IOSR Journal of Applied Geology and Geophysics (IOSR-JAGG)
e-ISSN: 2321–0990, p-ISSN: 2321–0982.Volume 7, Issue 4 Ser. I (Jul. – Aug. 2019), PP 09-26
www.iosrjournals.org

Rain Water Harvesting Using GIS at Darjeeling with Rain Water Harvesting Methodology and Foam Concrete

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Abstract: *This study covers the preparation of a GIS Master Plan for the Municipal Dock of Darjeeling covering the proposal for the drinking water supply system as well as the collection of rainwater, including identification of a slum house on the Darjeeling Municipal Map. We identify the current drinking water sources and among the city's residents with a view to evaluating the scenario and public water supplies in Darjeeling town. The use of GIS maps and water storage availability identify current water supply system problems in the town and correlate population growth with that of water supply & demand. The ultimate objective of this paper is to analyse the challenges for the water supply system in the Darjeeling city.*

Keywords: *Structural design, Concrete tank with non-evaporate coating, Using material science for evaporation process, Water recharging concepts*

Date of Submission: 26-07-2019 Date of Acceptance: 12-08-2019

I. Introduction

Darjeeling is a mid-sized district town located at an elevation of 2123 meters from M.S.L. Beautiful mountain atmosphere with small cottages and salivrias climatic conditions named the city with the title "Queen of Hill Stations". To date, Darjeeling is perhaps the most important tourist destination of eastern India. Due to the height of approximately 2,050 meters above sea level, there are winters and temperate summers in Darjeeling. There are many reasons behind the lack of water in Darjeeling, which is known as 'Queen of Hills' because of its richness of natural beauty."The population of Darjeeling (city) has increased in the last few years, because it is close to 2 lakh, but still we have only north and south lake to meet the demand of Darjeeling water. Apart from this, many other waterfalls (Dhar) are located within the city like Haridas Hatta Dhara, Bhote Dhara, Batasia Dhara, Vineeta Gram etc., which help in providing water to the people living in and around the city.

This study focus will also be used in the development of the water supply system **(Guha et al, 2009)** by constructing pipes in the entire Darjeeling city and creating reservoirs at various levels and places and these components have to be reflected in the digitized map (fig.2). Survey functions should also be prepared in a manner so that various development schemes can be implemented in the area on the basis of the data received. The main GIS map should have all the attributes specified in different layers and 1 in 1000 scale, while each ward is shown in 300 different scales in 1 separate and not more than 0.5 meters with the overall interval of the entire area.

Figure 1. Reviving drying springs

Table 1. Location of Natural Springs within Municipal Area

Springs	Latitude	Longitude	Elevation
Bhotae Dhara	$N\ 27^{\circ}03.363'$	$E\ 88^{\circ}15.061'$	1897 M
Kholi Ghar	$N\ 27^{\circ}03.263'$	$E\ 88^{\circ}15.259'$	1911 M
Haridas Hatta	$N\ 27^{\circ}02.866'$	$E\ 88^{\circ}15.685'$	1947 M
Lal Dhiki	$N\ 27^{\circ}02.696'$	$E\ 88^{\circ}16.025'$	2035 M
Muldhara	$N\ 27^{\circ}02.665'$	$E\ 88^{\circ}16.176'$	1911 M
Jail Dhara	$N\ 27^{\circ}02.534'$	$E\ 88^{\circ}15.675'$	1908 M
Dara Gaon	$N\ 27^{\circ}02.281'$	$E\ 88^{\circ}16.072'$	2055 M
Giri Dhara	$N\ 27^{\circ}02.267'$	$E\ 88^{\circ}15.740'$	2006 M
Police Dhara	$N\ 27^{\circ}02.231'$	$E\ 88^{\circ}15.486'$	1869 M
Vineeta Gram	$N\ 27^{\circ}0'886$	$E\ 88^{\circ}15.794'$	2157 M

Objective:

1. To develop geo-reference map showing position and location of important buildings, households of slum area, offices, houses, institutions road network, rail network, springs, river, lake etc
2. To develop and Desing a New Model based on the Structual Engg Concepts Tanks / Types : Trinagular /Trapezoidal / Circulat etc.
3. Apply Mathematical Modelling Techniques to derive a Good Tank Structure. Using underground Stone structure and Underground distribution system for planning natural tank structure
4. To develop water supply system in whole Darjeeling town by laying pipes and making reservoirs at different levels and locations & these component have to be reflected in digitized / referenced map.
5. GIS Map should contain all features in different layers in different wards of township.
6. Capture geo-tagged photograph (JPEG/Tiff format) of all the POIs (Place of Interest) like Hospitals, Government buildings, colleges, schools, hotels, households of slum areas where supply would be made.

