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SUSTAINABLE URBAN INFRASTRUCTURAL DEVELOPMENT FOR SMART CITY IN GUWAHATI, INDIA

The Smart City Mission of Guwahati plains to leverage city's unique locational advantages to establish its dominance and serve as the hub for the entire North-Eastern region and become a world-class destination in terms of tourism, business, trade, education and health. To achieve this, the mission plans to use the city's rich cultural heritage and natural beauty as the key anchors not only for attracting tourists, but also to help convert the city's present infrastructure challenges into opportunities. The main objective of the study is to analyse the presence of basic urban infrastructural facilities necessary for sustainable smart city.The stratified random sampling of houses in each 31 wards of the study area was conducted using the questionnaires method. The findings includes that public transport has increased approximately from 10 to 30 per cent. Under Jawaharlal Nehru Urban Renewal Mission (JNNURM) Phase-1 funding 200 buses have been acquired, increasing city's bus fleet to nearly 2500. Wholesale markets, Inter State Bus Terminus (ISBT) have been shifted to outskirts to de-congest the city. At present 40 percent have piped water supply for 1 hour a day. City engages NGO's for door to door solid waste collection, which is transported by GPS enabled vehicles. CCTV Cameras are getting installed at 18 identified locations. GMC is upgrading street lighting infrastructure i.e. LED and Solar lights. 2.59 lakhs houses and construction of metro was proposed in Guwahati Master Plan 2025. Bio-Metric attendance machine are operational in almost all government offices. Water pump are used to tackle the flash flood.
Keywords: infrastructure, development, smart city, transportation, flood, water supply, Guwahati.

Міїнг Гвра Басуматарі, Субхаш Ананд. СТАЛИЙ РОЗВИТОК МІСЬКОЇ ІНФРАСТРУКТУРИ ДЛЯ СМАРТ-СІТІ В ГУВАХАТІ, ІНДІЯ
Місія смарт-сіті на рівнині Гувахаті використовує унікальні локальні переваги міста, щоб встановити своє панування та служити центром всього північно-східного регіону і стати місцем світового класу з точки зору туризму, бізнесу, торгівлі, освіти й охорони здоров'я. Для досягнення цього місія планує використовувати багату культурну спадщину і природну красу міста як ключові основи не тільки для залучення туристів, а й для перетворення сучасних проблем інфраструктури міста в можливості. Основною метою дослідження є аналіз наявності основних міських інфраструктурних об'єктів, необхідних для сталого розвитку смарт-сіті. Стратіфіковану випадкову вибірку будинків у 31 відділенні досліджуваного району проводили методом анкет. Результати дослідження свідчать, що громадський транспорт збільшився приблизно з 10% до 30%. Щодо фінансування місії міського відновлення Джавахарлала Неру, фаза-1, було придбано 200 автобусів, що збільшило кількість автобусів міста до майже 2500. Оптові ринки, міжнародний автобусний термінал були перенесені на околиці, щоб розвантажити місто. В даний час 40% міста має водопровідну воду по 1 годині на день. Місто приваблює неурядові організації для збору твердих відходів «від дверей до дверей», які перевозяться за допомогою GPS-транспортних засобів. GMC модернізує інфраструктуру вуличного освітлення, тобто світлодіодне і сонячне освітлення. У Генеральному плані Гувахаті до 2025 року було запропоновано будівництво 2,59 тисяч будинків і метро, а також багато інших нововведень.
Ключові слова: інфраструктура, розвиток, смарт-сіті, перевезення, повінь, водопостачання, Гувахаті.

Минг Гвра Басуматари, Субхаш Ананд. УСТОЙЧИВОЕ РАЗВИТИЕ ГОРОДСКОЙ ИНФРАСТРУКТУРЫ ДЛЯ СМАРТ-СИТИ В ГУВАХАТИ, ИНДИЯ
Миссия смарт-сити на равнине Гувахати использует уникальные локальные преимущества города, чтобы установить свое господство и служить центром всего северо-восточного региона и стать местом мирового класса с точки зрения туризма, бизнеса, торговли, образования и здравоохранения. Для достижения этого миссия планирует использовать богатое культурное наследие и природную красоту города как ключевые опоры не только для привлечения туристов, но и для преобразования современных проблем инфраструктуры города в возможности. Основной целью исследования является анализ наличия основных городских инфраструктурных объектов, необходимых для устойчивого развития смарт-сити. Стратифицированную случайную выборку домов в 31 отделении исследуемого района проводили методом анкет. Результаты исследования свидетельствуют о том, что общественный транспорт увеличился примерно с 10% до 30%. По финансированию миссии городского восстановления Джавахарлала Неру, фаза-1, было приобретено 200 автобусов, что увеличило количество автобусов города к почти 2500. Оптовые рынки, международный автобусный терминал были перенесены на окраины, чтобы разгрузить город. В настоящее время 40% города имеет водопроводную воду по 1 часу в день.

Город привлекает неправительственные организации для сбора твердых отходов «от двери к двери», которые перевозятся с помощью GPS-транспортных средств. GMC модернизирует инфраструктуру уличного освещения, то есть светодиодное и солнечное освещение. В Генеральном плане Гувахати до 2025 года было предложено строительство 2,59 тысяч домов и метро, а также многие другие нововведения.

Ключевые слова: инфраструктура, развитие, смарт-сити, перевозка, наводнение, водоснабжение, Гувахати.

1. Introduction. Today, rapid urban growth is a worldwide phenomenon and the developing countries experiences an unprecedented growth in their cities (Tungnung and Anand, 2016). The population growth, urbanization and environmental challenges especially in urban cities of India are pushing urban infrastructures to sustain the resources and balance the supply demand (Sen et al., 2016)**.** The infrastructure in the smart city is the prior and major works establishment for introducing outline of smart city framework and infrastructures are considered as a central piece of the Smart City and technology is the enabler that makes it possible (Monzon, 2015).

Infrastructure in the smart city include those infrastructures which can access to better public transportation, reduced traffic congestion, safer living, safety against natural disaster, water and waste management and easy access to all other basic infrastructure and e governance.

The concept and definition of the smart city varies from city to city and country to country. It is defined according to its level of development, attitude of its residents and their aspiration to change, availability of revenues, resources and problems. In the last two decades, the concept of "smart city" has become more and more popular in scientific literature and international policies (Albino et al., 2015). The California Institute for Smart Communities was among the first to focus on how communities could become smart and how a city could be designed to implement information technologies (Alawadhi et al., 2012).It boosts the performance of the service in city by dropping rate of consumption and its expenses. The various application of smart technology in the city are in the sector of transportation, retail services, energy management, water supply, retail, disaster management and many more. For contouring the real time challenges and with the goal to bring positive changes in the management of urban services smart solution application is important. Infrastructure has several meanings depends on the term of context used in (Hadir and Rodzi, 2009).

