Chapter 1

INTRODUCTION

The Science of Geomorphology as the study of landforms, has aroused much interest amongst scientists, scholars and laymen alike since time immemorial. This is so because the understanding of this branch of knowledge leads us to straight thinking in terms of the interactions and relations of man and the landforms around him. Landforms like mountains, for example, are the storehouses of minerals and at the surface the landforms nurture living organisms like vegetation and animals, including man and provide a platform for all kinds of human activities.

Geomorphology, as the science of landforms, stems from the Greek terms, Geo, meaning ‘Earth’, Morphe, meaning ‘form’ and Logos meaning ‘discourse’; literally it means, ‘a discussion on earth forms’. The study of geomorphology is based on the principle that all landforms can be related to a particular geologic process and that the landforms thus developed may evolve with time through a sequence of forms dependent in part on the relative time a particular process has been operating.

As landforms are the most widespread geologic phenomenon, speculation as to their origin has gone on since the days of ancient philosophers. A discussion on the development of scientific ideas began
with the Greek and Roman Philosophers. We could in fact very well omit
discussion of their ideas as to the development of landforms, for what
little they had learned was largely forgotten during the Dark Age and had
to be relearned, but it will help us to get a more complete picture of the
evolution of geomorphic ideas and thought if we want to consider the
views of Herodotus, Aristotle, Strabo and Seneca.

During the many centuries that followed the decline of the Roman
Empire, there was little or no scientific thinking in Europe. Such
knowledge as survived was largely in monasteries but it was not natural
science. Some survival of learning persisted in Arabia and we find certain
ideas expressed there that have a modern flavour.

Abicenna (980-1037) held views upon the origin of mountains who
divided them into two classes, those produced by "uplifting of the ground
such as taking place in earthquakes" and those, "which result from the
effects of running water and wind hallowing out valleys in soft rocks". Thus, the concept of mountains and its forms resulting from differential
erosion was expressed.

With the coming of Renaissance, the occasional and increasing
alliance of philosophy and technology fostered afresh the urge to know
why and how things happened and landforms were largely explained in
terms of the prevailing philosophy of Castrophism. By his unsurpassed
and versatile genius, Leonardo de Vinci (1452-1519) firmly established
the pattern of combining philosophy and technology. He recognized that
landscapes are sculptured and worn away by erosion; that the fossil shells
found in the limestones of the Appenines are the remains of various
organisms.

The development of geomorphology on modern lines is said to
have its beginnings in the work of James Hutton (1726-1797) and he is
considered to be the originator of modern geomorphic ideas who laid
down the groundwork of the long and slow development of geologic
thinking by propagating the philosophy of Uniformitarianism into modern
g geomorphic thought. In 1785, he presented a Paper before the Royal
Society of Edinburgh, in which he propounded the “Theory of the Earth”.
This theory is better known as the “Doctrine of Uniformitarianism”.
Thus, the ‘science of geomorphology’ was born in Edinburgh in March
1785. This theory is based on the hypothesis that the “present is the key
to the past.”

After Hutton, the development of geomorphology took place in
different directions in Europe and America. In the wake of new ideas and
principles, the concept of ice age, marine erosion and, later, river erosion
came into existence. Thus, it can be safely stated that geomorphology had
established itself as a branch of geology by the end of the 19th century in
Europe, though the word geomorphology had not come into vogue and instead the word "Physiography" was commonly used.

In Europe, the French scholar, Buffon (1771-1788) stated that rivers were a powerful agent of erosion and their capacity to erode was so great that they could destroy land surface. Targioni Tozetti of Italy (1712-1784) also recognized the erosive power of streams. He was the first to suggest the concept of differential erosion.

Another French scholar, Dasmarest (1725-1845) has shown with reference to specific examples that the valleys through which the rivers of Central Europe flow have been in fact carved by them. He was the first to understand the evolution of landscape in successive gradual stages.