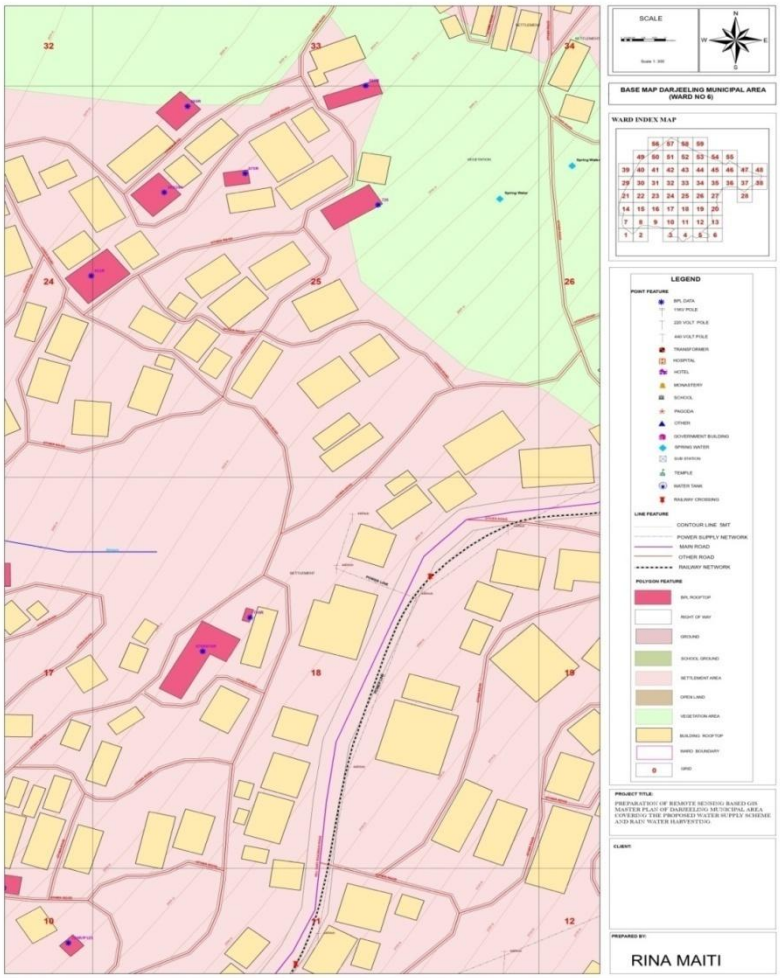

Figure 2. Ward Map Darjeeling

II. River Basin and Water Storage

For the city of Darjeeling, two main water storage facilities are Senchale Lakes (North and South), whose capacity is 20 MG and 13.5 Mg respectively. These two lakes are mainly fed from water coming from natural springs (i.e., Jhoras), whose number is currently 25. In the rainy season, Johar contributes a large amount of water, which is much larger than the capacity of the wetlands. This is the reason behind the plan of another lake, which has been temporarily given the name of the 4th lake, has been kept in mind. After an extensive study on the plan of additional reservoirs in Tiger Hill area, water source increase should be considered. Water is thrown directly from the South Sanchelle lake in the house of the bungalow. In addition, 10 natural springs feed directly into the bungalow's Filtrate House. This filter house of the loud bungalow is filled with water through St Paul's tank and main pipeline in Rockville Tank. The main pipeline is placed in landslide areas through Alobbari Military Engineering Services (MES) pump station. Due to natural slopes, where pipelines have been laid through Tenzing Norgay (TN) road, the flow of water is under gravity.

Another pipeline revolves through a pump house, roaming directly from the rooftop house, which acts as a populated area of the Ghom Town area. From the tank of St. Paul and Rockville, the water is fed in other sub-reservoirs such as Old Singmari, New Singori, Meadow Bank Tank, Butcher Tank, Devotee Bust Tank through various diameter pipelines.

The flow of water through the open drain, feeding 26 waterfalls located within the Senchele range, lays both these lakes. According to the report of Darjeeling municipality, (2010) Average water discharge through the open drain is 14,000 gallons per hour (i.e. 3.36 lakh gallons per day) and during the lean period, average discharge through open discharge is 80,000 Gallons per hour and 19.2 million gallons per day.

Sindhap Lake: Sindhap Lake is another important source of water for the city. This lake has the capacity to keep 15 million gallons of water. Due to the poor quality of the reservoir and seepage in the lake, it has not been satisfactory results. According to the municipal reports, it can hold up to 50% of its actual capacity.

Khong Khola: Khong Khola is a small perennial river near the city. According to the report of the municipality, in order to meet the demand of the people, during the dry season (fig.1) about 75,000 gallons of water is added to the lakes every day from this river.

Rambi Catchment Area: According to the Municipal Report (2010), this catchment area has a total yield capacity of 1, 50,000 gallons of water per day. Sometimes during the shortage of extreme water, the municipality collects water in these water and trucks from these streams and supplies it in the city to fulfill the city's demand.

Natural Springs:

Darjeeling is endowed with many natural waterfalls which come under rainy season. For the city of Darjeeling, the water of the Reddish, Bhigaldhara, Bhothara, Giridhara provides approximately 20000 gallons of water per day. Major sources of water and their capacity are given in table. 2:

Table 2. Water Demand in Darjeeling and the Shortage of Water Supply with respect to the Water Demand

Intake of Water	**Capacity (Gallons/day)**
Reservoir of Sinchel lakes	3,36,000
Pump from Khong khola	75,000
Springs from Rambi catchment area	1,50,000
Boxi Jhora	12,000
Laldhiki, Bhyaguldhara, Bhotedhara, Giridhara Springs	20,000
Total	**6,17,000**

Existing system of water storage tanks

On the Darjeeling, Darjeeling Water Park, Darjeeling is situated at an average elevation of 6,982 feet (2,128 meters) in the Himalayan hill region, which comes out of pride in the south. The range is Y-shaped, which is located in Katapahad and Jalpahad and has two weapons in the north of Observatory Hill. **(Sturm M et al, 2009)** The north-eastern side suddenly sinks and ends in the Lebanese spur, while the north-west arm passes through the north point and ends in the valley near the Tukwor T Estate. One of the most important civil facilities provided by the Darjeeling Municipality is the supply of drinking water.

In the water supply system of Darjeeling city, about 26 km from the catchment area of Sanchechal forest and Wildlife Sanctuary is about 15 km from the main city. Water from springs is collected in an Arrayer tank and fed in the Masonry line line (about 8 km long), which brings water to gravity for the twins-centric lakes. The combined capacity of both lakes is 33 million gallons (North 20 million and South 13 million gallons). Water is filtered through these lakes through pressure filters. Located in the Jörbunglow Filtration House, the water from St. Paul's tank capacity through large water is 2,35,812 gallons and a rock ville tank, 56,651 gallons (MS tank) and 58,012 gallons (masonry tanks) Has been done. These main reservoirs are

distributed in the city through two adjacent tanks located at various places and are also distributed directly through the distribution of various diameters. There are about 19 nos. The means of distributing each of Rockville and St. Paul's tanks (fig.3 & fig.4).

Figure 3. Rockville Water Tank

Figure 4. St. Paul Water Tank

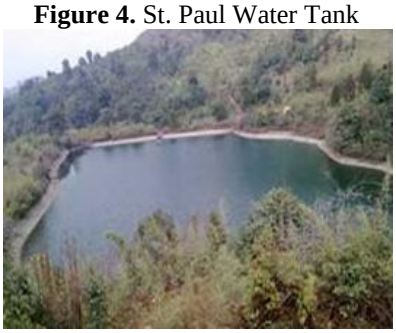

Figure 5. Twins Lake constructed by Thos Kenay in the year 1910, 1932

During the year 1910-1915, the existing water supply establishments were meant for the population of about 15000 (fifteen thousand), after which there were several water supply establishments like Khangkhola Station, Rambi Water Line, Sindap Lake (capacity 15 million gallons), Bokshi. Zora and bungalow were added, but it could not cope with the rapidly growing population, resulting in crying and crying (December to May) for drinking water, especially during the drought period, for a continuous last two decades Specialty has remained or so Due to the large scale degradation of trees, the crisis has reached its peak in the last few years due to the heavy drop in the amount of water in the natural waterfalls of the catchment area.

Transmission & Distribution Main

Darjeeling Town Water Supply System has about 35 km transmission man and 83 km distribution main (excluding service line and public hydrant) and many valves (fig.6).

