CHAPTER VIII

SUMMARY AND CONCLUSION

8.1 SUMMARY

The focal theme of investigation in the present work is the landform dynamics in Greater Guwahati area and its environment. The attempts adhered to the investigation as per theme partly lies on the quantitative techniques and partly on the GIS environment in addition to some most traditional techniques. The required geomorphic as well as non geomorphic parameters have been extracted from maps, satellite images, various publications and government sources. Intensive field work has been done specially in selected spots and areas to add micro scale data and information to the work and to gain more meaningful analysis. Emphasis has been given towards the quantitative analysis throughout the work.

The whole work is divided into three units and subdivided into eight chapters as summarized below.

The first chapter dealing with the introduction of the problem follows to state the problem, significance of the study, research questions, database and methodology, limitation of the work, review of the relevant works and terms and terminology used in this work.

The second chapter concerns with the introduction of the study area. Here, the chapter is segmented into location and situation, general geomorphological background, physical background along with the population background of the area. The Greater Guwahati is found to be located in such a place which is emerging as the hub not only of Assam but also of entire North-East India as a whole in terms of

political administration, education, commerce and many more. It is bounded by the Shillong plateau in the south, Brahamaputra plain in the north and west and Buragosain hill in the east. It is diverse in character, tectonically unrest and geomorphically very dynamic. Chronologically this urban centre came in contact with the Ahom kings, Koch kings, Mughal emperors, followed by British administration in the first half of the nineteen century when the urban area began to grow as modern town. According to 2001 census this urban agglomeration hard a population of 8, 09, 895 persons on a geographical area of 240 km^2.

Geomorphologically the study area may be divided into (i) floodplain (ii) young alluvial plain (iii) valley fills by deposits (iv) pediments (v) inselbergs and (vi) denudational hills. Physiographically the plain area of Greater Guwahati lies 54.17 meter above MSL (mean sea level). The highest elevation of 426m exists in the eastern part of Greater Guwahati at the Buragosain parbat. On the other hand, large number of beels and low-lying areas exist within the city. The Deepar Beel in the south western part of Greater Guwahati forms the major one.

The plain areas of the Greater Guwahati are divided into three parts on the basis of their location and characteristics, viz. (i) the Beltola plain in the east which extends for 15km from in the east to south west with an average width of about 4 km. (ii) the Guwahati plain in the central part and (iii) the Jalukbari- Azara plain in the west.

Further, the contour map shows the plains of comparatively high elevation and hills in the eastern part as compared to that in the western part of the study area.

The mighty Brahamaputra that uses to flow through the study area acts as the controlling agent of the most of the drainages as well as hydro-geomorphology. The Bharalu, a main tributary of the Brahamaputra within Greater Guwahati traverses a

length of 15.125km in the central part. There are a number of small streams and nallas which drain the study area. Some of these flow throughout the year and some seasonally during the rainy seasons.

The Greater Guwahati area falls within the monsoon type of climate of middle Brahamaputra valley. But micro variation of physiographic characteristics still has their influence on minor variability of rainfall and climate of the area. Here, summer is fairly hot and humid but the winter is slightly cold and foggy with moderately cool spring. The winter is not very long which lasts normally for the months of December to January. Monsoon rain starts from June and lasts up to September. Rain accompanied by thunderstorm starts from the second half of April and continues up to May. Temperature starts rising during this period. The direction of the prevailing wind in Guwahati is from north- east to south-west during the winter and in the summer it is in the reversed direction.

The soils of the Greater Guwahati area are having a great similarity with that in the rest of Assam. But there are some micro regional variations in the soil in Greater Guwahati of soil due to diversity of rock types and micro physiographic setting. Alluvial soils, red soil, sandy soil, lateritic soil etc are some of the soil found in the area. However, soils of the majority of Greater Guwahati are yet to be distinguished and demarcated.

The land use pattern in Greater Guwahati is controlled by the natural physiographic features as well as by the growing pressure of population in the area. The old human settlements established in the plains of the Guwahati city were confined along east- west direction between the river Brahamaputra in the north and the railway line in the south. But the rapid increase of population in the city used to extend its settlement in different directions. Recently, the gentle to medium sloped hills and the

marshy, swampy and low-lying areas as well are also encroached and used for settlement.

