weekly	BS	FP,KR	30	ED
34	Mynriah	-(5)	-(5)	FP	25	-
35	Langsiew	-(5-10)	-(5-10)	FP	53	-
36	Umpdem	-(5-10)	-(5-10)	FP	53	-
37	Wahumsim					
38	Madan Demkhlieng	-(5-10)	-(5-10)	FP	52	-
39	Ryngkya	-(5-10)	-(5-10)	FP	53	-
40	Rangbuli	-(10+)	-(10+)	FP	55	-
41	Mawlyngngot	Weekly	BS	KR	40	-
42	Iewrynghep	Weekly	BS	KR	42	-
43	Rngibah	-(5-10)	-(5-10)	FP	53	-
44	Klang	-(5)	-(5)	FP	33	-
45	Siltham	-(10+)	-(5)	FP	55	-
46	Khwad	-(5)	-(5)	FP	35	-
47	Nongpyrdi	-(5)	-(5)	FP	33	-
48	Pashang	-(10+)	-(5)	FP	46	-
49	Umsaw	-(10+)	-(5)	KR	45	-
50	Mawlang	-(10+)	-(5)	FP	55	-
51	Mawjatah	-(10+)	-(5-10)	FP	60	-
52	Siangkhnai	-(10+)	-(5)	FP	62	-
53	Syntung	-(10+)	-(5)	FP	50	-
54	Khlieh A Sem	Bi-weekly	BS	KR	48	ED
55	Mawsna	-(5)	-(5)	FP	50	-
56	Mawkhia	-(10+)	-(5)	FP	34	-
57	Khapmaw	-(5-10)	-(5-10)	FP	52	-
58	Iapdkhoh	-(5-10)	-(5-10)	FP	52	-
59	Thangbnai	-(5-10)	-(5-10)	FP	55	-
60	Mawlat	-(10+)	-(5)	FP	50	-
61	Mawrasai	-(10+)	BS	KR	53	-
62	Wah Lyngdoh	-(10+)	BS	KR	55	-
63	Umblai	-(10+)	BS	KR	58	-
64	Wahlakhiat	-(10+)	BS	KR	61	-
65	Nongryngkoh	-(5-10)	-(10+)	FP	62	-
66	Nohron	-(5-10)	-(5-10)	FP	15	-
67	Nonghulo	-(10+)	-(5)	FP	58	-

Description of the Abbreviations used in Appendix 3c & 3d.

PO	Post office
BS	Bus stop
PR	Pucca road
KR	Kutchra road
FP	Footpath
ED	electricity for domestic purpose
P	Primary school (includes Nursery, kinder garten, upto class III)
M	Junior secondary or middle school (includes class IV to VI)
H	Matriculation or secondary (includes class VII to X)
AC	Adult Literacy class/centre
D	Dispensary
PHC	Primary Health Centre
T	Tap water
W	Well Water
TK	Tank water
TW	Tube well
HP	Hand pump
R	River water
O	Others

If no facilities is available within the village, a dash (-) is shown, followed by the distance in broad ranges of the nearest place where the facility is available.

APPENDIX 3e

Village wise distribution of main workers and non workers

Code.	Name of Village	Main Workers			Non workers		
		Total	Male	Female	Total	Male	Female
1	Thangsning	305	152	153	389	200	189
2	Mawlali	329	187	142	348	170	178
3	Thynroit	1025	602	423	1227	561	666
4	Kharang	537	308	229	458	211	247
5	Pingwait	298	178	120	248	111	137
6	Dienglieng	253	146	107	237	106	131
7	Nongjriong	458	262	196	421	210	211
8	Syniasia	161	82	79	191	83	108
9	Umsning	104	67	37	180	81	99
10	Tanglei	86	46	40	107	52	55
11	Jongkhsha	723	381	342	859	397	462
12	Mawiapbang	116	61	55	103	47	56
13	Rableng	228	107	121	243	123	120
14	Laitdiengsai	192	107	85	208	111	97
15	Laitkyrhong	272	252	20	855	313	542
16	Rangphlang	234	147	87	350	138	212
17	Rasong	369	215	154	539	263	276
18	Laitlum	280	167	113	358	169	189
19	Mawblang	426	192	234	128	61	67
20	Umkhoi	36	19	17	35	17	18
21	Mawlein	250	146	104	264	120	144
22	Mawkynrew	119	86	33	209	74	135
23	Umtong	171	89	82	190	84	106
24	Laitmysang	103	48	55	83	38	45
25	Mysang	250	136	114	230	113	117
26	Mawdulop	59	36	23	39	22	17
27	Ksanrangi	87	52	35	75	43	32
28	Mawsir	61	36	25	30	15	15
29	Jatah Nonglyer	358	177	181	270	143	127
30	Jatah Lakadong	363	205	158	400	192	208

31	Ladryngngi	0			0		
32	Umsham	89	57	32	102	48	54
33	Lynshing	306	173	133	384	160	224
34	Mynriah	161	86	75	75	35	40
35	Langsiew	26	16	10	21	9	12
36	Umpdem	27	16	11	23	5	18
37	Wahumsim	0			0		
38	Madan Demkhlieng	78	37	41	57	21	36
39	Ryngkya	74	38	36	86	45	41
40	Rangbuli	20	11	9	21	12	9
41	Mawlyngngot	67	53	14	61	20	41
42	Iewrynghep	69	52	17	87	25	62
43	Rngibah	249	126	123	225	104	121
44	Klang	29	15	14	31	18	13
45	Siltham	79	43	36	68	30	38
46	Khwad	79	45	34	122	53	69
47	Nongpyrdi	107	56	51	174	71	103
48	Pashang	95	45	50	69	29	40
49	Umsaw	156	80	76	142	77	65
50	Mawlang	132	70	62	100	56	44
51	Mawjatah	262	139	123	229	110	119
52	Siangkhnai	135	72	63	50	27	23
53	Syntung	361	219	142	431	199	232
54	Khlieh A Sem	108	58	50	116	55	61
55	Mawsna	216	118	98	119	65	54
56	Mawkhia	235	147	88	458	189	269
57	Khapman	93	46	47	80	50	30
58	Iapdkhoh	107	54	53	121	61	60
59	Thangbnai	154	83	71	139	61	78
60	Mawlat	249	145	104	395	146	249
61	Mawrasai	82	55	27	165	76	89
62	Wahlyngdoh	328	170	158	232	112	120
63	Umblai	34	21	13	60	28	32
64	Wahlakhiat	338	198	140	489	205	284
65	Nongryngkoh	511	281	230	598	250	348
66	Nohron	564	295	269	454	217	237
67	Nonghulew	344	198	146	461	205	256
	Total	14217	8007	6210	15719	7142	8577

