Humans are an integral part of any ecosystem but human activity is a more pervasive force than is the case with other organisms. Maintenance of a quality environment requires action to be perceived in the light of their effects on the internal dynamic and regulating mechanisms of those ecosystems. Human divert energy, water and other materials from the natural system in order to create unstable artificial environments distinguished by high energy inputs and turnover rates and in most cases lowered species diversity and low stability. In brief many of human system or cultural landscapes are typical of simple early developmental stages of succession.

Humans have greatly modified their physical environment by large-scale removal of plant cover via filling, logging (Plate 6.1), burning, land drainage, earth moving and resource extraction. In many cases the devegetated land is then covered with concrete or other rock-like materials, resulting in greatly increased heat-holding capacity and reduced porosity. Such practices can increase ambient heat energy and surface water run off rate, conditions already aggravated by devegetation
and fossil fuel combustion respectively. Other often-mentioned impacts include lowering of ground water levels, reduction in exposed water surfaces like marshes, wetlands, ponds, etc. and weather and climate modification where lower humidity, reduced radiation and increased frequency of rainfall are observed.

But the most talked about impacts are those resulting from the practice of dumping into the air and water organic and inorganic, natural synthetic, bio-degradable and non-biodegradable substances which often disrupt or accelerate many of the processes so vital to ecosystem functions.

Clearly the ultimate source of impacts on the environment is the growth in the number of people and growth in the amount of resources required by each person. This growth of population even in a small city like Shillong as it is seen today has brought forth a vast array of goods and services, an ever-expanding spatial distribution of people as well as a host of urban problems.

The inexorable trend towards Shillong urban expansion is a result of forces whose origin lies in the political, social and economic system of our society. Of particular significance that promote or sustain urban growth two forces emerge. These are (i) population growth and (ii)
expansion of public investments. The linkage between the two are demand and development.

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

The significance of the 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 on the landscape are important, but not as important as the ‘receiving end’ effect that generates new housing followed eventually by the need for many other services. Most of the people involved recognise that the question is not whether we should treat indirect effects but rather given that indirect impacts are the most important of the two, how we compute and weigh them”.

With mounting concern over the impacts on natural environment, particularly from urbanisation it is necessary to demonstrate here an
urban geomorphological approach, developed during the course of this study, so that impacts and geo-environmental issues can be assessed.

**FIG. 6.1: INTERACTION MODEL OF URBANISATION PROCESSES**

In the above illustration the fundamental component of the urban geomorphological approach is the process of urbanisation. This approach focuses on the reciprocal nature of population growth, public investments and urbanisation as well as the impact urbanisation has on the environment – in this case geomorphic forms and processes.

From the above diagram it can be inferred that

(i) population growth enhances urbanisation (A) and at the same time urbanisation may influence population growth (a);

(ii) as population grows and increases (B), capital formation grows and more people migrate to urban areas (c). Population growth then places demand on government machinery for
provision of roads, electricity, water supply, etc. this is known as public investments;

(iii) the continuing process of urbanisation through population creates a demand for facilities while the facilities enables the urban area to accommodate more people. This results from the interaction of population growth and urbanisation that has direct and indirect impacts on the environment;

(iv) the facilities created through public investments have direct and indirect impacts (D) on the environment, in this case geomorphic variables like land forms, topography, drainage, climate, etc.

(v) urbanisation induced by population growth and expanded provision of facilities produces secondary impacts (E). These impacts are the focus of this study. Similarly, geomorphic variables determine the extent of urbanisation (e).

(vi) a missing link (F) between urbanisation through public investment and geomorphic variables requires the interaction between engineers, planners, geomorphologists and others.

In so far as geo-environmental issues are concerned. Berry et al. (1974) reviewed the relation between environmental quality and the type
and density of population in which he noted changes in environmental quality that accompany planned and unplanned development.

In this respect an urban area with its built up suburbs can be regarded as an ecosystem – a functional ecosystem, importing food, water, fuel, raw materials etc. and on the other hand, exporting, sewage, combustion products and solid and liquid wastes.

