

**GROWTH OF SHILLONG URBAN AGGLOMERATION
AND ITS IMPACT ON THE GEO-ENVIRONMENT WITH
SPECIAL REFERENCE TO SOLID WASTE DISPOSAL AND
WATER SUPPLY**

ABSTRACT

**THESIS
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Introduction:

Shillong, the capital of Meghalaya is an important urban center of North East India. It supports about 60 percent of the total urban population of the state and 96 percent of the East Khasi Hills District's urban population (census 2001). Shillong is a horst on the central upland zone of Meghalaya Plateau. Hence it is in the watershed zone between the streams which originate from this central upland area to drain either into the Brahmaputra system in the north or the Surma valley in the south. Numerous streams of primary order, which have low discharge, dominate the area and they are also the source of water-domestic, industrial and agricultural for the population living here. These streams are rain fed and the pollution of the streams in the source region naturally leads to problems in the down slope. It has been observed that with population growth more peripheral areas are becoming urbanized resulting in the growth of the Urban Agglomeration. Consequently, pressure on the fragile resource base viz. land, water and forest affect the geo-environment. The urban infrastructure facilities falls short of this rapid population growth and it is in this context that the present study of 'Growth of Shillong Urban Agglomeration and its impact on the geo-environment with special reference to solid waste disposal and water supply' was undertaken.

At present the world is in midst of a massive urban transition and it is estimated that by 2020 about 60 percent of the world's total population will be living in the urban areas (UN Report 1996-97)¹ and this rapid change is occurring particularly in the developing world where urban population are growing at the rate of 3.5 percent annually as opposed to less than 1 percent in the most of the developed region of the world.

Urbanization is often associated with higher income, employment opportunities, higher literacy, and improved quality of life but it also leads to environmental problems and social ills. Some of the problems associated with the developing countries are lack of access to drinking water and sanitation – It is estimated that more than 220million urban dwellers of the developing economies lack an access to clean drinking water, more than 420 million do not have access to the simplest latrines and between one third and two thirds of the solid waste generated is not collected (U.N. Report 1996)². It is piled up on the streets contaminating surface water bodies and blocking drains leading to flooding and the spread of diseases.

With urbanization the demand for water increases, due to population growth as well as better standard of living, but the total supply of water either remains the same or in some cases reduces due to loss of vegetation cover and constructional activities. Thus, need for proper management of water resources becomes urgent and this can be achieved by initiating policies that improve the efficiency of water use, avoid wastages, preserves and regenerates supplies by controlling water pollution and maintaining watersheds.

United Nations defines land as a delineable area of the earth's terrestrial surface, encompassing all attributes of the biosphere, above or below this surface including those of the near-surface climate, soil and terrain forms. The surface hydrology (including shallow lakes, rivers, marshes and swamps), the near surface sedimentary layers and associated ground water reserves (Kurian 2004)³. This needs to be protected. Hence this holistic definition of land suggests that the linkages between land and water are so intricately related at the management level, that land cannot be excluded from water resource and vice versa. It is in this context that hilly areas like Shillong with limited land due to the terrain

characteristics typified by steep slopes and rugged topography, land for urban use becomes a major constrain.

Like any other Urban center of the developing world, Shillong over the years has grown in most haphazard way under the impact of population growth taking within its ambit the peripheral land that are not exactly ideal for settlement or any other human activities. Due to rapid growth in population, space has become limited and the residents are often forced to settle on land unsuitable for development, such as the steep hillsides, water catchments, banks of rivers, streams etc. This has tremendous impact on the geo environment.

Shillong has grown as an enclave in the midst of tribal society and its growth can be traced back to the establishment of the British Station in 1863-64. In 1874 it was made the capital of the erstwhile-undivided Assam province. It remained the capital of Assam till 1972 when the state of Meghalaya was created. From a mere population of 3737 in 1881 Shillong has steadily grown over space taking within it the peripheral areas. Today the Shillong Urban Agglomeration consists of the Shillong Municipality, the Cantonment and five townships of Nongthymmai, Mawlai, Pynthorumkrah, Madanring and Nongmynsong (census 2001) supporting a total population of about 3 lakhs. With it has arisen many problems out of which the problem of waste disposal of the population and the demand for water is important as it affects directly the quality of life and health of the inhabitants living within the city.

