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

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

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Subrata Chakraborty

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CHAPTER I

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

1.1 Introduction

Urbanisation is a process by which the agriculture based rural landscape is turned into an urban landscape dominated by urban functions and services. Geographers look at urbanisation as a method by which human beings and their activities congregate over space (Mishra 1997)[1]. This is often associated with higher incomes, higher literacy, and improved quality of life, easier access to information, diversity, creativity and innovation. It is also associated with certain social ills. These include a diversity of problems such as lack of access to clean drinking water, pollution and degradation of the physical environment. These are due to unscientific waste disposal generated by the growing population of these urban centers, as they have a direct impact on the health conditions of the population living here but also on the geo-environment.

The world at present is in the midst of rapid urbanisation. It is estimated that by 2025 about two thirds of the world's population will be concentrated in the urban centers (United States Bureau 1996-97)[2]. This high rate of urban growth is more pronounced in the developing economies than the developed economies. United Nations report suggests that 90% of the present growth of urbanisation is concentrated in the developing countries. In the developed world of Europe and North America almost 70% of the total population lives in urban areas (Leitmann 1995)[3] hence urban growth here is at a much slower rate than in the developing world. The developing economies especially of Africa and Asia on the other hand are experiencing explosive growth of urbanisation at roughly 4% per year. This pattern of urban growth results to a multitude of problems, of which solid waste

disposal and supply of potable water is prominent as it is the basic need for the population living in urban centers.

It has been observed that with rapid population growth in the developing economies like India coupled with high rate of rural to urban migration the cities are overcrowded. The local governments are often starved for cash and do not have the resources to provide even the most basic environmental services for their residents. With population growth the marginal areas that are otherwise not suitable for habitation comes under urban activities resulting to high degree of deforestation.

Such growth and development results to various geo-environmental problems like soil erosion, mass wasting, loss of vegetation and biodiversity. These also creates lesser degree of percolation of water which results to change in the hydrology of the area, change in the microclimate, and higher degree of pollution of air, water and land. Due to deforestation and concrete structures the percolation capacity of the soil reduces hence the ground water level comes down and springs dry up. Then there is reduction in the total water quantum of the area. At the same time as the population concentrates over these urban centers, their quantum of waste generation increases which pollute the existing surface water resources by degrading the quality of water.

Hence urbanisation often leads to fall in the quantity and quality of water. But at the same time due to population growth and better standard of living in urban centers the demand for water increases resulting to severe crises. Throughout the developing world it has been observed that often the urban poor live in pathetic conditions. At least 220 million urban dwellers lack access to clean drinking water; more than 420 million do not

have access to the simplest latrines. Between one and two thirds of the solid wastes generated are not collected (UNDP Report 1996-97)[4]. This uncollected waste piles up on streets and in drains contributing to flooding and ultimately gets washed into the water bodies.These are resulting to the deterioration of the very source of water which is the foundation of water supply for the population living in the urban centers.

Although urban environment problems defy any categorisation, they can be grouped into two broad classes: those associated with poverty and those associated with affluence. In the developing countries like India the most threatening environmental problems are inadequate household water supply uncollected accumulated waste in the neighborhood which poses more serious problems than the waste in the city dumps. Human excreta are frequently the most critical pollutant, and unsanitary conditions in the home and neighborhood are generally more of a threat to health than industrial pollution.

In the developed nations the wealthy cities can easily afford the public finance and administration needed to regulate improved water supply and solid waste disposal systems in order to improve quality of live. But the resources consumed and greenhouse gases emitted to support these cities are, on a per capita basis, far greater than those associated with the poorer cities of the developing world. Hence the poor create environmental problems for themselves and their neighborhood while the wealthy create problems for a wider public.

The urban centers of the developing economies are affected by urban sprawl, which imposes severe demands on water supplies. But at the same time they lack the support of the taxpayers to this services as the big size of the population living here,are often

belonging to the unorganised tertiary sector,who have been pushed to these urban centers in search employment. Hence they consume more water and create extra demand on the existing infrastructural facilities needed for the water supply but do not contribute to its maintenance.

Technology, an integral part of culture plays an important role in the context of present urbanisation. Modern cities are largely dependent on technology which means that mechanical breakdowns of technology or absence of technology can have serious repercussions on the geo-environment of an area. In the developing countries due to financial constraints waste treatment is not up to the mark, hence urban centers which draw river and spring water for domestic use end up using contaminated water because these water bodies are often used as waste disposal sites. A river cannot naturally purify the huge loads of these untreated wastes. This leads to severe pollution of the rivers which are supplying domestic water requirement of the existing population of the urban centers and the population living downstream who use the dirty water.

A similar situation exists in Shillong which is located in the highest part of the Meghalaya Plateau. With this present context the urban growth of Shillong Urban Agglomeration is an important researchable problem which leads to various geo-environmental problems of solid waste disposal and water supply . Though the study is on the growth of the Shillong Urban Agglomeration but the emphasis is on solid waste disposal and water supply.

It has been observed that the critical determinants of the nature of environmental problems an urban area faces is largely dependent on the natural features of a city such as

its, relief , slope and climate, for instance in a hilly terrain characterised by steep slopes and rugged topography, land for urban use becomes limited thus with population growth the poor are often forced to settle on land unsuitable for development, such as the hillsides, water catchments areas, by the sides of streams etc. which are vulnerable to landslides, erosion and pollution. Hence while addressing the problems regarding the solid waste disposal and water supply of an urban area one should take into account the underlying geomorphology and climate of that area.

Any urban center has its unique characteristics, which has evolved over time. Therefore geo-environmental study of an area needs to take into account the physical, socio-cultural, historical and political factors of the urban centers. Instead of proposing homogenising solution to solid waste disposal and water supply system of the area a geo-environmental and socio-cultural appraisal of the urban center concernedneeds to be taken into consideration. A proactive planning process where the population themselves are an integral part of the resource management needs to be highlighted. Moreover as the urban center grows bigger it brings the twin problems of increase in the demand of water in one hand (due to the increase in population and rise in standard of living) and reduction in the natural supply of water on the other because of the 'roofing over' with settlements, pavements and concrete buildings which were forests, moisture content soils and streams in earlier years. Further the accelerated accumulations of the solid wastes of urban areas often leads to chemical, biological and sediment pollution of the streams. It is in this context that the present study is undertaken.

1.2 **Review of literature**:

The survey of various literatures suggests that no comprehensive work has been undertaken on the solid waste disposal and water supply of Shillong. Urbanisation and its impact on the geo-environment in general and hydrology in particular have drawn the attention of many social and environmental scientists including prominent geographers.

Leopold (1968)[5] from field investigation on the Creek Basin of Pennsylvania shows how under the impact of urbanisation the hydrology of the area changes which brings about a change in its peak flow characteristics, changes in total runoff, changes in quality of water and changes in the hydrologic amenities. The two principal factors governing the flow of streams are the percentage of area made impervious due to the type of land use (in an urban area the streams get canalised restricting the original flow), and the rate at which the water is transmitted across the land to the stream channel which is governed by the density, size and characteristics of the tributary channels which often act as storm sewerage hence increasing the frequency of floods in the urban centers.

As the volume of runoff is governed by infiltration characteristics and is also related to slope, soil and vegetation cover, it is thus directly related to the percentage of area covered by constructional activities like settlements, streets and other impervious surfaces which increases the surface runoffs resulting to the increase in the peak flow especially during heavy precipitation. On the other hand the increased runoff volume also affects low flow because the higher the percentage of direct runoff, the smaller the amount of water available for soil moisture replenishment and for ground water storage which is responsible for decreased flows. Thus increased imperviousness as associated with

urbanisation has the effect of increasing flood peaks during heavy precipitation and increasing low flows during dry season.

Another aspect of urbanisation especially in hilly topography is the exposure of the soil to storm runoff. This occurs mainly when bare ground is exposed during constructional activities that increases the sediment loads of the streams. Leopold also states that the major effect of urbanisation is the introduction of effluent from the population living here which degrades the water quality. The effluents often act as nutrients and promote algae growth which alters the balance in the stream biota. Thus the quality of the water body deteriorates under the effect of urbanisation, which is the source of water not only in these urban centers but also the population living downstream.

Urbanisation also leads to concentration of population over space hence the problem of waste disposal arises which is enhanced by not only the high growth rate of population in the urban centers but also due higher standard of living.That increases the resource utilisation and higher waste generation especially due to the "use and through culture". Such practises leads to geo-environmental degradation in general and water bodies in particular which are the source of the water supply to the population living here.

Eschman & Marcus (1972)[6] from their studies on New York, and Boston points out that throughout history geomorphology has perhaps played a significant role in the location and growth of urban centers. Cities are not simply where one finds them. They are located in response to a complex set of interacting processes and forces that encompasses a range of factors of site and situation. Site refers to the local environment on which the settlements are established and over which they grow. Modern men can to some extent

change and modify the initial conditions of the site through technology. Modern man is a major agent of landscape alteration which comes at a price not only economic which can be measured in terms of labour capital and investment but also environmental costs especially in the forms of earthquake landslides and floods. Hills and slopes often act as geologic resistance to urban growth which under the impact of population pressure comes under constructional activities. In the absence of proper technological innovation leading to slope failure and landslides is common. Sub-urban expansion or urban sprawl is particularly sensitive to geomorphologic conditions. technology can negate the geo-environmental constraints of some areas through investment. The population residing in such areas has to cope with problems associated with water supply and waste disposal.

Coates (1974)[7] states that the present urbanisation marked by population explosion has a tremendous impact on the physical resources especially land water ecosystem. Water is one of the most important determinants of urban live. The quality and quantity of water decreases with increasing urbanisation. The encroachment of urban development on stream beds and banks diminishes the storage capacity, and with population growth the demand for water is increasing at the same time the storage capacity is reducing which is increasing problems of the quantum of supply. In order to meet the required demand of water for these urban centers water needs to bought from outside as the local sources do not meet the demand. The water quality of the urban centers suffers due to the fact that the water bodies of these urban centers receives the organic and inorganic wastes. Hence this calls for basin and urban planning requirements.

Studies on waste problems of the urban India have drawn the attention of many scholars. Singh (1986)[8] shows how population increase in the urban centers has resulted to the problem of solid waste disposal which ultimately leads to land air and water pollution. Water which is an essential ingredient for human survival is under threat. With rapid population growth and technological developments in industries which are usually water intensive. The demand for water has increased at the same time the consumers are polluting the water bodies. Urban India faces serious water crises and the supply of drinking water to most of the urban centers leaves much to be desired. The per capita supply of water is far below the standard norm and the worst hit is the urban poor. The piped water supplied by the authorities is often not fit for human consumption from the bacteriological point of view. This is because of the contamination of the sources of water from surface runoff from the waste dumps, discharge of untreated industrial and municipal solid wastes, waste water and sewage which has resulted to severe pollution of water.

Kellar (1985)[9] states that present method of solid waste disposal have serious impact on the environment posing health risks to the population. This present problem of solid waste can be reduced by adopting a scientific waste management so that pollution is minimised. This is possible by treating the solid wastes as a renewable source of energy like other biomass.

According to Mishra (1992)[10] information regarding solid waste generated by the growing cities of the developing economies is scanty. Measurement is also difficult due to complexity of the material and lack of technical facilities. The quantity and character of solid wastes are also dependent on the culture, the geographical location and food patterns

of the population. At present however the different governmental agencies are improving the data base regarding solid wastes types, amount and characteristics. The union government of India has come up with a classification of solid wastes of the urban areas comprising of garbage, rubbish, ashes, constructional wastes, dead animals, industrial solid waste, mining solid waste and natural wastes. The domestic waste constitutes a bulk of the total solid waste generated by the urban centers. At present the "use and throw culture" of the west is catching up with the urban centers of our country. This is having a serious impact not only on the environment but is also responsible for draining the finite resources. The world has been witnessing major crises in resources. The developed countries want to conserve as much as they can and import resources from the developing countries. Hence developing countries like India needs to ponder upon efficient utilisation of resources and minimisation of environmental pollution. In order to achieve this the concept of recycling of wastes needs to be introduced which is already a part of our ancient culture.

The recycling of waste is a commercialised business in many countries and is not the monopoly of any particular age group, yet there is evidence that youth play a significant role in this area (Glyn 1996)[11]. According to Glyn in the underdeveloped world waste recycling has provided gainful employment opportunities. State funding has been made available in training the local youth on waste recycling involving low cost eco friendly technology.

Singh & Rahman (1998)[12] based on their study of solid waste disposal of Aligarh city has shown how income plays a significant role not only in the generation of the amount of solid waste but also in waste disposal infrastructural facilities. It is observed that

the localities dominated by lower income group of population do not enjoy the same facilities regarding waste disposal as the posh localities inhabited by the economically better off. The localities of this lower income group of population have accumulation of waste leading to not only environmental problems but also health hazards.

Wadhwani (2000)[13] has studied hospital waste management of Indian scenario, it is observed that the special guidelines which are laid down by the Union Ministry of Forest and Environment are not being followed. From his studies of medical waste storage, segregation, transportation and disposal of the premier hospitals of the country it is observed that none of the hospitals have implemented the waste management phases successfully and that is leading to health and environmental problems mainly through water.

Agarwal (2002)[14] has highlighted as to the huge amount of solid waste generation especially of the urban areas due to population explosion associated with the developing nations and high degree of consumerism of the developed nation and the rich in the developing nations. This enhances higher resource utilisation resulting to huge mound of waste. The solid waste includes domestic refuge and discarded materials from domestic, industrial and agricultural materials. This is basically an urban problem associated with aggregation of population over a smaller space, rapid population growth, rapid advanced technology, social attitudes and the belief that belief that resources and disposal areas for waste are infinite, which is causing serious problems. Hence the need of the hour is to view waste as a resource. This calls for waste management programmes. Improper disposal of solid waste not only pollutes the land, surface water and air but also leads to ground water

contamination through leachates. Waste dumps are also the source for breeding of disease carrying vectors which tell upon the health of the people. At present low cost eco friendly technologies are available for turning waste into wealth. Proactive planning with community involvement can minimise the environmental pollution arising out of improper waste disposal. The concept of reduction at source, recovery and recycle needs to be implemented.

Anuradha and Das (2003)[15] suggest that water pollution in urban India is a serious problem. 70% of its surface water resources are polluted and increasing ground water reserves are contaminated by biological, toxic, organic and inorganic pollutants. The high rate of water borne diseases prevailing in our country is due to the improper solid waste disposal system which contaminates and pollutes the very source of our drinking water. Runoff from garbage dumps and street litters are carried to the nearby streams, leachates from landfill and garbage pits percolates toxic substances and heavy metals to the groundwater table. Hence it is the community who should be sensitised as to the consequence of unscientific waste disposal system. It is necessary to make them aware of contamination of the water they use and drink. For this a seasonal assessing of the drinking water quality is essential. The youth can be mobilised to check the sources of water pollution and monitor the quality of water in their respective areas.

Singh (2005)[16] from his study on solid waste disposal of Varanasi City shows how the volume of waste generated by the city is increasing with population growth. But the infrastructural development of the city falls short of the population growth. Due to population growth the city is highly congested with fewer sewage facilities and constrain

in the availability of land for waste treatment. As a result of this waste generated in the alleys of the streets are not disposed off. This waste dumps are a major source of diseases besides pollution of the physical environment. A major percentage of the population here suffers from water borne diseases as the water sources supplying to the city gets contaminated by the bulk of the waste of the city.

For a comprehensive understanding of the underlying geomorphology, the study of Rai (1980)[17], Panda (1985)[18] and Agarwal (1989)[19] has been consulted.

For geological information of Shillong the reports of Mills (1853)[20] and Oldham (1858)[21] has been consulted which is one of the oldest records of the geological understanding of the Shillong plateau. The plateau is part of the ancient Deccan block of southern India detached from it by the Garo Rajmahal gap. The details of the geological formation of Shillong found in adequate details in the Geological Survey of India report (Roy 1988-89)[22].

1.3 **Statement of the problem.**

Shillong the capital of Megalaya is the second largest urban center of North East India. In terms of its economic. administrative and commercial importance it is perhaps second to Guwahati. The city is supporting about 60% and about 96% (2001 census)[23] of the total urban population of the State and the District of East Khasi Hills respectively.

Shillong is basically a horst located on the northern slopes of the Shillong ridges which marks the highest part of the Meghalaya Plateau. It is from here that the streams originate to flow either towards the north to the Brahmuptra river system or towards the

south in the Bangladesh plains in the Surma valley. Hence the city is very close to the watershed zone. Numerous streams of primary orders having low discharge dominate the area and the source of water for domestic, agricultural and industrial purposes. These streams are rain fed and dries up and creates water scarcity especially during the dry season. Such a situation may create pollution of the streams due to the unscientific waste disposal. This may also cause both geo-environmental and health hazards.

The growth of Shillong as an urban center can be traced back from 1863-64 when the British shifted the administrative headquarters of Khasi and Jaintia Hills from Cheerapunjee (due to its inclement weather) to Shillong associated with a salubrious climate and ample water resources for meeting the water demand of the population living within the station. (Pakem 1984)[24]. From a mere population of 9621 as per 1901 census, Shillong has grown with a total census recorded population of about 267881 persons (2001 census). But this figure has been debated by individual studies of various NGOs. They state that the present population of the Shillong municipality alone exceeds 4 lakhs. The total population of the present Shillong Urban Agglomeration consisting of the townships of Mawlai, Nongthymmai, Madanrting, Pynthorumkhrah and Nongmynsong along with the Municipality and the Cantonment supports at least 8,53,789 persons (Ryngnga 2003)[25].

This rapid urban population growth both natural and migration induced is having its toll on the existing resources, which was initially designed to sustain a much smaller size of population. Land which is a scarce resource in any urban area becomes scarcer in a hilly terrain, where rugged topography and slope characteristics act as a constraint for

development activities. With urbanisation the demand for water increases with population growth and better standard of living. But the total quantum of water supply remains the same or in some cases reduces due to loss of vegetation cover and constructional activities. Therefore proper management of water resources becomes an urgent issue and this can be achieved only by initiating policies that could improve the defficiency of water use, avoid wastages, preserves and regenerates supplies by controlling water pollution and maintaining watersheds.

United Nations (Kurian 2004)[26] defines land as a delineable area of the earth,s terrestrial surface, encompassing all attributes of the biosphere immediately above or below the 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 are 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 resources and vice versa. Hence urbanisation and growth of population has a pressure on the land resources which has its direct impact on the hydrology of the area. It is in this context that a hilly area like Shillong with its limited land, due to the terrain characteristics typified by steep slopes and rugged topography has been underken in this study.Here the impact of population growth on the geo-environment gets reflected not only in its high rate of deforestation of the steep slopes leading to slope failure, landslides, soil erosion which is dwindling water resources. This is also causing reduction of quantum of flow of water and severe pollution. The wastes generated by the population living here are ultimately

washed into the numerous streams of the study area due to the absence of proper waste disposal system.

The growth of Shillong is haphazard. It has grown as an enclave in the midst of tribal society attracting immigration of population from the rural areas and from smaller urban centers of the region as well as the neighboring states. According to the census (2001) the geographical area of Shillong Urban Agglomeration is over 25.40 sq km but the urban sprawl continues taking within its ambit with at least 174 sq km (Shillong Master plan area). According to the office of the Directorate of Urban Affairs the Master Plan Area has been delineated taking into account the extent of the built up area, the continuity of development, the immediate hinterland of the city and the future requirement of land for growth and expansion up to 2011 in the view of the vast expansion of Shillong. In the last two to three decades with the creation of Meghalaya many villages located in the fringes are now acquiring urban characteristics. With this expansion many problems such as waste disposal of the area, the demand for more water supply, quality of live and health of the inhabitants including the geo-environment of the area needs urgent attention.

1.4 **Selection of Area**

Shillong is characterised by moderately steep to steep slope marked with a landscape ranging from low valleys to steep escarpments often posing constraints in the urban growth. Deforestation in these moderately steep to steep slopes due to human settlements and other activities exposes the rocks to active weathering processes resulting to mass wasting and soil erosion. Coupled with this, the problem of slope failure mainly

due to anthropogenic activities are increasing. This 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 becomes more effective in the absence of vegetal cover, hence erosion of soil increases and the streams carry heavy loads of sediments. This sediment load increases the turbidity of water, reduces light transmition thereby reducing the photosynthesis process which affects the aquatic life. With unprecedented 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 which leads to the reduction in the oxygen level of the streams. This allows profused growth of algae and affects the aquatic life. These streams are also the source of drinking water of the city and the downstream population.

The urbanisation of drainage basin leads to restriction in the quantum of the flow of water due to constructional activities, as 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)[27]. Consequently the quantum of water decreases. With population increase the demand for water both potable and other domestic and industrial, agricultural uses increases manifold. This crisis, is not only peculiar to Shillong but also for other urban centers of the world in general. The paving, straightening and sometimes reclaiming land for urban functions from the stream channels reduces the time lag between rainfall and channel runoff that are causing floods.

The rapid population growth of the city, and the present situation made this study, which is an attempt to highlight the growth the Shillong Urban Agglomeration and its associated problems of solid waste disposal affection the geoenvironment and water supply. The present urban sprawl are often devoid of urban amenities including solid waste disposal and potable water supply. This present nature of growth has resulted in geo-environmental degradation in general and water bodies in particular. In this study a humble endeavor has been made to identify the major constraints in urban amenities and also suggest strategies associated with solid waste disposal and equitable supply of water to meet the needs of the growing population of the area.

1.5 **Location of the Study Area.**

The area of study falls in the Survey of India Toposheet No.0/14 located between 25°32′ North to 25°36′ north and 91°51′ east to 91°56′ east (Fig 1.1).

The study area includes the Shillong Urban Agglomeration which covers the Shillong Municipality, the Cantonment the townships of Mawlai, Nongthymmai Madanrting Pynthorumkhrah Nongmynsong. Due to the recent urban sprawl taking within its ambit peripheral villages leading to the contiguous growth of Shillong urban Agglomeration the Meghalaya Urban Development Authority has identified an area of 174 sq km in and around Shillong city which is called the Shillong Master Plan area (Fig 1.2). In this study the morphometric analysis of the entire Master Plan area has been undertaken.

LOCATION MAP

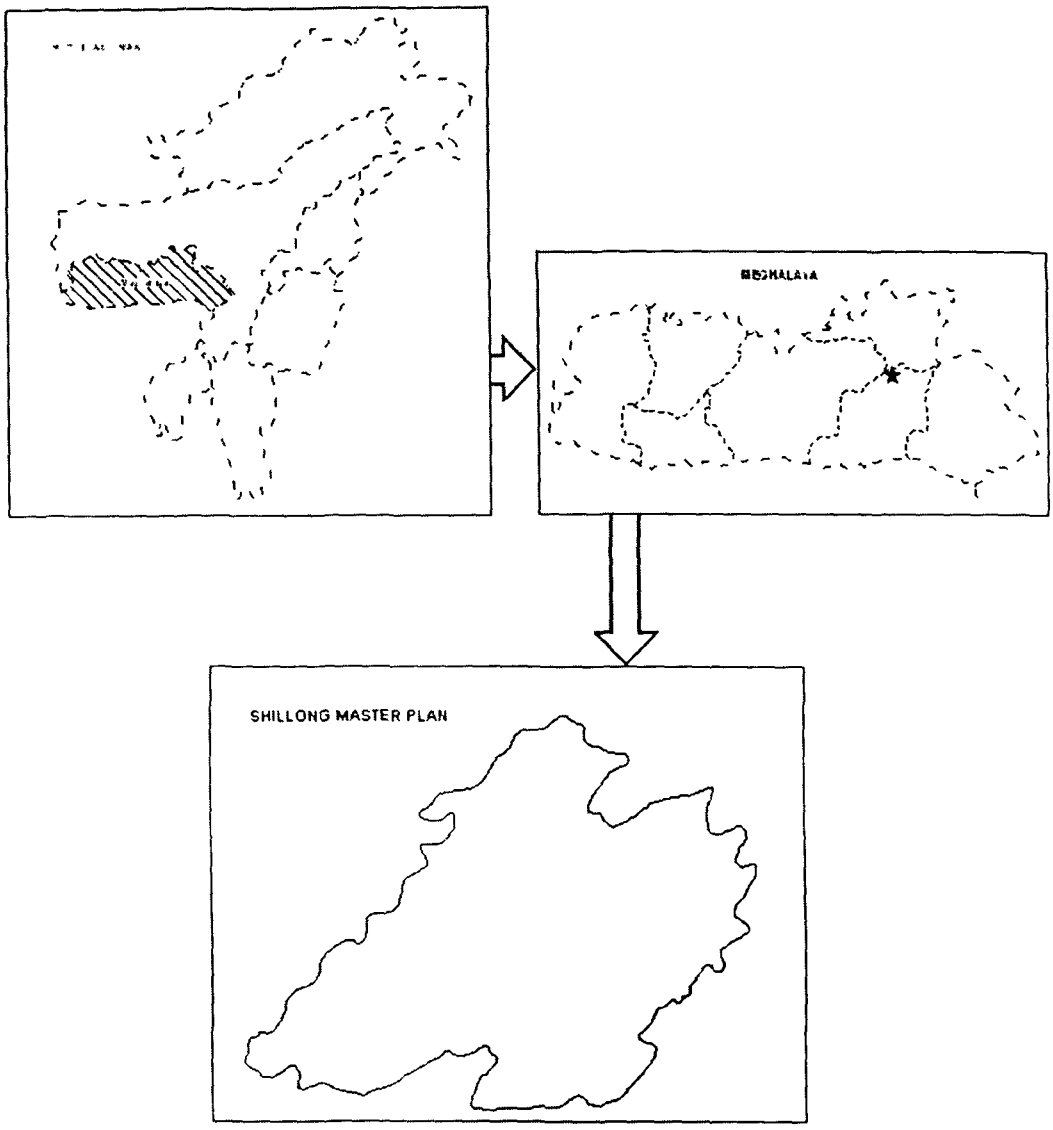
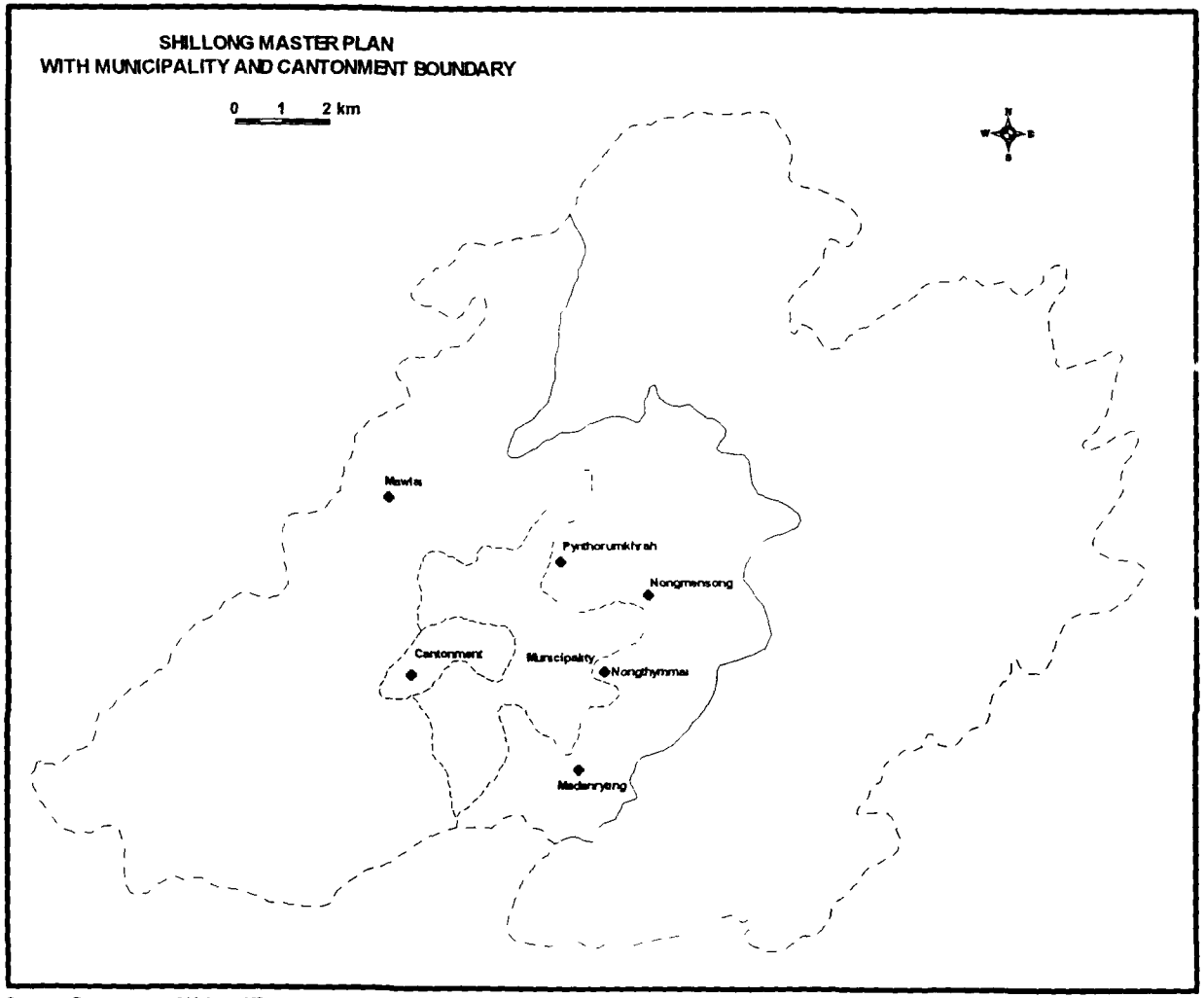


Fig. 1.1



Source Directorate of Urban Affairs

Fig 1 2

The boundary of the Master Plan area (Fig.1.2) is - in the north it is bounded by Barapani and Umiam, foot track from Wah Umiam up to the kutcha road going to Boilymbong, kutcha road from near Nonklaw to Wah Tamdong.

In the east the Master Plan area is bounded by the foot track from Wah Tamdong to Tynring, kutcha road from Tynring to Wah Umkhen and the road from Wah Umkhen up to national highway No.44 near Sohrenkham.

In the south the boundary consists of the national highway No.44 up to Laitkor, from Laitkor through Air Force area up to Shillong Peak, Kutcha road from Shillong Peak joining national highway No. 40 to near Nongpyiur.

In the west the boundary is formed by the river wah Umiam(Directorate of Urban Affairs 1991)[28]. This is a natural boundary.

The master plan boundary has been selected by the Meghalaya Urban Development Authority as Shillong is showing a contiguous urban growth within this boundary.

From the statement of the problem it is apparent that Shillong's growth is dynamic as far as its urban sprawl is concerned. With rapid urbanisation induced by population growth has its impact on the geo environment characterised by hilly terrain. The unrestricted growth of Shillong also leads to the problem of waste disposal generated by the increasing population living here. it also leads to more demand for water, but in the absence of proper waste disposal facilities and geo-environment constraints in regards to water, land and sewer facilities both the quantum and quality of water needed for the growing population of Shillong gets degraded.

1.6 Objectives of the Study

(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 system in relation to population and its impact on the geo-environment with particular reference to water.

(iv) To examine the existing water supply in relation to the population and geo-environmental 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 forest.

(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 human settlements on fringes of the city located on steep slopes are geo-environmentally sustainable?

1.7 **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 has been obtained through:

Pre-Field Work

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 selected localities of the study area. This highlighted the specific nature of the waste disposal, water supply and problems associated with both.

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 relief features a morphometric analysis of absolute relief, relative relief and average slope analysis has been undertaken.

The absolute relief has been calculated by dividing the map of the study area into equal number of grids, each grid representing one sq km. The absolute height of each grid has been noted by computing the maximum elevation from the contours and spot heights. These values have been categorised into five classes and has been demarcated on the map by the help of interpolation .This has been represented by choroplething.

The relative relief has been computed following Smith,s method where the study area has been divided into equal number of grids , each grid representing 1 sq km. The difference between the highest contour value/spot heights and lowest contour value in each case has been computed. These values have been categorised into classes and represented in the map with the help of interpolation and choropleth method.

In order to determine the average slope of the study area C.K. Wentworth's method has been used. The constant here is 636.6 as the toposheet No78 0/14 from which the contours have been plotted reads in Kilometers. The whole study area has been divided into equal number of grids, each grid unit representing 1 sq km of area. The average number of contour crossing in each grid has been computed.

The average slope is then determined by using the formula,

TAN θ = (N x I)/636.6

Where N=average number of contour crossing

I = contour interval

TAN θ = the angle of slope in degree

The values derived has been categorised into classes and represent by interpolation and choroplething

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. This 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 amenities available in regards to solid waste disposal 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 has been based on the socio-economic composition

For commercial solid waste- the nature, amount of solid waste generation and disposal method of Iewduh 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 have been collected through informal interview and questionnaires. Biomedical waste has been selected for this study as this is one of the most hazardous waste generated within the Shillong Urban Agglomeration. There are 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 waste.

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 this 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, as to treat it as resource.

The dumping of solid waste 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.

1.8 **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.

1.9 **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 in detail.

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 method as well as the infrastructural facilities available for this has also been discussed in detail. 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 have been highlighted for certain localities within the Shillong Municipality and the township where density of population is high (2001 census). 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 since it 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 organisations which are looking after the supply and the quantum of water supplied has 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 (2001 census) 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, here 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 quality. 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 area 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 encroaches 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 recommendations. The entire thesis has been summarised. In this chapter on the basis of the findings certain suggestions have been forwarded to minimise the present geo-environmental problems caused by the rapid urban proliferation under the impact of population pressure and waste disposal having an impact on the geo-environment and water supply.

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CHAPTER II

SHILLONG IN ITS PHYSICAL SETTING

2.1 **Introduction**

In order to view the nature of the growth of Shillong urban agglomeration and associated problems of waste disposal and water supply it becomes imperative to have an insight into the physical/geographical setting of Shillong. In this chapter an attempt has been made to have a general understanding of the underlying geology, topography, soil, climate and vegetation of the Urban Agglomeration of Shillong.

Under the impact of urban growth the steep slopes are coming under constructional activities thereby resulting to break of slopes, soil erosion, enhancing landslides and mass wasting. Hence an attempt has been made here for the morphometric analysis of the relief and slope as this helps in identifying the areas not ideal for settlements. The major drainage basins on which the urban units of Shillong are located have also been identified. The present urban sprawl is affecting these drainage basins due to unscientific waste disposal and land reclamation from the streams resulting to geo-environmental problems.

The underlying geology plays a significant role in the evolution of topography and the hydrological characteristics. Hence an attempt is being made here to have an understanding of the geology of Meghalaya in general and Shillong in particular

2.2 **Geology**

The first geological study of the Shillong Plateau was initiated by Oldham (1858)[1] followed by systematic mapping of the region carried out by Medlicott (1869)[2] who in spite of all the limitations and heavy odds of the hostile terrain has critically examined the geological occurrence of the area.

Other geological work in the area was carried out by Palmer (1923)[3] followed by Ghosh (1936-39)[4] which led to the establishment of the strategraphic sequence of the region. However, the compiled geological framework of Meghalaya plateau has been provided by Murthy (1976)[5] and Mazumdar (1986)[6]. The generalised stratigraphic sequence is given in the table 2.1 while the description of the lithographic groups are as follows:

Table 2.1: Geological Strategraphic Sequence of Geological Formations in Khasi and Jaintia Hills

Geological Age	Group Name	Formation	Rock type
Recent	Newer alluvium (Thickness unknown)	Unclaissified	Sand, silt and clay
		UNCONFIRMITY	
Pleistocene	Older alluvium (thickness unknown)	Unclassified	Sand, clay, Pebbles, Granite, Boulder deposits.
Eocene	Jaintia group	Simsang formation-1150m Shella formation 600m	Siltstone, sandstone, alteration, of limestone Calcarian Shale, Sandstone, limestone.
Upper cretaceous	Khasi group	Mahadek Formation-100m Bottom conglomerate-25ml Jadukata formation-140m	Arkose (Glauconite) Conglomerate Arkose Sandstone Conglomerate Alteration
Jurassic	Sylhet trap	Jadukata Formation-600m	Basalt, Alkali Basalt, Rhyolite acid –tuff
Proterozoic	Pre Cambrian	Intrusive Acid and Basic Khasi Greenstone Shillong Group	Porphyrite, Coarse granite, Quartz veins, Epidorite Basalt, Basic sills and Dykes mostly within the Shillong group, Quartzite, Phyllite and Conglomerate.
	Archaen	Gnessic Complex	Biotite,Grains Biotite, Hornblende, Gneiss magnetite, Mica Schist, Granite etc.

Source: Geological Survey of India 1975, Geology & Mineral Resources of the Survey India· Part IV, Misc, Publication No.30, 69-79

The Gneissic complex

The Gneissic complex is exposed in the central and northern part of the Meghalaya Plateau and comprises mainly of gneisses of various composition.

Structurally the Gneissic complex, which has been called the "Archean Gneiss complex", shows a very complex and polyphase folding, currently with multi stage metamorphism as has been identified by Murthy (1976)[7].

Non-Perphyritic Nigmatitic Granitites

This class of rocks occurs through out the Gneissic complex in all scales as vienlets, interspatial permeation, patches and smaller irregular bodies.

Shillong Group

This overlies the Gneissic complex with an unconformity, comprising of variable quartzite amid phyllites, sandstones, siltstones, schist etc.

The Shillong group of rocks is weakly metamorphosed except at few places, which show higher degree of metamorphism.

This group of rocks shows a zone of sub vertical dips with local reversals from west of Mawphalang up to Barapani, away from this zone the dips show gentle rolling disposition. Such folding represents "Intermediate crestal type folding", Beloussov (1962)[8].

The Khasi Greenstone

This group occurs as isolated bodies in the Shillong group of rocks. These are intrusive having both argillaceous and arenaceous character. The Khasi greenstones are represented mainly by dolerite, epidorite and amphibolites. The overall structural pattern of the Khasi Greenstone suggests a NE-SW axis.

The Sylhet Trap

This comprises predominantly of basalts, rhyolite etc. This type of rocks is found along the southern border of the Shillong plateau. The maximum exposed thickness is about 500-600m.

Cretaceous-Tertiary Sediments

These groups of rocks occupy the southern part of the Meghalaya plateau. They occur as thick extensive sedimentary sequence comprising of sandstones, shales and limestones that occur as- (a) Discrete outliers, (b) a continuous narrow belt fringing the southern margin of the state bordering the Bangladesh plains.

The sediments here are divided into three major groups: (a) Khasi group, (b) Jaintia group and (c) Garo group.

2.3 Geology of the Study Area

After discussing the geology of Meghalaya it becomes necessary to have an understanding of the geology of the study area.

The Shillong city has a predominance of the Shillong group of rocks which comprises of sub-metamorphosed phases of argillaceous and arenaceous members with a distinct superimposition in the argillites underlying the arenites (Annon 1988-89)[9].

The entire Shillong group of rocks lie over the basement of gneissic complex and the geological succession of the different types of rocks (Table 2.2). The Mesozoic tertiary sediments especially towards the south of the study area finally overlie the Shillong group of rocks.

While the Khasi greenstone is concentrated in the southeastern section (along the course of river Umkhen) western and northwestern section of the study area. (Fig 2.1).

Along the course of the river Umshirpi, Pologround and Golf course there is presence of valley fill sediments, while residual soil cover is prevalent in and around Mawprem.

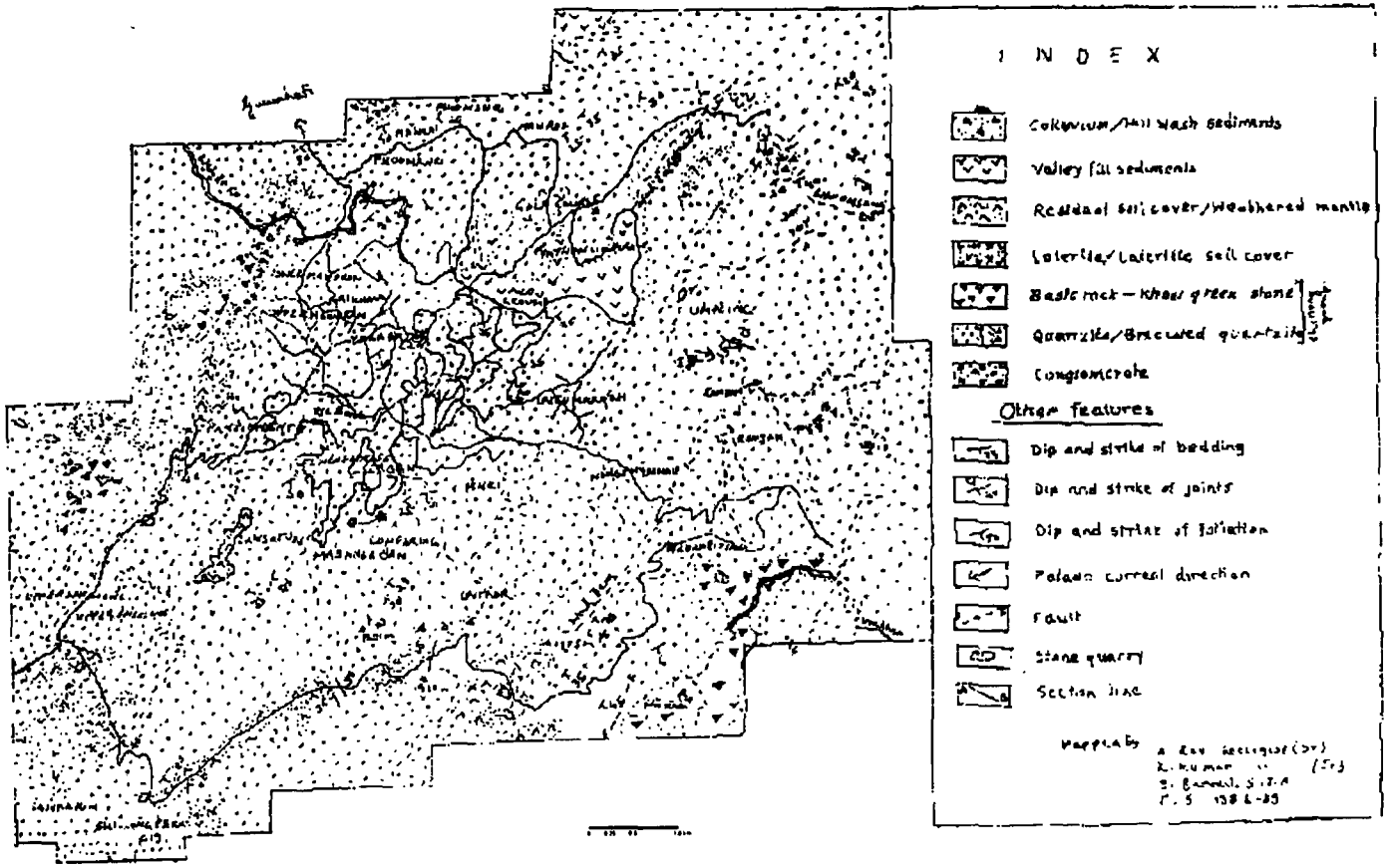
The Shillong group of rocks comprises of phyllites, quartz schist, quartzite, and intra formational conglomerates whose descriptions and distribution in the study area can be enumerated as follows:

Phyllites

These are reddish brown, pinkish to purple in color and are fine grained with well-preserved foliation and schistocity.