In Indian perspective, concept of Smart City is very new. Mission of the smart city has been launched by the present Government of India on 25th June 2015 (Roy, 2016). According to the Ministry of Housing and Urban Affairs, Government of India, the definition of the smart city is such that smart city contains a picture of wish list of infrastructure and services that describes his or her level of aspiration. To provide for the aspirations and needs of the citizens, urban planners ideally aim at developing the entire urban eco-system, which is represented by the four pillars of comprehensive development-institutional, physical, social and economic infrastructure. This can be a long term goal and cities can work towards developing such comprehensive infrastructure incrementally, adding on layers of "smartness". The main aims and objectives of the Mission are to derive the growth in economic sector and to bring growth and development in the life of citizens. Developments in the local region are undertaken by adopting technology and encouraging the city that offer the core infrastructure. There is expectation that the sustainable environment and decent quality of life will be attained with the introduction of the Smart city mission in India. The Mission wants to create a replicable model which will act a light house to other aspiring cities (Ministry of Housing and Urban Affairs, 2017). The present Government of India has decided to select the 100 cities of the country to develop into smart city. There will be competition among Indian cities to develop in the smart city based on its level of development, revenue generation and problems. The final decision for selection will be taken by the central government. Smart city mission is the great step towards building the world class sustainable cities. India has numerous cities that are suffering from the basic necessities such as shortage of water, power supply, sanitation and housing (Basumatary and Anand, 2016). With the application of the Information Communication System (ICT) the mission aims to meet the requirement of efficient service in the urban areas. In coming days its success will be analysed by its ability to lessen the gap between rich and poor class in society**.** The smart cities mission along with the convergence with Atal Mission for Rejuvenation and Urban Transformation (AMRUT), Housing for All and various other missions and schemes are expected to bring many benefits in the society.

As Guwahati is the biggest city of north east India and it is the hub and important centre of trade, commerce, education, medicine and tourism due to its strategic location, it is quite evident that population of the city would continue to grow rapidly in the future (City Development Plan, Guwahati, 2006)**.**The Guwahati city is facing difficulty to match with the pace of escalating growing demands of the city services and its facilities. It suffers from flash flood, traffic congestion, shortfall in infrastructure, overcrowding, mushrooming of slum, lack of drinking water and sanitation. Therefore, for the proper planning and management, the application of Information Communication Technology becomes very significant and crucial. The ICT and intelligent system such as internet of things will boost the city services, it will efficiently manage the infrastructures of the cities for smooth communication and information delivery. The traffic jamming and flash flood are the two major problems in the city. Each monsoon, with slight rainfall, roads get floods with water, this cause great damage to properties and lives. The problem of traffic congestion needs to be tackled with the application of ICT in traffic department and encouraging the people to travel through public transportation to avoid traffic jam. This problem can be solved by the introduction of the smart infrastructure in the city.

2. Review of Literature. Chandrasekhar and Venkatesh, (2014), proposed the comprehensive idea on fu-

tures cape of where to begin the preparation for Smart cities. To begin with, making a city smart would require it to develop people centric technological applications. The concept of harnessing the power of ICT for development and in particular for improving transparency and governance is not new in India and this idea predates the idea of building smart cities.

Asensio et al., (2015), described that in the city, there are several substances, many of them unseen but important; this is the case of signals. Signals are considered matter with reduced technological attention, but in their paper they proved that making them smart and integrating in the IoT (Internet of Thing) might be a related contribution to the Smart City.

Chandrasekhar, (2015), believes that India have to influence technology in favour of the digital Governance in Smart Cities in India. He draws the attention towards the digital governance for efficient development. Manual involvement where there can be digital, is what leads to inefficiencies, underutilization and leakages. The technology can be leveraged to govern our cities for more successfully and make them in fact world class. The government wish to make an integrated information infrastructure that will develop, integrate and enhance the utility services to have a broader outreach.

Bhasin, (2015), focuses on security alarm above the forthcoming smart cities in India. Some of the mechanisms and interventions allowed for a safety and secured city according to him include 1) Tele-Surveillance: The system maintains their availability round the clock and in times of an emergency, it can then be relied on to obtains directions and instructions from operational control cen-

tres. 2) Collaborative Response Efforts: It is an infrastructural response that allows organisations to take action in one system based on data coming from another- for example, if a system indicates that vehicle is stolen, it should automatically marshal nearby cameras to capture video of the driver. Data Integrity will mean the data is encrypted to manage data sharing over unsecured lines. Smart Cities are not merely concerning about providing ease, but also minimizing the impact of likely catastrophe.

Sridhar, (2015), emphasis on the use of ICT equipment such as GIS position and coordinates of bins and dumping sites, GPS enabled vehicles, automatic production of status (bins picked/ bins unpicked) of collection, providing an online monitoring mechanism; optimizing the direct passageway from the collection point to the dumping yard; optimizing the number of collection points and transport of garbage, and so forth. There are several advantages in such an automated system, in some instance; cities can install CCTV cameras in dumping sites to monitor the activities of waste workers and supervisors. However, it is best to keep in mind that ICT is only a tool, not a replacement, for addressing the substantive problems associated with sanitation and solid waste.