APPENDIX 3f

Village wise distribution of cultivators and agricultural labourers

Code	Name of Village	Cultivators			Agricultural Labourers		
		Total	Male	Female	Total	Male	Female
1	Thangsning	12	9	3	-	2	-
2	Mawlali	8	5	3	-	-	-
3	Thynroit	463	274	189	523	300	223
4	Kharang	36	32	4	4	2	2
5	Pingwait	3	2	1	-	1	-
6	Dienglieng	148	82	66	63	33	30
7	Nongjrang	455	261	194	-	-	-
8	Syniasia	159	82	77	-	-	-
9	Umsning	30	19	11	43	25	18
10	Tanglei	85	46	39	-	-	-
11	Jongkhsha	0	-	-	-	-	-
12	Mawiapbang	0	-	-	-	-	-
13	Rableng	0	-	-	9	7	2
14	Laitdiengsai	0	-	-	34	26	8
15	Laitkyrhong	0	-	-	-	-	-
16	Rangphlang	1	1	-	-	-	-
17	Rasong	0	-	-	-	-	-
18	Laitlum	0	-	-	-	-	-
19	Mawblang	0	-	-	93	41	52
20	Umkhai	0	-	-	-	-	-
21	Mawlein	1	1	-	-	-	-
22	Mawkynew	6	5	1	-	-	-
23	Umtong	1	1	-	-	-	-
24	Laitmysang	0	-	-	-	-	-
25	Mysang	79	54	25	-	-	-
26	Mawdulop	31	17	14	-	-	-
27	Ksanrangi	74	43	31	12	8	4
28	Mawsir	27	15	12	-	1	-
29	Jatah Nonglyer	0	-	-	-	-	-
30	Jatah Lakadong	20	11	9	7	6	1

31	Ladryngngi	0			0		
32	Umsham	0	-	-	-	-	-
33	Lynshing	0	-	-	-	-	-
34	Mynriah	0	-	-	-	-	-
35	Langsiew	0	-	-	-	-	-
36	Umpdem	0	-	-	-	-	-
37	Wahumsim	0	-	-	-	-	-
38	Madan Demkhlieng	0	-	-	-	-	-
39	Ryngkya	0	-	-	-	-	-
40	Rangbuli	0	-	-	-	-	-
41	Mawlyngngot	0	-	-	-	-	-
42	Iewrynghep	0	-	-	-	-	-
43	Rngibah	0	-	-	-	-	-
44	Klang	0	-	-	-	-	-
45	Siltham	0	--	-	-	-	-
46	Khwad	0	-	-	-	-	-
47	Nongpyrdi	0	-	-	-	-	-
48	Pashang	0	-	-	-	-	-
49	Umsaw	0	-	-	-	-	-
50	Mawlang	1	1	-	3	1	2
51	Mawjatah	209	99	110	20	15	5
52	Siangkhnai	135	72	63	-	-	-
53	Syngtung	43	23	20	10	9	1
54	Khlieh A Sem	0	-	-	-	-	-
55	Mawsna	0	-	-	-	-	-
56	Mawkhia	8	5	3	3	1	2
57	Khapman	0	-	-	-	-	-
58	Iapdkhoh	0	-	-	-	-	-
59	Thangbnai	0	-	-	-	-	-
60	Mawlat	0	-	-	-	-	-
61	Mawrasai	0	-	-	-	-	-
62	Wahlyngdoh	-	-	-	0		
63	Umblai	-	-	-	0		
64	Wahlakhiat	-	-	-	0		
65	Nongryngkoh	-	-	-	134	50	84
66	Nohron	-	-	-	0		
67	Nonghulew		58	97	98	67	31
	Total	2035	1218	972	1056	595	465

APPENDIX 3g

Village wise distribution of population engaged in primary activities and other services

Code	Name of Village	Livestock, Forestry, Fishing, Hunting & Plantation			Other Services		
		Total	Male	Female	Total	Male	Female
1	Thangsning	255	117	138	21	10	11
2	Mawlali	266	143	123	23	11	12
3	Thynroit	8	7	1	17	11	6
4	Kharang	409	221	188	29	7	22
5	Pingwait	259	155	104	18	6	12
6	Dienglieng	40	31	9	2	-	2
7	Nongjrong	0	-	-	3	1	2
8	Syniasia	0	-	-	2	-	2
9	Umsning	29	22	7	2	1	1
10	Tanglei	0	-	-	1	-	1
11	Jongkhsha	672	350	322	30	16	14
12	Mawiapbang	74	40	34	33	17	16
13	Rableng	176	76	100	7	4	3
14	Laitdiengsai	151	77	74	5	3	2
15	Laitkyrhong	264	246	18	6	4	2
16	Rangphlang	231	144	87	0	-	-
17	Rasong	368	214	154	1	1	-
18	Laitlum	270	164	106	8	2	6
19	Mawblang	333	151	182	0	-	-
20	Umkhoi	35	18	17	0	-	-
21	Mawlein	247	143	104	2	2	-
22	Mawkynrew	101	73	28	8	6	2
23	Umtong	166	85	81	3	2	1
24	Laitmynsang	103	48	55	0	-	-
25	Mynsang	159	76	83	11	5	6
26	Mawdulop	28	19	9	0	-	-
27	Ksarngi	0	-	-	1	1	-
28	Mawsir	33	20	13	0	-	-
29	Jatah Nonglyer	358	177	181	0	-	-
30	Jatah Lakadong	316	180	136	11	5	6

31	Ladryngngi	0			0		
32	Umsham	89	57	32	0	-	-
33	Lynshing	273	158	115	17	10	7
34	Mynriah	161	86	75	0	-	-
35	Langsiew	25	15	10	0	-	-
36	Umpdem	27	16	11	0	-	-
37	Wahumsim	0			0	-	-
38	Madan Demkhlieng	78	37	41	0	-	-
39	Ryngkya	74	38	36	0	-	-
40	Rangbuli	20	11	9	0	-	-
41	Mawlyngngot	60	48	12	4	3	1
42	Iewrynghep	52	39	13	12	10	2
43	Rngibah	0	-	-	7	4	3
44	Klang	29	15	14	0	-	-
45	Siltham	79	43	36	0	-	-
46	Khwad	79	45	34	0	-	-
47	Nongpyrdi	107	56	51	0	-	-
48	Pashang	95	45	50	0	-	-
49	Umsaw	0	-	-	156	80	76
50	Mawlang	128	68	60	0	-	-
51	Mawjatah	29	24	5	4	1	3
52	Siangkhnai	0	-	-	0	-	-
53	Syngtung	280	172	108	14	4	10
54	Khlieh A Sem	98	52	46	2	1	1
55	Mawsna	215	117	98	1	1	-
56	Mawkhia	217	137	80	4	1	3
57	Khapman	92	45	47	1	1	-
58	Iapdkhoh	105	53	52	1	-	1
59	Thangbnai	153	82	71	1	1	-
60	Mawlat	229	139	90	10	4	6
61	Mawrasai	69	50	19	7	3	4
62	Wahlyngdoh	325	168	157	2	1	1
63	Umblai	0	-	-	30	18	12
64	Wahlakhiat	333	196	137	3	1	2
65	Nongryngkoh	344	215	129	28	13	15
66	Nohron	553	289	264	9	4	5
67	Nonghulew	89	73	16	2	-	2
	Total	9858	5586	4272	559	276	283