In the north they are exposed on the entire length of Shillong-Barapani road with thick weathered cover(Roy 1989)[10].

GEOLOGICAL MAP OF GREATER SHILLONG



Source: GSI Rec 123 pt. IV

Fig. 2.1

Quartz schist, quartz-sericite schist

These are well-foliated light grey to white colored rocks exposed along the National Highways number 40 and 44 both in the north as well as south of the study area.

Quartzite

The quartzite is hard compact massive light grey to buff colored rocks exposed on the roads and quarry sections of the study area. These rocks are coarse to granular in nature with well-preserved sedimentary structures. Towards the north and north east of Beadon Bishop falls as well as in the vicinity of the Phudmawri village the quartzite display an acute tendency of oxidation resulting to thick lateritic cover.

Intra Formational Conglomerate

These occur as depositional pebble beds, usually found overlying the phyllites and interbedded with quartz-schist as well as quartzite. These rocks are mainly composed of flat elongated pebbles of one centimeter to about ten centimeter in size (Roy 1989)[11]. This variety of rock is exposed in the south and southwestern part of Beadon Bishop falls.

Basic Intrusive

These groups of rocks have undergone metamorphism and have a greenish to black appearance hence the name Khasi green stone. The textures of this group of rocks vary from fine, medium to coarse grained. Its composition varies from basalt to dolorite, amphibolite to gabbroic. The composition of the Khasi Green stone varies from higher

elevation to lower elevation as well as from north to south. The Khasi Green stone has undergone metamorphism in many places. It has been observed when the Khasi Green stone have come into contact with quartzite that has undergone occasional assimilation with the surrounding rocks due to contact metamorphism.

Granites

These are pink to light grey in colour and are found along with quartzite towards the south of the study area.

Geologically Shillong presents an interesting study with varying rock groups (table 2.2) which were laid down as a thick pile of sediments possibly on a secondary basin over the gneissic complex and the placement of granites as intrusive may be considered as the end number of the tectonic phase (Roy 1989)[12].

Table 2.2: Stratigraphic sequence of the Shillong

Geological age	Group name	Rock types
Tertiary	Langpar formation	Brown sandstone and Shales
Upper cretaceous	Khasi group	Sandstones and conglomerates
Pre Cambrian	Shillong group	Quartzites, Conglomerates
Archean	Gneissic Complex	Gneiss, Hornblende etc.

2.4 Topography

Shillong and its suburbs falls on the central upland zone of Meghalaya plateau. The Meghalaya plateau is but a part of the peninsular plateau separated from it by the Garo Rajmahal gap. It stretches in an east –west direction abutting between the alluvial plains of Bangladesh in the south and Assam plains in the north.

The plateau characteristics are more pronounced in the southern part of the area, which has, numerous rises and steep wall descending into the Bangladesh plains. The Shillong range and the Laitkor range situated in the southern part of the study area, i.e., Greater Shillong area is the highest part of the plateau. Some individual peaks like the Shillong peak (1964 m) and the Laitkor Peak (1940 m) (Roy 1989)[13] above mean sea level are situated here which acts as the water shed.

The city of Shillong lies in the earthquake belt and is a horst that has been uplifted to its present height during the post Mesozoic era (Mazumdar 1976)[14]. The region exhibits numerous faults, fractures and troughs indicating active tectonic activities.

There are a large number of waterfalls in and around Shillong city, e.g., Spread Eagle falls on the course of river Umkhrah, Sweet falls on the course of the river Umkhen, Elephant falls and Gunner falls lying in the south western section of the study area, Beadon and Bishop falls also found in the south western section of the study area at an absolute altitude of about 1400-1600 m above mean sea level. This indicates that there is also the presence of youthful topography in an ancient pre-Cambrian shield.

The main city lies at an absolute altitude of about 1400-1600m above mean sea level. Wah Umkhrah, Wah Umshyrpi and Wah Umkhen are the three main streams draining the main city. While Wah Umshing drains the township of Mawlai. The Shillong urban agglomeration can be divided into five physiographic units (Dympep 1998)[15], viz.,

(i) The northern slopes of the Shillong range found towards the southern part of the Shillong urban agglomeration, consisting of the different localities of Upper

Shillong, Nongthymmai, Madanrting, Malki, Lumparing, Upper Laban and Lawsohtun etc.

(ii) The Umshirpi valley is a narrow valley located towards the southwestern part of the city occupied by the Cantonment area, Mawprem, Laban Kenchestrace, Jhalupara, Rilbong, Dhankheti etc.

(iii) The Laitumkhrah –Mawkhar upland area is located at the central part of the city and is largely occupied by the localities of Laitumkhrah, Police Bazaar, European ward Jaiaw, Mawkhar etc.

(iv) The Umkhrah basin that has the lowest altitude of about 1420m (near pologround) lies to the northeastern side of the Shillong urban agglomeration and is mainly occupied by the township of Pynthorumkhrah, Nongmynsong etc.

(v) The Umkhrah Umshing water divides skirting the northern western edge of the Shillong Urban Agglomeration, which is now occupied by parts of the township of Mawlai.

Hence it is towards the north of upper Shillong that most of the localities of the Shillong Urban Agglomeration lie. The topography comprises of rolling hills and valleys with varying relief. It is also characterised by the presence of low relief hillocks with gentle undulating valleys with varying relief characteristics.

The study area exhibits three structural terraces between Laitkor in the south and Barapani in the north. This may be partly attributed to the fold movements and partly to the later block movements, which has been suggested by abrupt scarps. In fact a conspicuous scarp exists between Laitkor peak and Shillong city (Roy 1989)[16].

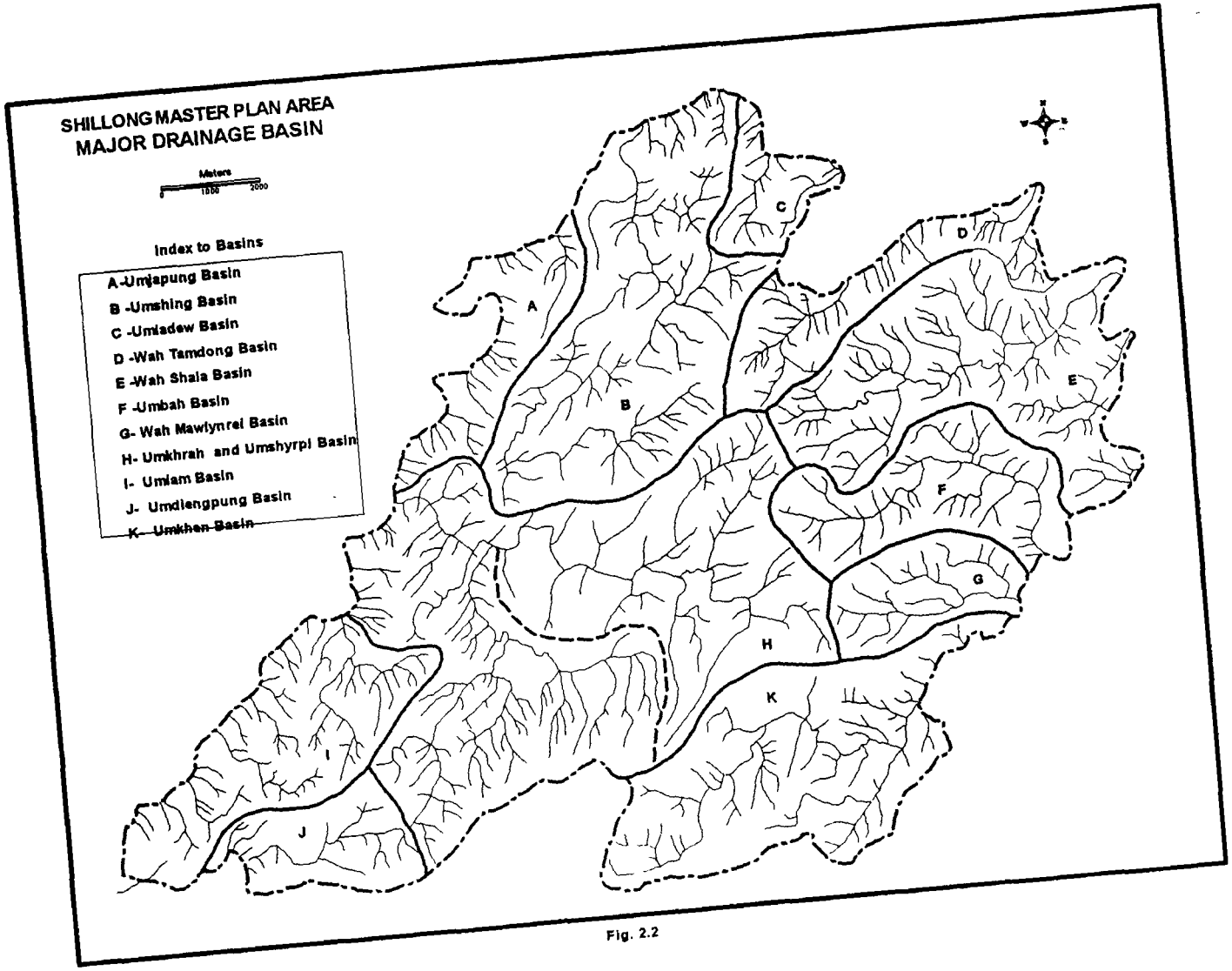

SHILLONG MASTER PLAN AREA
MAJOR DRAINAGE BASIN
Meters
0
1000
2000
Index to Basins
A -Umjapung Basin
B -Umshing Basin
C -Umladew Basin
D -Wah Tamdong Basin
E -Wah Shala Basin
F -Umbah Basin
G- Wah Mawlynrei Basin
H- Umkhrah and Umshyrpi Basin
I- Umiam Basin
J- Umdiengpung Basin
K- Umkhen Basin
A
B
C
D
E
F
G
H
I
J
K

Fig. 2.2

2.5 **Drainage**

The entire study area is divide into 11 river basins (Fig. 2.2) The Urban Agglomeration is located within the following basins:

(i) The Umshirpi and Umkhrah basin occupies the southern and central part of the study area, covers an area of about 51.62 sq km. The Shillong Municipality is located here having an area of about10.36 sq km. The Umshirpi starting from the Crinolines falls in the Lumparing area located in the south western section of the study area marks the southern boundary of the Shillong municipal limit. This river takes a north westerly direction and joins the river Umkhrah near the Beadon Bishop falls at Mawprem to form the Wah Ro-ro a tributary to Wah umium which marks the western boundary of the study area.

The Umkhrah has its source at Nan Syiem, and flows down the steep slopes of Nonghtymmai under the name of Demthring. Near Umpling it is joined by other primary order streams and is called the Umkhrah river which starts from Umpling, located towards the southeastern section of the Shillong city at an absolute altitude of about 1516m above mean sea level. This river flows through the northern sector of the Shillong city and roughly demarcates the northern boundary of the Shillong municipal limit. The Spread Eagle falls located near Umpling the river Umkhrah takes a north westerly direction and flows towards Beadon Bishop falls.

The streams feeding the Umshirpi and Umkhrah originate from the higher altitudinal zone of Shillong ridge having an absolute relief of about 1800-1900 m which is

located to the south of the study area. According to Nongkhlaw (2003)[17] there are nine over ground rivers viz. Umjasai, Ummawlong, Umsohkhlur, Umshynrut, Umshawshaw, Umrisa, Umkdait, Umdienglieng and Umjynriew which ultimately meets to form the Umshirpi and Umkhrah. However mention must be made here that both these streams have been encroached by the urban activities so much, that much of the stream areas have been filled up for constructional purposes. They can no longer be termed as rivers as they have been turned into sewage and garbage drains to serve the growing population of Shillong who dump their waste here.

(ii) The Umkhen basin drains the southeastern section of the study area. It occupies an area of about 39.26 sq km of the study area. The township of Madanrting an urban component of Shillong Urban Agglomeration is located in this basin. The Happy valley cantonment is also located here.

(iii) The Umroh basin (fig.2.2) occupies a very small section of the study area of about 4.56 sq km and lies in the outskirts of the Shillong Urban Agglomeration towards the eastern part.

(iv) The Wah Shella basin lies also in the eastern section of the study area on the outskirts of the Shillong Urban Agglomeration. It occupies an area of about 13.98 sq km.

(v) The Wah Tamdong basin is situated next to Wah Shella basin (Fig. 2.2) occupying an area of about 8.28 sq km

(vi) The Umshing basin occupying an area of about 29.64 sq km. lies in the northern sector of the Master plan area. The southern part of this river basin forms the northern fringe of the Shillong Urban Agglomeration Mawlai township is located.

The new township of Shillong is to be situated towards the north eastern section in the wah Shella and Wah Umroh basin. Mention must be made here that the Umshing, Wah Tamdong rises from the Mawpat ridges situated towards the north eastern part of Shillong

As the study area is characterised by a hilly topography, the first and second order streams dominate the area. The drainage pattern is mainly sub-parallel to dendritic in nature depicted in the drainage map of the area (Fig. 2.2) The streams tend to flow through the joints and faults of the area, which is reflected in almost straight stream courses. There is also presence of numerous 'V' shaped gullies in the study area. The major streams have also have cut deep gorges which are often narrow and have a depth of more than 600 m (Directorate of Urban Affairs 1991)[18].

2.6 **Soils**

Like other regions the soils here too is influenced by various factors like geology, relief climate and vegetation. There are four distinct categories of soils found here which are as follows:

1. Soils over gneissic terrain, which has been further sub-divided into the following.

The red loamy soil, this type of soil is found in the upland zone of Khasi Hills. This type of soil is derived from the weathering of granites, gneisses and diorites etc. In the study area this type of soil is found towards the south. This type of soil is rich in silica having a general loamy character, varying from clayey to sandy (Gopalakrishnan 1989)[19].

Soils over Shillong group- soils derived from rocks of Shillong group are medium to fine textured. The depth of the soil horizon varies between 20cm-200cm (Agarwal 1989)[20]. Due to continuous leaching the bases are leached out. The soil in general is homogenous, granular, and loamy to clayey. The colour varies from very dark grayish brown to yellow and brownish yellow. Due to the presence of evergreen forests the topsoil is rich in humus however due to the constructional activities in the Shillong Urban Agglomeration much of the humus content is lost.

Soils over Khasi Greenstone, this type of soil is typically lateritic giving a reddish brown hue to the landscape around. The soil is clayey to loamy, moderately fine and granular in characteristics. Its colour varies from yellow red to red.

2. The laterite soil this type of soil is found in broad belts extending from west to east in the northern part of Meghalaya plateau. This type of soil has been formed due to weathering of quartzites, schist, conglomerates etc. The soil is reddish or yellowish in color and rich in iron.
3. Red and yellow soils which are largely found in the in the foothills regions along the east and western belt of Meghalaya and as such is not an important soil category of the study area.

4. Alluvial soil, this type of soil is found along the north western and southern fringes of the plateau. In the study area it is found in the Pologround area, they vary from sandy to clayey loam with varying nitrogen content (agarwal 1989)[21]. They are rich in potash but poor in phosphate. In general the soils are thin, immature and light in colour.

Hence the soil of the study area reflects the geology, relief, climate and vegetation. According to Prasad (1981)[22] steep slopes accelerate removal of soil coupled with various agencies like high intensity of rainfall, and human activities. The study area being the largest urban center of Meghalaya the soil profile has been affected by human activities like constructional activities and jhum in the outskirts of the city that has resulted to high degree of soil erosion.

2.7 **Climate**

Climate plays a significant role in determining the amount of water supply in any area because it is the total amount and type of precipitation which will determine the nature and amount of surface runoff, this in turn will determines the amount of discharge in the streams.

Climate also plays a significant role in regards to solid waste disposal. Shillong situated in a plateau characterised by heavy rainfall most of the solid wastes dumped on the streams and roadsides are washed away from the waxing slope thereby giving Shillong a cleaner appearance.

The seasonal winds, i.e. southwest and northeast monsoon circulation as well as the altitude of the area controls the climate of Shillong.

The Shillong range lying in the south of the study area having an absolute altitude of about 1800-1900+ m above m.s.l. and extending in an east west direction across the path of the south west monsoon winds play a significant role in governing the weather condition of the area.

Due to Shillong's location on the northern leeward side of the range it is in the rain shadow zone, thus there is relatively less rainfall then Cheerapunji, Mawsynram areas (Hussain 1984)[23]. Shillong lies in the leeward side and thus receives less rainfall than Cherrapunjee which is about 50 km. south of Shillong.

The climate of the study area can be described as a typical mountainous monsoon climate with sufficient rains in summer.

Geographically the climate of Shillong can be classified under the humid sub-tropical climate, characterised by high rainfall mostly during summer.

According to Koppen's empirical classification of climate, with some minor modification the climate of Shillong can be classified under C climatic scheme known as Humid Mesothermal Climate (Hussain 1984)[24].

On the basis of temperature and precipitation the climate of Shillong comes under **Cmk** (Hussain 1984)[25] designation of Koppen's scheme where

C = Warm temperate rainy climate with mild winter
m = Monsoon regime of precipitation with short dry season compensated by heavy rainfall during rest of the year.
k = Mean annual temperature below 18^0 centigrade.

All these characteristics are found in the climate of the study area in the nature of cold dry winter, heavy rains from June-August Mean annual temperature of the warmest month above 18^0, i.e., ranging around $20\text{-}25^0$.

2.8 Natural Vegetation

Meghalaya is endowed with rich and luxuriant vegetation cover and is regarded as one of the biodiversity Hotspot of the country that supports dense natural forest cover. The natural vegetation of Megualaya can be divided into three groups viz.

1. Mixed evergreen forests in the southern parts.
2. The rolling grasslands and the pine forests of the central upland zone.
3. Grasslands with scattered pine trees, which have been observed in the higher altitudes.The hilltops are smooth with shallow sub-soil supporting the growth of several species of grass (rao 1968)[26].

Pinus Khasiana is the principal flora of the Shillong Urban complex The pinus khasia has fair to poor water retaining capacity and is found at an altitude of 950m- 1850m (Directorate of Urban Affairs 1991)[27]. As the average altitude of Shillong is around 1500 m above m.s.l. almost all the area is covered by Pine forests.

Shrubs are more prevalent on the moderately steep slopes especially on the absolute relief of more than 1900m, i.e. to the south of the study area.

The Pine forests dominate here. Forests of the study area occupy about 1220.40 hectares of the land accounting for 11.76 percent of the total Master plan area. Out of this

only 8 percent of the forests of Shillong is under the state control(Directorate of Urban Affairs 1991)[28], while the rest is classified as private forests.

The rapid growth of Shillong Urban Agglomeration is leading to indiscriminate felling of trees as more forested land is coming under constructional activities.

Due to the lack of sound plan and programme coupled with lack of scientific management of the forests, the natural vegetation of Shillong is under threat, which may have a serious repercussion not only on the water supply but also on the ecological balance of the city. The southern part of Shillong is the water shed zone of the Meghalaya plateau. Hence deforestation in such area can lead to serious natural hazards like soil erosion, loss of soil nutrients reduction of the percolation capacity of the soil, increase of surface runoff, mass wasting and lowering of the stream discharge etc.

This makes it essential to analyse the relief and slope characteristics of Shillong. The morphometric analysis of the terrain indicates that Shillong is not ideal for urban settlements and constructional activities.

2.9 **Morphometric Analysis**

(a) Absolute Relief

An initial step to study the geo-environment of any area is the analyses of its relief features. Variations of the earth's surface or part of it become the focus of any geographic study especially in this case where the study highlights waste disposal; and water supply of the Shillong Urban Agglomeration. Relief and other geomorphic elements on which the geo-environmental analyses are dependent are absolute relief, relative relief and slope

which ultimately help in classifying and mapping of those areas which are not suitable for settlements and other urban functions. Slope and relief analysis becomes significant especially in this study as it indicates the water source region that needs to be protected from urban activities. Here an attempt has been made to have an understanding of the relief and average slope analysis of the area so that the problems associated with water supply and waste disposal becomes minimal. The process of evolution of relative relief depends much upon geological structure, types of rocks, climatic conditions and nature of the original absolute relief of the area. The geology, types of rocks, climatic conditions have already been discussed in the above paragraphs; hence an analysis of the absolute relief becomes essential.

Distributional pattern of absolute Relief

The absolute relief of the study area varies from 1080m in the northwestern section of the study area to 1964m i.e. the height of Shillong peak located in the extreme south. The absolute relief of the study area varies from 1080 m to 1964 m (the height of Shillong peak) above mean sea level. The absolute relief increases from north to south. The highest part of the study area consists of a mildly undulating plateau top of limited width stretching along east west direction and having an altitude of 1800 m and above. The approximate area falling under this absolute relief category is about 10 sq. km. that is covering an area of about 5.9 percent of the study area (Fig.2.2) It is here that both Shillong peak and Laitkor peak are located . This marks the southern boundary of the study area.

The absolute relief has been divided into five categories ranging from less then1200m to more than 1800m at an interval of 200m (Fig. 2.3). Table 2.3 gives the area altitude relationship.

Table 2.3: Absolute Relief categories of Shillong Master Plan Area

Absolute Relief (meters)	Frequency of frids	Percentage of total frequency	Approximate area (Sq. Km)	Area in percentage to total area	Cumulative Area in percentage to the total
< 1200	14	7.53	9.26	5.67	5.67
1200-1400	54	29.03	54.51	32.49	38.16
1400-1600	67	36.02	60.24	35.48	73.64
1600-1800	35	18.82	35.42	20.86	94.10
> 1800	16	8.60	10.01	5.90	100.00

It has been observed (Fig. 2.3) that the absolute relief of the study area increases from north to south.About 9.62 sq km.is located to the extreme northeast bordering the umiam lake has an absolute relief of less then 1200m above m.s.l. This covers only about 5.67 percent of the Master Plan area area.

About 54.51 sq km.of the Shillong Master plan area has an absolute relief of 1200-1400m. This category accounts for 32.49 percent of the Shillong Master plan area. This category of relief is found towards the southern part where relief is less than 1200m, especially in the western, northern and eastern sector of the study area, stretching to the northern outskirts of the Shillong Urban Agglomeration. The Township of Pynthorumkhrah and part of the new township of Nongmynsong has an absolute relief of 1200-1400m. Much of Golf links, Pasteur Institute and the northwestern part of Mawlai Township has an absolute relief of 1200-1400m above m.s.l..

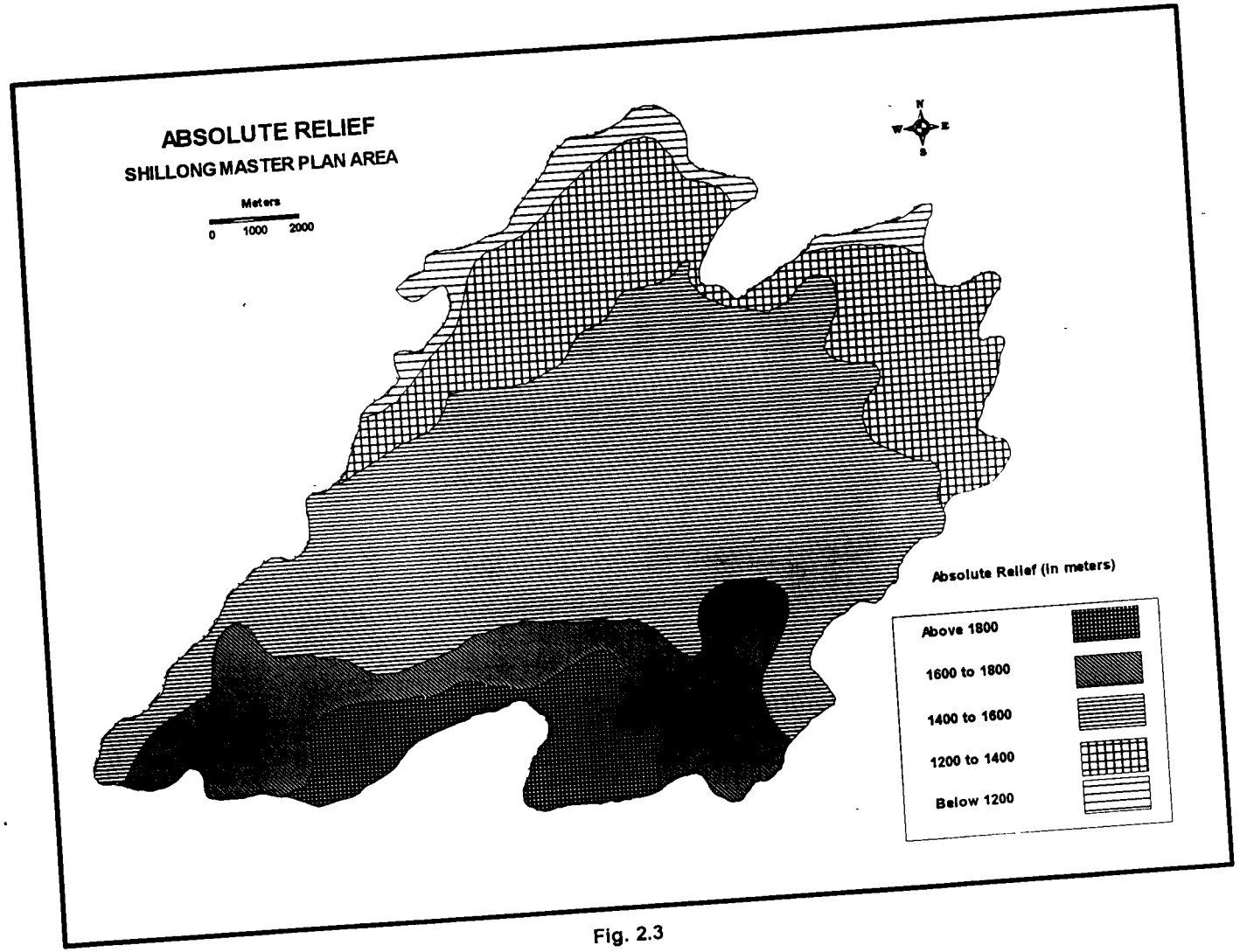

ABSOLUTE RELIEF
SHILLONG MASTER PLAN AREA
Meters
0 1000 2000
N
W
E
S
Absolute Relief (in meters)
Above 1800
1600 to 1800
1400 to 1600
1200 to 1400
Below 1200

Fig. 2.3

The next category of absolute relief ranging from 1400-1600m above m.s.l. covers the maximum area. About 60.24 sqkm of the Master plan area comes under this category of absolute relief and accounts for about 35.48 percent of the study area. This category of relief is found in Shillong proper comprising of Mawlai, Jhalupara, Barabazar, Police bazar Assembly complex, part of laban, part of Laitumkhrah, Umpling, Mawpat etc. in fact most of the Shillong Municipal area and part of the Cantonment is located here.

This is a highly congested area where much of the land is under settlements and roads. It is here that the numerous small streams have disappeared under constructional activities.

The subsequent category of absolute relief ranges from 1600-1800m lies to the south and occupies about 20.86 percent of the Master plan area (about 35.42 sqkm). This category of relief is found in the localities of the southern part of Laitumkhrah, Risa colony, Malki, Lumpering, Tripura castle road, Kenchestrance, Madan Laban within the Shillong Municipality and Lowsohtun, the townships of Nonthymmai and Madanrting

Due to population growth this area is now occupied by settlements. Deforestation in this zone is having detrimental effect on the water supply of the Shillong Urban Agglomeration. All the seven Municipal sources of water consisting of natural springs are located here. This area has some reserved forests controlled by the State Government this has restricted deforestation to some extent.

However field investigation shows that that area where the forest is under the community there are rampant deforestation, no data is available on the rate of

deforestation. But it is evident that much of the previous forested area has been cleared for human settlements and urban activities.

The populated Nongthymmai Township has the highest density in the Shillong Urban Agglomeration ie.11675 persons per sq km with a total population of 34207 (Census 2001)[29] in an area. Where 2.93 sq km has been deforested. This township consists of eleven localities with an absolute relief of 1600-1800m above m.s.l. spread over an area of 2.93 sq km. with certain localities like Lau-u-sib is only about a year old. Some of the respondents of this area are of the view that over the years the water supply of these localities which are usually spring fed are facing water scarcity especially in the dry season because of deforestation in the upper slopes. The water supply source of Dumdum a locality situated here, is shrinking and the community living here is looking for an alternate source of water. Certain localities like Nong-Khyreim, Demthring, Upper Lawjheinriew, are prone to mass wasting due to constructional activities.This is also a reason for water crises in these localities.

The extreme southern part of the study area has an absolute relief of above 1800m. This is the highest part of the study area where Shillong peak is located at an altitude of 1964m, which is also the highest part of the Meghalaya Plateau. The Laitkor peak located at an altitude of 1941m is also located here. There is a small lake towards the north east of Shillong peak; which has an absolute relief of above 1800m with an area of about10.01 sq km. ie.This accounts for about 5.90 percent of the total study area. This area, acts as the water shed zone of the Meghalaya plateau.

Hence an analysis of the absolute relief indicates that the height of the study area decreases from south to north thus the slope is also from south to north. It is the southern, southeastern and southwestern part of the study area, which is not geo-environmentally suitable for massive urban construction and urban activities. This area acts as the source region for Shillong's water supply. The river Umiew has its origin here and flows towards the south to Bangladesh plains. This river is tapped at Mawphalang about 30 km from Shillong proper,and supplied to the greater Shillong water supply scheme operating under the Public Health Department, Government of Meghalaya. The total capacity at present of this reservoir at Mawphlang is about 7.5 million gallons (PHE Report 2001)[30] of water per day whose total capacity will increase to about 11.3 million gallons (PHE Report 2001)[31] per day, i.e., after the completion of the project which was due by 2003 but still incomplete. Hence deforestation due to urban sprawl in this zone should be restricted, as deforestation will lessen the percolation capacity of the soil and may decrease the amount of discharge in the streams.This may also increase the surface runoff and soil erosion rate which may pollute the streams.

Moreover the seven natural springs and streams which are the sources of supplying water to the Shillong Municipality are also located close here at an elevation of about 1800m and above, hence the urban expansion will result to the 'roofing over' of the previous moisture retaining soils with concrete settlements, pavements and buildings. The population residing here often discharges their solid wastes directly into the streams affecting not only the quality of water but also the quantity.

(b) Relative relief

Relative relief is one of the techniques by which the three dimensional relief characteristics may be represented in two-dimensional maps. It visualises the sharpness of the relief that cannot be expressed by absolute relief maps, profiles and area height curves. The term relative relief in general denotes the actual variation of height in an unit area with respect to its local base level.

A scientific and system study of relative relief was done by Smith (1935)[32]. There has been frequent applications of relative relief concept since the time of Smith.

The distributional pattern of the relative relief (Fig 2.4) indicates that maximum area is covered by moderately high relative relief. Moderately high relative relief of 100-200m is found in the central portion of Shillong where the CBD of the city is located. Very high relative relief is found towards the western section bordering the wah Umiam.

Table 2.4: Relative relief categories and its area within the Shillong Master Plan

Relative relief groups (meters)	Frequency (number of grids)	Percentage of frequency to total frequency	Area in sq km (approximate)	Area in %	Cumulative area in %	Remark
<100	4	2.15	5.83	3.35	3.35	Moderate
100-200	130	69.89	114.51	65.88	69.23	Moderately high
200-300	34	18.28	31.80	18.30	87.53	High
300-400	12	6.45	11.22	6.46	93.97	Very high
> 400	6	3.23	10.44	6.0	100	Very high

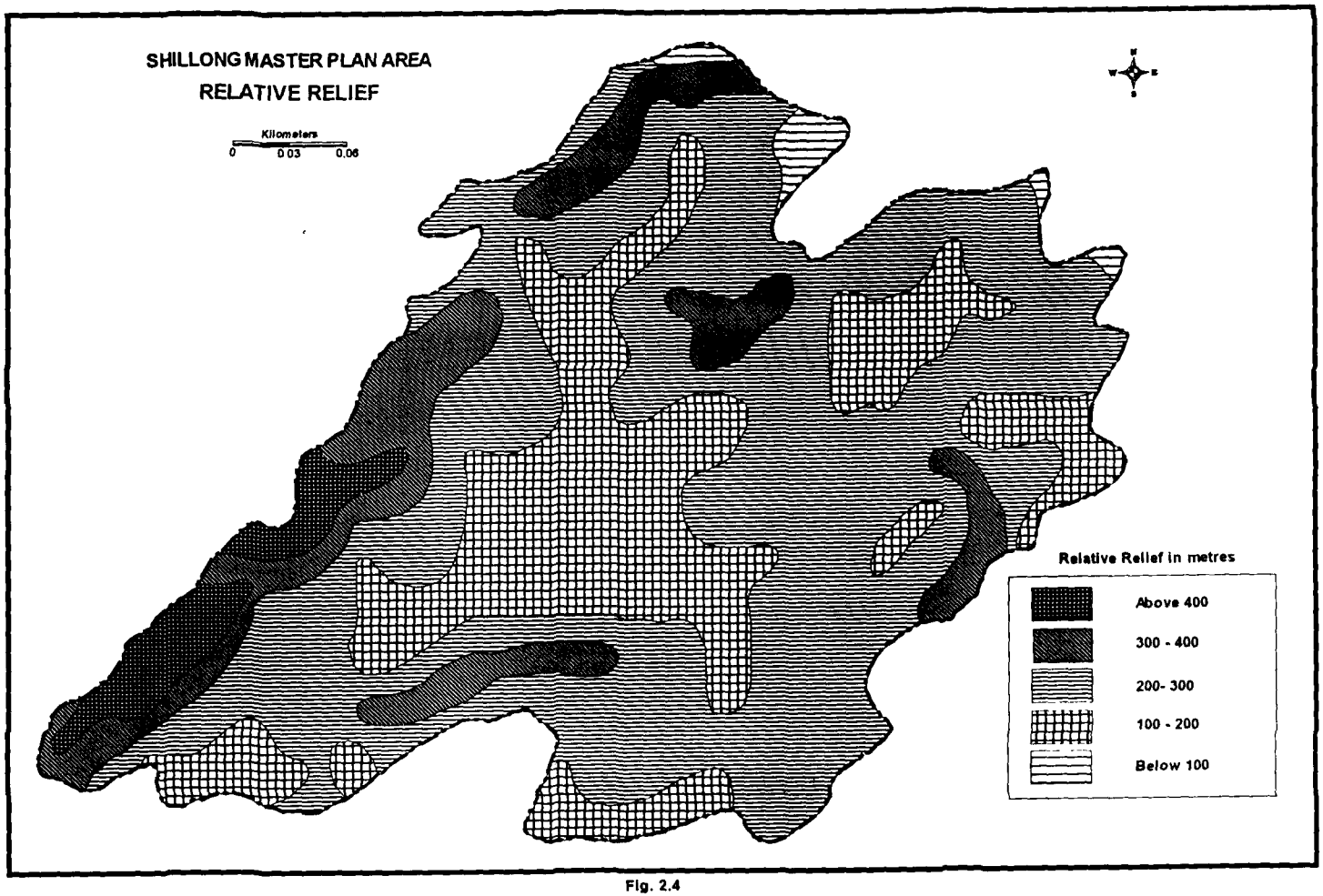

SHILLONG MASTER PLAN AREA
RELATIVE RELIEF
Kilometers
0 0.03 0.06
Relative Relief in metres
Above 400
300 - 400
200- 300
100 - 200
Below 100

Fig. 2.4

(c) Average Slope

Slope is a function of relief inclination usually shown in degrees. In the development of slopes, various factors are involved including tectonic and climatic factors. It is slopes, which often determine human activities, and it is again human activities, which often modify the slopes. Since the very beginning of geographical studies, which highlights man environment relationship, the slope analyses and its categorisation have received remarkable attention. The scientific and systematic studies of slopes were started in the late 19^{th} and 20^{th} centuries. Significant contribution in this field has been made by Finster Walder (1890), Rich (1930), Wentworth (1930), Raiz and Henry (1937), Smith (1938), Strahler (1956)[33] etc.

In this particular study a slope analyses becomes essential, as the study area is characterised by a hilly topography where the absolute relief ranges from 1080m to 1964m above m.s.l. Slopes are ubiquitous elements of the land surface. The slopes exert tremendous control over human activities besides development of soil profile, loss of soil due to erosion etc. A detailed analysis of slope of the study area becomes essential before chartering any developmental activities catering to the urban expansion and related activities of the city. The slope gradient of the study area has been analysed from a slope map using the modified version of C.K. Wentworth's method.

The study area has an average slope value ranging from 2^0 to 31^0.

An analysis of the table 2.5 and fig 2.5 reveals a clear picture of the distributional pattern of frequencies according to the slope categories. It highlights that the category of moderately steep slope accounts for 62.36 percent of the total frequency [illegible]

the maximum slope frequency, whose values ranges from 10-15^0 and 15-20^0. Next is the moderate slope 5-10^0 accounts for 22.04 percent of the total frequency followed by the steep slope of 20^0 and more which accounts for 12.37 percent of the total slope frequency. The least share of slope frequency of about 6 percent is held by the gentle slope category of 5^0 and less.

Consequently the distribution of slope frequency suggests that the study area is occupied mainly by slope gradient ranging from moderately steep to steep slope (table 2.5). This necessitates an understanding of the areal distribution and analyses of slope in order to understand the geo-environmental concerns of the study area especially in regards to the solid waste disposal and water supply of the area.

Table 2.5: Average slope categories and its area within the Shillong Master Plan Area

Class in ^{0}	Frequency of grids	Percentage of grids to total grids	Area in sqkm.	Percentage of each category to the total area	Remarks (Broad categories)
< 5	6	3.23	.99	57	Gentle slope
5-10	41	22.04	45.01	26.01	Moderate slope
10-15	66	35.48	60.02	34.69	Moderately steep slope
15-20	50	26.88	47.82	27.64	Moderately steep slope
> 20	23	12.37	19.19	11.09	Steep slope

Areal distribution of slope

An analysis of the broad categories of average slope (Fig 2.5) gives a clear insight into the areal distribution of the average slope on the study area which has been discussed under the following broad categories.

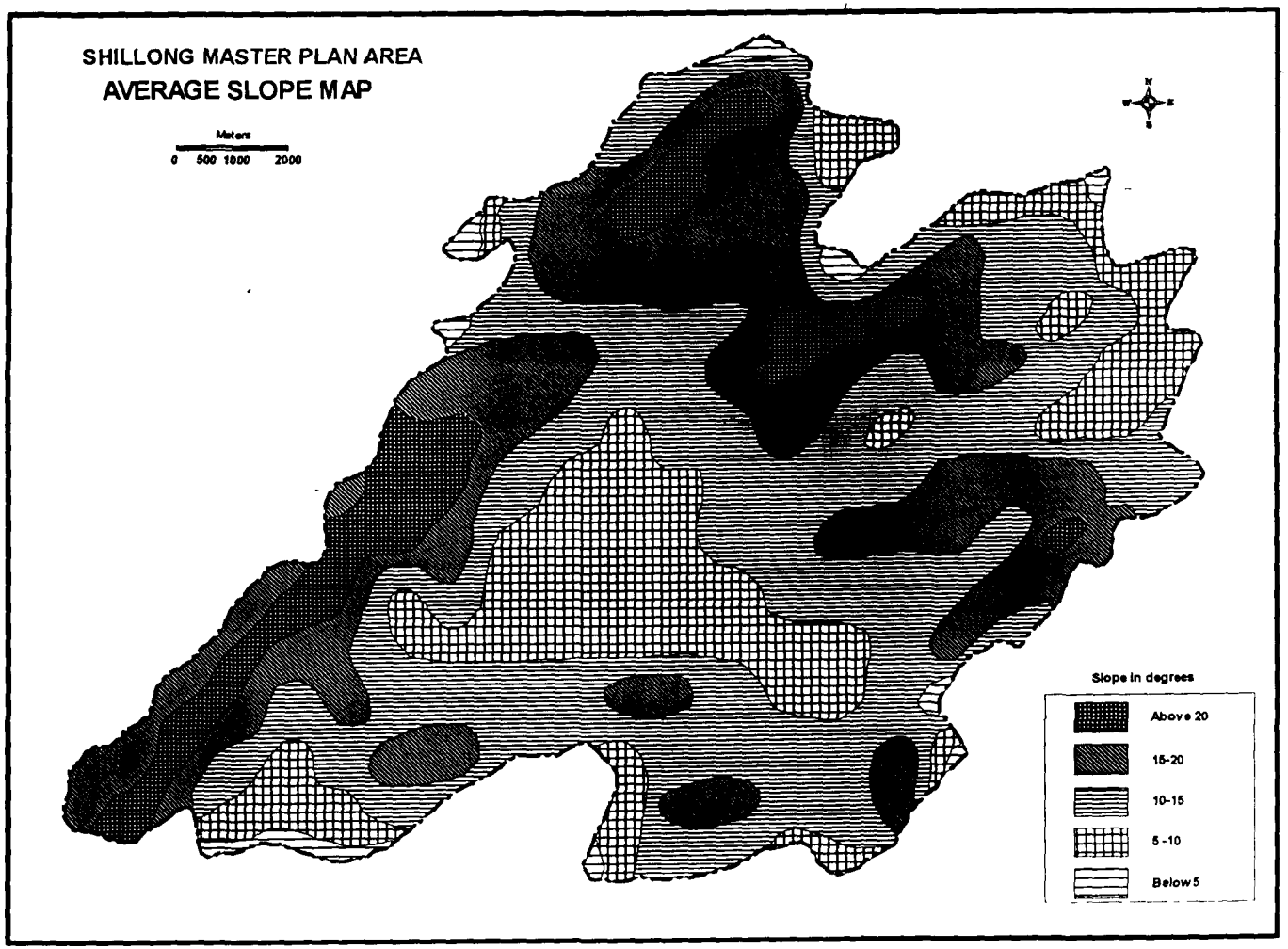

SHILLONG MASTER PLAN AREA
AVERAGE SLOPE MAP
Meters
0 500 1000 2000
Slope in degrees
Above 20
15-20
10-15
5-10
Below 5

Fig. 2.5

Gentle slope (5^0 and less)

This slope category records only for 0.99 sq km is found in small patches in the south western part of the study area near upper Shillong. This gentle slope is also found in the northwestern part of the city bordering the lake Umiam.

This slope is ideal for constructional and permanent settlements as it gives ample land with gentle slope. However recently due to solid waste dumping on the bank of the streams and filling up of the streams due to constructional activities these areas of gentle slope is prone to flooding. A recent newspaper report suggests that these areas are flooding annually[34].

