

Development and urban Flooding, Case - Guwahati

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Abstract—Guwahati city is plagued by the occurrence of urban floods every monsoon and it's a common sight after every heavy shower. Rapid urbanization with increased housing and construction activities in the city has led to more impervious or hard surfaces. The goal of this paper has been achieved through five set objectives. Under the different objectives, the interface of development and urban flooding for cities world over has been analyzed as well as the developmental patterns with respect to the urban flooding scenario in Guwahati has been studied; whereas critical flood prone areas along with the causative factors have been analyzed for Guwahati and finally planned formulated strategies were formed for mitigating the impact of urban flooding in Guwahati. This research paper concludes by creating urban planning solutions for Guwahati's waterlogging, which is not a disaster in entirety.

1. INTRODUCTION

There has been a growing trend of urban flood disasters in India in recent years by which the major cities of India have been severely affected. The most notable among them are Hyderabad in 2000, Ahmedabad, in 2001, Delhi in 2002 and 2003, Chennai in 2004, Mumbai, in 2005, Surat in 2006, Calcutta in 2007, Jamshedpur in 2008, Delhi in 2009 and Guwahati 2007 and Delhi in 2010. It has been an experience in most cities like Mumbai, Kolkata, Chennai, Bangalore and Guwahati that intensity of flooding has a certain relation with unplanned growth of urban areas under situations of tremendous demographic pressure. Unplanned urbanization leads to loss of urban green and open spaces, encroachment and filling up of natural drainage systems, reclamation of wetlands and increased construction in low lying flood prone areas of the cities. These land use changes results in the loss of natural buffers which otherwise act as sponges, absorbing excess rain water during times of heavy storm. It also hinders the natural egress of storm water flow, unplanned growth leads to a higher rate of surface run-off thus increase the carrying capacity of the natural drains and canals.

Guwahati city's Inundation owing to water-logging is has been a major catastrophe faced in several wards of Guwahati Municipal Corporation Area during the rainy season after every medium or heavy downpour. The public and the authority are equally concerned as it brings life to standstill and there has been several initiatives to solve the vexed issue, involving multi-departmental participation with tall claims – and the situation remain grim which lead to even loss of

human lives. This rapid development of the watershed areas decreases infiltration capacity of the land giving rise in runoff losses, which manifested in flash flood situation and indiscriminate unplanned urbanization leading to expansion of the city limit adds dimension to the calamity. Guwahati with its naturally gifted five storm water disposal and balancing system – Bharalu, Silsako, Borsola, Khanajan and Deepor Beel (RAMSAR wetland), and its deteriorating environment does not speak the developmental planning of the Guwahati municipal area .

This research paper attempts to create planning solutions for Guwahati's waterlogging, which is not a disaster in entirety; it is a problem and thus has planned interventions. Thus the research is upon the overall flood mitigating process in regional, city and area level zones which remain critical to urban flooding due to the pressure of unplanned development.

Objectives

- i. To assess the status of development pattern with respect to the urban flooding scenario in Guwahati.
- ii. To identify and analyses critical flood prone areas.
- iii. To identify the issues and arrive at the causative factors for urban flooding in Guwahati.
- iv. To formulate strategies of urban flooding and its impact in the urban areas of Guwahati.

2. INTRODUCTION TO THE STUDY AREA (GUWAHATI)

The city is situated on an undulating plain with varying altitudes of 49.5 m to 55.5 m above Mean Sea Level (MSL). The Southern and Eastern sides of the city are surrounded by hillocks. Apart from the hilly tracts, swamps, marshes, water bodies like DeeporBeel, Silpukhuri, DighaliPukhuri, BorsolaBeel and SilsakooBeel etc. also cover the city, moreover Guwahati is in between the Brahmaputra River and the Shillong Plateau, Guwahati straddles the valley of the river Bharalu which is a small tributary of the Brahmaputra. To its west lies the Nilachal Hill on the southern banks of the Brahmaputra, to the north is the Chitrachal Hill and to the south lies the Narakasar Hill to the west south-west of the city lies DEEPORBILL, a permanent freshwater lake (RAMSAR)

wetland ,acting as the natural storm water reservoir for the city.