Deforestation in the steep slopes due to human settlements and other activities exposes the rocks, which are acted upon by active weathering processes resulting in mass wasting and soil erosion. Coupled with this is the problem of slope failure mainly due to anthropogenic activities that makes the area vulnerable to landslides, erosion and pollution. In a city like Shillong, where there is heavy rainfall the kinetic energy of the raindrops become more effective in the absence of vegetal cover, hence erosion of soil increases as result of which the streams carry heavy load of sediments. This sediment load increases the turbidity of water, reduces light transmission capacity. This reduces the photosynthesis processes that directly affect aquatic life. With increase in population, the infrastructure facilities often fall short of the required norm. The problem of deteriorating urban environment is also reflected in Shillong's waste disposal infrastructure. The wastes accumulated are often dumped into the streams directly or are washed into these water bodies. The increase in the nutrient load of the streams, results in high biological oxygen demand this leads to the reduction in the oxygen level of the streams and profuse growth of algae affects the aquatic life. These streams are the source of water for the population; therefore the source of the drinking water gets contaminated.

As drainage basin urbanizes, the flow of the stream gets restricted due to constructional activities, it increases the percentage of impervious surfaces, leading to increase in the total volume of runoff and reduction in the amount of water that infiltrates into the ground (Leopold 1968)⁴. Consequently there is marked decrease in the quantum of water, but with population increase the demand for water both potable and other domestic, industrial, agricultural uses increases manifold. This is a crisis, which is not only peculiar to Shillong but also other urban centers of the world in general, and India in particular. The paving, straightening and sometimes reclaiming land for urban functions from the stream channels reduces the time lag between rainfall and channel runoff that results to floods.

It is in this background of population growth in the city, that the present study has been an attempt to highlight the growth of the Shillong Urban Agglomeration, which is defusing over space and taking within its ambit peripheral lands that are not ideal for urban

settlements and other activities and is devoid of urban amenities including solid waste disposal. This growth has resulted in geo-environmental degradation in general and water bodies in particular. A humble endeavor is made to identify the major constraints in urban amenities and also suggest strategies to meet the challenges associated with solid waste disposal and equitable supply of water to meet the needs of the growing population of Shillong

Review of literature:

The survey of various literatures suggests that no comprehensive work was undertaken as such on the solid waste disposal and water supply of Shillong. However, water quantum, quality and supply problems in general had in the past drawn the attention of many scholars from various disciplines. Coates (1974)⁵ had commented that urbanization and man's development has distorted many aspects of the land water eco-system. Leopold (1968) identified the effects of land use changes on the hydrology of an area. According to Leopold of all the changes in the land use urbanization is having the maximum effect on the hydrology of an area. Wolman (1967)⁶ from his study of Baltimore, USA had shown how construction induces erosion which is far greater than natural or even agricultural erosion. Similar works were done by Schaake (1972)⁷, Dikshit (2003)⁸, Gupta (2003)⁹, Singh (2003)¹⁰. The UN report on urban environment clearly indicates that the water resources are dwindling both in quality and quantity under the process of urbanization.

The problem of solid wastes of the urban areas finds mention in the UN report on urban environment (1996-97)¹¹. Many scholars like Singh(1998)¹², Peorbo(1991)¹³ have studied the impact of solid wastes on the environment.

The geomorphology of the study area finds mention in the works of Rai(1980)¹⁴, Panda(1985)¹⁵, Agarwal (1989)¹⁶. Some of the earliest geological study of Shillong are in the reports of Oldham (1858)¹⁷, Mills (1853)¹⁸. The details of the geological formation are of Shillong are derived from the Geological Survey of India report for Field Session (1988-89)¹⁹.