Moderate slope ($5\text{-}10^0$)

This slope indicates undulating uplands. However walking in this gradient requires considerable effort. This category of slope occupies 45.01 sq km of the study area> That accounts for about 26 percent of the total study area.

This slope category is found in patches to cover a large part of the study area and usually includes pediment and hill slopes, boulder outcrops and rock surface with thin soil cover.

Moderate slope is also found in patches in the northwestern part of the study area bordering the Umiam Lake.

This category of slope is good for housing and other urban functions. It has been observed that at this gradient the water supply to the individual settlements need special effort. Hence each individual house is supplied water from the main tanks of the locality

by individual pipelines. This often results to severe wastage and contamination of water as it becomes difficult to maintain so many pipes that often leak and usually passes through the main drains of the localities.

Moderately steep slope (10-15^0& 15-20^0)

Maximum part of the study area falls under this category of slope. About 107.84 sq km of the study area is under this category accounts for 62.33 percent of the total study area. Here the slopes are fairly steep and walking uphill in these areas needs much effort. This category of slope lies widely in the study area covering the localities of Lawsohtun, Kenchestrance, Bishnupur, Lumpering, Laitkor, part of upper Shillong, Happy Valley, Mawpat, Townships of Mawlai, Madanrting and upper Nongthymmai. Thus the eastern, northwestern, some portion of the south and central part of the Shillong Urban Agglomeration has a slope gradient of 10-20^0.

As a result of urban expansion constructional activities are increasing This is due to population pressure which ultimately is leading to deforestation. This in turn is leading to increase in soil erosion due to surface runoff. This is results to the development of furrows and gullies which are observed at the localities of Lumpering, Demthring and Laitkor where the soil loss has resulted to the formation of lateritic crust in these area ((Directorate of Urban Affairs 1991)[35].

The settlements which have come up here especially in the townships of Mawlai, Nongthymmai, Madanrting do not have any centrali[s]ed system of waste disposal as they are not under the Shillong Municipality. The field study on Nongthymmai Township has

been that about 45 percent of the surveyed households dispose off their wastes directly into the streams. As regards to water supply most of the settlements have to meet their own water requirement. This is usually managed and maintened by the local 'durbar'.

Steep slope (20^0 and more)

This fifth category of slope unit accounts for 19.19 sq km of area, i.e., 11.09 percent of the total study area which has a very steep slope. The extent of this slope class is limited (Fig 2.5). This category of slope is found in the south eastern, western and a small portion of the northwestern part of the Shillong Urban Agglomeration, covering small portions of Mawprem and the townships of Mawlai and Madanrting.

In this category the gradient of slope is formidable obstacle in leveling the ground for settlements. Forests bordering the river Umiam in the west mainly occupy this category of slope range. Physical constituents like slope, soil moisture content as well as forest litter helps in the growth of thick vegetation here.

However under the impact of population growth and the resultant urban sprawl these areas are coming under habitation thereby causing serious geo-environmental concerns. The loss of vegetation in these category of slope has accelerated high rate of run off which in turn has led to gully formation. The first and second order streams that dominate in these areas have been affected. Thus rill and gully erosion has enhanced here which in turn has promoted rock fall as there is no binding matrix (Directorate of Urban Affairs 1991)[36].

Limitations

In the preparation of the average slope map (Fig 2.5) that the slope units selected to express geographical significance are not rigidly true to angular scale,but a generalised picture. As for example a slope instead of being uniform may be concave or convex or it may be marked by knicks associated with rapids and waterfalls (this is found in large numbers in the study area). These irregularities has been overlooked while preparing the average slope map of the study area.

To conclude, this chapter basically highlights an understanding of how the physical setting of the study area has an impact on the water distribution and waste disposal of the study area. With population growth (discussed in chapter III of this thesis) the marginal areas come under habitation, that are often not ideal for settlements and human activities. These human activities habitually generate wastes when not properly disposed has a negative impact on our geo-environmental resource especially on water resource.

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CHAPTER III

POPULATION GROWTH AND RESULTANT URBAN EXPANSION

3.1 Introduction

After a detailed discussion on the geographical background of Shillong it becomes imperative to trace the historical growth of the city. Growth of Shillong as an urban centre can be traced to the British administration in India in the mid 19th century. However the present nature of urban growth of Shillong especially after the creation of the state in 1972 has been highlighted here as it is resulting to various geo-environmental concerns.

Shillong a hill station supports more than 60% of the urban population of the State. Due to its rugged terrain there are constraints in development. The topography is marked by relatively steep to steep slopes which restricts urban growth. Due to such topography large number of primary order streams dominates the landscape and this became the main source of water to the population living here. Under the impact of urbanization these streams are often the recipients of the effluents of the growing population of the city. These streams habitually disappear from the surface due to land reclamation and channelisation which leads to geo-environmental problems.

It has been observed that the townships of the Shillong Urban Agglomeration are growing at a much faster rate than the city proper which is acting detrimental to the geo-environment of the study area. These townships totally lacks in any form of organized solid waste disposal system. In the absence of proper solid waste disposal the effluents generated by this growing population are dumped into the streams, streets and roadside drains of the localities.

This is why the present chapter tries to analyse the nature and rate of growth of the urban components of Shillong.

This chapter basically deals with an overview of the rate of population growth and the resultant spatial growth of the city taking within its ambit the peripheral lands are not necessarily ideal for urban growth.

3.2 **Shillong as an Urban Center**

The process of urban growth of Shillong can be traced down to the period of 1863-64 when the British shifted their head quarters of Khasi and Jaintia Hills from Cherrapunjee to Shillong (Pakem 1984)[1].

Before 1864 Shillong was an unknown nomenclature. (Fig 3.1) Deep forests with Laban a small village and certain small villages under the United Khasi State of Shillong then covered its present area. It was in that year that Shillong became the administrative headquarter for the Khasi and Jaintia Hills. Hence the evolutionary history of the Shillong, being principally an administrative satellite center of the British Raj has till date preserved its characteristics of an administrative center essentially being service oriented.

With the acquisition of the Dewani of Bengal by the East India Company in 1765 A.D. (Chowdhury 1998)[2] and the Yandaboo Treaty in 1826 A.D. (Chowdhury 1998)[3] the Shillong plateau and the Khasi and Jaintia Hills came under the British rule. The British selected Cherrapunjee as the Military station for this region in 1829.

Due to the inclement weather conditions of Cherrapunjee as the highest rainfall place of the World and thoughts for better water supply facilities, the British administration felt the need to shift their headquarter from Cherrapunjee to a better centrally located area where water supply could be adequate as well as the weather

conditions are more pleasant. Consequently a Committee of Enquiry was appointed for this purpose, which comprised of Colonel Richardson (Syiemlieh 1989[4] the Commanding Officer of the British troops stationed at Cherapunjee and B.W.D. Morton the Deputy Commissioner of the United Khasi and Jaintia Hills.

The team after studying the surrounding areas like Sohrarim, Mairang, Laitlyngkot and Nonkrem ultimately selected a large open space to the north east and east of the Shillong peak as the future headquarter. But it was found that the area does not have sufficient water supply in all seasons of the year, thus such a location was not ideal for sustaining a larger population.

Finally it was decided that the best location might be the northern slopes of the Shillong Range and the Plateau of Iewduh, which is the present market center of Shillong and is now the heart of the city. Hence it is seen that the British administration gave due weightage to the water supply besides other factors before setting up the station here.

Accordingly on 8th December 1863, the British administration signed an agreement with the Syiem of Mylliem and Syiem of Khyrim (on whose state the proposed site was located) (Syiemlieh 1989)[5].

It is seen that the geo-environmental factors were given due weightage by the British while selecting the location. The new Headquarter was located at an absolute relief of 1400m–1600m in the Umshirpi basin.

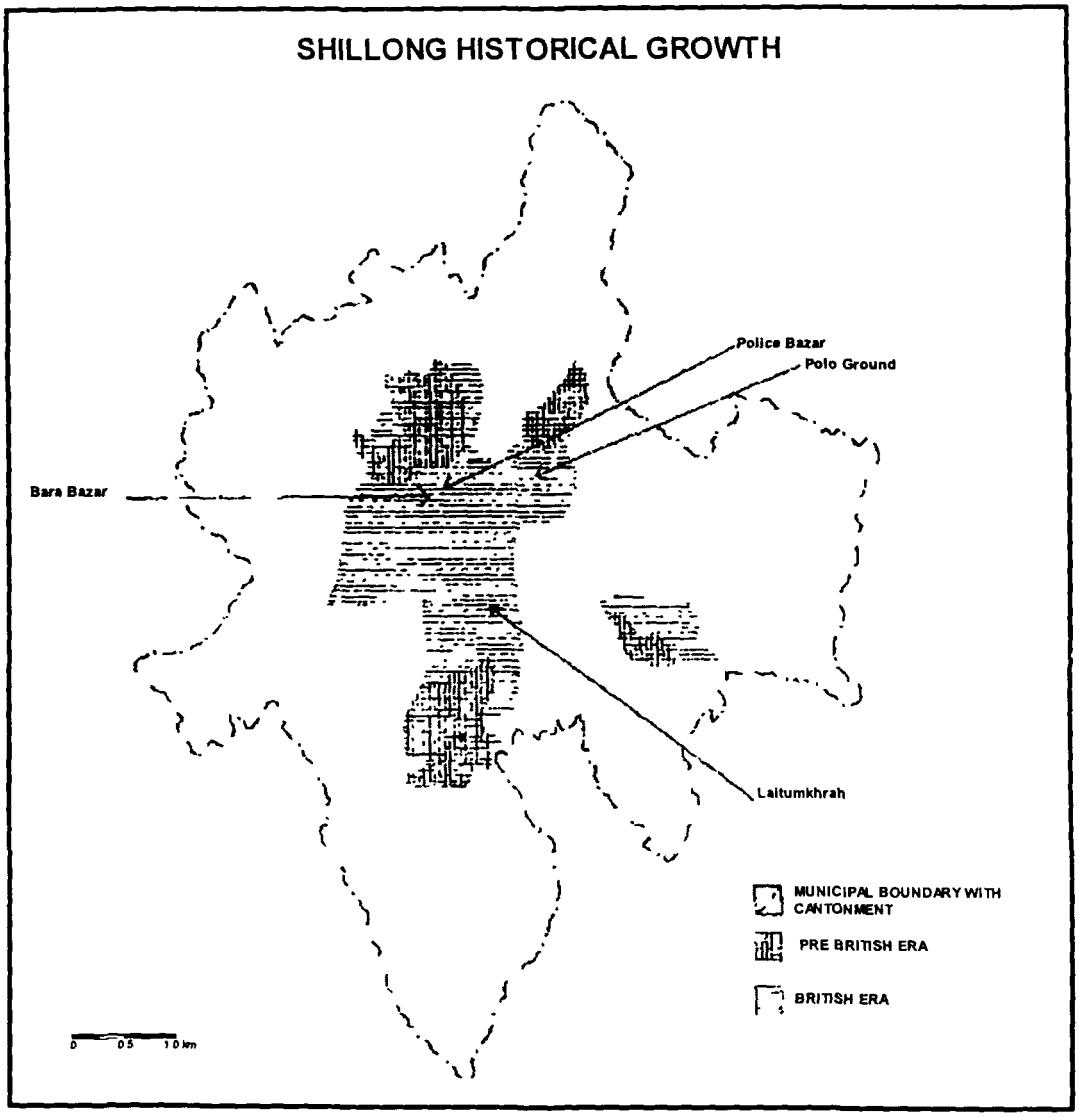

SHILLONG HISTORICAL GROWTH
Police Bazar
Polo Ground
Bara Bazar
Laitumkhrah
MUNICIPAL BOUNDARY WITH CANTONMENT
PRE BRITISH ERA
BRITISH ERA
0 0.5 1.0 km

Fig. 3.1

The British government went into an agreement with the Syiem of Mylliem and the Chief of Khyrim Raja Melay Sing and Raja Rabon Sing respectively who were ready to provide 1626 acres of land to the British Government for a token payment of Rs. 2000 The British acquired an additional seven hundred and fifty nine acres of land that was purchased from individual communities (Syiemlieh 1989)[6], for the station here.

With the transfer of the head quarters from Cheerapunjee to Shillong which has a more centralised location between the Sylhet plains in the south and the Brahmaputra valley in the north included within its ambit of Sadew village, Nonghseh village, Mawkhar village, Laban and Laitumkhrah village.

In the year 1866 the then Lieutenant Governor General of Bengal Sir John Peter Grant sanctioned the transfer of the Deputy Commissioners establishment from Cherapunjee to Shillong. In the same year Colonel Hopkins who was the Commissioner of Assam Province and agent to the Governor General of India strongly advocated in favour of Shillong as the future Headquarter of Assam Province. Accordingly on March 20th 1874 Shillong was declared as the capital of Assam Province[7] that had a population of about 1363 persons (Choudhury 1998)[8].

But as the town grew bigger the British gave due importance to the solid waste management, though the population size was negligible and waste generated was small compared to the present size. Hence in 1878 the township of Shillong came under the Municipal Act by which the town affairs including water supply and solid waste disposal was managed by the Deputy Commissioner. Though not much information on the method and management of solid waste disposal of Shillong by the British is available, yet it can

be ascertained that the problem of solid waste disposal was not so large in magnitude as of today, primarily because of the small size of population and the nature of resource utilization.

As the town grew bigger it was necessary to acquire more land, consequently the British Government with other agreements took on perpetual lease from the Syiem of Mylliem, those portions which are now known as European ward, consisting of Police Bazar, Jail Road and the present Cantonment (Chowdhury 1998)[9]. The Lachumiere hill was added to the township in 1895 (Chowdhury 1998)[10].

It is seen that even in the early days of Shillong settlements sprung up in the areas of the present city, which had a moderate slope, and in the area which could be easily accessible. Consequently the steep slopes of Upper Laban and Lumparing area in spite of being the sites of the earliest settlements did not grow at a fast rate as that of the moderate to moderately steep slope areas.

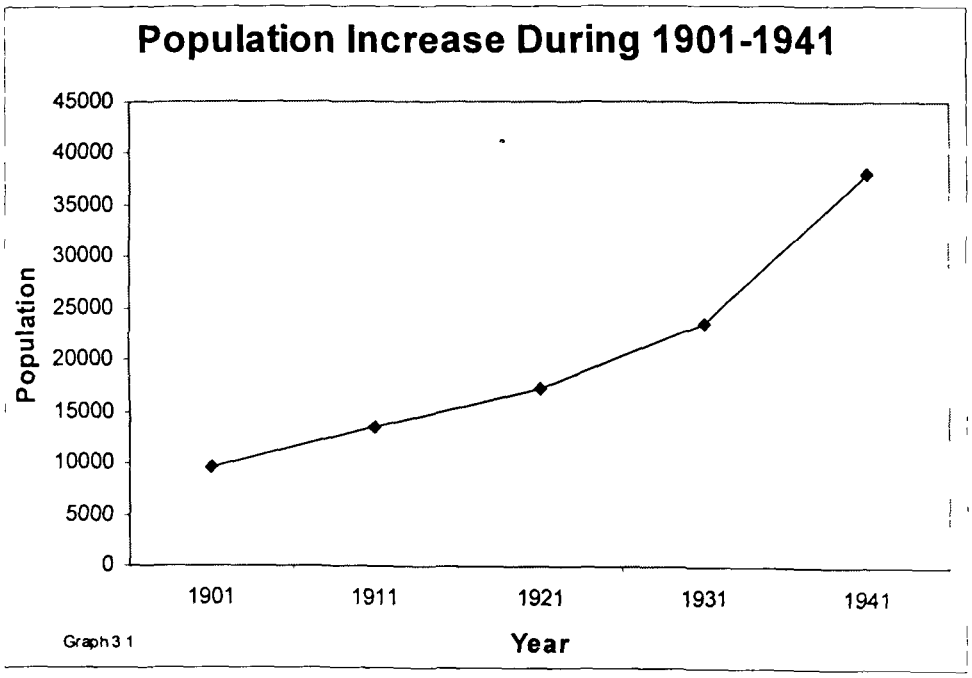
In 1901 the total population of the township was 9621(Census 1981)[11]. The Shillong Municipality was established in 1910 and new areas such as Laitumkhrah, Hopkinson Estate, Malki and Mawprem were included under the Municipal boundary just after two years. The population recorded at Shillong was 13639 (Census 1981)[12] showing a growth of +4018 and an increase of 41.76 percent (Table 3.1) as compared to the previous census records.

The population growth of Shillong before India's independence is shown in the table below:

Table 3.1: Population growth of Shillong before India's Independence (1901-1941)

Year	Population	Increase	Percentage increase	Remarks
1901	9621			
1911	13639	4018	41.76	Shillong Municipality Area
1921	17203	3564	26.13	
1931	23536	9333	54.25	
1941	38192	11656	43.93	

Source: Census of India, 1981 Provisional population total Meghalaya, series-14



The table 3.1 shows that the population of Shillong has a positive trend of growth even before Independence. This might have been attributed to the development of commerce and trade after the British established the administrative set up in 1874 when Shillong became the capital of the Assam province. The total population was 9621 in the beginning of the 20th century (1901 census) and increased to 38192 (1941 census) i.e. a total increase of 28571 persons in 1941 thereby showing about 296.96 percent increase.

Hence within a period of forty years the population of the Shillong municipality increased to three fold. Then Shillong emerged not only as an important administrative center of the British India but also as an important educational and commercial centre.

3.3 **Shillong after Independence**

After the Independence of India in 1947, Shillong experienced a new thrust of horizontal and vertical expansion due to large immigration and influx of displaced people from the erstwhile East Pakistan (present Bangladesh). Hence with these population increases there were resultant urban expansion of Shillong.

In 1951 census the population of Shillong was 58512 persons thereby showing an increase of 20320 persons from the previous census of 1941. The percentage increase was about +53.20percent. Hence within ten years the increase of population was above 50 percent percent. The urban area however was restricted to the Shillong municipality and the cantonment areas.

No planning for residential expansion was done at this stage thus settlements started encroaching the steep slopes and rugged terrains of Lumparing, Laitumkhrah, Laban etc.

In 1961 the townships of Mawlai and Nongthymmai were included and formed two census towns of the Shillong Urban Agglomeration as indicated in Fig.2.2. Due to unrestricted residential expansion, changes in municipal boundary of the surrounding areas like Happy Valley, Umlyngka, Upper Shillong Nongkseh, Lawsohtun, Madanrting, Pynthorumkhrah, Nongmynsong and Umpling developed urban characteristics.

This growth trend continues till date. At present Shillong Urban Agglomeration consists of a total population of 267881 people distributed over seven units of the Shillong Urban Agglomeration viz. Mawlai, Nongthymmai, Madanrting, Shillong Municipality, Shillong Cantonment, Pynthorumkhrah, and Nongmynsong (2001 census).

To keep pace with the fast growth of the city the Meghalaya Urban Development Authority has come up with a Master Plan area of Shillong so as to introduce planned development by 2011. This master plan area recorded a population of 155600 persons in 1971 and 217274 persons in 1981 showing a growth rate of 39.64 percent. Since the population figures of the rural components were not available, the projected population for 1991 was 292445 with the same growth rate of 39.64 percent.

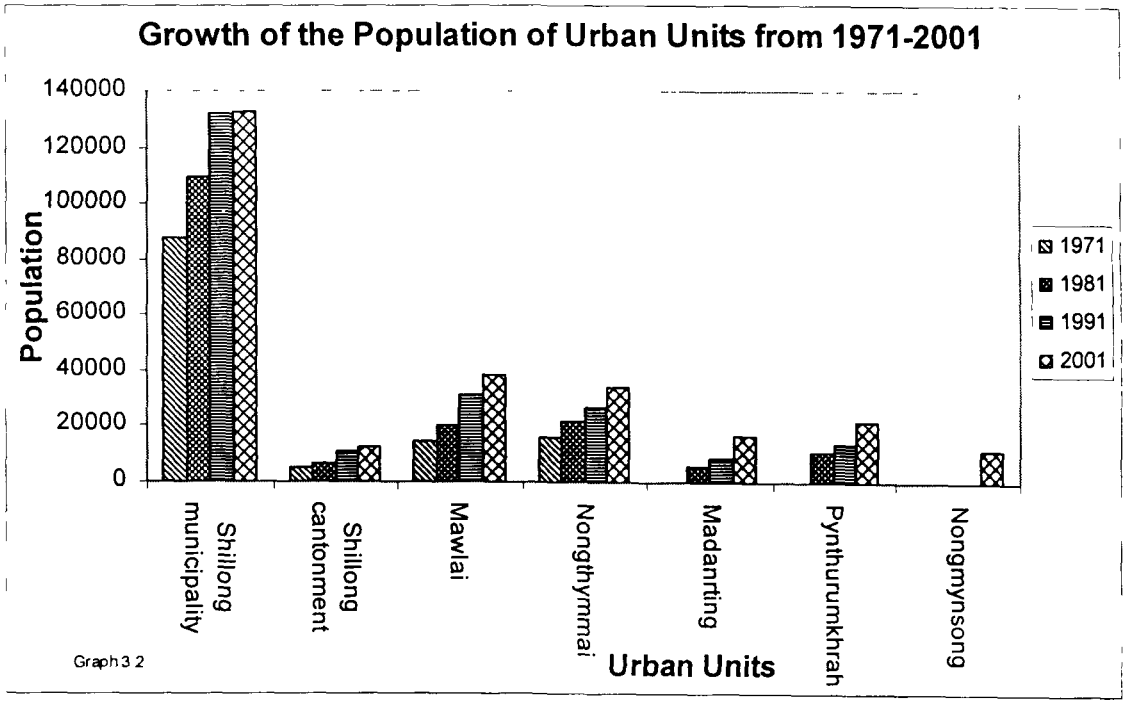
3.4 **Expansion of Shillong since 1971**

After the creation of Meghalaya in 21st January 1972, the capital of Assam was shifted to Dispur and Shillong became the capital of the newly created Meghalaya. The 1971 census of Shillong Urban Agglomeration shows a population size of 122792 persons as compared to 94039 persons in 1961 census, thus showing a marginal increase of 28753 persons, i.e., a decadal growth of about +30.57 percent. Table 3.2 shows the population growth of Shillong Urban Agglomeration from 1971 onwards.

Table 3.2: Population Growth of Shillong Urban Components (1971-2001)

Urban units	1971	1981	1991	2001	Decadal growth (in %)		
					1971-81	1981-91	1991-2001
Municipality	87659	109244	131719	132876	+24.62	+20.57	+.88
Cantonment	4730	6620	11076	12385	+39.86	+67.31	+11.82
Nongthymmai	16103	21558	26938	34209	+33.86	+24.96	+26.99
Mawlai	14260	20405	30964	38241	+43.09	+51.75	+23.50
Madanrting		6165	8987	16700		+45.77	+85.82
Pynthorumkhrah		10735	13682	22108		+27.45	+61.58
Nongmynsong				11362			
Total UA	122752	174724	223366	267881	+42.34	+27.84	+19.93

Source: (i) Census of India 1971 Meg. Series 13 Part II A; (ii) Census of India 1981 Meg. Series 14 Part XIII A&B; (iii) Census of India 1991 Meg. 14 Part II A&B; (iv) Census of India 2001 Meg. Series 18.

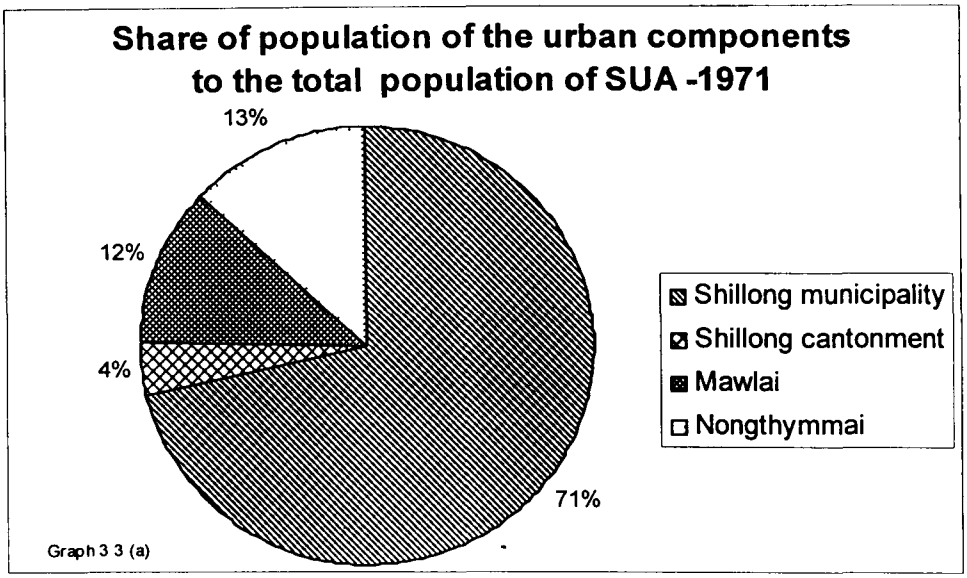


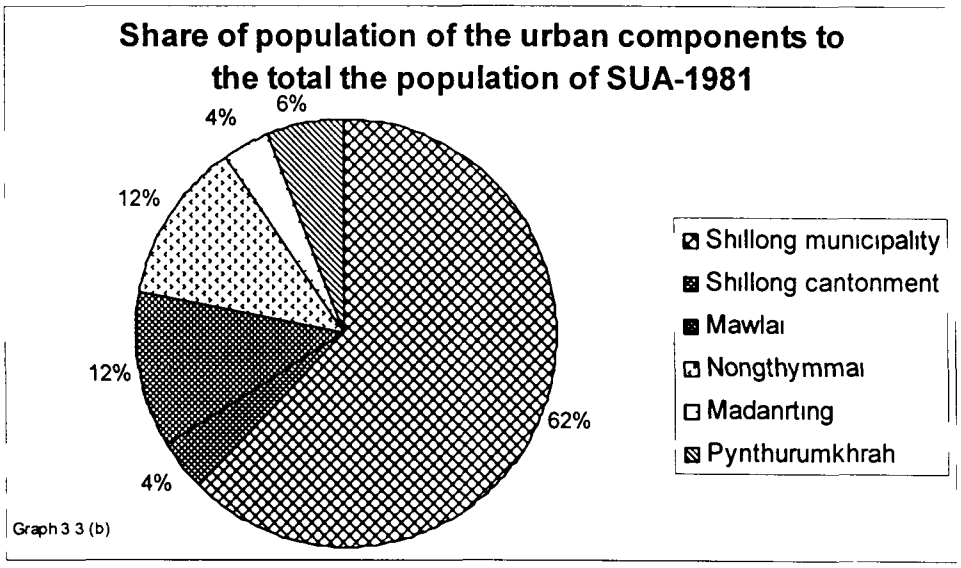
At the time of the creation of the state there were four urban units supporting a total population of 122752 persons in a geographical area of 21.27 sq km having a density of 5771 persons per sq km. (Table 3.4).

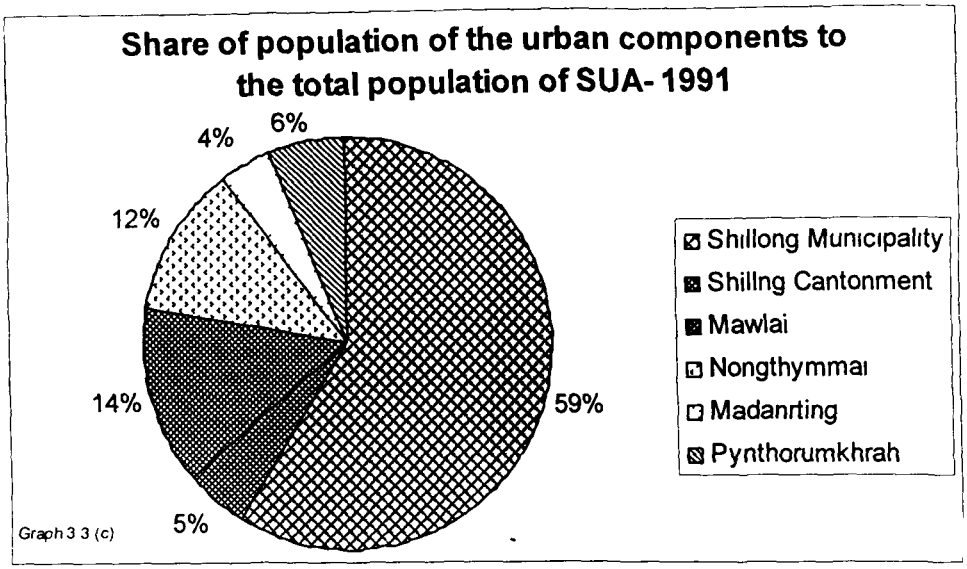
Table 3.3: Population, Area and Density of the Urban Components and Percentage of Population of each Component to the total Population of the Shillong Urban Agglomeration (1971-2001)

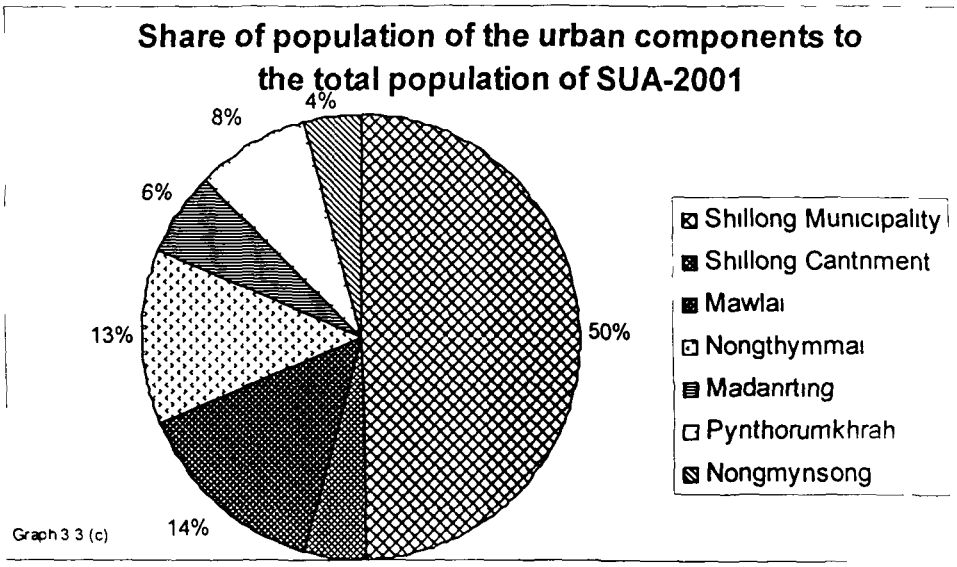
Components	Year	Total population	Area in sq km	Density/ sq km	% of population to the total population of SUA
Municipality	1971	87659	10.36	8461	71.41
	1981	109244	"	10,545	62.53
	1991	131719	"	12,714	58.97
	2001	132876	"	12826	49.60
Cantonment	1971	4730	1.84	2570	4
	1981	6620	„	3598	4
	1991	11076	„	6020	4.96
	2001	12385	„	6731	4.62
Mawlai	1971	14260	6.14	2322	12
	1981	20405	„	3323	12
	1991	30964	„	5043	14.86
	2001	38241	„	6228	14.28
Nongthymmai	1971	16103	2.93	5496	13
	1981	21558	„	7358	12
	1991	26938	„	9194	12.06
	2001	34205	„	11675	12.77
Madanrting	1971				
	1981	6165	2.11	2922	4
	1991	8987	„	4529	4.02
	2001	16700	„	7915	6.23
Pynthorumkhrah	1971				
	1981	10711	2.02	5302	6
	1991	13682		6773	6.13
	2001	22108		10477	8.25
Nongmynsong	2001	11362	N.A	N.A.	4.24

Source: Census of India 1971 Meg. Series 13 Part IIA; Census of India 1981 Meg. Series 14 Part XIII A & B. Census of India 1991 Meg. Series 14 Part IIA&B; Census of India 2001 Meg. Series 18.


Share of population of the urban components to the total population of SUA -1971
13%
12%
4%
71%
Shillong municipality
Shillong cantonment
Mawlai
Nongthymmai
Graph 3 3 (a)


Share of population of the urban components to the total the population of SUA-1981
4%
6%
12%
12%
4%
62%
Shillong municipality
Shillong cantonment
Mawlai
Nongthymmai
Madanrting
Pynthurumkhrah
Graph 3 3 (b)





The trend of occupying the steeper and forested slopes of the study area had already set in. Not much attention was paid to the unplanned nature of growth of the city, water supply of the city was managed by the Shillong municipality which had its water source from the seven spring/stream sources located in the southern steep slopes of the study area

The new townships of Nongthymmai and Mawlai (Fig 3.2) remain outside the jurisdiction of the Shillong Municipality till date. The populations living here have to manage their own waste disposal and water supply.

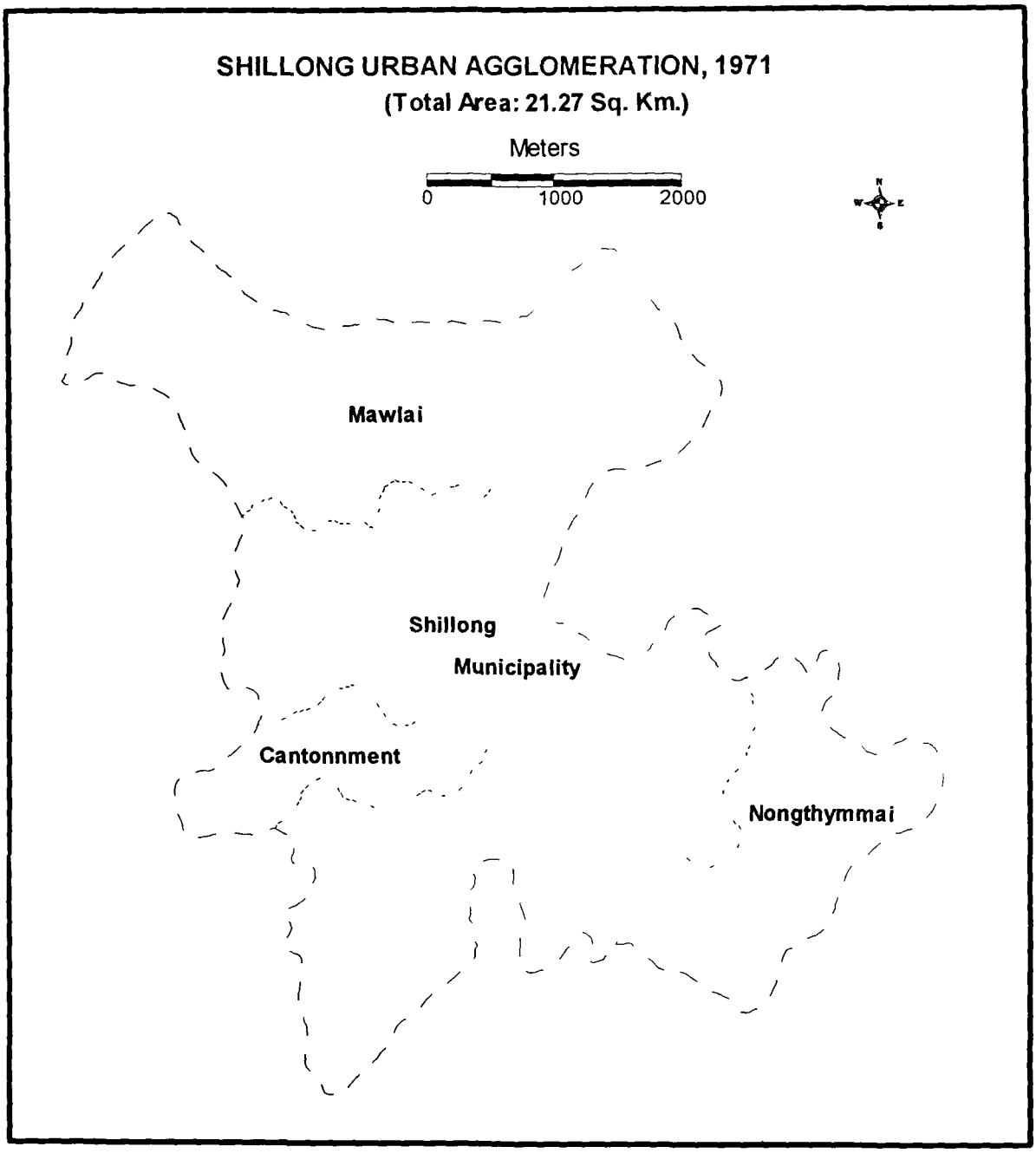
Analysis of the table 3.3 suggests that during the creation of the state

(i) The Shillong municipality having an area of 10.36 sq km. supporting about 87659 people i.e. 71.41 percent of the total population of the Shillong Urban Agglomeration, with a density of 8461 persons per sq km.

(ii) The cantonment having an area of about 1.84 sq km supporting a population of 4730 persons, i.e. approximately 4 percent of the total population of Shillong Urban Agglomeration with a density of about 2570 persons per sq km.

(iii) Mawlai Township situated on a moderately steep-to-steep slope is an integral part of the Shillong Urban Agglomeration with a total population of 14260 persons in an area of 14 sq km. This accounts for 12 percent of the total population of the Shillong Urban Agglomeration i.e. 2322 persons.

(iv) Nongthymmai an integral part of the Shillong Urban Agglomeration recorded a total population of 16103 persons in 1971 occupying a total geographical area of 2.93sq km. This segment accounts for 13 percent of the total population of Shillong urban agglomeration with a density of 5496 persons per sq km.



Source: Census of India, 1971 Meghalaya Series-13

Fig. 3.2

The 1981 census recorded a population size of 174703 showing (Table 3.2) a decadal growth rate of about +42.32 percent. The resultant urban expansion of the Shillong Urban Agglomeration also grew in its size since two new urban components were added within the Shillong Urban Agglomeration namely Pynthorumkhrah and Madanrting (Fig 3.3).

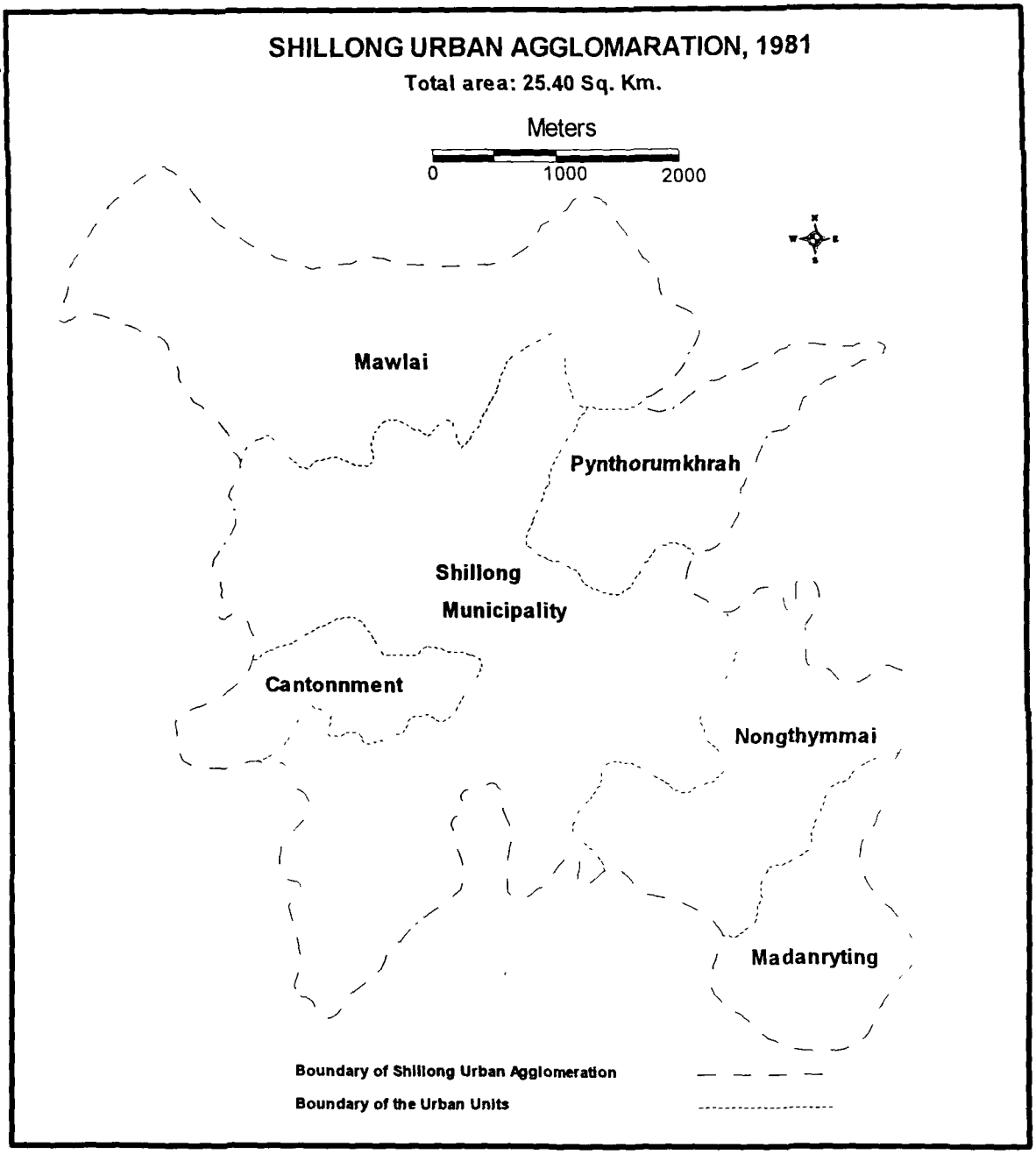
The total area of the Shillong Urban agglomeration increased to 25.40 sq km. (from the previous census the total area under the Shillong Urban Agglomeration increased by 4.73sq km.). It may be mentioned here that the township of Pynthorumkhrah on the Umkhrah basin skirting the north-eastern part of the Shillong Urban Agglomeration is located at an elevation of 1400 meters above m.s.l. Unlike other township Shillong Urban Agglomeration does not have any organized civic bodies for systematic disposal of solid waste. Most of the residents here manage their own solid waste disposal and often the solid wastes are disposed directly into the streams. Shortage of water supply has been discussed in details in chapter IV.

The distribution of population of the different urban components recorded in the 1981 census is as follows (Table 3.2 & 3.3).