3. Study Area. Guwahati the major city of Assam is located in north east India, at 26°10″ north latitudes and 92°49″ east longitudes (Figure 1). It is horse shoe shape and is located in between the south banks of the mighty river Brahmaputra and Shillong Plateau in the south (Deka, 2000).
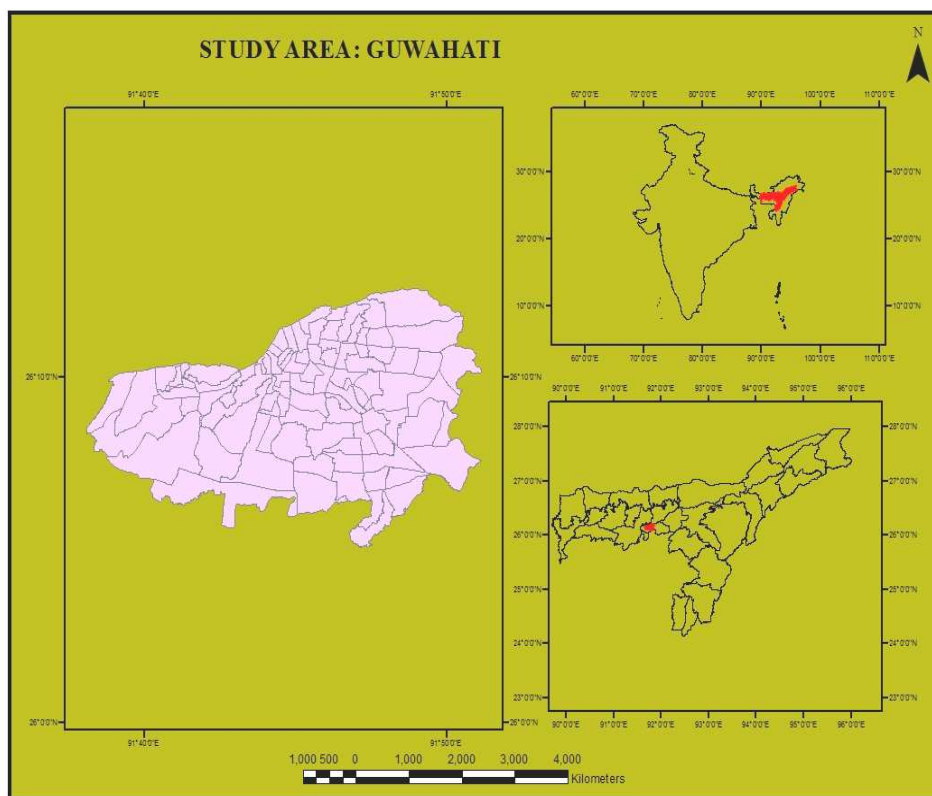

Fig. 1. Location of the Study Area
Source: Prepared by Authors based on Assam Remote Sensing Application Centre (2017)

The city is in the Assam Brahmaputra valley and it surrounded by hills on either side of the river and large portion of the areas covered by the water bodies. The land-use pattern that has evolved in Guwahati is essentially multi-functional in character (Borah and Bhagabati, 2015). The city is governed by Municipal Corporation which comes under Guwahati Metropolitan Region. Guwahati being the major city of the north-east India has developed road, rail and air connectivity with the rest of the country. Guwahati is the business hub and largest city of Assam and the North-East (Mahadevia et al., 2014).

Guwahati is at the junction of National Highway-31, National Highway-37 and National Highway-40. The National Highway-31 connects Guwahati with the rest of the country in the west, while other National and State Highways connect Guwahati city with north-eastern

states of Tripura, Meghalaya, Mizoram, Manipur, Nagaland and Arunachal Pradesh. A broad-gauge railway line connects thestudy area with major parts of India. Another railway line connects Guwahati to Dibrugarh, Tinsukia and to other places of north-eastern states. Guwahati airport is the largest and the busiest airport in this region, which connects Guwahati to major cities in the country as well as to other major cities in Assam and north-eastern region. Guwahati airport is converted into an international airport. This route has been virtually closed after partition of the country (Gogoi, 2013).

The study is confined to the Guwahati Municipal Corporation of the Guwahati City which covers the total area of 176 sq km. The city has the 229717 number of household and total number of population is 957351. Ward wise name and its area and availability of open space are given in Table 1.

Table 1

Ward wise information of areas, household, population and availability of the open space

Ward No.	Ward Name	Area (in Sq Km)	Household	Population	Population Density	Available Open Space (Sq. Km)
1	Guwahati University	14.98	7269	33305	2223	0.115
2	Pandu Port	1.69	4981	21277	12590	0.014
3	North Jalukbari	1.41	5693	23257	16494	0.010
4	KamakhyaMandir	3.64	4647	20366	5595	0.011
5	Maligaon	3.38	6908	30076	8898	0.054
6	Ganeshpara	25.97	11308	49021	1888	0.100
7	Pub Boragaon	13.03	9693	42772	3283	No Open Space
8	Machkhowa	1.14	4663	22388	19639	0.015
9	Chatribari	0.91	3220	16816	18479	0.049
10	Guwahati Railway Station	2.19	4891	21443	9791	0.059
11	Uzan Bazar	2.06	5329	22100	10728	0.006
12	Navagraha	3.08	6124	24443	7936	0.010
13	Nehru Stadium	2.05	6195	25540	12459	0.033
14	CRPF Battalion Outpost	1.22	5100	22340	18311	0.003
15	Fatasil	1.28	6498	28419	22202	0.012
16	Lokhra	2.50	9009	37806	15122	0.035
17	Kahilipara	4.49	7598	32006	7128	0.017
18	Rupnagar	2.93	7722	31138	10627	0.008
19	GMC Hospital	3.53	6588	27125	7684	0.023
20	Japorogog	3.46	8075	31722	9168	0.004
21	Geetanagar	3.36	8307	33057	9838	0.059
22	Noonmati	13.25	9264	38081	2874	0.042
23	Bamunimaidan	2.15	5340	21462	9982	0.016
24	Narengi	8.15	8380	35524	4359	0.032
25	Hengrabari	8.89	9821	38724	4356	0.009
26	Dispur	6.72	12447	48085	7156	0.046
27	Sonaighuli	9.89	7566	31238	3159	0.108
28	Basistha Mandir	5.30	10079	39350	7425	0.050
29	Hatigaon	5.42	9012	35894	6623	0.005
30	Beltola	6.28	8090	33460	5328	0.112
31	Khanapara	11.70	9899	39116	3343	0.042
Total		176.05	229716	957351	-	1.099

Source: ASDMA, 2016

4. Database and Methodology. The main objective of the article is to analyse the availability and propose infrastructure for the smart city mission in Guwahati. Both primary and secondary data source is used for the study. Primary data which is generated for a specific purpose is collected using satellite map, and ground truth data using GPS and field survey. Secondary data is collected from the Guwahati Municipal Development Authority (GMDA), Guwahati Municipal Corporation (GMC), Guwahati Remote Sensing Centre and Census Board. Satellite map are obtained from Google Earth. Unlike the other city plan, in which planning are done by local urban bodies, Smart City Mission's plan is done by the Special Purpose vehicle (SPV) and Smart City Mission Limited company, in Guwahati.

Data collected from the fields is vital for quality assessment and evaluation of the spatial information derived from satellite data. The sources for acquiring ground truth data under this study for thematic mapping activity included-visual observations of sample doubt-ful points in field for verification/correcting image interpreted spectral signatures of thematic details, taking field photographs and collecting GPS derived measurements in field. The grounds data collections are also includes non-spatial or attribute or attribute information essential for integration with spatial data using GIS.