APPENDIX 4a

Soil Survey Analysis of sample villages

Name of location	Horizon	Depth (in Cms)	colour		Structure	pH	Description
Kherang Loam	A-3	0-9	Yellowish brown	10YP5/6	Fine silty loam, granular, moist friable, slightly sticky, many roots, clear smooth boundary	5.9	<u>Range in characteristics</u> Depth of the soils ranges from 65 to 90 cm; the colour of the surface horizon varies from yellowish brown to brown in 10 YR hue, value 5, croma 3-6
	B II	9-22	Dark yellowish brown	10MI4/6	Silty loam, weak subangular blocky, moist friable, wet slightly sticky and slightly plastic; common roots, smooth, gradual boundary	5.5	
	B 12	22-38	Dark yellowish brown	10YP4/6	Silty clay; weak subangular blocky moist friable, wet sticky and plastic, few roots, smooth gradual boundary	5.54	<u>Topography</u> Hilly (15 – 30%)
	B 21	38-51	Dark brown	7.5YP4/6	Silty clay, subangular blocky, moist friable, wet sticky and plastic, very few roots, smooth gradual boundary	5.05	<u>Drainage of Permeability</u> Well drained from surface with moderately rapid permeability
	B 22	51-75	Strong brown	7.5YP5/6	Silty clay, subangular blocky; moist friable, wet sticky and plastic; smooth and gradual boundary	5.25	<u>Vegetations</u> Mainly undergrowths with scattered pine trees <u>Present landuse</u> Fallow after bun cultivation

Piengwait Silty loam	A-3	0-10	Strong brown	7.5YR5/6	Silt loam granular, slightly sticky; insect holes present; many roots; clear and smooth boundary	5.65	<u>Range in characteristics</u> Depth of the soils ranges from 70 to 90 cm; the colour of the surface horizon varies from strong brown to dark brown in 7.5 YR hue, value 4- 5, croma 4-6
	B 1	10-30	Brown	7.5YR5/4	Silty loam, fine weak sub-angular blocky; insect holes present , many root; smooth and gradual boundary	5.20	
	B 2	30-47	Dark brown	7.5YP4/4	Silty loam; medioarse sub-angular blocky; i-ct hole present, common roots, smooth and gradual boundary	5.10	<u>Topography</u> Undulating Hilly
	B 3	47-88	Dark yellowish brown	10YR3/4	Silty clay, medium strong sub-angular blocky; sticky; few roots; smooth and gradual boundary	5.10	<u>Drainage of Permeability</u> Well drained from surface with moderate to rapid permeability <u>Vegetations</u> undergrowths and grasses <u>Present landuse</u> bun cultivation
Umjar silt	A 3	0-13	Very dark brown	10YR2/2	Silty loam, granular; friable, slightly sticky; roots many; pores fine common; clear smooth boundary	5.00	<u>Range in characteristics</u> Depth of the soils ranges from 90 to 110 cm; texture ranges from loam to silty clay loam soil, 10 YR hue, value 2-4, croma 2-3. <u>Topography</u>
	B 11	13-25	Very dark brown	10YR2/2	Silty loam, fine weak sub-angular blocky, friable slightly sticky; roots many; smooth and gradual boundary	4.60	

	B 12	25-39	Dark yellowish brown	10YR3/4	Silty clay, medium coarse sub-angular blocky, friable, sticky; roots medium common; smooth and gradual boundary	4.60	Moderately sloping (3-10%) <u>Drainage of Permeability</u> Well drained from surface with moderately rapid permeability <u>Vegetations</u> Mainly undergrowths <u>Present landuse</u> Fallow after bun cultivation
	B 13	39-57	Very dark grayish brown	10YR3/2	Silty clay; medium strong sub-angular blocky, friable and very sticky; roots few fine; thick patchy cutans; smooth and gradual boundary	4.70	
	B 21	57-88	Very dark grayish brown	10YR3/2	Silty clay; medium strong sub-angular blocky; friable and very sticky; very few roots; thick patchy cutans; smooth and gradual boundary	5.05	
	B 22	88-110	Very dark grayish brown	10YR3/2	Silty clay, medium; coarse sub-angular boundary, friable and very sticky, very few fine roots, smooth and gradual boundary	4.95	
Mawkynrew silty loam	A 3	0-11	Dark yellowish brown	10YR 4/4	Silty loam; medium granular structure; many roots; moist friable and wet, slightly sticky; clear and smooth boundary	5.45	<u>Range in characteristics</u> Depth of the soils ranges from 45 to 100 cm. The colour of the surface horizon varies from dark brown to dark yellowish brown with 10 YR hue, value 3-4, cromax 3-6. <u>Topography</u> Undulating to hilly <u>Drainage of Permeability</u>
	B 11	11-20	Yellowish brown	10YR5/6	Silty clay; fine weak sub-angular blocky; moist friable, wet sticky and plastic; common roots; smooth and gradual boundary	5.20	
	B 12	20-84	Yellowish brown	10YR5/6	Silty clay; strong sub-angular blocky; wet sticky and plastic; few roots; smooth and gradual boundary	5.60	

	B 2	84-154	Yellowish brown	10YR5/8	Silty clay; strong sub-angular blocky; wet sticky and plastic, few roots; smooth and gradual boundary	5.15	moderately rapid permeability <u>Vegetations</u> Grass and undergrowth
Tanglein	A 3	0-9	Dark brown	7.5YR4/4	Silty loam, sub-angular blocky structure; moist friable; wet slightly sticky; clear and smooth boundary	5.75	<u>Present landuse</u> To be put under bun cultivation
	B 21	25-43	Reddish brown	2.5YR4/4	Silty clay; medium sub-angular blocky; moist friable and wet roots; sticky and plastic, common fine roots, gradual smooth boundary	5.25	
	B 22	43-64	Reddish brown	2.3YR4/4	Silty clay, moderate medium sub-angular blocky; moist friable, wet sticky and plastic, common fine roots, gradual smooth boundary	5.60	
	B 23	66-99	Red	2.5YR4/6	Silty clay; moderate medium sub-angular blocky, moist friable, wet sticky and plastic; few fine roots; Gradual smooth boundary	5.10	
Deingling silty loam	A 3	0-6	Dark yellowish brown	10YR3/6	Silty loam, granular structure, moist friable, wet slightly sticky; many medium and fine roots, clear, smooth boundary	5.60	<u>Range in characteristics</u> Depth of the soils ranges from 50 to 100 cm; The colour of the surface horizon varies from dark yellowish brown to yellowish brown with 2.5 to 10 YR hue, value 3-5, chroma 3-6.
	B 1	6-13	Dark yellowish brown	10YR3/6	Silty loam, weak sub-angular blocky, moist friable, wet slightly sticky, common, medium and fine root; smooth and gradual boundary	5.70	