(i) The Shillong municipality with an area of 10.36 sq km recorded a population size of 109244 thereby showing an increase of +22.85 percent compared to the1971 census. However the percentage of population to the total population of the Shillong Urban Agglomeration decreased by 8.87 percent in comparison to the 1971 census as the Shillong municipality had a share of about 62.53 percent of the total Urban Agglomeration population in 1981 census. This is

perhaps because of the growth of urban agglomeration. The density of population was 10545 persons per sq km with an increase of 2084 persons per sq km. and a decadal variation of +23.64 percent compared to 1971 census. Hence this component created further congestion in the city. The number of waste bins and cleaners engaged by the municipality remained unchanged even after the significant growth of urban population and area. There was no substantial increase in the solid waste disposal infrastructure to meet the needs of the extra population. The amount of water supply also remained the same, since the Municipal identified no new sources of water. However the Public Health Engineering Department of the Government of Meghalaya had come up with its plan of Greater Shillong Water Supply S Scheme in 1978, which was formulated to meet the water demand of the increasing population. Through this scheme the water supply of greater Shillong has improved significantly but still many areas are yet to be supplied under this scheme.

(ii) The cantonment having an area of 1.84 sq km recorded a population size of about 6620 persons with an increase of about 39.95 percent then the previous census. The density also increased by 40 percent from the previous census (3598 persons per sq km). However the percentage share of the cantonment population to the total population of the Shillong Urban Agglomeration remained at 4 percent.



Source:- Census of India 1981 Provisional Population Total Meghalaya Series-14

Fig. 3.3

(iii) The township of Mawlai having an area of about 6.14sq km recorded a total population size of 20405 persons thereby with an increase of about 43 percent which is indeed very high in comparison to the rest of the urban components. The density recorded was 3323 persons per sq km. with an increase of +43.11 percent. At this stage the township has started showing signs of congestion and at the same time solid waste and water requirement has increased.

(iv) The township of Nongthymmai having an area of 2.93 sq km records a total population of 21558 persons in 1981 census thereby showing an increase of 33.88 percent. The density recorded was 7358 persons per sq km. The increase was to the tune of 34.37 percent. This is equivalent an absolute increase of 1862 persons per sq km. This highly dense township has no proper waste disposal and water supply.

(v) The new township Madanrting located towards the south east of Nongthymmai occupies an area of 2.11 sq km. with a population size of 6165 persons (density of 2922 persons per sq km in 1981 census). This new unit was declared urban in 1981 census and was included in the Shillong Urban Agglomeration. The township is located at an absolute relief of 1600-1800 m above mean sea level has a moderately steep to steep slopes. The main drainage line in this township is Wah Demthring which is highly polluted due to domestic and trade effluents. The wastes are directly disposed off to the streams. The township is also managing its own water supply, which are usually surface springs and streams.

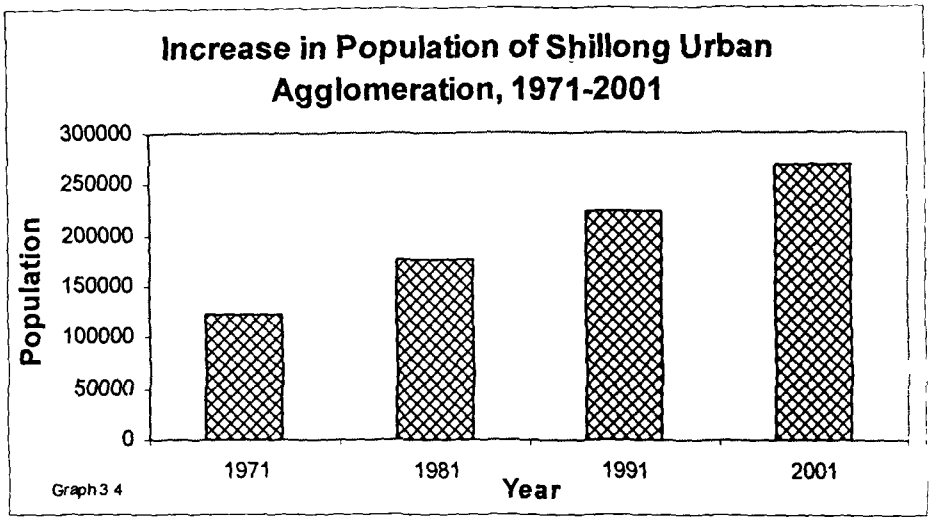
(vi) The township of Pynthormumkhrah located at an absolute altitude of above1400 meters having an average slope of moderate category is actually ideal for urban expansion. The township is located towards the north east of the Shillong Municipality recorded a total population of 10711 persons occupying a total geographical area of 2.02 sq km in 1981 census. The density recorded was 5302 persons per sq. km. The percentage share to the total population of the Shillong Urban Agglomeration of this township was 6 percent.

The 1991 census suggests that there was no increase of urban units but the population increase was 27.85 percent. Hence the urban areas became more congested leading to more problems of solid waste disposal and water supply as there is no additional infrastructure to meet the demands of the of the additional population. The total population in 1991 census was 223366 persons occupying an area of 25.40 sq km. (density of 8793 persons per sq km) (Table 3.4).

Table 3.4: Area, population density and decadal variation of population of Shillong Urban Agglomeration (1971-2001)

SUA	1971	1981	1991	2001
Area (sq km)	21.27	25.40	25.40	+25.40
Total population	122752	174703	223366	267881
Density/sq km	5771	6878	8793	
Decadal variation (%)		+42.32	+27.85	+19.93

Source (i) Census of India 1971 Meg. Series 13 Part II A; (ii) Census of India 1981 Meg. Series 14 Part XIII A&B, (iii) Census of India 1991 Meg 14 Part II A&B; (iv) Census of India 2001 Meg. Series 18



The distribution of population and density of the urban units, their percentage increase in population and the share of each urban unit to the total population of the Shillong Urban Agglomeration are:

(a) The Shillong Municipality occupies an area of 10.36 sq. km with a total population of 131719 persons which has an increase of 22475 persons (20.57 percent) in1991. The share of this urban population was 58.97 percent to the total population of the Shillong Urban Agglomeration.

(b) The Shillong cantonment has a geographical area of 1.84 sq km with a total population of 11076 persons, with an absolute increase of 4456 persons. The decadal variation was +67.31 percent. This is indeed high in comparison to the growth rate of other urban components as well as the overall growth rate of 27.85 percent. Population density was 6020 persons per sq. km. with an increase of 2422 persons per sq km, which is about 67.32 percent, increase. This has resulted to further overcrowding of the cantonment especially the slum of Jhalupara. The percentage

share of this component to the total urban population in the 1991 census was 4.96 percent thereby showing an increase of 0.96 percent than the previous census.

(c) The township of Mawlai has a geographical area of 6.14 sq km with a total population of about 30964 persons. The absolute increase of population was to the tune of 10559 persons. The decadal variation was +51.75 percent. The township recorded a density of 5043 persons per sq km. The percentage share of this component to the total urban population was to the tune of 14.86 percent thereby showing an increase of 2.86 percent.

(d) The Nongthymmai town has a geographical area of 2.93 sq km with a total population of about 26938 persons with an absolute increase of about 5380 persons. This account for +24.96 percent of decadal variations, which is comparatively less in comparison of 1971-81 i.e. more than 30 percent. The share of population of Nongthymmai to the total population of Shillong Urban Agglomeration was 12.06 percent indicating a marginal increase of 0.06%. Infrastructure facilities like water supply and solid waste disposal never increased. The density per sq km increase was 1836 persons i.e. 24.95 percent increase.

(e) The township of Madanrting with the same geographical area recorded a population size of about 8987 persons with an absolute increase of about 2822 persons accounting for +45.77 percent. The density increased by 1337 persons per sq. km that is an increase of 45.76 percent. The density recorded in 1991 census was 4259 persons per sq km which was 2922 persons per sq km in 1981. This indicates that

population pressure on land led to deforestation as the urban sprawl increased to the steeper slopes and to the fragile areas which is not suitable for urban expansion.

(f) The township of Pynthorumkhrah with a geographical area of 2.02 sq. km recorded a population of about 13682 persons with an absolute increase of about 2971 persons (+27.74%). The population density recorded in this census was 6773 persons per sq. km i.e. an increase of 1471 persons per sq. km. This indicates about 27.74 percent increase.

(g) The recent census of 2001 recorded a total population of 267881 persons with a decadal variation of +19.93 percent. Thus the rate of population increase has a slower growth in comparison to the 1991 census, which had a decadal variation of +27.85 percent. Consequently the present census recorded about 7.92 percent less growth rate in comparison to the previous census. However the geographical area under the Shillong Urban Agglomeration has increased after the addition of Nongmynsong Township located towards the north east of Pynthorumkhrah (Fig 3.4). However, the geographical area under this township has not been recorded in the census record of Meghalaya. Hence the total geographical area under the Shillong Urban Agglomeration has increased but the data pertaining to the exact amount of increase is yet not available (Fig. 3.5).

The salient features that emerged from the above analyses of population of the Shillong Urban Agglomeration in1971 census onwards are as follows.

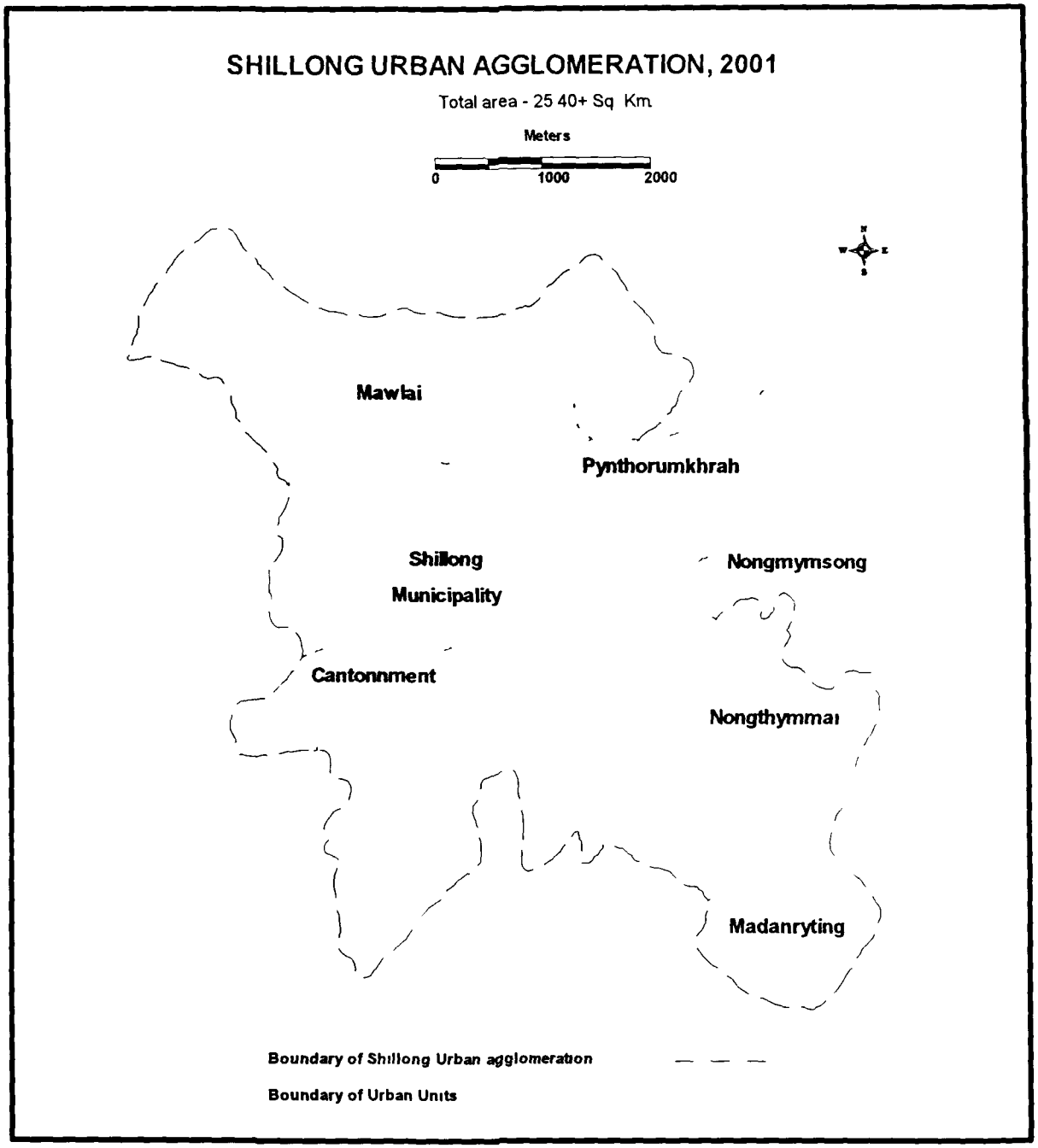

SHILLONG URBAN AGGLOMERATION, 2001
Total area - 25 40+ Sq Km
Meters
0
1000
2000
Mawlai
Pynthorumkhrah
Shillong
Municipality
Nongmymsong
Cantonnment
Nongthymmai
Madanryting
Boundary of Shillong Urban agglomeration
Boundary of Urban Units

Fig. 3.4

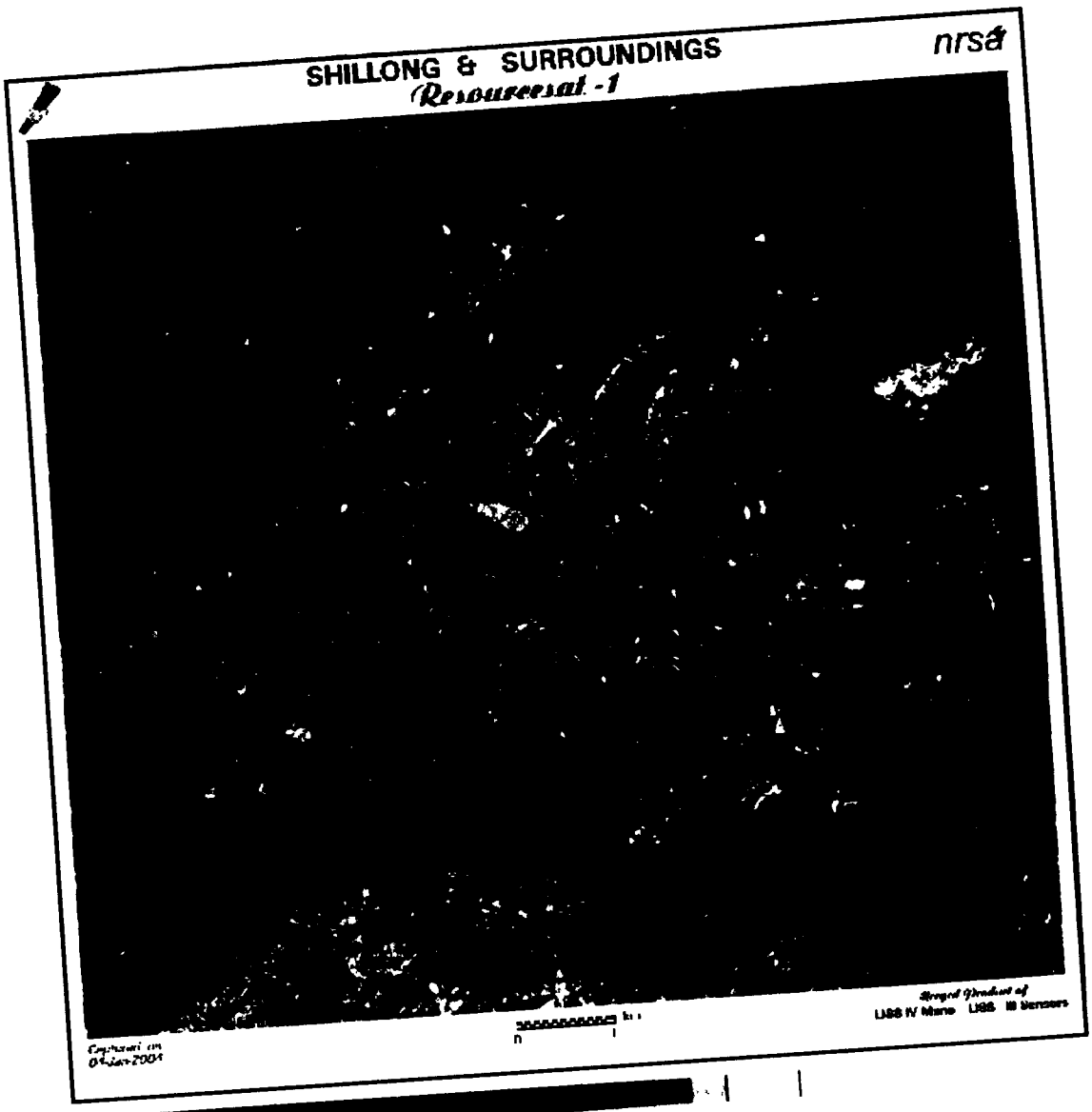


Fig. 3.5

1. During the creation of Meghalaya the capital city of Shillong consisted of four urban units viz. The Shillong municipality, the Cantonment and the township of Mawlai towards the northwest and township of Nongthymmai towards the south east.(Fig3.2) The total geographical area was 21.27 sq km supporting a population size of 122752 persons with a density of 5771 persons per sq km. (table 3.4). It is seen that about 71.41 percent of the total population was supported by the Shillong municipality while about 25 percent of the total population lived in the two urban townships. The cantonment had a share of only 4 percent of the total population.
2. The 1981 census shows a population growth rate of +42.32 percent. Indicating a fast growth of the city. The geographical space of the city was 25.40 sq km thereby recording a total increase of 4.13sq km. The urban area expanded at the rate of 33.65 percent in 1981 census. The two new townships were included in this census year (Fig 3.3) and the density of population of the Shillong Urban Agglomeration was 6878 persons per sq km. The Municipality showed a relatively less growth rate of +22.85 percent. The township of Mawlai had the highest growth rate of + 43 percent. In fact it is observed that the urban units out side the municipality were supporting 65459 persons in a total area of 15.04 sq km. The municipality had 109244 persons in a total area of 10.36 sq km. Thus the urban units were expanding at a faster rate than the municipality as suggested by the growth rate of the other urban units. The urban units supported about 37.47 percent of the total population while the municipality had a share of 62.53 percent to the total population of Shillong Urban Agglomeration.

3. The 1991 census recorded a further stagnation on the growth of the Shillong municipality which had a decadal variation of only +20.57 percent. The urban units like the cantonment,s decadal variation was +67.31 percent followed by Mawlai, at a growth rate of about +51.75 percent. The geographical area of the Shillong Urban Agglomeration did not increase, as no new units were included in this census year. The population recorded in this census was 223366 persons showing a decadal variation of +27.85 percent. The density recorded was 8793 persons per sq km with a total increase of 1951 persons per sq km i.e. increase of 27.84 percent per sq km. The urban units supported 91647 persons i.e. 41.02 percent of the total population while the municipality supported about 58.97 percent of the total population.
4. The 2001 census shows the inclusion of another new township to the Shillong Urban Agglomeration namely Nongmynsong. (fig.3.4). The decadal variation as seen is +19.93 percent as the total population recorded was 267881 persons. The urban units like Madanrting show a decadal variation of +86.02 percent followed by Pynthorumkhrah (+61.58 percent.). The municipality supports only 49.60 percent of the total population whereas the other urban units support a total population of 118305 persons that is about 44.16 percent of the total population of the Shillong Urban Agglomeration.
5. The above analyses indicate that the other urban components are growing at the expense of the Shillong Municipality. The Greater Shillong Water Supply Scheme is yet to cover such areas, but the present situation is such that the water is not enough to support the population within the municipality especially during the dry

season. Field investigation of Nongthymmai Township has been found that about 78 percent of the total population are dependent on their own source of water supply, which is owned by the local durbars. The water is not sufficient even in the rainy season. There is no planned waste disposal system and water supply to these new areas where 44.16 percent of the total population of Shillong resides.

6. To summarise one can say that the growth of population in Shillong Urban Agglomeration is mainly due to the high growth rate of the satellite townships located in the periphery of the municipality. The present trend of the growth of Municipality is more vertical than horizontal. The urban sprawl continues and is taking within its ambit the peripheral areas comprising of rugged terrain and escarpments.

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CHAPTER IV

SOLID WASTE DISPOSAL

4.1 Introduction

Solid waste refers to the heterogeneous material produced as municipal garbage and rubbish consisting of both organic and inorganic wastes. This waste is unique because it can move from land to water and air. As cities grow their capacity to generate waste also increases, Shillong is no exception to this. In the previous chapter it is observed that Shillong has grown both in regards to population and space. At present about 45 percent of the population (2001 census) are living outside the Municipal limit. This population is without any organised waste disposal facilities. Consequently modern man is generating wastes of all kinds at an unprecedented rate. It is a problem common to both developed and underdeveloped world and is truly a global phenomenon. The urban authorities are facing increasing problems with collection and disposal of this waste.

It has been estimated that in the United States of America, Municipal solid waste averaged at 1.2kg per person per day in 1920. This quantity rose to 2.3 kg per person per day in 1970 and 3.6 kg per person per day in 1980 and now the quantity is more than 4.5 kg per person per day (Nagar 2003)[1]. It has been observed that the amount of solid waste generated is directly related with prosperity of the area. On an average the Indians generate only about 0.2kg of solid municipal waste per day (Nagar 2003)[2]. The amount of waste generation per capita is determined by the size of the city. In the Indian context the larger cities tend to produce more per capita waste, as its resource utilisation per capita is higher.

India like other developing nations does not have the required infrastructure. India lacks in financial resources, social and political will to treat this garbage. Hence it is littered in the drains, streets, streams and rivers of the urban centers giving an ugly look to

the cities as well as polluting the geo-environment (land, water and air) Shillong is no exception to this problem.

4.2 **Classification of Solid Waste**

The solid waste here refers to the heap of garbage generated by anthropogenic activities consisting of both organic and inorganic refuse. However it may be mentioned that in this study some wastes are viewed as resource because all garbages are not pollutants to the environment. It is more accurate to say that waste is resource out of place, and are often leftovers that have not yet found their way to an appropriate user (Murk 1996)[3]. Thus it requires proper solid waste management. Therefore it is necessary to classify solid wastes. As waste comes from so many sources and takes so many forms it is virtually impossible to come up with a classification scheme that fits all kinds of waste and the waste management.

(i) Sometimes it is useful to classify waste according to their source such as industrial, municipal, household and agricultural waste.

(ii) In other cases it is more useful to classify wastes according to their physical form such as solid liquid and gaseous.

(iii) It is more useful to classify waste according to their special properties such as ordinary municipal solid waste, consisting of mainly biodegradable waste and non biodegradable waste, toxic waste such as medical waste, radio active waste etc. which requires special handling.

In this study Shillong's solid waste have been classified on the basis of their sources (Fig 4.1).

(a) Institutional wastes are generated from the various institutes, the characteristics of this waste are depend on the nature of the institute.

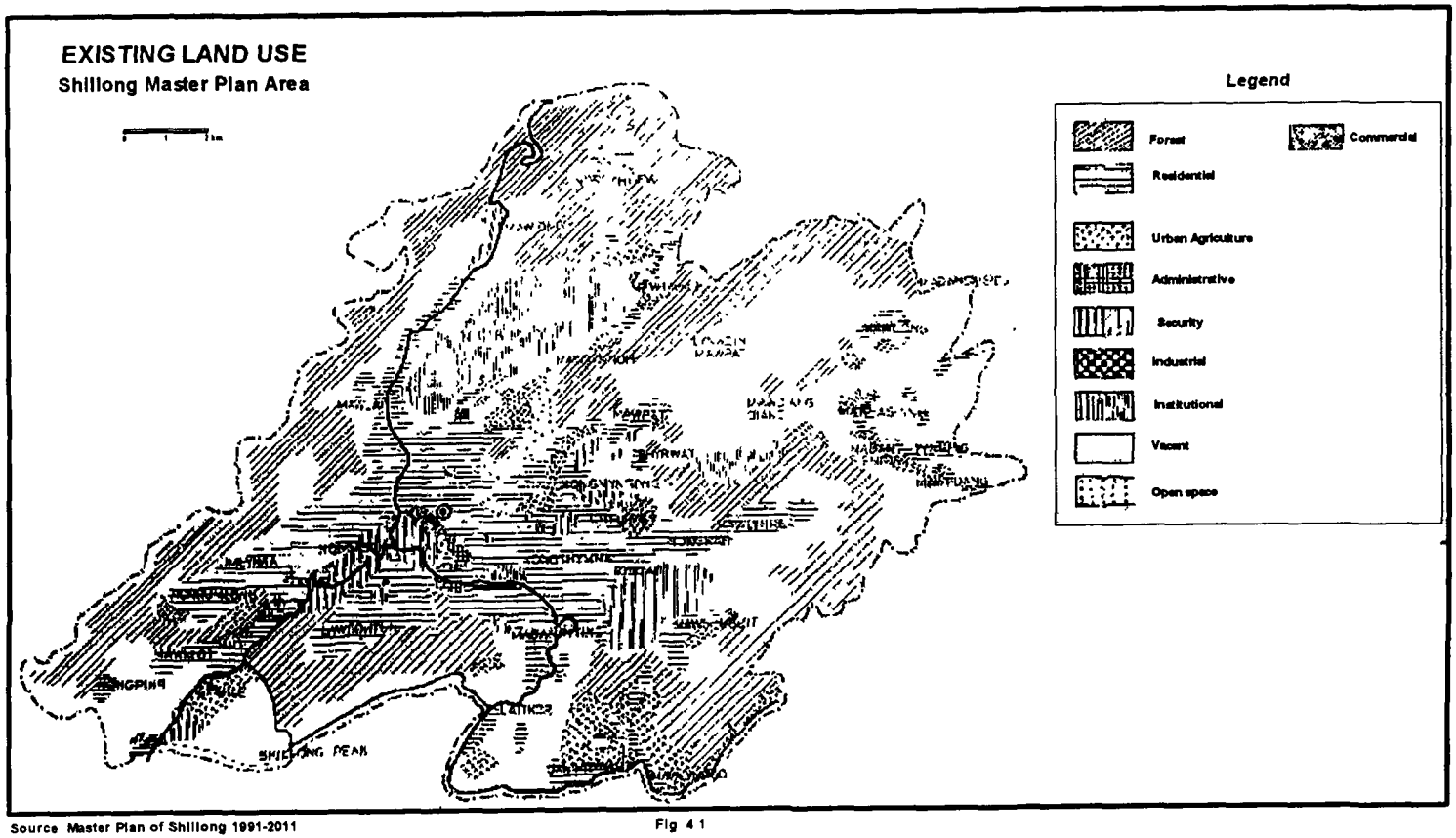
(b) Domestic wastes are generated by the households. This forms the bulk of the municipal solid waste. It comprises of - (i) kitchen waste like left over food, bones, vegetables and ash etc which are mainly organic in character, (ii) other domestic waste comprising of news papers discarded bottles, clothes, paper, packets, tins, medicines etc. These are both organic and inorganic in character, (iii) natural wastes, consisting of plant remains, mainly organic.

(c) Commercial wastes are generated by the market centers. It consist of strong stench organic waste such as animal, fruit or vegetable residues and rubbish consisting of paper, plastics, packing material and glass, etc.

(d) Constructional/demolition wastes are generated by the construction, demolition sites, consisting of mainly bricks, sand, cement and paint etc.

(e) Industrial wastes are generated by the industries. The characteristics of this waste are dependent on the type of the industry. Shillong lacks in industries hence this type of waste is negligible. However the stone quarries and the motor garages are the main sources of industrial wastes.

(f) Natural wastes are consisting of plant and animal remains.



Source Master Plan of Shillong 1991-2011

Fig 4.1

(g) Biomedical wastes are generated during the diagnosis, treatment and immunisation of men and animals. The wastes generated during research activities pertaining to the production and testing of biological materials. This type of waste requires special handling. The main source for this category of wastes comes from various hospitals/nursing Homes and clinics located in Shillong.

Thus domestic, commercial, constructional and natural wastes constitute the Municipal solid wastes.

4.3 **Types of Solid Waste studied**

The main types of solid waste generated within Shillong.

Household Wastes

This refers to the household garbage which includes food scarps, old newspapers variety of plastic items, bottles, and discarded papers, wood, worn out furniture, broken toys, natural wastes and constructional wastes etc. The total amounts of such solid wastes are large and increasing.

Commercial Wastes

This refers to the waste generated by the commercial activities of men. In this the waste generated by the commercial activity of market has been studied with particular emphasis on the perishable commodity market of Iewduh as it is the largest wholesale

market of Shillong. This market is catering not only the Shillong Urban Agglomeration but also the peripheral areas.

Bio-Medical Wastes

This includes different types of waste generated by the different hospitals/ nursing homes, clinic dispensary, veterinary institution, animal house, pathological laboratory, blood bank etc located within the city. A survey on the wastes of hospital/nursing homes wastes was carried since these are generating biomedical waste. The hospital wastes are the most hazardous of all and require special handling, management and disposal. The guidelines are laid down under the Biomedical Waste Management and Disposal Notification 1998. The emphasis of this study is how far these institutions, organizations are adhering to the norms.

Industrial waste

Regarding industrial waste it has been observed that most of the industrial activities taking place in the city are secondary and small-scale units. Automobile workshops are found to be the dominant activity generating industrial effluents, which in most cases are liquid to semi-liquid in nature and thereby under the preview of study. However a study conducted by the State Pollution Control Board reveals that there are about 182 numbers of automobile workshops located haphazardly all over the city. These units are directly disposing of their wastes into the public drains and streams without any

treatment (SPCB Report 2003)[4]. This is causing serious repercussions on the geo-environment of the study area.

4.4 **Amount of Solid Waste**

At present the amount of the different types of solid wastes generated within Shillong are estimated below:-

Household Wastes

Household wastes form the bulk of municipal solid wastes (Kurien 2004)[5]. As no separate data is available regarding the exact quantity of household wastes the quantum of municipal solid wastes of Shillong has been undertaken in this study. Table 4.1 gives an idea about the amount of solid waste generated within the Shillong municipality which is as high as 112 MT / day. The per capita generation is as high as 800gm / day.

Table 4.1: The approximate solid waste generated/ day within the Shillong Municipal wards

Ward Number	Areas covered	Area in sq km	Total population	Total households	Approximate Waste generation/ day in MT
1	Laitumkhrah, -Nongrimba, Nongrimmaw, Lumsohra, Demseiniong	.5732	9738	2174	7.7984
2	Upper and lower new colony, Bhagyakul and Nongkynrih	.4138	2397	559	1.9176
3	Upland Road, Don Bosco, Jacobs ladder	.6665	6133	1214	4.9064
4	Lummawrie	.3581	2995	625	2.396
5	Dhankhati,,Kharmalki, Risa colony, Khlieh Shnong, Wakhdiat	.5194	3413	726	2.703
6	Umshyrpi, Chinapatty,Nongshylliang, Mission Pdengshnong	.2011	7494	1541	5.9952
7	Red cross, Keating Road, Barik, Secretariat hill, Temple road and European ward	.5695	4753	989	3.8024
8	Quinton Road, Oakland, Pine wood hotel, Wards Lake,	.8577	4261	857	3.4088
9	Police Bazar	.1242	1529	247	1.3761
10	Upper Jail Road	.2358	4988	957	3.9904
11	Nonmali and Forest colony	.7866	4536	830	3.6288
12	Umsohsun & Mawkhar	.1261	2173	449	2.173
13	Wahingdoh and Riatsamthiah	.1658	6027	1240	5.4243
14	Jaiaw Shyiap, Lumpyllun& Jaiaw Pdeng	.086	4901	985	3.9208
15	Jaiaw Laitdom, Lumsyntiew & Jaiaw Pdeng	.2845	3547	706	2.8376
16	Jaiaw Langsning	.2515	2667	519	21336
17	Mission Compound & Wahthapbroo	.1365	3375	629	2.7
18	Sunny Hill , Quallapatty & wathpbroo	.13	5189	962	41512
19	Lower Mawprem	.1007	5431	1084	4.3448
20	Upper Mawprem	.5891	8900	1681	8.9
21	Naspatighari & Mawprem	.4864	12052	2457	12.052
22	Rilbong, Kenche's Trace	.164	3589	735	2.8712
23	Bishnupur & Kenche's Trace	.5505	3703	799	2.9624
24	Laban West	.14	4501	955	4.0509
25	Laban East	.1911	3139	634	2.5122
26	Lumparing	.9128	7278	1498	5.8224
27	Lumpariang Riat Laban and Madan Laban	.6328	4148	877	3.3184
Total		**10.36**	**132876**	**26929**	**112.1243**

Source Solid waste Management data from Shillong Municipality (2006)

The available data reveals that the Shillong Municipal Board is lifting only about 75-80 metric tons of solid waste per day from the 27 wards. Hence about 30 percent of the waste generated/ day within the Municipality is not being collected or disposed. The cantonment board is lifting about 15-18 metric tons of waste per day (SPCB Repot 2003)[6], from the cantonment area. The estimated solid waste generated in the other towns of Shillong Urban Agglomeration, viz., Madanrting, Nongthymmai, Mawlai, Pynthorumkhrah and Nongmynsong (total population of 122620 persons as per 2001 census) is around 25.47 tons/day (Table 4.2). This amount has been computed on the basis of the average per capita amount of municipal solid waste generation in Indian urban centers (with population of less than one lakh) is 0.21 kg/capita/day. The garbage generated from the floating population is around 8.5 tons per day (Table 4.3). This suggests that at present the total quantum of the municipal solid waste generated by the Shillong Urban Agglomeration is approximately 165 metric tons/day.

Table 4.2: The estimated amount of Solid waste generated/day in the different Townships of Shillong Urban Agglomeration

Urban units	Total population (2001Census)	Estimated solid waste generated at .21kg/capita/day	Quantity Tons/day
Mawlai	38241	8030.61	8.03
Nongthymmai	3429	7183.89	7 18
Madanrting	16700	3507	3 51
Pynthorumkhrah	22108	4642.68	4.64
Nongmynsong	11362	2386.02	2.39
Total	91840	25750.2	25.75

Source Computed by the researcher

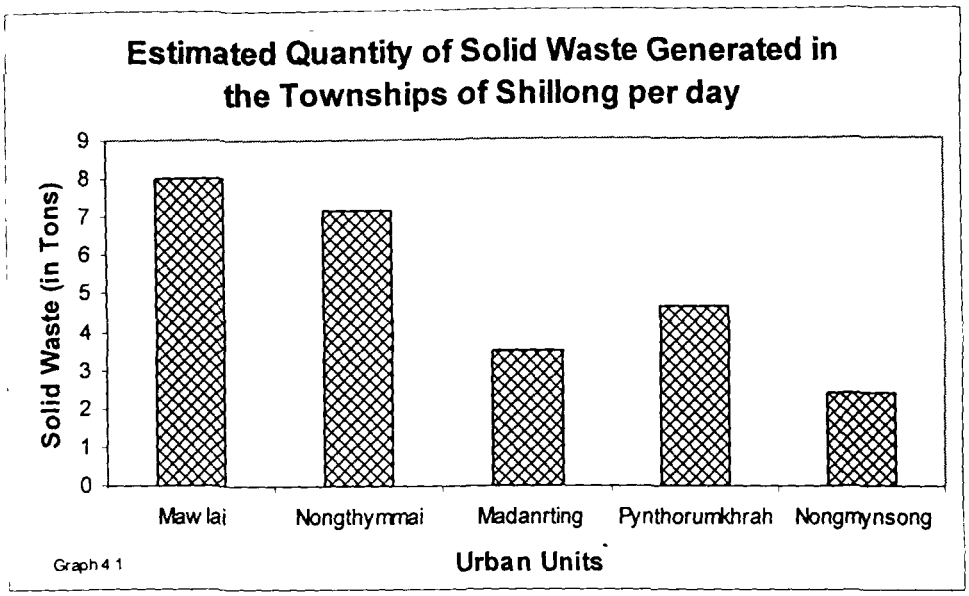


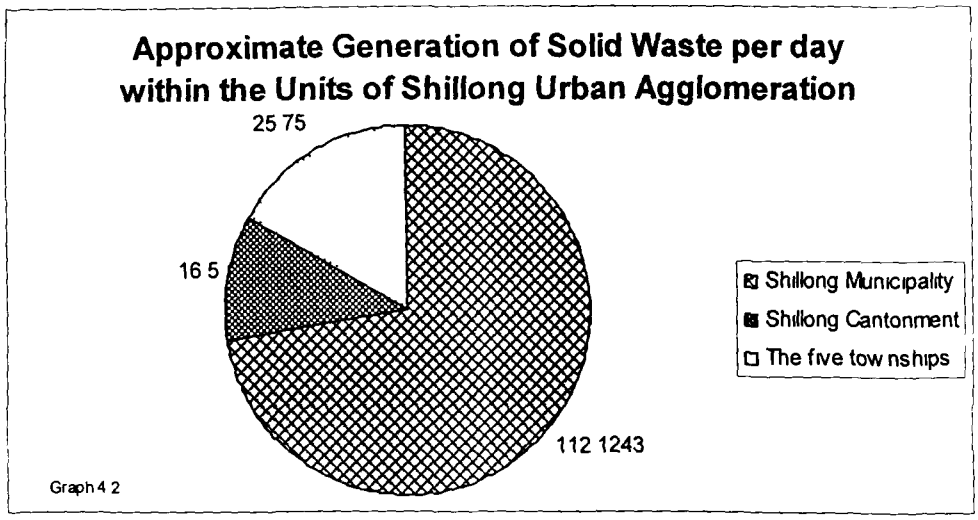
Table 4.3: Approximate Quantum of solid waste generated /day within the Shillong Urban Agglomeration

Urban Components	Area in sq km	Population	Approximate Quantum of Solid waste/ day (MT)	Solid waste generation/capita/day
Shillong Municipality	10.36	132876	112.1243	.800 kg
Shillong Cantonment	1.84	12385	15-18	1-1.5 kg
The five townships	13.20+	91840	**25.75	.21 kg
Total	25.40+	267881	155.87	0.58 Kg/capita/day

Source. Shillong Municipality &State Pollution Control Board

* Garbage generation from floating Population / day is 8.5 metric tons (Source Municipality Board 2006 data) Hence total generation of waste /day is 164.37 approximately. Of this 100MT/day of biodegradable waste is being turned into compost in the Mawiong Plant. The rest of it about 65MT (38percent)/day is unaccounted.

** Estimated waste.



The anaerobic waste disposal plant at Mawiong can handle only 100 metric tons of organic waste /day. Hence approximately 40 percent of the municipal solid wastes generated per day within the Shillong Urban Agglomeration are not accounted. These heaps of garbage are scattered in the streets ultimately reaches to the water bodies. a These wastes often mix with rainwater and percolate down to contaminate the ground water resources. The soil is also affected by such haphazard dumping of wastes. Thus the entire geo-environment Shillong is affected.

Commercial Waste

Commercial waste is an important component of municipal solid. As no data is available regarding the exact amount of commercial wastes generated within Shillong, a survey was carried out at Iewduh the largest wholesale market of Shillong to the study the amount and method of disposal of the solid wastes .The survey was conducted at the

perishable goods market where vegetables, fishes, and meat are sold. The waste generated here are mainly of a bio-organic in nature, if handled and disposed properly.

This may be a resource. This can be utilized efficiently by composting. The compost can find a good market if properly promoted and made conveniently available to the farming community in the rural areas and for gardening purposes in the urban centers.

According to the information collected from the Syiem's office on Oct 2003. The amount of waste collected per day from the three dustbins situated at Mowlonghat, and Paltan bazar (constituting Iewduh) is about 6 metric tons. This is disposed off at Mawiong plant. However the amount of solid waste generated in the whole market is approximately 12- 24 metric tons per day. Hence more 50 percent of the waste generated per day is not being disposed.

Table 4.4 gives an idea about the nature and amount of waste generated by the perishable commodities market at Iewduh. There was no no secondary data available regarding the quantity of solid waste generated from the vegetable, fish and meat market. Hence the study is based only on primary data that has been generated by interviewing 10 percent of the shopkeepers in each category. Table 4.4 gives an idea about the amount of solid waste generated from the different sectors of the perishable commodities market.

Table 4.4: Commercial Waste – Commodities Market of Iewduh (Mowlonghat)

Commodities	Approximate number of shops	Approximate amount of waste generated/ shop/ day	Approximate amount of waste generated/day
Vegetables market			
Unorganised whole sale	200-300	5-10kg	1875 kg
Vendors	100-150	½-1kg	125 kg
Organised wholesale	600	2-5kg	1850 kg
Fish	125	5-10	1125 kg
Meat			
Beef	55	3-5 (which is being sold out)	minimal
Mutton	100	½-1kg(which is being sold out)	minimal
Pork	40	3-5kg	150 kg
Chicken	35-40	N.A	N.A
Total			5125 Kg/day

Source: Data collected by the researcher.

Vegetable Market

The vegetable market of Iewduh (Mowlonghat) has been divided into three main sectors, which are as follows.

The unorganised whole sale sector

(a) In this the village people directly sells their produce. In this there are about 200-300 vendors are selling their farm produce directly in an open area by transporting their produce from the farm to the market.

An average each vendor is generating 5-10 Kg Of solid waste daily. Therefore the amount of waste generated in this sector is about 1000 to 2000kgs or about 1500–3000 kgs

of waste daily. This waste is a good source for composting. Unfortunately much is wasted and dumped as waste.

Road Side vendors around Iewduh

There are about 100-150 vendors selling vegetables. Here the generation of waste per shop is about 1kg per day. Hence the total amount of waste generated is about 50-100 kgs or 75-150 kgs per day i.e. the average waste of 125 kgs per day.

Organised wholesale Market

There are approximately 600 shops in this category. Each shop sells around 100-125 kg vegetables; this is generating around 2-5 kg of waste per shop per day. Hence the total amount generated is 1200-3000 kg. Thus the average waste generated per day from this sector is about 2100 kgs of waste.

Consequently the vegetable market alone generates approximately 4100 kg, i.e., slightly more than 4 metric tons of solid waste/day which is totally organic in nature.

Fish Market

The fish market of Iewduh is divided into two sectors.

Wholesale Fish Market

6 whole sellers manage the entire fish trade of Shillong. They buy 2-3 trucks of fish per day which comes from all over India. Each truck load carries 4550 kg of fishes. Hence

the total amount of fishes coming to Shillong is approximately 9100 -13650 kgs. The amount of waste generated by this sector is negligible as the waste is collected and carried away by the trucks. The husks used for fish packing are sold as poultry feed by the whole sellers. Hence in this sector there is a concept of reuse and there by waste is converted into an economic commodity.

Retail Market

In this sector there are about 125 .shops catering to the retail fish selling. Approximately 100-120 kgs of fishes is being sold here. Each shop generates about 5-10 kgs of solid waste per day. Hence the total amount of waste generated per day ranges between 500-100 kg or 100-2000 kg and 750-150 0kg i.e. on an average about1125 kgs of waste is being generated per day. The waste is dumped in the market itself and later it is collected by the cleaners engaged by the Syiem of Mylliem.

Meat Market

The meat market of Iewduh is divided into four sectors according to the type of meat being sold. This is as follows;

Beef Market

There are approximately 55 beef shops. The meat is cleaned in the slaughterhouse. On an average beef sold is around 250-300 kg per day. Waste generated is about 2-3 kgs per day per shop. Therefore the total amount of waste being generated is around 110-165

kgs that is on an average of 137.5 kgs. But here all the wastes are being sold at Rs 20 a kg. Hence the waste generated here is negligible.