Figure 6. Transmission Main Line

About 95% of pipelines and valves were laid during the supply of water through the pipeline in Darjeeling city (fig.7). In the past, no work was done in the past to replace old pipelines or leaking valves and very few maintenance works were done because most repairs/restoration works were taken only on an ad-hoc basis. This is one of the reasons why leakage is seen in many places in the city and there is an adverse impact on the normal water supply. As such, priority should be given for re-alignment and replacement of pipelines and valves before moving into the redistribution system.


Figure 7. Rockville Tank Bifurcation Networks

Figure 8. Bifurcation line at St. Paul compound

Figure 9. Bifurcation Line near T.V Tower

Pipeline bridges: There are fourteen (14) pipeline bridges with transmission head, four of which (4) need immediate repair/reconstruction because they are collapsing.

Scarcity of Water in Darjeeling Municipal Area

The lack of drinking water in Darjeeling Town is being felt for the last thirty (30) years or more. In order to solve the problem plans such as the Indus Lake, Bangla opened, the initial scheme for water turbines of waterfalls at different places was done earlier, but the problem remained unsettled. In the end, the comprehensive Rambi water supply scheme was done with an improvement of 1.5 million gallons of total yield per year, but the second phase of the scheme of the phase was left on PHE's report, although it was approved.


Figure 10. Illegal tappings of water in the main transmission line at Rangbull & Aloobari, Ganeshgram

Figure 11. Illegal tapping of water in the main transmission line at Aloobari, Ganeshgram

III. Study of Catchment area

The entire jurisdiction of Darjeeling Nagar area (The total number of wards is 32, in accordance with coverage estimated area 10.60 km², total population as per 120414 census 2011).

Darjeeling Municipal Town is located between 26 '31' and 27 '13' and 87 '50' and 88 '53' of the northern latitudes and the distance between east longitude and altitude is 1981.20 meters to 2286 meters. This is an English letter 'Y' shaped ridge whose base is in the cut-offs and watercourses, while two weapons emerge from the mall, one passes towards Northwest, suddenly passes through St Joseph's College and finally near Tukwar tea The estate ends in the valley Initially, the Darjeeling Municipality had to cover the whole area which was cited by the King of Sikkim for sanatorium. Now it covers an area of 10.60 km²

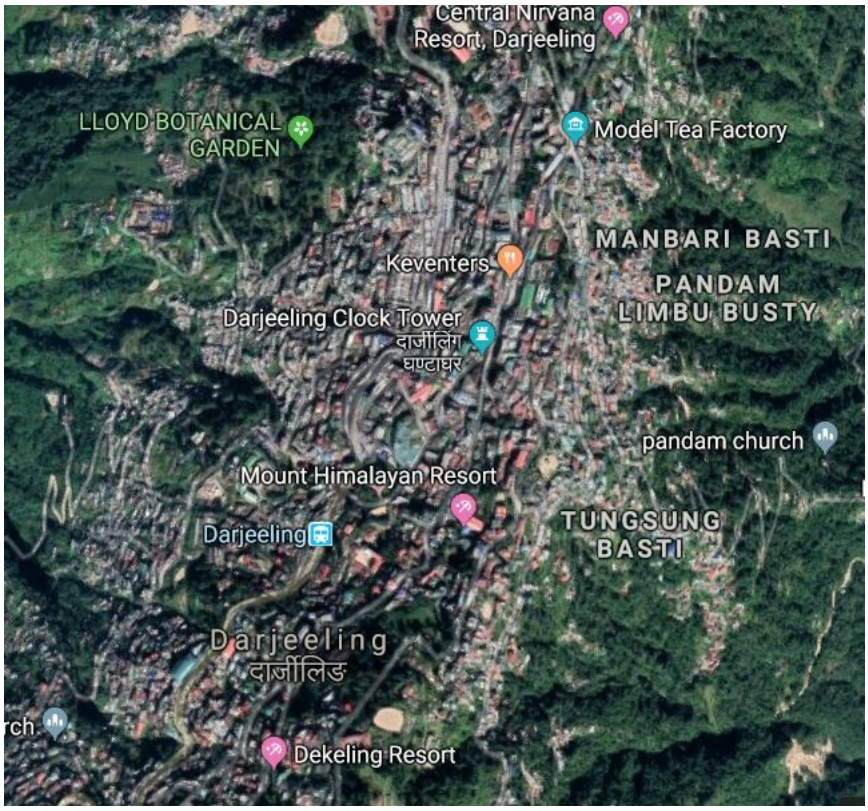

Figure 12. Darjeeling Google map

Figure 13. Rain water harvest ward map Darjeeling

Topography:

The Darjeeling city has all the topographical features, which are usually found in the Himalayan range in mountainous cities. Normal topography is very high with vertical slopes.

Climate:

From March to May in Darjeeling and from mid-September to mid-November, Salubi is the season. The average annual rainfall is 2812 mm and the average relative humidity is 32%. The mean maximum and average minimum temperature is 16.7 ° C and 10.2 ° C, the maximum and minimum temperature is 23.5 ° C and 0.9 ° C.

Land use pattern

- ✓ Reconnaissance survey by Rec Consultants and through the investigation of the fields, the current land use pattern updated by the consultants has been presented in the drug. No. 8512 / DAR / 01 According to the report "Darjeeling for Integrated Urban Development Projects" **(Bashar et al, 2018)** prepared by the Development and Planning Department (T & C), West Bengal Government in June 1982, 375 land area of Darjeeling districts is under forest and about 286060 hectares of land Are working. Tea plantation It is believed that about 59,000 people work in 144 tea gardens.
- ✓ The tea plantations in the vicinity of the Darjeeling Municipal Corporation are Happy Valley, Van Tukvar, Stabong, Rungnet, Fountshesharing, Ging, Bannock Burn, Pandem, Bloom Field, Arya and Steinathal.

Genesis of the study:

The area of Darjeeling municipality is 10.6 sq km. With the main area of about 200 acres, where all major activities occur in both social and administrative. In the census of 1981, there is a record of 57,603 persons in the municipal area, which is now more than 60,402 and has a tourist population of 7,000 against 20,000, for which the city was built.