The area of study of De Saussure of Switzerland (1740-1799) was the Alps. He laid great stress on the power of streams to erode the mountains and put forward the view that the river valleys in the Alpine mountains are the creation of the rivers that flow through them.

Another contemporary of James Hutton also deserve mention. He was the founder of modern Russian geomorphology and geology. He was the first to suggest that the landscapes are the result of interactions between internal and external forces and that these processes are universal in nature.
In North America, the maximum development of geomorphology took place between 1875 and 1900. This is known as the Heroic Age in American geomorphology, as it was during this period that the most important geomorphological theories were propounded. The names of J.W. Powell (1834-1902), G.K. Gilbert (1843-1918) and C.E. Dutton (1841-1912), are particularly noteworthy as these were the people who showed the way and it was basically on the foundation of concepts formulated by them that later on, W.M. Davis built his ‘Theory of Geomorphic Cycle’.

If Hutton is considered as the founder of geomorphology, then W.M. Davis is undoubtedly the father of American geomorphology. The impact of W.M. Davis on geomorphology was greater than any one man. Based on the works of his predecessors, Davis synthesized many geomorphic ideas and moulded them into a unified system for the study of landforms. W.M. Davis recognised that the origin and evolution of topography was dependent upon geologic structure, geomorphic processes and stages of development. The concept was based on the work of running water, which, according to Davis was the process of normal erosion. This concept, therefore, provides the framework for interpretative geomorphology and, thus, its understanding is imperative to the students of geomorphology.
During the last 30 years or so there has been a considerable progress in all branches of sciences. On a modest scale, the part time science of geomorphology, has achieved a great deal during this time and the geographers, geologists, hydrologists and specialists from other fields who all contributed to the study of geomorphology have become aware of the comparative suddenness of change within the context of landform studies. This suddenness of change was affected by the recognition of anthropogenic presence in nature where man is identified as the most potent and powerful agent of destruction.

The impact of man's activities became more and more pronounced leading to environmental degradation by anthropogenic acts such as establishing a squatter settlement on a steep hillslope, construction of dams, road, railways, industries, etc. Therefore, the application of geomorphic knowledge in ameliorating damages from natural and man made hazards and in the management of the environment has been incorporated and integrated leading to the emergence of a sub-field of geomorphology, known today as Applied Geomorphology.

In applied geomorphology landforms are studied in relation to human and economic aspects such as population, settlements' and environment. A mere qualitative description of the landforms is no longer sufficient to fulfill the requirements of applied geomorphology.
Applied geomorphology has diverse applications over a large area of human activity. According to Verstappen (1968) applications of geomorphology can be grouped into the following:

(i) Application in the fields of earth sciences, thematic mapping and resource studies.

(ii) Application in the field of environmental studies in the survey of natural hazards, landslides, avalanches, earthquakes, land subsidence, floods and droughts.

(iii) Application in the field of rural development and planning emphasizing landuse, erosion control, conservation and river basin development.

(iv) Application in engineering including assessment for communication network, river and coastal engineering.

(v) Application in the field of urbanization for urban extension, site selection or mining.

It is in the light of the above ideas that Shillong and its environs was chosen for making a detailed study in the field of urban geomorphology. The importance of this study lies in highlighting the significance of geomorphological studies related to the problems of urbanization.
Statement of the Problem

Man's impact on the landscape is manifold. One of the direct impacts of man in the environment is the establishment of a settlement. The inexorable trend towards very large, extremely complex urban places is a result of forces whose origin lies in the political, economic and social systems of our society. Of particular significance that promote or sustain urban growth two forces emerge, these are (i) population growth and (ii) the expansion of public investment. The linkage between the two is demand and development.

The resulting effects of these two factors are demand for and pressure on land. Impacts on land result also from changing use of land as it is converted from natural areas to agriculture and to sub-urban, urban, commercial, industrial uses. These can be termed as direct impacts. Indirect impacts result from the promotion of growth, development and urbanization.