In 1865, the Guwahati municipal area had a population of about 7000 which increased to 8,236 in 1891. Since 1921, the decennial growth of population had registered steady trend even at the advent of more economic activities and expansion of the town limit. During 1951- 1961 the urban area had increased from 7.77 km^2 (in 1921) to 14.29 km^2. The decennial growth of population then recorded 130.899 percent which is the highest decennial growth rate in Guwahati. According to 1991 census the population of Greater Guwahati was 5, 84342 spread over 34 wards and it increased to 8, 14, 575 in 2001 within its newly demarcating 60 wards.

The third chapter is devoted to analysis of geological and topographical bases of the study area. Geological analysis is done mainly through the secondary data collected from different agencies as well as through external limited field survey. Topographic analysis is carried out applying quantitative methods such as relative relief, average slope, profile drawing, dissection index and multiple correlation study on dissection index, relative relief, average slope, drainage density and drainage frequency. In addition to that slope analysis, 3D modeling etc are done applying GIS environment. For this purpose topographical maps prepared by Survey of India and the satellite imagery (FCC of Land Sat ETM +, 2002) are used.

Geologically, the Greater Guwahati area lies on the pre-cambrian rocks foundation of the Meghalaya plateau akin to the rocks basement of the Deccan peninsula. Here, hills and hillocks are of archaen and pre-cambrian rocks; plain are formed of quaternary sediments of Pleistocene epoch to sediments of recent age. The pre-cambrian rocks act as the parent material for soil formation in Greater Guwahati. The low-lying, plain and the valley areas over the pre-cambrian rocks basement have

been the result of continued deposition of the eroded material coming down from the surrounding hills. There quaternary alluvial deposits ranging from Pleistocene epoch to recent age consist of angular fragments of rocks gravels, pebbles, silt and clay. The geological evolution of Greater Guwahati had started in pre-cambrian era and continued to recent age. Structurally a number of faults and lineaments in hard rocks and alluvial terraces are exist here.

Geologically, the surface of Greater Guwahati is having the existence of archaen rocks groups to recent alluvial deposits. The alluvial plain shuts between the hills and hillocks having thickness ranging from a few centimeters to about 140 meter. The lithological structures of different areas in Greater Guwahati render minor variations in respect of composition and depth as given in table: 3.2.

The topographic characteristics of the Greater Guwahati are the outcome of the northward extension of the Meghalaya plateau mostly in the form of hills and inselbergs. The highest elevation (426 m) above the mean sea level lies in the middle of the eastern part where Buragosain parbat in located. The flatness of the area is much broken in its southern part in the neighborhood of the Meghalaya plateau. The hill and hill ranges of Greater Guwahati are aligned in north- east to south- west direction. These hills have been denuded by streams, torrents and rains. As a result strips of plain land are located by the sides of these hills.

Topographic profiles drawn to analyse the topographic charactristies of the study area are aligned in N-S and W-E directions. The profiles are drawn on the basis of contour maps having contour interval of 20 meter. They are verified in the field. An analysis of different profiles drawn for 16 hills and hillocks in Greater Guwahati reveals that the hills are having quite different relief characteristic marked by differential relief amplitudes and slope conditions.

Relative relief of the study area is analysed by applying Smith's method. It is found that 27.34 percent of the study area lies under less than 10meters of relative relief and 2.22 percent area lies above 200meter. The Wentworth's method of average slope determination (1930) is found to fit well with the topographic nature of Greater Guwahati. The average slope ranging from 1^0 to 10^0 occupies 70.85 percent of the study area. The average slope of more than 20^0 covers an area equivalent to 3.178 percent of Greater Guwahati's total area. High slopes marked at 10^0 to more than 20^0 lies in the central part running from west to east and also in the southern and eastern hill margin. Further GIS techniques have been applied for the determination of slope and it is found that 57.78 percent of the study area is having less than 8.685 degree of slope and 22.846 percent area is having more than 57.120 degree of slope. Dissection index is used as a way for morphometric analysis of erosional landform and probable processes of characteristic landform. The dissection value found in the study area ranges 0.25 to 0.859. It is seen that about 70 percent of the total area of Greater Guwahati contain dissection value below 0.6. The areas under moderate to high dissection indices are found mainly in the central north east, south-east hilly part and in the Basistha area. The Greater Guwahati area is divided into five micro relief areas in order to analyse to explain small scale irregularities and heterogeneous topographic characteristics. A multiple correlation study on dissection index, relative relief, average slope, drainage density and drainage frequency is carried out. Here, dissection index and relative relief reveals the strongest correlation of 0.86.