Guwahati has a humid subtropical climate, falling just short of a tropical savanna climate. The climate of the state is characterized as warm and humid. The monsoon brings heavy rains to Guwahati. The average temperature is 31.5°C to 24.7°C in summers and 24.9°C to 12.5°C in winters.

Average annual rainfall in Guwahati is more than 1700 mm and is amongst one of the most heavily rainy areas in India. The highly irregular distribution of rainfall, characteristics of monsoon climate, leads to very high rainfall intensities occasionally throughout the year. The high rainfall intensities associated with such irregular annual distribution produces, occasionally very large run-offs and leads to severe drainage congestions, moreover the rainfall intensity in Guwahati is more vigorous in the first one and half hours resulting in the flash flooding situation every time in the urban areas.

Evolution of the city (Guwahati)

During 1911-1912

The built-up land was confined only to the Uzan Bazaar – Chenikuthi and Fancy Bazaar area surrounding the two river ports of Brahmaputra namely Sukleswar and Kachari Ghat. Rest of the land was under agriculture with minimal habitation, low lying areas and forests. The area under total built-up land in 1911-12 was around 7.00 sq km.

During 1967-1968

The built-up land had grown from 7.00 sq. km in 1911-12 to about 83.80 sq. km in 1967-68. It registered an increase of about 76.80 sq. km area between 1912 and 1968. The tendency of the growth of built-up land remained linear along the road network in the peripherals of the city.

During 1990

Though the city has shown the tendency to grow on all sides, the growth was more pronounced on the southern side to the Dispur-Basistha plain across the narrow corridor between Japorigog and Fatasil hills. The growth was also seen along the National Highway 37 from Basistha to Tetelia.

The total built-up land in 1990 was 132.19 sq. km. The city's population grew from just three-hundred thousand in 1971 to more than five hundred thousand in 1991 and in the census of 2001 the city's population was found to be 8,90,773. It is now a million plus city. Although the spatial growth has been considerable, unequal spatial development has led to pockets of high density to support employment and population, putting pressure on the infrastructure of the city.

3. CONDITION OF DRAINAGE BASINS

Guwahati is gifted naturally with six drainage basins but still the toll on nature and the major developmental pattern coming

up in the main or the core city area has led to the overall halt in the process of urban drainage.

Bharalu basin being the biggest drainage basin is the worst affected as the major old CBD area is being developed in this area further which the trend of development remains unchecked for, The stretch of Bharalu and Bahini which traverses through the densest areas of Guwahati is approximately 16 km long with a catchment area that is almost equally divided between the hilly regions and the plains. Specifically, the hilly upstream section of the Bharalu has a catchment area of 60 sq. km (where it is known as Bahini), and a catchment area of 40 sq. km in its downstream stretch passing through Guwahati .

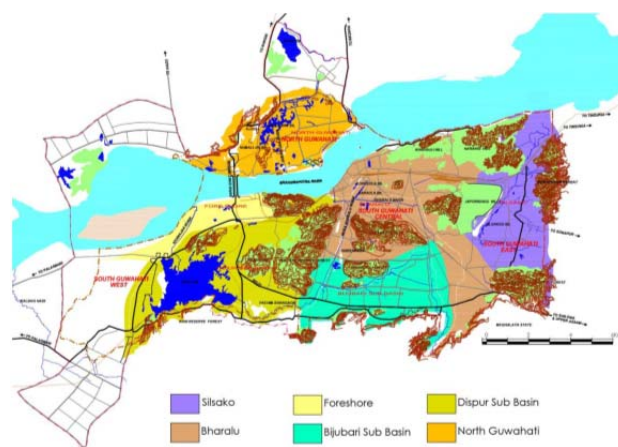


Fig. 1: Drainage Basins of Guwahati [1-2]

The present drainage condition is as follows

Underground Drainage System- 70% of the city,

Mainly in the Bharalu, Bijubari, south-Guwahati (E) and Dispur sub basin.