IV. Focus of the Research

In the mountainous areas of the Darjeeling area, water supply is mainly based on spring water. Keeping in mind the water crisis during the summer months, rainwater and spring water conservation has to be encouraged at appropriate places in different types of reservoirs and to be used with proper treatment. It requires improvement for the old and complex water distribution system to create a similar supply system. For this, it is necessary to reconstruct the main supply line with necessary changes in the delivery system under the supervision of an expert engineer. An alternative drain should be constructed for the Sankhal lake covering the distance of 5 kilometers from Khong Khola, so that there is no problem for repairing the old drain. Especially in Rockville Tank and main distribution lines, the reservoir leakage is required to be fixed as soon as possible, which can save water @ 15% to 20% of the total demand of water..

Aim:

1. To evaluate the present scenario and public water supply provisions in Darjeeling town
2. To identify the present sources and availability of drinking water amongst the town residents
3. To identify the present problems related to water supply system in the town
4. To correlate the growth of population with that of water supply & demand
5. The ultimate aim is to analyze the challenges for the water supply system in the town

The causes of non-availability of water in Darjeeling can be summarised as given below:

- Drying out of some of the Jhoras
- Most of the Jhoras are not perennial and water flows only in the monsoon season
- Lack of rainwater harvesting in Darjeeling (fig.15)
- Hilly Terrain of the Area
- Leakages in main and submain pipelines
- Disruption in Pipelines due to frequent occurrence of earthquakes and landslides
- Excessive use of ½'' pipe connections
- Lack of sewerage treatment and water filtering facility
- Freezing of water in pipelines when the temperature drops below zero degrees Centigrade in winter

Figure 14. Water leakage

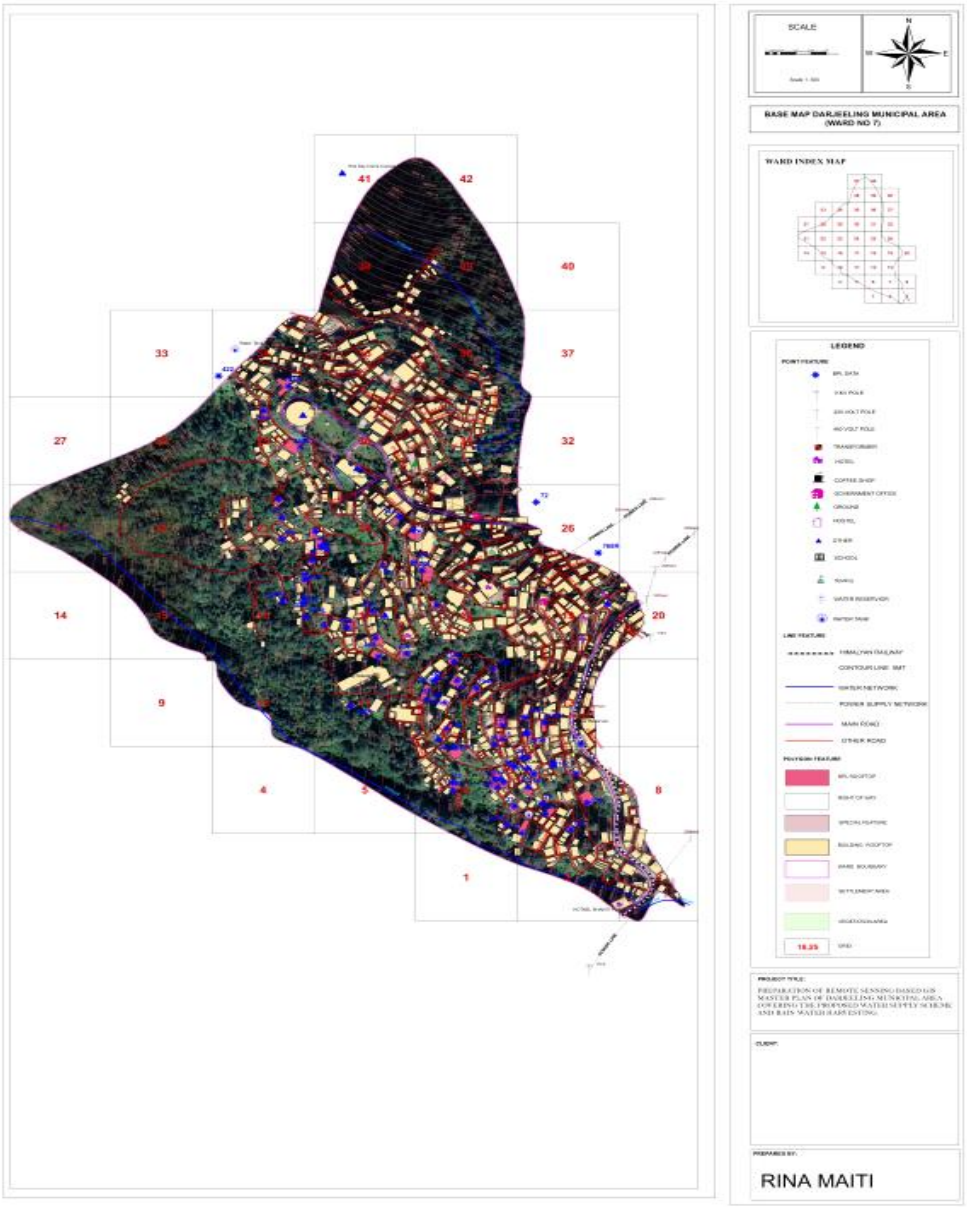

Figure 15. Rain Water Harvesting Scheme Darjeeling

Houses have been built on existing pipelines; Therefore, it is difficult to identify illegal connection/leakage. In such places, this problem can be solved by laying an alternative pipeline. Wherever the new pipeline is to be laid, it should be preferentially laid with adequate soil cover to avoid illegal exploitation **(Domènech, L., Saurí, D., 2011)**.

In order to ensure the supply of pure drinking water to the citizens and tourists of the town, all old and damaged water pipes of private lines should be removed from the gutter and jhora, because most people in the city are forced to drink contaminated water since most of the pipes are passing through the groove and jhora..

Due to the local authority laying down its pipeline under the drain, the local NGOs should seek the help of locally to detect the number of homes drinking contaminated water. Therefore some repairs and renovation works have been started to improve the existing water distribution system in and around Darjeeling municipal area.

Besides, the discrepancy between the allocated quantity and demand should be penalized. In fact, these penalties are expressed as 'terms cost conditions' in the objective function due to lack of water for a fixed period. The penalty shows somehow the loss due to water deficiencies and the time should be different because the consequences of water shortage are not same for all the users at all times.