The fourth chapter concerns with the geodynamic factors like earthquake, faulting and lineaments, etc. as related to development of landform and environment in Greater Guwahati. This chapter directed mainly towards the exploration and analysis of the nature, characteristics, magnitude and risk of geotectonic forces and the

earthquakes in the Greater Guwahati area. Faults and lineaments that exist here are also considered for topographic and environmental studies. Geotectonically North East India including the Greater Guwahati area lies on the frontal zone of the Indian plate and it is moving at a rate of 5 cm per year towards north.

An earthquake is considered as an agent of landform and environment modification. The study area lies on the seismic zone-v (the most vulnerable seismic zone). During 1548 to 1988 as many as 25 major earthquakes had occurred in North East India, majority of which are felt in the Greater Guwahati area. It is found that the study area is surrounded by major faults of the region which are considered as seismically vulnerable. In the northern part there lies the Main Central Thrust (MCT) and the Main Boundary Thrust (MBT). In the southern and eastern sides there exist the Dauki fault and the Kopili fault respectively whereas the western side is bounded by Hajo fault. Being a geotectonically unstable, the region had suffered from many remarkable seismic events during the historical past. All these earthquakes have been associated with remarkable changes of land, damage of life and properties as well as environment as a whole.

The fifth chapter is devoted to topographic dynamics, which includes soil dynamics and its characteristics such as distribution and variation of soil, soil quality and capability; etc. Topographic processes such as weathering and debris formation, slope failure are also discussed here. Hydrologic processes covered by stream net and their dynamic nature, water and sediment flows and pattern of water infiltration; and nature of underground water are also having berths in this chapter.

Soils are varied in the Greater Guwahati. This is because of their formation, development and distribution in response to geology, topography, micro-climate as soil forming factors and also to the soil dynamics related to consistency, strength, crusting,

etc. the Greater Guwahati area at present covers 18.37 percent of total area under dissected hills and hillocks composed of pre-cambrian rocks generally containing medium to high growth of grasses, bushes, trees, etc. They allow water to percolate down giving a congenial situation to chemical and biotic weathering on the skin of the Greater Guwahati area. This weathered debris gets transported by small streams, run-off, rainfall gravity, etc. The dumping of transported soil and weathered debris elsewhere get converted into soil. The soil of the Greater Guwahati area have been classified into eleven types having the characteristic extent, texture, thickness PH values etc. as started in table 5.1 and fig 2.6. As the surface of the study area ranges from to unconsolidated granite rocks to clay, porosity ranges from 1% to 45%.

The geomorphic processes that are operating in the study area are broadly akin to that of other areas in the humid and sub-humid regions. Here, the processes of weathering and incidence of landslide, mass wasting, slope failure etc. are intensified during the monsoon months of stormy rainfall.

Hydrologic processes have a great role in framing the fluvio- geomorphic processes in the Greater Guwahati area where the surface and ground water are the main agent of hydraulic processes. The surface waters in Greater Guwahati have been drained by (i) the Bharalu, (ii) the Basistha, (iii) the Bahini, (iv) the Khana jan and also by some small streams. But the spatial pattern of stream frequency (below 3) in the study area shows low natural drainage coverage in 65.33 percent of the area. Only 1 percent of the total area has stream frequency of more than 11 no km^2. Regarding the drainage density it is found that 74.87 percent of the study area is having extremely low drainage density marked by less than 0.570 and only 10.8 percent area is covered with a drainage density of more than 2.85.

It is found that in almost every rainy season, the water of the Brahamaputra gets spilled over the Bank causing floods in low lying areas of the Greater Guwahati area. It is also observed that the present depth and width of the Bharalu are not large enough to carry total discharge coming from its entire catchment, especially at the time of heavy downpour. During the high flood times the Bharalu carries discharges differently in different sections as stated in table 5.5 (b).

Out of the total area of 240 km^2, a share of 91 km^2 is covered by hard rocks and rest by soft rocks. And it is known that infiltration rate is more dependent on surface slope and type of sediments. Ground water movement and storage are found dependent on infiltration rates, size and shape of grain, aquifer thickness and their areal extent, etc.

The Greater Guwahati area is having a large volume of ground water spread over both vertically and horizontally. It is found at a depth range of 5 to 15 meters during pre-monsoon and 0.02 meter to 5.35 meters during post- monsoon periods. The general trend of ground water flow line is observed to trend towards the Brahamaputra. The thickness of the aquifer in the Greater Guwahati area is found as stated in table - 5.10.