5. Result and Findings

5.1. Water Facilities of the City. It has been observed from the field survey that most of the house in the plain region of the city has its own water source by means of well or pump. The house in the hilly region collect the water from the natural stream though they also are not devoid of well and pump.

All the houses of the northern wards of the city have water supply facilities, few houses of Dispur and adjacent wards of northern wards has partial water supply and houses in the rest of the wards are devoid of GMC water supply facilities. It is found from the data of GMC, questionnaire method , observation and overlay technique that some area in the city obtain full, partial and no water supply at all (Figure 2).
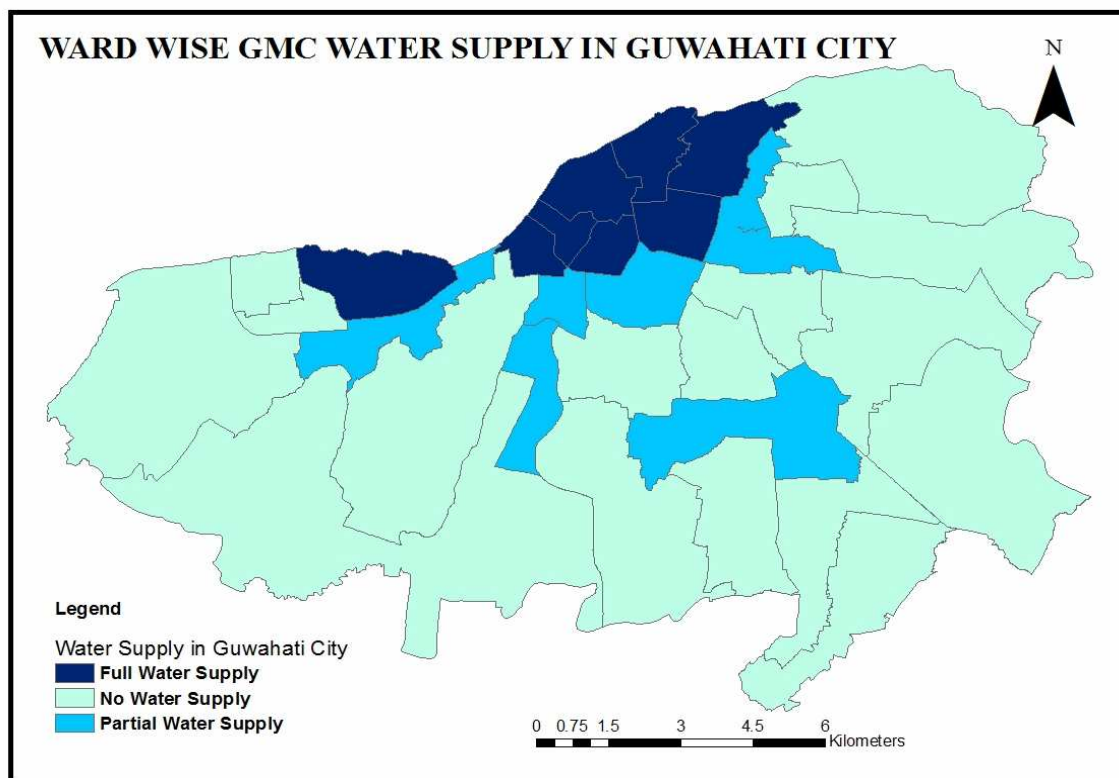

Fig. 2: Ward wise GMC water supply status in Guwahati city
Source: Prepared by Authors on the basis of data from Guwahati Municipal Corporation and primary survey, 2016

The city gets the sufficient water during the monsoon season i.e. from May to August but the city also faces scarcity of water during the winter and spring season. The underground water table shrinks, water in well and tube dry up during January, February and March. The common residents cannot drink the water of the great Brahmaputra River because it is highly contaminated and contains deadly germs. The water from the river can only be consumed after high level purification.

Since long time, the city has been suffering badly from the problem of not only water scarcity but also from the contaminated water and related water borne disease. At current scenario, only around 30 per cent population of the city is getting the piped water supply and that too only for 1 hour a day (Primary Survey, 2017). The quality of the underground water in the city is poor and contaminated due to the underground pipe leakage and presence of metals such as iron, fluoride and arsenic. City is still using the outdated service facilities for the water supply. New infrastructure with smart me-

ter is urgently required for efficient supply of water. With the scarcity of water and water contamination problem the residents are forced to buy the supplied tank water at very high price. The poor suffers the most because they cannot afford to buy the water from the vehicle tank and they become the prey of water borne germs by relying on the contaminated ground water and open lake. The poor drainage and sanitation condition worsen the fate of poor residents of the city by contamination of water by deadly water borne disease causing bacteria and virus. Addressing those problems Guwahati Jal Board is established under the Guwahati Metropolitan Development Authority.

The GMDA has undertaken the infrastructure work for the facility to purify and provide the service of supplying the clean safe drinking piped water to residents 24/7 at minimal cost. To ensure the safe and sustainability of the piped water supply, smart city mission with the smart information communication technologies in Pan

City Development will provide the smart metering and open source network of information to minimise the cost and wastage of the precious portable water (Guwahati Municipal Development Authority, 2016).