Table 3. Model Parameters

Parameter	Magnitude
Index i	Supply source, i.e. dam, ground reservoir, desalination unit, water transport
Index j	User, i.e. irrigation, urban sector, industry, other adjacent places
t	Time step in the horizon under consideration
B_{jt}	Benefit for the use of the water from user j at time interval t (in €/m^3)
D_{jt}	Demand of water from user j at time interval t (m^3)
Q_{jt}^{MIN}	Minimum water flow to user j at time interval t (m^3)
S_{it}	Capacity of the supply source i (m^3) at time interval t
P_{jt}	Penalty for not satisfying the demand of user j at time interval t (€/m^3)
C_{it}	Cost of water from supply source i at time interval t (€/m3)
V_{max}	Maximum volume of water that can be stored in the storage tank (m^3)
V_{min}	Minimum volume of water that should be stored in the storage tank (m^3)

Table 4. Model Variables

Variable	Magnitude
F_{it}	Flow of water from supply source i at the time interval t (m^3)
Q_{jt}	Water flow allocated to user j at time interval t (m^3)
V_t	Water volume stored in the reservoir at time interval t (m^3)

Approaches based on methodology (Montalto, F., et al, 2010)
The Program comprises mainly three components
Part A: Procurement of High Resolution Stereo Satellite Image (Fresh Collection)
Part B: Survey
Part C: Preparation of Base Map showing all features on a scale of 1:1000 based on procured Satellite imageries, these are using for water supply

The methodology adopted for the present work is outlined below:

- To be included in GIS map (residential and institutional) using the remote sensing data of the structure of all houses and field survey (about 4855 nos for the rain water harvesting project), the place of springs, roads, rivers etc. Will be identified. GIS platforms and surveyed data will be linked beneficially using GPS (Global Positioning System) for study.
- The primary objective of this survey is to use the latest satellite data (the Directorate has to purchase the agency at its registration and cost at least 0.3M resolution satellite image) with the help of remote sensing technology and digitalization of required areas with the help of GIS. Software.
- Field survey is also required with the help of latest field survey equipment, DGPS, RTK etc. and transfer of GPS (Global Positioning System) data from field survey has to be transferred to the digitized map.
- The Master Plan will provide all the cases needed for the proper development of the area covered by the plan.

Provide proper GIS survey techniques using features and all captured data. Following the map is Geographic and WGS84 / UTM data. Geo-location data of different POI / Government Assets / Domains (latitude-longitude) will be collected using GPS devices.

Water Diversion

1. Divert from small channels/rivers
2. Receiving waters from waterfalls itself through pipes to plain surface area
3. Water distribution and connecting different waterfalls pipes

Figure 16. Water supply in Darjeeling (Bindu Dam)

The causes of non-availability of water in Darjeeling can be summarised as given below:

- Drying out of some of the Jhoras
- Most of the Jhoras are not perennial abd water flows only in the monsoon season
- Lack of rainwater harvesting in Darjeeling
- Hilly Terrain of the Area
- Leakages in main and submain pipelines
- Disruption in Pipelines due to frequent occurrence of earthquakes and landslides
- Excessive use of ½" pipe connections
- Lack of sewerage treatment and water filtering facility
- Freezing of water in pipelines when the temperature drops below zero degrees Centigrade in winter

Common

This water is seen in two forms, the first is the surface runoff in the rivers and rivers which occur in the water flowing areas and the other alluvial reservoirs have groundwater which can be used for the flow of rain and water bodies on the surface of the ground and the groundwater **(Biswas et al, 2017)** inflow is generated from.

The use of water resources available to humans occurs in three primary categories: (1) agriculture, (2) municipal and industrial (3) recreation and maintenance of natural vegetation and wildlife. The water appearing in rivers and streams is shed in the flood water during the dry months of the year through the canals and other irrigation works. In areas where the local surface water is not available in adequate supply, pumps are installed to use groundwater. The excess water not utilized by the crops either goes back to the streams in the form of surface water or is destroyed for reuse in the groundwater reservoir. Surface and underground water resources are transformed by humans through municipal and industrial systems. Before returning to the sources, sewage and other extra water can be treated. Water is mainly used as a part of water storage and carrier systems for recreation and maintenance of natural vegetation and wildlife. Some water used by non-profit phreatophytes by proper management of wetlands can be made available for other uses.

Basic Characteristics and Structure of the Proposed Model

As mentioned above, the proposed decision support system relies on an optimization model that identifies optimal solutions in the operation of the water system, taken into account:

- Various supply sources, each with the cost of water at each possible time and with a fixed and potentially different time capacity.
- Different users are associated with changing demand at all times and there is also a different time benefit created by using water.

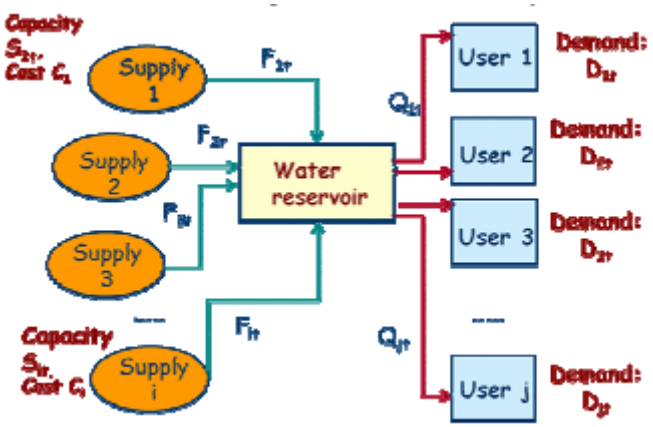

Figure 17. Schematic representation of the water system

The purpose of the model is to determine the amount of proper water allocated to each user and input flow from every supply source, keeping in mind that the availability of total water can be less than the total demand. Therefore, the time period may be that all demands are not met. Allocation of the amount of available water will be done after a more enduring principle that the real and most urgent needs must be satisfied first. In parallel, potential inefficiencies of the water system will be identified, such as a severe reduction in a fixed time period, inadequate supply from some sources, extremely high-cost solutions, etc. The picture above shows a schematic representation of the system under consideration.

Supply sources provide water in a real or virtual storage tank; There is a specific capacity (upper limit) of the storage tank and a lower limit which should never be violated. If there is no actual storage tank, the lower and upper capacity limit is set to zero and the water goes directly from the supply source for the user.