Objectives:

The objectives which the present thesis highlights are

- (i) To analyse the type of relief and slope characteristics and demarcate the major river basins of the study area.
- (ii) To understand the dynamics of population changes and its resultant urban expansion.
- (iii) To examine the existing solid waste disposal in relation to population.
- (iv) To examine the existing water supply in relation to population and geo-environment conditions.
- (v) On the basis of the above study to suggest desirable/suitable improvements in solid waste disposal and water supply.

On the basis of the above objectives the research queries the present study has undertaken are;

- (a) The impact of population growth on the limited resource base of the city viz, land, water and forests.
- (b) What are the scopes for the future expansion of settlements in the city?
- (c) What strategies are to be adopted to meet the problems associated with water supply and disposal of solid wastes?
- (d) How far the present settlements on the fringes of the city on the steep slopes are geo-environmentally sustainable?

Data Base and Methodology

For attaining the above objectives the present research work is based on analyses and interpretation of both secondary and primary data. The whole study is based on empirical facts and figures which have been obtained through:

Pre-Field Work

This involves investigation and analyses of secondary data undertaken along with survey of existing literature on the proposed study.

Field Investigation

Of the present waste disposal, dumping, quarrying activities, deforestation and present nature of water supply in and around Shillong in general.

Based on household schedule, random sample survey was carried out in certain localities of the study area. This highlighted the specific nature and problems associated with the waste disposal, water supply

In the selection of the localities, the demographic composition of the population and socio-economic criteria were taken into consideration so as to study whether socio-economic factors play a role in regards to both generation and disposal of waste.

Post field

This involved interpretation and evidences collected during the pre-field and field investigation. This has been done so as to identify the present nature of urban growth of Shillong Urban Agglomeration and associated problems of solid waste disposal and water supply.

In order to understand the dynamics of population changes a short history of Shillong along with the population growth and land use of the city from 1971 census onwards has been analysed, interpreted and represented by using suitable cartographic techniques. The decadal population growth and resultant urban expansion of the city has been mapped. The census report of 1971 has been taken as the base year since the state of Meghalaya was created in Jan. 1972.

Data pertaining to the existing amenities in pattern of land use in the Shillong Urban Agglomeration, generation and disposal of waste, present nature of water supply etc. especially in the new settlements which have sprouted up by the side of the streams and in moderately steep to steep slopes of the city, has been collected from various agencies and through field study. The data generated has been further analysed and categorised into biomedical wastes, commercial waste, household and domestic waste.

To study the socio-economic factors that may play a role in generation and disposal of domestic solid waste and water supply - a sample of 300 households of specific localities within the municipality and 187 households of the township having the highest density of population (2001 census) has been considered. The information pertaining to the socio-economic characteristics (community, educational status and occupation of the head of the family, size of the family and approximate family income/month etc.), amenities available for water supply and waste disposal, habits, approximate amount of waste generated, source, quality and quantity of water supply have been collected. This has been further discussed in the appropriate chapters. Selections of the localities have been based on the socio-economic composition.

For commercial solid waste- the nature, amount of solid waste generation and disposal method of Lewduh especially of perishable commodities like vegetables, fish and meat market has been selected. Information has been collected on the basis of informal interview with the vegetables, fish and meat sellers.

Information pertaining to the bio-medical wastes generation and disposal of all the hospitals/nursing homes of Shillong has been collected through informal interview and questionnaire. Biomedical waste has been selected for this study as this is one of the most hazardous waste generated within the Shillong Urban Agglomeration. This requires certain guidelines laid down by the Ministry of Environment and Forest, Government of India in its disposal method. Based on these guidelines it has been analysed to see how many of them follow such norms in disposing off their wastes.

Data and evidences collected both from primary and secondary sources have been further explored, interpreted and represented with suitable statistical and cartographic methods relevant to the study in order to comprehend the above research queries. Alternative use of the solid wastes generated especially from household and perishable commodity markets have been further analysed, so as to treat it as a resource.