5.2. Solid Waste Management. Waste disposal problem is the main concern of hygiene in India, directly 22 diseases are caused due to improper management of urban waste (Anand, 2010). Just few years back the garbage waste could be seen scattered in the road of the city for many days. It creates the suitable breeding ground for the insects, mosquito and flies which stinks the environment, pollute the quality of the air, water and spread disease. Despite the bio-medical waste regulation in India, the biomedical waste finds its way into the municipal solid waste to some extent in Guwahati. At present, there is only one dumping site in the municipal area of the city. This dumping site is located in the west Boragaon, extreme south west of the city (Figure 3).
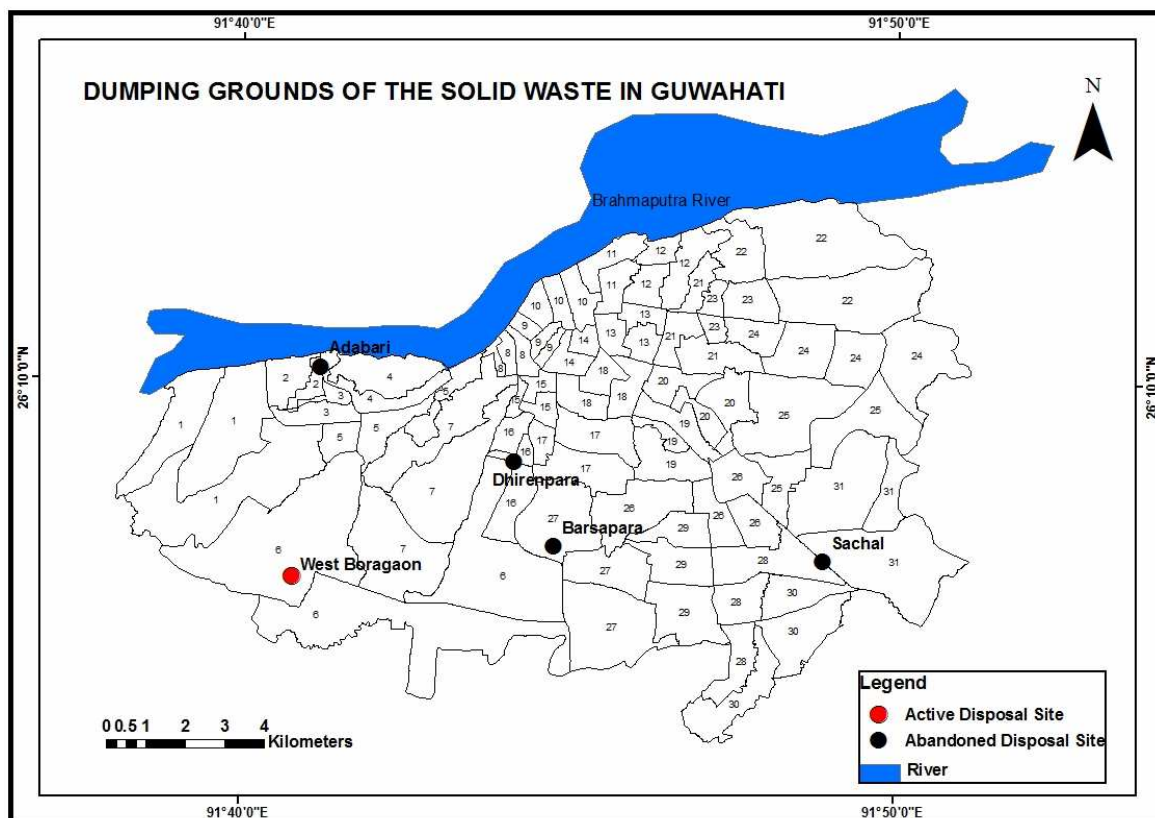

Fig. 3. Disposal Site in the Guwahati Municipal Corporation Area
Source: Prepared by the Authors based on Primary Survey, 2016

The current west Boragaon dumping site is in very pathetic condition. There is no proper disposal system, the waste brought by the GMC vehicle is just left openly in the dumping site. The whole dumping site has become heap and taken the shape of small hills. The whole area stinks very badly. All the waste of the city starting from the sanitation waste to the dangerous infectious waste is thrown openly in this area. The waste is just burn down from time to time to worsen the air pollution of the city. The famous Deepor Bill is located just at close proximity to the dumping site. The waste from the dumping site is polluting this lake which results into the death of rare

vulture after consuming fish and water from this lake. The strange part of this dumping site location is that in dumping site itself the migrated people of the state and Bangladesh. The condition of life in this site is in very dismal, the residents are deprived of electricity, water, fresh air, education and health. They are very poor and their main source of income comes from rag picking of reusable waste material. The record of the production of daily amount of solid waste in the city varies according to the various sources within the city. According the primary field survey report the daily average waste generated from each household resident in the city per day is

3.2 kg.

The Ministry of Tourism, Government of India has ranked the Guwahati city as the 12th cleanest city in country. The story behind this great achievement lies on the competent administration, infrastructure and application of the ICT technologies. The Global Positioning System enable vehicle has been used by the state government and NGO to collect the garbage. The composting plant of high composing capacity is under operation and the city is heading towards zero landfill with the implementation of home composting and decentralized composting.

5.3. Public Transportation. Smart mobility is reliable means of transportation because the poorly managed traditional mobility is quite slow and affects the valuable time of individuals (Benevolo, et al., 2016). Since the current decade the public transportation in the city are increasing. 200 buses have been obtained under the Phase 1 funding of the Jawaharlal Nehru Urban Renewable Mission (JNNURM) scheme. JNNURM was a massive city-modernisation scheme launched by the Government of India under Ministry of Urban Development. At present, the city has around 2500 total city buses. Master Plan of City waits the funding for the building infrastructure for the proposed metro rail service in the city. It has been observed that location of the whole sale market, trade centre, Inter district and Interstate Bus Terminus inside the city region has been causing traffic congestion. So, to decongest the traffic jam in the city all those mentioned has shifted from the core city region to the outskirts of the city (Mission Smart Guwahati, 2015).

In the recent time, for the sustainable and last mile connectivity e-rickshaw is playing very crucial role in the city. The government has to create fast charging infrastructure facilities to promote these vehicles. Technologies are fast evolving in this segment, particularly batteries. The electric vehicle revolution has already started in India and it has the tremendous potential for future growth too. There is the good demand for electric rickshaw in the city as these have been able to prove as the only viable option for last mile connectivity. It is poised to replace the pedal rickshaw in coming days. For last mile connectivity from bus stand or railway station, electric rickshaws can be very cost effective, no pollution, and solution for transportation. This smart mobility will boost better connectivity. With the availability of high speed internet connection, GPS enabled smart mobile and information communication technologies the use of manual and auto rickshaw vehicle is being replace by the digital enhanced Ola and Uber cab services. Unlike the auto the calculation of fare in smart Ola and Uber service is accurate, it has GPS enabled facilities to pick up the person from his location and can estimate the traffic, speed, direction and stipulated time to reach the destination. The Guwahati city has undertaken to develop or strengthen their public transportation networks to encourage their increased use and thereby reduce the use of private vehicles. Citizens will enjoy wide footpaths with public seating at regular intervals and easy mobility for the differently able.

Inter-city ferry and boat service are also active in the city for public and goods transportation. Under the area based development of the Brahmaputra river bank, initiative has been taken to develop the bank area and introduce high speed motorised boat for recreation activities. The famous river island Umanada temple is located near the railway island and it is the belief in the city that the pilgrimage visit to the world famous Kamakhya temple is incomplete without the visit of Umananda temple. There are no roadway facilities to reach temple so the boat and ferry service play the very crucial role. Daily commuters from the north Guwahati also avail the waterways transportation facilities to attain the office and visit to city.