The significance of these impacts, direct and indirect, has been stated explicitly by Robert H. Twiss (1974), “Environmental impacts are seldom important solely in terms of their direct physical effects. That is, if a road is built into a new area, the soil erosion and visual scars are important but not as important as the ‘bombaret’ effect at the end of the road that generates new housing followed eventually by the need for
many other services. Most of the people involved recognize that the question is not whether we should treat indirect effects, but rather, given that indirect effects are the most important of the two, how we compute and weigh them”.

With mounting concern over the impacts on natural environment, particularly from urbanization, it has become apparent that an objective analytical strategy is necessary to assess the subtle but far reaching impacts of geomorphological forms and processes, because such a strategy could profit from interdisciplinary modelling experiences and findings. It is in the light of this context that the city of Shillong has been selected as an area for study.

The evolution of Shillong from small and scattered hamlets into a big city of today started in 1863 where the British acquired lands on lease for the purpose of creating civil station and sanatorium. In 1874, it was made the capital of Assam, with some interruptions, till 1972. And from 1972 till today it has become the capital of Meghalaya. Through the formative years, Shillong, steadily grew and expanded in size. Its geographical area is 174 sq. kms. according to the Shillong Master Plan 1991-2011. Its population in 1881 was a mere 3,737 persons and today over a hundred years later, its population soared to over two lakhs (2001 Census).
As it grows it is also beset with problems of space, resulting in the mushrooming growth of unplanned settlements plus a host of other problems like sanitation, water supply, narrow roads, traffic jams, etc. This unprecedented growth of population with limited urban facilities and amenities has led to a tremendous pressure on land. As such, this is another point which needs attention for remedial measures in proper planning and management of the land with due emphasis on geomorphic characteristics.

Because of the complexity and urgency of urban problems, an urban geomorphological approach can be adopted to provide a comprehensive and interdisciplinary approach model to aid in studying the complicated nature of our cities.

An urban geomorphological approach can be adopted as geomorphology, being the science of landforms, falls within the broad framework of geography which is concerned with the interaction between man and environment.

**Review of Literature**

Many articles, papers, news, tourist pamphlets and books have been written on the evolution, history and scenic beauty of Shillong but no relevant literature existed or been written on urban geomorphology
though scanty literature on geology, climate, vegetation and its people are available.

However, some geomorphic studies of Meghalaya existed and have been undertaken by R.P. Singh (1968), R.K. Rai (1985), P.C. Panda (1985), G.C. Panda (1987), M. Agarwal (1993), H.J. Syiemlieh (1997), L. Cajee (2002). So far no work has been undertaken on urban geomorphology in any part of the state.

Elsewhere, in other parts of the world, studies on urban geomorphology have gained ground. Notable studies on this line worth mentioning are "Geomorphology and Urban Development in the Manchester Area" by Ian Douglas (1990). This work underlined the impact of geomorphology on river dynamics, urban growth, glacial deposits, subsidence, sewer collapse and ground conditions.

Then another notable work, *Aspects of Urban Geomorphology - Ground Movements in Parts of Salford and Bury* by C. Harrison and J.R. Petch (1990), traced and explained the history of ground movements and landslips. It was a pioneering work in so far as ground movements affect urban growth and development.

There are also other works worth mentioning such as "Urban Geomorphology in Dry Lands", undertaken by R.G. Cooke, D. Brunsden, J.C. Doornkamp and D.K.C. Jones (1985). This study was undertaken as
a consequence of serious soil erosion, landslides and widespread flooding where hundreds of people were killed and thousands of homes were ruined. The dominant environmental processes responsible for this crisis are geomorphological problems, problems relating to the nature of the land surface and the forces that act upon it.

In India, the study of Urban Geomorphology first appeared in 1988. The study was, “Mussoorie and Its Environs” undertaken by H. Prasad (1988). This study underlined the impact of geomorphology in identifying areas for establishment of new settlements.