The sixth chapter deals with the anthropogenic dynamics of landform development. This chapter is discusses the nature of human habitation, nature of human dynamics and landform development. In case of the nature of human habitation in the Greater Guwahati area it is found that the topographic characteristics of the hills and plains, availability of habitable land and potable water, economic opportunities derived from resource mobilization and utilization, transport and communication act as the main factors for the development of settlement. Different activities such as related to business, industry, education, etc did help in the expansion of this urban centre. Further

the shifting of the state capital from Shillong to Dispur causes accelerated increase of its area as well as activities. Thus unused and vacant lands have decreased from 43.09% in 1957-58 to 32.77% of the total area in 2001. The field observation as stated in table-6.3 and fig-6.4 to 6.8 it reveals that some of the hill slopes have rendered highly increasing pressure of population, human habitation and their diverse activities. Regarding the nature of human dynamism in the Greater Guwahati area it is found that at times human habitation was mainly concentrated in the built up areas of the city. Of late, specially during the last 20 years human habitation has spread like anything in the areas of Guwahati. As a result there has been hill cutting and low lying area filling. These characteristics of human dynamism have greatly influenced in changing the environmental condition in the Greater Guwahati area.

As regards landscape development in the Greater Guwahati area, it is found that the inhabitation and exercising for various kinds of productive works by man have changed the scene of landform into cultural landscape. Further, these activities have influenced to render soil erosion, landslide, flood, waterlogging etc. The study thus helps to visualize that about 30% of the hilly areas of Greater Guwahati are now under human settlement and the encroachment by man is seen even up to 70^0 slopes in the Greater Guwahati area.

It is also observed that large areas of beels that are located in the study area are depleting at a faster rate and presently only 5% (11.72 sq km) of the study area is under wetlands. The pattern of hill dynamics arising out of the influence of man can be explained taking into consideration of different stages as stated figs 6.10 to 6.13. Thus large scale change of landform and environment had taken place to make the present posture of Greater Guwahati.

The seventh chapter concerns with the impact of geodynamic and human dynamics on development and development of landscape and environment. In the Greater Guwahati area it is seen that the geomorphic and human dynamics have been transforming the natural landscape in an integrated manner since past few decades. The processes have gone more and more accelerated because of impact of human activities as observed in different areas of Greater Guwahati. Some selected geomorphic indicators such as slope relative relief, drainage density, drainage frequency and dissection index of all the 16 major hills when analysed by considering composite score values indicate the areal variation in the status of hill vulnerability and dynamics. Land fractures and faults causing lowland in many areas of Greater Guwahati have given the situation for waterlogging and degradation of land and environment. These areas have also been under highly vulnerable to earthquakes. It is also found that, many of the landslide incidences are due to anthropogenic activities.

All the hills situated in and around Guwahati are influenced by either minor or major landslide incidences, most of them being slump type followed by debris slide and rock fall. These geodynamic incidences have been transforming slowly the morphometric characteristics of the topography as well as the environment of different parts of Greater Guwahati.

The recent trend of using more and more ground water has obviously depleted ground water and aquifer in the study area. It is seen that extensive plain areas of Greater Guwahati below 60meter contour level are badly affected by man-induced phenomena. On the other hand, the hill slopes have also lost sound environment.

The unplanned growth of roads, building and private as well as government enterprises in Greater Guwahati has largely disturbed both the natural and human

ecosystem. The activities also disturbed the natural system of drainage order and arrangement.

It is also seen that large areas of past water reservoirs have been decreasing because of either private or Government encroachment. At the same time hill slopes of high magnitude as well as altitude and the low lying areas are transformed into human settlement areas. Expansions of human habitations away from the former core centers are also observed in fig- 7.7 and 7.8. The majority of the areas between the Fatasil-Sonaighulli-Narakasur-Japorigog hill alignment and the Meghalaya plateau have been used for the purpose of mainly growing rice. But recently large areas are either lying vacant with boundary walls or new human settlements. Recently garbage quarries and small factory pollution have been slowly degrading the whole environment of Greater Guwahati.

Finally, the chapter eighth presents summary and conclusion with general suggestions.

8.2 CONCLUSION

The study reveals that the problem under study bears a great significance with the geomorphic situation, environmental condition and anthropogenic characteristics of the Greater Guwahati area. The landform dynamics in the study area is found to be active due to geo-tectonic unrest and active geomorphic processes. The accelerated anthropogenic disturbances during the last 2 to 3 decades have also at the present juncture of time intensified the dynamic processes of landform modification and development in the Greater Guwahati area. The causes, intensity and areal variability of landform dynamics and development visualized in the study may be the effective base for the analysis of accelerated change of landforms creating landform as well as geo-environment problems in the area.