The dumping of solid wastes into the primary order streams of the study area has been further analysed by taking water samples from certain selected points of the streams (especially those areas where settlements have come up along the streams itself and those areas where dumping of solid waste is done directly into the streams) and testing its quality so as to find the level of water pollution and contamination.

Limitations

While every attempt has been made to make this study valuable and useful yet it suffers from many constraints. These are related to the lack of data and other relevant information. Non-availability of proper base maps with detailed topographic information, lack of aerial photography and proper recorded data on settlements and their mode of solid waste disposal and water supply have seriously limited the study.

Data pertaining to the study of the socio-economic factors affecting solid waste generation and disposal is more of an overview. While selecting the sample areas there were no records available in the economic tables on population of Shillong Urban Agglomeration, hence it was through mere observation that a few posh localities of Shillong were considered and thus Lachumiere area was selected.

No statistical tests have been carried out. Accurate quantity of solid wastes generated/day/family is more of an approximation and needs further investigation. The respondents were reluctant to provide accurate information on their family income/ month; therefore an approximation was done on the basis of family size, number of family members working and their occupation etc.

Organisation:

The thesis has been arranged in seven chapters:

The first chapter deals with Introduction to the problem of the research, the location of the study area, its scope and methodology adopted. An attempt has been made to survey the existing literature as well as the limitations faced in the present study.

The second chapter describes the Physical setting of Shillong Urban Agglomeration; here an attempt has been made to have an understanding of the physical background of the study area. For this a detailed account of the geology, topography, climate, soil and vegetation has been

discussed. In order to understand the landform characteristics a morphometric analysis of absolute and relative relief, average slope and identification of the major drainage basins within the study area has been undertaken. This chapter provides an overall background to the study area.

The third chapter discusses the Population growth and resultant urban expansion of Shillong, highlighting as to why the British administration set up their station here in 1863-64. It also gives an historical overview of how Shillong grew as the Capital of Assam under the British and in Independent India. After the creation of the state of Meghalaya in 1972 how Shillong Urban Agglomeration has been growing over space under the impact of population pressure has been highlighted where the density, the decadal growth rate and percentage share of population of all the existing urban units has been discussed.

The fourth chapter is Solid waste disposal- deals with the definition of solid waste; an attempt has been made to have an understanding on the types of solid waste generation within the Shillong Urban Agglomeration. An attempt has also been made to quantify the total amount of municipal solid waste generated within the Shillong Urban Agglomeration. The different organisations looking after the solid waste collection and disposal methods as well as the infrastructural facilities available for this has also been discussed in details. The present method of disposal of this waste has also been discussed. A general overview of whether socio-economic factors are responsible in solid waste generation and the amenities available for its disposal has been highlighted for certain localities within the Shillong municipality and the township where density of population is high (census 2001). A general overview on the waste generated by perishable commodities wholesale market of Shillong, its amount and the present nature of disposal has been highlighted. The perishable commodity market has been chosen as it generates huge amount of organic waste that can be converted to a resource by composting it. A survey on the type, quantity and method of storage, transportation and disposal of bio-medical wastes generated by the hospitals/nursing homes of Shillong has been undertaken as it is the most hazardous waste generated within the Shillong Urban Agglomeration and needs special handling Rules as notified by the Ministry of Forest and Environment.

The fifth chapter deals with the water supply of the study area- here an attempt has been made to identify the present nature of water supply of Shillong. The organizations which are looking after the supply and the quantum of water supplied have been studied. Distribution pattern and the quality of water have also been discussed. In order to find out the water crises areas within the Shillong Urban Agglomeration, the zoning pattern of the Greater Shillong Water Supply scheme has been studied where the relation between the amount of water supplied and the present population size (census 2001) has been discussed. From the field data the source and the approximate quantum and quality of water available in certain localities within the municipality and the township where density of population is high, has been further discussed to see whether socio economic conditions have anything to do with the quantum and quality of water supply.