Public transportation facilities in the city is not up to the mark and satisfactory. The city lacks the metro rail and fast means of transportation. Majority of the city bus are privately owned and they are profit oriented, so their service is very slow. They hesitate to run from bus stop unless they get the desired customer. So, city bus service is not much reliable.

5.4. Efficient Streetlight. The city spent huge amount of capital in street light. The entire part of the city especially the interior of the city lacks the street light facilities. The local roads and residential roads remain darks after sunset. It is danger for the women to pass through the dark street of the city as it host dangerous activities and acts as the hub of the local rogue. It is important for the city to cover each and every corner of the street with efficient low cost and lesser power consuming sustainable street light. This can be attained by harnessing the energy from the solar and replacing the high power consuming street light with the energy efficient street lights.

5.5. Public Toilets. The number of the presence of public toilets in the city is very less and for females, neglible toilets are there. The public toilets are located in very specific location. The condition of the toilets in the city is in very pathetic condition, very unhygienic and it stinks a lot. Open defecation can be seen along the railway tracks and some pockets of the city specially near the market place and bus stop and dumping site. Many parts of the city still do not have the public toilets. Public toilets present in some location are on paid basis. Constructions of the public toilets are under process.

In response to the present scenario of sanitation and hygiene in Guwahati, critical locations have been identified around the city to construct toilets for public convenience. These sites are all located at prime locations where there is a high necessity of toilets. All these toilets have been designed so as to accommodate proper sanitary facilities especially for women and differently abled (Table 2).

5.6. Disaster Management

5.6.1. Flood. The study reveals that approximately 70 per cent of the city is prone to flood and 29 per cent of the area which is mostly consisting of hills and almost abstains from the flood. Out of the total flood prone region, 25.8 per cent is chronically flooded zone, 16.3 per cent is occasionally flooded zone and 28.1 per cent is rarely flooded zone (Figure 4).

The Functional Public Toilets in the City Executed by Guwahati Municipal Corporation in PPP mode

Location	Seats	Proposed Location
Fancy Bazar	20	Bhangagarh Flyover (Underneath)
Nepali Mandir	2	Basistha Temple
Khanapara	6	Mathgharia
Bhangagarh	4	DC Office Premises, Panbazar

Source: https://gmc.assam.gov.in/portlet-innerpage/toilets, 2017
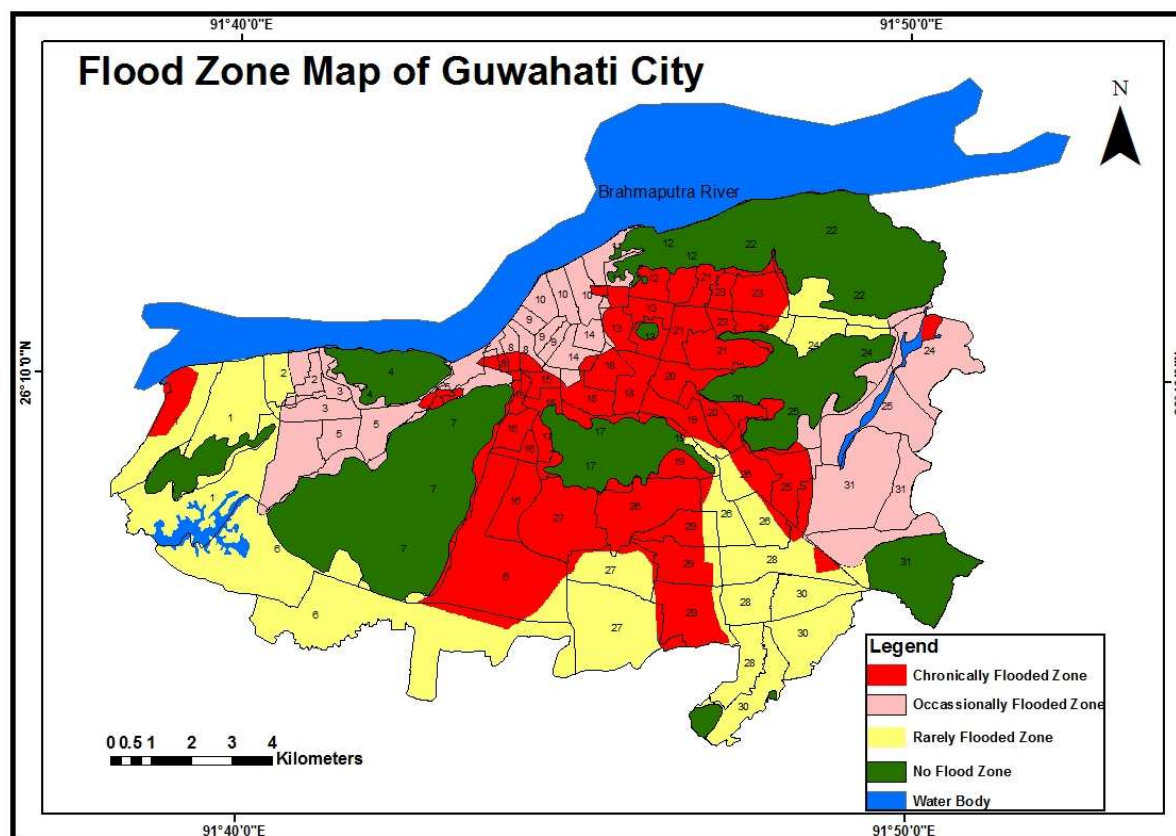
Fig. 4. Floods Prone Area of the Guwahati City
Source: Prepared by Authors based on Overlay analysis, 2016

5.6.1.1. Drainage System of the City. The drainage system in city depends heavily on the existing natural drains. The conditions of these channels are not very convincing as they are constantly covered with garbage, waste material and sewage. The water resource department had prepared a comprehensive plan for the clearing and management of these drain channels, which are like a lifeline of city for the purpose of draining out water currently. The city does not have planned drainage system to take care of sewage or waste water which is being generated, so the natural channels become all the important.

During monsoon season, the river Bharamaputra flows over the danger level and low lying areas of the city face problems of water logging and floods. The feeder drains to the main channels run overflowing, and because of siltation problem of drains, the carrying capacity is also reduced significantly. It is been decided to check the reverse flow of water from the Brahmaputra river, sluice gate will be constructed near the Panbazaar beach which is located in the upstream and then excess water will be diverted through canal toward the Kamakhya river beach which is located downstream (Figure 5).