	B 21	13-16	Dark brown	7.5YR4/4	Silty clay; sub-angular blocky, moist friable, set sticky and plastic, few fine roots, few cobbles and pebbles present; smooth and gradual boundary	5.5	Hilly <u>Drainage of Permeability</u> Well drained from surface with moderately rapid permeability
	B 22	16-55	Strong brown	7.5YR5/6	Silty clay; sub-angular blocky; moist friable; wet sticky and plastic	5.45	<u>Vegetations</u> Undergrowth and scattered trees <u>Present landuse</u> Fallow after bun cultivation
Umtang silty loam	A 3	0-10	Dark brown	10YR4/3	Silty loam, granular structure; moist friable; wet slightly sticky and slightly plastic; many roots; clear and smooth boundary	5.05	<u>Range in characteristics</u> Depth of the soils ranges from 55 to 100 cm. The colour of the horizon varies from dark brown to brown with 10 YR hue, value 3-5, croma 3-6.
	B 11	1-24	Dark yellowish brown	10YR4/5	Silty loam; weak sub-angular; blocky, moist friable; wet slightly plastic, common roots, smooth gradual boundary	4.95	
	B 12	24-57	Dark yellowish brown	10YR3/6	Silty loam, moderate sub-angular blocky; moist friable; wet sticky and plastic; few fine roots; smooth gradual boundary	5.15	<u>Topography</u> Undulating and hilly <u>Drainage of Permeability</u> Well drained from surface with moderately rapid permeability
	B 21	57-95	Dark yellowish brown	10YR3/6	Silty clay; moderate sub-angular blocky, moist friable; wet sticky and plastic; very few roots, gradual boundary	5.05	<u>Vegetations</u> undergrowths
	B 22	95-120	Yellowish brown	10YR5/6	Silty clay; sub-angular blocky; moist friable; wet sticky and plastic; smooth gradual boundary	5.20	<u>Present landuse</u> Fallow after bun cultivation

APPENDIX 4b

Details of Soil Characteristics in different sample sites.

Sl. No.	Village	Profile No.	Depth in Cms.	Sand in %	Silt in %	Clay in %	Texture	PH	T.S.S	Organic Carbon as Average Nitrogen in %	Average P205 kg/ha	Average K20 kg/ha
1	2	3	4	5	6	7	8	9	10	11	12	13
I	Dienglieng	1	0-6	10	70	20	Silty Loam	5.45	0.043	1.98	0.45	425.9 H
			6-15	10	68	22	-do-	5.45	0.021	2.12	2.69	347.2 H
			15-50	18	59	23	-do-	5.60	0.017	2.04	0.90	173.6 M
			50-76	20	55	25	-do-	5.15	0.047	1.47	4.04	156.8 M
			76+	8	49	43	Silty Clay	5.40	0.011	1.45	0.45	145.6 M
		2	0-6	12	67	21	Silty Loam	5.60	0.039	1.50	0.00	633.3 H
			6-13	15	60	25	-do-	5.70	0.021	0.42	5.38	380.8 H
			13-16	15	58	27	Silty Clay	5.50	0.015	1.05	1.62	302.4 H
			16-55	16	54	30	-do-	5.45	0.008	0.91	1.79	106.4 L
			55-99	45	18	37	Sandy Clay	5.60	0.008	0.91	3.59	67.2 L
		3	0-12	15	64	17	Silty Loam	5.10	0.039	5.76	0.00	207.4 M
			12-34	17	59	20	-do-	5.10	0.020	1.87	0.00	140.0 M
			34-44	20	55	25	-do-	5.20	0.024	1.61	6.73	145.6 M

			44-54	20	54	26	-do-	5.20	0.032	2.60	4.04	128.8 L
			54-110	15	60	25	Silty Loam	5.05	0.024	1.93	1.35	123.2 L
		14	0-11	6	73	21	Silty Loam	5.55	0.015	1.80	1.79	229.8 M
			11-22	8	72	20	-do-	5.30	0.025	2.72	3.59	156.8 M
			22-48	14	62	24	-do-	5.40	0.018	2.55	4.48	156.8 M
			48-84	15	45	40	Silty Clay	5.25	0.014	1.47	0.45	190.4 M
2	Pingwait		0-13	8	72	20	Silty Loam	5.15	0.34	3.66	0.90	134.5 L
			13-27	12	68	20	-do-	5.65	0.027	0.31	6.73	123.2 L
			27-52	15	63	22	-do-	5.30	0.012	1.42	6.73	128.8 L
			52-90	12	61	27	-do-	5.25	0.014	1.47	4.48	123.2 L
		13	0-10	7	72	24	Silty Loam	5.65	0.018	2.52	1.79	174.0 M
			10-30	8	70	27	-do-	5.20	1.024	2.44	4.93	140.0 M
			30-47	6	70	40	-do-	5.10	0.014	1.42	0.45	112.0 L
			47-88	5	65	46	Silty Clay	5.10	0.014	1.20	6.73	151.2 M
3	Umtong	16	0-10	10	70	20	Silty Loam	5.05	0.027	2.40	4.40	134.5 L
			10-24	10	64	26	-do-	4.95	0.023	2.21	7.17	95.2 L
			24-57	10	60	30	-do-	5.15	0.013	1.55	0.00	100.8 L
			57-95	8	52	40	Silty Clay	5.05	0.014	3.09	4.93	134.4 L
			95 +	8	42	50	-do-	5.20	0.009	0.40	1.35	72.8 L
		17	0-10	8	67	25	Silty Loam	5.05	0.014	1.02	5.38	78.4 L
			10-26	5	60	35	Silty Clay	4.95	0.023	2.21	7.17	95.2 L

			26-47	5	50	45	-do-	5.15	0.013	1.55	0.00	100.0 L
4	Umsing	11	0-15	15	65	20	Silty Loam	5.35	0.014	2.22	0.00	128.9 L
			15-28	15	45	40	Silty Clay	5.25	0.014	1.02	5.38	78.4 L
			28-35	10	40	50	-do-	5.30	0.014	1.94	1.35	56.0 L
			35-95	5	43	52	-do-	5.40	0.010	0.40	14.80	50.4 L
5	Mawlein	7	0-10	8	72	20	Silty Loam	5.50	0.040	0.60	2.24	532.4 H
			10-31	10	68	22	-do-	5.40	0.024	3.11	0.92	56.0 L
			31-54	8	68	24	-do-	5.20	0.021	3.06	0.92	56.0 L
			54-82	6	67	27	-do-	5.10	0.043	2.44	2.24	151.2 M
			82-99	8	65	27	-do-	5.30	0.016	1.47	1.35	117.6 L
		8	0-11	6	68	26	Silty Loam	5.50	0.011	1.38	0.00	403.5 H
			11-20	5	67	28	-do-	5.25	0.019	2.58	1.35	224.0 M
			20-45	5	65	30	-do-	5.30	0.017	1.67	1.35	168.0 M
			45-88	5	55	40	Silty Clay	5.30	0.013	1.50	0.45	128.8 L
			88+	5	50	45	-do-	5.75	0.014	0.93	11.21	128.8 L
		9	0-16	8	67	25	Silty Loam	5.30	0.015	1.38	0.00	84.0 L
			16-32	10	64	26	-do-	5.45	0.059	2.55	3.14	386.4 H
			32-40	10	63	27	-do-	5.10	0.014	1.33	0.90	112.0 L
			40-68	8	52	35	Silty Clay	5.30	0.014	1.36	4.04	72.8 L
			68-74	7	45	48	-do-	5.55	0.010	0.74	3.59	50.0 L
		10	0-19	9	65	26	Silty Loam	5.40	0.006	3.06	0.45	39.2 L