Wolman (1967) has already described the changes in a three-stage time square following urbanisation of a basin. According to him these are:

**Stage 1: Pre-urban Conditions** – During this stage natural vegetation, stream channels and other natural system are found to be well adjusted to ambient conditions.

**Stage 2: Construction and Development Activities** – This stage is a brief period where due to developmental works, vegetation and soil structure are disturbed and destroyed.

**Stage 3: New Urban Landscapes** – The original site or area existed in Stage 1 has been replaced by built up areas like buildings, roads, parking lots, etc.

From the above description of changes by Wolman it is clear that any perturbation to any part of the environment will have repercussions throughout the environment. Life on earth depends on flow of energy and
the cycling of materials through the ecosystem. The abundance of organisms and the complexity of their relationships are all controlled by these factors. Disturbances, whether large or small, affecting these relationships by man's interference may disturb the functions of the environment as a whole.

Again, according to Wolman, the effects of urbanisation is heightened when:

(i) Urbanised drainage basin is small in area.

(ii) A significant portion of the basin is urbanised.

(iii) The basin has some relief.

(iv) The sediments brought to stream channels is coarse and large in amount.

(v) The rain frequently falls with high intensity.

Applying the above characteristics to the study area, it is seen that:

(i) The Shillong Urban Agglomeration is located in two small basins, the Umkhrah basin and Umshyrpi basins. Covering an area of 25,494 sq. km. and 22,903 sq. kms. respectively.

(ii) The relative height is 300 metres ranging from 1300 metres to 1600 metres above mean sea level with undulating topography, flatlands and steep slopes.
(iii) Rainfall is intense during rainy season and sediments in the stream channels are coarse and large in amount.

The manifestation of urbanisation leads to the emergence of some well known geo-environmental problems which is summarised as follows:

a) Large areas are covered by impervious areas that intercept precipitation and increase run off.

b) Concrete drainage systems increase run off.

c) Large number of septic tanks pollutes shallow aquifers.

d) Wastes disposal pollutes streams.

e) Urbanisation encroaches on stream banks.

f) Accelerated erosion and sediment production from construction, quarrying and deforested sites.

g) Increased slope failure.

h) Flooding and changes in the stream channels.

The emergent geo-environmental concerns arising out of urbanisation as underlined above that are also seen in the study area, can be categorised into the following:

**Quarrying:** The increasing quarrying activities for economic exploitation of rocks and sands in the vicinity of Shillong has resulted into extensive degradation of significantly landforms relics of parts of the
Shillong plateau and this process is continuously shrinking the green cover of Shillong. It is estimated that on the average about 1000 workers per day are engaged in quarrying activities in the twenty existing quarries of Shillong (Plate 6.2). With regard to the socio-economic benefits, quarrying has proved to be potential source of employment. But the conventional method of quarrying adversely affects the health of workers.

Some of the impacts of quarrying on the environment is air pollution, water pollution and disturbance of flora and fauna (Plate 6.3). Air pollution occurs in the form of dust particles during blasting, loading and unloading. Water pollution occurs in the form of water stagnation, addition of dust particles and innumerable pollutants (Plate 6.4). The other types of pollution arising out of quarrying in the study area are solid waste disposal land degradation and soil erosion.

**Landslides:** The encroachment of urbanisation process on hill slopes affect slope processes and mass movement of rock wastes. Construction of roads, buildings, laying out of water pipelines, laying of electric high tension power lines, construction of sewers etc. on higher hill slopes decrease the resisting force of slope materials. Since such construction activities are not properly planned, slope failures and landslides occur (Plate 6.5). Landslides in Shillong, of late, have become a recurring phenomenon where, sometimes, several lives are lost in areas
like Mawblei, Jaiaw, Laitumkhrah and Nongrimmaw. These landslides occur due to combined anthropogenic and intense rainfall and we frequently see during the rainy season. It is also observed in several parts of the study area even areas with slopes in the category of 5°-20° are severely affected by landslides but fortunately such landslides occur mostly in the uninhabited parts of the study area (Plate 6.6).

However, the magnitude of the occurrence of landslides when compared to other urban areas like Mussoorie is much less, most landslides in Shillong are of localised nature and small in extent. 