Pork Shops

There are 40 shops in the pork business. Pork is brought from the slaughterhouse where all the cleaning is done. Waste generated per shop is 3-5 kg per day on the average. Hence the total waste generated per day is about 120- 200 kg per day. Hence on an average 320 kgs of waste is being generated per day. This waste is being dumped in the open dustbin mixed with beetle nut and other vegetable wastes.

Mutton Shops

There are 100 mutton shops. Each shop generates around about 1 kg of waste per day. Approximately 75 kg of waste is being generated per day from this sector. This waste is again being sold out therefore the waste generated from the mutton market is minimal.

Chicken Shops

There are 35-40 shops but no accurate data could be collected as to the amount of waste generated.

The total amount of waste generated from the perishable commodity market viz. vegetables; fish and meat markets (excluding the chicken market) are approximately 5545 kg of waste per day.

Biomedical Wastes of the Hospitals/Nursing Homes

The disposal and management of waste of these organisations is causing a serious impact on the geo-environment of the area in general and the water bodies in particular. Most of the private hospitals/nursing homes are located close to the stream beds (Fig 4.2) at present there are two government dispensaries, three private nursing homes, six government hospitals and five private hospitals in Shillong. This is besides the various clinics and private doctor's chambers which cater to the medical needs of at least 267881 persons (2001 census). Shillong being the primate city of the state of Meghalaya also caters to the medical need of the peripheral areas. While there is need for more medical amenities yet at the same time there are problems regarding the biomedical wastes management and disposal of the present hospitals and nursing homes.

Various categories of Hospital wastes which requires special mode of storage treatment and disposal outlined by the Ministry of Environment and Forest under its notification of Bio-medical Wastes (management and handling) Rules 1998, has been neglected in Shillong. The changing scenario in health care centers and increase use of antibiotics, cytotoxic drugs, use of corrosive chemicals and radioactive substances. Thus there is rise in biomedical waste too. Rising HIV and other infectious diseases are due to unscientific waste management practices like discharge of untreated waste and chemical discharges into the sewage system which are also leading to severe pollution of the surrounding environment.

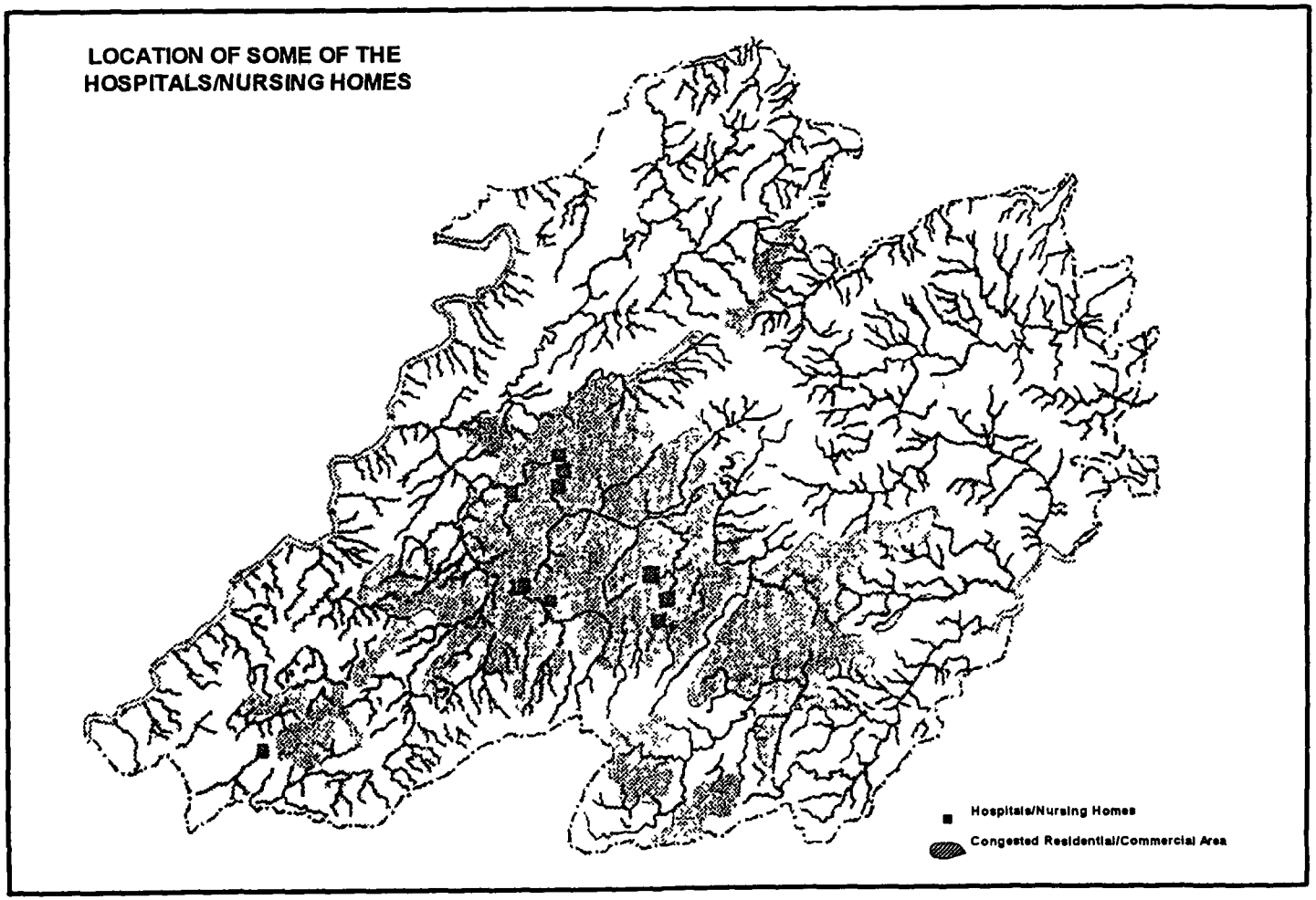

LOCATION OF SOME OF THE
HOSPITALS/NURSING HOMES
Hospitals/Nursing Homes
Congested Residential/Commercial Area

Fig 4.2

Hence a field survey was carried out with the help of scheduled questioners in 2003 to collect information on the types, amount, and mode of storage and disposal of the different categories of waste generated by these health centers. This data was compared with the annual reports submitted for the year 2002-2003 by the different hospitals/nursing Homes of Shillong to the Meghalaya Pollution Control Board.

It is observed that though it is mandatory on the part of all hospitals and nursing homes of Shillong to submit annual report to the Pollution Control Board all the hospitals/nursing homes. But some of the hospitals/nursing homes did not submit their annual reports.

During field investigation only 42 percent of the hospitals/nursing homes supplied the necessary information. The type of wastes generated from these hospitals/nursing homes are presented in table 4.5.

Table 4.5: Categories of bio- medical waste and method of disposal

Waste category Number	Type	Treatment and disposal
Category 1	Human anatomical waste (Human tissues, organs, body parts)	Incineration/deep burial
Category3	Microbiology and biotechnology wastes (wastes from lab. Cultures, stocks or specimen of micro organisms etc	Local autoclaving/microwaving/incineration
Category 4	Waste sharps(needles, syringes, scalpels etc.	Local autoclaving/microwaving/ mutilation /shredding
Category 5	Discarded medicines and cytotoxic drugs	Incineration/ destruction and drugs disposal in secured landfills
Category6	Soiled waste(items contaminated with blood, body fluids etc)	Incineration/autoclaving/microwaving
Category 7	Solid waste (catheters, tubings, . intravenous etc)	Mutilation/shredding
Category 8	Liquid waste (generated from laboratory, cleaning, disinfection activities, etc.)	Disinfection by chemical treatment and discharge into drains
Category 9	Incineration ash	Disposal into municipal landfills
Category 10	Chemical waste (chemicals used in production of biologics, chemicals etc.)	Chemical treatment and discharge into drains.

Source-Bio-medical waste (management and Handling) Rules 1998Ministry of Environment and Forests.

Table 4.6: Amount of different categories of waste generated by the hospitals/nursing homes of Shillong

Category of Waste (No.)	Amount of Waste*	Amount of Waste**	Discrepancy
1	57.75 Kg/week	59 Kg/week	- 1.25 Kg/week
3	37 Kg/month	30 Kg/month***	+7 Kg/week
4	81.5 Kg/month	87.5 Kg/month	7 Kg/month
5	18.0 Kg/month	NA	
6	307.0 Kg/month	141.5 Kg/month	165.5 Kg/month
7	199.0 Kg/month	NA	
8	11065 Lt/day	NA	
9	40 Kg/month	NA	
10	193 Lit/month	NA	

Source (a) Annual Report submitted to the Pollution Control Board in 2003

(b) Information gathered through field investigation.(only 42percent of the Hospitals /nursing homes supplied the necessary information)

** According to the annual report*

*** According to field investigation.*

**** This figure is only from one hospital, as the others did not supply the necessary information.*

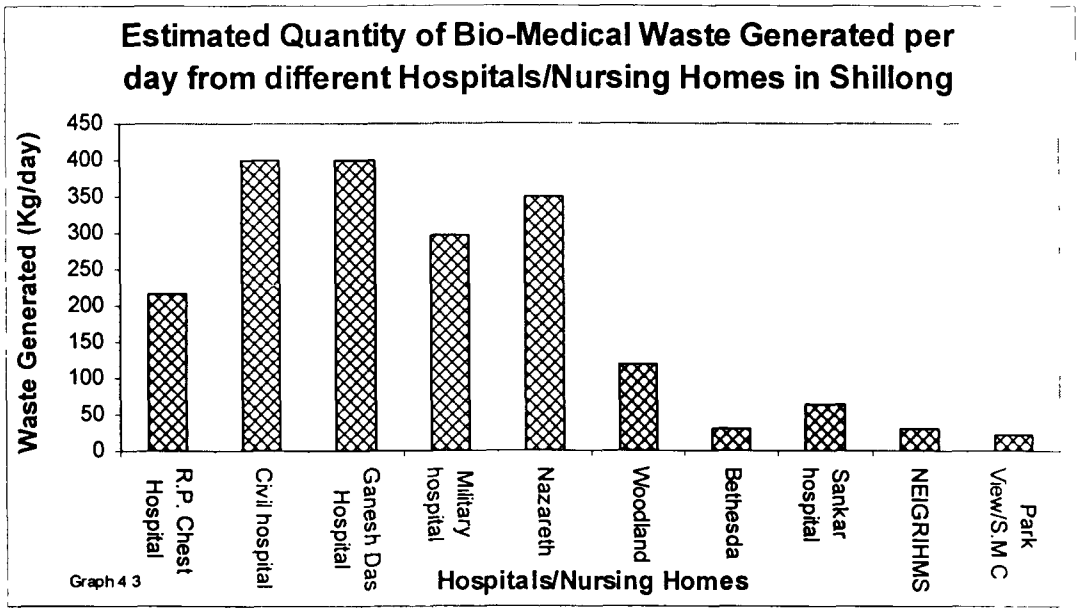
Table 4.7: Number of beds of the important Hospitals/nursing homes of Shillong and their estimated quantity of infectious and other bio-medical wastes generated per day

Name of the major Hospital/nursing home	Number of beds	Estimated quantity of Biomedical waste Generated in Kg/day*	Estimated quantity of Infectious waste generated In kg per day **
R.P. Chest Hospital	217	217	54.25
Civil hospital	400	400	100
Ganesh Das Hospital	400	400	100
Military hospital	297	297	74.25
Nazareth	350	350	87.50
Woodland	120	120	30
Bethesda	30	30	7.50
Sankar hospital	65	65	16.25
NEIGRIHMS	30	30	7.5
Park View/S.M.C	22	22	5.50
Total		1931 Kg/day	482.5 Kg/day

Source- Manual on Hospital Waste Management (2000) Central Pollution Control Board

*Assumed biomedical waste generation as 1kg per bed per day

** Assumed infectious biomedical waste generation as 250gm/bed/day



The amount of waste generated under each category reported from field investigation and as reported in the Government report submitted by these hospitals/

nursing homes to the Pollution Control Board Government of Meghalaya are presented in Table 4.6.

(i) The Government report and field investigation does not tally with each other.

(ii) In regards to the amount of waste generated its method of collection, treatment and disposal the field investigation of the different hospitals/nursing homes does not tally with the annual report of the individual hospitals/nursing homes submitted to the government. The discrepancy is high.

(iii) If the number of beds available in the important hospitals/nursing homes of Shillong are considered and a calculation is made according to the standard norm (Table 4.7). Then each patient should be generating on an average 1kg of waste per day of which 25 percent consisting of infectious pathological and anatomical waste (Kerac 1992)[7]. From this one can ascertain that at least 2281 kg of biomedical wastes is being generated per day from the different hospitals/nursing homes of which 565 kgs are highly infectious (Table 4.7). Hence in a week about 15967 kg of waste is being generated of which 3955 kg are highly infectious.

4.5 **Present method of the disposal of the municipal solid waste and medical waste**

At present Shillong's solid waste collection, transportation and disposal can be categorised as:

Organised sector manned by the Shillong Municipality, the Shillong Cantonment Board and Syiem of Mylliem.

(i) The Shillong Municipal Board and Meghalaya Urban Development Authority looks after the waste collection and disposal of the 27 wards within Shillong Municipality.

(ii) (ii) The Cantonment Board looks after the waste collection and disposal of the areas under the Cantonment.

(iii) The Syiem of Mylliem looks after the waste collection and disposal of Iewduh (Bara Bazar the state's largest wholesale market) and certain areas under the Syiemship.

The unorganised sector consists of the five townships of the Shillong Urban Agglomeration, viz., Mawlai, Nonthymmai, Madanrting, Pynthorumkhrah and Nongmynsong. These townships supporting more than 45 percent of the total population of Shillong Urban Agglomeration have to manage their own waste collection and disposal. In the absence of any organised waste collection and disposal infrastructure the wastes are often dumped into the numerous natural streams.

Municipal Board

The municipal board is looking after the solid waste disposal of 27 wards located within the Shillong Municipality covering an area of 10.36 sq km supporting a population of 132876 persons living in 26929 households (2001 census). The waste collection is done here in two ways.

(a) House to house collections in certain selected localities.

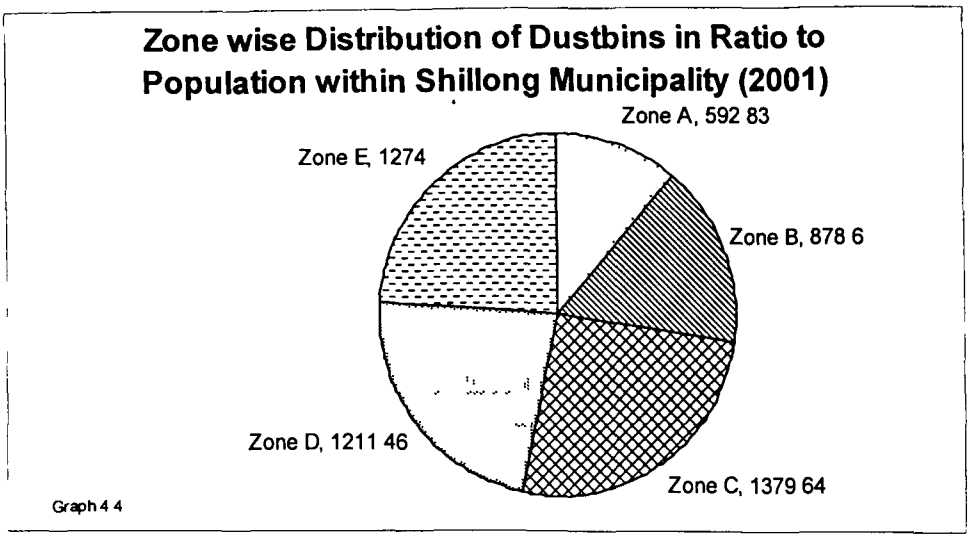
(b) Collection from the dustbins.

At present there are 112 dustbins located within the 27 wards (Table 4.8). Due to hilly terrain the handcarts cannot be taken to the steep slopes hence a conical shaped basket known as '*thapa*' is used for collecting the waste from the bins which are then put in the refuse vehicles to be carried away to Mawiong compost centre.

Table 4.8: Zone wise distribution of dustbins within the Municipality in ratio to population (2001)

Zone	Ward name	Number of bins	Open spot	Total population	Number of population in ratio to a dustbin
Zone A	Police Bazar European ward, Nehru colony	35	7	20749	592.83persons : 1 dustbin
Zone B	Kenchestrace, Bishnupur, Rilbong Madanlaban, Lumparing Laban	30	9	26358	878.6persons:1dustbin
Zone C	Mawkhor, Wahingdoh, Riatsumthiah, Jaiaw	14	6	19315	1379.64persons:1dustbin
Zone D	Laitumkhrah,Malki Cleevecolony,	26	13	31498	1211.46persons:1dustbin
Zone E	Mawprem, Quallapattey	NA	NA	34947	
Total		105	35	133867	1274persons:1dustbin

Sources: (i) Final Report of NEERI(1991) "Planning For Solid Waste Management At Shillong" Sponsored by Department Of Urban Affairs Govt. of Meghalaya.
(ii) Census of India 2001 Meghalaya Series



Organisation of the Municipal Board

The municipal board is headed by a chairman and is assisted by Chief Executive Officer and a board of 12 members. The health officer is in charge of the solid waste activities and is assisted by senior sanitary inspectors and sanitary inspectors. The 27 wards are grouped into 5 zones (Table 4.8) and each sanitary inspector is looking after 4-5 wards gets its work done under the supervision of conservancy supervisors, head jamadars and sweepers.(Govt. Report 1991)[8]. An analysis of Table 4.8 suggests that

Zone 'A' consisting of wards of Police Bazar, Jail Road European ward Oakland Forest colony, Polo Ground, and Lachumiere are having moderately steep slope of 10-20°. This zone is having 35 community bins and 7 open spots from where solid waste is being collected in a daily basis. This zone supports a population size of about 20749 persons hence on an average 573.34 persons share a dustbin for disposing of their waste.

Zone 'B' consisting of the localities of Kenches' Trace, Bishnupur, Rilbong, Madan Laban, Lumpering and Laban located at moderately steep slope of $10\text{-}20^0$. This

zone has 30 community bins and 9 open spaces for dumping of its wastes. This is being collected on a daily basis. This zone supports a population size of 26358 persons hence on an average 878.6 persons share a dustbin.

Zone 'C' consists of the localities of Mawkhar, Wahinghdoh, Jaiaw, Mowlonghat has 14 community bins and 13 open spots where all types of solid wastes are disposed. This zone supports a population size of 19315 persons hence on an average 1379.64 persons share a dustbin.

Zone 'D' consists of Laitumkhrah, Malki, Dhankheti, and Cleeve Colony having a population of about 32180 persons. This zone has 26 community dustbins and 13 open spaces for solid waste disposal. Hence about 1237.69 persons on an average share a dustbin.

Zone 'E' consisting of Upper and Lower Mawprem and Naspati Ghari with a population of 34947 persons has no access to dustbins within the localities. Most of the waste finds its way into the streams and drains of the area.

The number of vehicles engaged for waste disposal of the Municipality are 7 open bodied trucks, 9 hydraulic tippers and 2 three wheelers. The number of workers employed to collect the solid wastes from the 27wards are 512 persons (SMB 2003)[9]. The waste is collected daily from the city and disposed at Mawiong. Here there is an aerobic plant which composts 100 tons of organic wastes daily. The inorganic wastes are simply dumped into the slopes of Mawiong which ultimately washes down to the Umiam Lake.

Cantonment Board

The Cantonment having a total area of 1.84 sq km, supports a population of about 4.62 percent (2001 census) of the Shillong Urban Agglomeration. According to the State Pollution Control Board the Cantonment Board lifts around 15-18 metric tons of solid waste every day.

The Cantonment of Shillong has a very clean look except the civilian portion of Jhalupara, which is a recognised slum of Shillong. The Board looks after the waste disposal of 2476 households (2001 census). The information collected on June 2003 from the Cantonment Board suggests that there are 50 dustbins (40 dustbins within the Army area, 3 dustbins in the Cantonment Board area and 7 dustbins in Jhalupara.). Every day wastes are collected from approximately 20 dustbins hence every alternate day the dustbins are cleared. Two trucks are employed for collecting the waste from the dustbins. Wastes are collected manually and there is no segregation of waste at source. This waste is than disposed off at Mawiong where waste is segregated into organic and non organic. The organic waste is turned into compost along with other organic waste from the Shillong Urban Agglomeration.

Syiem of Hima Mylliem

The Syeim of Hima Mylliem looks after the solid waste disposal of the biggest wholesale market of the State viz. Barabazar/ Iewduh. Information collected from the Syiem's office on Nov. 2003. The Syiemship is looking after waste disposal of 2401 shops and a large number of households. There are 3 dustbins where the refuse from the market

is being dumped. There are 2 open bodied trucks having a capacity of 3 tons each to carry the waste of the entire market. However practically it is one truck, which does two trips to carry the refuse from the dustbins to the waste disposal site at Mawiong. Segregation of waste at source is not practiced.

The number of workers engaged in carrying out the waste collection, transportation and disposal have remained the same since the inception of the state in 1971 i.e.30 workers. Since the inception of the state 1 kuttcha and 2 concrete dustbins have remained until recently when under the Australian Aid Programme a dustbin has been constructed at Motphran in 2004. Waste collection is done with the help of manual labourers.

Traditionally for packing of fish, meat wild variety of leaves were used as but now a days plastics bags are being used.

Field survey of Barabazar/Mowlonghat vegetable market indicates a chaotic situation. The entire area has fowl stench.

i. In both the organised and the unorganised sectors leave behind their refuse refuse in the market place. Few cleaners are employed by the Syiem every morning to clean the market area. They just collect and dump these wastes in a nearby open dustbin.

ii. About 10 percent of the waste generated from the unorganised wholesale vegetable market is collected and used by the villagers to maintain their piggery, and composting purposes. Therefore a rudimentary concept of reuse of the waste is present in the traditional Khasi society. Hence about 150-225 kgs of waste generated per day is being recycled.

iii. In the fish market the retail sellers pay Rs10 per shop to the Syiem for waste disposal of the fish market. The fish waste is collected in tins by the retail sellers by the sides of their respective shops which are collected every morning by the cleaners and dumped in the open dustbin where the vegetable wastes etc are collected.

iv. The waste generated from the meat market, relatively less in amount, is being dumped in the open dustbin where the beetle nut wastes are collected.

v. Field survey indicates that all the three dustbins are in a dilapidated state. The Mowlonghat dustbin is located on the crest of the slope hence during rainy season all the wastes are washed to the busy road, which is the entrance to the vegetable market. Waste collection by the cleaners and dumping of the waste in the trucks are carried out in the peak business hours around 2 p.m. in the after noon. Therefore, the entire place is polluted with unbearable stench. The entire area is littered, with leaking water pipes thus creating unhealthy situation. These are a source of contamination of water. The lanes are extremely narrow and highly congested and wastes are being dumped in and near the shops which is often mixed with the water. Consequently the entire area is extremely slippery and accident-prone. The presence of water with the waste hastens the process of decomposition thereby making the market place a haven for breeding of germs and other microorganisms.

Medical Waste

The various waste management phases i.e. segregation, storage, transportation and treatment of biomedical wastes at the various health centers of Shillong Urban Agglomeration reveals that none of the biomedical waste management phases are complied. It is in total contradiction with the rules imposed by the Ministry of Environment and Forests.

It is noteworthy to mention that the Civil Hospital of Shillong, which has 400 beds, clearly states in its annual report submitted to the Pollution Control Board on March 13, 2003 that "all types of hospital waste with quantity amounting to eight truck loads monthly is collected by the Municipal trucks from the dustbins of the hospital.

At present only 4 hospitals have functioning incinerators. These incinerators are both commissioned and monitored by the Pollution Control Board. It could not be ascertained if the incinerators installed conform to the specifications laid down by the apex court.

Most of the hospitals/nursing homes have a dumping ground from where the waste is being collected by the municipality. The Municipal authority has identified a landfill for hospital waste, though it is not functional. At present the Municipality collects the solid wastes from the hospitals/nursing homes and deposits them at the aerobic plant generating Bio-Plus (compost) at Mawiong.

There are certain technical difficulties regarding installation of incinerators in some of the city hospitals/nursing homes. The location of certain hospitals in the city is such that the installation of an incinerator is not possible. They are located in congested part of the

city surrounded by residential/commercial and educational areas, which are on a higher elevation. Consequently installations of incinerator are not possible in such hospital/nursing homes that are situated on depressed valleys.

Field survey reveals that except Military Hospital (which also maintains the color code) segregation of waste at source according to the guidelines laid down by the Ministry of Environment and Forest "Biomedical Waste (Management and Handling) Rules 1998 are not followed at all. The reason could be due to the lack of infrastructural facilities, profit motive and lackluster attitude of the concerned Government Agencies responsible for implementing the rules.

It has been observed that the workers responsible for handling hospital waste rarely wear protective gear when collecting and transporting infectious wastes.

The mishandling of incinerator ash, which consists of both fly ash and bottom ash contributes to health hazards. The hospital waste contains heavy metals, dioxins etc. When these wastes are dumped in landfills they lead to ground water contamination. Through leaching of these infectious materials people are suffering from diseases like cholera, jaundice, gastroenteritis, typhoid etc.

4.6 (a) **Socio-economic factors affecting generation and disposal of waste (Organised Sector)**

After a detailed discussion on the types, amount and method of solid waste disposal within Shillong, it is studied whether socio-economic factors determine the amount of household solid waste.

It has been observed that one of important problems, which present day people face, is that of disposal and management of household garbage and solid waste. Residential domestic waste forms the bulk resources of solid waste within the city (Singh 1998)[10].

The highest levels of resource utilisation tend to occur in the wealthiest cities and among the wealthier groups within the city (Annon 1996-97)[11]. By contrast the per capita resource use and levels of waste generation tend to be low among the urban poor. Similarly the different socio–cultural factors may have a role to play in both waste generation and its disposal

It is in this context that a field survey was carried out in Ward 7 of the Municipality in the locality of Lachumiere where people are relatively economically well off. Ward 21 of the Municipality in the locality of Jhalupara a slum area representing economically poorer neighborhood. Ward 22 of the Shillong Municipality at the Rilbong locality having the highest concentration of non tribal population (census 2001). The township of Nongthymmai has the highest density of population (census 2001) and located close to the water source region of Shillong.

The empirical data on various parameters affecting generation of waste and its disposal has been generated with the help of household survey based on questionnaires. The sample size was 487 households, 100 households each from the localities of Jhalupara, Lachumiere and Rilbong, 187 households surveyed randomly from the 11 localities of Nongthymmai township

In Shillong the segments (sub-locality) within a locality can be easily identified as there is a concept of a headman of a locality, locally known as '*Rongbha Shnong.*' The

'Rongbha Shnongs' control the *'Rongbha Dongs'* which consists of headmen of the sub localities.

Background of the areas studied

Jhalupara is located in ward number 21 under the Municipality but its civic amenities including water supply and waste disposal are within the jurisdiction of the Shillong Cantonment Board. It is a recognised slum of Shillong having a population of 12052 persons of which 2589 are tribal (2001 census) about 75 percent of the total population living here are non-tribal. It is divided into three sectors. Jhalupara has a moderately steep-to-steep slope. It is located by the side of the stream close to the Gunner Falls, in the Umshirpi basin. Unlike the slums in the plains the slums of Shillong are less bleak because of its social structure, topographic advantages and low level of industrialisation. The slums of Shillong have some unique characteristics, as there is cordial existence as neighbors irrespective of their economic status. Recent survey in some of the slum areas indicates that urban poor in the slum areas comprise of 20-30 percent of the total population (Govt. Report 1991)[12].

Lachumiere is situated in the watershed zone of Umkhrah and Umshirpi water divide. This locality has been selected to represent one of the posh localities of Shillong.

The average slope of the area is about 10-15 and 15-20 degrees which is moderate to moderately steep slope. As per 2001 census the total population of the ward is 74753 persons living in 989 households. The composition of the population is about 19.73 percent

are tribal and 80.27 percent are non-tribal. In Lachumiere field survey suggests that majority of the houses are owned by the tribal people while the tenants are non-tribal.

The Lachumiere locality has 5 sectors consisting of Upper Lachumiere, which has two segments, and lower Lachumiere which has three segments.

Rilbong is located towards the south western section of the study area. It is within the Shillong Municipality situated in Ward No. 22. The total population is 3589 persons (2001 census). Out of which 84 percent are non-tribal. This ward has the maximum concentration of non-tribal population next only to Police Bazar. Rilbong has been selected to represent a non tribal locality.

Rilbong is situated in a moderate to moderately steep slope near Umshirpi River close to the Shillong Cantonment. In fact river Um Jasai a tributary to river Umshirpi is flowing through this locality.

(a) Lachumiere has 60 percent of its respondents belonging to the Khasi tribal community. The majority of them follow Christianity, though about 17percent of the respondents are practicing the original Khasi religion. About 65 percent of its respondents are having educational qualification of graduate and above. About 18 percent of the respondent's occupation is professionals consisting mainly of Doctors, Engineers, Lawyers etc (Table 4.9a). The other area is Jhalupara where the educational levels of the maximum respondents (about 67%) are below graduate. About 95 percent of the respondents are non-tribal belonging to various communities. The majority of the respondents (above 50 percent) are Nepalese and the rest belong to Marwari, Bihari and other communities. In Rilbong 90 percent of

the respondents are non tribal where the dominants are Bengali community. The educational qualification of the (76%) respondents is graduate and above (Table 4.9a).

Table 4.9(a): Socio Economic Characteristics of selected localities, their approximate amount of solid waste generation /day within the organised sector and the Township of Nongthymmai

Population Composition	Jhalupara (No.of respondents 100)	Lachumiere (No Of Respondents 100)	Rilbong (No of respondents 100)	Nongthymmai (No of Respondents 187)
Tribal Non-tribal	5 % 95 %	60 % 40 %·	10 90 %	88.24 % (168) 11.76 % (22)
Educational qualification of the Head of the Family				
Illiterate	Nil	Nil	Nil	(6)
Below Matriculate	45%	Nil	2%	9.09% (17)
Matriculate	22%	17%	10%	11.23% (21)
Graduate and above .	24%	65%	76%	60.96% (114)
Others/ technical	9%	18%	12%	15.51% (29)
Occupation of the Head the family				
Business	51%	28%	10%	22.46% (42)
Private job	20%	12%	28%	26.20% (49)
Govt.Job	16%	60%	62%	35.83% (67)
Govt. Jobs & business	13%	Nil	Nil	15.51% (29)
Approximate Family Income/month (Rs)				
< 4000 (low)	20%	Nil	Nil	10.16% (19)
4000-8000 (medium)	36%	Nil	16%	37.43% (70)
8000-16000 (high)	24%	8%	47%	34.22% (64)
> 16000 (very high)	20%	92%	37%	18.18% (34)
Family size (Members)				
<4 (Small)	11%	30%	26%	14.44% (27
4-6 (Medium) >6 (Large)	43% 46%	37% 33%	63% 11%	39.04% (73) 46.52% (87)
Approximate Sold Waste Generated/day/family				
< 1/2kg	28%	2%	20%	14.97% (28)
1/2kg-1kg	49%	26%	10%	29.41% (55)
1-2kg	12%	32%	36%	26.74% (50)
>2kg	11%	40%	14%	28.88% (54)

Source: Field data

(b) Field study suggests that educational qualification of the head of the family plays an important role in occupation. In Jhalupara about 51 percent of the head of the family are engaged in business as their occupation. About 13 percent are employed in the government sector. In Lachumiere about 60 percent of the head of the family are employed in government sector while 28 percent are engaged in business. In Rilbong 62 percent of the head of the family are employed in the government sector.

(c) Educational level often determines the nature of occupation, which in turn determines income of the family. In most of the households there is more than one earning member in the family. Consumption and generation of waste is determined by the income of the entire family.

(d) It has been observed that income level plays an important role in generation of solid waste. Wealth is a primary determinant of how much solid waste a city produces (Govt. Report 1991)[13]. There is a discrepancy in regard to solid waste production between the rich and the poor in the developing cities of the world. Shillong is no exception to this. The family size data has been collected to show the per capita income of the dependents and the amount of solid waste generation.

(e) In Lachumiere about 33 percent of the total respondents are living in large families, In Jhalupara about 46 percent of the respondents are living in large families. While in Rilbong the respondents living in large families are only 11 percent of the total respondents. It is important to mention here that Lachumiere is predominantly tribal population of Khasis. Among the Khasis joint family system is still prevalent.

(f) About 40 percent of the total respondents of Lachumiere are generating more than 2 kg of domestic waste/day. In Jhalupara only 11 percent of the total respondents is generating domestic waste more then 2 kg/ day though more respondents living in large families than in Lachumiere. In Rilbong only 14 percent of the respondents generate more than 2 kg of domestic waste /day. Hence from this it can be conferred that income level plays an important role in the generation of household waste as the per capita consumption is higher.

Table 4.9b suggests how habits and amenities play a significant role in the generation and disposal of wastes.

(a) The study shows that packed food is consumed more by the affluent population of Lachumiere. Almost 100 percent of the total respondents are in the habit of taking packed food. About 27 percent of the respondents take packed food daily, 31 percent take packed food at least 2-3 times a week. Where as in Jhalupara none of the respondents take packed food daily and 70 percent of the respondents are not in the habit of taking packed food at all. In Rilbong about 40 percent of the respondents do not consume packed food. Hence the use and throw culture associated with packed food consumption is more common in Lachumiere than in other localities. Thus Lachumiere generates more waste than Jhalupara or Rilbong yet it wears a clean look due to the amenities, which it enjoys regarding waste disposal infrastructure. With increased wealth the composition pattern also changes leading to changes. This leads to more waste generation. Compared to primary

biodegradable organic materials plastics and synthetic materials, takes much longer to decompose.

(b) Amenities like toilet types, discharge of the house drains, presence of dustbins, plays an important role in the nature of waste disposal. In Jhalupara 33 percent of the total respondents do not have any access to proper toilet facilities as they have to share common service toilets located outside the compound of their residences. There are 7 toilets catering to at least 33 percent of the respondent families. These toilets are in a terrible state. Cleaning of the toilets is not done regularly. The locations of these public toilets are by the side of the stream and some wastes are directly dumped into the stream. To use these public toilets people pay tax called latrine tax biannually to the Cantonment Board even if they are not using these public toilets. This tax was levied by the British government in 1916 for all the settlements within the Shillong municipality (Assam Secretariat 1916)[14]. 10 percent of the total respondents are using '*Kutcha*' manually cleaned toilets (pit latrine) where the waste is disposed off directly into the stream flowing through Jhalupara. Hence pollution from night soil disposal is very high in this area.

(c) Disposal of domestic waste water remains a problem in Shillong it is observed that the house drains of all the three localities are discharging either into the street drains or to the streams directly (Table 4.9 b). Disposal of plastics to the drains are causing clogging of the drains and streams. These are creating water logging in Shillong.

(d) In Lachumiere 54 percent of the respondents are disposing their plastics and other wastes straight into the municipal vehicle as there is house to house waste collection system. 38 percent of the respondents of Lachumiere are disposing their wastes into the street bins (three in number). This waste is collected by the municipality almost every day. Only 5 percent respondents of Lachumiere are disposing their plastics and other wastes straight into the streams. Contrary to this in Jhalupara about 55 percent of the total respondents are disposing their waste straight into the streams. About 7 percent of the respondents dispose their wastes on the streets, 33 percent into the dustbins. The Cantonment Board collects these wastes from the dustbins every two to three days a week. In Rilbong 38 percent of the respondents dispose of their wastes into the dustbins from where the municipality vehicle collects every alternate day. There are three dustbins in the locality. About 14 percent of the total respondents are disposing off their waste straight into the streams.

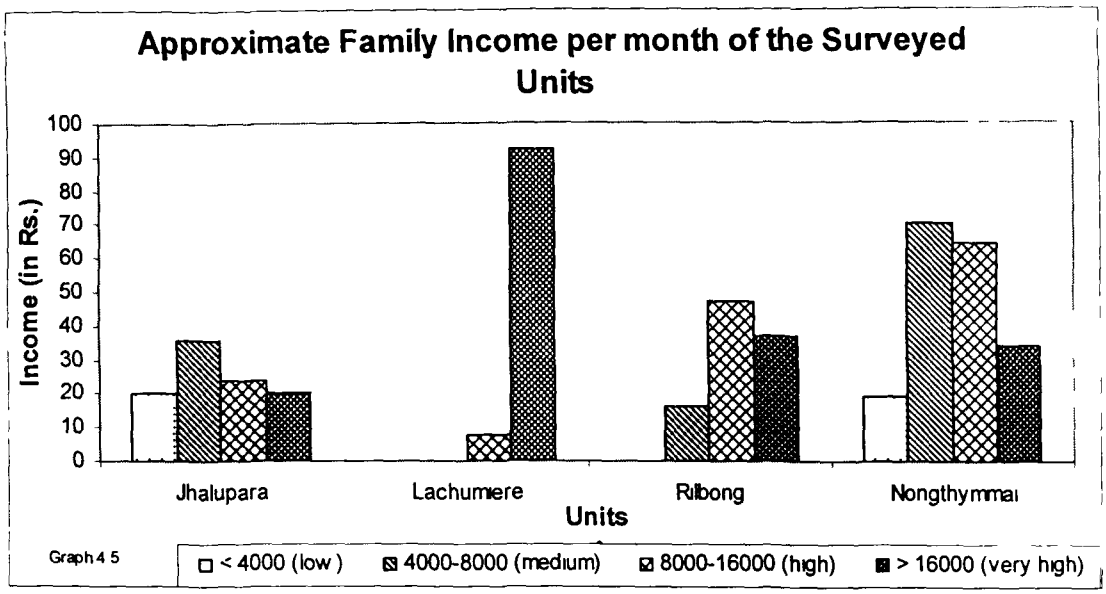
(e) The disposal of other recyclable domestic waste generated in the form of old bottles, news papers, left over clothes, magazines, broken furniture etc in Jhalupara about 59 percent of the respondents sell their recyclable wastes. In Lachumiere only 14 percent of the respondents sell their recyclable wastes. In Rilbong 100 percent of the respondents sell their recyclable wastes.

Table 4.9 (b): Amenities available, Habits and method of waste disposal

Type of toilet	Jhalupara (Nos. of Respondents 100)	Lachumiere (Nos. of Respondents 100)	Rilbong (Nos. of Respondents 100)	Nonthymmai (Nos. of Respondents 187)
Common community latrine	33%	Nil	Nil	nil
Pit latrine	10%	Nil	Nil	nil
Sanitary latrine	57%	100%	100%	96.26% (3.74% deface out in the open)
Location of the toilet				
Outside the compound of the house	33%	Nil	Nil	nil
Outside the house	30%	2%	10%	24.06% (45)
Within the house	37%	98%	90%	72.19% (135)
Where do the house drains discharge				
Into a street drain	34%	90%	45%	41.71% (78)
Into a stream	60%	8%	55%	52.41% (98)
Into the street	6%	Nil	Nil	5.35% (10)
Into a pit	Nil	2%	Nil	0.52% (1)
Frequency of packed food consumption				
Daily	Nil	27%	Nil	nil
2-3times a week	4%	31%	20%	4.27% (8)
once a week	26%	32%	33%	19.25% (36)
once a fortnight	Nil	10%	7%	17.11%(32)
Minimal	70%	Nil	40%	59.36% (111)
Disposal of the kitchen and other domestic waste*				
Street	7%	Nil	Nil	5.35% (10)
Community dustbin	33%	38%	86%	nil
Drain	Nil	Nil	Nil	nil
Stream	55%	5%	14%	49.20% (92)
Pit	5%	8%	Nil	45.46% (85)
Respondents selling recyclable solid waste	59%	14%	100%	98.93% (185)
Burning of waste				
Yes	6%	8%	Nil	45.46% (85)
No	94%	92%	100%	54.54% (102)
Practice of dumping of waste to be later used as manure				
Yes	6%	8%	Nil	45.46% (85)
no	94%	92%	1005	54.54% (102)

* 54% of the respondents of Lachaumiere have access to door-to-door collection

Source: Field data.



(f) Composting of waste is not practiced at Rilbong. In Lachumiere and Jhalupara about 8 percent of the respondents and 6 percent of the total respondents respectively is practicing composting. This section of the respondents dumps their organic waste into pits to be used later as manure. It must be mentioned here that in Lachumiere where the settlements consist of mostly bungalows and cottage type of houses with a proper compound and garden the natural waste is often collected and dumped in pits to be used as manure

To conclude it is observed from empirical data that more than social factors it is the economic factor that play role in regards to the amount of waste generation but also in the disposal of the waste Empirical data clearly suggests that the economically better off section of the society have better amenities and are provided with better method of waste disposal system than the economically poorer section of the society.

It is interesting to note that within the localities too the space has been divided on economic lines where the relatively poorer section of the locality tend to concentrate in certain sectors as observed in Jhalupara. The survey as already mentioned is more of an overview and opens the scope for further research.

4.6 (b) **(Unorganised sector)**

Previously it has already been mentioned that the waste of the census townships of Shillong is unaccounted as there are no agencies, which collects this waste or maintains any records. These townships support about 45 percent of the population of the Shillong Urban Agglomeration. A field study was conducted on June 2003 in the 11 localities of Nongthymmai Township with the help of questionnaires. This township was chosen as it records the highest density of population i.e. 11675 persons (Census 2001)[15] among the five townships of Shillong (census 2001). The total area of this township is 2.93 sq km and supports a population size of 34209 persons. The total number of households as per 1991 census is 5474 households.

Background of Nongthymmai Township

The township of Nongthymmai is situated towards the south eastern section of the study area which is very close to the water source region of Shillong. The township has an average slope of 15-20 degrees and an absolute relief of 1600-1800 meters above m.s.l. It is situated in the catchment area of Umkhrah basin. This township has seen rapid

urbanisation as the national high way linking Meghalaya with Assam, Mizoram and Tripura passes through this township.

It is observed that settlements have come up haphazardly in the steep slopes. Encroachment of the stream beds are a common phenomena here. In the absence of any organised waste collection system, most the population dispose of their waste straight into the streams or the streets. This is ultimately washed into the water bodied especially during the rainy season. It has been observed that settlements by the side of streams have their sanitary toilet outlets straight into the streams. The township has eleven localities viz. Lumpyngad, Lumdiangsoh, Lumsohpoh, Lawjynriew, Nongkhyrium, Demthring, Nongrim, Nongshylliang, Pokseh, Lumiablot Dumdum and Pokteh and Lau-u sib

(1) Field study suggests that 88.24 percent of the respondents are tribal people where dominant group is the Khasi. Demthring has a good concentration of Mizo population who has settled here.