			19-44	8	65	27	-do-	5.10	0.013	1.36	4.04	61.6 L
			44-61	7	65	28	-do-	5.20	0.027	3.17	2.69	134.4 L
			61+	7	63	30	-do-	4.90	0.034	1.90	1.35	100.8 L
6		18	0-11	9	4	27	Silty Loam	5.45	0.013	2.64	4.09	95.2 L
			11-20	8	58	34	Silty Clay	5.20	0.010	0.91	0.00	106.4 L
			20-48	8	42	50	-do-	5.60	0.013	0.48	6.73	84.0 L
			48-54	8	40	52	-do-	5.15	0.013	1.07	1.45	56.0 L
7	Kharang	5	0-9	12	65	23	Silty Loam	5.90	0.014	1.22	0.45	241.0 M
			9-22	11	60	29	-do-	5.50	0.014	1.07	1.90	156.8 M
			22-38	10	55	35	Silty Clay	5.45	0.014	3.74	7.62	140.0 M
			38-51	9	50	41	-do-	5.05	0.033	0.91	6.28	128.8 L
			51-75	10	45	45	-do-	5.25	0.012	0.85	1.79	72.8 L
		6	0-9	14	61	25	Silty Loam	5.00	0.044	1.14	0.00	202.0 M
			9-22	12	61	27	-do-	4.90	0.063	0.96	4.93	173.6 M
			22-27	12	58	30	-do-	5.00	0.038	3.06	4.93	134.4 L
			27-46	10	55	35	-do-	5.05	0.021	0.25	5.83	84.4 L
			46-61	10	45	45	Silty Clay	5.40	0.019	0.85	0.45	56.0 L
			61+	10	40	50	-do-	5.70	0.016	0.82	2.69	16.8 L
8	Umjar	18	0-8	52	28	20	Sandy Loam	5.15	0.013	3.60	0.00	61.6 L
			8-28	55	15	30	Sandy Clay	5.10	0.021	2.18	3.14	112.0 L
			28-45	55	5	40	-do-	5.25	0.013	0.91	2.24	56.0 L

		20	0-13	12	58	20	Silty Loam	5.00	0.044	9.58	1.35	196.2 M
			13-25	11	67	22	-do-	4.60	0.057	3.29	6.73	128.8 L
			25-39	9	60	31	Silty Clay	4.60	0.049	3.06	4.04	184.8 M
			39-57	10	55	35	-do-	4.70	0.034	3.00	1.79	100.8 L
			57-88	10	45	45	-do-	5.05	0.031	0.88	0.45	78.4 L
			88-110	9	45	46	-do-	4.95	0.021	1.95	3.38	100.8 L
9	Kotanglei	12	0-7	12	60	28	Silty Clay	5.35	0.028	1.50	1.53	397.9 H
			7-30	11	47	42	-do-	5.20	0.016	0.91	1.79	207.2 M
			30-39	11	45	44	-do-	5.20	0.012	0.96	3.59	112.0 L
			39-90	10	42	48	-do-	5.25	0.016	1.90	4.48	15.6 L
		15	0-9	15	68	17	Silty Loam	5.75	0.020	2.46	5.83	386.7 H
			9-25	12	65	23	-do-	5.30	0.035	1.45	1.79	173.6 M
			25-49	15	50	35	Silty Clay	5.25	0.014	0.91	2.24	184.8 M
			49-64	15	45	40	-do-	5.60	0.029	0.34	7.62	100.8 L
			64-99	14	44	42	-do-	5.10	0.009	0.79	2.24	89.6 L

APPENDIX 6a

Umsong Watershed

Landuse/Landcover

Landuse/Landcover	Area in Km ²	Area in %
Barren Land	0.44	0.79
Builtup	1.72	3.08
Bun Cultivation	3.51	6.29
Dense Forest Cover	7.18	12.87
Fallow Land	2.28	4.09
Grass/Shrubs	19.55	35.05
OpenForest Cover	14.24	25.53
Permanent Cultivation	4.05	7.26
Plantation	0.17	0.30
Sandy/Rocky	1.4	2.51
Water Bodies	1.24	2.22
	55.78	100

Physiography

Physiography	Area in Km ²	Area in %
Central Uplands	33.52	60.09
Southern Steeplands	22.26	39.91
	55.78	100

Relief

Relief in Mts	Excessiveness	Area in Km ²	Area in %
More than 1600	Less excessive	22.69	40.68
1300 – 1600	Moderately less excessive	10.86	19.47
1000 – 1300	Moderately excessive	9.42	16.89
700 – 1000	Excessive	8.02	14.38
400 - 700	Strongly excessive	4.79	8.59
		55.78	100

Average slope

Slope in Degrees	Slope category	Area in Km ²	Area in %
NAME	Slope category	Area in Km ²	Area in %
2-5	Gentle	2.24	4.02
5-10	Moderate	10.67	19.13
10-18	Moderately Steep	5.81	10.42
18-30	Steep	30.91	55.41
30-45	Very Steep	6.15	11.03
		55.78	100

Drainage density

Drainage Density per Km ²	Drainage Category	Area in Km ²	Area in %
Below 1	Low	1.91	3.42
1-2	Moderate	21.19	37.99
2-3	Medium	31.08	55.72
3-4	High	1.6	2.87
		55.78	100.00

Drainage Frequency

Drainage Frequency Km/Km ²	Drainage category	Area in Km ²	Area in %
2 – 4	Moderate	12.45	22.32
4 – 6	Medium	31.07	55.70
Above 6	High	12.26	21.98
		55.78	100

Soil

Mapping unit	Area in Km ²	Area in %
2	3.26	5.84
3,A	4.03	7.22
4	1.35	2.42
5,C	47.14	84.51
	55.78	100

Land Capability Classification

LCC	Area in Km ²	Area in %
II	3.98	7.14
III	5.56	9.97
IV	10.06	18.04
VI	2.62	4.70
VIII	33.56	60.16
	55.78	100

Existing Landuse/Landcover under different land capability class

Landuse/Landcover	II	III	IV	VI	VIII	Total	% to total
Builtup	0.25	0.23	0.57	0.12	0.55	1.72	3.08
Permanent Cultivation	0.44	0.85	0.68	0	2.08	4.05	7.26
Bun Cultivation	0.5	0.74	0.65	0.09	1.53	3.51	6.29
Plantation					0.17	0.17	0.30
Dense Forest Cover	0.17	0.18	0.51	0.06	6.26	7.18	12.87
OpenForest Cover	0.38	0.66	1.27	0.87	11.06	14.24	25.53
Grass/Shrubs	2.09	2.57	6.38	1.32	7.19	19.55	35.05
Fallow Land				0.16	2.12	2.28	4.09
Sandy/Rocky		0.2			1.2	1.40	2.51
Barren Land	0.15	0.13			0.16	0.44	0.79
Water Bodies					1.24	1.24	2.22
Total	3.98	5.56	10.06	2.62	33.56	55.78	100
% to total	7.14	9.97	18.04	4.70	60.16	100	

APPENDIX 6b

Umjar Watershed

Landuse/Landcover

Landuse/Landcover	Area in Km ²	Area in %
Barren Land	0.58	1.02
Builtup	2.47	4.35
Bun Cultivation	2.29	4.04
Dense Forest Cover	11.48	20.23
Fallow Land	1.94	3.42
Grass/Shrubs	12.81	22.58
Open Forest Cover	20.87	36.78
Permanent Cultivation	1.98	3.49
Plantation	0.34	0.60
Sandy/Rocky	0.6	1.06
Water Bodies	1.38	2.43
	56.74	100