Proposed Solutions to the Shortage of Water Supply

1. In the reservoirs the inlet pipe should be shifted to the top of the full supply level in the reservoirs or the reservoirs should be installed in the feeder lines to the non-return valve.
2. Flow meters should be installed in the filter house to monitor flow rates on each pipeline. Apart from this, such flow meters should also be installed on the main outlet of the reservoirs for proper water inspection and leakage detection.
3. For proper regulation of supply hours, along with the regulation of pressure and flow in pipelines, it is recommended to eliminate all half inch connections (approximately 300 meters) from the service reservoir. Alternatively, to complete the proper discharge, the normal mainline, sub-main and desired pipelines of diameter should be provided from the main instead of the reservoirs. This practice has been successfully adopted at one place near Rockville Tank and it is necessary to be extended to all other places. Also, there is another scope for improving the connections in St. Paul's tank and Rockville Tank to reduce the number of valves/feeder lines to regulate water distribution.
4. The houses have come to existing pipelines; Therefore, it is difficult to identify illegal connection/leakage. In such places, this problem can be solved by laying an alternative pipeline. Wherever the new pipeline is to be laid, it should be preferentially laid with adequate soil cover to avoid illegal exploitation.
5. Some service reservoirs are very old, like Toong Soong Tank. Important reservoirs from these reservoirs appear to be clear from the growth of algae. Therefore, it is necessary to revive such reservoirs. If necessary, capacity addition should also be made to facilitate distribution of water to serve the population in the future.
6. Insufficient disinfection in the Jor Bangla filter house is insufficient. The use of proper disinfectant dosage is highly essential in the public health perspective.
7. Ganeshgram village has an acute water problem. Illegal exploitation of pipelines can be eliminated by providing public water taps with specified hours of supply. The provision of different service reservoirs can also help solve the problem of water pressure in the main areas.
8. Construction of additional storage reservoirs in the foothills of the Mahakalal temple (near the wind house) will solve the problem of distribution of water in Bhutia Basti and Lembu Basti. The feasibility of feeding the existing tank near the air home should be evaluated by laying out the main or alternate places, for the construction of groundwater reservoirs (GSR), the Bhutia settlement should be identified for the supply of water.

9. At present, only one pump is being used to feed the three heads in the filter house. This practice cannot be in addition to discharge in all pipelines due to uneven pressure distribution. Separate pump set should be used for each pipe to have accurate control over the discharge
10. It has been observed that there is no proper waste collection and treatment facility for the municipal area. This facility should be planned for the protection of public health.

V. Forests in Darjeeling Hill Areas

The main economy of Darjeeling Hill Area depends on tea production, horticulture, agriculture and forestry. Major areas of the forests are found today at a height of 2000 meters and above **(related study on Srivastava et al, 2017)**. The area located between 1000-2000mts is cleared either for tea plantation or for cultivation. There are four major forests, according to the different types found in Darjeeling hill areas:

Tropical moist deciduous forest (300-1000mts)
Tropical evergreen lower montane forest (1000-2000mts)
Tropical evergreen upper montane forest (2000-3000mts)
Temperate forest (3000-3500mts)
Sub temperate forest (above 3500mts)

About 30% of the forest cover found in lower hills are deciduous. Evergreen forest is only 6% of the total forest coverage. Shora robusta tropical remains the most prominent species of deciduous forest and with this huge development is also occurring. This type is found in the slopes in the southern part of the Tista and the Great Colt Valley and in the forests of Gok. These species can not grow in low rainfall areas. Tropical lower Montana Evergreen forests are found on vertical high slopes, where the drainage conditions are good; Incense (cryptomyria zaponica) is a known variety. Human influence on this type is very special.

Tropical Upper Monastery Evergreen Forests are found in those areas where high humidity is available along with dense fog and low sunlight. Underground is thick and contains nets, raspberries, firms, and bamboo. On vertical streaks, rhododendron and bamboo are abundant. The above forest areas are comfortable for the storage area of rainwater.

VI. Matel GeoGrid beds for water storage tanks grip (avoid damages)

Geo-grids are like openly attached material of polymers, as shown in Figure 18. They are Planner Polymeric Materials, which are equipped with customary open networks of tensile components associated with the class or rectangular opening. The association between tractable components may be the removal, holding or linking. They are basically used to support soil. Their quality can be more remarkable than the more specific geotechnical textile. Geo grids have fewer stretch and only 2% to 5% spread under load.

Biaxial Geogrid **TriaxialGeogrid** **Uniaxial Geogrid** **Tri-Planar GeoNet**

(a) **(b)** **(c)** **(d)**

Figure 18. Different types of Geo-Grid

Table 5. Requirements of Geo

General Properties	Index Properties
Material Type & Construction Polymer (S) Mass, Thickness, Specific, Gravity, Absorption	Strip tensile strength (2%-5% strain and ultimate tensile strength), Grab strength, Creep resistance, Flexural strength, Cutting-Trapezoidal tear strength, Shear modulus, Poisson's ratio, Burst Strength, Puncture Resistance, Penetration, Flexibility (Flexural Strength)

Common functions of geosynthetic

Application of a geosynthetic material for a road enterprise will cost the acquisition of both the supply and installation of the item. This helps us to understand why the item is being used, and the right capacity is we expecting or requesting items. There are 5 primary functions that we can get from geosynthetic in an asphalt application.

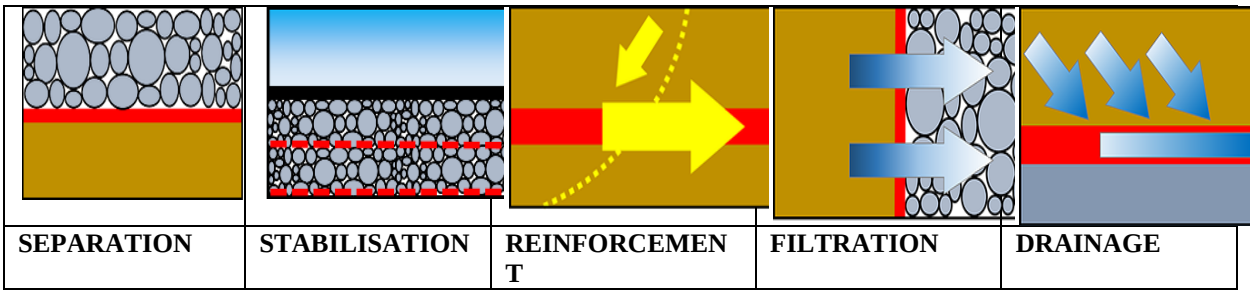

Figure 19. Common functions of geosynthetic

VII. Basic experiment of GG reinforcement

(Production from land sliding or overload or heavy rain)

The Geo Grid (GG) includes the important soil cylinder and it remains from the falling flat. We take the sand which is mixed with a little water and add it to the 2 dim cylinder. The sand will be included in small layers, next we will replace the soil layers with one hand. We re-applied the soil layer in the barrel on the right use of the original, screen material that will talk to the Geo Grid which is used regularly as part of the construction of the wall, starting the process again and includes additional layers of sand and reinforcement. Each layer will be inserted. We currently expel the gray cylinders and weigh on the unprotected soil. Unsatisfied soil cannot take much weight. We put a uniform load on the strong soil now. Support enables to hold the soil together and deal with extra weight. Here we can locate stacked small clay and reinforcement.