Sixth chapter is solid waste disposal and its impact on the geo-environment and water - an attempt has been made to study the impact of the present nature of urban growth and solid waste disposal on the geo-environment especially water quantity. The present nature of population induced urban growth of Shillong leading to urban proliferation especially in the higher ridges close to the water source region have been discussed. The present population pressure leading to high rate of deforestation and its impact on the geo-environment has been highlighted. The present system of '*bun*' cultivation in the catchment of the water sources

having an impact on the geo-environment has been conferred. The present system of quarrying activities to supply materials for constructional purposes has been highlighted as it has a negative impact on the geo-environment. The dumping of wastes in the streams and its impact on the water bodies leading to pollution and loss of aquatic life has been discussed. It is observed that urbanisation within the Shillong Urban Agglomeration has led to the emergence of the following geo-environmental problems- large areas are being covered by impervious areas that reduces percolation capacity but enhances surface run off thereby disturbing the hydrological cycle. Urban proliferation often encroach the stream banks resulting to reduction in the natural flush action of the streams and loss of water sources. The present method of dumping of wastes is leading to severe pollution in the streams affecting not only the population living within the Shillong Urban Agglomeration but also the population living downstream. Improper sewerage disposal within the study area is leading to not only surface water contamination but also pollution of the shallow aquifers. All these factors are having a negative impact on the quality and quantum of the water supply of Shillong.

The last Chapter is Summary, conclusion and recommendation. The entire thesis has been summarized in this chapter. On the basis of the findings certain recommendations have been suggested to minimise the present geo-environmental problems caused by the rapid urban proliferation under the impact of population pressure and waste disposal which has an impact on the geo-environment and water supply.

Findings:

The Shillong Urban Agglomeration lies to the south of the Shillong Ranges, which marks the highest part of the Meghalaya Plateau. Absolute relief increases from north to south. The absolute relief varies between 1080 meters to 1964 meters. About 35.48 percent of the total area is having absolute relief of 1400-1600 meters. An analysis of relative relief indicates that about 42 percent of the total area has a relative relief of 100-200 metres above m.s.l. An analysis of average slope also indicates that maximum area of about 62.33 percent is under moderately steep slope of 10-15° to 15-20°. The topography such as steep slope accounts for 11.09 percent of the total area. This steep slope and escarpments deter urban expansion.

There are 11 drainage basins found in the study area. The Umkhrah and Umshirpi basin encloses the Shillong municipality having an area of about 10.36sq km. The township of Nonthymmai is located on the upper course of Umkhrah basin in which the important stream Demthring is located. The townships of Pynthorumkhrah and Nongmynsong located at a lesser elevation than the Shillong proper. Madanrting Township is located in the Umkhen basin. The Mawlai Township lies partly in the Umshing- Umkhrah water divide and partly in the Umshing basin which has its source from the Mawpat ridge. The Umkhrah, Umshirpi marks the northern and southern boundary of the Shillong municipality respectively. The Umkhen has its water source from the Shillong ridges in the south.

With unprecedented population growth there has been an increasing demand and pressure on land. This is amply demonstrated by the inclusion of another township (Nongmynsong) within the Urban Agglomeration (census 2001). During the time of the creation of the state there were four units forming the Shillong Urban Agglomeration. The total geographical area was 21.27sqkm. The municipality supported a population of about 71.41 percent of the total population of Shillong Urban Agglomeration. In 2001 Shillong Urban Agglomeration consists of seven units viz the Municipality, the Cantonment and five

townships of Mawlai, Nongthymmai, Pynthorumkrah, Madanrting and Nongmynsong. At present the Municipality supports only 49.60 percent of the total population of the Shillong Urban Agglomeration and the townships supports more than 45.86% of the total population of Shillong Urban Agglomeration. In fact the Municipality recorded the least decadal growth rate of + 0.88 percent while the other extreme was the townships of Madanrting recording the highest decadal growth rate of + 85.82 percent (1991-2001 census). The growth of population in Shillong Urban Agglomeration is mainly due to the high growth rate of the satellite townships located in the periphery.