Surface Drainage System - 27% of the city, south Guwahati (W), Foreshore and North Guwahati

4. URBAN FLOODING AREAS IN GUWAHATI

Major issues related to flooding in Guwahati are that entire old city area falls in vulnerable zone risking all heritage buildings and settlements. High density of population resides in flood prone areas of Paltan Bazaar, Anil Nagar etc, and these areas face water logging of 80cm to 120cm for 15-20 days every monsoon. Other issues contributing to the problem of flooding is encroachment on river beds and wetlands by unauthorized construction and large number of unauthorized colonies slums and plotted development fall in chronically flooded areas. Major reason for flooding is that area lacks open spaces and greens to soak the flood water. Major roads and transport network like GS road, RG Baruha road chronically gets flooded with water logging of 30cm-60cm for 3-7 days.

Thus to further analyses the floodable area, a 1 m digital elevational model was prepared and was interpolated with the help of GIS and the 4 major critical areas along with the cities flood mapping was done so as the entire picture of floodable area could come out in real time and could easily be compared it to the overall cities urbanizational trends.

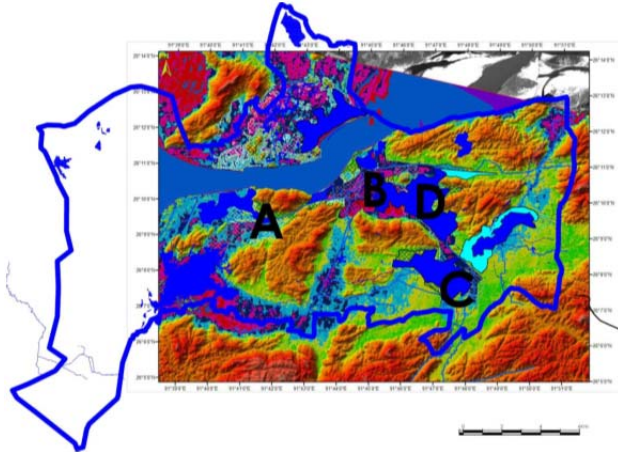


Fig. 2: 1m digital elevation model [2, 3]

The GMC falls within the climatic Zone 1 which comprises northern and northeastern India as well as adjoining parts of Nepal, Bhutan, Bangladesh and North Myanmar. In this zone, rainfall generally occurs in the monsoon months from June to September while the months from November to February are generally dry with occasional winter rains. In this basin, four meteorological conditions are mainly responsible for heavy rainfall and subsequent floods:

- i. Movement of a monsoon trough to the northeast from the Bay of Bengal to the sub-basin
- ii. Shifts of the monsoon trough to the north from its normal position.
- iii. Formation and movement of lowlands or land depressions over North-East India.
- iv. Circulation of cyclonic upper air over North-East India.

Thus it is clear that heavy rainfall will always be there for Guwahati city but that can be further created as a problem by having unplanned urbanization in the floodable area, the present floodable area of Guwahati as shown below.

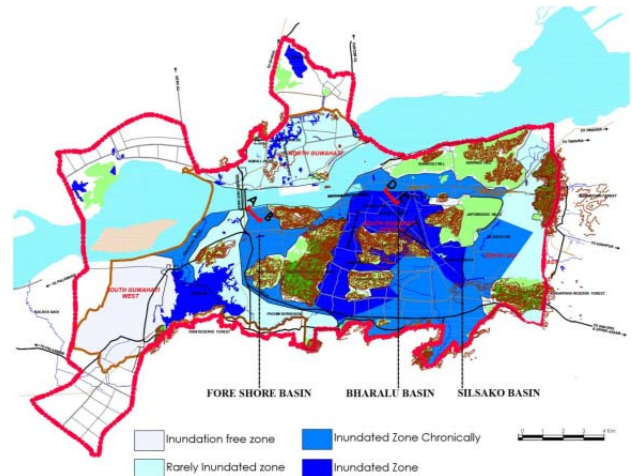


Fig. 3: Flood Plain Mapping [1, 3]

Thus from the analysis it is clear that about 11% of the entire city is inundated and 31% of the total area is chronically inundated.