(2) The educational qualification of the respondents varies from locality to locality. About 3.21 percent of the respondents (head of the family) are illiterate mainly consisting of milkman and few farming families. In Nongthymmai about 60.96 percent of the total respondents are graduates. About 15.51 percent are having technical qualification.

(3) Educational qualification plays a significant role on the occupation of the respondents which ultimately determines the income level and thereby the economic status of the respondents. Empirical data suggests that maximum number

of head of the family are working in the government sector accounting for 35.83 percent, (Table 4.9 a)

(4) Occupation also plays a significant role in determining the monthly income of the respondents. Empirical data suggests that the maximum respondent of Nongthymmai Township draw a family income of Rs 4000-8000 per month (37.43 percent) of the total respondents (Table 4.9a). The township has more of medium and high income groups of population.

(5) Family size of the respondents is important to determine the per capita waste generation; hence it is observed that about 46.52 percent of the total respondents of Nongthymmai Township are living in large families where the number of family members is more than six. About 39.04 percent of the total respondents are having medium sized families with 4-6 members while only 14.44 percent of the total respondents live in small sized families of less than 4 members.

(6) The amount of solid waste generated by the households about 28.88 percent of the respondents generate more than 2 kg of waste/day and about 29.41 percent generate (about ½-1kg) of waste/day, 26 percent of the respondents generate about 1-2 kg of waste while only 14.97 percent of the respondents generate only about ½ or even less than that of waste/day. Hence the amount of waste generation is relatively less here in spite of having large families.

(7) There are no dustbins in the entire Nongthymmai Township. Recently a truck from the municipality comes every alternate day to certain localities to collect the solid waste. This has been introduced by the local M.L.A of the area. However the rest of

the waste finds its way to the streets and drains of the area and ultimately washed down to the streams of the Township. About 45.46 percent of the respondents are dumping their waste in pits to be later used as manure while the non bio-degradable commodities are burnt. However during the rainy season the waste is directly disposed into the streams or streets.

(8) About 96.26 percent of the respondents have access to proper sanitary toilets. However about 3.74 percent of the respondents use open spaces, thus creating environmental pollution of the locality.

(9) About 24.06 percent of the respondents go to common toilets located within the compound of the house while the rest 72.19 percent of the respondents have their own toilets within the house.

(10) Nearly 42 percent of the total respondents waste water house is discharged into street drains, while 52.94 percent of the total respondents' waste water is discharged directly into streams. About 5.35 percent of the house drains of the respondents discharges into the neighboring compounds or into the streets directly.

(11) Most of the respondents here do not have the habit of packed food consumption. The generation of plastics is not as high as Lachumiere locality of Shillong municipality. However the generation of plastics from packed food varies from locality to locality within Nongthymmai.

To conclude it is observed that there is a marked difference between the waste disposal facilities between the organised and unorganised sectors.

There is community cleaning practices in the localities of Nongthymmai at least once a year. They clean their localities in an organized manner. But the collection of the wastes through trucks by the civic authorities is not in a regular manner. Within the unorganized sector of Nongthymmai most people compost their wastes for reuse purpose. The local Durbar plays an important role in cleaning the drains by the community.

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CHAPTER V

WATER SUPPLY

5.1 **Introduction**

After a detailed discussion on the population growth of Shillong and associated problems of waste disposal it becomes imperative to have an understanding of the water supply scenario of the population living here. Water is an essential ingredient for the survival of life and human beings are no exception to this. With the growth of population and urbanisation this natural resource is becoming scarce. As population grows the demand for water increases, but at the same time the water resources gets contaminated and polluted due to improper solid waste disposal.of the increasing population. Higher living standards lead to higher consumption of water. At the same time higher living standards results to higher waste generation. This waste in a hilly area like Shillong having high rainfall gets washed into the streams. These streams are the sources of water.

With rapid urbanisation the process of deforestation also increases due to this runoffs also increases and water from precipitation gets wasted as run offs instead of feeding the streams. Urbanisation leads to creation of concrete structures this reduces percolation capacity of the soil, and reduces the stream discharge and sometimes the streams dries up. Thus water scarcity occurs in many parts of the city.

A city in order to sustain itself must have an adequate supply of water for its growing population. Shillong being hilly area water is a scarce commodity in the absence of a major river or rich ground water aquifers. Like other Indian cities Shillong too faces acute water crises during dry season. The large section of the people do not have access to water supply and those having access, too are facing shortage and using contaminated water as water supplied is polluted with their own waste (Singh 1986)[1].

In the context of India it is seen that approximately 16 percent of the world's total population is concentrated in 2.45 percent of the world's land area and 4 percent of the world's water resources. A recent study by the World Bank indicates that per capita availability of water that was in the order of 5000 cubic meter per year during Independence. This has drastically come down to 2000 cubic meter per year at present. According to a study conducted by the Central Ground Water Board the under ground water will be dried up by 2025 in as many as 15 states in India if the present level of exploitation and misuse of under ground water continues (Dikshit 2003)[2].

Consequently water is one of the biggest crises that is faced in Urban India where there is more demand than supply. As city grows and towns' sprouts adequate policy measures regarding water are not given its due priority, this has resulted to emerging water problem. Most Municipalities and Corporations are focused on the immediate tapping of the ground water resources in and around the city which is causing adverse effect on the ground water level. With the process of urbanisation the traditional system of managing water resources are often dismantled. the problem of mismanagement and wastage of water during collection, distribution and delivery of water is rampant. In Mumbai alone about 600million litres of water per day finds its way to the gutters (Shanker 2003)[3]. The scene is the same in most of the urban centres of the country where water has become a luxury. With water pipes running empty, the water tankers have now become the sources of water for most of the population living in our cities. Similar situation is faced in Shillong, though situated in the highest rainfall region of the country with an annual precipitation of about 2400 mm. Yet the city reels under severe water problems especially during the dry season.

A recent study on the water supply of Shillong by an NGO suggests that about 1247.4 million gallons of water is lost annually due to leakages. This is sufficient to cater to the water needs of 40 percent of the present population (Sahu 2005)[4].

This chapter makes an attempt to get an insight into the present nature of water supply, the quantum and quality, the distribution pattern, the socio-economic factors and the role geo-environmental factors that play in the water supply of Shillong.

5.2 **Present Nature of Water Supply**

Shillong Urban Agglomeration is served by piped water, connected mainly from the 7 spring sources and 3 river sources. This system is looked after by two State organisations and the local Dorbars. Hence he following bodies are looking after the water supply of the city

(i) The Shillong Municipal Board.

(ii) The PHE Department

(iii) The Local Dorbars.

In Shillong surface water is undoubtedly the most dependable source. There is not much scope for exploration of the ground water sources in and around the city owing to the rugged topography. Some wells are the source of water in the water deficient zones to augment the present water requirement especially in the valley lows, e.g. Pynthorumkhrah where there is shallow aquifers. Except Umsohlang the other sources are located towards

the south of Shillong close to the Shillong ridge (absolute relief of above 1800 meters). These streams are rain fed hence there is a seasonal fluctuation.

The city at present does not have any one integrated water supply system. Water supply distribution was first laid as early as 1930 by the British administration when the population was only 2100 (Dympep 1998)[5]. After the creation of the State the Greater Shillong Water Supply Scheme was adopted in 1976 to meet the needs for water of the growing population but till date the plan is incomplete.

As population grows additional pipes are added to the original system without adequate increase in the capacity of the overhead water tanks. The increase in population has increased the demand of water within the Shillong Urban Agglomeration and many areas in the city today are facing acute water shortage. The fringe of the city where urban sprawl is occurring, there are shortage of water especially during the dry season.

5.3 Organisations and their Sources of Water supply

The following organisations are looking after water supply of Shillong.

1. The Shillong Municipal Board supplies a total amount of 2.73 million litres of water per day. This mainly comes from 7 natural springs/streams which are as follows:-

(i) Umjasai spring sources, located near the Government sericulture farm bordering Lawsohtun (a rural component of Shillong Standard Urban Area) this source was tapped by the Assam P.H.E. department during 1950 (PHE Report 2001)[6]. At

present the water from this source supplies water to Mawprem and Barabazar. The Umjasai source has basically two natural springs.

(ii) Wah Jalynnoh spring this was tapped by the erstwhile British Government during 1920 (PHE Report 2001)[7]. Originally this spring source was tapped to cover the water needs of the population residing in Bishnupur, Kenchs Trace, Rilbong, Madan Laban, Red cross, Barik, Secretarial hill, Temple Road and Keating Road. However with population increase the water from this source is not adequate to meet the demands of these localities. . The additional water requirement is looked after by PHE Department of the State. The Shillong Municipal Board does not do any scientific treatment of the water before supplying it to the overhead tanks whereas the water from PHE department is treated at Mawphlang Plant before supplying it to the over head tanks.

(iii) Madan Laban spring source is located at about 0.4 km upslope of Raid Laban School. This source was originally tapped by the British government during 1936 (PHE Report 2001)[8]. The water from this source meets the demands of the population residing in Madan Laban, Laban East and Laban West.

(iv) Pathakhana spring source is located near Madan Laban spring source and was originally tapped by the British government during 1930 (PHE Report 2001)[9]. The water from this source meets the demand of the population residing in Madan Laban and Laban.

(v) Warisa spring source has a reservoir fed by three springs located at a distance of about 150 meters from each other. This source was first tapped by the British

government during 1920 (PHE Report 2001)[10]. This source is located in Upper Lumpering. This source supplies water to Malki, Lachumiere, Barik, Keating Road besides Lumpering, and Riat Laban.

(vi) Crinoline spring source is situated about 1.50 km south west of Nong Malki road/Hydari Park, this source was originally used by the British government in 1876 at a rental of rupees 50 a year from the people of Raid Laban (PHE Report 2001)[11] and was later it was tapped by the Shillong Municipal Board. The water from this source meets the partial requirement of the population living in the localities of Secretariat hills, Nong Malki, Barabazar, and the water requirement of Civil Hospital, TB Hospital, and KJP Hospital.

(vii) Wah Dienglieng spring source consists of six number of natural spring sources located in the reserved forests of upper Motinagar/Lumpyngad, this source was originally tapped by the British in the year 1930(PHE Report 2001)[12]. All the six sources supply water to Nongrim Hills, Risa Colony, Lum Mawrie and other areas.

The reservoirs built in all these spring sources are in a dilapidated condition and no repair or reconstruction has been done since its inception. Much of the water is lost through leaking pipes. This water is not treated but basically disinfected by adding some bleaching powder to the service reservoirs, and then it is supplied directly into the distribution systems.

The water sources supplying under the Shillong Municipal Water Supply lie in the central upland zone of Meghalaya, i.e., the south of the study area where the absolute elevation is around 1600-1800m above m.s.l. If constructional activities and waste disposal is done directly in the streams and streets in these localities, may spell disaster to the geo-environment of the city. This region to the south of the city acts as the water source region of Shillong. Deforestation in this area may lead to the drying up of the springs and streams of Shillong. According to a government report seven springs (Directorate of Urban Affairs 1991)[13] of Madan Laban, Lowsohtun and upper Nongthymmai have dried up due to deforestation and constructional activities. All the seven sources do not have any proper treatment plants and water is directly fed to the service reservoir that supply to the households. A portion of this Shillong ridge comes under the reserved forest category. Therefore this area has been not disturbed so far.

*2. **The Public Health Engineering Department*** of the state looks after the major water supply of the city. The main sources of water from where the water supply is done are:

(i) River Umiew, which has its reservoir at Mawphlang with a capacity of about 11.5 million gallons per day, since the project is incomplete, it supplies only 7.5 million gallons of water per day (PHE Report 2001)[14] to the entire city. This comes under the Greater Shillong Water Supply Scheme, Government of Meghalaya.

(ii) River Umkhen and several small other springs are supplying water to the Nongthymmai Township, Madanrting Township and partly in the Municipal area.

This has a reservoir with a capacity of about 7.44 lakh gallons per day (Table 5.1).

(iii) River Umsohlang, supplies water to the Mawlai Township which has a reservoir capacity of about 90 lakh gallons per day

Except Umsohlang the river Umiew and Umkhen are towards the south of the city from where water is tapped and supplied to the city.

3. The local Dorbars also have identified some spring sources and maintains them. Most of these sources are towards the south of Shillong. Deforestation of these areas is leading to the drying up of the sources.

5.4 **Quality and quantum of water**

The water quality in the modernised water treatment plant at Mawphlang maintained by the Public Health Engineering Department of the state has high coliform level much higher then the permissible limit of 10 mpn/100 ml of water. This is mainly because of two factors viz.

(i) Both treated water from PHE and untreated water form Municipality gets stored in the same reservoir before being supplied to the individual consumers through pipes

(ii) Leaking pipes are passing through numerous dirty drains and streets and garbage dumps these sometimes lead to contamination of water.

(iii) No proper waste disposal system functions within the city. It is only the Municipality of Shillong and the Cantonment which have an organised waste disposal system. The other five units of the Shillong Urban Agglomeration do not have any organised waste disposal system. Thus it leads to water contamination

The seven spring sources of Shillong Municipal Board have water contamination. The coliform level of Umjasai source (A) is as high as 140 mpn/100ml of water While source (B) has coliform level of 1600 MPN/100ml of water. The permissible limit of coliform level is 10mpn/100 ml of water. Hence the water is actually not suitable for human consumption (PHE Report 2001)[15].

The Wah Jalynnoh source of water has a high coliform level of 920mpn/100ml of water and the PHE report (2001) clearly states that the water is supplied untreated. The water analysis report furnished by the Meghalaya Pollution Control Board indicates a high degree of contamination; hence the water is not fit for human consumption. This source was tapped by the British Government in 1920 and no proper maintenance has been taken up after the British left the state. At present the existing collecting chamber is badly damaged. The existing feeder pipe lines passing through rugged terrain are in some places hanging in absence of any support pillars. Leakages are in many pipe joints in the feeder and main pipe lines (PHE Report 2001)[16]. In this source water contamination is severe due to surface run off especially during the rainy season.

The Madan Laban spring source has two spring sources situated close to Raid Laban School. This source was also tapped by the British government and no proper repair

or maintenance or repair work was taken up after the tapping up of this spring source. The existing spring tapped chamber is damaged and not easily repairable. The area around these two sources is prone to soil erosion since the area has loose soil (PHE Report 2001)[17]. Due to urban expansion of Shillong this area has come under habitation. Habitation has aggravated the erosion problem. Mass wasting during rainy season is a common phenomenon in this area resulting to higher water contamination. According to the PHE Report (2001) submitted by the State Pollution Control Board the coliform level of this source is as high as 1600mpn/100 ml of water, hence it is not fit for human consumption(PHE Report 2001)[18]. This water too is supplied by the Municipal Board to the consumers without any proper treatment.

The Pathakhana spring source was also tapped by the British and no major repair was undertaken since its inception. As a result the existing spring tapped chamber is damaged and water is contaminated. The coliform level is 1600mpn /100ml of water (PHE Report 2001)[19].

The Wah Risa spring sources, which was also tapped by the British no repair of the reservoir was undertaken since its inception, and there are leakages. With urban sprawl these areas have come under human settlements and are not having proper disposal of their wastes. Therefore the wastes are thrown in the springs this has aggravated the contamination of the water sources. The water analysis report suggests that the water is not safe for human consumption in all the three sources as the coliform level in Source (A) is as high as 1600 mpn/100 ml of water. Source (B) has coliform level as high as 1600 mpn per 100 ml of water while the sample of source (C) indicates a coliform level of

920mpn/100 ml of water (PHE Report 2001)[20]. Hence all the three sources require treatment of the water before it is supplied to the consumers. But this is not done and people are using such water for drinking and other purposes. Thus people are suffering from water related diseases.

Wah Dienglieng Spring source consist of six springs and was tapped by the British in 1930. Since there is no repair carried out the water is not only wasted through leakages but is also highly contaminated. The water analysis report from the State Pollution Control Board indicates high coliform level of 1600mpn/100ml of water in all the six sources (PHE Report 2001)[21]. Though this water is used many it is not potable.

The Crinoline spring source water analysis report was not available with PHE department. However all the six out of the seven sources of Shillong Municipality water sources suggests that the quality of water supplied to the population of Shillong is indeed not fit for human consumption since the coliform level or bacteria is very high. This is partly because of extremely faulty waste disposal system of the Shillong city which is growing at a very fast pace and the urban amenities especially waste disposal facility is lagging behind. In the absence of proper waste disposal system the population of Shillong is consuming water which has been polluted by them.

The PHE water supply comes from mainly the river Umiew located in the Shillong Ridge south of the Shillong city and flows towards Bangladesh. The PHE department taps the water of Umiew at Mawphlang point where there is a conventional treatment plant consisting of coagulation, filtration and disinfection of the water before being supplied to the population of the study area. Hence coliform level of the treated water is negligible i.e.

about 9mpn/100ml of water, which is within the permissible limit. But due to leaking pipes the water gets contaminated before reaching to the population. Report of four samples of water collected from four different localities suggests that all are having coliform level higher then the permitted level. For Lachumiere sample the coliform level is 33mpn/100 ml. Rilbong sample has a coliform level of 33mpn/100 ml. Jhalupara sample has a coliform level of 22 mpn/100 ml. The cantonment's water supply is having less of coliforms than the Municipality or PHE supply but all the three samples cross the permissible limit of drinking water, thus water is not fit for direct human consumption.

Contamination of water could be due to haphazard waste disposal and leakage of pipes. The water sample from Rilbong shows lower PH value of 5.7 which can be harmful for the population consuming this water. The State Pollution Control Board clearly suggests that the water is not potable.

The Umsohlang source under the PHE department treats the water before it is supplied to the Mawlai Township. The coliform level of the water supplied to the population of the township is only 9mpn/100ml of water (SPCB Report 2003)[22]. This is within the permissible limit for consumption.

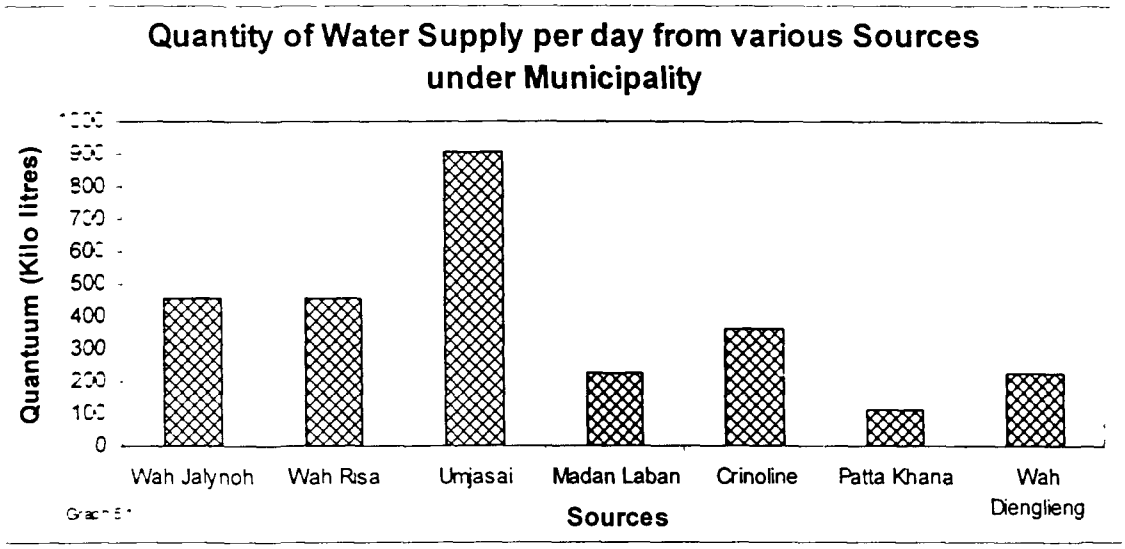
Quantity of Water

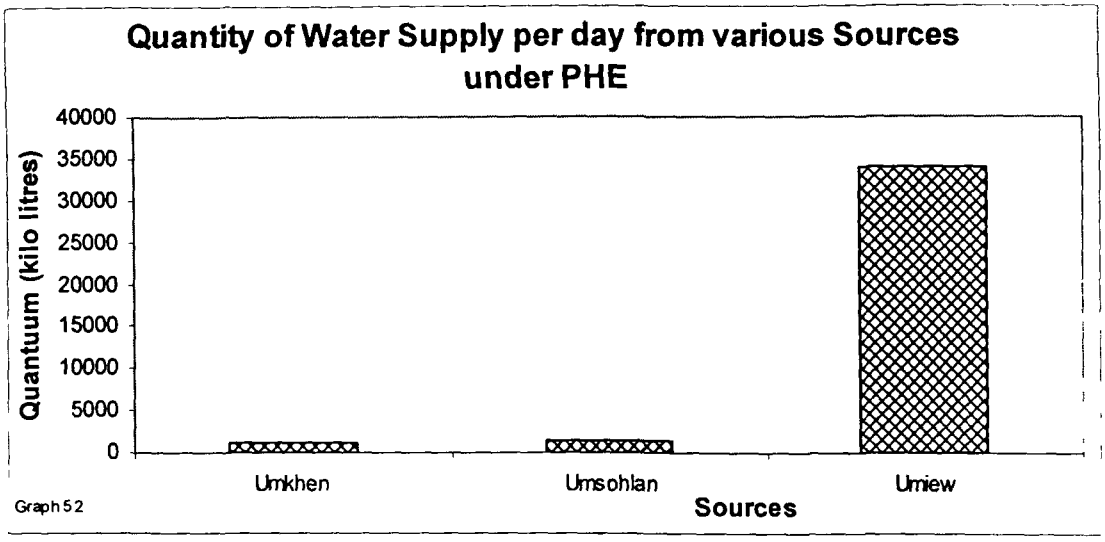
At present the quantum of supplied water within the Shillong Urban Agglomeration is approximately 39504.7 Kilo litres/day (Table 5.1).

Table 5.1: Sources, Quantity and command area of water supply within the SUA

Sources	Quantum(in KLt) Supplied/day	Command area
Municipal Sources		
Wah Jalynoh	454.6	Municipality
Wah Risa	454.6	,,
Umjasai	909.2	,,
Madan Laban	227.3	,,
Crinoline	363.7	,,
Patta Khana	113.6	,,
Wah Dienglieng	227.3	,,
PHE Sources		
Umkhen W.S.S.	1295.6	Nongthymmai, Madanrting townships & parts of Shillong Municipal area.
Umsohlang W.S.S	1363.8	Mawlai township
Greater Shillong W.S.S. (Umiew)	34095	Shillong Municipal area and other parts of The town
Total	39504.7	

Source: State Pollution Control Board Report titled "The State Of Environment Of Shillong"





Approximately per day 39 thousand 505 kilo litres of water is being supplied to meet the water requirements of Shillong city. According to 2001 census the total population of Shillong Urban Agglomeration is 267881 persons; consequently the per capita water supply was 147.47 litres per day. This amount meets the requirement of water within Shillong. The Central Public Health and Environmental Engineering Organisation of the Indian Union recommended 125-200 litres of water/capita/day for Class I cities (Singh 1986)[23]. But this quantum of water is not equally distributed as suggested by the zoning of water supply within the Agglomeration. Therefore there are certain severe water deficient zones within Shillong city.

5.5 **Distribution**

As there is no water meters installed in the Zonal tanks the quantity of water supplied to the various localities cannot be assessed accurately. However from the capacity

of zonal tanks some general inferences can be drawn to the amount of water supplied to the various localities of Shillong. Table 5.2 gives an idea of the total amount of water supplied by the Municipality and Public Health Engineering Department of Meghalaya.

Table 5.2: Total quantum of water supplied within the greater Shillong area by the Municipality and the PHE department (Govt. of Meghalaya)

Capacity of the Reservoir (lakh Gallons)	Location	Remarks (Source of Supply)
6	Mawphlang	PHE Reservoir
6	4 ½ mile Upper Shillong	PHE Reservoir
3	Barabazar	PHE Reservoir
1.60	Barabazar	Municipal Reservoir
1.50	Barabazar	Municipal Reservoir
0.75	Mawprem	PHE Reservoir
0.60	Mawprem	Municipal Reservoir
0.75	Barapathar	PHE Reservoir
0.45	Lachumiere	PHE Reservoir
2.15	Lachumiere	Municipal reservoir
0.60	Upland Road	Municipal reservoir
0.75	Pasteur Institute	PHE Reservoir
2.56	Assembly Complex	PHE Reservoir
1.50	MawlaiWawroh	PHE Reservoir
0.05	Mawlai Mawroh	*Inv. Div. PHE
0.12	Datbaki	Inv. Div. PHE
0.20	Datbaki	Inv.Div. PHE
0.20	Kynton Massar	Inv. Div.PHE
0.25	PhudMawri	Mawlai Zonal Reservoir Under GSWSS**
0.20	Motsyiar	,,
0.15	Nonglum	,,
0.20	Nonglum	,,
0.10	Iewrynghep	,,
0.20	Nongkwar	Inv. Div. PHE
0.10	Nongkwar	,,
0.05	Iewrnghep	,,
0.25	Nonglum	,,
2.79	Upper Lumpering	PHE Reservoir
4.40	Upper Malki	,,
3.85	Upper Malki	,,
0.50	St. Edmunds	,,
0.20	Nongrimmaw	,,
7.44	Upper Nongthymmai	,,

Sources: Public Health Engineering Department Govt of Meghalaya.

* Investigation Division of PHE Dept.

** Greater Shillong water supply scheme

The amount of water supplied to the different localities is computed by taking into account the capacity of the overhead tanks situated in the various localities. It is assumed that these overhead tanks are receiving the full tank capacity per day. The per capita water supply, has been computed by taking the total population receiving water from a particular tank in full capacity. The zoning concept as followed by the PHE department has been considered in this study (Table 5.3).

The zonewise data reveals that

(i) Zone I consisting of police Bazar and Jailroad contains the CBD of Shillong. This zone occupies the central part of the study area situated in the Laitumkhrah-Mawkhar upland physiographic unit. This zone is characterised by moderately steep slope and an absolute relief of 1400-1600metres above m.s.l. being the nucleus of the city, this is the most congested and densely populated area. Here a large number of hotels and restaurants are situated which consumes large quantity of water. Hence the water consumption here is much higher then in the other parts of the city. During dry season this area suffers from water scarcity inspite of having surplus water supply in comparison to others.

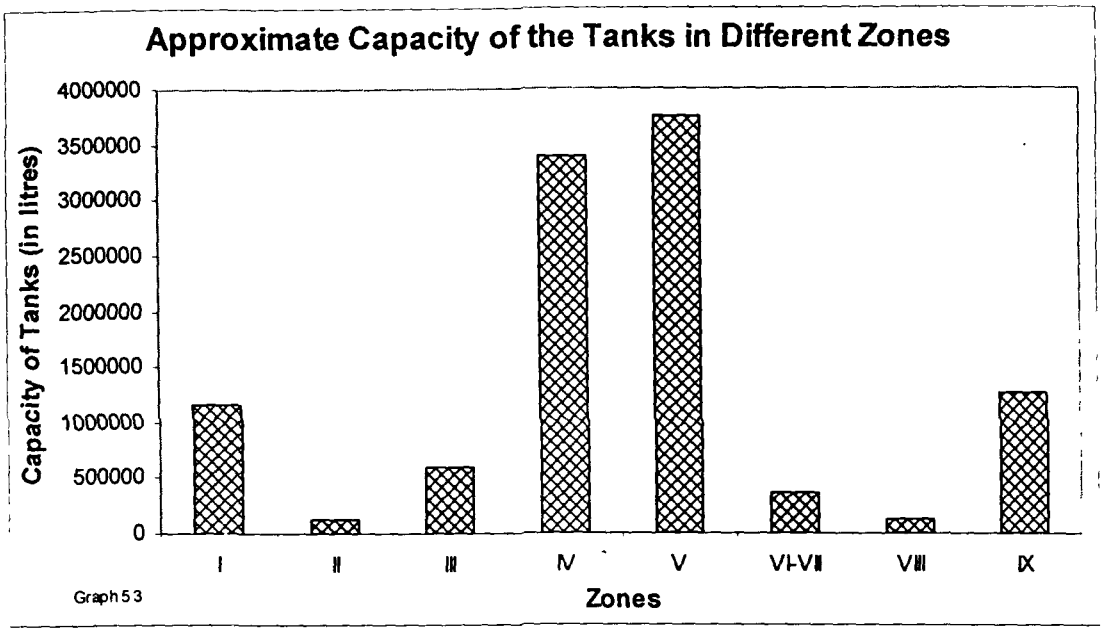
(ii) Zone II consisting of Lachumiere and Raj Bhavan area situated in the Laitumkhrah–Mawkhar physiographic unit. Due to constructional activities numerous small streams are no longer visible as their beds have been filled up by concrete structures, residential and office buildings. The absolute relief is 1400-1600 m above m.s.l. This locality is having surplus water supply. The population here are mainly consisting of economically well off section of the society. Most

of the high officials' quarters are also located here. Field study suggests that most of the houses have water supply throughout the year and have connections both from the PHE and Municipality departments.

Table 5.3: Different zones of Shillong Urban area showing average per capita water supply/day

Zone	Ward Nos Townships	Localities	Total population (2001 Census)	Capacity of the tanks in litres	Average Per capita Supply/ day in litres	*Remarks*
I	9&10	Police Bazar and Jail Road	6517	11,65000	178 76	*The CBD of Shillong There are a number of Hotels situated here catering to the floating population and tourists*
II	7&8	European Ward Lachumiere, Raj Bhavan	9014	11,8300	131 24	*Mainly Residential and Administrative area Having surplus water*
III	1-4	Laitumkhrah. New Colony, Don Bosco	21273	5,92000	27 83	*Mainly residential institutional and commercial centre having acute shortage of water*
IV	5 & 6	Tripura castle, Dhankheti Malki area	10907	3385000	310 35	*Mainly Residential and Commercial area having the highest per capita water supply in Shillong Water surplus Zone*
V	Town ships of Madanriting & Nongthymmai	All the localities of Madanriting & Nongthymmai	50909	3754000	73 74	*Mainly residential area with some commercial Activities*
VI&	11 & Townships of Pynthorumkhrh Nongmynsong	Nehru colony, Pynthorunkhrh, Nongmynsong	38006	3 64000	9 58	*Mainly residential area with some commercial activities This area has the least per capita water Supply*
VII	Township of Mawlai	All localities of Mawlai	38241	126900	38 91	*Mainly residential area with some commercial & institutional activities*
IX	22-27	Rilbong, Kenches trace, Laban Lumpering	26358	12,69000	48 14	*Residential area with some commercial activities Water shortage zone*
X	*12-21*	*Mawkhar Umsohsoh Riasamthia Wahingdoh Jaiaw Paltan bazar Quallapatty Mawprem Jhalupara*	*54262*	*21 3900*	*39 41*	*Commercial and Residential area Water shortage is acute*

Sources PHE Department and Census of Meghalaya (2001)
The Per capita water supply is computed by the researcher



(iii) Zone III consist of Laitumkhrah. New colony, Donbosco area. This is mainly a residential cum institutional zone. This area can be regarded as a sub city centre. Most of the schools and colleges of Shillong are located here. This zone is located in the Laitumkhrah-Mawkhar upland physiographic unit. The southern and central part of this zone is having more or less uniform terrain. The northern part is abruptly falling towards the Pynthorumkhrah valley. Most of this zone has an absolute relief between 1400meters to 1600 meters while the southern part of this zone has an absolute relief of 1600-1800 meters above mean sea level. The average slope for this zone is moderately steep. The water distribution within this Zone is unequal. Due to the nature of the slope gradient the water supply to the different settlements requires special efforts. Hence each individual house is supplied water from the main tanks of the locality through individual pipelines.

This often results to wastage and contamination of water as it becomes difficult to maintain so many pipes that often leaks. The pipes pass through the drains of the localities. Therefore there are possibilities of contamination. The per capita water shortage is acute here due to the presence of many private hostels that caters to the residing in the hostels. During shortage individuals buy water. During the rainy season some families collect rain water to meet their water demand.

(iv) Zone IV comprising of Tripura Castle, Dhankheti and Malki localities are close to the water shed zone of Shillong. Malki and Tripura Castle are located in the northern slopes of the Shillong range. The absolute relief of this zone is 1800-1600 meters above m.s.l. This Zone has moderately steep to steep slopes. A large number of primary order streams are coming down the slopes of this Zone which have now turned into garbage dumps. It is observed that the population living in this zone is having surplus water as the per capita supply per day works out to be as high as 310 litres on an average. The PHE maintains that much of the extra water from this zone is supplied to the water deficient Zone III

(v) Zone V consists of the townships of Nongthymmai and Madanrting situated towards the northern slopes of the Shillong ridge marking the southern boundary of Shillong. This township occupies a total area of 2.93 and 2.11 sq km of area respectively and supports 19 percent of the total urban population of Shillong. But the water supply for this population works out to be 73.74 litres per capita per day. Hence the shortfall per capita even at 100 litres per person per day is about 26.26 percent. Field study (during May & June 2003) suggested that the tank

installed by the PHE department is not functioning. The population living here are dependent on local supply of water from the springs located in the reserved forests close by.

(vi) Zone VI and VII comprises of Municipal Ward 11 and the adjacent townships of Pynthorumkhrah and Nongmynsong located towards the north eastern part of the study area. These townships have an absolute relief of 1400-1600 meters above mean sea level. This zone suffers from acute shortage in water as it receives only 9.58 litres per capita per day. In order to meet this shortfall the local population is using the under ground water as the maximum part of this zone lies in the topographically low area.

(vii) Zone VIII consists of Mawlai Township which is situated in the Umkhrah-Umshing water divide. The absolute relief is about 1400-1600 meters. The township supports about 14.27 percent of the total urban population of Shillong Urban Agglomeration. It occupies about 6.14 sq km area. It is mainly a residential area having a density of 6228 persons per sq km. The locality receives 38.91 litres of water per capita per day.

(viii) Zone IX consist of Municipal Ward numbers 22,23,24,25, 26 and 27 comprising the localities of Rilbong, Kenchestrace Laban and Lumpering located toward the south western part of the study area towards the northern slopes of the Shillong ranges. River Umshirpi and its primary order streams flow through this zone. It is mainly a residential zone supporting 9.84 percent of the total population of Shillong Urban Agglomeration. The households receives water about 48.14 litres

per day per capita hence the shortage is about 51.86 percent per capita per day if the WHO norm is taken into consideration. This zone is close to the Municipal water source of the Shillong Urban Agglomeration. This fragile water zone is required proper care so that no deforestation and unwanted urban growth takes place. The absolute relief here ranges from 1600 meters to 1800 meters with some area toward the south having an absolute relief of more then 1800 meters above mean sea level.

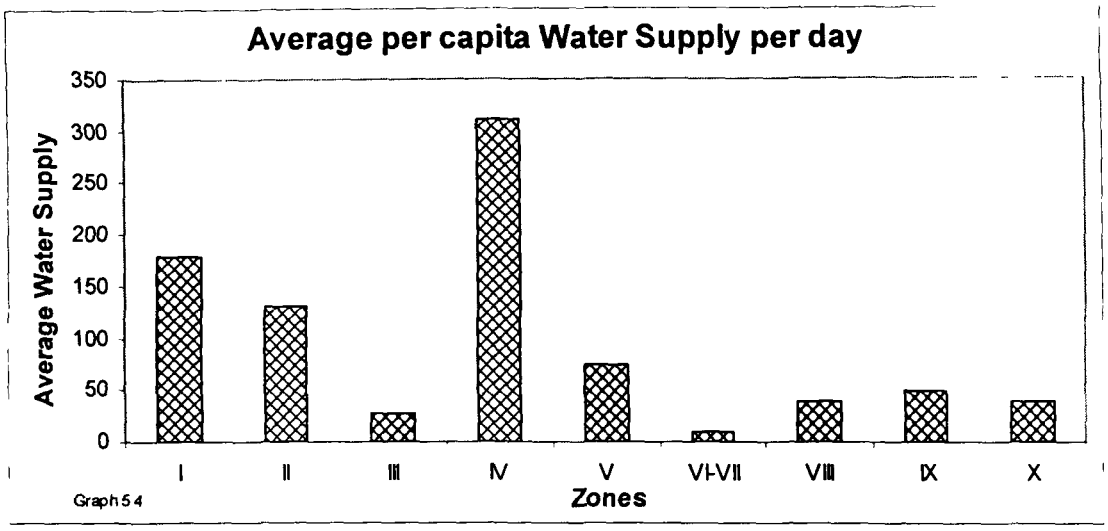
(ix) Zone X consists of the localities of Mawkhar, Umsawsohn, Paltanbazar, Mawprem and Iewduh area. It is densely populated with the whole sale market being located here. The zone is having both residential and commercial activities. The zone supports 20.25 percent of the total population of Shillong Urban Agglomeration. The area receives water about 39.41 litres per capita per day (Table 5.4).Therefore this zone has water shortage.

Besides these zones the Cantonment of Shillong located in the Umshirpi basin towards the western side of the Shillong Municipality has its own water supply from the Riad Laban source near forest nursery about 0.5 km upslope from the adjacent PWD road (PHE Report 2001)[24].

Table 5.4: The Zonal water Distribution within Shillong Urban Agglomerations and the per capita per day supply

Zone	Ward Nos. Townships	Localities	Total population (2001 Census)	Capacity of the tanks in litres	Average Per capita Supply/ day in litres	Remarks
I	9&10	Police Bazar and Jail Road	6517	11,65000 (Actual Requirement 814625 litres)	178.76	CBD of Shillong There are a number of Hotels situated here catering to the floating population and tourists
II	7&8	European Ward-Lachumiere, Raj Bhavan Area	9014	11,8300 (actual requirement 1126750 litres)	131 24	Mainly residential and Administrative area having surplus Water
III	1-4	Laitumkhrah, New Colony Don Bosco	21273	5,92000 (Actual Requirement 2659125litres	27.83	Mainly residential, institutional and commercial centre having acute shortage of water to the tune of 2067125 litres/ day
IV	5&6	Tripura castle, Dhankheti, Malki area	10907	3385000 (actual requirement 1363375litres)	310.35	Mainly residential and commercial area having the highest per capita water supply in Shillong Water surplus is to the tune of 2021625 litres/day
V	Town ships of Madanrting & Nongthymmai	All the localities of Madanrting and Nongthymmai	50909	3754000 (actual requirement 6363625litres	73 74	Mainly residential Area with some commercial activities There is Shortage of water to the tune of 2609625 litres/day
VI&VII	11&Townships of Pynthorumkhrh, Nongmynsong	Nehru colony. Pynthorunkhrh Nongmynsong	38006	3,64000 (actual requirement 4750750litres	9 58	Mainly residential area with some commercial activities This area least capita water supply The shortage is to the tune of 4386750 litres /day
VIII	Township of Mawlai	All localities of Mawlai	38241	126900 (actual requirement 4780125litres	38 91	Mainly residential area with some Commercial and institutional activities There is shortage of water to the tune of 4653225 lit/day
IX	22-27	Rilbong, Kenchestrace. Laban, Lumpering	26358	12,69000 (actual requirement 3294750litres	48 14	Residential area with some commercial activities Water shortage is to the tune of 2025750 litres/day
X	12-21	Mawkhar,Umsohson, Riasamthia, Wahingdoh, Jaiaw, Paltan bazar Quallapatty, Mawprem,Jhalupara	54262	21,3900 (actual requirement 6782750litres	39 41	Commercial and Residential area Water shortage is to the tune of 6568850 lit/day

Source PHE Department and Census of India (2001)
The researcher taking 125litres/capita/day has calculated the actual requirement of water/day



Graph 5.4

5.6 Socio-economic factors determining water supply (Within the Municipality)

Like other urban centres of India Shillong faces similar problems in regards to water distribution (Table5.3). The zoning concept of the PHE Department clearly suggests that there are water surplus zones and water deficient zones. Hence here an attempt has been made to see the influence of socio-economic factors in the distribution of water. Field study of the localities referred in Chapter IV of this thesis has been undertaken to see the influence of socio-economic factors in the distribution of water.

The findings suggest that Lachumiere located in the European Ward has the best water supply in comparison to the other selected localities of the study area. Lachumiere having a gentle to moderate slope is ideally suited for settlement. This locality supports generally the economically well of sections of the society; here more than 92 percent of the total respondents are having a monthly income of above Rs. 16000. (Table 5.4)

Lachumiere has also surplus water supply to the tune of 131.24 litres /capita /day. Majority of the houses are owned by tribal population while the tenants are mainly non tribal.

From the Upper Lachumiere Rongbha Shnong, the following information was gathered on Oct. 2003.

(a) There is a main water tank and two sub tanks supplying water to five sectors of Lachumiere. Professors' colony located in Lower Lachumiere has its own supply, tapped from a spring.

(b) The Shillong Municipality and the PHE Department looks after the supply of water to the main water tank.

(c) Some of the households of lower Lachumiere are using underground water. There are a few springs found in lower Lachumiere especially in Hopkinson Road.

(d) There is adequate supply of water even during dry season.

(e) Leakages of water through pipes are negligible.

(f) The local Dorbar collects Rs. 50 to Rs. 100 per family annually for maintaining water facilities of the people living here.

(g) 100 percent of the houses have tapped water service within the compound or in the house.

The next component of the survey is Rilbong representing a non tribal locality. Its growth can be traced back towards British era when a large section of the Indian officials serving under the British especially from the erstwhile Bengal migrated here and settled near the Cantonment. This locality is predominantly non tribal in character about 82.08

percent of the total population is non tribal (2001 Census). Information collected from the Rongbha Shnong of Rilbong on Oct. 2003 suggests that.

(a) There are 8 water tanks supplying water to this locality

(b) Data regarding the total capacity of these tanks are not available.

(c) The Municipality supplies water to these 8 watertanks. Water is supplied for 2-3 a day.

(d) There are no taps near the overhead water tanks. The water tanks and their leakages are maintained by the locality.

(e) The residents get sufficient water through out the year.

(f) There are two community taps here, one in Rilbong Community centre and the other at Kenches Trace Community centre.

(g) All the households are supplied water through pipes.

Jhalupara is a designated slum of Shillong. Information collected from the Head man of Jhalupara on Sept 2003 suggests that

(a) There are three water tanks supplying water to Jhalupara area.

(b) The source of water to these water tanks is from a spring source tapped by the Cantonment Board

(c) Data regarding the capacity of these three water tanks are not available

(d) There is an acute shortage of water here. Even in the rainy season there is a water shortage due to leaking pipes.

(e) Water charges are relatively high. The cantonment Board charges Rupees 60 per connection per quarterly in a year irrespective of the fact that often these piped connections to the households remain dry.