**Mudflow:** Of late, the occurrence of mudflow is noticed in areas in the average slope category of 15°-20°, particularly in the Riat Laban, Upper Shillong and Laitkor reserved forests. This phenomenon also occurs only during the rainy season and affects the valley sides of the parallel streams.

**Soil Erosion:** Soil erosion in the study area can be attributed mostly to anthropogenic processes. Human activities in the study area affecting and accelerating soil erosion is preceded by deforestation where large tracts of wooded landscape are cleared and felled for timber logging resulting in a land use changes (Table 6.1).
Rai (1995) has highlighted the effects of damages due to deforestation in the Barapani area on the outskirts of Shillong Urban Agglomeration. According to Rai, this area as a whole is extremely susceptible to large-scale soil erosion.

Table 6.1
Landuse Changes in the Study Area (1910-11 and 1966-67)

<table>
<thead>
<tr>
<th>Landuse</th>
<th>1910-11 Area (sq km)</th>
<th>1966-67 Area (sq km)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Forest</td>
<td>38.5 – 26.9</td>
<td>35.5 – 24.8</td>
</tr>
<tr>
<td>Agriculture</td>
<td>11.3 – 7.9</td>
<td>-</td>
</tr>
<tr>
<td>Shillong Township</td>
<td>4.3 – 3.0</td>
<td>9.9 – 6.9</td>
</tr>
<tr>
<td>Completely deforested</td>
<td>11.0 – 7.7</td>
<td>-</td>
</tr>
<tr>
<td>Lake</td>
<td>-</td>
<td>10.0 – 7.0</td>
</tr>
</tbody>
</table>


Another aspect of geo-environmental concern is the waste disposal aspect. Rapid urbanisation has resulted in creating numerous waste dumps in and around the study area often in close proximity to human habitations and thus posing a grave threat to public health (Plate 6.7). These wastes dumping sites automatically become the breeding sites of various disease vectors like flies, mosquitoes and rats which in turn can transmit diseases such as typhoid, cholera etc. On the average, the present population of Shillong Urban Agglomeration generate around 210 tons of waste per day.
Another aspect of waste is the domestic sewage comprising of human body wastes (faeces and urine). The residential houses in Shillong generally use septic tanks and ordinary pit latrines. Besides, the tendency today is to construct houses along stream banks and the city dwellers discharge their domestic sewage directly into such water bodies. All these contribute to unsanitary and severe pollution of streams in and around Shillong.

But by far the utmost geo-environmental issues prevalent in Shillong today are:

a) Accelerated soil erosion.

b) Permanent loss of water sources.

c) Loss of nature aquatic life.

**Geo-Environmental Issues**

1. Accelerated Soil Erosion: Slow removal of soil is part of the natural geological process of denudation and is both inevitable and universal. On the other hand accelerated soil erosion refers to the increased rate of erosion covered by various landuses effected by man. Erosion and sedimentation under natural conditions are part of any denudation system and do not cause any significant problem except some catastrophic events but accelerated erosion caused by human activities
results into several environmental problems which adversely affect plant and animal life.

In the long history of agriculture in the study area little change has taken place in traditional methods of agriculture. Most of the systems are followed without soil and water conservation measures and consequently there is a heavy soil loss in the study area.

One the traditional methods of agriculture are the *Bun* method of cultivation that is prevalent in the study area (Plate 6.8). Table 6.2 gives an idea of soil erosion in the study area.

<table>
<thead>
<tr>
<th>Landuse</th>
<th>Soil Erosion (tonnes/ha./year)</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Forest</td>
<td>0.04 to 0.5</td>
<td>Low erosion</td>
</tr>
<tr>
<td><em>Bun</em> method of cultivation</td>
<td>40.0 to 50.0</td>
<td>Soil erosion as high as 5.1 to 170.2 tonnes/ha./year</td>
</tr>
</tbody>
</table>


Unscientific agricultural methods and deforestation are the main factors of soil erosion in the study area.