The Ecological Management Practices (EPM) can be implemented in the hilly urban area for controlling sediment and water yield from the upper catchment, due emphasis will also have to be given towards controlling sediments and debris from entering into the drainage system by various traditional method. Pumping in suitable locations is also required for increasing efficiency of the drainage network. The citizen of the city has the high expectation from the ongoing smart city mission. Installation of water pumps at various high alert zones to pump out the stagnant water and divert its direction has already begun in some selected places of the city. Under the pan city development Hydrological Information System (HIS) will get installed to give the early signal alert of the flood.
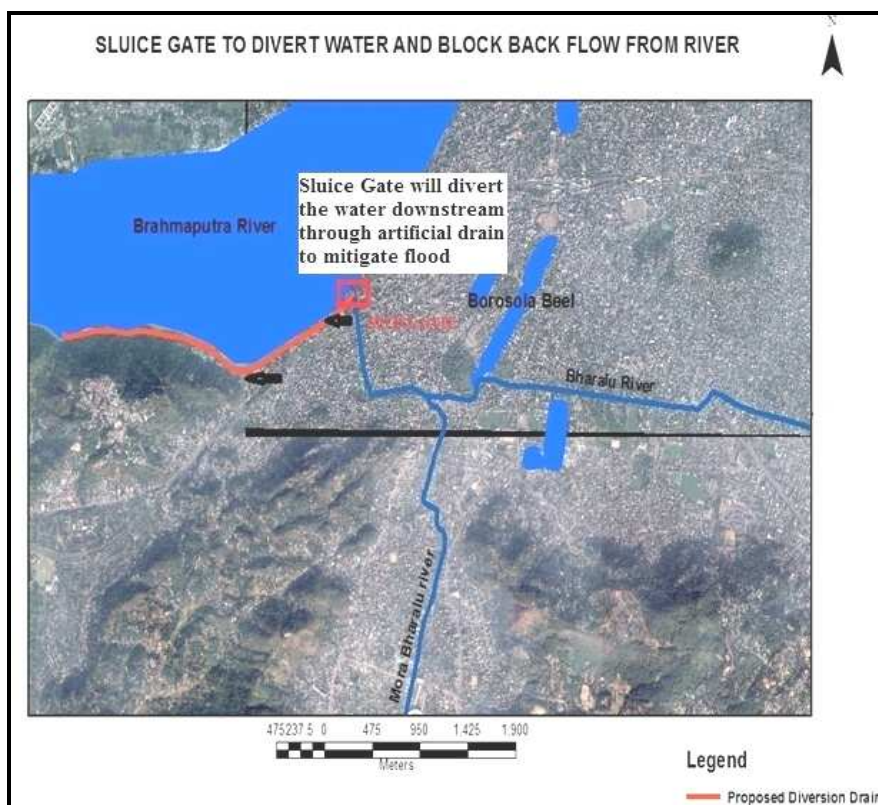
Fig. 5. Flood Mitigation Project on the Brahmaputra River Bank
Source: Prepared by the Authors based on Mission Smart Guwahati, 2015

5.6.2. Landslide. Out of the total area of India about 1 lakh sq km of an area in North east is vulnerable to landslide (Phukanet al., 2012). Sixty people have lost their lives in last 8 years due to landslide in Guwahati (Das et al., 2014). The landslide prone was analysed using the data of geological, topographic features and the primary field survey. The area having dissected hills and falling under Sonapur geological formation zone is more prone to landslide in Guwahati region (All India Disaster Mitigation Institute, 2014). Almost all the hills of the city is prone to the landslide. The Kharguli and Narengi hills in the north-eastern part, Japorigog hills in the east, Narakasur hills of central, Nilachal hill in north and Silapahar hills of the western part is high landslide prone area of the city. The area prone to rock fall was also analysed using the union map of topography, land use and primary field survey. The north-eastern most part of the Narengi hill is prone to rock fall as the slope is steep and vegetation cover is decreasing due to encroaching in this region. Out of the total area of the city, it has been found that 33.3 per cent, 7.3 per cent and 59.4 per cent is prone to landslide, rock fall and landslide free zone region respectively. The area is also prone to seismic activities which led to instability of slope in the region. Seismic activity and rainfall plays a major role in the occurrence of landslide in the region (Figure 6).

The Guwahati city has large number of dissected hills across the city. These hills are highly erosive in nature, which has resulted into occurrence of landslide in the region. The slopes of these hills are moderate but are highly vulnerable due to low vegetation cover. The for-

ests have very low vegetation cover which has exposed the upper surface to agent of erosion. The land without scrubs is also vulnerable to rock fall landslide. Rainfall is one of the most important triggering factors which have resulted into occurrence of landslide in the region. The problem of landslide in the city can be prevented by checking the encroachment of the forest areas, plantation of trees and embankment infrastructure in the landslide prone area.