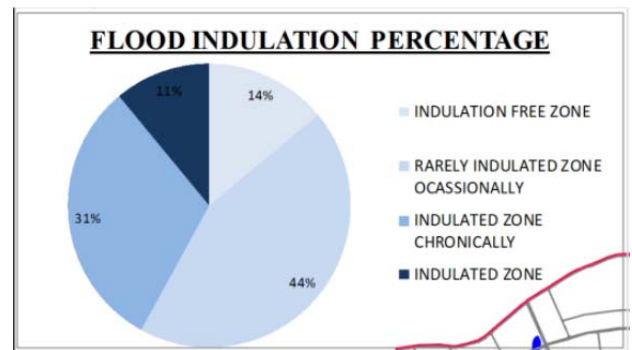


Fig. 4: Flood Inundation Percentage [1]

5. REGIONAL LEVEL ANALYSIS (GUWAHATI)

External factors such as development near Meghalaya border have also led to change in the topography. There are flash floods near agricultural university area. A lot of industries, schools, colleges etc. have been built along the border which not only threat the environment of the city (cutting of hills is a major problem) by aggravating and causing floods, siltation, air pollution; but are also putting pressures on the infrastructure and services of the city as this development is depending on Guwahati city for its requirement.

The catchment area of Guwahati is not just limited to one state its flow generates from the Meghalaya slopes and extra pressure of 35 % of the water flowing in the river networks of Guwahati is powered by the run-off the hills there is a overburden of water catchments from both the southern and northern portions of city limit.

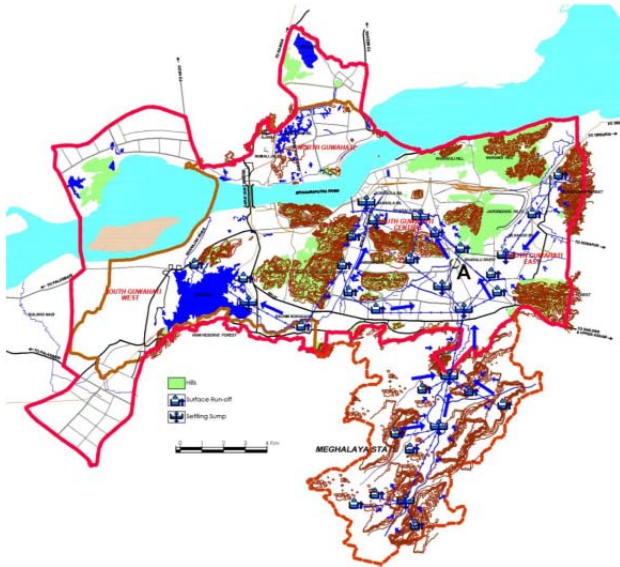


Fig. 5: Regional Water Catchments [1]

6. CITY LEVEL ANALYSIS

According to the Assam State Disaster Management Policy (2010), landslides and urban floods are the two most prevalent hazards that undermine the urban development of Guwahati. Flooding events have become quite common in Guwahati in past few years. A typical situation of manmade hazard as the city does not experience normal flooding events but is characterized by urban flooding owing to a number of issues like lack of drainage, unmanaged solid waste, reclamation of low lying lands and unchecked/ unplanned urban growth, hill cutting, etc. Another reason is the increased intensity of rainfall occurring in a very short duration. Although there are no recorded statistics on this but it has been observed that frequency of such extreme events has increased.