**Loss of Water Sources**

Shillong was once famous for its springs, waterfalls, sparkling streams and its fresh water systems. Today all its water systems have
been polluted into such magnitude that the Government of Meghalaya has banned people from using its streams for washing and bathing. However, the most serious is the loss of water sources. The loss of water sources is primarily due:

(i) Deforestation which then led to the growth of settlements (Plate 6.9).

(ii) Quarrying at the water source sites (Plate 6.10).

(iii) Construction of houses right over the water sources (Plate 6.11).

(iv) Seepage of human coliform from graveyard sites.

It is an accepted fact that vegetation cover helps infiltration of rainwater and that water can be retained more quantitatively for longer periods in the geological strata. Depletion of vegetation cover ultimately leads to loss of water sources such as springs. Some of the streams in the study area whose sources have been affected in the manner prescribed above are Umshyrpi and Umkhrah. Similarly, other water sources in the other basins have also been affected in much the same way. Most of the water sources have a flow of water only during the monsoons, whereas during the months of February, March and April are all dried up.

Quarrying of sandstones and quartzites also is another form of anthropogenic act leading to loss of water sources. Demolishing water
source of Umkhrah at Nongthymmai (Plate 6.12) have been destroyed by quarrying of quartzites and the changed landscape in the quarry sites have been replaced by settlements.

In areas like Madanrting where the topography is steep, the forested land is being consistently encroached by settlement. The water supply to Madanrting from one of the water sources located upslope is affected by the existence of five graveyards just about 100 metres upslope from the water source. During monsoons the rainwater seeps into the graveyard pits then percolates down to the water sources bringing with it a number of human coliform bacteria and pathogenic organisms that arise from the decomposition of human corpses in the pits.

Another geo-environmental issue of grave concern is the loss of aquatic life in all the streams in the study area particularly Umkhrah and Umshyrpi basins. Organic pollution of urban freshwater bodies result chiefly from the entry of untreated sewage, domestic wastes and effluents. As a consequence there is increased bio-chemical oxidation, depletion of dissolved oxygen and increase in nutrient loads. These in turn, result in 'Fish-kills' and leads to the elimination of a variety of fishes and bring changes in biotic composition such as profuse growth of slimy sewage fungus, blue-green algae and undesirable insects like flies and gnats.
The consumers of such polluted water face a high risk of suffering from various water borne diseases like hepatitis, typhoid fever, dysentery etc.

**Remedial Measures**

Thus geo-environmental problems and issues in the study area as seen is rapidly increasing. The situation will further worsen beyond rehabilitation within the next few years unless appropriate preventive measures are taken to keep the situation under control. It is, therefore, desirable that concerned authorities should take up some short-term and long-term remedial measures to partly or wholly address these problems.

**Short-Term Remedial Measures**

The short-term remedial measures suggested are:

a) Prevention of environmental degradation in and around the study area by stopping or restricting sand and stone of quarrying and indiscriminate felling of trees.

b) Banning construction of any establishments like houses, offices, tea stalls with or without toilets on the banks of rivers and streams.
c) Undertaking of a comprehensive solid waste collection and disposal scheme for Shillong Master Plan area with people’s participation.

d) Development of urban settlements with minimum facilities for transport, education, medical care, markets, etc.

e) Creation of an appropriate administrative authority covering the Shillong Master Plan area for effective management of different facilities.

f) Burial grounds like cemeteries, graveyards and burning ghats should be relocated to remote and unproductive landscapes to prevent seepage of human coliforms to the water sources.

However, the most effective means of environmental management is through education which should aim at understanding the adverse effects of activities like directly discharging wastes into any sources of water, prevailing poor sanitation, etc. This can best be done through mass media for which concerned authorities should adopt some long-term measures.

**Long-Term Remedial Measures**

The long-term remedial measures are:
a) Introduction of conservation oriented education policy at appropriate levels and improvement of environmental education and training.

b) Adoption of a natural resource conservation strategy.

c) Incorporation of environmental consideration into all public and private development planning.

d) Strengthening of programmes for environmental manpower development.

e) Development of environmental management systems and implementation of environmentally sound sustainable projects.
REFERENCES