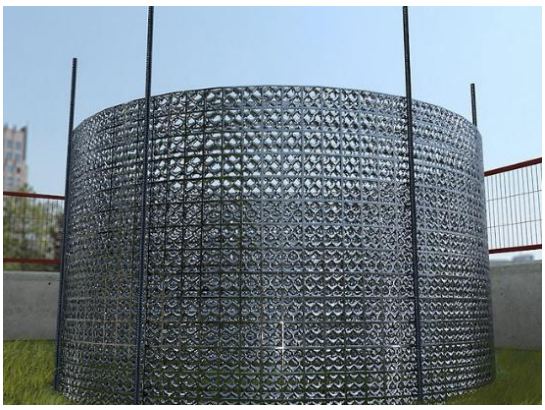

Figure 20. Sample of Metal GEO Grid Solutions

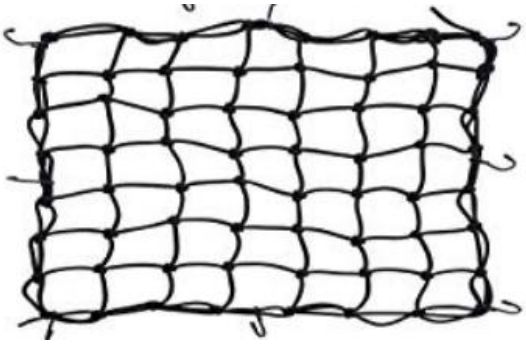

Figure 21. Sample of Metal GEO Grid with Nails

The above (fig.20 and fig.21) structure can fill the foam concrete mixture, it is a better solution to make more tanks with different sizes and sizes depending on available areas. At the same time, we have to design the water tank structure with two layers **(Shah, T. and Raju, K. V. 2001)**. Need to fill the outer steel structure with foam concrete mixture and fill the steel structure inside concrete mixture with a waterproof solution. Because, depending on the density of foam and flexibility during water storage, there will be variation. So, better two-layer water tank structures with lower cost can use. With the government's budget, we can build enough storage water tanks.

Cube Strength Quality of Foam Concrete

Preparation of solid sample can be done on the basis of BS EN 12350 - 1: 2000, a test of the fresh concrete sample (BSI, 2000B). Compressed strength of the foam concrete sample can be measured in relation to BS EN 12350 - 3: 2000, a test of hard concrete. Code BSI will provide a brief power of 2000 test samples. To ensure accuracy in the measurement test samples is manufactured in 150 mm instead of 100 mm. To keep the remaining concrete in the mold until the test, special disposal polystasy mold can be employed if necessary. Foam concrete is not provided any type of tamping or vibration. The sample is kept uncovered and kept covered for 3 days. After that, the sample is covered with plastic bags and doped and corrected at 20 by 20C. The strength difference seen in formed concrete is higher than seen in normal concrete samples.

Applications of Foam Concrete in Construction Works

The demand for foam concrete in its huge application is based on the following properties that it possesses:

- Good void filling capability
- Provides a rigid structure
- No deflection under lower load conditions
- Low density structure
- Enhanced thermal and fire resistance

Advantages of Foam concrete

In the weak soil, foam concrete inserted into the haemorrhoids in the haemorrhoids is established for the purpose of haemorrhoids piles of skin. The density of foam concrete used for this purpose is in1200kg/m^3.

The concept of a balanced foundation with the help of foam concrete can be employed. Those areas have weak soil, the weight of the foam concrete and the weight of the structure should be constructed, the total weight is designed so that it is equal to the digging soil. This will not let the tension increase in the soil diminish and thus the possibility of disposal will be reduced. The foam used for this purpose varies from concrete density 300-600kg/m^3.

Applications of Foam Concrete for Raft Foundation Construction

This paper storage is introducing foam concrete in water tank construction. To behave as a lightweight fleet with thermal properties, foam concrete is the best choice. This manufactured layer is protected through concrete blocking or floor screw. The concrete blinding layer also treats the load as a mode. The density used here is in the range of500kg/m^3 with an average thickness of0.2m. Foam concrete using a density of 400 to 600kg/m^3 is used in the construction of the levee foundation. The thickness of 0.75 m is employed for those houses which are constructed above the water. In the marina, foam concrete is used as floating pontoon.

The foamed concrete is a good solution, as it behaves as a better backfilling technique. It gains the following properties:

- The foamed concrete does not settle once placed
- It does not require any compaction
- No transmission of axle loads to the services in the trench
- The final resurfacing can be carried out next day
- The material is readily available
- Easy Excavation are permitted
- No need for skilled labor or complicated equipment

To compress the bitumen surfacing with foam concrete, a compressed power of approximately 1N/mm^2 is required.

Flexural Strength

Flexure Strength Test was done according to IS 516-1959. The results of the flexibility of the changing density of foam concrete have been presented in Table.6:

Table 6. Test Results of Flexure Strength of Concrete

Density of foam $\{\frac{kg}{m^3}\}$	Flexural Strength for 28 days (MPa)
800	1.84
1000	2.26
1200	2.54
1400	2.97
1600	3.08
1800	3.31
No Foam	**3.71**

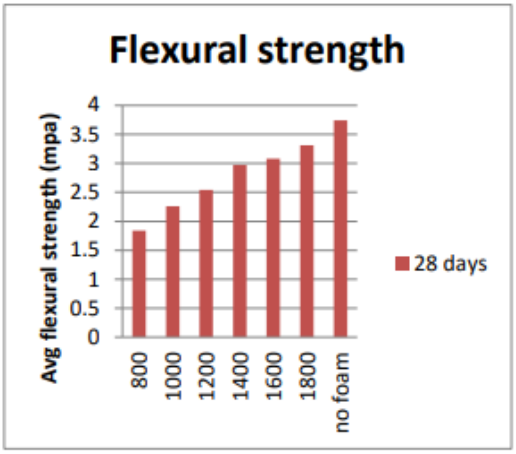

Figure 22. Variation of Flexural Strength with Different densities of foam

Water absorption

The water absorption calculates as given below:

Absorption, percent =(A-B)/B * 100

where,

A=wet mass of unit in kg.