Other works related to geomorphology and urban and environmental problems brought about by urbanization processes have been undertaken by various other workers such as, “Geomorphology and Engineering”, by D.R. Coates (1985). This study emphasized the need for geomorphological mapping and morphological mapping to aid in roads and building construction.

Then there are other works on water supply to urban areas such as Water Resources Distribution, Use and Management by John R. Mather and Perspectives on Water edited by David H. Speidel.

Environmental pollution arising out of urbanization have been well documented in a study, Environmental Chemistry by A.K. De.
Besides the above works, other works appearing in some journals have been read and consulted in order to give a better picture and clearer understanding on the relevance of geomorphology in urban studies. Such works worth mentioning are “Morphological Aspects of Kundaaktivanka River Basin” by T.S. Rao (1996) appearing in the *Indian Journal of Landscape Systems and Ecological Studies*. Then another paper “Paradigm Shifts in Geomorphology: Trends and Implications” by K.R. Dikshit (1999) which discussed about a sequence of paradigm shifts in geomorphology from uniformitarianism of the late 18th century to one of dynamic geomorphology of the last century.

**Study Area**

Shillong, the capital of the State of Meghalaya, adopted as an area of study is located at 25°34’ North latitude and 91°53’ East longitude and a height of 1496 metres above mean sea level (Fig. 1.1). Originally, during the British Raj, Shillong covered only the Shillong Cantonment and Shillong Municipality. When the British took the lands on lease from the Nongkhlaw clan, the Kurkalang clan, the Sohtun clan and Kharkongor clan, boundaries, with numbered pillars were erected and this gives us an idea of the size of Shillong then.
The name “Shillong” is derived from “U SHULONG” meaning “One who exists by himself”. The name is used in reference to God who, as believed, has His abode on the highest mountaintop of Meghalaya, named U LUM SHYLLONG. The original name “Shulong” got corrupted into “Shillong” to suit the British way of spelling and pronunciation.

The evolution of Shillong from small and scattered hamlets into a big city of today owes its origin to the British Administration of Assam. Today, Shillong is a growing city, as it grows it is beset with problems of space resulting in the mushrooming growth of unplanned settlements plus a host of other problems like sanitation, water supply, narrow roads, traffic jams, etc. However, the jovial and jolly character of its citizens offsets all these. Its reputation as a centre of learning, as a health resort and centre of social and intellectual interactions spread far and wide. Many world famous dignitaries and celebrities have visited and lived here, like Pope John Paul II who visited Shillong in 1986, Verrier Elwin, the anthropologist who lived and died here, E.P. Gee the naturalist, C.V. Raman the Nobel Laureate Physicist, Rabindranath Tagore, the Nobel Laureate Poet. Even the modern science of Seismology owes its origin to the thorough studies of the Shillong earthquake, 1897, by famous geologists such as R.D. Oldham.
The demarcation or delineation of the study area, in regard to urban areas has always been a problem. In the case of Shillong, the problem is further compounded by the absence of official notification of its limits and extent. The Census of India in 1971 has declared Shillong as an Urban Agglomerate comprising of Shillong Municipality, Shillong Cantonment, Nongthymmai, Madanrting, Mawlai and Pynthorumkhrah. But again the expansion of Shillong in terms of size, as it is today, is credited to its inhabitants who construct houses and settlements with the consent and permission of the local traditional durbars, which in most cases the Government, has no say on the matter, except by extending infrastructure like roads, electricity, telephone lines and postal services. The hitherto villages surrounding the Shillong Urban agglomeration has, of now, attained urban character such as Mawshbuit, Laitkor, Mawpat, Mawlynrei, Umlyngka, Mawiong and Upper Shillong.