The study reveals that the study area is lithologically akin to the Deccan plateau of India, characterised by gneiss and schist-composed hills and hillocks along will small alluvial plains marked by streams, marshes, swamps and built-up tracts. It has been observed from the study that the lithological formations below characteristic landform relief and slope have been influencing the genesis and change of fluvio-geomorphic environment in the Greater Guwahati area. They have been substantially analysed throughout the chapters II to V.

The human interferences in the hills, plains and low-lying areas and the with uncared uses of the hill and lowland resources by the fast growing urban population of Greater Guwahati resulting in accelerated change of the face of the hills, streams and lowlands have taken berths in the study. These are established through the analysis incorporated in chapters VI and VII Here the second research question takes a berth to establish the fact.

One of the important finding of the study is that the lack of proper management of hills and lowlands morphometry and their resources has caused many problems such as inefficient flow of water through natural as well as artificial drainages. Such an ill or inadequate management has also caused waterlogging, etc in the Greater Guwahati area. Chapters VI and VII have revealed these problems and the third research question has thus been found to be valid with the analysis made in chapter II.

The continuous depletion of ground water levels due to high degree of extraction of ground water to fulfill the need of growing population has its far-reaching impact on the change / modification of the geomorphic and environmental scenario of Greater Guwahati. The analysis incorporated in chapter V has not only substantiated the reality of ground water depletion and also the change of waterlogged areas but also

it proves the validity of the 4th research question. The study furthermore helps in visualizing some of the significant developments as indicated below:

i) The profile drawn on 16 hills and hillocks in Greater Guwahati reveal that the hills are having quite different relief characteristics marked by different relief amplitudes and slope conditions as stated in chapter-III.

ii) In spite of large number of hills and hillocks 70.849 percent of Guwahati's total area is having less than 10^0 of average slope as stated in table-3.4(a).

iii) The study has also revealed a positive relation among the geomorphic indicators of relative relief, average slope, dissection, drainage density and drainage frequency which help in visualizing the reality of topographic complexities as shown in table-3.6.

iv) The study area is surrounded by major as well as minor faults which can show the area as seismically active leading to the occurrences of large numbers of earthquakes of varying magnitudes that might have been accelerating the dynamism of landform development and production of changing geo-environmental situation in Greater Guwahati. Such a pattern of development is rightly stated in chapters IV and VII.

v) The study area has been characterised by a very low stream frequency as well as low drainage density. It is found that 65.33 percent of the total area goes to stream frequency of below 3, while 81.109 percent of the total area is having drainage density less than 2 in as indicated in chapter V.

vi) The study also shows that the vacant land, hillslopes and low-lying swampy areas are drastically encroached by the dwellers of Greater Guwahati to pursue their activities and settlements. Such an encroachment has rendered high degree of degradation of natural landscape as well as the geo-environment

of Greater Guwahati. Presently the human settlements, it is observed, have gone up to more than 60^0 of hill slope. Large areas of marshy and swampy tracts have also now been used for human habitation and activities. It is analysed in chapters VI and VII.

vii) The study also finds that unplanned construction of roads, buildings etc. coupled with storm rains, disturbance in drainage network, etc have been responsible for waterlogging problems in Greater Guwahati. It is observed throughout the work there is good reflection of differences in rocks, soil, relief, etc which ultimately have yielded strong influences on the genesis and change of landforms and environment. All this reflection clearly validates the content of the first research question.

8.3 SUGGESTIONS

Throughout the study lots of problems and the causes thereof at various levels of dynamism have been identified on the arena landforms and geo-environment of Greater Guwahati. As the problems are many and complex in nature complete solutions of all these fragmented problems are not an easier task. However, the long term planning and strategies formulated for proper management of landform, landuse, etc. through the mutual co-operation between authorities and city dwellers can help the rightful production of geo-environment and sustainability of land, water, air, human society in the area. The following programmers may, however, be adopted for the purpose.

1. No further hill cutting and low land aggression should be allowed.
2. the existing natural drainage network should be properly trained and managed for keeping their carrying capacity.

3. As regards hill degradation and occurrences of landslides, more detailed studies can be conducted.
4. Expansion of urban zone is important to reduce pressure of population on hills, lowlands, swamps, marshes and other places of water reservoirs.
5. As the ground water has its relation with geomorphology and environment, suggestions can be forwarded as regards its detailed studies. The use of ground water may be reducing by searching for more use of surface water derived from the Brahmaputra.
6. Moreover, an integrated study of various aspects of landform, human habitat and geo-environment may lead to understand, evaluate and manage the complex pattern of geo- environment and the problems associated to it.

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