According to the city assessment report, backflow of the water from the River Brahmaputra, due to blockage in the drainage system through Bharalu, Khanajan, causes floods frequently every monsoon. Bharalu basin is the most flood prone area in the region. This is probably because most of the drains fall on the upstream side of River Bharalu. The river is at a higher level than the level of the drains leading to the retarded outlet of the water (Master Plan) Also, there is heavy siltation and dumping of garbage in the Bharalu River. The following map shows the built-up area overlaid with flooded areas in Guwahati. The map shows that the stretches along the Basistha River and the Bharalu River basin are chronically flooded areas while some patches near the Brahmaputra River lie in the occasionally flooded areas. These are also the densely populated areas of the city.

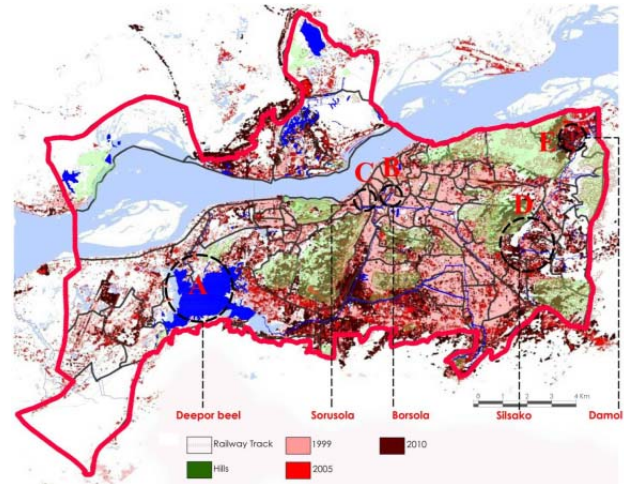


Fig. 6: Land utilization changes from 1999, 2005 and 2010 [1]

From the above analyzed map it is clear that the growth pattern of Guwahati city has been in the lines of the river channels and this phenomenon had continued till the very wetland areas itself, thus making it very hard for the five naturally gifted wetlands namely Deeporbeel (RAMSAR) site, Sorusola, Borsola, Silsako and Damol to maintain its natural process of water intake and also the cycle of Plant and Animal life.

Table 1: Increase in Built-up in Guwahati [1]

YEAR	1999	2005	2010
Built up area in Plain(sq km)	117.3	132.4	187.3
INCREASE IN BUILT UP AREA IS 1.5 TIMES			
Built up area in Hills(sq km)	7.3	27.9	60.2
INCREASE IN BUILT UP AREA IS 8.2 TIMES			

7. VULNERABILITY ANALYSIS OF WATER CATCHMENTS IN GUWAHATI

Due to rapid population growth and urbanization, illegal settlements, industries and excessive growth of invasive species the natural resources has been degrading gradually. As a result hills and wetlands are encroached. Hence, with a depleting green cover on the hill tops and hill slopes, shrinking wetlands and low lying areas due to human interference and encroachment, the environment in the city is witnessing and experiencing unprecedented pollution [4]. Wetlands and hillocks of Guwahati have taken the maximum battering because of rapid urbanization. Wetlands recharge ground water and serve as storm water deposits, they also influence a regions micro-climate.

Due to waste water and garbage being dumped in these sensitive areas, the quality of water had degraded, and the drainage capacity had also decreased. As all these natural reservoirs of water are being encroached and filled up as a result flood has become a regular phenomenon in the city

leading to an unhealthy situation. The natural environment is progressively destroyed for unplanned construction of buildings and roads, release of industrial wastes to the drainage channels, stagnation of filthy water in the intermittently unfilled depressions, which become the breeding place of mosquitoes, etc. have created serious problem of natural resource degradation and environmental pollution, endangering the health of civic life of Guwahati. Guwahati's maximum progress in last two decades have come up on the on the areas covering up wetlands. Lot of construction have taken place on the wetlands. The large number of wetlands that Guwahati once had is now being reduced to fragmented forms.