Such random expansion in unplanned and haphazard manner is rather confusing when demarcation of the study area is warranted. As a practice in geomorphological studies, the watershed or drainage basin of an area is always considered and treated as one geomorphic unit where many environmental and cultural factors come into play, which in most cases are related and interdependent. This is one problem where there is no conformity between the geomorphic and cultural set up of an area.
Gulick (1958) analyzed the problems of urbanization as “Urbanization in and of itself, as a pattern of life, increases the dependence of our culture on the natural resources”.

Besides, Shillong being located on a high seismic zone where earth tremors like the Shillong earthquake of 1897 destroyed it, a clear and rationale approach can be pursued by understanding the geomorphology, and the forces that play, on which it is located so that urban expansion can be carried on with disaster management in mind.

Objectives of the Study

From the discussion as appeared in the study area, it is apparent that Shillong is dynamic as far as the spread of urban sprawl is concerned which is going on without interruption even at this moment. Such dynamism produce impacts, these impacts are (i) modification of the environment; (ii) influence of the physical environment on urban form, functions and growth and (iii) continuous feedback in the city from man, culture and physical environment. Keeping the above points in mind, the main objectives of the study are:

(i) Analysis of geomorphic characteristics.

(ii) Identification and delineations of geomorphic provinces, geomorphic characteristics and their distributions.
(iii) Identification and delineations of morphometric parameters like slopes, tilt, relief, etc.

(iv) Delineations of settlements and their patterns.

(v) Identification of roads and water supply, their impact on landuse and problems.

(vi) Determination of gravity flow of drainage and identification of sewage disposal problems and their impacts on the environments.

Data

The data for this study has been generated primarily by extensive fieldwork and secondary sources. Primary data are acquired by fieldwork (the researcher is a professional surveyor and cartographer), where data of slope, rock types and rock exposures, forest cover, soils and landuse are derived and collected in the spots where these occur.

Secondary data were collected from various sources to supplement the requirements of the study for a better and clearer understanding of the complexities and realities of physical and cultural parameters. The main secondary data, however, that has been used as base for mapping the relief, drainage and landuse was the use of toposheets of the Survey of India on scales varying between 1:63360, 1:50,000, 1:10560, 1:10000 and 1:5000.
These toposheets are also used to compare changes of the physical and cultural parameters that determined the evolutionary history and growth of Shillong into its present form.

Methodology

The methodology adopted is the standard methodology adopted by geomorphologists. The parameters worked out include (i) the linear aspects like stream order, stream number, stream length and bifurcation ratio and length ratio; (ii) the areal aspects which include basin area, basin length, form factor, circularity ratio, elongation ratio, drainage density and stream frequency; (iii) the relief aspects such as basin relief, relief ratio and ruggedness number.

The significance of morphometric characteristics in various sub-basins and for the whole basin has been highlighted. Collection of data relating to vegetation cover, landuse and extent of urbanization and types of environmental degradation have been undertaken to obtain a clear understanding of the impact of urbanization on landforms and environment.

All the quantitative descriptions given above have been converted into maps in order to display and highlight the spatial distributions as found in the ground.
In view of the above, it is apparent that the study in all its entirety and completion can be grouped into three phases, namely, (i) Pre-field work; (ii) Field work and (iii) Post-field work.

(i) Pre-field Work Phase: This is the first stage. It includes the collection of relevant literature and involves the thorough study of meteorological data, geological and topographical maps so as to evolve a strategy for the research work. In this stage morphometric data were extracted and were used to prepare, relief, drainage and slope maps. Diagrams such as long profiles, superimposed profiles, area-height curves, etc. have been prepared to help visualizing the nature of landscape.

(ii) Field Work Phase: As the term implies, fieldwork means hands on and visual contact with the phenomena under study. On reaching the study site, identification of rock types, soil characteristics, slope characteristics, landuse and vegetation cover etc. were noted, measured and mapped and photographed.