Physiography

Physiography	Area in Km ²	Area in %
Central Uplands	18.67	32.90
Southern Steeplands	38.07	67.10
	56.74	100

Relief

Relief in Mts	Excessiveness	Area in Km ²	Area in %
More than 1600	Less excessive	6.1	10.75
1300 - 1600	Moderately less excessive	12.58	22.17
1000 - 1300	Moderately excessive	10.83	19.09
700 - 1000	Excessive	18.7	32.96
400 - 700	Strongly excessive	6.86	12.09
Less than 400	Very strongly excessive	1.67	2.94
		56.74	100

Average slope

Slope in Degrees	Slope category	Area in Km ²	Area in %
5-10	Moderate	6.42	11.31
10-18	Moderately Steep	10.34	18.22
18-30	Steep	39.98	70.46
		56.74	100

Drainage density

Drainage Density per Km ²	Drainage Category	Area in Km ²	Area in %
1-2	Moderate	37.45	66.00
2-3	Medium	17.87	31.49
3-4	High	1.42	2.50
		56.74	100.00

Drainage Frequency

Drainage Frequency Km/Km ²	Drainage category	Area in Km ²	Area in %
Below 2	Low	0.64	1.12
2 – 4	Moderate	16.35	28.82
4 – 6	Medium	23.15	40.80
Above 6	High	16.60	29.26
		56.74	100

Soil

Mapping unit	Area in Km ²	Area in %
2	5.96	10.50
3,A	2.58	4.55
4	19.31	34.03
5,A	7.09	12.50
5,C	21.8	38.42
	56.74	100

Land Capability Classification

LCC	Area in Km ²	Area in %
III	1.26	2.22
IV	8.58	15.12
VI	16.6	29.26
VII	6.33	11.16
VIII	23.97	42.25
	56.74	100

Existing Landuse/Landcover under different land capability class

Landuse/Landcover	III	IV	VI	VII	VIII	Total	% to total
Builtup	0.02	0.1	0.42	0.71	1.22	2.47	4.35
Permanent Cultivation	0.09	0.29	0.3		1.3	1.98	3.49
Bun Cultivation	0.03	0.02	1.73	0.17	0.34	2.29	4.04
Plantation	0	0	0.01	0.08	0.25	0.34	0.60
Dense Forest Cover	0.06	1.16	1.64	1.93	6.69	11.48	20.23
OpenForest Cover	0.87	1.64	7.43	1.82	9.11	20.87	36.78
Grass/Shrubs	0.05	5.37	4.15	1.51	1.73	12.81	22.58
Fallow Land	0	0	0.26	0	1.68	1.94	3.42
Sandy/Rocky	0.02	0	0	0.11	0.47	0.6	1.06
Barren Land	0	0	0	0	0.58	0.58	1.02
Water Bodies	0.12	0	0.66	0	0.6	1.38	2.43
Total	1.26	8.58	16.6	6.33	23.97	56.74	100
% to total	2.22	15.12	29.26	11.16	42.25	100	

APPENDIX 6c

Umsi Watershed

Landuse/Landcover

Landuse/Landcover	Area in Km ²	Area in %
Barren Land	0.92	1.60
Builtup	1.5	2.61
Bun Cultivation	1.43	2.49
Dense Forest Cover	10.45	18.21
Fallow Land	2.41	4.20
Grass/Shrubs	18.51	32.26
OpenForest Cover	18.33	31.94
Permanent Cultivation	1.08	1.88
Plantation	1.03	1.80
Sandy/Rocky	0.87	1.52
Water Bodies	0.85	1.48
	57.38	100

Physiography

Physiography	Area in Km ²	Area in %
Central Uplands	22.54	39.28
Southern Steeplands	34.84	60.72
	57.38	100

Relief

Relief in Mts	Excessiveness	Area in Km ²	Area in %
1300 – 1600	Moderately less excessive	22.55	39.30
1000 – 1300	Moderately excessive	11.11	19.36
700 – 1000	Excessive	11.25	19.61
400 – 700	Strongly excessive	8.67	15.11
Less than 400	Very strongly excessive	3.8	6.62
		57.38	100

Average slope

Slope in Degrees	Slope category	Area in Km ²	Area in %
5-10	Moderate	10.29	17.93
10-18	Moderately Steep	9.08	15.82
18-30	Steep	38.01	66.24
		57.38	100

Drainage density

Drainage Density per Km ²	Drainage Category	Area in Km ²	Area in %
Below 1	Low	3.82	6.66
1-2	Moderate	35.87	62.51
2-3	Medium	16.6	28.93
3-4	High	1.09	1.90
		57.38	100.00

Drainage Frequency

Drainage Frequency Km/Km ²	Drainage category	Area in Km ²	Area in %
Below 2	Low	1.35	2.35
2 – 4	Moderate	21.55	37.56
4 – 6	Medium	17.40	30.32
Above 6	High	17.08	29.77
		57.38	100

Soil

Mapping unit	Area in Km ²	Area in %
1	14.95	26.05
4	8.29	14.45
5,A	32.39	56.45
5,B	1.75	3.05
	57.38	100

Land Capability Classification

LCC	Area in Km ²	Area in %
IV	8.84	15.41
VI	12.71	22.15
VII	24.25	42.26
VIII	11.58	20.18
	57.38	100

Existing Landuse/Landcover under different land capability class

Landuse/Landcover	IV	VI	VII	VIII	Total	% to total
Builtup	0.47	0.26	0.68	0.09	1.50	2.61
Permanent Cultivation	0.77	0.06	0.08	0.17	1.08	1.88
Bun Cultivation	0.03	0.32	0.92	0.16	1.43	2.49
Plantation	0.01	0.07	0.5	0.45	1.03	1.80
Dense Forest Cover	0.63	0.82	6.3	2.7	10.45	18.21
OpenForest Cover	0.76	1.32	10.47	5.78	18.33	31.94
Grass/Shrubs	6.17	9.43	2.56	0.35	18.51	32.26
Fallow Land		0.15	1.14	1.12	2.41	4.20
Sandy/Rocky		0.06	0.43	0.38	0.87	1.52
Barren Land		0.22	0.61	0.09	0.92	1.60
Water Bodies			0.56	0.29	0.85	1.48
Total	8.84	12.71	24.25	11.58	57.38	100
% to total	15.41	22.15	42.26	20.18	100	

APPENDIX 6d

Umngot Watershed

Landuse/Landcover

Landuse/Landcover	Area in Km ²	Area in %
Barren Land	1.33	3.02
Builtup	1.61	3.65
Bun Cultivation	0.46	1.04
Dense Forest Cover	4.45	10.10
Fallow Land	3.41	7.74
Grass/Shrubs	11.76	26.68
Open Forest Cover	16.46	37.34
Permanent Cultivation	1.35	3.06
Plantation	0.96	2.18
Sandy/Rocky	2.29	5.20
	44.08	100

Physiography

Physiography	Area in Km ²	Area in %
Central Uplands	10.18	23.09
Southern Steeplands	33.9	76.91
	44.08	100