As the natural reservoirs and wetlands are being encroached upon, as a result floods have become a regular phenomenon in the city. Loss of forest cover is an important contributing factor to the occurrence of land slide in the city in recent years. Flash floods, water logging and dust pollution have aggravated in the area due to the deforestation and earth-cutting in the foothills. Moreover improper disposal of Municipal Solid Waste clog the drains of the city and in rainy season artificial floods are occur. The twin man-made factor creates flash flood in Guwahati city.

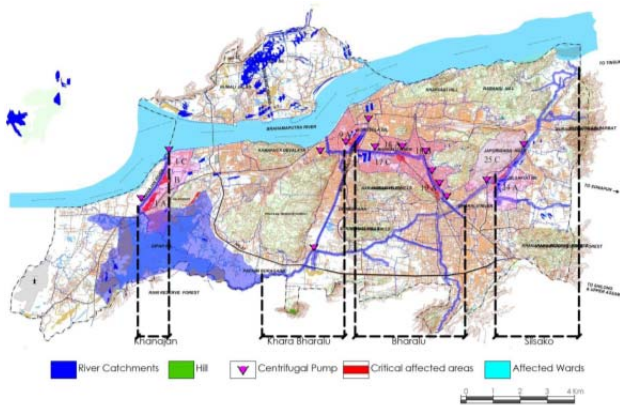


Fig. 7: Water Catchment Criticality in Guwahati [1, 2]

Also, there is heavy siltation and dumping of garbage in the Bharalu River. The following map shows the built-up area overlaid with flooded areas in Guwahati. The map shows that the stretches along the Basistha River and the Bharalu River basin are chronically flooded areas while some patches near the Brahmaputra River lie in the occasionally flooded areas. These are also the densely populated areas of the city. The map also shows the location of landslides in the city which shows that some of these are near to the chronically flooded areas.

River Criticalities

Urbanization trends have made it very hard in the natural drains to cope up with the surface run off. Surface ran-off coming from the mountains are the major concerns in the main

CBD areas, including the run-off coming from Meghalayan hills. Slums settlements in the wetland areas have altered the water pecculation phenomenon resulting in massive urban flooding.

The bar diagram below provides with all the important factors of criticality of the river tribunals flowing inside the city.

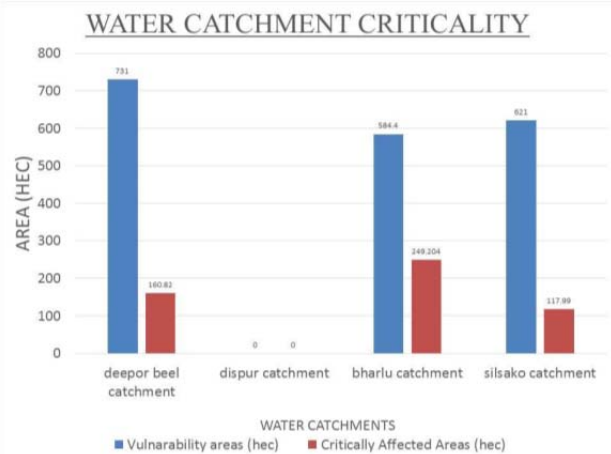


Fig. 8: Water Catchment Criticality in river channels [1]

Thus , it is clear that every major water catchment apart from Dispur catchment is heavily affected however this trend shows very sharply the impact of urbanization on wetlands and its environs , the places near the Dispur catchment is still not proliferated with the deforestation and the natural vegetation is not hampered , the built up has grown and is planned around its environ and not inside it or encroaching it thus making its criticality lowest than the other areas, however the major water catchments that is the Bharalu and Deeporbeel remain under constant pressure of unplanned growth which has resulted even minor showers for about 15 to 20 min to create an high volume of water stagnant in the roads , and this phenomenon is usually seen in the old city and the core city areas, i.e in the Ganeshguri , Chandmari , Nepali Mandir , Nabin Nagar, Lachit Nagar, Anil Nagar and even Maligoan.