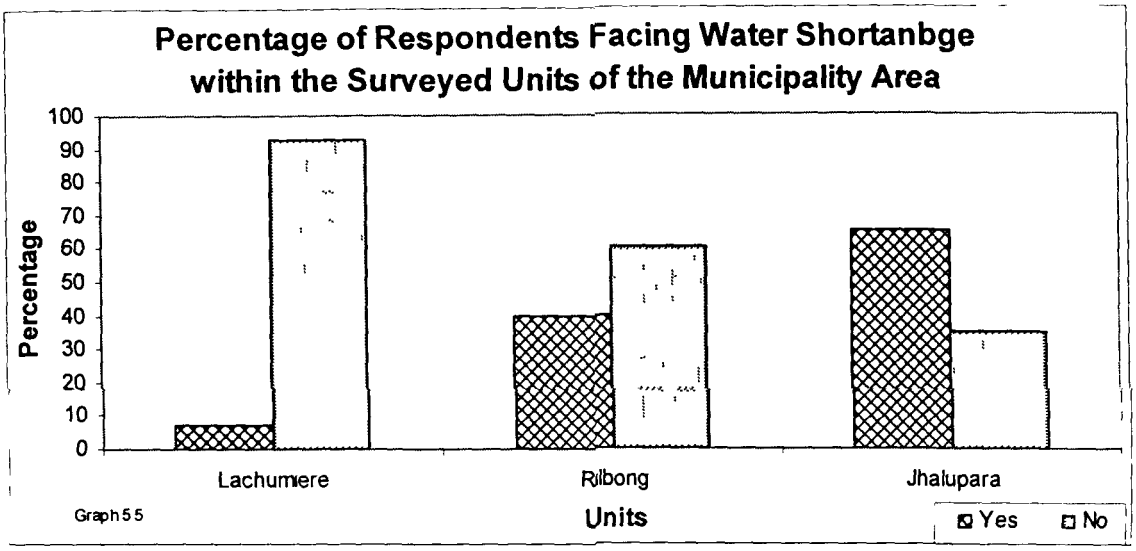
(f) About 65-70 percent of the population receives piped water supply within their house compound. The rest of the populations have to collect water from the public taps.

(g) Water is being bought and sold within this locality. Each '*bhar*' of water consisting of about 10litres approximately costs Rs 15-20 depending on the distance of the houses from the public taps.

Table 5.5: Socio-economic characteristics and the nature of water supply of the selected localities within the municipality

Population Composition	Lachumiere (No. of respondents-100 persons)	Rilbong No. of respondents 100 Persons)	Jhalupara (No. of respondents100)
Tribal	60 percent	10 percent	5 percent
Non-Tribal	40 percent	90 percent	95 percent
Income of the Family (in Rupees/ month)			
< 4000	Nil	Nil	20 percent
4000-8000	Nil	16 percent	36 percent
8000-16000	8 percent	47 percent	24 percent
> 16000	92 percent	37 percent	20 percent
No. of Family Members			
< 4 (small)	30 percent	26 percent	11 percent
4-6 (medium)	37 percent	63 percent	43 percent
> 6(large)	33 percent	11 percent	46 percent
Quantity of Water Used/day (Avg. amt)			
<300litres	Nil	23 percent	44 percent
300-600litres	10 percent	26 percent	14 percent
600-900litres	20 percent	20 percent	14 percent
900-1200litres	23 percent	31 percent	10 percent
>1200litres	47 percent	nil	18
Quantity of Water Actually required at 100 litres/ capita/day			
< 400litres	30 percent	26 percent	11 percent
400-600litres	37 percent	63 percent	43 percent
>600litres.	33 percent	11 percent	46 percent
Is there Shortage of Water			
Yes	7 percent only during dry season)	40 percent during dry season	65 percent (through out the year)
No	93 percent	60 percent	35 percent
Is Water Bought			
Yes	7	25 percent	44 percent
No	93 percent	75 percent	56 percent
Source of Water			
a. Public tap out side the compound of the House	Nil	Nil	49 percent
b. Tap within the compound of the house	100 percent	100 percent	51 percent

Source: Field investigation.



Graph 5 5

The Table 5.4 reveals that

(1) Lachumiere is predominantly a posh locality where 92 percent of its respondents enjoy a monthly income of above Rs16000 is also enjoying sufficient supply of water. This locality has surplus water supply. All the households have piped water supply within the compound of their houses.

The family size of the respondents is essential in order to understand the daily requirement of water. At Lachumiere about 30 percent of the total respondents live in small families where the family size is less then 4 members. Hence they basically need around 400 litres of water per day (if a minimum of 100 litres/person /day is taken) About 37 percent of the respondents of Lachumiere need 400-600 litres of water per day as their family size are 4-6 members. About 33 percent of the total respondents here need about 600 litres of water per day as their family size is more then 6 members. But in reality

Lachumiere has excess quantity of water supply. Here 47 percent of the total respondents use water on an average more then 1200 litres/day of water. This excess consumption of water is possible because the supply of water here is relatively higher in comparison to the other zones. The last decadal variation of households here is relatively less about +19.73 (2001 census) Hence the over head tanks are not overburdened with new connections. Here only 7 percent of the total respondents suffer from water shortage during the dry season.

(2) Rilbong has a dominance of middle class population (more than 50% of the respondents belonging to the middle income group of Rs. 4000-16000). The family sizes here are also smaller. About 26 percent of the total respondents live in small families having less then 4 members hence the requirement of water is less than 400 litres on an average/day. About 63 percent of the respondents are from medium sized families where the water requirement on an average is 400-600 litres / day. About 11 percent of the total respondents live in large families where water requirement/day is more then 600 litres. Field study suggests that 23 percent of the respondents of Rilbong use less then 300 litres of water/day. About 26 percent of the total respondents use 300-600 litres of water/day. 26 percent of the total respondents use 600-900 litres of water/ day while another 20 percent of the total respondents here use 900-1200 litres of water. The people of this locality use water judiciously since the quantity of water supplied is not adequate. The decadal growth rates (1991-2001) of households are very high (+104.98% as per 2001 census). Consequently the demand for water also increases with the increase in population and households, but the water supply has remained same as the number

and capacity of the over head tanks have not increased to meet the demand of the newly added population in the last decade. Here 40 percent of the total respondents face water shortage during the dry months. About 25 percent of the total respondents purchases water during the dry months.

(3) Jhalupara represents a water scare locality of Shillong. Only 11 percent of the total respondents live in small families where the actual requirement of water on an average is about 300 litres per day. Field study reveals that about 44 percent of the total respondents have lees than 300 litres of water supply /day indicating severe water shortage. About 65 percent of the total respondents here suffer from water shortage throughout the year. 44 percent of the total respondents purchase water for their daily need. 51 percent of the total respondents collect their daily their daily requirement of water from public taps located by the side of the street.

Hence within the Shillong Municipality water distribution system is not uniform while some areas have excess water others suffer from acute shortage of water. A general observation suggests that more than geo-environmental factors like relief average slope etc. It is perhaps income that determines the quantum of water supply.

Field data suggests that the economically well of section within these selected localities enjoy and use more water than the economically deprived sections. The relatively poorer section of the population often purchases water at a price which is costing their meagre income.

After a discussion on the distribution of water of certain specific localities of Shillong within the Shillong Municipality and Cantonment it becomes essential to study the water distribution and management of the unorganised sectors consisting of the five townships which manages their own waste disposal and to some extent their own water requirement.

(Outside the Municipality)

The PHE is supposed to look after the water requirement of the five townships (lying outside the Shillong Municipal limit) under the Greater Shillong Water Supply Scheme, though not been implemented fully. The eleven localities of Nongthymmai are: (i) Lumdiangsoh, (ii) Lumpyngad, (iii) Lumsohpoh, (iv) Lawjynreih, (v) Nongkhyreim, (vi) Dimthring, (vii) Nongrim Hills, (viii) Nongshyllia, (ix) Pokteh, (x) Lumiablot Pumdum Pokteh and (xi) Lau-u-Sib.

(a) About 88 percent of the total respondents belong to the tribal communities of which the Khasis are the dominant group. About 11.76 percent of the total respondents of Nongthymmai are from non tribal communities. It is observed that the localities of Pokteh, Lumsohpoh and Lawjynriew have 100 percent of their respondents belonging to tribal communities. Lau-u-sib has the maximum number of non tribal respondents in comparison to the other localities of Nongthymmai accounting for 29.41 percent of the total respondents.

(b) As regards to the economic status it is observed that Nongthymmai as a whole is consisting of residents from the moderate income group. Lumdiansoh, Nongrim hills, Pokteh have more of richer section of the population as 41.18 percent of the total respondents have a monthly income of above Rs 16000/month. While in Pokteh 52.94 percent of the total respondents generate a monthly income of above Rs 16000/month. Lau-u-sib and Lumiablot, Dumdum, Pokteh are having relatively poorer section of the population where 35.29 percent and 23.53 percent of the total respondents' monthly income is less then Rs 5000 a month.

(c) The family size is an important indicator to understanding the actual requirement of water/day. It is observed that 46.52 percent of the total respondents live in large families having more then six members. While only 14.44 percent of the total respondents live in small families having less than 4 members and about 39.04 percent of the total respondents live in medium sized families. The total water requirement is about 400-600 litres/day as the family members vary between 4-5 members. Since there is a shortage of water supply people buy water during dry season.

(d) Regarding the source of water supply it is observed that about 100 percent of the respondents are using taps which are fed from natural springs from the nearby forest. The Kharkongor clan of the locality is controlling the water resource of this township as these spring sources located in the reserved forest of the Shillong ranges originally belonged to the Kharkonger clan. About 75.23 percent of the respondents are paying about Rs 10-20 per month to their respective '*Rongbha*

Shnong' for the water supply. Every locality has its own source of water and also manages their water distribution. Hence a locality wise study as to the source of water and its management becomes essential and is discussed below.

(1) Lumpyngad located in the upper slopes of Nongthymmai close to the AG quarters and the reserved forest gets its water supply from Wah Dienglieng Spring source which is maintained by the local '*Dorbar'*. The water is collected in two large tanks from where it is supplied to six other tanks. Than it is supplied water to the individual houses. Each household pays Rs 20/ month to the local '*Dorbar'*. The water is sufficient during rainy season but during dry season there are shortages. Water supply is regulated to 1-2 hours in the morning and in the evening. There are no community taps in the locality and selling of water is strictly prohibited by the local '*Dorbar'*.

(2) Lumdiangsoh situated on the upslope of Fire Brigade has its own arrangement of water supply. The local '*Dorbar'* taps water from a spring source located within the reserved forest. Water is collected and brought to two overhead tanks and is supplied to the individual houses. One house one water connection is strictly followed. The house owners have to pay Rs35 / month and the tenants are charged Rs20/month by the local '*Dorbar.*' There is no acute water shortage in the rainy season but during dry season the locality faces water shortage, there is regulated water supply for two hours a day usually in the morning and evening. There are no community taps and water sellers here.

(3) Lumsohpuh located close to the SMC hospital has its own water supply located in the Reserved Forest. This was initially looked after by the PHE department but at present is looked after by the local '*Dorbar*'. There are two tanks supplying water to the locality. About 20 percent of the households here do not have any piped water supply and have to collect water from the community taps. The water sellers are not allowed to collect water from these community taps. Every household pays Rs 25/ month as water charges to the local '*Dorbar*'. During dry season there is shortage of water. Water is regulated and supplied to the houses every alternate day for few hours in the evening and morning.

(4) Lawjynriew is the largest locality of Nongthymmai. This locality has three spring sources of water situated in the reserved forest on the upslope of Nongthymmai. These three sources are controlled by the Kharkongor clan of the Khasis. Rs 20/month / household are charged for the water supply. There are three community taps. The PHE also supplies water to this locality but it is not sufficient to meet the demand. According to the '*Rongbha Shnong*' of the locality the water supply over the years is reducing and not sufficient to meet the actual demands. During rainy season rain water is collected to meet the water requirement. Most families need to buy water as the shortage is very high. The water sellers are available in this locality and according to the distance of the households from the community taps the charges are made. According to the '*Rongbha Shnong*' entire Nongthymmai was supposed to

come under the greater Shillong Water Supply Scheme, a water tank has already been constructed having a capacity of 3754000 litres. But till date this facility is yet to reach the people of the locality.

(5) Nongkhyrium situated towards the upslope of Nongthymmai close to the reserved forest is characterised by steep slopes. This locality has its water supply from a spring source located within the reserved forest .The PHE supplies a portion of the water requirement of the people. About 70 percent of the population have piped water supply within their houses. There are no community taps in this locality and people collects water from the water tanks and the streams located nearby. There are three water tanks supplying water to this locality. The capacities of the water tanks are 10000 gallons, 15000 gallons and 10000 gallons. Hence the total water supplied to this locality seems to be 35000 gallons /day if the tanks are filled every day. The people here face acute water crises especially during the dry season and are required to buy water.

(6) Demthring situated on the upper slope of Nongthymmai by the side of the National Highway has its water supply from spring source located in the upper ridges of the reserved forest. Each household pays Rs 20/ month to the local '*Dorbar*' as their water charges. About 20 percent of the population are not having piped water supply within their compound. There are community taps in this locality. There is an acute shortage of water especially during the dry season and some families augment their supply of water by purchasing it from the water sellers.

(7) Nongrim, Nongshilliang and Pokteh have their water supply partly met from the PHE and partly from the Umphyrnai spring sources located in the upper ridges of Nonthymmai in the reserved forest. Local '*Dorbar*' collects Rs 20/ momth/household as the expanses for water. There are about 9 community taps situated within these localities. The people of this locality buy water during dry season.

(8) Lumiablot, Dum Dum and Pokteh have two sources of water viz. Demthring spring source which is not within the reserved forest, hence the catchment area of this source is occupied by people and ecology of the area is disturbed which is causing water shortage. The second source is near Laitkor Peak situated within the reserved forest. The PHE has built a reservoir here. Rs5 is charged as per connection/month by the local '*Dorbar*' charges Rs 5/month/household as water tax. There are 5-6 community taps within these localities. The water sellers collects water from these taps and sell it to the residents.

(9) Lau-u-Sib is a new locality is less crowded than the other localities of Nongthymmai. Water is collected from the nearby streams. 75 percent of the population uses the stream for washing purposes. Drinking water is collected from the community taps which is fed from a spring source located within the reserved forest. The local '*Dorbar*' collects Rs 20 /month /household as water charges.

In Nonthymmai Township

(i) Most of the water sources feeding this township are community owned spring/streams located within the reserved forest which skirts the southern boundary of this township.

(ii) The Kharkonger clan emerges as the most dominant clan having a control over the water resource of this township.

(iii) All the '*Rongbha Shnongs*' of Nongthymmai are of the opinion that the flow of water has reduced over the years with the growth of the township. Further with the growth of Madanrting Township the water supply is further reducing.

(iv) The local '*Dorbars*' manages the water supply of this township in a better way than the Shillong Municipal Board, PHE Department or the Cantonment Board which comes under the organised sector of water distribution. The cleaning of the over head tanks in most of the localities is undertaken annually by the local community at least once a year. However in the absence of proper treatment of water the water sample collected from one of the taps of the locality fed by a spring source indicates high coliform level to the tune of 140 mpn/ 100 ml of water. with Ph value of below permissible limit. Therefore the water is not potable.

5.7 **Emerging geo-environmental issues**

At present both the quantity and quality of Shillong water is not adequate to meet the present demand. Besides the socioeconomic factors there are certain geo-environmental issues associated with the existing water supply of the city.

The terrain characteristics make it possible for gravity flow of water and most of the over head tanks are situated on the upslope.

(i) Due to the undulating topography, underground water cannot be used in most localities except in the valley areas.

(ii) The management of water is difficult due to rugged topography. The areas in the higher altitude the water flow is better due to high pressure than the lower altitudes.

(iii) The terrain characteristics of the study area often act as a hindrance to the routing pattern of distribution networks, which result in uneven distribution. Moreover in the present system of distribution of separate pipes use to feed individual households, so that water can reach the households located away from the main tanks. Thus a large number of pipes are seen circuiting throughout Shillong. These pipes often pass through the main drains of the different localities. Due to leakage of pipes water tends to get contaminated especially during the rainy season.

(iv) With the growth of population and demand for water increases, thus some parts of Shillong is facing acute water crisis. Moreover the capacity of the tanks supplying water to the different localities has not increased while the population has increased hence the demand for water has increased.

(v) About 3.89 percent of the population occupying approximately 9 percent of the geographical area of Shillong, people are getting 165 litres of water per capita per day which is higher than the standard norm. While 96.11 percent of the

population living in 91 percent of geographical area suffers from shortage of water.

(vi) Drainage patterns in a hilly area like Shillong are determined by natural contours. These channels have been disturbed due to constructional activities resulting into seepage of water into the sub soil, thereby reducing the adhesive quality of the soil. These results to slope instability and causes silting and flooding of the natural courses.

The government of Meghalaya with the help of Australian aid has been trying to improve both the quality and quantity of water supply within the study area and are also working on a more scientific and organised method of waste disposal.

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CHAPTER VI

SOLID WASTE DISPOSAL AND ITS IMPACT ON THE GEO-ENVIRONMENT AND WATER

6.1 **Introduction**

The population induced urban growth of Shillong and associated problems of solid waste disposal and increasing demand for water has been highlighted in the previous chapters. Here an attempt has been made as to how the urban growth of Shillong characterised by moderately steep to steep slopes and marked escarpments are having its impact on the fragile geo-environment. Population concentration over space is associated with urban problems. Shillong urban area is dominated by numerous primary order streams, these streams are used as a waste disposal sites by the population residing here. The unscientific waste disposal is posing serious problems to the hydrology of the area affecting both quantum and quality of water. Shillong often referred to as the "Scotland of the East." is experiencing pollution, loss of water bodies due to increase in urban areas which is reducing the green areas.

Urbanisation induced by population growth results in increasing demand for water. But at the same time there occurs a change in the hydrology of the area. Of all the land use changes urbanisation has by far the maximum impact on the hydrology of the area which can be grouped into four separable but interrelated effects. These are- (i) changes in the peak flow characteristics of the streams, (ii) changes in total runoff, (iii) changes in quality of water, and (iv) changes in the hydrologic amenities (Leopold 1968)[1].

The change in the flow characteristics of the streams are determined by two principal factors, viz., the percentage of area made impervious and the rate at which the water is transmitted across the land to the stream channels. The former is governed by the type of land use and the latter is governed by the density and characteristics of the tributary

channels which in an urban area is dominated by storm channels. Shillong is characterised by hilly topography with a large number of primary order streams. The peak flow characteristics of the streams of Shillong are changing due to channalisation of its numerous streams and creation of impervious layers along the banks. Land reclaimed from these stream areas for urban use is causing high frequency floods during heavy rain (Plate 6.1 a, b.).

The volume of runoff is governed primarily by infiltration characteristics and is related to slope, soil and type of vegetation cover. Hence it is directly affecting the area covered by settlements, streets and other impervious surfaces. Consequently the volume of runoff increases due to increase in concrete structures, at the same time the percolation capacity of the soil reduces due to impervious layer of concrete structures that also reduces the ground water recharge and leads to decreased water flows and drying up of the streams. Thus increased imperviousness in Shillong due to rapid urban growth is increasing the floods during heavy rainfall and decreasing the flow of stream/spring during causing water scarcity.

The principal affect of land use are due to the exposure of the soil to storm runoff. This occurs mainly when bare ground is exposed during construction (Leopold 1968)[2]. In a hilly area like Shillong where more than 75 percent of the study area is characterised by moderately steep to steep slopes the sediment yield from the constructional sites tends to increase as deforestation on the slopes accelerates the erosion and mass wasting processes. This sediment load is ultimately carried by the numerous primary order streams of the

study area which increases the turbidity of the streams affects the photosynthesis processes; this ultimately affects the stream biota.

Moreover in the absence of proper waste disposal facilities the major effect of urbanisation of Shillong is the release of effluent both organic and inorganic from the population into the streams. This is degrading the water quality of the entire stream and thus affecting the very source of water for the population residing not only within Shillong but also living in the downstream.

6.2 **Urban growth and geo-environmental degradation**

Urbanisation necessitates a change from a predominantly rural society into an urban one where the number of people living over space increases in relation to the rural settlements. It is one of the major causes of social and environmental changes especially in the developing economies like India. The process of urbanisation brings a continuous change not only in the quality of life of the residents (the places they work, the quality of water they drink, the air they breathe and in the house they live) but also a change in the geo-environment of that area. Urban areas affect the geo- environment in three ways: (i) Conversion of land to urban uses, (ii) The extraction and depletion of natural resources and (iii) The disposal of urban wastes

When cities expand the prime agricultural land and habitats such as forests and wetlands usually transforms into housing: roads and other associated urban functions. In a hilly topography like Shillong unrestrained urban growth associated with deforestation especially in the moderately steep to steep slopes results to various geo-environmental

concerns. The significant concerns are deforestation and improper solid waste disposal which has a impact on the geo-environment especially on water.

(i) Deforestation

Extensive deforestation is taking its toll on the geo-environment. Many new localities have come up on forested areas due to population growth. In the relatively steep-to-steep slopes of above 15°, which are otherwise not suitable for settlements, have become urban areas. Both private landowners and government machinery is responsible for the urban proliferation into the forested areas especially the main water shed zone located towards the south of the study area. Both the central and the state government have set up its officer's residential quarters towards the south of the study area within the forested region e.g. Motinagar, Risa Colony and Cleave Colony. The proliferation into these protected forests areas as the government does not have enough land in other areas of the city.

Due to population growth settlements have come up in the higher slopes of Madanrting, Nongthymmai, Malki, Lumparing, Upper Laban, Kenches Trace, Lawsohtun localities. These localities and townships are within or very close to the water sources that feeds the water supply of Shillong. Therefore there are impacts on water sources, which may lead to water crises in future.

Table 6.1: Location of water sources of the Shillong Municipality and its quality

Sources	Location	Coliform level/100ml of water
Umjasai spring sources -1&2	2km upslope from the sericulture farm at Lowsohtun	Source 1- 140MPN Source 2-1600MPN
Wah Jalynnoh spring	I km upslope from the sericulture farm at Lowsohtun	920MPN
Madan Laban spring	0.4 km from Raid Laban School	1600MPN
Pathakhana spring	0.3 km upslope of Madan laban Spring source	1600MPN
Wahrisa spring sources -1,2 &3	1km upslope from the PHE officials residential quarters at Upper Lumpering	Source 1-1600MPN Source 2-1600MPN Source 3-1600MPN
Crinoline stream	1.50 km upslope from Nongthymmai, Malki Road/ Hydari Park	NA
Wah Dienglieng spring sources – 1, 2, 3, 4 &5	3km upslope from the AG official residential quarters at Motinagar/Lumpyngad	All the sources – 1600MPN

Source-Public Health Engineering Department, Government of Meghalaya, June 2001.

Table 6.1 suggests that urban proliferation has almost reached to the seven spring sources of the Shillong Municipal water supply that is resulting to the low flow of water and increase in contamination (high coliform level). The coliform level suggests that the bacteriological characteristics of the sampled water from all the municipal sources are not fit for drinking as the coliform level is much higher than the permissible limit of 10mpn/ 100 ml of water (PHE Report 2001)[3].

The urban proliferation of Shillong has encroached towards the highest point of the Meghalaya plateau. The forests towards the south of the city which covers an area of approximately 20 hectares is the critical catchments for the streams and springs that feeds almost entire population of Shillong. Within this area population encroachment is rampant. Therefore, it is bound to affect the water source and its aquifer, if not today but within a short period of time.

The Madanrting Township records the highest positive population growth rate of 81.57 percent in the last decade (census 2001). Deforestation in the higher ridges has reduced the percolation capacity of the soil, which has caused not only a low discharge of the streams but also drying up of the streams and spring sources. The Government report shows that seven springs, which feeds some of the major localities, have dried up in the recent years. In localities of Laban, Lowsohtun and Upper Nongthymmai are the most affected areas in the recent years (Directorate of Urban Affairs 1990)[4]. Indiscriminate felling of trees and clearing of forests in the catchments have made the problem of water supply more acute as discussed in the chapter V. Thus, the problem of deforestation is creating many more associated problems to the geo-environment of the city. The impact of deforestation on the geo-environment is multiple and important one's are:

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 pipes etc on higher hill slopes exposes the slopes to the forces of weathering as the vegetal cover is lost. These weathered material under the impact of gravity and heavy rainfall as associated with the study area triggers landslides, which are quite common here affecting not only the geo-environment but also the population living here. Moreover as construction activities are not properly planned, slope failures and associated landslides are quite common here especially in the steep slopes of Lumparing and Malki localities.

Mudflow

Of late, the occurrence of mudflow is noticed in the average slope category of 15-20°, particularly in the Raid Laban, Upper Shillong and Laitkor area. This phenomenon occurs during the rainy season and affects the valley areas of the streams.

Soil Erosion

Soil erosion in the study area can be attributed mainly to anthropogenic activities. Due to deforestation large tracts of previously wooded landscapes are cleared and felled for both constructional activities as well as demand for timber, this results to high degree of soil erosion. Moreover as deforestation exposes the bare earth surfaces the kinetic energy of the rain drops increases and leads to high soil loss. Once disturbed the slow growing vegetation is difficult to re-establish especially in a hilly area like Shillong. This may spell disaster as the steep slopes are with thin soils which are prone to mass movements.

Sedimentation of the Streams

The high degree of soil erosion associated with urban constructional activities and deforestation has resulted to high sediment deposition on the streambeds which affects aquatic life. The sediment load increases the turbidity of water and reduces the light transmition thereby affecting the photosynthesis process, which is changing the stream biota (Plate 6.2).

(ii) Stone Quarry

Urban growth necessitates demand for materials for constructional activities mainly boulders and gravels. This has resulted to quarrying activities especially on the moderately steep to steep slopes which were previously forest areas. Quarrying of stone and sand, which are carried out with much intensity in certain areas are degrading the already fragile environment. The quarries are mainly to meet the increasing demand for stones, pebbles and sands for construction activity. Of late, mechanical stone crushers have been installed in the quarry sites which generate noise pollution, air pollution and lots of wastes. When these wastes are being washed down to the streams, it results to heavy sedimentation in the down streams (Plate 6.3). This creates flooding due shallowness of the streams and pollutes the water. In areas where stone quarrying is carried out; it changes the landforms due to its complete removable of vegetal cover and landmass from the landscape. In and around Shillong Urban Agglomeration there are 21 numbers of stone and sand quarries where mechanical stone crushers are used. From these quarries alone, an estimated 160-180 tones of fine sand and silt are added annually to the streams of Shillong (SPCB Report 2003)[5] thereby destroying the aquatic habitat and life forms of the streams.

(iii) Solid Waste Disposals

Urban growth of Shillong has resulted to the concentration of population in the urban agglomeration. But to meet the needs of the urban population such as waste disposal facilities are not looked into. These are some of the common problems of Indian cities, so is Shillong. The ever increasing waste generations in the cities are primarily due to: (a)

Population growth, (b) increase in standard of living due to high income resulting to more waste generation.

In absence of proper waste disposal facilities numerous waste dumping places have been created in and around the city especially in the localities inhabited by economically poorer section of the society. It has already been mentioned that the urban sprawl of Shillong which has resulted to the growth of at least five satellite townships. They are outside the purview of any solid waste disposal facilities. These townships support more than 45% of the present population of the study area (census 2001). Hence 45% of the population's wastes are totally unaccounted. Within the Municipality and the Cantonment area some amount of the wastes are collected and dumped at Mawiong. The waste plant at Mawiong can handle only 100 tons of bio-degradable wastes per day: the non biodegradable waste is pushed down to the slopes of Mawiong which is the catchments of the Umiam Lake. The wastes which are released untreated are causing serious water pollution to the lake.

The rough estimate from the present population (Census2001) of Shillong suggests that the city is presently generating at least 160 metric tons of solid waste/day. Out of this only 62 percent of the wastes are collected and 38 percent are left behind that pollutes the geo-environment of the city. The impact of this unscientific waste disposal has led to the following geo-environmental problems on water.

(a) *Degradation in the Quality of Water*

In the absence proper sewage disposal, the surface water drained out from the various households, especially settled near the stream courses is directly discharging their wastes on the streams (Plate 6.4). Moreover even the older settlements of Shillong do not have proper sewage disposal facilities and often these households discharge their sewage in the local drains which later are discharged into the streams causing more pollution.

Land reclamation on the stream sides are everyday happening (Plate 6.5). It is also observed that both sides of the streams are usually occupied by motor garages. They discharges wastes directly into the streams that results severe pollution to the streams. (Table 6.6 & 6.7)

The various waste dumping grounds around the city are not only a source of breeding ground of diseases but also affects the water body. The formation of leachates in the waste dumps due to high humid conditions percolates to the ground water sources which pollutes ground water. The surface water bodies are also affected due to the present nature of waste disposal. The frequent runoffs due to high precipitation of the area carry loads of wastes to the streams of Shillong which leads to water pollution of the streams (Table 6.2 & 6.3).

Table 6.2: Water quality of river Umkhrah (1997-1999)

Sampling Time	PH	DO mg/l	BOD mg/l	COD mg/l	TC MPN /100ml	FC MPN/ 100ml
Nov 1997	7	3	94.5	178.5	160000	110000
March 1998	7.1	2.5	96.0	189.0	179000	115000
April1999	7.6	-	112.5	210	200000	130000

Source Meghalaya Pollution Control Board (2000) Shillong

Table 6.3: Water quality of river Umshyrpi (1997-1999)

Sampling time	pH	DO mg/l	BODmg/l	CODmg/l	TC MPN/100ml	FC MPN/ 100ml
Nov.1997	7	5.0	79.5	130.0	94000	49000
March 1998	7.6	4.3	84.7	140.5	100000	54000
April 99	7.4	2.9	90.8	150.0	1100000	60000

Source: Meghalaya Pollution Control Board (2000) Shillong

(b) *Loss of Aquatic Life*

In Shillong due to the population growth and high degree of present nature of waste disposal system has lead to the deterioration of aquatic life of the streams. Absence of fishes a biological indicator of pollution marks the streams of Shillong. However this was not the condition of the streams during the British days that had set up their cantonment here. The presence of fishes especially trout have been recorded (Allen 1916)[6].

(c) *Loss in the Quantity and Quality of Water*

Human activities in the water source regions have resulted to severe loss in both quantity and quality of water. (Plate 6.6)

In areas like Madanrting where the topography is steep and the forest land is consistently encroached by settlements. The water supply to Madanrting from one of the water sources located upslope is affected by the existence of five graveyards just about 100 meters upslope near the water source (Nongkhlaw 2003)[7]. As Shillong receives heavy rainfall the rain water seeps into the graveyard pits that percolates down to the water sources then collects coliforms and pathogenic organisms from the decomposition. Thus water gets polluted in the source itself

Due to dumping of wastes into the water bodies the quality of water in the streams of Shillong is highly polluted. Table 6.2and 6.3 reveals that both Umkhrah and Umshirpi are highly polluted.

The quality of water in a stream is determined by the amount of dissolved oxygen level. Higher the dissolved oxygen level better is the quality of water. Organic pollution of fresh water bodies as well as dumping of solid wastes from domestic and other types of wastes results in the increase in biological oxygen and chemical oxygen demand, which depletes the dissolved oxygen level of the streams. This is happening in the streams of Shillong. Table 6.2 and 6.3 clearly indicates that the dissolved oxygen level in both the streams of Umshyrpi and Umkhrah are decreasing every successive year, while the BOD and COD are increasing every successive year due to load of wastes dumped into the water bodies. These loads of nutrients ultimately results in 'fish kills' and leads to elimination of a variety of fishes (a biological indicator to pollution). Ultimately the entire biotic compositions of the streams are changed resulting to the growth of harmful algae, which is termed as eutrophication. The consumer of this water may get water borne diseases as reflected in the table 6.4.

Table 6.4: Cases reported and treated for water borne diseases in East Khasi Hills (mainly Shillong)

Diseases	2001 Number & P.C.	2002 Number & P.C.	2003 Number & P.C.
Acute diarrhea (including gastroenteritis and cholera)	41072 (99.89%)	35696 (99.90%)	36181(99.95%)
Enteric Fever	5 (.02%)	5 (.02%)	2 (.01%)
Viral hepatitis	40 (.09)	28 (.08)	17 (.04%)
Total	41117	35729	36200

Source. Directorate of Health and Family welfare-Government of Meghalaya

Shillong predominantly was designed to cater to the need of the British administration of the Assam province. Initially it was not only the capital of Assam but was also famous for its salubrious climate that made the British set up their Sanitarium here. It was regarded as a health center where the British troops could revive their health. At present the population induced urban growth has been posing problems to the fragile geo-environmental resource base of the city. Large quantities of pollutants and wastes are being continuously released into the city environment, which is polluting the water resources of the study area. Table 6.4 shows a patient is being treated for water borne diseases. More than 99% of people suffer from gastroenteritis and cholera which are directly linked to consumption of contaminated water.

6.3 **Urban Growth and Change in Hydrology**

Cities are expanding towards prime agricultural lands, forests and wetlands. These prime lands are transformed into settlements, roads and other associated urban functions. With population growth and concentration in the urban areas the demand for the essential services are increasing including water. This process of urbanisation is distorting the hydrological systems of the area.

Table 6.5 gives a general idea of how the land use in the urban area brings about a change in the hydrology of the area.

Table 6.5: Urban land use changes affecting the hydrology of the area (Modified after Savini & Kammerer 1961)

Changes in land and water use	Possible hydrological effect
Transition from pre urban to early urban stage – Removal of trees or vegetation, construction of scattered houses	Decrease in transpiration and increase in storm flow. Increased sedimentation of streams
Transition from urban to middle urban stage-Bulldozing of land for mass housing, removal of top soil	Accelerated land erosion and stream sedimentation, increased flood flows. Elimination of small streams.
Mass construction of houses, paving of streets, building of culverts	Decrease in infiltration, resulting in increased flood flows and lowered ground levels, occasional flooding in channel constrictions.
Diversion of nearby stream for public water supply	Decrease in run off between points of diversion and disposal
Untreated or inadequately treated sewage discharged into streams	Pollution of streams, death of fishes and other aquatic life. Inferior quality of water available for supply for the population living downstream
Transition from middle to late urban stage-More urbanisation of the area by addition of more houses and streets, public and commercial buildings	Reduced infiltration and lowered water table. Streets and gutters act as storm drains creating higher flood peaks and lower base flow of local streams
Large quantities of untreated waste discharged into local streams	Increased pollution of streams and concurrent increased loss of aquatic life. Additional degradation of water available to downstream users

Source. Environmental Geomorphology and Landscape Conservation Vol. II: Urban areas. P 62

Thus urban growth of Shillong is affecting the hydrology of the area. The wastes have a negative impact on the geo-environment, as the local ecosystem is not in a position to assimilate them. Both organic and inorganic discharges contaminate air, land and water with nutrients and toxics these leads to degradation of both flora and fauna. The population growth in Shillong is enhancing the growth of urbanisation. This continuous process of urban proliferation creates increasing demand for water. At the same time the hydrology of the area is undergoing changes which are creating water crises in the sources.

6.4 **Problems of Water Resources**

The main impact of urbanisation on the water resources of Shillong are – (a) deterioration of the water catchments areas and (b) Deterioration of the stream basin.

Both of them have a negative impact on the quantity and quality of the water supply of the area.

(i) Deterioration of the Catchments

The catchments of the main water sources of Shillong lie towards the south of Shillong at higher altitudes. Due to urban sprawl there has been marked deterioration of the water catchments, since the quality and quantity of water in a river basin is dependent on the conditions of the catchments

Due to urban sprawl some of the catchments especially in the fringe areas of Shillong have been devoid of vegetal cover, which have a negative impact on both quantity and quality of flow of water of the streams.

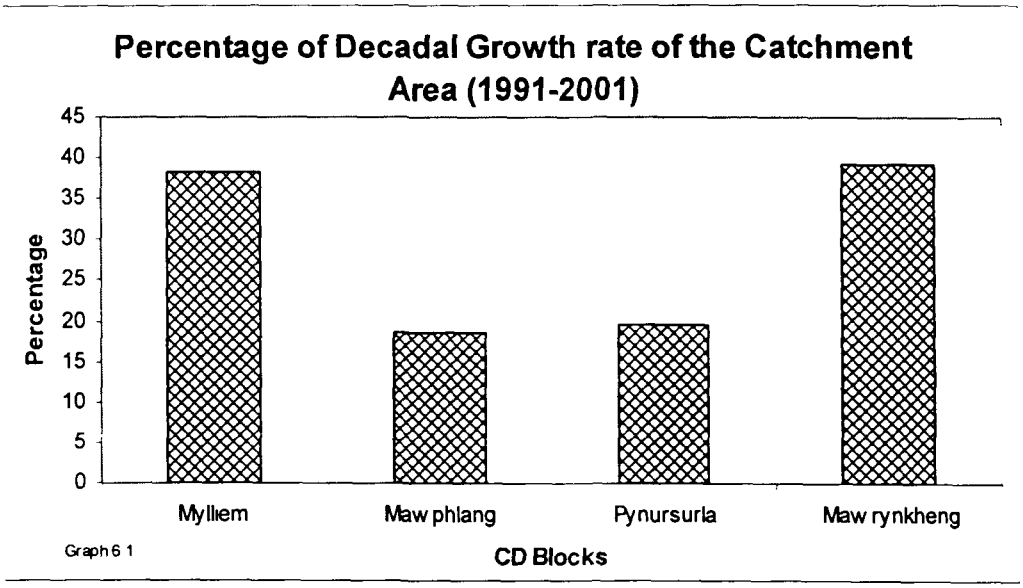
The traditional practice of bun cultivation which involves cutting and burning of vegetation cover has a negative impact on the geo-environment. The Catchments of the streams feeding Shillong's water supply falls under the jurisdiction of Mylliem, Mawphlang, Pynursla, and Mawryngkneng CD Block. The population of these blocks except Mylliem, are rural in character (census 2001). The total rural population consists of 259483 (census 2001) persons whose primary occupation is agriculture. Majority of the lands are either privately owned land (particularly the cultivable lands) or community

owned lands (Dympep 1998)[8]. The population growth rates in these catchments are seen in Table 6.6.

Table 6.6: Population growth rate of the catchments and water supply sources of Shillong

CD Blocks	Total population 1991 census	Total population 2001 census	Decadal variation (1991-2001)	Growth rate in % (1991-2001)
Mylliem	70607	97559	+26952	+38.17
Mawphlang	46685	55441	+8756	+18.76
Pynursurla	4717	86448	+9277	+19.67
Mawrynkheng	35914	50053	+14121	+39.32
Total	157923	289501	+131578	+83.32

Source: Census of India 1991&2001, Series 16 Meghalaya Part VII A&B



The populations residing in these blocks are mainly agriculturalists. The Neolithic agricultural practices in these blocks are not in coherent with the geo-environment. The present system of agriculture practice is unsustainable where '*bun*' cultivation is practiced (Dympep 1998)[9]. The population pressure is forcing these traditional agricultural fields for more use of chemical fertilisers, fungicides and insecticides to increase the productivity of

agriculture. These fertilisers, fungicides, insecticides and pesticides are often used beyond the permissible limit. Therefore the impact is not only on the soils but also on the water resources as these chemicals gets washed into the water sources thereby contaminating the water.

The practice of forest leasing out for timber logging without any strong local institutional binding and management on felling system, the trees are being cut haphazardly. This is resulting to severe ecological transformation that has an impact on the geo-environment. This is degenerating the quality and quantity of the water. In the absence of forest cover the surface runoff increases, which results not only to soil loss but also water loss.

'Bun' system cultivation accelerates the rate of soil erosion, reduces the water quantity especially during dry season and increases the surface runoff. The practice of *'bun'* method is leading to aridity of the soil since organic matter in the soil is reduced. This is reducing the porosity of the soil and may lead to drought (Dympep 1998)[10].

(ii) Deterioration of the Stream Basins

Urban growth of Shillong has resulted to severe pollution of the stream basins as indicated in the following tables -6.7 and 6.8. This gives an idea as to the major types of waste effluent being discharged into the numerous primary order streams feeding the main streams of Shillong viz. Umkhrah and Umshirpi.

Table 6.7: Types of waste in the major tributaries of Umhkrah

Name of Tributaries	Location of confluence	Command Area	Major Characteristics of Solid waste
Wah Disoi	Below Mawpdang bridge Mawprem	Mawprem,Garikhana, Lamavilla, Jaiaw Lengsning,Naspathigari, Slaughter House area	Domestic and Trade effluent.
Jaiaw Lumsyntiew Drain	Behind old CRPF camp , Mawlai	KJP Synod Hospital ,Jaiaw	Domestic and Hospital effluent
Mawlai Phudmuri	Slaughter House	Mawlai Phudmauri Slaughter House	Domestic and Slaughter house effluent
Mawlai stream	Near cremation ground Jaiaw	Mawlai, Phudmauri, Nongmali	Domestic and trade effluent
Jaiaw Drain	Near Lawmali Graveyard	Riatsamthia, Jaiaw	Domestic effluent
Riatsamthia Wahingdoh drain	Lawmali Bridge	Riasamthia, Wahingdoh	Domestic and Hospital effluent
Lawmali drain	Lawmali Bridge	Ganesh Das Hospital and Pasteur Institute	Domestic, Trade and Hospital effluent
Wahingdoh-Raimohan drain	Wahingdoh Bridge	Keating Road, Mawlonghat, Motphran, Mawkhar, Policebazar, Umsohsun, Jail Road, Wahingdoh	Domestic and trade effluent
Oakland drain	Polo bazar	Botanical garden, Wards Lake, Oakland	Domestic and trade effluents
Laitumkhrah Drain	4th Furlong	Lower lachumiere and Laitumkhrah	Domestic effluent
Wah Thangsniang stream	Damsiengiong	Lawjynriew,Lumpyngnad, Jingkieng,Nongthymmai,Nongrim Hills, Nongrimbah, Demseingiong	Domestic and Trade Effluent
Wah Kdiat	Below Spread Eagle Falls	Mawpat and Lalchand	Domestic effluent
Phud raimut	Lapalang Bridge	Happy valley	Domestic effluent
Wah Demthring (principal source of Umkhrah)		Nongthymmai,demthring, Madanrting	Domestic and Trade effluent

* All the streams have sewage effluent.

Source: State Pollution Control Board (2003): The State of Environment of Shillong City.

Table 6.8: Type of Wastes in the Major Tributaries of Umshyrpi River

Name of the tributaries	Location of the confluence	Command area	Types of solid waste
Motinagar stream	Fish dale	Motinagar, Fire brigade, Park view nursing home	Domestic, trade, and hospital effluent
Dhankheti stream	Near Wood land Hospital	Parts of Laitumkhrah, woodland hospital	domestic , trade and hospital effluent
Malki stream	Near seven set school	Malki area	Domestic effluent
Wah Risa stream	Near crinoline Swimming pool	Malki Reserved forests	Fresh water
Um Kynrud	Idgah Laban	Laban area	Domestic effluent
Wah Sohkhlur	Near Kenchestrace Bridge	Madan laban, Kenchestrace	Domestic and garage effluent
Um Jasai	Near Rilbong bridge	Rilbong, Lawsohtun, Defence area	Domestic effluent
Wah Dienglieng (principal source of Umshyrpi		Lum Shillong reserved forests	Fresh water

Source: State Pollution Control Report (2003) the state of Environment of Shillong City

* All the streams have sewage effluent.