Relief

Relief in Mts	Excessiveness	Area in Km ²	Area in %
1300 - 1600	Moderately less excessive	10.18	23.09
1000 - 1300	Moderately excessive	9.15	20.76
700 - 1000	Excessive	8.78	19.92
400 - 700	Strongly excessive	10.97	24.89
Less than 400	Very strongly excessive	5	11.34
		44.08	100

Average slope

Slope in Degrees	Slope category	Area in Km ²	Area in %
5-10	Moderate	1.11	2.52
10-18	Moderately Steep	12.47	28.29
18-30	Steep	29.32	66.52
30-45	Very Steep	1.18	2.68
		44.08	100

Drainage density

Drainage Density per Km ²	Drainage Category	Area in Km ²	Area in %
Below 1	Low	2.41	5.47
1-2	Moderate	32.11	72.84
2-3	Medium	9.56	21.69
		44.08	100.00

Drainage Frequency

Drainage Frequency Km/Km ²	Drainage category	Area in Km ²	Area in %
Below 2	Low	0.45	1.02
2 – 4	Moderate	14.55	33.01
4 – 6	Medium	19.59	44.44
Above 6	High	9.49	21.53
		44.08	100

Soil

Mapping unit	Area in Km ²	Area in %
1	4.72	10.71
4	20.2	45.83
5,A	8.04	18.24
5,B	11.12	25.23
	44.08	100

Land Capability Classification

LCC	Area in Km ²	Area in %
IV	4.62	10.48
VI	9.31	21.12
VIII	30.15	68.40
	44.08	100

Existing Landuse/Landcover under different land capability class

Landuse/Landcover	IV	VI	VIII	Total	% to total
Builtup	0.11	0.58	0.92	1.61	3.65
Permanent Cultivation	0.04	0.12	1.19	1.35	3.06
Bun Cultivation			0.46	0.46	1.04
Plantation		0.73	0.23	0.96	2.18
Dense Forest Cover	0.47	0.59	3.39	4.45	10.10
OpenForest Cover	0.03	0.94	15.49	16.46	37.34
Grass/Shrubs	3.49	5.49	2.78	11.76	26.68
Fallow Land	0.09	0.18	3.14	3.41	7.74
Sandy/Rocky	0.12	0.04	2.13	2.29	5.20
Barren Land	0.27	0.64	0.42	1.33	3.02
Water Bodies					0.00
Total	4.62	9.31	30.15	44.08	100
% to total	10.48	21.12	68.40	100	

APPENDIX 6e

Wahrasin Watershed

Landuse/Landcover

Landuse/Landcover	Area in Km ²	Area in %
Builtup	0.95	3.8
Bun Cultivation	0.12	0.48
Dense Forest Cover	3.47	13.88
Fallow Land	0.5	2
Grass/Shrubs	12.99	51.96
OpenForest Cover	4.25	17
Permanent Cultivation	1.73	6.92
Plantation	0.99	3.96
	25	100

Physiography

Physiography	Area in Km ²	Area in %
Central Uplands	11.44	45.76
Southern Steeplands	13.56	54.24
	25	100

Relief

Relief in Mts	Excessiveness	Area in Km ²	Area in %
1300 - 1600	Moderately less excessive	11.21	44.84
1000 - 1300	Moderately excessive	9.97	39.88
700 - 1000	Excessive	3.82	15.28
		25	100

Average slope

Slope in Degrees	Slope category	Area in Km ²	Area in %
5-10	Moderate	7.72	30.88
10-18	Moderately Steep	11.01	44.04
18-30	Steep	6.27	25.08
		25	100

Drainage density

Drainage Density per Km ²	Drainage Category	Area in Km ²	Area in %
1-2	Moderate	21.21	84.84
2-3	Medium	3.79	15.16
		25	100.00

Drainage Frequency

Drainage Frequency Km/Km ²	Drainage category	Area in Km ²	Area in %
Below 2	Low	2.45	9.80
2 – 4	Moderate	11.43	45.72
4 – 6	Medium	9.05	36.20
Above 6	High	2.07	8.28
		25.00	100

Soil

Mapping unit	Area in Km ²	Area in %
1	5.43	21.72
4	0.55	2.20
5,A	2.58	10.32
5,B	16.44	65.76
	25	100
	360	

Land Capability Classification

LCC	Area in Km ²	Area in %
IV	4.56	18.24
VI	14.79	59.16
VIII	5.65	22.60
	25	100

Existing Landuse/Landcover under different land capability class

Landuse/Landcover	IV	VI	VIII	Total	% to total
Builtup	0.23	0.45	0.27	0.95	3.80
Permanent Cultivation	0.22	0.46	1.05	1.73	6.92
Bun Cultivation		0.12		0.12	0.48
Plantation	0.15	0.8	0.04	0.99	3.96
Dense Forest Cover	0.15	1.97	1.35	3.47	13.88
Open Forest Cover	0.04	2.05	2.16	4.25	17.00
Grass/Shrubs	3.78	8.53	0.68	12.99	51.96
Fallow Land		0.41	0.09	0.5	2.00
Total	4.57	14.79	5.64	25	100
% to total	18.28	59.16	22.56	100	

APPENDIX 6f

Wah Pamksew Watershed

Landuse/Landcover

Landuse/Landcover	Area in Km ²	Area in %
Barren Land	1.02	3.28
Builtup	2.68	8.62
Bun Cultivation	1.45	4.66
Dense Forest Cover	5.17	16.63
Grass/Shrubs	11.95	38.44
OpenForest Cover	6.12	19.68
Permanent Cultivation	1.63	5.24
Plantation	0.78	2.51
Sandy/Rocky	0.29	0.93
	31.09	100

Physiography

Physiography	Area in Km ²	Area in %
Southern Steeplands	11.22	36.09
Central Uplands	19.87	63.91
	31.09	100

Relief

Relief in Mts	Excessiveness	Area in Km ²	Area in %
1300 - 1600	Moderately less excessive	19.86	63.88
1000 - 1300	Moderately excessive	11.23	36.12
		31.09	100

Average slope

Slope in Degrees	Slope category	Area in Km ²	Area in %
18-30	Steep	10.41	33.48
10-18	Moderately Steep	13.49	43.39
5-10	Moderate	7.19	23.13
		31.09	100

Drainage density

Drainage Density per Km ²	Drainage Category	Area in Km ²	Area in %
1-2	Moderate	28.2	90.70
Below 1	Low	2.89	9.30
		31.09	100.00

Drainage Frequency

Drainage Frequency Km/Km ²	Drainage category	Area in Km ²	Area in %
Below 2	Low	4.76	15.31
2 – 4	Moderate	24.11	77.55
4 – 6	Medium	2.22	7.15
		31.09	100

Soil

Mapping unit	Area in Km ²	Area in %
1	6.79	21.84
5,A	0.17	0.55
5,B	24.13	77.61
	31.09	100

Land Capability Classification

LCC	Area in Km ²	Area in %
IV	4.66	14.99
VI	12.71	40.88
VII	4.88	15.70
VIII	8.84	28.43
	31.09	100