The present solid waste collection and disposal within the Shillong Urban Agglomeration is divided into two sectors. Organized sector- consisting of

(a) The Municipality (looking after the waste disposal of 27 wards within the municipality) generating around 112 metric tons of solid waste / day. The total waste collected from these wards is approximately 80 metric tons / day. Hence slightly above 30 percent of the waste generated /day is not being disposed

(b)The Cantonment Board looks after the solid waste collection and disposal of the cantonment. The total waste collection from here is 15-18 metric tons / day

(c)The Syiem of Myllem looks after the waste collection and disposal of Iewduh. Here the approximate waste generation is 12-24 metric tons / day of which only 6 metric tons of waste is being disposed off at the composting plant at Mawiong.

The unorganized sector consisting of five townships where there are no organizations looking after the solid waste disposal. Here the estimated solid waste generation is approximately 25.75 metric tons /day.

The types of solid waste generated within the Shillong Urban Agglomeration are mainly municipal solid wastes (consisting of household waste, constructional / demolition waste, institutional waste, commercial waste and natural waste), bio-medical wastes and negligible amount of industrial waste.

The amount of municipal solid waste generated within the Shillong Urban Agglomeration is approximately 165 metric tons / day. The anaerobic waste disposal plant at Mawiong can handle only 100 metric tons of biodegradable solid waste in a day hence approximately 40 percent of the municipal solid waste generated per day are unaccounted.

Bio medical waste generated from the hospitals/nursing homes of Shillong is around 15,967 kg per week of which 3955 kg per week are highly infectious. There are certain specific guidelines laid by the Ministry of Environment and Forests for storage, collection and disposal of this waste. Except the Military hospital the rest of the health centers are not following these guidelines. The wastes generated from two slaughter houses are also unscientifically managed.

The collection of waste followed by the Municipal Board are door to door collection from some localities and collection from the dustbins once a day within the 27 wards of the municipality. The Cantonment Board collects waste from the dustbins every alternate day. While the commercial waste generated by the Iewduh market is collected twice daily by one truck having a capacity of 3 tons from the three dustbins located within the market

As regards water supply of the Shillong Urban Agglomeration there are three organizations looking after viz The Shillong Municipal Board, The PHE department of the state and the local 'Dorbars.' At present the Municipality supplies approximately 2650.3 kiloliters of water every day. This water is not treated and comes from its seven springs and stream sources located within the Shillong Ridge to the south of the city. The PHE has its

source from the Umiew River where water is collected at Mawphlang. The total installed capacity is 11.5 million gallons per day but at present only 34095 kiloliters of water is being supplied. The water is treated before being supplied to the households. River Umkhen is also tapped by the PHE to supply water; approximately 1295.6 kiloliters of water per day is being supplied to the townships of Madanrting, Nongthymmai and other areas within the municipality. River Umsohlang is tapped by the PHE, which pumps around 1363.8 kiloliters of water every day to meet the water requirement of Mawlai Township. The local 'Dorbars' have their own sources from within the reserved forests of Shillong.

At present the quantum of water supplied within the Shillong Urban Agglomeration is around 39504.7 Kiloliters / day i.e. approximately 39505000 liters / day of water is being supplied to meet the water needs of at least a population size of 267881 persons. Thus the per capita water supplied per day is 147.47 liters. Hence there is not supposed to be any water shortage within Shillong. But the quantum of water is not equally distributed as suggested by the zoning of water supply by the PHE department. There are severe water deficient zones while some zones have surplus water.

Water is being treated scientifically at Mawphlang for quality supply to the people. Due to rugged terrain typified by moderately steep to steep slope the households have to be supplied water through individual pipelines from the main reservoirs, these pipes usually pass through drains and waste dumps. The leaking pipes thus become source of contaminated water. Field study suggests that all the samples of water collected from the surveyed localities have coliform level beyond the permissible limit and thus is not potable.