8. RECOMMENDATION

Regional level recommendation

Separate drainage line for Meghalaya hill surface run –off is created and then about 37% of extra carrying capacity will decrease and the overall city sub-system will get a relief from overburdened carrying capacity.

Separate growth pattern is proposed so as the master plan of 2025 cannot have an adverse effect on the city's urban water drainage and wet land conservation, thus the change in the orientation of the growth pattern is shown in the map above and the table below shows exactly the amount of area required to build up that part of developed area.

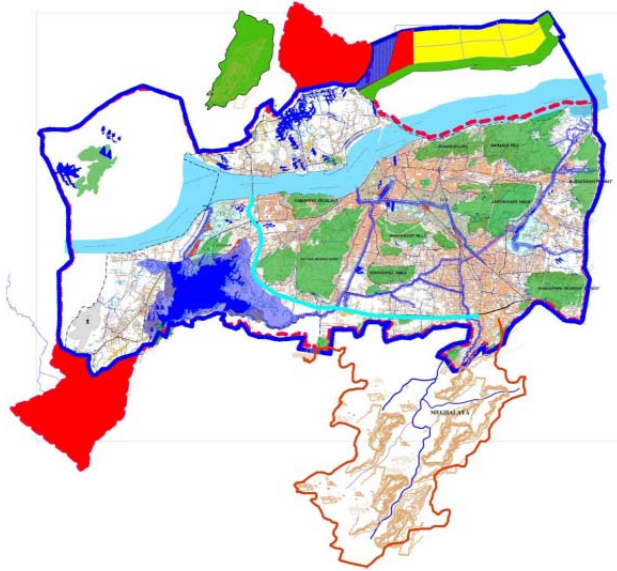


Fig. 9: Recommendation for regional level issues [1]

City Level Recommendation

Identification and demarcation of natural water bodies (Beels). Creating legislative framework to preserve the integrity of these wetlands. It is proposed to develop the adjoining area connecting the National Highway as Capital Complex and the Beel area to form a nature reserve as extension of the Capital Complex.

To check depletion of wetlands, earth filling in the wet and low lying areas should be stopped.

The water quality of Sola Beel is highly polluted mainly because of the dumping of rice bran and other wastes from the wholesale fish market. This dumping of waste in Sola Beel should be stopped. The area could be used as tourist attraction.

Area Level Recommendation

Currently Guwahati city heavily relies on the natural drainage system, and there is no proper drainage plan to cater the needs of the city. The existing natural drain channels needs to be cleared from garbage and keep it clean for the movement of storm water during monsoon season. The rivulet channels should be kept clear of any waste disposal, and all the drains falling in them should be relocated. The interconnectivity of these natural drains can be handy in directing out the flood water from the city in quick time; hence the encroachments over the drain channels should be removed. Also a systematic storm water drainage system should be planned along with the other infrastructure services

After all the analysis it is clear that water coming down from the hills in Guwahati is the major prime reason behind the bowls or the plains in the city core of getting flood inundated, thus urban planning schemes of watershed management in hills can be planned by using GIS and calculating the slopes.

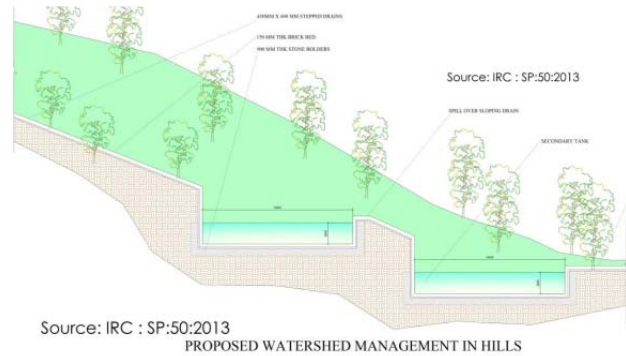


Fig. 10: Recommended watershed management in hills [1]

9. ACKNOWLEDGEMENT

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