Consequently population induced urban growth without proper facilities are creating geo-environmental problems in Shillong which is leading to: (i) accelerated soil erosion, (ii) permanent loss of water sources and (iii) loss of aquatic life.

The impact on the environment is heightened when the urbanised drainage basin are small (Wolman 1967)[11]. The following discussion proves to be true in case of Shillong.

(i) The Shillong Urban Agglomeration is located between two small basins of Umkhrah and Umshyrpi where Shillong Municipality, the Cantonment, the townships of Nongthymmai, Pynthorumkhrah and Nongmynsong are located. The localities support more than 85% of the present population (census 2001).

(ii) Maximum area of the Shillong Urban Agglomeration comes under relative relief of 100-200 meters and the absolute relief ranges between 1400-1800 meters above sea level which indicates considerable relief with undulating topography, flatlands and steep slopes.

(iii) The rainfall is intensive with an annual average of 2400mm.

The manifestation of urbanisation in Shillong is leading to the emergence of some well-known geo-environmental problems, these are: (a) Large areas are being covered by impervious areas that intercept precipitation and increases runoff, (b) the concrete drainage systems are increasing the runoff, (c) urbanisation is encroaching the stream banks, (d) improper waste disposal system is polluting the streams, (e) urban growth is accelerating the erosion and sedimentation processes and (f) changing stream channels are increasing frequency of floods.

Shillong is located on a hilly terrain, water is becoming a scarce commodity in the absence of major rivers and rich ground water aquifers. More demand for water is due to the unprecedented population growth in the last few decades. The rampant pollution is creating more problems to the meager water resources of the study area. Due to solid waste disposal to the streams more pollution is created which is much beyond their assimilative capacities. Table 6.7 & 6.8 reveals the nature of pollutants being added to the main streams of Shillong at different locations.

An analysis of the Tables 6.2 & 6.3 indicates that both the rivers Umshyrpi and Umkhrah have become heavily polluted due to the indiscriminate discharge of municipal

solid wastes and raw sewage into these water courses. Regarding the quality of water the State Pollution Control Board designates the streams of Shillong viz. Umshyrpi and Umkhrah as the lowest category E and the water here is not fit for even washing of cloths.

River Umkhen receives all the wastes from Madanrting Township while Mawlai Township's waste is being received by Umshing. These water bodies ultimately reach the Umiam Lake. This is causing eutrophication and lowering the expected age of this lake.

The present urban growth of Shillong is leading to problems of waste disposal and affecting the water supply of the area. At present the water catchments of the Umkhrah, Umiew, Umkhen, Umshing, Umsohlang have been greatly disturbed by human interference in the form of urban expansion, quarrying, deforestation and solid waste disposal. Some of these catchments especially on the fringes of the study area can be regenerated and conserved by proactive planning.

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CHAPTER VII

SUMMARY, CONCLUSION AND RECOMMENDATIONS

Summary and Conclusion

From the discussion in the preceding chapters it is seen that population growth of Shillong has ushered in rapid urbanisation of this hill station taking within its ambit marginal lands which are not ideal for settlements and other urban function. The population induced urban growth and the associated waste generated by this growing population creating an impact on the fragile geo-environment of this area especially on water. Hence the whole study can be summarised below.

(i) Shillong the capital of Meghalaya is an important urban centre of North East India. It supports about 60 percent of the urban population of the State and 96 percent of the urban population of the East Khasi Hills District.

(ii) Physiographically Shillong is situated on the Meghalaya Plateau. this represents the north eastern extension of the Indian peninsular separated from it by the Garo-Rajmahal gap. The plateau has a chequered history of geological evolution uplifted to its present height of about 600-1900 meters above mean sea level during the post Mesozoic times.

(iii) Shillong is a horst in the central upland zone of Meghalaya plateau. Its average height is 1500 meters above mean sea level The Shillong Peak and Laitkor Peak are the highest part of the Meghalaya plateau marks the southern boundary of the city. Hence it is in the watershed zone between the streams which originate from this central upland zone to drain either into the Brahmaputra system in the north or Surma valley in the south. Numerous streams of primary order which have low

discharge, dominate the landscape, which is the source of water (domestic, agricultural and industrial).

(iv) Geologically the core of the plateau comprises of the oldest rocks in the State, the gnessic complex with dominance of Shillong group of rocks comprising of Khasi greenstones, siltstones, shale, phyllites, sandstone phyllites, quartzites and conglomerates.

(v) Topographically Shillong consist of five units. They can be identified as the northern slopes of the Shillong Ridge located towards the south of Shillong. The Umshirpi valley skirting the south-western part of the study area, the Laitumkhrah-Mawkhar upland where the main localities of Shillong are located. The Umkhrah basin lying at a lower altitude, skirts the north eastern section of the Shillong Urban Agglomeration. The Umkhrah-Umsning water divide is found towards the north of Shillong. The area slopes gradually toward the north.

(vi) There are 11 drainage basins found in the study area. Of which the Umkhrah and Umshirpi basin encloses the Shillong Municipality having an area of about 10.36 sq km. The township of Nongthymmai is located on the upper course of Umkhrah basin in which the important stream Demthring is located. The townships of Pynthorumkhrah and Nongmynsong have less 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 mark the

northern and southern boundary of the Shillong Municipality respectively. The Umkhen has its water source from the Shillong ridges in the south.

(vii) Climatically Shillong can be classed under Cmk designation of Koppen's climatic scheme with heavy rainfall during summer and mean annual temperature below 18° centigrade. The average temperature of the hottest month is above 18° centigrade. The natural vegetation consists mainly of pines and shrubs.

(viii) The Shillong Urban Agglomeration lies to the south of the Shillong Ranges. 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, which are ideal for urban expansion. An analysis of relative relief indicates that about 42 percent of the total area is under moderate relief of less than 100-200 meters suggesting gentle undulating topography of the area. This is located towards the central and north-eastern part of the study area indicating ideal conditions for urban development. An analysis of average slope also indicates that maximum area of about 62.33 percent of the master plan area is under moderately steep slope of 10-15° to 15-20°. The topography such as steep slope accounting for 11.09 percent of the total master plan area and escarpments deter urban expansion.

With population growth there has been an increasing demand and pressure on land ading to urban sprawl.

(i) This is amply demonstrated by the inclusion of another township (Nongmynsong) within the urban agglomeration (2001census).

(ii) In the evolution of Shillong it is seen that the city had its birth with the establishment of the Headquarters of the Khasi and Jaintia Hills by the British in 1863-64, which later became the capital of Assam Province in 1874. While selecting Shillong for the capital, the climate, presence of water and topography was kept in mind by the British.

(iii) After Independence it was the capital of Assam till 1972 when it started functioning as the capital of Meghalaya.

(iv) During the time of 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, Pynthorumkhrah, Madanrting and Nongmynsong.

(v) At present the Municipality supports about 49.60 percent of the total population of the Shillong Urban Agglomeration and the townships supports about 45.86 percent of the total population of Shillong Urban Agglomeration. In fact the Municipality records the least decadal growth rate of −0.88 percent while the other extreme is the townships of Madanrting recording the highest decadal growth rate of +85.82 percent (1991-2001). The growth of population in Shillong

Urban Agglomeration is mainly due to the high growth rate of the satellite townships located in the periphery.

With population growth and resultant urban expansion the solid waste generated by this growing population has also increased. The solid waste collection and disposal within the Shillong Urban Agglomeration is divided into two sectors. Organised sector- consisting of

(i) 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 ward is approximately 80 metric tons /day. Hence slightly above 30 percent of the waste generated /day is not being disposed

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

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

(iv) The unorganised sector consisting of five townships where there are no organisations looking after the solid waste disposal system. Here the estimated solid waste generation is approximately 25.75 metric tons/day.

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

(vi) 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 38 percent of the municipal solid waste generated per day are unaccounted.

(vii) 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 centres are not following these guidelines. The wastes generated from two slaughter houses are also unscientifically managed.

(viii) The collection of waste followed by the Municipal Board is door to door collection from certain localities and collection from the dustbins once a day within the municipal wards. 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.

(ix) The field study reveals that both waste disposal and water supply requires much more than attention what it is at present. Lachumiere area has a concentration of population with economically well off are having better waste disposal facilities and better water supply system. Jhalupara area has the least facilities of waste disposal and water supply since people living here are economically poor. About

10 percent of the respondents of Jhalupara use pit latrines whose waste is dumped every alternate day into the streams, 33 percent of the respondents here do not have access to proper sanitary latrines, 55 percent of the respondents dispose off their domestic wastes in to the streams directly. In Lachumiere area 5 percent and in Rilbong area 13 percent of the respondents dispose off their wastes directly into the streams. There are three dustbins each in Rilbong, Jhalupara and Lachumiere. But Lachumiere locality is provided with door to door waste collection facility everyday except on Sundays. This suggests that the economically well off sections have better facilities in regards to their waste disposal. They also generate more wastes due to higher standard of living and more resource utilisation.

(ix) In Nongthymmai there are 11 localities without a dustbin thus about 65 percent of the total respondents dispose off their domestic wastes directly into the streams. The community manages their own waste disposal. About 45 percent of the respondents here burn their waste during the dry season.

With population growth the demand for water has also increased. At present the water supply of the Shillong Urban Agglomeration is managed by three organisations

(i) 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 in 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. Here 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 per day to the townships of Madanrting, Nongthymmai and the 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 its own sources from within the reserved forests of Shillong.

(ii) At present the quantum of water supplied within the Shillong Urban Agglomeration is around 39504.7 kiloliters/day i.e. approximately 39505000 litres/day, to meet the water needs of a population of at least 267881 persons (census 2001). Thus the per capita water supplied per day is 147.47 litres. 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.

(iii) The water is being treated scientifically at Mawphlang for quality supply of water to the people. But the other sources which are tapped by the Municipal Board water is not treated. This untreated water has high coliform gets mixed up with the treated water in the overhead tanks of the 12 zones within the Shillong Urban

Agglomeration that receives water from both sources and ultimately the people of Shillong get contaminated water.

(iv) The leaking pipes passing through the numerous drains which act as waste dumps are also a source of contaminated water gets into the pipes which supplies water to households.

(v) Socio-economic factors may have a role to play in the distribution of water. In Jhalupara about 49 percent water supply is from public taps located in a common place whereas in Lachumiere and Rilbong 100 percent of the respondents have access to water supply within their compound. 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. The PHE and the local Dorbars looks after the water supply for the population of Nongthymmai. Here the local Dorbars are tapping the spring/stream waters from nearby reserved forests of the Shillong Ridge. However the volume of water received are reducing every year, may be due to deforestation.

(vi) The Kharkongor clan controls the local water sources. The overhead tanks where water is collected and distributed are cleaned every year. There are few community taps made available from were water is being sold to the locality through small tankers and human carriers. Hence community plays an important role in the present distribution and management of water in Nongthymmai.

(vii) Due to rugged terrain characteristics where slopes are moderately steep to steep the households requires individual pipelines. These pipelines usually pass through the drains which often act as waste dumps. The leaking pipe passing from these drains contaminates the water. Water sample collected from the four sources shows high coliform level. Therefore water is not potable.

(viii) The population induced urban growth of Shillong without proper facilities are creating geo-environmental problems having its impact on water.

(ix) It is observed that with urban sprawl to the upper ridges towards the south of Shillong which are the main source of water for the population living here are encroached upon. The deforestation is accelerating the landslides, mass wasting and high soil erosion. This in turn is resulting to the problem of sedimentation of the streams affecting aquatic life. Due to deforestation permanent loss of water bodies are taking place as the percolation capacity of the soil is affected.

(x) The Quarrying activities associated with urban growth of Shillong are further accelerating soil erosion and sedimentation problems.

(xi) 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.

The Shillong Urban Agglomeration is located between the two small basins of Umkhrah and Umshyrpi which supports about 85 percent of the present population. The

manifestation of urbanisation in Shillong is leading to the emergence of some well-known geo-environmental problems, which can be summarised as:

(i) Large areas are covered by impervious surfaces that are intercepting precipitation and increasing run off.

(ii) The concrete drainage systems are increasing runoff.

(iii) The stream banks are encroached upon by urbanisation.

(iv) Improper waste disposal system is polluting the streams.

(v) Urban growth is accelerating the erosion process and sedimentation of the streams

(vi) Changing stream channels are increasing frequency of floods.

From the present study the following conclusion can be drawn

(i) Shillong is located on a hilly terrain where water is generally scarce. It becomes a scarcer commodity in the absence of major rivers and rich ground water aquifers.

(ii) More demand for water is due to the unprecedented population growth in the last few decades. At the same time the quantum of water availability is reducing due to deforestation and growth of concrete structures reducing the percolation capacity of the soil.

(iii) Due to solid waste disposal in the streams, there is rampant pollution, creating more problems to the meager water resources. The streams are loaded with waste which is much beyond their assimilative capacities.

(iv) Umshyrpi and Umkhrah are polluted due to the indiscriminate discharge of municipal solid wastes and raw sewage into their water courses. Regarding the quality of water the State Pollution Control Board designates the streams of Shillong viz. Umshyrpi and Umkhrah as the lowest category 'E' and the water is not fit for even washing of cloths.

(v) River Umkhen receives all the wastes from Madanrting Township while Mawlai Township's waste is being received by Umshing. These water bodies ultimately reach the Umiam Lake leading to severe eutrophication of the lake.

(vi) The present urban growth of Shillong is leading to problems of waste disposal and affecting the water supply of the area. At present the water catchments of the Umkhrah, Umiew, Umkhen, Umshing, Umsohlang have been greatly disturbed by human interference in the form of urban expansion, quarrying, deforestation and solid waste disposal. Some of these catchments especially on the fringes of the study area can be regenerated and conserved by proactive planning.

Recommendations

To check further geo-environmental degradation in the area the following strategy may be undertake:

(i) The urbanisation processes near the catchment areas of the water sources needs to be checked. Hence the growth of Shillong towards the southern ridges is not advisable. The Meghalaya Protection of Catchment Areas Act 1990 needs to be implemented. This act prohibits the felling of trees, destruction and clearance of

grooves, bushes or any vegetative cover, jhumming or cultivation or use of any insecticides or pesticide, quarrying of sand or stones, excavation of earth, carrying of any activity, which in the opinion is likely to damage the springs, streams, rivulets or water sources in the area.

(ii) Intensive afforestation especially in the catchment area in order to boost the supply of water into the streams of Shillong needs to be encouraged.

(iii) Plantation of indigenous varieties of trees in non-agricultural land in the moderately steep-to-steep slopes should be undertaken urgently. The existing forests needs to be preserved and judicious cutting measures should be undertaken.

(iv) Suitable steps can be undertaken in order to check hazardous exploitation of stone quarries within the catchment areas. A series of small check bunds can to be built downstream of the existing quarries in order to check sedimentation of the streams. To prevent soil loss, land management is important. For this the catchment area must be able to absorb maximum precipitation so as to store water. Hence all the agricultural and non-agricultural land within the catchments needs to be effectively treated for soil and water losses.

(v) A buffer zone needs to be created on the sides of the stream in order to check waste disposal and constructional activities.

(vi) The present municipal supply of water needs to be treated scientifically before being supplied to the overhead tanks of the different localities.

(vii) Dumping of garbage on the banks of the streams should be banned. The population needs to be sensitised on the impact of improper waste disposal on their health.

(viii) In order to check contamination and pollution of the geo-environment from the unscientific disposable of biomedical wastes of the hospitals and nursing homes of Shillong. Segregation of biomedical waste at source needs to be practised; a common incinerator can be built outside the congested areas of the city. The present nature of disposing off the biomedical wastes along with the other municipal wastes needs to be discouraged and the guidelines of the Ministry of Environment and Forest (in regards to bio-medical waste disposal) needs to be implemented

(ix) The concept of reduction at source, recycle and reuse of the waste generated needs to be encouraged. Here the community can play an effective role in sensitising the population as to convert resource out of the waste.

(x) The community needs to be involved in waste disposal programmes. Waste should be segregated at source into bio degradable and non-biodegradable. The services of the unemployed youth can be harnessed as they can be mobilised to collect waste from the households (door to door collection) against a small amount of payment. The waste 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-biodegrable waste can be collected from a common source by different organisations that could be reused

as their raw material for production. Hence waste needs to be viewed as a resource which can enhance both capital and employment opportunities.

(xi) The duplication of organisations in regards to waste disposal and water supply needs to be addressed as no single organisation can be held responsible for the present state of affairs. One household one water connection system should be implemented.

(xii) 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.

(xiii) The concept of rain water harvesting can be introduced to augment the present supply.

(xiv) Above all the for the future urban expansion of Shillong the environment impact assessment should be undertaken before identifying areas for urban growth.

PLATES

Flood Waters entering settlements located by stream sides

Plate 6.1(a)

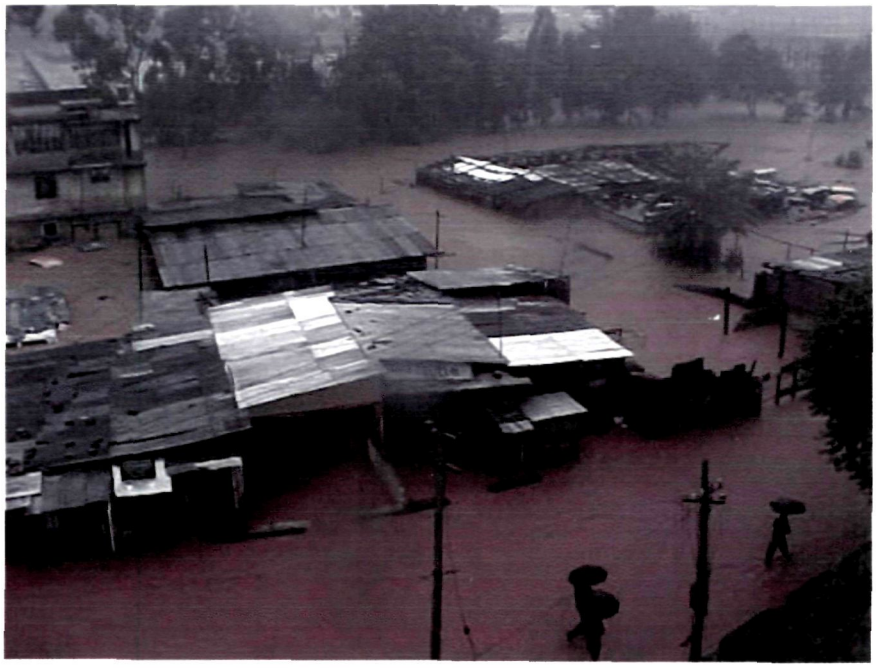

Plate 6.1(b)

Plate 6.2 Sedimentation and pollution of the stream due to waste dumping.

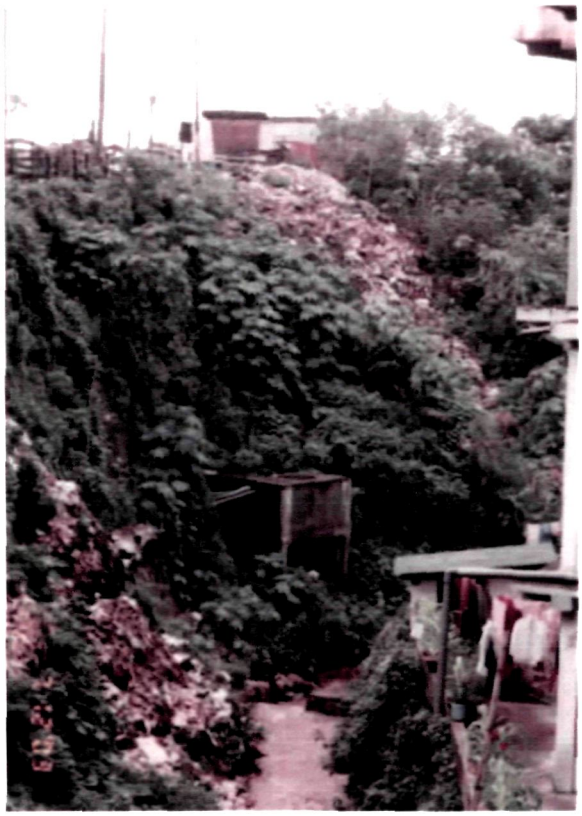

Plate 6.3 Quarrying activities in the up slope resulting to sedimentation of the streams (Demthring)

Household waste being dump into the stream (Nongthymmai)

Plate 6.4 (a)

Plate 6.4 (b)

Land reclamation on stream sides.

Plate 6.5 (a)

Plate 6.5 (b)

Plate 6.6 Land reclamation on water source of Lapalang.

Plate 6.7 Hospital waste mixed with Municipal solid waste dumped in the open

Plate 6.8 Leaking water pipes on the road side.

Plate 6.9 Street drains clogged with garbage.

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APPENDICES

APPENDICES

Annexure – I

Section I: Locality Schedule

1. Name of the locality .....
2. No. of wards looked after by the locality .....
3. Total population of the locality ..... Total households .....
4. Composition of the population
   Tribal ..... Non-Tribal .....
5. No. of headmen in the locality .....
6. Total population under each headmen .....

Waste Disposal System of the Locality

(i) Dustbin used? Yes/No
(ii) No. of dustbins .....
(iii) Type of dustbin .....
(iv) Who maintains the dustbin .....
(v) How frequently are the dustbins cleaned?.....
(vi) Who cleans the dustbins? .....
(vii) Nalas used? Yes/No
(viii) Length of the drains .....
(ix) Labour engaged? Yes/No
(x) No. of labour engaged .....
(xi) (xi) Waste dumped in a pit? Yes/No
(xii) No. of Pits .....
(xiii) Waste burned? Yes/No
(xiv) Vermiculture practiced? Yes/No
(xv) Night soil disposed? Yes/No
(xvi) How often is septic tank cleaned? .....
(xvii) Where and how is the waste disposed? .....
(xviii) Community involvement in waste disposal .....

Water Supply of the Locality

(i) No. of tanks supplying water to the locality? .....
(ii) Capacity of the tanks .....
(iii) Organisations looking after the water supply .....
(iv) Is there any alternate source of water supply? Yes/No
(v) Is there severe water shortage during any part of the year? Yes/No
(vi) Approximate no. of households supplied water from each tank .....
(vii) Are there any severe leaking pipes near the tanks? Yes/No
(viii) Are there public taps located near the tanks? Yes/No
(ix) Is water being sold from these public taps? Yes/No
(x) Approximate percentage of the households having piped water supply within the compound of their house? .....
(xi) Any other information .....

Annexure – II

Household Schedule

I. Identification schedule

Name of the locality .....
Name of the respondent .....
Community –
Tribal (specify) .....
Non-tribal (specify) .....
Religion .....
Caste .....

II. Demographic and socio-economic structure

Name	Age	Sex	Relationship with head of family	Occupation			Monthly income
				Govt. Employee	Private	Business	
				Post	Post	Type	

Educational qualification of the head of the family.

Literate							Illiterate
Technical	Non-Technical						
	Non-matric	Matric	Inter	Graduate	PG	Ph.D.	

III. Type of Accommodation

Rented	Self owned	No. of rooms	Approx. built up area of the house (in sq.ft /Km)	Building material used			Frequency of renovation/ repair
				Assam Type	RCC	Others	

IV. Facilities available

(i) Type of night soil disposal .....
(ii) Toilet (inside/outside of the house) .....
(iii) No. of toilets .....
(iv) Kitchen type and type of fuel used .....
(v) Source of water (a) Tape ..... (b) Well ..... (c) Others .....
(vi) No. of drains and their outlet .....
(vii) Where do the drains discharge? .....
(viii) Is waste dumped in a pit? Yes/No
(ix) Is waste burned? Yes/No
(x) Is Vermiculture practiced? Yes/No
(xi) Is Night soil disposed? Yes/No
(xii) How often is septic tank cleaned? .....
(xiii) What is the method used to clean the septic tank .....
(xiv) Where is the waste disposed? .....

V. Habits

(i) How often is marketing done? .....
(ii) Whether packed food is frequently consumed? Yes/No
How often? .....
(iii) Where are the packets disposed? .....
(iv) Type of cooking gadgets used? .....
(v) How often is washing done? .....
(vi) Amount of washing .....
(vii) Amount of water consumed for washing .....

VI. Generation of waste per day/per week/per month (quantification of waste is done with the help of 16 litre bucket)

Type of waste*:

(a) Kitchen waste (Amount generated)	(b) Domestic waste (Amount generated)	(c) Constructional waste (Amount generated)	(d) Natural waste (Amount generated)

How are they disposed:

(a) Kitchen waste	(b) Domestic waste	(c) Constructional waste	(d) Natural waste

* (a) Kitchen waste – vegetables, leftovers food, bones, ash, etc.; (b) Domestic waste – cloths, tin, plastic bags, newspapers, toilet paper, bottles/broken glasses, unused medicines, toys, disposable napkins/diapers, leather, etc.; (c) Constructional waste – paint, tin, cement, bricks, etc.; (d) Natural waste – dry leaves, branches and twigs, flowers, carcasses of animals, etc.

VII. Water Supply

(i) Is there a piped water supply within the compound of the house? Yes/No
(ii) Quantity of water used per day in litres .....
(iii) Quantity actually required .....
(iv) Is there water shortage? Yes/No
If yes, during which part of the year .....
(v) Is water bought? Yes/No
If yes, how much and at what price approximately per week .....
(vi) Is rain water collected? Yes/No
If yes, what is the method used:
(a) Cemet tanks (b) Plastic containers (c) Any others

Annexure – III

Office of Municipal Board/Cantonment Board/The Syiem of Myliem

1. Total area under the Municipality/Cantonment/Syiem .....
2. Total population of the area .....
3. Total no. of settlements in the area under the Municipality/Cantonment/Syiem .....
4. Total no. of dustbins maintained and its location .....
5. Is there any increase in the no. of dustbins Yes/No
   If yes, when (which year) and where? ...
6. Type of dustbins – Kucha/Pacca
7. Approximate amount of waste collected from the dustbins each day/weak .....
8. How frequently is the waste collected? .....
9. Besides dustbins, what other methods are employed to collect the waste? .....
10. Type of vehicles engaged in waste collection and disposal

    Closed lorry ..... Nos .....
    Open lorry ..... Nos .....
    Hydrolic tipper ..... Nos .....
    Others .....
11. How much waste can the vehicle carry? .....
12. How many vehicles are employed in collecting the waste? .....
13. Is there any increase in the no. of vehicles? Yes/No
    If yes, when and how many? .....
14. Is there a method of separating biodegradable from the non-biodegradable waste? Yes/No
    If yes, specify .....
15. Is there a method of categorising waste like domestic waste, commercial waste/industrial wate, etc? Yes/No
16. No. of workers engaged in waste disposal from –
    1971 ..... 1981 ..... 1991 ..... 2001 .....
17. Where is the waste dumped/disposed? How far is it from Shillong? .....
18. What is the area of the waste dumping ground? .....
19. Besides dumping of the waste, what other method is adopted for waste disposal? ....
20. Is there a method of recycling the waste? Yes/No
    If yes, please specify .....
21. Does the mMunicipality/Cantonment/Syiem plan to have other sites for waste disposal? Yes/No
    If yes, where and when this site will be functional? .....
22. What renovations have been done in the new site for waste disposal? .....
23. What problems are faced by the Municipality/Cantonment/Syiem in their waste disposal programme? .....

Processing of Waste

1. Location of site .....
2. Name of waste processing technology .....
3. Details of processing technology .....
4. Quantity of waste to be processed per day .....
5. Utilisation programme for waste processed .....
6. Measurement taken for prevention and control of environment pollution .....
7. Measures taken for safety of workers in the plant .....

Sewage and Sewage Disposal

1. Is there any integrated sewage disposal system within the area looked after by Syiem? Yes/No
   If yes, since when and how does it function? .....
2. Are there public toilets maintained by the Syiem? Yes/No
   If yes, the no. and there location from 1971 onwards .....
3. Are there any dry laterines? Yes/No
   If yes, how many and in which locality are they located? .....
4. How is the night soil carried and disposed? .....
5. Is manual scavenger involved in the night soil disposal? Yes/No
   If yes, no. of scavengers employed since 1971? .....
6. How frequently is the night soil carried – daily/alternate day/weekly, etc.? .....
7. Approximate amount of night soil carried - daily/alternate day/weekly, etc.? .....
8. Suggestion for elimination of manual scavengers in night soil disposal .....
9. Problems faced by the Syiem for night soil disposal and sewage disposal .....
10. The area where sewage is disposed .....
11. Is there any treatment of the sewag before it is finally disposed? .....

Drains and Drainage System

1. Total length and no. of drains maintained by the Syiem .....
2. Is there any increase in the length and no. of drains? Yes/No,
   If yes, which year and in which locality? .....
3. Type of drains – Kacha/pacca
4. How frequently are the drains cleaned? .....
5. Where are the waste disposed from the drains? .....
6. No. of workers employed in maintaining the drains within the area under the Syiem .....
7. Any other information regarding waste disposal, sewage disposal, and drain maintenance? .....

Annexure – IV

Cantonment Board

1. Total area under the Board .....
2. Total population of the area .....
3. Total no. of settlements in the area under the Cantonment Board .....
4. Total no. of dustbins maintained and its location .....
5. Is there any increase in the no. of dustbins Yes/No
   If yes, when (which year) and where? .....
6. Type of dustbins – Kucha/Pacca
7. Approximate amount of waste collected from the dustbins each day/weak .....
8. How frequently is the waste collected? .....
9. Besides dustbins, what other methods are employed to collect the waste? .....
10. Type of vehicles engaged in waste collection and disposal .....
11. How much waste can the vehicle carry? .....
12. How many vehicles are employed in collecting the waste? .....
13. Is there any increase in the no. of vehicles? Yes/No
    If yes, when and how many? .....
14. Is there a method of separating biodegradable from the non-biodegradable waste? Yes/No
    If yes, specify .....
15. Is there a method of categorising waste like domestic waste, commercial waste/industrial wate, etc? Yes/No
16. No. of workers engaged in waste disposal from 1971 ....
17. Where is the waste dumped/disposed? How far is it from Shillong? .....
18. What is the area of the waste dumping ground? .....
19. Besides dumping of the waste, what other method is adopted for waste disposal? .....
20. Is there a method of recycling the waste? Yes/No
    If yes, please specify .....
21. Does the mMunicipality/Cantonment/Syiem plan to have other sites for waste disposal? Yes/No
    If yes, where and when this site will be functional? .....
22. What renovations have been done in the new site for waste disposal? .....
23. Besides the Cantonment area, any other area looked after by the Board in their programme of waste disposal? Yes/No
    If yes, please specify .....
24. What problems are faced by the Board/Syiem in their waste disposal programme? .....

Sewage ad Sewage Disposal

25. Is there any integrated sewage disposal system within the area looked after by Syiem? Yes/No
    If yes, since when and how does it function? .....
26. Are there public toilets maintained by the Cantonment Borad? Yes/No
    If yes, the no. and there location from 1971 onwards .....
27. Are there any dry laterines? Yes/No
    If yes, how many and in which locality are they located? .....
28. How is the night soil carried and disposed? .....
29. Is manual scavenger involved in the night soil disposal? Yes/No
    If yes, no. of scavengers employed since 1971? .....
30. How frequently is the night soil carried – daily/alternate day/weekly, etc.? .....
31. Approximate amount of night soil carried - daily/alternate day/weekly, etc.? .....
32. Suggestion for elimination of manual scavengers in night soil disposal .....
33. Problems faced by the Cantonment Board for night soil disposal and sewage disposal .....
34. The area where sewage is disposed .....
35. Is there any treatment of the sewag before it is finally disposed? .....

Drains and Drainage System

36. Total length and no. of drains maintained by the Cantonment Board.....
37. Is there any increase in the length and no. of drains? Yes/No,
    If yes, which year and in which locality? .....
38. Type of drains – Kacha/pacca
39. How frequently are the drains cleaned? .....
40. Where are the waste disposed from the drains? .....
41. No. of workers employed in maintaining the drains within the area under the Syiem .....
42. Any other information regarding waste disposal, sewage disposal, and drain maintenance? .....

Annesure – V

Bio-Medical Waste

1. Name of the Hospital/Nursing Home .....
2. Name of the locality where it is located .....
3. When it was established .....
4. No. and the name of the departments functioning within the hospital/nursing home .....
5. No. of beds available in each department in general .....
6. Average no. of patients admitted in each department/in general (average daily/weekly/monthly) .....
7. Average no. of out patients visiting the hospital/nursing home (average daily/weekly/monthly) .....
8. Average no. of surgery (minor & major) conducted in the hospital/nursing home (average daily/weekly/monthly) .....
9. Does the hospital/nursing home have its own incinerator? Yes/No
   If yes, what is its capacity? .....
10. How many hours does the incinerator operate daily? .....
11. Are the waste segregated? Yes/No
    If yes, the method of segregation .....
12. How many people are employed in this segregation? .....

13. Average amount of solid waste generated (category wise) and how are they disposed:

Category of waste	Type of waste	Amount of waste in Kg (average daily/ weekly/ monthly)	Method of disposal	Remarks (Problems and suggestions)
1	Human anatomical waste			
2	Microbiological & bio-technological waste (waste from lab. Cultures, etc.)			
3	Waste sharps (needles, syringes, scalpel, blades etc. used and unused)			
4	Discarded medicines & cytotoxic			
5	Solid waste (items contaminated with blood, body fluids etc)			
6	Solid waste (waste generated from items other than waste sharps such as tubes, catheters, intravenous sets etc)			
7	Liquid waste (waste generated from lab. Washings, cleaning etc)			
8	Incinerator ash			
9	Chemical waste (chemicals used in production of biological, chemical used in disinfection)			
	Total			

Any other suggestions/informationm .....

Meghalaya Pollution Control Board

CENTRAL LABORATORY

"ARDEN", MOTINAGAR, SHILLONG - 793 014

1. Sender's name & addres : Subrata Purkayastha Dept. of ... St Marys college Shillong.
2. Sender's reference : Letter Nil dated Nil
3. Name of source & place of Collection of sample : Cantonment supply, Thalupara
4. Type of source : Tap source.
5. Time & date of collection : 17.11.03
6. Purpose of a nalytical study : Total coliform, Total solids, Chloride, Nitrite, Sulphate, Iron, Flouride, pH, Turb, Cond
7. Time & date of receipt of the sample : 17.11.03.
8. Laboratory reference : G/185/03.

ANALYTICAL REPORT (POTABLE WATER)

A. PHYSICAL CHARACTERISTICS

1. Temperature °C : /
2. Colour pt-Co scale : /
3. Odour TON : /
4. Turbidity NTU : 1.5
5. Conductivity mho/cm : 26.0
6. pH : 7.0
7. Total Solids mg/l : 102.0
8. T D S mg/l : —

B. CHEMICAL CHARACTERISTICS mg/l

1. M-Alkalinity : 18.0
2. P-Alkalinity : Nil
3. Acidity : —
4. Total hardness : 24.0
5. Chloride : 5.0
6. Residual Chlorine : /
7. Total Cl Demand :
8. Flouride : 0.01
9. Sodium : /
10. Potassium : /
11. Iron : 0.1
12. Ammonia-N :
13. Nitrate-N : /
14. Nitrite-N : Nil
15. Total Kjeldhal-N :
16. Sulphate : 4.0
17. Calcium :
18. Magnesium :
19. Total Phosphorus :
20. Dissolved Oxygen :
21. Any other test :
    (A) B. O. D. : /
    (B) C. O. D. : /
    (C) Manganese : /

C. BACTERIOLOGICAL CHARACTERISTICS MPN/100 ml.

1. Total Coliform : 26
2. Faecal Coliform : —

REMARKS: Total coliform is found to be above the permissible limits of drinking water standards. Other parameters tested are within the permissible limits

Dated, Shillong,
the 9/12/03 199

Chief Chemist,

Meghalaya Pollution Control Board, Shillong.

Meghalaya Pollution Control Board

CENTRAL LABORATORY

'ARDEN', MOTINAGAR, SHILLONG - 793 014

1.	Sender's name & addres	: Subrata Purkayastha Dept of C, St Mary's College, Shillong
2.	Sender's reference	:
3.	Name of source & place of Collection of sample	: Spring water, Nongthymmai
4.	Type of source	:
5.	Time & date of collection	: 17.11.03.
6.	Purpose of a nalytical study	: Total coliform, Total solids, Iron, Nitrite-N, pH, turbidity, Conductivity, Sulphate, flouride
7.	Time & date of receipt of the sample	: 17.11.03.
8.	Laboratory reference	: CL/186/03

ANALYTICAL REPORT (POTABLE WATER)

A. PHYSICAL CHARACTERISTICS

1.	Temperature °C	:	5.	Conductivity mho/cm	: 14.0
2.	Colour pt-Co scale	: /	6.	pH	: 6.0
3.	Odour TON	:	7.	Total Solids mg/I	: 100.0
4.	Turbidity NTU	: 0.8	8.	T D S mg/I	: -

B. CHEMICAL CHARACTERISTICS mg/I

1.	M-Alkalinity	: 18.0	11.	Iron	: 0.06
2.	P-Alkalinity	: Nil	12.	Ammonia-N	:
3.	Acidity	: –	13.	Nitrate-N	: /
4.	Total hardness	: 24.0	14.	Nitrite-N	: Nil
5.	Chloride	: 10.0	15.	Total Kjeldhal-N	:
6.	Residual Chlorine	:	16.	Sulphate	: 3.0
7.	Total Cl Demand	: /	17.	Calcium	:
8.	Flouride	: 0.01	18.	Magnesium	:
9.	Sodium	:	19.	Total Phosphorus	:
10.	Potassium	: /	20.	Dissolved Oxygen	:
			21.	Any other test	:
				(A) B. O. D.	:
				(B) C. O. D.	: /
				(C) Manganese	:

C. BACTERIOLOGICAL CHARACTERISTICS MPN/100 ml.

1.	Total Coliform	: 140
2.	Faecal Coliform	: –

REMARKS : pH is found to be below the permissible limits and Total coliform above the permissible limits of drinking water standards. Other parameter tested are within the permissible limits.

Dated, Shillong,
the 9/12/03 199

Chief Chemist,

Meghalaya Pollution Control Board, Shillong.

Meghalaya Pollution Control Board

CENTRAL LABORATORY

'ARDEN', MOTINAGAR, SHILLONG - 793 014

1. Sender's name & addres : Subrata Purkayastha Dept of Geog St Marys College, Shillong.
2. Sender's reference : Letter No Nil Dated Nil
3. Name of source & place of Collection of sample : Municipality & PHE supply, Lachumiere
4. Type of source : Tap Source.
5. Time & date of collection : 17 11 03
6. Purpose of a nalytical study : Total Coliform, Total Solids, Chloride, Nitrite, Sulphate, Iron, Flouride, pH, Turb. + conductivity.
7. Time & date of receipt of the sample : 17 11 03
8. Laboratory reference : C/184/03.

ANALYTICAL REPORT (POTABLE WATER)

A. PHYSICAL CHARACTERISTICS

1.	Temperature °C	: /	5.	Conductivity mho/cm	: 57.0
2.	Colour pt-Co scale	: /	6.	pH	: 6.7
3.	Odour TON	: /	7.	Total Solids mg/I	: 95.0
4.	Turbidity NTU	: 2.0	8.	T D S mg/I	: —

B. CHEMICAL CHARACTERISTICS mg/I

1.	M-Alkalinity	: 14.0	11.	Iron	: 0.1
2.	P-Alkalinity	: Nil	12.	Ammonia-N	: /
3.	Acidity	: -	13.	Nitrate-N	: /
4.	Total hardness	: 44.0	14.	Nitrite-N	: Nil
5.	Chloride	: 6.0	15.	Total Kjeldhal-N	: -
6.	Residual Chlorine	: /	16.	Sulphate	: 18.3
7.	Total Cl Demand	: /	17	Calcium	:
8.	Flouride	: 0.02	18.	Magnesium	:
9.	Sodium	: /	19.	Total Phosphorus	:
10.	Potassium	: /	20.	Dissolved Oxygen	:
			21.	Any other test	:
				(A) B. O. D.	:
				(B) C. O. D.	:
				(C) Manganese	:

C. BACTERIOLOGICAL CHARACTERISTICS MPN/100 ml.

1. Total Coliform : 33.
2. Faecal Coliform :

REMARKS: Total coliform is found to be above the permissible limits of drinking water standards. other parameters tested are within the permissible limits

Dated, Shillong,
the 9/12/03 199

Chief Chemist,

Meghalaya Pollution Control Board, Shillong.

Meghalaya Pollution Control Board

CENTRAL LABORATORY

"ARDEN", MOTINAGAR, SHILLONG - 793 014

1. Sender's name & addres : Subrata Purkayastha Dept. of St. Mary's College, Shillong.
2. Sender's reference : Letter No Nil Dated Nil
3. Name of source & place of Collection of sample : Municipality & PHE Supply, Rilang
4. Type of source : Tap source.
5. Time & date of collection : 17.11.03
6. Purpose of a nalytical study : Total Colifarm, Total Solids, Chlorid, Nitrite, Sulphate, Iron, Flouride pH, Thio Conductivity.
7. Time & date of receipt of the sample : 17.11.03
8. Laboratory reference : G/183/03

SR. 103814. dtd 5-10-07

ANALYTICAL REPORT (POTABLE WATER)

A. PHYSICAL CHARACTERISTICS

1. Temperature °C	: /	5. Conductivity mho/cm	: 12.0
2. Colour pt-Co scale	: /	6. pH	: 5.7
3. Odour TON	: /	7. Total Solids mg/l	: 126.0
4. Turbidity NTU	: 1.0	8. T D S mg/l	: —

B. CHEMICAL CHARACTERISTICS mg/l

1. M-Alkalinity	: 10.0	11. Iron	: 0.01
2. P-Alkalinity	: Nil	12. Ammonia-N	:
3. Acidity	: -	13. Nitrate-N	: /
4. Total hardness	: 14.0	14. Nitrite-N	: Nil
5. Chloride	: 6.0	15. Total Kjeldhal-N	: —
6. Residual Chlorine	: /	16. Sulphate	: 2.7
7. Total Cl Demand	: /	17. Calcium	:
8. Flouride	: 0.03	18. Magnesium	:
9. Sodium	: /	19. Total Phosphorus	:
10. Potassium	: /	20. Dissolved Oxygen	:
		21. Any other test	:
		(A) B. O. D.	:
		(B) C. O. D.	:
		(C) Manganese	:

C. BACTERIOLOGICAL CHARACTERISTICS MPN/100 ml.

1. Total Coliform : 33
2. Faecal Coliform : —

REMARKS: pH is found to be below the permissible limits and Total colifarm above the permissible limits of drinking water standards. Other paramaters tested are within the permissible limits

Dated, Shillong,
the 9/12/03 199

Chief Chemist,

Meghalaya Pollution Control Board, Shillong.