B = dry mass of unit in kg

Table 7. Test Results of water absorption for foam Concrete

Density of foam $\{\frac{kg}{m^3}\}$	% of water absorption
800	11.87
1000	11.51
1200	11.37
1400	10.96
1600	9.98
1800	8.91
No foam	**8.21**

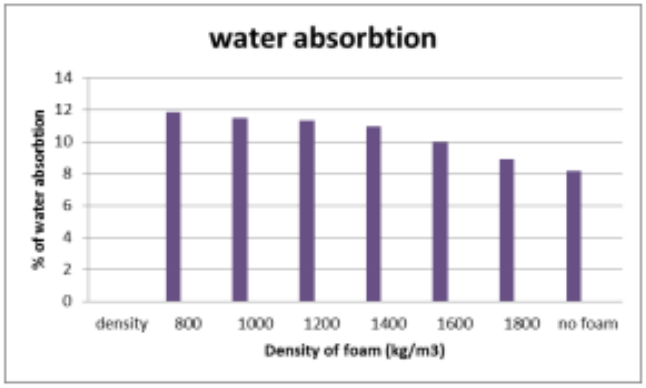

Figure 23. Variation of water absorption with different densities of foam

Compressive Strength

The results of compressive strength of foam concrete for different densities of foam are presented in Table.8 and Fig.24,

Table 8. Test Results of Compressive Strength of Concrete

Foam density(kg/m3)	Average Compressive Strength (MPa)				
	3 days	7 days	28 days	56 days	90 days
800	1.2	4	7.2	15.4	18.5
1000	1.32	4.56	9.86	16.2	18.8
1200	1.67	5.1	12.4	17.3	20
1400	3.25	7.1	16.3	19.4	22.6
1600	3.8	7.7	16.9	22.6	29.5
1800	4.23	8.8	18.3	26.3	29.9
No foam	8.91	15.8	21.5	29.3	30.4

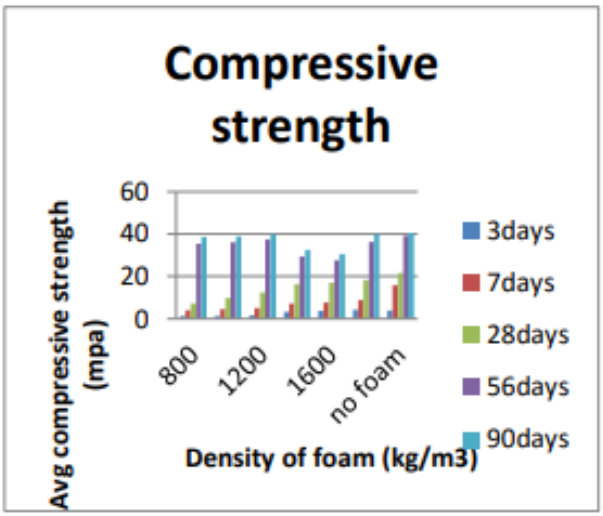

Figure 24. Average Compressive strength

The difference of cubic compressive power of size 150x150x150 mm with different densities of foam concrete is shown in Fig.25. The strength is given at different ages. The cube compressive strength indicates the average of three exam results for 3, 7, 28, 56 and 90 days. Results show that strength is increasing with increasing density. Compared to the current results, the strength of 1200 kg / m3 is 12.36 MPa. Compressive strength for 800kg / m3, 1000 kg / m3, 1200kg / m3 foam for 3 days is more on the same power with small changes. The strength of 800 kg / m3 and 1000 kg / m3 for 90 days is approximately 1600 kg / m3 and the power equal to 1800 kg / m3 is almost equal. Using the power of any foam in 90 days, there is 30.4 MPa. In foam conditions, the strength is approximately equal to 56 days and 90 days i.e. 29.3MPa, 30.4MPa.

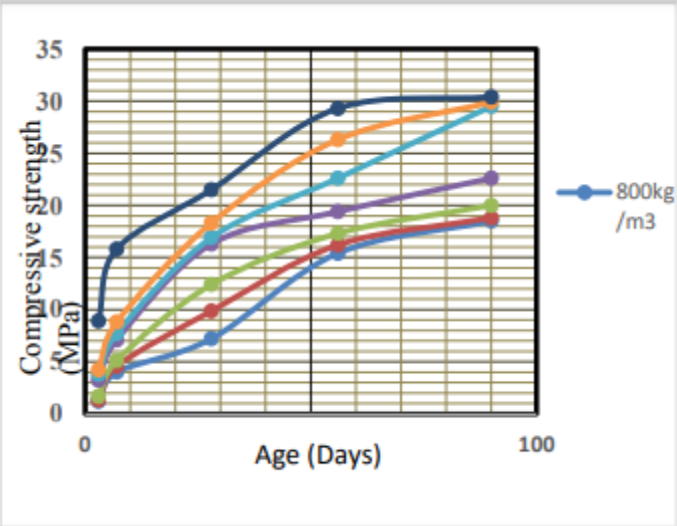

Figure 25. Compression strength of foam at different ages

If the change is more than 10%, then it is important, otherwise, it is unimportant. Considering the maximum compressed power of brick 7.0MPa, the compressed power of foam concrete in different ages varies from 1000.2 / m3.1200 kg / m3 at 2.87%, 40.5%, 800.2 / cubic meter density respectively. Percentage change is unimportant at 800 kg / m3, while percentage changes for other densities are important. If the difference in the strength of the reference mixture is more than 10%, then it is considered important. Otherwise, it can be considered important.

VIII. Conclusion

Darjeeling has ompine water resources in the form of rivers, rivers, waterfalls and natural springs in the city, and its surrounding areas. From the above study, it can be clearly understood that adequate water resources are available in Darjeeling to meet the daily demand of the people. Darjeeling is one of the highest rainfall areas in the region with the highest rainfall receiving rainfall in India and due to its high relief and flow of water, groundwater flows out in the form of waterfalls. Due to rapid urbanization, deforestation in the catchment area and water sources **(Wallace, C.D et al, 2015)**, a large number of water resources available in the recent decades have been badly affected, a large number of constructions are increasing and there is a huge reduction in water in the town. is. Besides the natural disasters that threaten the environment, the increase in the number of human activities has added more problems to the environment of the Darjeeling hills, which eventually resulted in problems like water shortage. Regardless of the presence of adequate resources to maintain the need of the people, the authorities are unable to utilize these resources to make them adequate for the purpose of drinking. For proper management and maintenance of sustainable water resources, long term proper planning in the hills is of great importance.

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