5.7. Infrastructures through E-Governance. The implementation of Smart City Mission in Guwahati is incomplete without the functioning of the E- Governance. E- Governance is a single platform from where citizens can access all and any details and also help them get all services done. The e- governance will build the common cloud platform where the data can be shared among the citizen and between citizen and government. In smart city the citizen will have benefits of all the facilities of the services. The city will have the magnificent infrastructure for regular water supply, electricity, and mobility. The citizen will have the high speed time bound cheap efficient public transportation. The city will encourage every section of the society. There will be smart meter for the water and electricity supply. Hydrological information system will be installed in the city to give the prior alarm of the flood. The city will be safe and there will be high speed internet service in the city. Customer can do the online shopping and transaction. The city will mostly depend on the renewable source of energy.
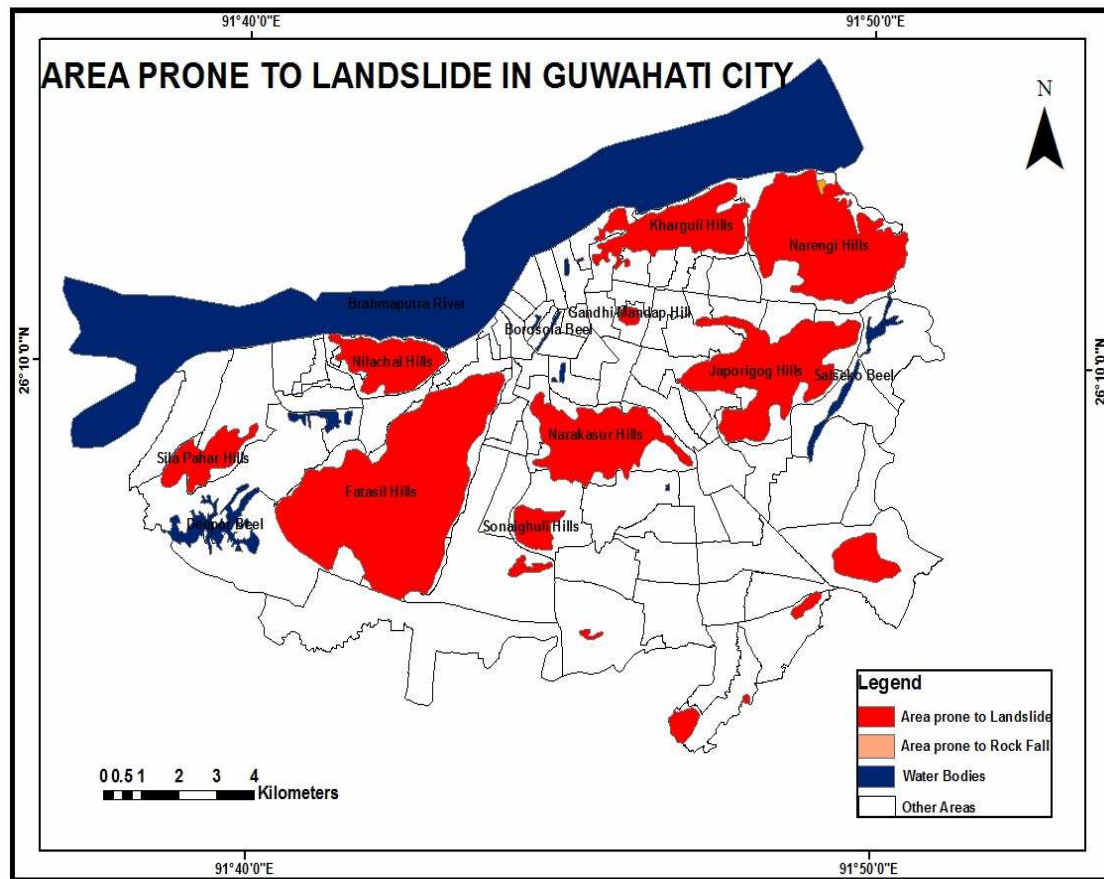
Fig. 6. Landslides Prone Area in the Guwahati City
Source: Prepared by Authors based on Overlay Analysis, 2016

This will bring transparency and efficient in the government services. Integrated fare cards, smart combined city governance, 'one city one website', Mapping in GIS and free Wi-Fi hotspots have been considered as some of smart solutions to smart city**.** The major field where the E-Governance is being implemented at small scale in the city are:

5.7.1. Access to Better Public Transport. The Smart Cities will incorporate the fast GPS enabled public transpiration in the city. The service of the public transport system will be reliable and time bound so that the citizen can fully depend on it. In this was it will encourage public to use the public transportation service and when the citizen will not drive their private vehicle it will decrease the intensity of the vehicle in roads and thus traffic congestion can be prevented. The city bus stop will be built is such a way that it will have the solar rooftop, smart toilet, digital board to display the bus timing and street light and wifi hotspot. Last mile connectivity of the city will be boosted by the e-vehicle and e-rickshaw.

5.7.2. Availability of Adequate Parking. The location of the public parking can be identified through the smart mobile and internet services. The driver will get the notification of the availability of the space for the parking of vehicle nearby his /her location and accordingly can booked the parking slot online. Online payment facilities are also available. To make the optimum use of the available space there will be smart computer-

ised underground parking facilities

5.7.3. Reduced Traffic Congestion. The monitoring of the traffic in the city will be done by high resolution CCTV camera. GPS enabled vehicle will give the live time data of traffic in the road. There will be enough over bridge and tunnel in the city. There will be separate lane for different vehicle. There will be separate lane for bus, car, pedestrian and bicycle. Along the major roads there will be separate bus bay. There will be separate lane for different vehicle speeding in different speed.

5.7.4. Safer Living. Providing safe environment to its citizen is one of the top priorities of the smart city mission. It should provide safety to every section of the society. There will be smart efficient street light in every street of the city. The high resolution camera will be installed in every corner of the city to monitor the activities of the citizen. The cab service to provide the safety to passenger will have the alarm installed in it. The emergency number to police, fire bracket and medical will stay active all the time. The citizen the lodge the first information report in police station online.

5.7.5. Safety Against Natural Disasters. The smart city will have the capacity to mitigate the disaster and full fill its loss of material in very short period of time. With the applicatiion of its latest technology it will lessen the impact of disaster in the city. The citizen will get the prior information about the disaster. They will be informed the probable timing of strike of the disaster and to take the precautionary measure. During the disaster

they will be shown shortest pathsca to escape from disaster site.

6. Conclusion. The Ministry of Urban and Housing Affairs, Government of India believe that for the city to become smart, smart sustainable development of the city infrastructure such as transportation, water management, waste management, street light, disaster management is important. Maintaining sustainability of the city very important aspects of the smart city mission that's why the paper stresses on the development of the city. Present paper analyse the current problems and infrastructure facilities and suggest for proposed Guwahati smart city. It has been observed that the major problem the city, facing today is of traffic congestion, scarcity of portable drinking water, unhygienic environment and shortages of public toilets. There is loss of life and properties in city, due to disasters like earthquake, flash flood and landslide during monsoon season. To check the traffic congestion important whole shale market, trade centre has been shifted from the city centre to the outskirt, numerous over bridges are constructed, city roads are widens. Encouragement to use public means of transportation by developing and increasing its speed and regularity will solve the traffic congestion problem. Nearly 40 per cent of the vehicles are parked in the road side and this cause traffic congestion, so construction of parking infrastructure is important. The faith of the Guwahati city is such that during monsoon there is flash flood and landslide in the city and on the other hand during winter season there is the scarcity of the water. The problem of flood can be solved by the proper maintenance of drainage system, installation of motor pump and construction of sluice gate. It has been found that majority of the households in the city have wells and tube wells and during winter due to underground water depletion water dries up. This problem can be solved by the construction of infrastructure for regular water supply pipeline by the government. The e-governance will create the common single platform for the citizen and government for sharing of data and information for better functioning and governance. In this way, it will maintain the transferability of the government works. There is urgent need that all stakeholders including civil society, community based organisations, government work in coordinated manner for the integrated sustainable development and of Guwahati smart city.

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