The field study suggests that both waste disposal and water supply requires much more than what it is at present. Lachumiere area has a concentration of populations who are economically better off and have better waste disposal facilities and better water supply system. Jhalupara area has the least facilities of waste disposal and water supply since people living belong to economically poorer section of the society. About 10 percent of the respondents of Jhalupara use pit latrines whose waste is being dumped into the streams, 33 percent of the respondents here do not have access to proper toilet conditions, 55 percent of the respondents dispose off their domestic wastes directly into the streams. In Lachumiere only 5 percent and in Rilbong about 13 percent of the respondents dispose off their wastes directly into the streams. There are three dustbins each in Rilbong, Jhalupara and Lachumiere which are not sufficient enough to take care of the waste that is generated. But Lachumiere is provided by door to door waste collection facility everyday except on Sundays.

In Jhalupara about 49 percent of the respondents collect water from the public taps outside the compound of their residence. In Lachumiere and Rilbong 100 percent of the respondents have access to water supply inside their house. In Jhalupara 65 percent of the respondents are facing water shortage through out the year. In Rilbong 40 percent of the respondents face water shortage during the dry season and in Lachumiere about 7 percent of the respondents face water shortage only during the dry season.

In Nongthymmai there are 11 localities without dustbins thus about 65 percent of the total respondents dispose off their domestic wastes directly into the streams. The PHE and the local 'Dorbar' looks after the water supply for the population here by tapping the stream waters from nearby reserved forests of the Shillong Ridge. However the volume of water is reducing every year, may be due to deforestation. The Kharkhongor clan controls the local water sources. The overhead tanks where water is collected and distributed are cleaned every

year. There are few community taps from where water is being sold to the locality through small tankers and human carriers.

The population induced urban growth of Shillong without proper facilities are creating geo-environmental problems having its impact on water. The urban sprawls to the upper ridges towards the south of Shillong which are the main source of water for the population are encroached upon. The deforestation is accelerating the landslides, mass wasting and high soil erosion. This is resulting not only to the sedimentation of the streams but also permanent loss of the water bodies as the percolation of the soil is affected. The rampant waste disposal into the streams of Shillong has made the water not only unfit for human use but also affected the aquatic life. The waste dumps are acting as 'fish kills', in fact the streams of Shillong are without any fish.

Suggestions:

To check further geo-environmental degradation in the area the following suggestion may be incorporated in the future developmental processes of Shillong.

1. Deforestation in the upper ridges especially close to the water sources needs to be checked.
2. 'Bun' system of cultivation in the catchments needs to be addressed. Use of pesticides, insecticides etc needs to be checked.
3. Stone quarrying in the upper ridges should be banned
4. A buffer zone needs to be created in the sides of the streams in order to check waste disposal and constructional activities.
5. Burial grounds like cemeteries, graveyards and burning ghats should be relocated to remote unproductive landscapes to prevent seepage of human coliform to the water sources.
6. In order to meet the water requirement the concept of rainwater harvesting can be introduced.
7. The concept of reduction, recycle and reuse needs to be introduced in order to control solid waste generation.
8. The community needs to be involved in waste disposal programmes. Wastes should be segregated at source into bio degradable and non-biodegradable. The services of the unemployed youth can be harnessed as they can be mobilized to collect waste from the households (door to door collection) against a small amount of payment. The wastes thus collected, can be then collected by the concerned authorities to be disposed off in the composting plant at Mawiong (biodegradable) for production of compost. The non bio- degradable waste can be collected from a common source by different organizations that could be reused as their raw material for production. Hence wastes needs to be viewed as a resource which can enhance both capital and employment opportunities.
9. A common incinerator for the biomedical wastes needs to be installed away from the congested areas of the city. The present method of dumping biomedical wastes with other municipal wastes needs to be checked as this may lead to health hazards.
10. The duplication of organizations in regards to waste disposal and water supply needs to be addressed since no single organization can be held responsible for the present state of affairs. One household one water connection system should be implemented.

11. Water distribution system should be metered with proper pricing policy in regards to water supply to the households. This can check water wastage and misuse.
12. Above all an environment impact assessment is necessary before undertaking any area for future expansion of Shillong.

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