Pinpointing or benchmark location of rock types, slopes vegetation cover, types of landuse expansion of urban sprawl has been done in the field by using surveying instruments and available toposheets. By the method of insertion and deletion, a standard method adopted by the Survey of India, for updating of topographical maps by ground
verification has been used as the investigator is himself a professional surveyor.

The field work stage is also gratifying in the sense that the parameters under study have been captured by means of photographs and are attached along with this study.

(iii) Post-Field Work Phase: This phase included the final preparation of maps, diagrams, interpretation and presentation of the findings. This phase is comprised of the following activities:

(a) The morphometric data extracted from toposheets have been used for statistical analysis such as correlation and regression analysis, significance test, scale ratios, linear and non linear equations to arrive at fairly accurate results in landscape analysis.

(b) Using the morphometric data and field data and other informations, a descriptive account of geology, landform, soil, vegetation, landuse and extent of urbanization has been undertaken.

(c) All the above data are then analyzed and cartographic representations have been done.

Plan of Work

The entire study is divided into seven chapters with appropriate headings as given below:
Chapter-I deals with an introduction to geomorphology and its relevance to the study of urban areas in terms of applications of geomorphological knowledge and techniques. In this chapter the following have been included, these are:

(a) Statement of the problem
(b) Study area
(c) Objectives of the Study
(d) Survey and Review of Literature
(e) Data base and Methodology.

Chapter-II, deals with the physical aspects such as geology, topography, drainage systems, climate and vegetation. The topographical features like undulating landscape, isolated flat lands and slopes and toponyms as appeared in the landscape have been discussed. Toponyms mostly of Khasi origin when interpreted sometimes give us explanations on the nature of landscape.

Drainage systems complete with stream ordering and patterns as well as their sources have been discussed. Stream ordering also known as *Kt Kyrdan Wah* in Khasi, assigned as first, second, third, fourth and fifth order streams exist. However, instead of grading the streams into different orders, the Khasi concept of stream ordering appear in the form of terminologies of Khasi fluvial morphology and hydronyms.
Interpretation of the meaning of these terminologies and hydronyms give us the characteristics of the streams.

The geological set up has been discussed in the light of rock exposures at different localities of Shillong. The rocks seen in around Shillong are the Khasi green stones seen at Mawlong and Umkhen river valley. The quartzites are seen exposed at many localities, particularly at Laitkor, Umkhen, Demthring, Noh Kaliar and Shyiap. The sandstones are seen as overlayers of quartzites at many localities. Conglomerates are found at two locations, one at Lawsohtun the other at Elephant’s Falls in Upper Shillong. Granites are seen south of Shillong Peak. All the above rocks in geological literature are known as ‘Shillong Group of Rocks’.

Fossilized remains of plants are found in a layer of sandstone south of Shillong Peak. Ripples marked rocks are found at Mawblei. Both the fossilized remains of plants and the ripples marked rocks have been found by the investigator himself in the course of his fieldwork. A petrified wood is also found by the investigator near the N.E.H.U. Campus Nongthymmai.

Soils in terms of characteristics and thickness have been discussed. Climatic factors like rainfall, wind, and temperature have been discussed and shown in tables and diagrams. Vegetations that are still seen in and
around Shillong have been discussed. The important species along with Botanical names and Vernacular names are also given.

Chapter-III deals with the morphology of Shillong urban environment in terms of linear, areal and relief aspects.

Chapter-IV deals with geo-environmental problems brought about by urbanisation in terms of deforestation, water supply, topographical constraints and environment degradation.

Chapter-V deals with the growth and increase of population at different decades. In this respect census data for many years were collected and tabulated so that the rate of urbanization can be determined.

Chapter-VI deals with emerging geo-environmental issues and suggestions for remedial measures to mitigate the current geo-environmental issues prevailing as a result of the absence of a master plan for overall development of Shillong.

Chapter-VII deals with an overview of the entire study where general summary and conclusions are presented.
REFERENCES


Coates, D.R. *Geomorphology and Engineering*.