Existing Landuse/Landcover under different land capability class

Landuse/Landcover	IV	VI	VII	VIII	Total	% to total
Builtup	0.29	0.96	0.76	0.67	2.68	8.62
Permanent Cultivation	0.05	0.27	0.36	0.95	1.63	5.24
Bun Cultivation	0.24	0.34	0.54	0.33	1.45	4.66
Plantation	0.03	0.28	0.09	0.38	0.78	2.51
Dense Forest Cover	0.67	1.24	1.08	2.18	5.17	16.63
OpenForest Cover	0.59	2.13	0.61	2.79	6.12	19.68
Grass/Shrubs	2.62	6.75	1.33	1.25	11.95	38.44
Sandy/Rocky				0.29	0.29	0.93
Fallow Land					0.00	0.00
Barren Land	0.17	0.74	0.11		1.02	3.28
Total	4.66	12.71	4.88	8.84	31.09	100
% to total	14.99	40.88	15.70	28.43	100	

APPENDIX 6g

Umtangphar Watershed

Landuse/Landcover

Landuse/Landcover	Area in Km ²	Area in %
Barren Land	0.08	0.17
Builtup	2.83	6.10
Bun Cultivation	2.56	5.52
Dense Forest Cover	6.31	13.61
Fallow Land	0.12	0.26
Grass/Shrubs	19.78	42.67
OpenForest Cover	10.55	22.76
Permanent Cultivation	2.99	6.45
Plantation	0.16	0.35
Water Bodies	0.98	2.11
	46.36	100

Physiography

Physiography	Area in Km ²	Area in %
Southern Steeplands	13.73	29.62
Central Uplands	32.63	70.38
	46.36	100

Relief

Relief in Mts	Excessiveness	Area in Km ²	Area in %
More than 1600	Less excessive	0.59	1.27
1300 – 1600	Moderately less excessive	32.64	70.41
1000 – 1300	Moderately excessive	13.13	28.32
		46.36	100

Average slope

Slope in Degrees	Slope category	Area in Km ²	Area in %
10-18	Moderately Steep	20.63	44.50
18-30	Steep	11.60	25.02
5-10	Moderate	14.13	30.48
		46.36	100

Drainage density

Drainage Density per Km ²	Drainage Category	Area in Km ²	Area in %
Below 1	Low	2.25	4.85
1-2	Moderate	40.49	87.34
2-3	Medium	3.62	7.81
		46.36	100.00

Drainage Frequency

Drainage Frequency Km/Km ²	Drainage category	Area in Km ²	Area in %
Below 2	Low	4.15	8.95
2 – 4	Moderate	26.25	56.62
4 – 6	Medium	12.90	27.83
Above 6	High	3.06	6.60
		46.36	100

Soil

Mapping unit	Area in Km ²	Area in %
1	7.97	17.19
3,A	8.47	18.27
5,A	2.69	5.80
5,B	27.21	58.69
5,C	0.02	0.04
	46.36	100

Land Capability Classification

LCC	Area in Km ²	Area in %
II	0.28	0.60
III	2.64	5.69
IV	15.83	34.15
VI	9.52	20.53
VII	16.97	36.60
VIII	1.12	2.42
	46.36	100

Existing Landuse/Landcover under different land capability class

Landuse/Landcover	II	III	IV	VI	VII	VIII	Total	% to total
Builtup	0.04	0.14	1.11	0.41	1.13		2.83	6.10
Permanent Cultivation		0.26	1.37	0.13	1.04	0.19	2.99	6.45
Bun Cultivation	0.03	0	1.23	0.31	0.87	0.12	2.56	5.52
Plantation			0.01		0.15		0.16	0.35
Dense Forest Cover		0.15	1.44	0.75	3.62	0.35	6.31	13.61
OpenForest Cover	0.01	0.3	2.2	1.54	6.07	0.43	10.55	22.76
Grass/Shrubs	0.2	1.79	8	6.26	3.52	0.01	19.78	42.67
Fallow Land				0.12			0.12	0.26
Barren Land			0.08				0.08	0.17
Water Bodies			0.39		0.57	0.02	0.98	2.11
Total	0.28	2.64	15.83	9.52	16.97	1.12	46.36	100
% to total	0.60	5.69	34.15	20.53	36.60	2.42	100	

APPENDIX 6h

Umlew Watershed

Table-3.2.I. Landuse/Landcover

Landuse/Landcover	Area in Km ²	Area in %
Barren Land	1.26	2.89
Builtup	3.32	7.62
Bun Cultivation	3.27	7.51
Dense Forest Cover	6.07	13.93
Fallow Land	0.79	1.81
Grass/Shrubs	16.24	37.27
OpenForest Cover	7.4	16.98
Permanent Cultivation	4.55	10.44
Plantation	0.63	1.45
Sandy/Rocky	0.04	0.09
	43.57	100

Physiography

Physiography	Area in Km ²	Area in %
Central Uplands	33.1	75.97
Southern Steeplands	10.47	24.03
	43.57	100

Relief

Relief in Mts	Excessiveness	Area in Km ²	Area in %
More than 1600	Less excessive	20.36	46.73
1300 – 1600	Moderately less excessive	14.41	33.07
1000 – 1300	Moderately excessive	8.8	20.20
		43.57	100

Average slope

Slope in Degrees	Slope category	Area in Km ²	Area in %
2-5	Gentle	2.93	6.72
5-10	Moderate	15.89	36.47
10-18	Moderately Steep	16.74	38.42
18-30	Steep	8.01	18.38
		43.57	100

Drainage density

Drainage Density per Km ²	Drainage Category	Area in Km ²	Area in %
Below 1	Low	3.31	7.60
1-2	Moderate	31.8	72.99
2-3	Medium	8.46	19.42
		43.57	100.00

Drainage Frequency

Drainage Frequency Km/Km ²	Drainage category	Area in Km ²	Area in %
Below 2	Low	1.00	2.30
2 – 4	Moderate	20.91	47.99
4 – 6	Medium	20.84	47.83
Above 6	High	0.82	1.88
		43.57	100

Soil

Mapping unit	Area in Km ²	Area in %
3,A	15.09	34.63
5,B	24.6	56.46
5,C	3.88	8.91
	43.57	100

Table-3.2.VIII. Land Capability Classification

LCC	Area in Km ²	Area in %
II	1.62	3.72
III	7.25	16.64
IV	18.67	42.85
VII	8.3	19.05
VIII	7.73	17.74
	43.57	100

Existing Landuse/Landcover under different land capability class

Landuse/Landcover	II	III	IV	VII	VIII	Total	% to total
Builtup	0.39	0.5	1.12	0.81	0.5	3.32	7.62
Permanent Cultivation	0.22	1.38	2.37	0.38	0.2	4.55	10.44
Bun Cultivation	0.02	0.43	0.86	0.86	1.1	3.27	7.51
Plantation				0.31	0.32	0.63	1.45
Dense Forest Cover		0.33	1.8	2.11	1.83	6.07	13.93
Open Forest Cover		0.71	2.99	1.83	1.87	7.40	16.98
Grass/Shrubs	0.99	3.53	7.83	2	1.89	16.24	37.27
Fallow Land		0	0.79			0.79	1.81
Sandy/Rocky		0.04				0.04	0.09
Barren Land		0.33	0.92		0.01	1.26	2.89
Water Bodies						0.00	0.00
Total	1.62	7.25	18.68	8.3	7.72	43.57	100
% to total	3.72	16.64	42.87	19.05	17.72	100	